FISHERY DATA SERIES NO. 67

ABUNDANCE ESTIMATES OF THE ESCAPEMENT OF CHINOOK SALMON INTO THE KENAI RIVER, ALASKA, BY ANALYSIS OF TAGGING DATA, 1987[1]

By

R. H. Conrad

Alaska Department of Fish and Game
Division of Sport Fish
Juneau, Alaska 99802

September 1988

[1] This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-3, Job No. S-41-2.

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ABSTRACT

Drift gill nets were used to capture adult chinook salmon *Oncorhynchus tshawytscha* in the lower Kenai River for tagging. Tagged fish were recovered during a creel survey of the recreational fishery. The number of chinook salmon entering the Kenai River from 20 May to 28 July was estimated using the tag release-and-recapture data. Effort and catch data from the drift gill nets were used to estimate the abundance of chinook salmon from 29 July to 11 August. The estimated total return of chinook salmon to the lower Kenai River from 20 May to 11 August was 90,667. The abundance of late-run fish (65,024) was more than twice that of early-run fish (25,643). The major age groups of returning chinook salmon were 1.3 (31 percent) and 1.4 (66 percent). The mean length-at-age of male and female chinook salmon increased throughout the return.

KEY WORDS: Kenai River, chinook salmon, *Oncorhynchus tshawytscha*, tag release and recapture, abundance estimate, gill net effort and catch statistics, age-sex-length compositions.

INTRODUCTION

Alaska's largest recreational fishery in freshwater occurs in the Kenai River. This fishery had more than 320,000 angler-days of effort in both 1985 and 1986 (Mills 1986, 1987). Most of the effort by anglers is directed at returning chinook salmon *Oncorhynchus tshawytscha* and occurs during June and July in the mainstem of the river downstream from Skilak Lake (Figure 1). In 1987, both estimated angler-effort and harvest of chinook salmon by this fishery were the largest since a creel survey of the fishery was begun in 1977 (Figure 2). Fishing effort is expected to continue to increase because the Kenai River is near a major population center and is easy to access.

The Kenai River has two stocks of chinook salmon: (1) an early run which enters the river from mid-May until late June; and (2) a late run which enters the river from late June through early August. Fish from both stocks are highly valued by anglers because of their large size, especially fish from the late run. Chinook salmon in the late run average about 18 kg (40 lb) and often exceed 36 kg (80 lb). The world record for a sport-caught chinook salmon was taken from the Kenai River in 1985; it weighed 44 kg (97 lb).

Management of the recreational fishery in the Kenai River is complicated by the relatively large harvests of chinook salmon returning to the Kenai River by sport and commercial fisheries in the marine waters of Cook Inlet, particularly by the commercial set net fishery along the east side of the Inlet (McBride et al. 1985). Estimates of the abundance and biological characteristics (age and sex compositions, mean length at age) of the chinook salmon escapement are needed to effectively manage the sport fishery. The Sport Fish Division of the Alaska Department of Fish and Game (ADF&G) proposed a tag release and recovery program in 1975 to provide the required estimates. Electrofishing equipment, drift gill nets (Hammarstrom 1980), fish traps, and fish wheels (Hammarstrom and Larson 1982, 1983, 1984) were tested as methods for catching chinook salmon. Drift gill nets were found to be the most effective and were used to estimate abundance of late-run chinook salmon in 1984 (Hammarstrom et al. 1985), 1985 (Hammarstrom and Larson 1986), and 1986 (Conrad and Larson 1987). The abundance of early-run chinook salmon was estimated in 1985 (Hammarstrom and Larson 1986) and 1986 (Conrad and Larson 1987). Improved equipment and tagging techniques in 1984 increased the number of fish tagged, while improved data collection procedures and more recovery personnel in 1985 and 1986 increased the number of fish inspected for tags.

This report describes the methods used to estimate the number of chinook salmon in the escapement to the Kenai River during 1987. In addition to an abundance estimate, biological data from chinook salmon sampled during tagging and spawning ground surveys are presented. These data, in conjunction with estimates of numbers of fish and age composition for the recreational harvest (Hammarstrom 1988), are used to estimate the numbers of fish and age composition of the spawning population. These

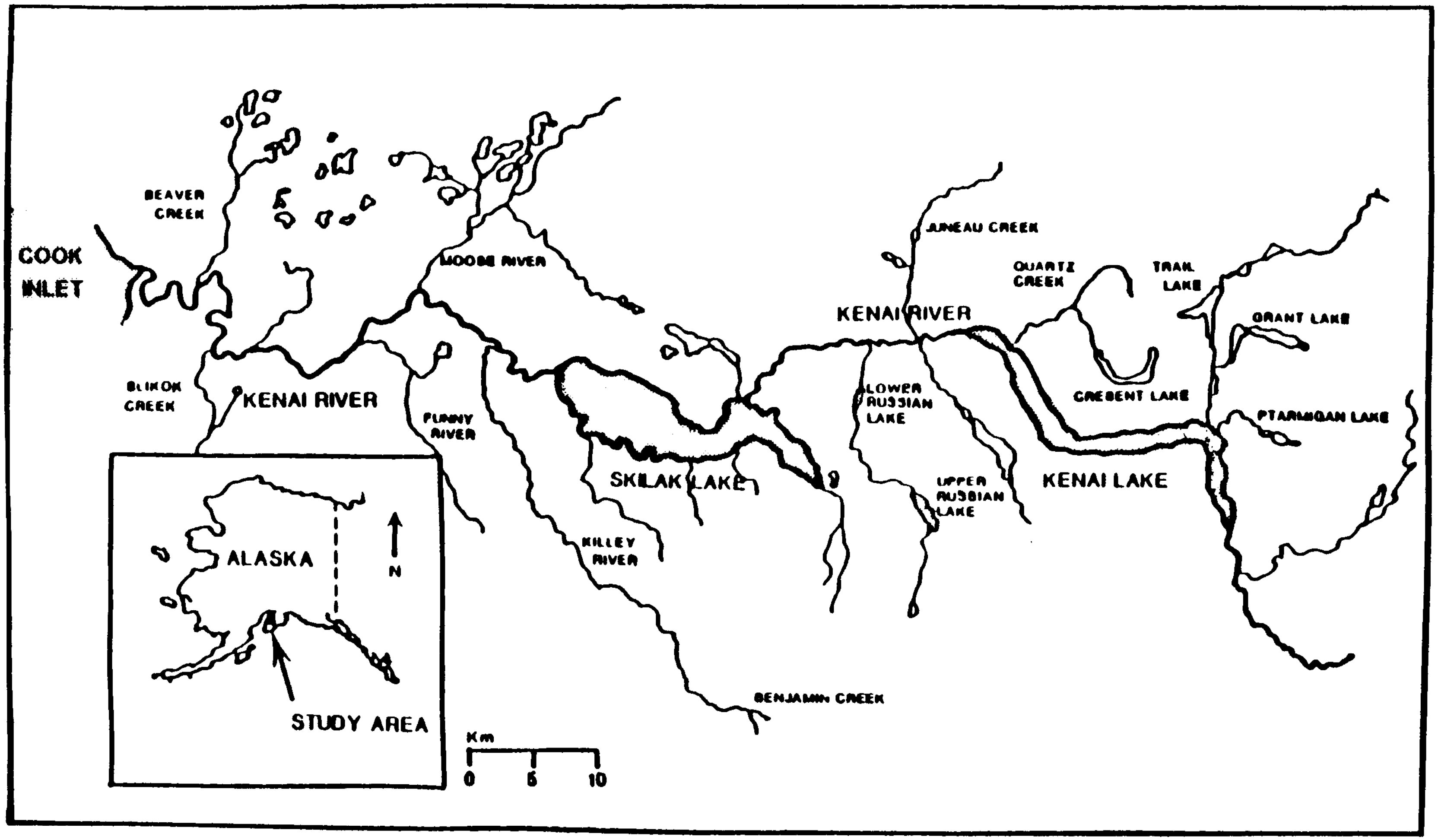

Figure 1. Map of the Kenai River system.

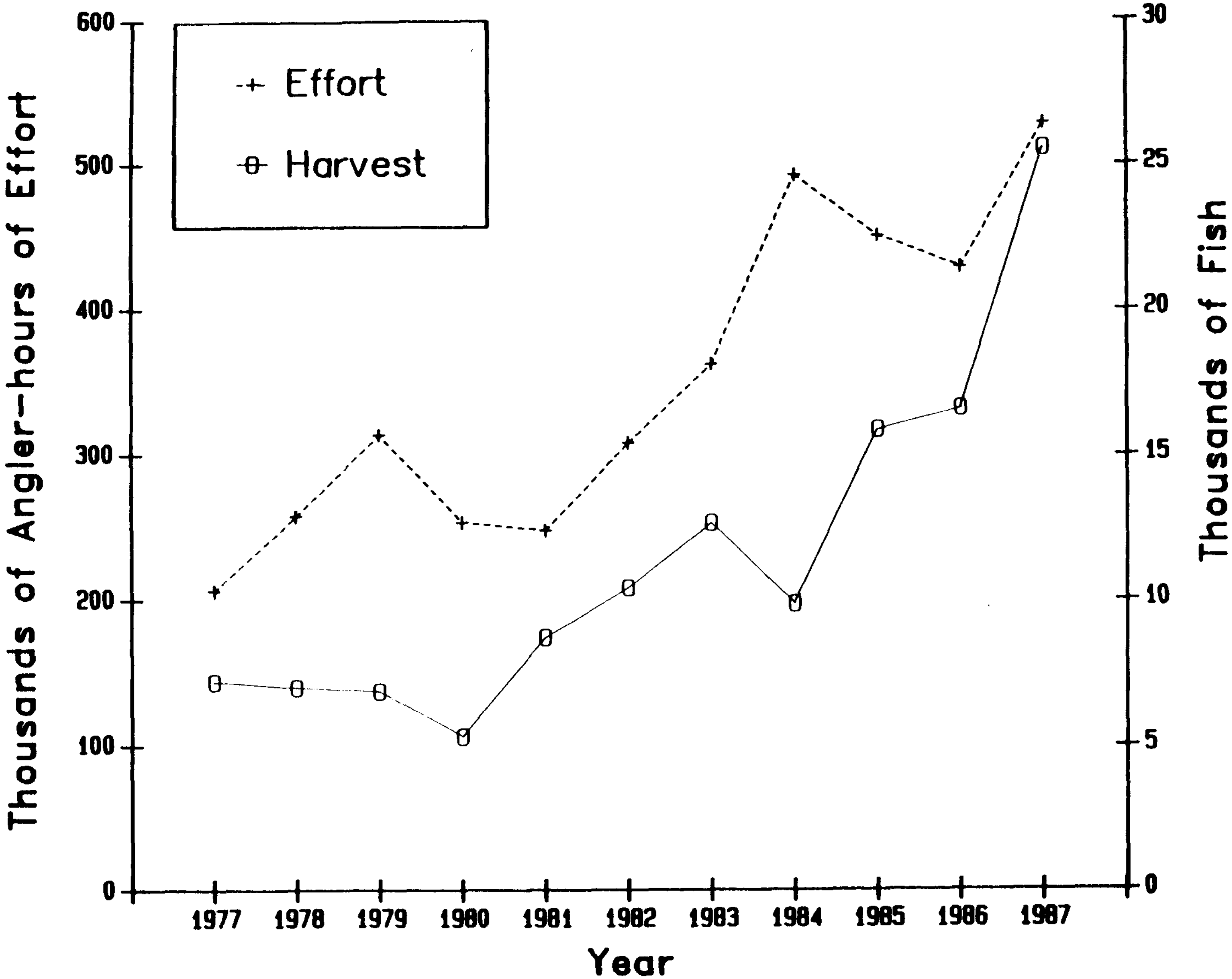

Figure 2. Estimates of angler-effort and harvest of chinook salmon for the recreational fishery in the Kenai River during May, June, and July, 1977-1987.

data supply an integral part of the long-term database of total return information so that spawner-return relationships may be estimated in the future.

METHODS

Tagging

Four, 2-person crews tagged chinook salmon. Tagging was conducted between 6.8 to 9.3 river miles (RM) above the mouth of the Kenai River (Figure 3) each day between 20 May and 11 August, inclusive. Two crews usually operated on 4 days of each week and all four crews operated on the remaining 3 days of each week. Sampling could be conducted during daylight hours only and was restricted to the 9 hours before high tide because catches of chinook salmon were highest during this period in other years (Hammarstrom and Larson 1982, 1983, 1984). Two crews worked each tide on days when two high tides occurred during daylight. When only one high tide occurred during daylight, either two, three, or four crews operated depending on crew availability. Each sampling period was about 6.5 hrs long.

Each crew used a 19 cm stretched-mesh drift gill net about 15 m long to capture chinook salmon. The net was set from the bow of an outboard powered skiff by releasing one end of the net near the shoreline and rapidly backing the skiff toward the middle of the river channel. Once the net was extended, it was allowed to drift downstream with the current until either a fish was caught, the net encountered a snag on the river bottom, or the boundary of the tagging area was reached.

