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ABUNDANCE AND AGE-SEX-SIZE COMPOSITION OF THE 1987 SALCHA RIVER CHINOOK SALMON ESCAPEMENT

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ABSTRACT

The number of adult chinook salmon *Oncorhynchus tshawytscha* that returned to spawn in the Salcha River near Fairbanks, Alaska was estimated using a mark-recapture experiment. Gill nets and electrofishing gear were used to capture 381 chinook salmon in July and August, 1987. The chinook salmon were marked with jaw tags, fin clipped, and released. In August, 851 fish were collected during carcass surveys; 64 fish had been marked during July and August. Using a stratified Petersen estimator, the total chinook salmon abundance was estimated at 4,771 (standard error = 504); 2,481 females (standard error = 349) and 2,289 males (standard error = 363). Four aerial counts of chinook salmon were conducted from 24 July to 10 August. The peak count occurred on 4 August, at which time, 1,736 live and 162 dead adult chinook salmon were counted; about 40 percent of the mark-recapture point estimate.

The proportion of males and females in the population was nearly equal (52 percent and 48 percent, respectively). The major age class was 1.4 which accounted for 85 percent of the females and 54 percent of the males in the population. The estimated egg production for the 1987 spawning run was 25.9 million eggs (standard error = 3.2 million eggs).

KEY WORDS: chinook salmon, *Oncorhynchus tshawytscha*, enumeration, Salcha River, age-sex-size composition, aerial survey, fecundity, egg production

INTRODUCTION

The complex nature of the escapement and exploitation of Yukon River chinook salmon *Oncorhynchus tshawytscha* stocks requires that accurate estimates of escapement be made in a number of major spawning streams. The Salcha River is a 250 km long clear runoff river flowing into the Tanana River about 60 km east of Fairbanks (Figure 1). The Salcha River is one of the most important producers of chinook salmon in the middle Yukon River drainage. Waters of the middle Yukon River (includes the Tanana River drainage) produce up to one-third of the total chinook salmon harvested in the Yukon River system (Wilcock 1985).

Since 1972, the number of mature chinook salmon counted in the Salcha River during aerial surveys has ranged from 391 to 6,757 (Table 1; Barton 1984). However, only a portion of the population is usually present during an aerial survey and the number of chinook salmon counted is affected by weather, water level, water clarity, and overhanging vegetation. Barton (1987a and 1987b) found that the number of mature chinook salmon counted during an aerial survey was less than one-fifth of the estimated population abundance based on mark-recapture experiments in the Chena River (near Fairbanks) and fish counts through a weir in Clear Creek (near Nenana).

The goal of this project was to estimate the abundance and composition of the spawning escapement of chinook salmon in the Salcha River during 1987; and then estimate the proportion of these fish that were observed during an aerial survey of the Salcha River in 1987.

MATERIALS AND METHODS

Capture and Marking

Under the original sampling design, adult chinook salmon were captured in the lower Salcha River near the Richardson Highway Bridge using two 30-meter long gill nets from 3 July through 31 July 1987. Each gill net had one panel 15 m long and 3.7 m deep with 15 mm (5.75 inches) stretched multifilament mesh and one panel 15 m long and 4.9 m deep with 21 mm (8.25 inches) stretched multifilament mesh. One end of each gill net was tied to a post on shore, and the other end was anchored in the river so that the gill net was angled slightly downstream. The gill nets were in the river from 6 to 24 hours each day.

Relatively few fish were caught with gill nets and as a result, adult chinook salmon were also captured with a riverboat equipped with electrofishing gear (Roguski and Winslow 1969) during the period 31 July through 2 August. Fish were stunned with pulsating direct current electricity, dipped from the river with long handled nets, and placed in an aerated holding box. The lower 97 km of the river, up to the confluence of Caribou Creek, were sampled in this manner and this area was divided into three sections of approximately equal length for later analysis (Figure 1). Past surveys of the Salcha River have shown that few chinook salmon spawn above Caribou Creek (Fred Andersen, Alaska Department of Fish and Game, Fairbanks, personal communication). Each section