When a fish became entangled in the net, the floats on the net bobbed violently and the net was then immediately retrieved. A soft, braided rope was looped around the caudal peduncle of each chinook salmon captured. The fish was then untangled from the net and slipped into a cradle for processing. The tagging cradle was a rigid, foam-padded device which hung from the side of the skiff with its base about 15 cm below the water line. The cradle immobilized the captured fish and kept it in the water during processing. The date, time of capture, and approximate river mile of capture were recorded for each chinook salmon brought to the skiff, in addition to the tag number for fish tagged.

The condition of each captured chinook salmon was assessed prior to tagging. Chinook salmon with deep scars, damaged gill filaments, a lethargic condition, or fish requiring extended processing time were not tagged. Fish were tagged with individually numbered Floy FT-4 plastic spaghetti tags cut to 50 cm lengths. Different tag colors were used during approximate 2-week temporal strata. Identifying each release stratum with a different tag color allowed tags recovered with no recorded tag number (due to an omission by the creel survey technician) to be associated with a release stratum for the abundance estimate. The following tag colors were used during the specified temporal strata:

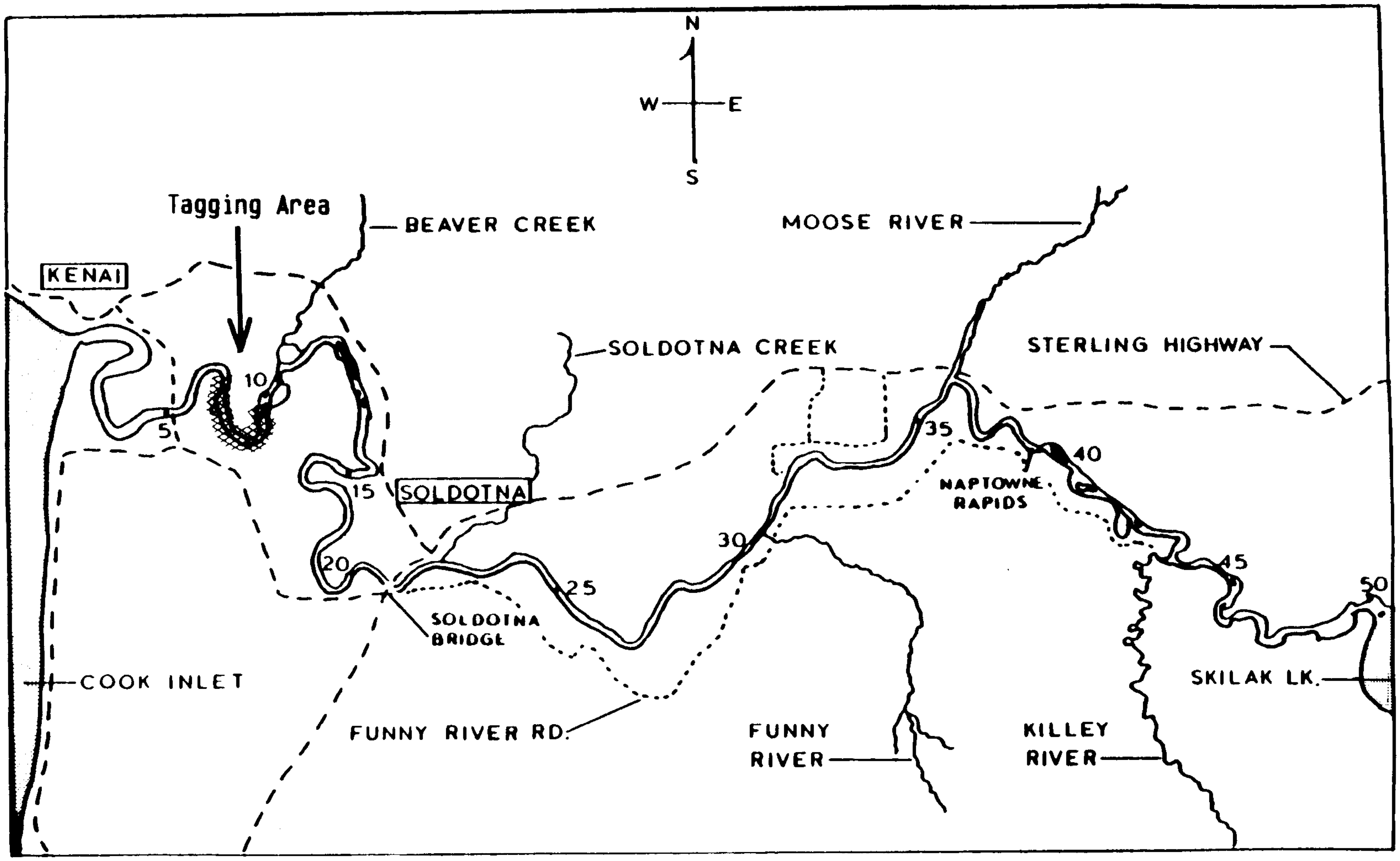

Figure 3. Map of the lower Kenai River between Cook Inlet and the outlet of Skilak Lake.

green	-	20 May	through 31 May,
white	-	01 June	through 14 June,
orange	-	15 June	through 30 June,
yellow	-	01 July	through 15 July,
blue or pink	-	16 July	through 31 July,
red	-	01 August	through 11 August.

Each tag was inserted below the posterior insertion of the dorsal fin with a large needle and secured with an overhand knot. The adipose fin of each chinook salmon tagged was removed so that any tag loss could be identified during recovery. The mid-eye to fork-of-tail length (measured to the nearest 5 mm) and the sex (identified from inspection of external characteristics) of tagged fish were recorded. Three scales were removed from the preferred area (Clutter and Whitesel 1956) of each chinook salmon and mounted on an adhesive-coated card.

Effort and catch for each set with the gill net were recorded. Effort was measured as the number of minutes the net drifted before being retrieved and catch as the number of chinook salmon caught. Captured chinook salmon were tallied according to five categories: (1) untagged fish which were captured and tagged; (2) untagged fish which were captured but not tagged because of a poor condition; (3) fish which were captured and positively identified as chinook salmon but escaped before being processed; (4) previously tagged fish which were recaptured; and (5) fish with healed adipose finclips[1]. Any chinook salmon with a healed adipose finclip was sacrificed so that the head could be inspected for the presence of a coded-wire tag (CWT). The tag numbers of fish in category 4 were recorded.

Tag Recovery

The recreational fishery, which is restricted by regulation to the area between the outlet of Skilak Lake and Cook Inlet, was the mechanism for tag recovery. A creel survey of the fishery was used to estimate the proportion of chinook salmon in the river that were tagged. Nearly all sport fishing in the Kenai River occurs upstream of the area where the tagging occurred. The fishery and the creel survey are described in detail by Hammarstrom (1988).

The creel survey was conducted in the downstream (Cook Inlet to Soldotna Bridge) and upstream (Naptowne Rapids to the outlet of Skilak Lake) sections of the Kenai River (Figure 3). In 1987, approximately 82% of the angler-effort and 86% of the chinook salmon harvest occurred in the downstream section (Hammarstrom 1988). The downstream section was

[1] Healed adipose finclips were easily distinguished from the scars caused by adipose fin removal during tagging. Fish with healed adipose finclips should denote the presence of a coded wire tag. The heads of these fish were sent to the Fisheries Rehabilitation, Enhancement, and Development (FRED) Division of the ADF&G for processing.

surveyed between 16 May and 31 July and the upstream section was surveyed from 2 June to 31 July.

Anglers were interviewed for effort, harvest, and catch rate information primarily at seven popular boat landings in the downstream section:

1. Soldotna Bridge (RM 21.5),
2. Centennial Park (RM 20.5),
3. Poacher's Cove (RM 17.5),
4. King Run resort (RM 15.0),
5. Big Eddy jetty (RM 14.0),
6. Big Bend campground (RM 13.9), and
7. Eagle Rock (RM 11.5).

Additional angler interviews in the downstream section were conducted by two roving creel survey technicians responsible for conducting angler counts to estimate fishing effort. A roving creel survey technician interviewed anglers throughout the upstream section of the river.

The following information was recorded for each angler interviewed: (1) completed-trip or incomplete trip angler; (2) guided or unguided angler; (3) number of hours spent fishing; (4) number and species of fish retained; (5) number and species of fish released; (6) docking location; and (7) number of chinook salmon present with a tag or fresh adipose finclip. In addition, the following information was recorded for tagged chinook salmon: date of capture, location of capture, and tag number. Untagged chinook salmon were carefully inspected for the presence of a fresh adipose finclip.

If an angler interviewed at an access-site location had a chinook salmon in possession, the creel survey technician asked if the fish had been observed previously by a roving creel survey technician. If a chinook salmon had been previously examined by a roving creel survey technician, the fish (whether tagged or untagged) was removed from the totals for the roving creel survey and attributed to the access-site recoveries.

<u>Spawning Ground Surveys</u>

Chinook salmon carcasses from spawning grounds on the mainstem of the Kenai River were sampled to estimate age, sex, and length compositions. Three areas were surveyed: (1) from Cook Inlet to Soldotna Bridge was surveyed from 2 September to 8 September; (2) from the upstream end of Naptowne Rapids to the outlet of Skilak Lake was surveyed on 9 September; and (3) the inlet of the mainstem river to Skilak Lake was surveyed on 10 September (Figure 3). The mainstem is primarily the spawning area for late-run chinook salmon (Burger et al. 1985).

All chinook salmon carcasses observed during the surveys were measured for mid-eye to fork-of-tail length (measured to the nearest 5 mm), the sex identified, and three scales were removed from the preferred area and mounted on an adhesive-coated card. The number of any tag present and the presence/absence of the adipose fin were recorded, also. The pectoral fins of all chinook salmon carcasses observed were removed to prevent duplicate sampling.

Analyses

There were three sets of data analyzed: (1) the chinook salmon tag release and recovery data; (2) the effort and catch data from the gill nets used to capture the chinook salmon; and (3) the biological data collected during tagging and surveys of the spawning grounds.

Abundance Estimate Using Tagging Data:

The hypothesis that recovery rates of tagged chinook salmon by the three creel surveys (upstream roving survey, downstream roving survey, and access-site survey) were equal was tested with a chi-square statistic. The numbers of tagged and untagged chinook salmon observed by each survey were compared.

Two chi-square tests described by Seber (1982) were used to determine if tagging and recovery samples were random with respect to length of the fish. Three length categories were established based on the length frequency distribution of tagged chinook salmon: small fish (≤ 775 mm in length); medium fish (> 775 mm and ≤ 975 mm in length); and large fish (> 975 mm in length). The numbers of fish in each length category for the tagged and untagged recoveries were compared to test the randomness of the releases. The recaptures were tested by partitioning the release sample into the portion recovered and that which was not and comparing the numbers in each length category.

Constant probabilities of capture at times of tagging and recapture are important assumptions necessary for Petersen-type abundance estimates (Seber 1982). When tagging and recovery occur over an extended period of time these assumptions are often violated. The tagging data were tested to determine if they were consistent with these assumptions. A series of chi-square tests described by Seber (1982, pages 438-439) were used to test these hypotheses. Probabilities of capture were not constant (all $P < 0.05$), therefore, a stratified population estimator that is not predicated on a closed population (i.e., no immigration, no emigration, and no mortality) was used (Darroch 1961). When there are equal numbers of release and recovery strata, the stratified estimator is (Seber 1982):

$$\underline{\hat{W}} = D_u M^{-1} \underline{a} \qquad [1]$$

where:

$\underline{\hat{W}}$ = a vector with the estimates of the number of untagged chinook salmon in each tagging stratum just after the release of the tagged fish,

D_u = a diagonal matrix of the number of untagged fish observed in each recovery stratum j,

M = a matrix of m_{ij}, the number of tagged fish in each recovery stratum, *j*, which were released in tagging stratum *i*, and

$\underline{a}$ = a vector of the number of tagged fish released in tagging stratum *i*.

The number of chinook salmon in each stratum at the time of tagging is the sum of the estimated number of untagged fish present and the number of tagged fish released during the stratum. The variance-covariance matrix of $\hat{\underline{W}}$ was estimated using equations 11.20-11.23 on page 441 of Seber (1982). The variance of the point estimate for the total number of chinook salmon present is the sum of the variance and covariance estimates for the individual strata.

Assumptions necessary for the abundance estimates are (Seber 1982):

1. All chinook salmon in the j^{th} recovery stratum, whether tagged or untagged, have the same probability of being harvested (caught and kept) by the recreational fishery.

2. Tagged fish behave independently of one another with regard to moving among strata and being caught.

3. An angler is equally as likely to release a tagged chinook salmon as an untagged fish.

4. There is no tag loss, either naturally or by anglers removing tags from chinook salmon which they catch and subsequently release.

5. All tagged fish are recognized as such during recovery.

6. There is no tagging induced mortality.

The estimate of chinook salmon abundance from the analysis of the tag release and recovery data was for the period 20 May through 28 July. Four temporal strata for the tagging estimate were defined so that separate estimates for the early and late runs could be generated and the algebraic conditions necessary for the stratified estimator were met. The start of the second stratum was moved to 4 June to correspond with the beginning of the sonar counts for chinook salmon. Other temporal stratifications were possible and several were examined to determine how sensitive the estimates and their variances were to different stratifications. Six alternate stratifications were generated and the point estimate and variance of each calculated using the procedures described previously.

Abundance Estimate Using Gill Net Effort and Catch Data:

To estimate the number of fish that entered the river from 29 July through 11 August, the relationships between effort and catch statistics from the drift gill nets and the abundance estimates were examined. Seventeen statistics in addition to the traditional measure of fishing success, catch per unit effort (CPUE), were investigated (Table 1). Fourteen of these statistics had been examined previously in 1986 (Conrad and Larson 1987). As was done in 1986, those fish recaptured on the same day that they had been tagged were excluded from compilation of the catch statistics.

In contrast to 1986, when the effort and catch statistics collected by all four crews working a single tide were excluded from the analysis because of gear competition (Conrad and Larson 1987), gear competition did not have a significant effect on the statistics in 1987 (Appendix A). The data from all sets by all crews were used to estimate the statistics for each of the four tagging (temporal) strata because there were very few significant differences for the 14 effort/catch statistics having between-crew variation. The linear correlations between the statistics and the estimated abundance of chinook salmon were then calculated.

Only four strata were defined for the estimates of chinook salmon abundance in 1987. To increase the number of data points used to estimate a relationship, the relationship between estimated abundance and the effort/catch statistics was assumed to be the same in 1986 and 1987. By combining the data from the drift gill nets for the 1986 analysis (Conrad and Larson 1987) with the 1987 data, the number of points used to estimate the relationship increased from four to nine. In contrast to 1986, when the number of days in the temporal strata were fairly consistent (ranging from 13 to 17 days), the number of days in the strata varied considerably in 1987 (from 10 to 28 days). To standardize abundance for each stratum, the estimated abundance of chinook salmon for each stratum was divided by the number of days in the stratum for a mean number of fish present per day.

The nine statistics with the highest correlation were used to build linear, power, and exponential models describing mean chinook salmon abundance per day as a function of the effort/catch statistic. The models were (Zar 1974):

for the linear model, $\hat{Y} = aX + b$, [2]

for the power curve, $\hat{Y} = aX^b$, and [3]

for the exponential curve, $\hat{Y} = ae^{bX}$, [4]

Table 1. Definitions of the effort and catch statistics analyzed.

Acronym	Definition
1. TOTSETS	The total number of drift gillnet sets made during a stratum.
2. TOTEFF	The total number of minutes of gillnet effort during a stratum.
3. MNDUR	The mean duration (in minutes) of the gillnet sets during a stratum.
4. TOTCAT	The total catch of chinook salmon during a stratum.
5. MNCAT	The mean catch of chinook salmon per gillnet set during a stratum.
6. CPUE	The quotient of the total catch of chinook salmon and the total effort during a stratum.
7. MNCPUE	The mean of the individual set CPUE during a stratum.
8. MNLNCPUE	The mean of the natural log of (CPUE+1) for sets during a stratum.
9. TOTEFF=0	The total number of minutes of effort by sets which caught no chinook salmon during a stratum.
10. MNDUR=0	The mean duration (in minutes) of sets which caught no chinook salmon during a stratum.
11. %EFF>0	The percent of the total effort (as measured in minutes) during a stratum by sets which caught at least one chinook salmon.
12. SETS>0	The total number of drift gillnet sets which caught at least one chinook salmon during a stratum.
13. %SETS>0	The percent of the total number of sets that caught at least one chinook salmon during a stratum.
14. MNDUR>0	The mean duration (in minutes) of sets which caught at least one chinook salmon during a stratum.
15. SETS/CD	The mean number of sets per crew-day[1] during a stratum.
16. EFF/CD	The mean number of minutes of effort per crew-day during a stratum.
17. CAT/CD	The mean catch of chinook salmon per crew-day during a stratum.
18. SETS>0/CD	The mean number of sets per crew-day that caught at least one chinook salmon during a stratum.

1 A crew-day is at least one set by a crew during a day.

where, $\hat{Y}$ is the estimated mean abundance of chinook salmon per day, X is the effort/catch statistic, and *a* and *b* are regression coefficients. Procedure NLIN of SAS (1982) and the Marquardt method of minimizing the error sum-of-squares were used to calculate least-square estimates for the parameters of the nonlinear models. Models were compared by computing a chi-square statistic for the fit of each model to the observed data ($\chi^2 = \Sigma$[predicted - observed]^2/predicted). The statistic and model having the smallest chi-square statistic were selected to estimate the number of chinook salmon entering the Kenai River from 29 July to 11 August (stratum 5).

The variance of the estimate of abundance for stratum 5 was estimated empirically by Monte Carlo simulation. Rubinstein (1981) describes a procedure for generating values from random variates with a multinormal distribution using the variance-covariance matrix of the variates. The regression parameters (a and b) represent a vector of random variates and, using the variance-covariance matrix for a and b supplied by procedure NLIN, 1,000 new estimates of the regression parameters are generated. These were then used to generate 1,000 estimates of abundance using the value of the effort and catch statistic for stratum 5. The variance for the estimate of chinook salmon abundance for stratum 5 was then calculated empirically from the 1,000 estimates.

Biological Data:

The age compositions of the chinook salmon tagged and those sampled during spawning ground surveys were estimated from the scale samples collected. Letting p_{ghj} equal the proportion of the sample from stratum *j* belonging to sex *g* and age group *h*, the variance of p_{ghj} was estimated using the normal approximation to the binomial (Scheaffer et al. 1979):

$$V(\hat{p}_{ghj}) = \hat{p}_{ghj}(1-\hat{p}_{ghj})/(n_{Tj}-1), \qquad [5]$$

where, n_{Tj} is the number of legible scales read from chinook salmon sampled during stratum *j*. A chi-square test was performed on the numbers assigned to each of the major age groups for temporal strata in each run (early run and late run) to determine if there were significant changes in age composition during a run. The age compositions of each sex were tested separately.

The numbers of chinook salmon entering the Kenai River were estimated by sex and age group for each stratum as follows:

$$\hat{N}_{ghj} = \hat{N}_j(\hat{p}_{ghj}), \qquad [6]$$

and the variance of $\hat{N}_{ghj}$ was estimated using Goodman's (1960) formula for the variance of the product of two independent random variables:

$$V(\hat{N}_{ghj}) = \hat{N}_j^2 V(\hat{p}_{ghj}) + p_{ghj}^2 V(\hat{N}_j) - V(\hat{p}_{ghj}) V(\hat{N}_j) \quad [7]$$

where:

$\hat{N}_{ghj}$ = the estimated numbers of chinook salmon of sex *g* and age group *h* entering the Kenai River during stratum *j*, and

$\hat{N}_j$ = the estimated numbers of chinook salmon entering the Kenai River during stratum *j*.

Totals, and variances, by sex and age group for the early and late runs were calculated by summing the stratum estimates.

The numbers by sex and age group for the chinook salmon spawning escapement to the Kenai River for the early and late runs were estimated by subtracting the numbers estimated for the recreational harvest from those estimated for the total inriver return. The variances of the differences were estimated as the sum of the variances.

Mean length at age by sex and its variance were estimated using standard procedures for normally distributed random variables. For each sex-age group, the mean length of chinook salmon sampled by the tagging crews was compared to the mean length of the recreational harvest samples with a 2-sample t-test (Zar 1974).

RESULTS

Abundance Estimate using Tagging Data

Temporal strata were established so that the abundance of early-run and late-run chinook salmon could be estimated separately and changes in abundance within each run examined. Five temporal strata were initially defined: (1) 20 May to 3 June; (2) 4 June to 14 June; (3) 15 June to 30 June; (4) 1 July to 15 July; and (5) 16 July to 28 July. The second stratum was begun on 4 June to coincide with the beginning of sonar counts of chinook salmon in the Kenai River. A necessary condition of the stratified estimator is that the estimated probability for an animal surviving and, if present in the j^{th} stratum, being captured in that stratum, must be positive for all strata (Seber 1982). To meet this condition it was necessary to combine strata 4 and 5 for the estimate.

Tag Releases:

During the period 20 May through 11 August, 3,980 chinook salmon were tagged (Table 2). Although tagging continued until 11 August, only the 3,193 chinook salmon tagged and released between 20 May and 28 July were used for the abundance estimate. Because tag recovery ended on 31 July when the sport fishery closed, releases after 28 July were omitted to ensure that fish tagged during the last temporal stratum had approximately the same probability of recovery as earlier releases. The ending date of 28 July was selected because more than 60% of the tag

Table 2. Tag releases by day and recoveries from each daily release for chinook salmon in the Kenai River, 1987.

Date of Release	Number Tagged	Out-of-System[1]	Adipose Clips[2]	Number Recovered[3]
20-May	4			
21-May	13			
22-May	12			
23-May	15			1
24-May	9			
25-May				
26-May	15			1
27-May	20			
28-May	24			
29-May	43	1 (K)		4
30-May	33			
31-May	65			3
01-June	17			
02-June	59	1 (K)		3
03-June	68		1	2
Subtotal	397	2	1	14
04-June	75			4
05-June	49			1
06-June	65	1 (CS)	1	4
07-June	45	1 (CS)		2
08-June	33			1
09-June	50	1 (K)		2
10-June	37			
11-June	41			2
12-June	29			2
13-June	25			1
14-June	45			5
Unknown[4]				1
Subtotal	494	3	1	25
15-June	37	1 (CS)	2	3
16-June	61			1
17-June	56			1
18-June	39			1
19-June	11			3
20-June	26			1
21-June	26			3
22-June	17			
23-June	29			
24-June	65	1 (CS)		6
25-June	67	1 (CS)		3
26-June	48	2 (CS)		3
27-June	29	1 (CD)		1
28-June	16			2
29-June	27	1 (CD)		1
30-June	27			
Unknown[4]				1
Subtotal	581	7	2	30

-continued-

Table 2. **Tag releases by day and recoveries from each daily release for chinook salmon in the Kenai River, 1987 (continued).**

Date of Release	Number Tagged	Out-of-System[1]	Adipose Clips[2]	Number Recovered[3]
01-July	34			
02-July	29			1
03-July	21	1 (CS)		
04-Jul				
05-July	53			
06-July	40			4
07-July	66	1 (CS)		4
08-July	43			2
09-July	25			1
10-July	23	1 (CD)		1
11-July	20			1
12-July	28			1
13-July	41			1
14-July	74	2 (CS), 1 (CD)		6
15-July	69	2 (CS)		3
Unknown[4]				2
Subtotal	566	8	0	27
16-July	85			2
17-July	95	2 (CS)		5
18-July	53			
19-July	55	1 (CD)		
20-July	62	3 (CS)		2
21-July	135	3 (CS), 2 (CD)		2
22-July	153	1 (CS), 4 (CD)		5
23-July	121	1 (CS), 3 (CD)		1
24-July	68	1 (CS)		
25-July	91	3 (CS)		
26-July	68	3 (CS), 1 (CD)		
27-July	58			
28-July	111	1 (CS)		
Unknown[4]				1
Subtotal	1,155	29	0	18
TOTAL[5]	3,193	49	4	114

-continued-

Table 2. **Tag** releases by day and recoveries from each daily release for **chinook** salmon in the Kenai River, 1987 (continued).

Date of Release	Number Tagged	Out-of-System[1]	Adipose Clips[2]	Number Recovered[3]
29-July	72			
30-July	115	1 (CS), 1 (CD)		
31-July	103	1 (CS), 1 (CD)		
01-August	77			
02-August				
03-August	48	1 (CS)		
04-August	107			
05-August	84			
06-August	44			
07-August	36			
08-August	42			
09-August	20			
10-August	22			
11-August	17			
Subtotal	787	5	0	0
GRAND TOTAL	3,980	54	4	114

1 Tags recovered outside the Kenai River:
CD - recovered in the commercial drift gillnet fishery,
CS - recovered in the commercial set net fishery,
K - recovered in the Kasilof River.

2 Number of fish captured by the tagging crews with healed-over or missing adipose fins (not freshly clipped).

3 Recoveries from roving and access-site creel surveys only.

4 **Tags** recovered without recording the tag number but whose **release** stratum is known from the color of the tag.

5 **Total** for the data included in the tagging estimate.

recoveries by the creel surveys occurred within 3 days of the time of release (Figure 4).

Fifty-four chinook salmon tagged in the Kenai River were eventually recovered outside of the system: 3 in the Kasilof River; 17 in the commercial drift gill net fishery; and 34 in the commercial set net fishery (Table 2). Tagged chinook salmon caught by the commercial fisheries in the marine waters outside of the Kenai River should not be interpreted as all being from systems other than the Kenai River. This group of fish probably includes fish from other systems and Kenai River fish which backed out of the system, possibly due to the effects of tagging.

Four chinook salmon with healed adipose finclips were captured during the tagging. Heads were removed from all four fish and stored for processing. Unfortunately, the heads were lost before the coded-wire tags were decoded.

Tag Recoveries:

During the period 20 May through 31 July, 2,300 chinook salmon were examined for tags and 114 tags were recovered by the creel surveys (Table 3 and Appendix Table 1). The majority of fish were examined by the access-site creel survey in the downstream area (1,360 chinook salmon examined). About equal numbers of tags were recovered by the roving creel survey and the access-site survey in the downstream section. Only two tags were recovered during the roving creel survey in the upstream section. Because recovery rates of tags in the roving surveys and in the access-site survey were not significantly different ($P > 0.10$), the recovery data from all three surveys were combined.

Neither the chi-square test of the hypothesis that the tagging (capture) sample was random with respect to fish length ($P > 0.10$) or the chi-square test of the hypothesis that the recovery (creel survey) sample was random with respect to length of fish ($P > 0.50$) was significant (Figure 5).