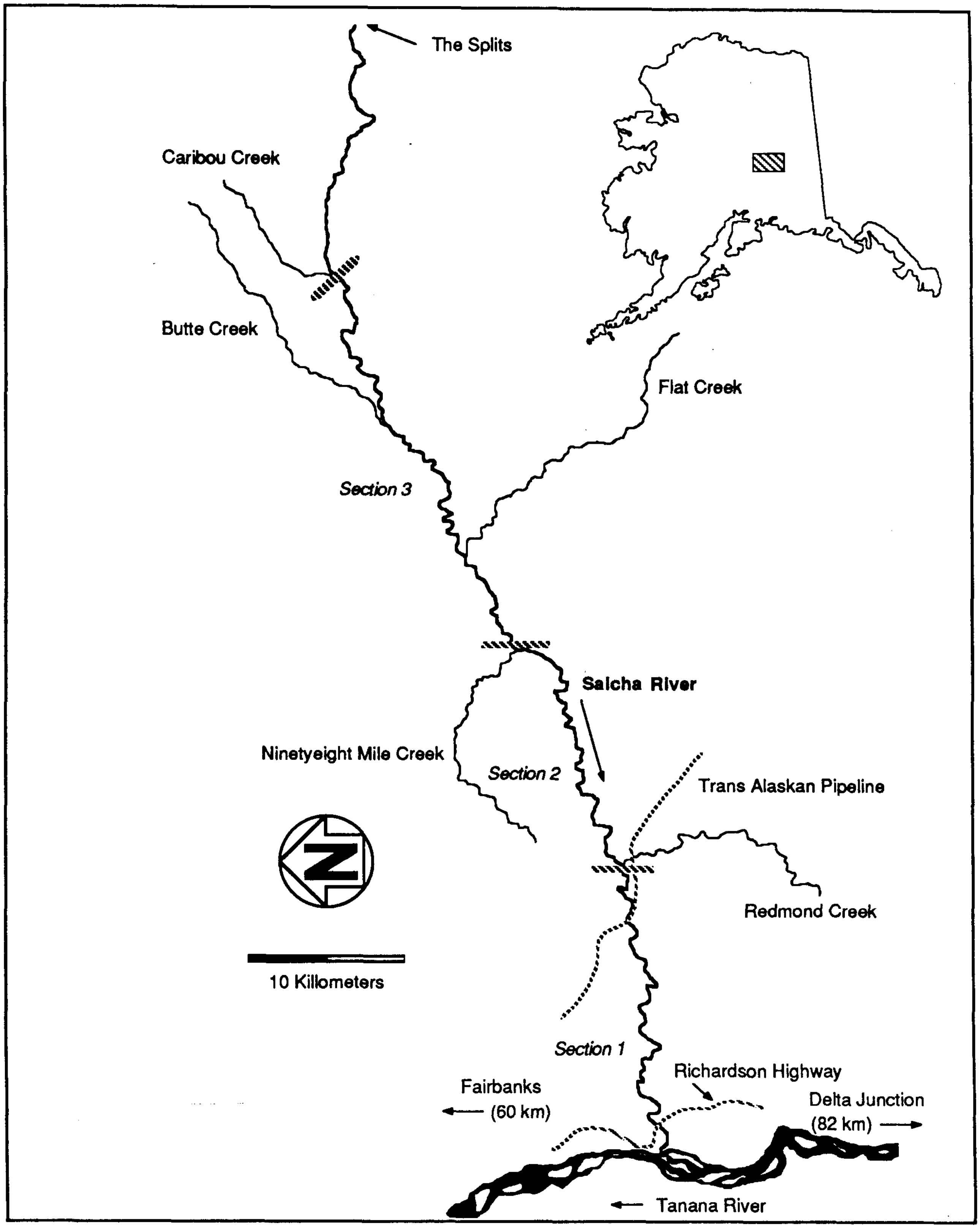

Figure 1. Salcha River study area.

Table 1. Abundance of chinook salmon estimated during aerial surveys of the Salcha River, 1972-1987 (Barton 1984 and Barton, Alaska Department of Fish and Game, Fairbanks personal communication).[1]

Year							
1972	1973	1974	1975	1976	1977	1978	1979
1,193	391	1,857	1,055	1,641	1,202	3,499	4,789

Year							
1980	1981	1982	1983	1984	1985	1986	1987
6,757	1,237[2]	2,534	1,961	1,031	2,035	3,368	1,898

[1] Data are the highest count when more than one survey was made each year.

[2] Minimal count due to poor survey conditions.

was sampled by making one pass starting at the upstream boundary. Only one section was sampled each day starting with Section 1 and ending with Section 3.