Abundance Estimate:

The chi-square tests of columns A and B and rows C and D in Table 4 were both significant ($P < 0.01$ and $P < 0.05$, respectively. Therefore, a Petersen estimate of abundance was not appropriate and the methods of Darroch (1961) were used. The estimates of the abundance of chinook salmon ranged from 7,583 for the third stratum to 43,331 for stratum 4 (Table 5). The estimated abundance for the early run (20 May through 30 June) was 25,643 chinook salmon. The estimated number of chinook salmon entering the Kenai River from 20 May through 28 July was 68,974 fish. This total includes fish which are from the Kenai River system and those which have "strayed" into the river from non-Kenai systems.

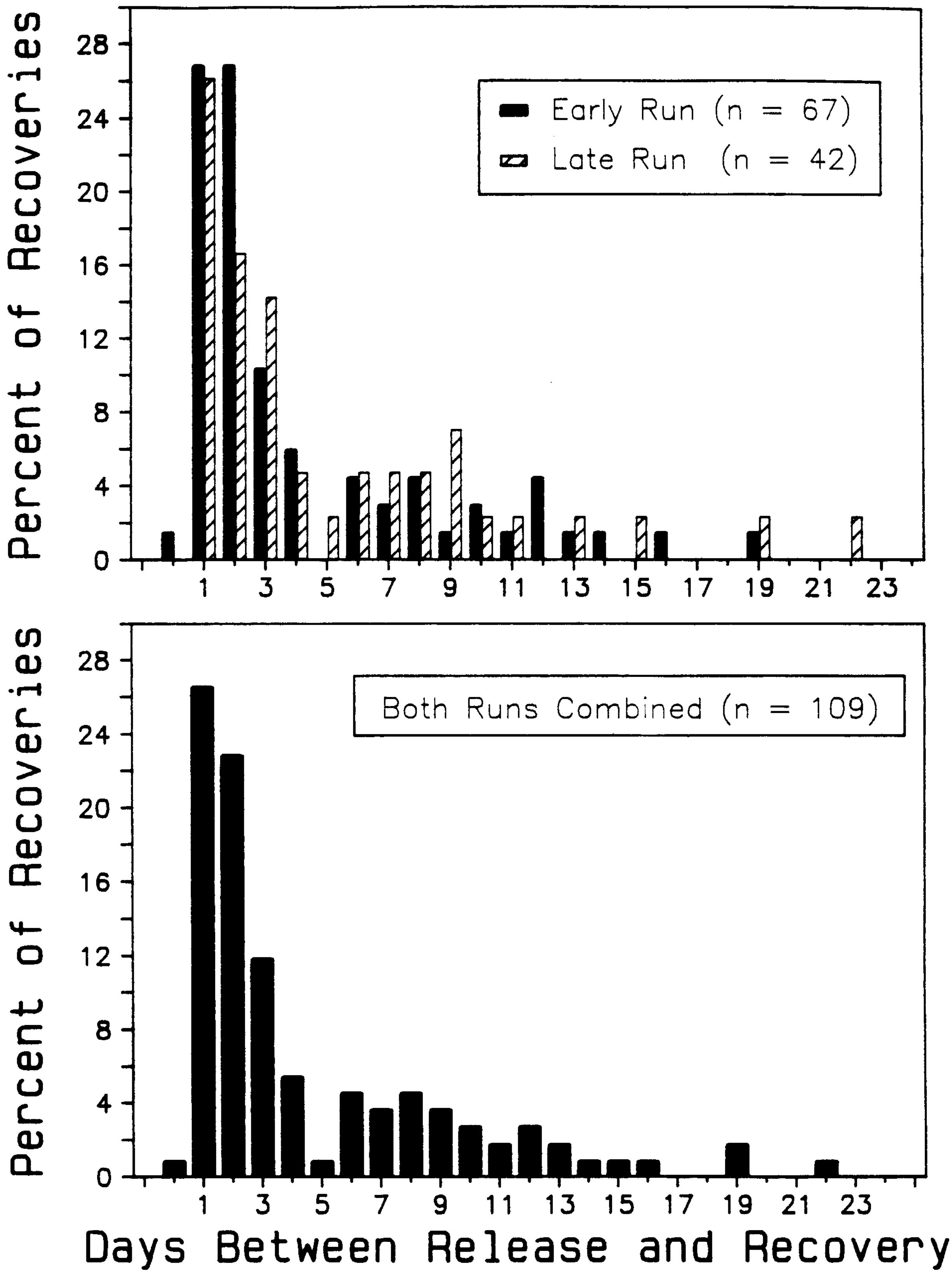

Figure 4. Number of days between tag release and recovery in the sport fishery for chinook salmon in the Kenai River, 1987.

Table 3. **Recoveries of tagged chinook salmon by the roving and access-site creel surveys of the Kenai River, 1987**[1].

	ROVING						ACCESS-SITE	
	Number Examined			Number Recaptured			Number	Number
Date	Dwnstr	Upstr	Total	Dwnstr	Upstr	Total	Examined	Recap.
21-May	0	0	0	0	0	0	9	0
22-May	0	0	0	0	0	0	0	0
23-May	1	0	1	0	0	0	12	0
24-May	1	0	1	0	0	0	17	0
25-May	4	0	4	0	0	0	4	0
26-May	18	0	18	1	0	1	7	0
27-May	2	0	2	0	0	0	0	0
28-May	5	0	5	0	0	0	1	0
29-May	1	0	1	0	0	0	13	0
30-May	18	0	18	0	0	0	23	0
31-May	10	0	10	0	0	0	50	0
01-June	0	0	0	0	0	0	0	0
02-June	11	0	11	2	0	2	24	2
03-June	12	0	12	1	0	1	29	1
Subtotal	83	0	83	4	0	4	189	3
04-June	4	0	4	1	0	1	7	0
05-June	25	0	25	3	0	3	15	2
06-June	12	0	12	1	0	1	20	0
07-June	15	0	15	0	0	0	28	0
08-June	0	0	0	0	0	0	0	0
09-June	15	0	15	0	0	0	29	2
10-June	7	0	7	1	0	1	24	1
11-June	23	0	23	1	0	1	26	1
12-June	19	1	20	3	0	3	6	1
13-June	14	2	16	0	0	0	25	2
14-June	22	1	23	0	1	1	36	1
Subtotal	156	4	160	10	1	11	216	10
15-June	0	0	0	0	0	0	0	0
16-June	20	0	20	3	0	3	52	4
17-June	22	5	27	1	0	1	25	0
18-June	8	0	8	1	0	1	22	1
19-June	13	0	13	3	0	3	20	0
20-June	16	1	17	2	0	2	20	0
21-June	17	1	18	2	0	2	8	0
22-June	0	0	0	0	0	0	0	0
23-June	28	9	37	3	0	3	3	0
24-June	10	0	10	1	0	1	19	0
25-June	13	12	25	1	1	2	25	0
26-June	5	0	5	1	0	1	24	3
27-June	19	1	20	0	0	0	22	4
28-June	18	0	18	0	0	0	39	4
29-June	0	0	0	0	0	0	0	0
30-June	5	8	13	0	0	0	3	0
Subtotal	194	37	231	18	1	19	282	16

-continued-

Table 3. Recoveries of tagged chinook salmon by the roving and access-site creel surveys of the Kenai River, 1987[1] (continued).

	ROVING						ACCESS-SITE	
	Number Examined			Number Recaptured			Number	Number
Date	Dwnstr	Upstr	Total	Dwnstr	Upstr	Total	Examined	Recap.
01-July	14	0	14	0	0	0	7	0
02-July	6	0	6	0	0	0	12	2
03-July	24	0	24	2	0	2	20	0
04-July	14	0	14	0	0	0	12	0
05-July	21	0	21	0	0	0	25	2
06-July	0	0	0	0	0	0	0	0
07-July	27	0	27	1	0	1	15	1
08-July	8	0	8	0	0	0	30	0
09-July	14	4	18	1	0	1	25	2
10-July	0	2	2	0	0	0	3	1
11-July	3	4	7	0	0	0	10	0
12-July	16	0	16	2	0	2	22	0
13-July	0	0	0	0	0	0	0	0
14-July	9	1	10	1	0	1	16	3
15-July	36	0	36	1	0	1	14	2
Subtotal	192	11	203	8	0	8	211	13
16-July	13	0	13	1	0	1	34	0
17-July	18	0	18	0	0	0	42	1
18-July	21	0	21	4	0	4	31	2
19-July	8	1	9	0	0	0	20	0
20-July	0	0	0	0	0	0	0	0
21-July	11	0	11	1	0	1	15	1
22-July	4	0	4	0	0	0	26	1
23-July	35	0	35	1	0	1	55	1
24-July	11	0	11	0	0	0	13	2
25-July	26	0	26	3	0	3	46	2
26-July	13	0	13	1	0	1	28	0
27-July	0	0	0	0	0	0	0	0
28-July	29	0	29	1	0	1	29	1
29-July	8	0	8	0	0	0	48	1
30-July	37	1	38	3	0	3	21	1
31-July	27	0	27	2	0	2	54	0
Subtotal	261	2	263	17	0	17	462	13
TOTAL	886	54	940	57	2	59	1,360	55

1 Tagged or untagged chinook salmon observed by both the roving creel survey in the downstream area and the access-site survey are recorded in the access-site survey.

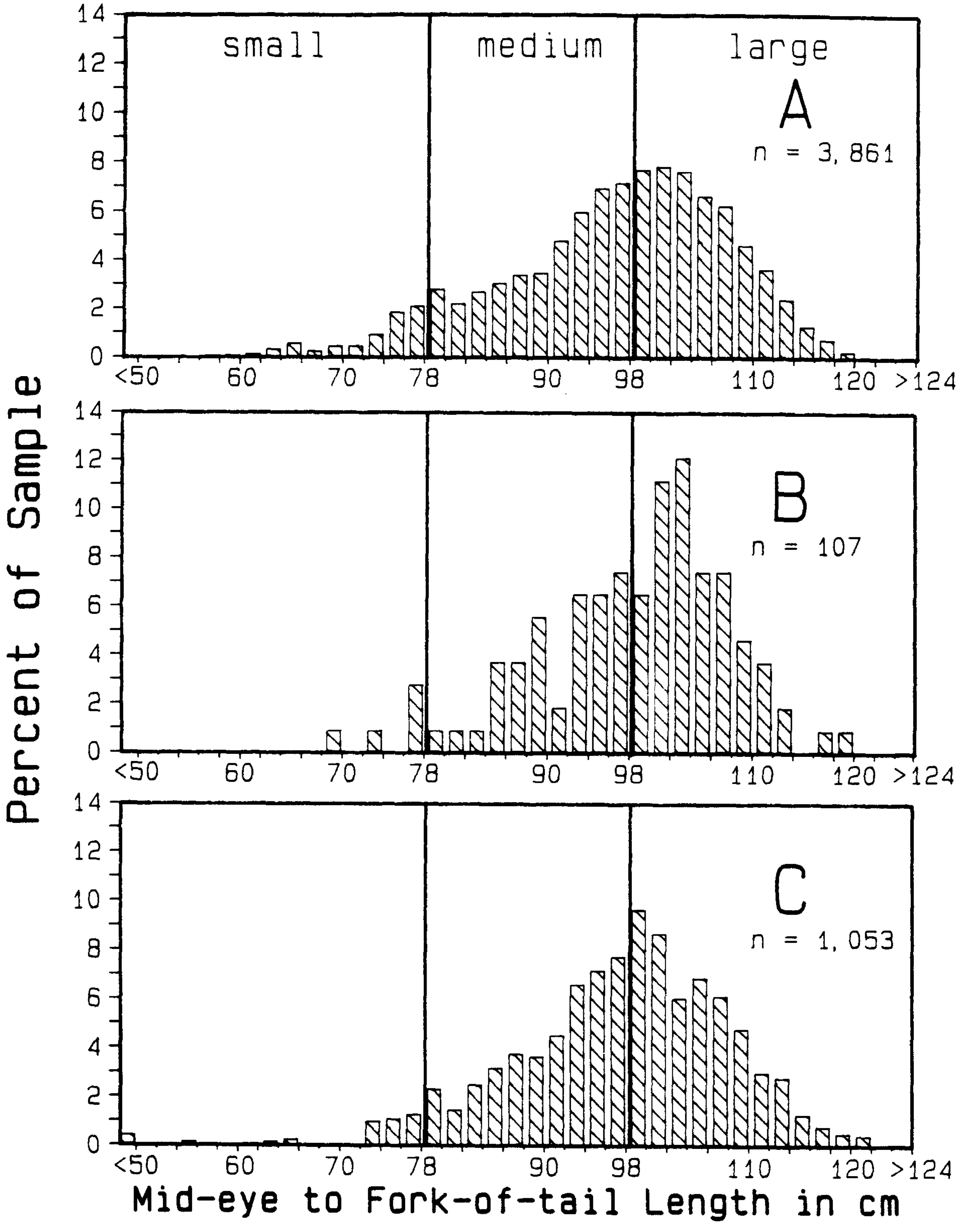

Figure 5. Length frequencies of chinook salmon which were: (A) tagged but not recovered during the creel surveys of the sport fishery; (B) tagged and recovered by the creel survey (these were used for the abundance estimate); and (C) never tagged but examined during the creel survey.

Table 4. Summary of tag releases and tag recoveries, by stratum, for chinook salmon in the Kenai River, 1987[1].

Stratum[2]		Creel survey tag recoveries 1	2	3	4	(A) Number Recovered	(B) Not Recovered	Number Released	Percent Recovered
	1	7	7	0	0	14	383	397	3.5
Tag	2	0	14	11	0	25	469	494	5.1
Releases	3	0	0	24	6	30	551	581	5.2
	4	0	0	0	45	45	1,676	1,721	2.6
(C) Tagged		7	21	35	51	114	3,079	3,193	
(D) Untagged		265	355	478	1,088	2,186			
Examined		272	376	513	1,139	2,300			
% Tagged		2.6	5.6	6.8	4.5				

1 The matrix defined by each of the four release and recovery strata corresponds to the M matrix; a diagonal matrix of the first four elements of row D is the D_u matrix; and the column of Number Released is the vector a.

2 Release and recovery strata:
1 = 20 May - 3 June,
2 = 4 June - 14 June,
3 = 15 June - 30 June,
4 = 1 July - 28 July (release) and 1 July - 31 July (recovery).

Table 5. **Numbers** of chinook salmon entering the Kenai River during each **stratum** estimated by analysis of the tagging data, 1987.

Stratum	Point Estimate	Standard Error[1]	95% Confidence Interval[2]
1. 20 May - 3 June	9,125	4,567	397 - 18,077
2. 4 June - 14 June	8,935	2,905	3,241 - 14,629
3. 15 June - 30 June	7,583	2,417	2,845 - 12,321
Early Run Total	25,643	4,597	16,632 - 34,654
4. 1 July - 28 July	43,331	6,247	31,086 - 55,576
Total Strata 1-4	68,974	7,289	54,687 - 83,261

[1] Standard errors for the totals include covariance terms and are not simply the sum of the variances of the stratum estimates.

[2] The lower bound of the 95% confidence interval equals the total number of chinook salmon tagged during the stratum (not including any recaptures of previously tagged fish) if the lower bound on the 95% confidence interval is smaller than this total.

Sensitivity of Tagging Estimate:

The estimates of abundance from the tagging data were not sensitive to the definition of the temporal strata. The coefficient of variation for the point estimates of total abundance was 3.8% (Table 6). The coefficient of variation for the standard errors of the point estimates was very high (49.0%), but this was due to a single stratification with a very large standard error. The largest coefficients of variation were for the point estimates of the early run and its standard error, 9.4% and 98.3%, respectively. Some of this variation in the abundance estimates for the early run is due to the different ending dates used to define the early run (from 24 June through 30 June).

Abundance Estimate using Gill net Effort and Catch Data

For the combined 1986 and 1987 data, three of the four statistics expressed as the mean for a crew-day during a stratum (SETS/CD, CAT/CD, SETS>0/CD) had the highest linear correlations with the estimated mean abundance of chinook salmon per day (Table 7). The catch per unit effort statistics (CPUE, MNLNCPUE, and MNLNCPUE) had the next highest correlations.

Model Evaluation:

The exponential model for the statistic CAT/CD had a much smaller chi-square statistic than any other model for the fit of the observed mean abundance per day to predicted mean abundance per day. This model was selected to estimate the number of chinook salmon entering the Kenai River from 29 July to 11 August.

Abundance Estimate:

The nonlinear, least-squares parameter estimates for the exponential model using the statistic CAT/CD resulted in the following model (Figure 6):

$$\hat{Y} = 49.197e^{(CAT/CD)^{0.126}} \qquad [8]$$

where, $\hat{Y}$ is the estimated mean abundance of chinook salmon per day. For stratum 5, CAT/CD = 27.38 which results in an estimate of mean abundance of 1,549.5 chinook salmon per day for stratum 5. The empirical estimate of the standard error (SE) for this estimate from the Monte Carlo simulation was 1,699. For the 14 days from 29 July through 11 August, this gives an estimated total abundance of 21,693 chinook salmon with a standard error of 23,785.

Summary

The estimated numbers of chinook salmon entering the Kenai River were 25,643 fish (SE = 4,597) during the early run and 65,024 fish (SE = 24,592) during the late run (Table 8). From 20 May through

Table 6. **Estimates of the numbers of chinook salmon entering the Kenai River using different temporal stratifications of the tagging data**, 1987.

Strata		TOTAL		EARLY RUN		LATE RUN[2]	
Number	Definitions	Estimate	SE[1]	Estimate	SE	Estimate	SE
4	Selected	68,974	7,289	25,643	4,597	43,331	6,247
5	E[3] 5/20-6/05 E 6/06-6/14 E 6/15-6/24 L 6/25-7/08 L 7/09-7/28	65,748	6,819	22,971	3,644	42,777	6,122
4	E 5/20-5/31 E 6/01-6/14 E 6/15-6/30 L 7/01-7/28	72,652	19,679	29,321	19,178	43,331	6,247
4	5/20-6/03 6/04-6/14 6/15-7/15 7/16-7/28	72,698	9,375	NA[4]		NA	
4	E 5/20-6/11 E 6/12-6/19 E 6/20-6/28 L 6/29-7/28	68,887	7,066	24,512	3,934	44,375	6,327
4	5/20-6/11 6/12-6/19 6/20-7/15 7/16-7/28	71,919	9,143	NA		NA	
3	E 5/20-6/14 E 6/15-6/30 L 7/01-7/28	67,966	6,849	24,635	3,454	43,331	6,247
Mean		69,835	9,460	25,416	6,961	43,429	6,238
Coef. of **Variation**[5]		3.8%	49.0%	9.4%	98.3%	7.5%	1.3%

1 SE - standard error.

2 Late run through 28 July only.

3 Run designation, E - early run and L - late run.

4 Not able to calculate early run and late run totals.

5 Coefficient of variation x 100.

Table 7. Correlations between the estimates of mean abundance of chinook salmon per day for a stratum and the effort/catch statistics computed using data from 1986 only, data from 1987 only, and the 1986 and 1987 data combined.

Statistic[1]	1986[2]	1987	Combined
1. TOTSETS	0.897	0.927	0.281
2. TOTEFF	-0.737	0.838	-0.048
3. MNDUR	-0.763	-0.893	-0.688
4. TOTCAT	0.876	0.943	0.387
5. MNCAT	0.753	0.563	0.713
6. CPUE	0.859	0.847	0.844
7. MNCPUE	0.781	0.977	0.777
8. MNLNCPUE	0.786	0.963	0.772
9. TOTEFF=0	-0.777	0.647	-0.451
10. MNDUR=0	-0.875	-0.611	-0.748
11. %EFF>0	0.860	0.468	0.748
12. SETS>0	0.869	0.939	0.332
13. %SETS>0	0.691	0.788	0.651
14. MNDUR>0	-0.728	-0.920	-0.680
15. SETS/CD	0.911	0.983	0.850
16. EFF/CD	-0.720	0.317	-0.520
17. CAT/CD	0.889	0.979	0.873
18. SETS>0/CD	0.886	0.995	0.851

1 Statistics defined in Table 1.

2 Only data when three or fewer crews worked a tide were used.

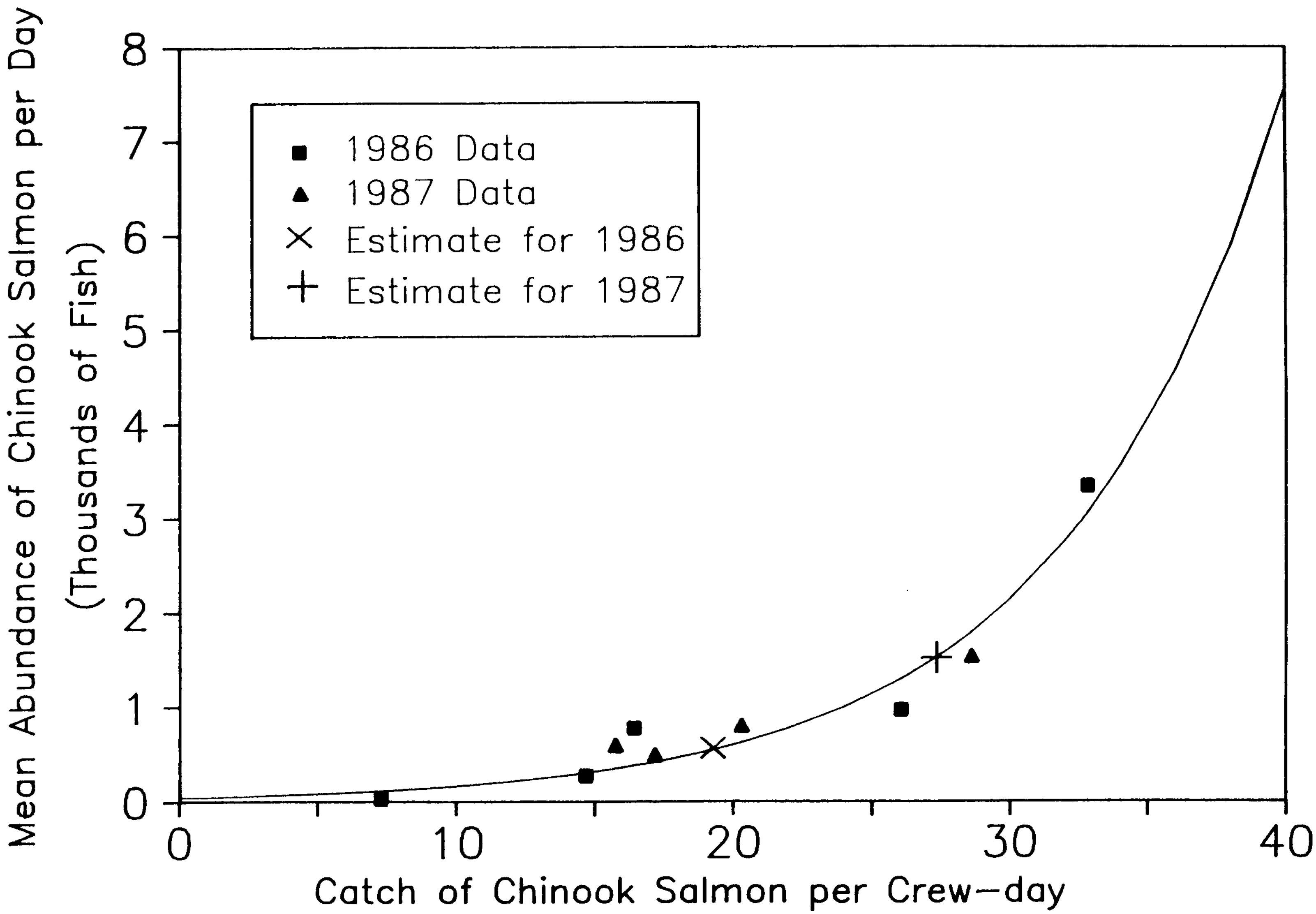

Figure 6. Catch statistic CAT/CD versus the estimated mean abundance of chinook salmon per day for strata in 1986 and 1987 and the model used to estimate the abundance for stratum 5 (29 July to 11 August) in 1987.

Table 8. **Estimated numbers of chinook salmon, by stratum, entering the Kenai River**, 1987.

Stratum	Point Estimate	Standard Error[1]	95% Confidence Interval[2]
1. 20 May - 3 June	9,125	4,567	397 - 18,077
2. 4 June - 14 June	8,935	2,905	3,241 - 14,629
3. 15 June - 30 June	7,583	2,417	2,845 - 12,321
Early Run Total	25,643	4,597	16,632 - 34,654
4. 1 July - 28 July	43,331	6,247	31,086 - 55,576
5. 29 July - 11 August	21,693	23,785	787 - 68,312
Late Run Total	65,024	24,592	16,824 - 113,223
SEASON TOTAL	90,667	24,877	41,908 - 139,425

1 Standard errors for run totals and season total include covariance terms for the abundance estimates from the mark-recapture estimate and, therefore, are not simply the sum of the variances of the stratum estimates.

2 The lower bound of the 95% confidence interval equals the total number of chinook salmon tagged during the stratum (not including any recaptures of previously tagged fish) if the lower bound on the 95% confidence interval is smaller than this total.

11 August, 90,667 chinook salmon (SE = 24,887) were estimated to have entered the Kenai River.

Biological Data

Gill Net Samples:

The age compositions of both male and female chinook salmon sampled by the tagging crews changed significantly ($P < 0.01$) during the early run (Appendix Table 2). There were no significant ($P > 0.10$) changes in the age compositions of males and females during the late run (Appendix Table 2). For the sexes combined, the 1.3 and 1.4 age groups composed more than 90% of the age composition samples in every stratum. Age 1.4 chinook salmon were the most abundant age group in every stratum.

Age 1.3 and age 1.4 chinook salmon composed 37.7% and 58.0% of the early run, respectively, and 27.9% and 68.9% of the late run, respectively (Table 9). Age 1.4 female chinook salmon were the most abundant sex-age group in both the early run (31.8%) and the late run (40.7%).

Generally, the mean lengths by age and sex of the chinook salmon sampled during the late run were larger than those sampled during the early run (Table 10). Age 1.3 females were larger than age 1.3 males in every stratum. Conversely, age 1.4 males were larger than age 1.4 females in every stratum. This was true in 1986, also (Conrad and Larson 1987).