All captured chinook salmon were tagged, finclipped, measured, and placed in a holding pen or live box. Each uniquely numbered metal tag was attached to the lower jaw. A combination of adipose and pelvic fin clips was used to identify the capture method and capture period. The length was measured from mid-eye to fork of tail (ME-FK) to the nearest 5 millimeters. The sex was determined from observation of body morphology.

Recovery

Tag recoveries were obtained by collecting carcasses of dead chinook salmon from the same three river sections in which electrofishing was conducted. The first carcass sampling event occurred on 3, 4, 5, and 7 August and the second event occurred on 10, 11, and 12 August. Carcasses were collected from only one section per day starting with Section 1 and ending with Section 3 (Section 1 required 2 days of sampling during the first carcass sampling event). During each of the two sampling events, carcasses were collected from all three sections.

One pass was made through each section in a drifting riverboat starting at the upstream end of the section. Long handled spears were used to collect carcasses. The carcasses were measured and examined for fin clips and jaw tags. The sex was determined from observation of body morphology. Three scales for age analysis were removed from the first 600 carcasses. Dorsal fin rays, vertebrae, and tissue samples (heart, muscle, liver, and eye) were collected for other research studies conducted by the Division of Commercial Fisheries of the Alaska Department of Fish and Game and the United States Fish and Wildlife Service.

Abundance Estimator

The estimated number of adult chinook salmon was calculated using the adjusted Petersen estimator described by Chapman (1951, cited in Seber 1982):

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

where:

N^* = the estimated abundance of adult male or female chinook salmon;

n_1 = the number of individuals marked in the first sample;

n_2 = the number of individuals in the second sample; and,

m_2 = the number of marked individuals in the second sample.

The variance of N^*, $V(N^*)$, was calculated using the formula provided by Seber (1982):

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

The total population abundance and associated sampling variance was then estimated as the sum of the estimates for males and females. The results from the mark-recapture experiment were investigated with a battery of statistical tests (described in the results) to determine if a Petersen estimator was appropriate.

Tag Loss

The proportion of tags lost during the study was estimated using:

(3) $$p_t = n_u/n_r$$

where:

p_t = the proportion of tags lost;

n_u = the number of recaptured fish without tags; and,

n_r = the total number of fish recaptured.

The variance of p_t was estimated using:

(4) $$V(p_t) = p_t(1-p_t)/(n_r-1)$$

where:

$V(p_t)$ = the variance of the proportion of tags lost.

Age, Sex, and Length Composition

The proportion of females and males by ocean age was estimated using:

(5) $$p_i = a_i/n_t$$

where:

p_i = the estimated proportion of females (or males) of ocean age i in the sample;

a_i = the number of females (or males) of ocean age i in the sample;

n_t = the total number females and males in the sample; and,

i = the ocean age (1, 2, 3, 4, and 5).

The variance of p_i was estimated using:

(6) $$V(p_i) = p_i(1-p_i)/(n-1)$$

where:

$V(p_i)$ = the estimated variance of the proportion of females (or males) of ocean age i in the sample.

The abundance of females (or males) by ocean age was estimated using:

(7) $$N_i = p_i(N^*)$$

where:

N_i = the estimated abundance of females (or males) of ocean age i in the population.

The variance of the product N_i was estimated using (Goodman 1960):

(8) $$V(N_i) = N_i^2V(p_i)+p_i^2V(N_i)-V(p_i)V(N_i)$$

where:

$V(N_i)$ = the estimated variance of the abundance of females (or males) of ocean age i in the population.

Population Egg Production

The total egg production for the Salcha River chinook salmon escapement was estimated using:

(9) $$E = \Sigma p_iF_i$$

where:

E = the total population fecundity;

N_i = the estimated number of females of ocean age i from Equation (7); and,

F_i = the mean fecundity for females of ocean age i as determined by Nelson and Biwer (1969) for chinook salmon in the Nushagak District of Bristol Bay (Table 2).

The variances of N_iF_i and E were estimated using (Goodman 1960):

(10) $$V(N_iF_i) = N_i^2V(F_i)+F_i^2V(N_i)-V(N_i)V(F_i);\text{ and}$$

(11) $$V(E) = \Sigma V(N_iF_i);$$

Table 2. Mean lengths, mean fecundities, and associated standard errors for chinook salmon from the Nushagak District in Bristol Bay, 1967-1968 (Nelson and Biwer 1969).

Age	Sample Size	Length (mm)		Fecundity	
		mean	SE	mean	SE
1.3	10	776	7.73	8,358	387.148
1.4	46	884	8.44	10,299	314.861
1.5	13	974	13.79	12,214	568.975

where:

$V(E)$ = the variance of the total population egg production;

$V(F_i)$ = the variance of the mean fecundity for females of ocean age i; and,

$V(N_i)$ = the variance of the estimated number of females of ocean age i.

Aerial Survey

Personnel from the Division of Commercial Fisheries of the Alaska Department of Fish and Game counted the number of live and dead adult chinook salmon in the Salcha River on four different occasions from 24 July to 4 August. Counts was made from a low flying fixed-wing aircraft. The methods used by the Division of Commercial Fisheries for aerial surveys are described by Barton (1987c).

RESULTS

With gill nets, 94 chinook salmon (34 females and 60 males) were captured and tagged from 3 July to 31 July (two chinook salmon were killed by the sampling gear). With electrofishing gear, an additional 287 chinook salmon (132 females and 155 males) were captured and tagged from 31 July to 2 August (three chinook salmon were killed by the sampling gear). A total of 851 chinook salmon were examined for tags during the two carcass sampling events, 3 August to 12 August.

Tests of Assumptions for a Petersen Estimator

Lengths of all marked and all recaptured fish were compared using a Kolomogorov-Smirnov Two-Sample test (Conover 1980) to determine if sampling gear was size selective. The length distributions of marked and unmarked fish were not significantly different (DN = 0.18, P = 0.30) and therefore, no stratification of the abundance estimates by length group was necessary.

Females were recaptured more frequently than males; 57% for females versus 45% for males. A comparison of the number of females and males that were recaptured and not recaptured was marginally significant (χ^2 = 3.3, df = 1, P = 0.07; Table 3). This indicated that the estimate should be stratified by sex.

The assumption of equal probability of capture through time was evaluated by comparing the rate of recapture of fish that were marked during the early part of the experiment (3 to 21 July) with the recapture rate of fish marked during the second half of the experiment (22 to 31 July). All fish were captured using gill nets during these time periods. The rate of recovery for the two marking periods was significantly different (χ^2 = 4.06, df = 1, P = 0.04; Table 4) with only 7% of the fish marked during the early period being recaptured and 25% of the fish marked during the second period being recaptured. The failure of this assumption

Table 3. Goodness-of-fit test for differences in recovery rates between male and female chinook salmon in the Salcha River, 1987.

	Males	Females	Total
Recaptured	29	186	215
Not Recaptured	35	131	166
Total Released	64	317	381
Recovery Rate	0.45	0.57	

Chi-square value with continuity correction = 3.343;
Degrees of freedom = 1;
P-value = 0.07.

Table 4. Goodness-of-fit test for differences in recovery rates of Salcha River chinook salmon marked early and late in the run.[1]

	Early	Late	Total
Recaptured	3	13	16
Not Recaptured	39	39	78
Total Released	42	52	94
Recovery Rate	0.07	0.25	

Chi-square value with continuity correction = 4.057;
Degrees of freedom = 1;
P-value = 0.044.

[1] The early marking period was 3 - 21 July; the late marking period was 22 - 21 July.

(equal probability of capture through time) indicates that the abundance estimate should be stratified by time period (Schaefer or Darroch methods, Seber 1982 and Brannian 1986). Unfortunately, too few recaptures were obtained from the first marking period to use these methods.

One possible cause for the differences in rates of recapture between fish marked early and late in the run is difference in run timing by sex in combination with differences in catchability between males and females during marking or recapture. A higher proportion of males (0.74) were marked during the first sampling event than during the second event (0.56) (Table 5). Although the proportions are not significantly different (χ^2 = 2.54, df = 1, P = 0.111), this indicates that males probably entered the river earlier than females. Since females were recaptured more frequently than males, recaptures would more likely come from the late marking period.

The assumption of equal probability of recapture through time was evaluated by comparing the rate of recovery of marked fish during the first and second recapture events. The number of marked and unmarked fish collected from 3 to 7 August and from 10 to 12 August was not significantly different (χ^2 = 0.40, df = 1, P = 0.53; Table 6).