Recreational Harvest Samples:

The age compositions of the samples from the recreational harvest were more similar among strata than the samples from the gill nets (Appendix Table 3). Only the age composition of early run males changed significantly within a run ($P < 0.005$). The 1.4 age group composed from 58% to 78% of the sample from each stratum.

Age groups 1.3 and 1.4 composed 29.0% and 63.5% of the early run, respectively, and 23.1% and 73.8% of the late run, respectively (Table 11). Age 1.4 female chinook salmon were the most abundant sex-age group in both the early-run and late-run harvests (40.6% and 38.4%, respectively).

There were temporal changes in the mean lengths of the major sex-age groups in the harvest, also. Similar to the gill net samples, the mean lengths by age and sex of the chinook salmon sampled from the harvest during the late run were larger than those sampled during the early run (Table 12). As was found in the gill net samples, age 1.3 females were larger than males in all strata but one and age 1.4 males were larger than age 1.4 females in every stratum.

Table 9. Estimated numbers of chinook salmon, by sex and age group, entering the Kenai River during the early and late runs, 1987.

Component	Sex	Statistic	Age Group 1.2	1.3	1.4	1.5	Other[1]	Total
EARLY RUN	Male	Percent	1.5	19.3	26.2	1.6	0.2	48.8
		Estimated Number	387	4,950	6,722	401	45	12,505
		Standard Error	126	1,113	1,725	152	34	
	Female	Percent	0.0	18.4	31.8	0.7	0.3	51.2
		Estimated Number	0	4,706	8,163	194	75	13,138
		Standard Error	0	1,028	2,054	99	46	
	Combined	Percent	1.5	37.7	58.0	2.3	0.5	100.0
		Estimated Number	387	9,656	14,885	595	120	25,643
		Standard Error	126	2,081	3,732	224	61	
LATE RUN	Male	Percent	1.7	16.9	28.2	0.6	0.4	47.8
		Estimated Number	1,084	11,011	18,335	390	260	31,080
		Standard Error	321	3,740	5,338	165	135	
	Female	Percent	0.1	11.0	40.7	0.4	0.0	52.2
		Estimated Number	43	7,154	26,487	260	0	33,944
		Standard Error	51	3,228	11,988	135	0	
	Combined	Percent	1.8	27.9	68.9	1.0	0.4	100.0
		Estimated Number	1,127	18,165	44,822	650	260	65,024
		Standard Error	327	6,916	17,203	256	135	
SEASON TOTAL	Male	Percent	1.6	17.6	27.6	0.9	0.3	48.0
		Estimated Number	1,471	15,961	25,057	791	305	43,585
		Standard Error	345	3,902	5,610	225	140	
	Female	Percent	0.1	13.1	38.2	0.5	0.1	52.0
		Estimated Number	43	11,860	34,650	454	75	47,082
		Standard Error	51	3,388	12,163	168	46	
	Combined	Percent	1.7	30.7	65.8	1.4	0.4	100.0
		Estimated Number	1,514	27,821	59,707	1,245	380	90,667
		Standard Error	351	7,222	17,603	340	148	

1 Age groups 1.6, 2.1, 2.3, and 2.4 combined.

Table 10. **Mean length (mm), by sex and age group, of chinook salmon caught by the drift gillnets in the Kenai River, 1987.**

Stratum / Sex	Statistic	Age Group 1.2	1.3	1.4	1.5	2.4
5/20 - 6/03						
Male	Mean Length	510	830	1,000	1,099	990
	Sample Size	1	47	100	8	1
	Standard Error		11	7	15	
Female	Mean Length		847	956	1,078	990
	Sample Size	0	34	117	5	1
	Standard Error		10	5	21	
6/04 - 6/14						
Male	Mean Length	616	822	1,003	1,095	1,000
	Sample Size	8	95	89	6	1
	Standard Error	8	8	6	11	
Female	Mean Length		840	945	1,010	970
	Sample Size	0	96	124	1	1
	Standard Error		6	6		
6/15 - 6/30						
Male	Mean Length	617	835	1,059	1,080	
	Sample Size	6	50	62	1	0
	Standard Error	20	12	10		
Female	Mean Length		839	968	1,100	
	Sample Size	0	54	68	1	0
	Standard Error		7	7		
7/01 - 7/15						
Male	Mean Length	647	850	1,066	1,130	1,150
	Sample Size	10	74	158	2	1
	Standard Error	8	10	5	10	
Female	Mean Length	660	887	1,009	1,030	
	Sample Size	1	32	147	1	0
	Standard Error		10	4		
7/16 - 7/28						
Male	Mean Length	656	859	1,042	1,203	
	Sample Size	5	55	72	3	0
	Standard Error	9	12	10	19	
Female	Mean Length		936	1,014	1,020	
	Sample Size	0	39	115	2	0
	Standard Error		10	5	50	
7/29 - 8/11						
Male	Mean Length	665	893	1,081	1,160	
	Sample Size	2	36	50	1	0
	Standard Error	5	14	9		
Female	Mean Length		938	1,017	1,140	
	Sample Size	0	32	120	1	0
	Standard Error		8	4		

Table 11. Estimated numbers of chinook salmon, by sex and age group, harvested by the recreational fishery in the Kenai River during the early and late runs, 1987.

Component	Sex	Statistic	Age Group 1.2	1.3	1.4	1.5	Other[1]	**Total**
EARLY RUN (n = 493)[2]	Male	Percent	0.8	13.2	22.9	3.5	0.2	40.6
		Estimated Number	106	1,753	3,041	465	27	5,392
		Standard Error	54	233	321	114	27	
	Female	Percent	0.2	15.8	40.6	2.4	0.4	59.4
		Estimated Number	27	2,098	5,392	319	53	7,889
		Standard Error	27	258	460	94	38	
	Combined	Percent	1.0	29.0	63.5	5.9	0.6	100.0
		Estimated Number	133	3,851	8,433	784	80	13,281[3]
		Standard Error	60	371	623	150	46	
LATE RUN (n = 429)[2]	Male	Percent	0.5	11.2	35.4	1.4	0.2	48.7
		Estimated Number	61	1,371	4,332	171	24	5,959
		Standard Error	42	205	392	70	26	
	Female	Percent	0.5	11.9	38.4	0.5	0.0	51.3
		Estimated Number	61	1,456	4,700	61	0	6,278
		Standard Error	42	212	412	42	0	
	Combined	Percent	1.0	23.1	73.8	1.9	0.2	100.0
		Estimated Number	122	2,827	9,032	232	24	12,237[3]
		Standard Error	59	306	624	82	26	

1 Age groups 1.1 and 2.4 combined.
2 n = sample size.
3 From Hammarstrom (1988).

Table 12. Mean length (mm), by sex and age group, of chinook salmon sampled during creel surveys of the sport fishery in the Kenai River, 1987.

Stratum / Sex	Statistic	1.2	1.3	1.4	1.5	2.4
		Age Group				
5/16 - 6/03						
Male	Mean Length	550	823	1,008	1,109	
	Sample Size	1	10	24	10	0
	Standard Error		21	14	17	
Female	Mean Length		849	968	984	
	Sample Size	0	10	51	5	0
	Standard Error		10	6	29	
6/04 - 6/14						
Male	Mean Length	525	865	1,031	930	940
	Sample Size	2	28	30	1	1
	Standard Error	45	15	13		
Female	Mean Length	550	867	955	978	
	Sample Size	1	35	69	4	0
	Standard Error		10	8	37	
6/15 - 6/30						
Male	Mean Length	490	833	1,035	1,142	
	Sample Size	1	27	59	6	0
	Standard Error		14	11	19	
Female	Mean Length		878	979	1,040	910
	Sample Size	0	33	80	3	1
	Standard Error		10	6	40	
7/01 - 7/15						
Male	Mean Length	650	888	1,075	1,140	
	Sample Size	1	16	63	2	0
	Standard Error		28	8	10	
Female	Mean Length	630	897	1,032	1,140	
	Sample Size	1	15	60	1	0
	Standard Error		19	8		
7/16 - 7/28						
Male	Mean Length	650	882	1,074	1,125	
	Sample Size	1	29	67	2	0
	Standard Error		16	7	65	
Female	Mean Length	630	920	1,004		
	Sample Size	1	26	72	0	0
	Standard Error		17	7		
7/29 - 7/31						
Male	Mean Length		927	1,069	1,085	
	Sample Size	0	3	22	2	0
	Standard Error		18	12	15	
Female	Mean Length		920	1,015	1,160	
	Sample Size	0	10	33	1	0
	Standard Error		26	9		

Comparison of Gill net and Harvest Samples:

There were significant ($P < 0.025$) differences between the age compositions of male chinook salmon sampled by the gill nets and the sport fishery samples in strata 1 and 6. For females, the only significant ($P < 0.025$) difference between the two sets of samples was in stratum 3.

The mean lengths of ages 1.3 and 1.4 chinook salmon from the gill net samples were compared to the samples from the creel survey in each strata. Age 1.3 males and females sampled during the creel surveys were significantly larger ($P < 0.05$) than those sampled by the tagging crews in stratum 2. Age 1.3 females in the creel survey samples were significantly larger ($P < 0.05$) in stratum 3, also. The creel survey samples for age 1.4 males in strata 2 an 5 and age 1.4 females in stratum 4 were all significantly larger ($P < 0.05$) than the gill net samples.

Spawning Escapement:

There were no significant differences among the age compositions of the scale samples collected during the 6 days of the spawning ground surveys. The majority (76.9%) of the scale samples collected during the spawning ground surveys of the mainstem Kenai River were age 1.4 (Table 13). Next most abundant were fish aged 1.3 (20.2%). Age 1.3 females were larger than age 1.3 males, while age 1.4 males were larger than females of the same age (Table 14).

The estimated number of chinook salmon in the early run available for spawning was 12,578 fish (Table 15). Males were more abundant than females; they composed 57.1% of the total for the early run. The most abundant age groups were 1.4 (51.3%) and 1.3 (46.1%). The estimated number of chinook salmon in the late run available for spawning was 52,805 fish (Table 15). Males and females were nearly equally abundant; they composed 47.6% and 52.4% of the total for the late run, respectively. The most abundant age groups were 1.4 (67.7%) and 1.3 (29.1%).

DISCUSSION

The definitions of the early run (20 May to 30 June) and the late run (1 July to 11 August) are idealistic representations of the timing of the runs and, in reality, there is overlap of their timing. Evidence for the gradual change in the mixture of early-run and late-run fish in the return is the increasing mean length for all sex-age groups throughout the season in the gill net and recreational harvest samples. The larger mean size-at-age of late-run fish compared to early-run fish has been documented previously (Burger et al. 1985, McBride et al. 1985). Linear discriminant function analysis using length-at-age was demonstrated as a feasible method of estimating the proportion of late-run chinook salmon from the Kenai River present in mixtures of other

Table 13. Estimated age composition of chinook salmon sampled during surveys of spawning grounds on the mainstem of the Kenai River, 1987.

			Age Group					
Dates	Sex	Statistic	1.1	1.2	1.3	1.4	1.5	**Total**
9/02 - 9/10 (n = 420)[1]	Male	Percent	0.5	1.4	10.7	28.8	0.7	42.1
		Standard Error[2]	0.3	0.6	1.5	2.2	0.4	
	Female	Percent	0.0	0.0	9.5	48.1	0.3	57.8
		Standard Error	0	0	1.4	2.4	0.2	
	Combined	Percent	0.5	1.4	20.2	76.9	1.0	100.0
		Standard Error	0.3	0.6	2.1	3.3	0.5	

1 n = sample size.

2 Standard error of proportional estimate of age composition x 100.

Table 14. **Mean** length (mm), by sex and age group, of chinook salmon **sampled** during surveys of spawning grounds on the mainstem of the Kenai River, 1987.

Dates Sex	Statistic	Age Group 1.1	 1.2	 1.3	 1.4	 1.5
9/02 - 9/10						
Male	Mean Length	450	673	858	1,045	1,127
	Sample Size	2	6	45	121	3
	Standard Error	10	24	15	6	33
Female	Mean Length			921	1,000	1,000
	Sample Size			40	202	1
	Standard Error			8	4	

Table 15. Estimated numbers of chinook salmon, by sex and age group, in the spawning escapement to the Kenai River during the early and late runs, 1987.