The assumption of equal mixing of marked and unmarked fish in the population was evaluated using a contingency table of the number of fish marked by area against the number of marked fish recaptured by area or not recaptured. I was not able to use this test because half of the expected frequencies were less than 5. However, equal mixing of marked (using electrofishing gear) and unmarked fish in the population may be assumed because fish were captured and marked throughout a 97 km section of river that includes the major spawning areas. The rate of recovery of marked fish among the lower, middle, and upper carcass survey areas was evaluated using a contingency table. No significant differences occurred between the number of fish recaptured and not recaptured among the three carcass survey areas (χ^2 = 0.76, df = 2, P = 0.7; Table 7). Therefore, no stratification by area was necessary.

Because all marked fish received both a metal jaw tag and a finclip, I was able to estimate the proportion of tags lost during the mark-recapture experiment. Sixty-four marked chinook salmon carcasses were recovered; 51 had tags, and 13 had only a finclip. The estimated proportion of tags lost during the mark-recovery experiment was 0.203 (SE = 0.051).

Abundance Estimate

Based on the previous test of assumptions results, a Petersen abundance estimate stratified by sex was performed. The total estimated number of females in the run was 2,481 (SE = 348) and the estimated number of males was 2,290 (SE = 363), for a total run estimate of 4,771 (SE = 504) (Table 8).

Table 5. Goodness-of-fit test for differences in numbers of female and male chinook salmon captured during early and late gill net periods in the Salcha River, 1987.[1]

	Early	Late	Total
Females	11	23	34
Males	31	29	60
Total Captured	42	52	94
Capture Rate			
Females	0.26	0.44	
Males	0.74	0.56	

Chi-square value with continuity correction = 2.54;
Degrees of freedom = 1;
P-value = 0.111.

[1] The first carcass recovery period was 3 - 7 August; the second carcass recovery period was 10 - 12 August.

Table 6. Goodness-of-fit test for differences in recovery rates of marked chinook salmon between the first and second carcass recovery time periods.[1]

	Carcass Survey	
	Period 1	Period 2
Marked	45	19
Not Marked	595	201
Total Recovered	640	220
Recovery Rate	0.07	0.09

Chi-square value with continuity correction = 0.402;
Degrees of freedom = 1;
P-value = 0.53.

[1] The first carcass recovery period was 3 - 7 August; the second carcass recovery period was 10 - 12 August.

Table 7. Goodness-of-fit test for differences in recovery rates between three carcass recovery areas on the Salcha River, 1987.

	Recovery Area			
	Lower	Middle	Upper	Total
Recaptured	12	15	12	39
Not Recaptured	57	98	80	235
Total Released	69	113	92	274
Recovery Rate	0.17	0.13	0.13	

Chi-square value = 0.756;
Degrees of freedom = 2;
P-value = 0.7.

Table 8. Estimated abundance of adult chinook salmon in the Salcha River, 1987, based on Petersen mark-recapture experiment stratified by sex.

	Released	Captured	Recaptured	Estimated Abundance	SE
Females	166	534	35	2,481	349
Males	215	317	29	2,290	363
Both Sexes	381	851	64	4,771	504

Aerial Survey

Four aerial survey counts of chinook salmon in the Salcha River were made from 24 July to 4 August (Table 9). The maximum count occurred on 4 August; this coincided with the first carcass sampling event. Survey conditions were rated as "fair" on a scale of "poor, fair, and good." During the aerial survey of 4 August, 1,736 live and 162 dead adult chinook salmon were counted. The combined count of 1,898 is about 40% of the mark-recapture point estimate.

Age, Sex, and Length Composition

Sex composition varied among the three methods of sampling. The percentage of females was: 36% in the gill net sample (N=94); 50% in the electrofishing sample (N=294); and 63% in the carcass sample (N=851). Using the Petersen abundance estimate stratified by sex, females comprised an estimated 52% of the spawning escapement (Table 10).

During carcass sampling, age, sex, and length data were obtained from 549 chinook salmon (Tables 10 and 11). Aging of these scales showed that ocean age of the fish ranged from 1 through 5 years and that all fish spent 1 year in freshwater. The dominant age class for both females and males was 1.4 (brood year 1981). Over 95% of the females were age 1.4 or older and about 56% of the males were age 1.4 or older (Table 10). The length of females ranged from 565 to 1,010 mm; males ranged from 445 to 1,075 mm (ME-FK). There was no consistent trend for females to be larger on average than males (Table 11).