			Age Group					
Component	**Sex**	Statistic	1.2	1.3	1.4	1.5	Other[1]	**Total**
EARLY RUN	**Male**	Percent	2.2	25.4	29.3	0.0	0.2	**57.1**
		Estimated Number	281	3,197	3,681	0[2]	18	7,177
		Standard Error	137	1,137	1,755	190	43	
	Female	Percent	0.0	20.7	22.0	0.0	0.2	42.9
		Estimated Number	0	2,608	2,771	0[2]	22	5,401
		Standard Error	27	1,060	2,105	137	60	
	Combined	Percent	2.2	46.1	51.3	0.0	0.4	100.0
		Estimated Number	281	5,805	6,452	0	40	12,578
		Standard Error	140	1,554	2,741	234	74	
LATE RUN	Male	Percent	1.9	18.3	26.5	0.4	0.5	47.6
		Estimated Number	1,023	9,640	14,003	219	236	25,121
		Standard Error	324	3,746	5,352	179	137	
	Female	Percent	0.0	10.8	41.2	0.4	0.0	52.4
		Estimated Number	0[2]	5,698	21,787	199	0	27,684
		Standard Error	66	3,235	11,995	141	0	
	Combined	Percent	1.9	29.1	67.7	0.8	0.5	100.0
		Estimated Number	1,023	15,338	35,790	418	236	52,805
		Standard Error	331	4,950	13,135	228	137	

1 Age groups 1.1, 1.6, 2.1, 2.3, and 2.4 combined.

2 More fish were estimated for the harvest than were estimated for the total return, estimates set to zero.

stocks by McBride et al. (1985). This technique could be used to better define the timing of the early and late chinook salmon runs into the Kenai River. This would require that length samples representing the early run and late run be collected to establish standards for the discriminant analysis. This may be difficult as the samples need to be randomly selected from each run. The only samples which are composed entirely of either early-run or late-run fish are the spawning grounds samples. While samples from late-run fish from the Kenai River mainstem spawning areas are usually readily available, early-run samples from Kenai River tributary systems are often difficult to obtain (as was the case in 1986 and 1987). The earliest and latest samples collected by the gill nets are not viable alternatives for the standards because they are not random samples.

Abundance Estimate using Tagging Data

Some of the sources of error which could potentially affect the estimate of chinook salmon abundance from the tagging data are tag loss and the presence of fish bound for spawning sites other than the Kenai River.

In 1987, there were no chinook salmon observed with a freshly clipped adipose fin and no spaghetti tag attached during the creel surveys. In previous years, loss of tags by chinook salmon tagged by the gill net crews has been observed to be very small (less than 0.5%). There is no direct evidence of tag loss in 1987.

As was found in 1985 and 1986 (Conrad and Larson 1987), small numbers of chinook salmon tagged in the lower Kenai River were recovered in other systems in 1987. The largest number of out-of-system recoveries have been from the Kasilof River (11 recoveries in 1985, 5 recoveries in 1986, 3 recoveries in 1987). Tags have been recovered from the Susitna River (1 in 1985, 2 in 1986) and Deep Creek (1 in 1985), also. The four chinook salmon with adipose fins recovered by the tagging crews in 1987 were lost before they were processed for coded-wire tags so their point of origin is unknown. In 1986, 676 chinook salmon from Crooked Creek hatchery were estimated to be present in the lower Kenai River from 17 May to 30 June from analysis of coded-wire tag data (Conrad and Larson 1987). Because of the proximity of the Kasilof River to the Kenai River, we expect that more fish from this stock are present in the lower Kenai River than any other stock. We conclude that the presence of chinook salmon stocks from outside the Kenai River was not a major source of error.

Comparison of Estimates to Sonar Estimates

The sonar designed to count chinook salmon at RM 8.6 of the lower Kenai River provides an independent estimate of abundance for the period 4 June through 10 August. The total chinook salmon abundance estimated for this period using the tag release and recovery data (4 June to 28 July) and the gill net effort and catch data (29 July to 11 August) was 81,542 fish compared to 70,036 fish estimated by the sonar (Table 16). The difference of 11,506 fish is about 16% of the sonar

Table 16. **Comparison** of the numbers of chinook **salmon** estimated for each temporal **stratum** from the tagging data and the sonar estimates for the same strata, 1987.

Stratum	Point Estimate	Sonar Count
2. 4 June - 14 June	8,935	12,375
3. 15 June - 30 June	7,583	9,538
4. 1 July - 28 July	43,331	35,767
5. 29 July - 11 August	21,693	12,356
TOTALS	81,542	70,036

estimate. However, most of this difference is due to the estimate for stratum 5 (29 July to 11 August). If the estimate for stratum 5 is omitted and the total abundance estimated using only the tag release and recovery data (strata 2 to 4) is compared to the sonar estimate, the difference is only 2,169 fish (3.8% of the sonar estimate).

We feel that the agreement between the tag release and recovery estimate and the sonar estimate indicates that both methods are accurately estimating the total abundance of chinook salmon entering the Kenai River. The large difference between the estimates for stratum 5 indicates that the method of estimating chinook salmon abundance using the gill net effort and catch data may not be accurate. The poor precision of the abundance estimate for stratum 5 for this method is reflected by its large coefficient of variation, 109.6%.

RECOMMENDATIONS

1. If tag recovery rates are significantly different between chinook salmon of different lengths in the future, the present method of collecting data in the creel surveys will not allow separate estimates to be produced, as should be done. This is because the lengths of all fish examined during the creel surveys are not recorded, only a subsample of fish are actually measured. One solution to this problem is to compare examined fish to a standard template so that they can be visually classified as either small, medium, or large. This eliminates the need to measure each fish.

2. The sample design for collecting biological data (sex, age, and length data) from chinook salmon by the tagging crews and creel surveys should be temporally stratified as there are significant changes during the return. The approximate 15-day periods used in 1986 are recommended.

3. Chinook salmon with adipose finclips caught by the tagging crews should continue to be sacrificed so that coded-wire tag data can be analyzed.

4. If length-at-age standards for the early run and late run can be collected, methods similar to McBride et al. (1985) should be used to estimate the proportion of each run in the gill net samples and sport fishery samples.

ACKNOWLEDGEMENTS

Steve Hammarstrom was the project leader for this project. Under his direction, all aspects of this project were effectively and efficiently executed. The leaders of the gill net tagging crews are thanked for their hard work and dedication: Mary King, Mary Whalen, Nicole Jones, and Larry Dubois; as are their assistants: David Krom, John Roemer, Kurt Shuey, and Jerry Strait, and Shawn Lynch. Also, thanks are extended to the individuals conducting the various creel surveys: Larry Marsh, Gino DelFrate, Elizabeth Lenart, Jim Gebhard, and Laurie Flagg. Sandra Sonnichsen and Jay Carlon are thanked for their assistance with some of the data compilation.

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APPENDIX TABLES

Appendix Table 1. Detailed release and recovery information for the 114 tags recovered from chinook salmon during creel surveys of the Kenai River, 1987.

Tag Number	Tag Color	Date Tagged	Date Recover.	Days Out	Recovery Source[1]	Mile Tagged	Mile Recover.	Miles Between
9120	green	23-May	26-May	3	DRS	8.3	14.3	6.0
9124	green	26-May	03-Jun	8	DRS	7.7	18.1	10.4
9064	green	29-May	02-Jun	4	DRS	9.2	18.1	8.9
9165	green	29-May	02-Jun	4	ASS	7.3	18.1	10.8
9071	green	29-May	10-Jun	12	DRS	9.3	18.1	8.8
9160	green	29-May	11-Jun	13	DRS	7.3	43.5	36.2
9243	green	31-May	02-Jun	2	ASS	8.7	14.3	5.6
9197	green	31-May	02-Jun	2	DRS	9.3	11.4	2.1
9234	green	31-May	14-Jun	14	URS	8.8	42.0	33.2
64	white	02-Jun	03-Jun	1	ASS	8.8	14.3	5.5
82	white	02-Jun	05-Jun	3	DRS	8.9	18.1	9.2
181	white	02-Jun	14-Jun	12	ASS	7.4	14.3	6.9
269	white	03-Jun	04-Jun	1	DRS	8.4	14.3	5.9
198	white	03-Jun	05-Jun	2	DRS	9.1	11.0	1.9
250	white	04-Jun	05-Jun	1	ASS	9.0	13.6	4.6
220	white	04-Jun	05-Jun	1	DRS	8.7	14.3	5.6
249	white	04-Jun	05-Jun	1	DRS	8.9	14.4	5.5
326	white	04-Jun	06-Jun	2	DRS	8.9	13.6	4.7
408	white	05-Jun	16-Jun	11	ASS	7.5		
505	white	06-Jun	12-Jun	6	DRS	7.4	11.4	4.0
392	white	06-Jun	12-Jun	6	DRS	7.3	11.4	4.1
507	white	06-Jun	16-Jun	10	ASS	9.4	20.3	10.9
438	white	06-Jun	25-Jun	19	URS	7.4	42.0	34.6
480	white	07-Jun	09-Jun	2	ASS	9.1	14.3	5.2
478	white	07-Jun	13-Jun	6	ASS	9.3	18.1	8.8
658	white	08-Jun	11-Jun	3	ASS	8.8	21.1	12.3
614	white	09-Jun	09-Jun	0	DRS	9.3	11.4	2.1
24	white	09-Jun	10-Jun	1	ASS	8.9	11.4	2.5
106	white	11-Jun	12-Jun	1	ASS	8.6	13.5	4.9
105	white	11-Jun	12-Jun	1	DRS	8.6	10.1	1.5
126	white	12-Jun	13-Jun	1	ASS	9.3	11.4	2.1
587	white	12-Jun	19-Jun	7	DRS	6.8	14.3	7.5
	white		16-Jun					
137	white	13-Jun	17-Jun	4	DRS	6.9	10.4	3.5
162	white	14-Jun	16-Jun	2	DRS	7.3	11.4	4.1
155	white	14-Jun	16-Jun	2	ASS	8.3	18.1	9.8
174	white	14-Jun	16-Jun	2	DRS	9.4	11.4	2.0
152	white	14-Jun	16-Jun	2	ASS	8.6	22.1	13.5
706	white	14-Jun	24-Jun	10	DRS	7.4	16.8	9.4
7248	orange	15-Jun	16-Jun	1	DRS	7.3	10.1	2.8
7817	orange	15-Jun	18-Jun	3	DRS	6.8	13.6	6.8

-continued-

Appendix Table 1. Detailed release and recovery information for the 114 tags recovered from chinook salmon during creel surveys of the Kenai River, 1987 (continued).

Tag Number	Tag Color	Date Tagged	Date Recover.	Days Out	Recovery Source[1]	Mile Tagged	Mile Recover.	Miles Between
7813	orange	15-Jun	23-Jun	8	DRS	6.8	17.4	10.6
8081	orange	16-Jun	18-Jun	2	ASS	8.6	11.4	2.8
8205	orange	17-Jun	20-Jun	3	DRS	7.3	18.5	11.2
8223	orange	18-Jun	19-Jun	1	DRS	7.3	10.1	2.8
8235	orange	19-Jun	20-Jun	1	DRS	8.9	11.4	2.5
8240	orange	19-Jun	21-Jun	2	DRS	7.4	14.3	6.9
8303	orange	19-Jun	28-Jun	9	ASS	6.7	22.9	16.2
8314	orange	20-Jun	21-Jun	1	DRS	8.3	13.6	5.3
8402	orange	21-Jun	23-Jun	2	DRS	7.4	18.5	11.1
8454	orange	21-Jun	23-Jun	2	DRS	7.5	18.1	10.6
8458	orange	21-Jun	03-Jul	12	DRS	8.8	23.9	15.1
8350	orange	24-Jun	25-Jun	1	DRS	8.0	10.1	2.1
8444	orange	24-Jun	26-Jun	2	ASS	7.3	17.2	9.9
8507	orange	24-Jun	26-Jun	2	ASS	7.3	18.1	10.8
8491	orange	24-Jun	26-Jun	2	DRS	8.5	10.1	1.6
8338	orange	24-Jun	27-Jun	3	ASS	7.3	17.4	10.1
8433	orange	24-Jun	02-Jul	8	ASS	7.9	18.1	10.2
8367	orange	25-Jun	26-Jun	1	ASS	7.0	11.4	4.4
8783	orange	25-Jun	27-Jun	2	ASS	7.4	18.1	10.7
8520	orange	25-Jun	28-Jun	3	ASS	8.3	18.5	10.2
8542	orange	26-Jun	27-Jun	1	ASS	9.1	14.3	5.2
8674	orange	26-Jun	27-Jun	1	ASS	8.6	13.0	4.4
8795	orange	26-Jun	28-Jun	2	ASS	9.0		
8687	orange	27-Jun	28-Jun	1	ASS	9.1	14.3	5.2
8805	orange	28-Jun	02-Jul	4	ASS	7.5	14.3	6.8
8691	orange	28-Jun	05-Jul	7	DRS	9.2	10.1	0.9
	orange		09-Jul					
8806	orange	29-Jun	15-Jul	16	ASS	8.7	30.5	21.8
1005	yellow	02-Jul	03-Jul	1	DRS	8.0	12.3	4.3
1021	yellow	03-Jul	05-Jul	2	ASS	9.2	10.1	0.9
1063	yellow	06-Jul	07-Jul	1	DRS	9.2	10.1	0.9
1331	yellow	06-Jul	07-Jul	1	ASS	9.0	8.0	-1.0
1065	yellow	06-Jul	09-Jul	3	DRS	8.9	15.3	6.4
1338	yellow	06-Jul	25-Jul	19	DRS	7.4	18.1	10.7
1181	yellow	07-Jul	09-Jul	2	DRS	9.2	18.1	8.9
1218	yellow	07-Jul	14-Jul	7	ASS	9.4	10.1	0.7
1349	yellow	07-Jul	18-Jul	11	DRS	8.9	10.1	1.2
1508	yellow	08-Jul	14-Jul	6	ASS	7.5		
1242	yellow	08-Jul	30-Jul	22	ASS	8.7	15.3	6.6
1095	yellow	09-Jul	10-Jul	1	ASS	9.3	15.3	6.0
1108	yellow	10-Jul	12-Jul	2	DRS	8.0	10.1	2.1

-continued-

Appendix Table 1. Detailed release and recovery information for the 114 tags recovered from chinook salmon during creel surveys of the Kenai River, 1987 (continued).