Population Egg Production

Total egg production by the estimated 2,481 female chinook salmon in the Salcha River in 1987 was determined using average fecundity estimates for specific age classes (Nelson and Biwer 1986). The total estimated egg production was 25.9 million eggs (standard error = 3.2 million) (Table 12). Age class 1.4 females accounted for about 84% of the total egg production.

DISCUSSION

Gill nets were not an effective tool for capturing upstream migrating chinook salmon in the Salcha River. Only 94 fish were marked during the entire month of July using gill nets. Barton (1987) successfully tagged fish in the Chena River in 1986 using gill nets. However, at the available gill net sites, the Salcha River is swifter and clearer than the Chena River. Fish were observed avoiding the nets on the Salcha River during periods of clear water. Electrofishing was employed as an alternate capture method because of the low number of fish marked (94) using gill nets from 3 to 31 July, and because, by 28 July, 424 adults were observed on the spawning grounds during aerial surveys (Table 9). Electrofishing was an effective sampling tool. A total of 294 fish were tagged in only 3 days of sampling. Three fish were killed by the electrofishing gear; delayed mortality was not investigated.

Table 9. Abundance of live and dead chinook salmon counted during aerial surveys of the Salcha River, 1987 (Barton, Alaska Department of Fish and Game, Commercial Fisheries, personal communication).

	24 July	28 July	4 August	10 August
Live	130	419	1,736	763
Dead	1	5	162	542
Total	131	424	1,898	1,305

Table 10. Estimated proportion and abundance of female and male chinook salmon by age class in the Salcha River, 1987.

Females					
Age Class	Sample Size	Proportion	Standard Error	Abundance	Standard Error
1.1	0	0	0	0	0
1.2	1	0.003	0.003	7	7
1.3	13	0.038	0.010	94	28
1.4	293	0.849	0.019	2,107	300
1.5	38	0.110	0.017	273	57
Totals	345	1.0		2,481	

Males					
Age Class	Sample Size	Proportion	Standard Error	Abundance	Standard Error
1.1	1	0.005	0.005	11	11
1.2	31	0.152	0.025	348	79
1.3	56	0.275	0.031	629	122
1.4	111	0.544	0.035	1,245	213
1.5	5	0.025	0.011	57	26
Totals	204	1.0		2,290	

Table 11. Length at age of chinook salmon collected during carcass surveys of the Salcha River, 1987.

Females:

Age Class	Sample Size	Length (mm) Mean	SE	Range
1.1	0			
1.2	1	565	0	0
1.3	13	749	17.07	645 - 830
1.4	293	868	2.79	670 - 990
1.5	38	906	8.03	830 - 1,010
Total	345			

Males:

Age Class	Sample Size	Length (mm) Mean	SE	Range
1.1	1	455		
1.2	31	566	15.64	425 - 895
1.3	56	695	10.21	545 - 930
1.4	111	858	8.60	600 - 1,075
1.5	5	875	64.34	650 - 1,025
Total	204			

Males and Females Combined:

Age Class	Sample Size	Length (mm) Mean	SE	Range
1.1	1	455		
1.2	32	566	15.14	425 - 895
1.3	69	705	9.21	545 - 930
1.4	404	865	3.11	600 - 1,075
1.5	43	903	9.92	650 - 1,025
Total	549			

Table 12. Estimated egg production by age class of Salcha River chinook salmon, 1987.

Age Class	Estimated Number of Females	Average Fecundity[1]	Estimate Number of Eggs (millions)	SE
1.2 + 1.3	101	8,358	0.84	0.04
1.4	2,107	10,299	21.70	3.16
1.5	273	12,214	3.33	0.71
Totals	2,481		25.87	3.24

[1] From Nelson and Biwer (1969).

Results of the mark-recapture experiment indicate that significant bias occurred in the capture of chinook salmon by sex: 36% in the gill net sample; 50% in the electrofishing sample; and 63% in the carcass sample. The different sex ratios were probably the result of sexual dimorphism and differences in behavior. Male chinook salmon were probably more likely to be captured in gill nets because their hooked nose and teeth are more developed and are more easily tangled in the mesh. Males were more likely to be captured using electrofishing gear because they were observed to swim to the surface when shocked. Females remained near the bottom and were sometimes out of reach of the capture crew. Also, females over redds were often accompanied by more than one male which makes the probability of capturing males more likely. Kissner (1974), while operating a weir to collect salmon carcasses, observed a difference in the timing of death after spawning between female and male chinook salmon which may affect the sex ratio of the available carcasses through time. The daily count of male carcasses peaked about 6 days before the peak of the daily count of female carcasses. A Kolmogorov-Smirnov Two-Sample test was used to evaluate the difference between the distributions of the daily counts of female and male carcasses; the difference was significant ($DN = 0.62$, $P \le 0.001$). After stratification, the abundance of female and male chinook salmon was estimated at 2,481 and 2,290, respectively, for a ratio of 1.1 to 1.

There was a significant departure from the assumption of equal probability of capture through time when gill nets were used to capture chinook salmon for marking. Chinook salmon marked during the early part of the experiment (3 to 21 July) were less likely to be recaptured than fish marked during the second half of the experiment (22 to 31 July). Thus, a Schaefer or Darroch estimator was the appropriate model. However, two factors precluded the use of these estimators for estimating abundance. First, too few recaptures were obtained from the early marking period to allow for stratification based on time. One possible reason for the early number of recaptures during the early period is a higher rate of washout of carcasses that were marked in the early marking period. Flooding occurred between the first and second marking periods, and this could have caused washout of carcasses of fish marked during the first period. However, no carcasses were observed prior to the flooding, and this bias is assumed to be minimal. A second possible reason for the low recapture rate of fish marked during the first period is difference in run timing by sex. A higher proportion of males (76%) were tagged during the first sampling event than during the second event (56%). This indicates that males entered the river earlier than females, and since females were obtained more frequently than males during carcass sampling, recaptures would more likely come from the late marking period. The second reason that time stratified estimators of abundance could not be used was that a second sampling method (electrofishing) captured fish on the spawning grounds. The run timing of these fish could not be determined which prevented the use of the time stratified estimators. A Petersen estimator was selected as the best alternative.

The Petersen abundance estimate, 4,771 fish, will be biased high or low depending on how the marking varied in relation to abundance (Brannian

1986). However, the magnitude of this bias may not be large. A comparison of the estimated abundance of fish captured only with electrofishing gear with that of fish captured only with gill nets also confirms this conclusion. The respective abundance estimates, 4,371 (standard error = 702) and 4,351 (standard error = 1,233), are not significantly different ($P > 0.5$). Since fish captured with electrofishing gear were marked on the spawning grounds and fish captured with gill nets were marked during the upstream migration, the fact that the two estimates are not different suggests that washouts of large numbers of early run fish had not occurred prior to electrofishing. The different recapture rates by sex is best explained by the different availability of females and males during marking and recovery. Any bias is removed when the abundance estimate is stratified by sex.

The peak aerial survey estimate was subjectively judged as "fair" and was about 40% of the mark-recapture point estimate. Aerial survey estimates are usually low for a number of reasons including: fish may still be arriving; fish may have died and been washed from the river; or not all of the fish present are visible because of weather conditions, water level, water clarity, and overhanging vegetation. For the Chena River in 1986, the number of fish counted during an aerial survey was 22.4% of the abundance estimated by a mark recapture experiment (Barton 1987). The lower percentage of fish counted in the Chena River (under similar survey condition) is probably due to different stream morphology. The Salcha River is generally shallower and clearer than the Chena River, which would probably result in more of the population being visible during an aerial survey of the Salcha River.

Additional comparisons between abundance estimates and aerial surveys are needed to further define their relationship on the Salcha River. I recommend that electrofishing be used as the capture method in future mark-recapture experiments in the Salcha River, and that marking be performed over a period long enough to capture both early and late run fish.

The estimates of average fecundity of chinook salmon by age class obtained from Bristol Bay by Nelson and Biwer (1986) were used because there is no adequate fecundity data for specific age classes of Yukon River chinook salmon. The Alaska Department of Fish and Game, Division of Commercial Fisheries, has used a single average estimate of chinook salmon fecundity for all age classes to determine population egg production of Yukon River chinook salmon (Andersen 1981). Bigler (1982) obtained fecundity data of Yukon River chinook salmon, however, the sample sizes used to determine average fecundity of age class 1.3 and 1.5 fish were too small. I have assumed that the average fecundities for chinook salmon by age class are similar in Bristol Bay and the Yukon River.

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