Tag Number	Tag Color	Date Tagged	Date Recover.	Days Out	Recovery Source[1]	Mile Tagged	Mile Recover.	Miles Between
1423	yellow	11-Jul	12-Jul	1	DRS	7.3	10.1	2.8
1526	yellow	12-Jul	14-Jul	2	DRS	9.0	15.3	6.3
1256	yellow	13-Jul	14-Jul	1	ASS	9.3	11.4	2.1
1455	yellow	14-Jul	15-Jul	1	DRS	9.2	10.1	0.9
1283	yellow	14-Jul	15-Jul	1	ASS	8.4	11.7	3.3
1285	yellow	14-Jul	16-Jul	2	DRS	7.0	8.0	1.0
1139	yellow	14-Jul	17-Jul	3	DRS	9.3	12.3	3.0
1457	yellow	14-Jul	18-Jul	4	ASS	8.9	14.3	5.4
	yellow		23-Jul					
1440	yellow	14-Jul	24-Jul	10	ASS	9.4	17.4	8.0
	yellow		31-Jul					
1677	yellow	15-Jul	18-Jul	3	DRS	7.3	16.0	8.7
1717	yellow	15-Jul	22-Jul	7	ASS	6.9		
1467	yellow	15-Jul	30-Jul	15	DRS	9.2	11.4	2.2
2102	blue	16-Jul	18-Jul	2	ASS	9.6	8.0	-1.6
2127	blue	16-Jul	21-Jul	5	ASS	6.7	11.4	4.7
2143	blue	17-Jul	18-Jul	1	DRS	8.7	10.1	1.4
2086	blue	17-Jul	18-Jul	1	DRS	9.4	11.4	2.0
2091	blue	17-Jul	21-Jul	4	DRS	9.7	17.4	7.7
2185	blue	17-Jul	25-Jul	8	ASS	9.4	14.3	4.9
2144	blue	17-Jul	30-Jul	13	DRS	8.7	17.4	8.7
2493	blue	20-Jul	28-Jul	8	ASS	7.4	17.4	10.0
2235	blue	20-Jul	29-Jul	9	DRS	7.3	27.0	19.7
2409	blue	21-Jul	23-Jul	2	DRS	6.6	11.4	4.8
2532	blue	21-Jul	30-Jul	9	DRS	9.1	11.4	2.3
2723	blue	22-Jul	25-Jul	3	DRS	7.2	16.0	8.8
2526	blue	22-Jul	25-Jul	3	DRS	9.4	22.9	13.5
2706	blue	22-Jul	25-Jul	3	ASS	7.9	14.3	6.4
2621	blue	22-Jul	28-Jul	6	DRS	7.5	18.1	10.6
2816	blue	22-Jul	31-Jul	9	DRS	7.4	13.6	6.2
2656	blue	23-Jul	24-Jul	1	ASS	8.8	17.4	8.6
	blue		26-Jul					

[1] Recovery sources: DRS = downstream roving creel survey,
URS = upstream roving creel survey, and
ASS = access-site creel survey.

Appendix Table 2. Estimated numbers, by sex and age group, of chinook salmon in each stratum for the Kenai River abundance estimate, 1987.

Stratum	Sex	Statistic	Age Group 1.2	1.3	1.4	1.5	Other[1]	Total
5/20 - 6/03	Male	Percent	0.3	15.0	31.8	2.6	0.3	50.0
(n = 314)[2]		Estimated Number	27	1,369	2,902	237	27	4,562
		Standard Error	28	703	1,467	134	28	
	Female	Percent	0.0	10.8	37.3	1.6	0.3	50.0
		Estimated Number	0	986	3,404	146	27	4,563
		Standard Error	0	512	1,717	92	28	
	Combined	Percent	0.3	25.8	69.1	4.2	0.6	100.0
		Estimated Number	27	2,355	6,306	383	54	9,125
		Standard Error	28	1,194	3,163	207	44	
6/04 - 6/14	Male	Percent	1.9	22.6	21.1	1.5	0.2	47.3
(n = 421)		Estimated Number	170	2,019	1,885	134	18	4,226
		Standard Error	79	679	636	66	19	
	Female	Percent	0.0	22.8	29.5	0.2	0.2	52.7
		Estimated Number	0	2,037	2,636	18	18	4,709
		Standard Error	0	685	877	19	19	
	Combined	Percent	1.9	45.4	50.6	1.7	0.4	100.0
		Estimated Number	170	4,056	4,521	152	36	8,935
		Standard Error	79	1,335	1,484	73	29	
6/15 - 6/30	Male	Percent	2.5	20.6	25.5	0.4	0.0	49.0
(n = 243)		Estimated Number	190	1,562	1,935	30	0	3,717
		Standard Error	94	532	648	31	0	
	Female	Percent	0.0	22.2	28.0	0.4	0.4	51.0
		Estimated Number	0	1,683	2,123	30	30	3,866
		Standard Error	0	570	708	31	31	
	Combined	Percent	2.5	42.8	53.5	0.8	0.4	100.0
		Estimated Number	190	3,245	4,058	60	30	7,583
		Standard Error	94	1,059	1,314	46	31	

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Appendix Table 2. Estimated numbers, by sex and age group, of chinook salmon in each stratum for the Kenai River abundance estimate, 1987 (continued).

Stratum	Sex	Statistic	Age Group 1.2	1.3	1.4	1.5	Other[1]	Total
7/01 - 7/28	Male	Percent	2.1	18.0	32.0	0.7	0.4	53.2
(n = 719)		Estimated Number	910	7,800	13,866	303	173	23,052
		Standard Error	264	1,282	2,134	140	104	
	Female	Percent	0.1	9.9	36.4	0.4	0.0	46.8
		Estimated Number	43	4,291	15,772	173	0	20,279
		Standard Error	51	782	2,401	104	0	
	Combined	Percent	2.2	27.9	68.4	1.1	0.4	100.0
		Estimated Number	953	12,091	29,638	476	173	43,331
		Standard Error	272	1,885	4,337	181	104	
7/29 - 8/11	Male	Percent	0.8	14.8	20.6	0.4	0.4	37.0
(n = 243)		Estimated Number	174	3,211	4,469	87	87	8,028
		Standard Error	182	3,513	4,893	87	87	
	Female	Percent	0.0	13.2	49.4	0.4	0.0	63.0
		Estimated Number	0	2,863	10,715	87	0	13,665
		Standard Error	0	3,132	11,746	87	0	
	Combined	Percent	0.8	28.0	70.0	0.8	0.4	100.0
		Estimated Number	174	6,074	15,184	174	87	21,693
		Standard Error	182	6,654	16,647	182	87	

1 Age groups 1.6, 2.1, 2.3, and 2.4 combined.

2 n = sample size.

Appendix **Table** 3. Estimated age composition, by stratum, of chinook salmon harvested by the recreational fishery in the Kenai River, 1987.

Stratum	Sex	Statistic	Age Group					Total
			1.2	1.3	1.4	1.5	Other[1]	
5/16 - 6/03	Male	Percent	0.9	9.0	21.6	9.0	0.0	40.5
(n = 111)[2]		Standard Error[3]	0.9	2.7	3.9	2.7	0.0	
	Female	Percent	0.0	9.0	46.0	4.5	0.0	59.5
		Standard Error	0.0	2.7	4.8	2.0	0.0	
	Combined	Percent	0.9	18.0	67.6	13.5	0.0	100.0
		Standard Error	0.9	3.7	4.5	3.3	0.0	
6/04 - 6/14	Male	Percent	1.2	16.4	17.5	0.6	0.6	36.3
(n = 171)		Standard Error	0.8	2.8	2.9	0.6	0.6	
	Female	Percent	0.6	20.5	40.3	2.3	0.0	63.7
		Standard Error	0.6	3.1	3.8	1.1	0.0	
	Combined	Percent	1.8	36.9	57.8	2.9	0.6	100.0
		Standard Error	1.0	3.7	3.8	1.3	0.6	
6/15 - 6/30	Male	Percent	0.5	12.8	28.1	2.8	0.0	44.2
(n = 211)		Standard Error	0.5	2.3	3.1	1.1	0.0	
	Female	Percent	0.0	15.6	37.9	1.4	0.9	55.8
		Standard Error	0.0	2.5	3.3	0.8	0.7	
	Combined	Percent	0.5	28.4	66.0	4.2	0.9	100.0
		Standard Error	0.5	3.1	3.3	1.4	0.7	

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Appendix Table 3. Estimated age composition, by stratum, of chinook salmon harvested by the recreational fishery in the Kenai River, 1987 (continued).

Stratum	Sex	Statistic	Age Group 1.1	1.2	1.3	1.4	Other[1]	Total
7/01 - 7/15	Male	Percent	0.6	10.0	39.4	1.3	0.6	51.9
(n = 160)		Standard Error	0.6	2.4	3.9	0.9	0.6	
	Female	Percent	0.6	9.4	37.5	0.6	0.0	48.1
		Standard Error	0.6	2.3	3.8	0.6	0.0	
	Combined	Percent	1.2	19.4	76.9	1.9	0.6	100.0
		Standard Error	0.9	3.1	3.3	1.1	0.6	
7/16 - 7/28	Male	Percent	0.5	14.7	33.8	1.0	0.0	50.0
(n = 198)		Standard Error	0.5	2.5	3.4	0.7	0.0	
	Female	Percent	0.5	13.1	36.4	0.0	0.0	50.0
		Standard Error	0.5	2.4	3.4	0.0	0.0	
	Combined	Percent	1.0	27.8	70.2	1.0	0.0	100.0
		Standard Error	0.7	3.2	3.3	0.7	0.0	
7/29 - 7/31	Male	Percent	0.0	4.2	31.0	2.8	0.0	38.0
(n = 71)		Standard Error	0.0	2.4	5.5	2.0	0.0	
	Female	Percent	0.0	14.1	46.5	1.4	0.0	62.0
		Standard Error	0.0	4.2	6.0	1.4	0.0	
	Combined	Percent	0.0	18.3	77.5	4.2	0.0	100.0
		Standard Error	0.0	4.6	5.0	2.4	0.0	

1 Age groups 1.1 and 2.4 combined.

2 n = sample size.

3 Standard error of proportional estimate of age composition x 100.

APPENDIX A

Three possible sources of variation for each of the 14 effort/catch statistics having between-crew and between-day variation were investigated: (1) between-set variation for sets made on the same day by the same crew; (2) between-crew variation; and (3) between-day variation. The possible sources of variation contributing to each of the statistics are summarized in Appendix Table A1. Four of the statistics have between-day variation only.

Methods

Two-factor analysis of variance (ANOVA) was used to analyze those variables which had between-set variation. Two-factor ANOVA for unequal number of observations in each cell was conducted using a regression approach to test the significance of interaction of the factors and the main-effects as described on pages 362-367 in Kleinbaum and Kupper (1978). Separate analyses of the gillnet effort and chinook salmon catch statistics were conducted for tides when only two crews fished, tides when only three crews fished, and tides when all four crews fished so that a complete-block design could be used. All ANOVA were conducted with SPSS (Norusis 1983).

Those variables in Appendix Table A1 with only crew and day as sources of variation were tested to determine if there were significant differences among crews on tides when multiple crews operated. On tides when only two crews operated, the Wilcoxon signed-rank test (Conover 1980) for two related samples was used. The *k* sample extension of the Wilcoxon signed-rank test, the Quade test (Conover 1980), was used for tides when three or four crews operated. For these tests, crews corresponded to the treatments and tides (days) the blocks in the experimental design.

Based on the results of the previous analyses, variance for the statistics measured by set (those variables in Appendix Table A1 with three sources of variation) were estimated using a two-stage sample design. Days were considered the primary sample units (with a finite number available) and sets the secondary sample units (with an unknown number of sample units available). Variance of effort or catch statistic x for tagging stratum j was estimated by (Sukhatme et al. 1984):

$$V(\bar{x}_j) = [1 - (d_j/D_j)]\ s^2_{Bj}/d_j + (\sum_{i=1}^{D} s^2_{ij}/m_{ij})/d_jD_j \qquad [A1]$$

where:

d_j = number of days sampled during stratum j,

D_j = number of days during stratum j,

Appendix Table A1. Possible sources of variation for the 18 effort and catch statistics investigated.

Statistic[1]	Sources of Variation
TOTSETS	crew, day
TOTEFF	crew, day
MNDUR	set, crew, day
TOTCAT	crew, day
MNCAT	set, crew, day
CPUE	set, crew, day
MNCPUE	set, crew, day
MNLNCPUE	set, crew, day
TOTEFF=0	crew, day
MNDUR=0	set, crew, day
%EFF>0	crew, day
SETS>0	crew, day
%SETS>0	crew, day
MNDUR>0	set, crew, day
SETS/CD	day
EFF/CD	day
CAT/CD	day
SETS>0/CD	day

[1] Statistics defined in Table 1.

s_{ij}^2 = sample variance for sets on day *i* of stratum *j*,

s_{Bj}^2 = between-day variance for sets during stratum *j*, and

m_{ij} = number of sets made on day *i* of stratum *j*.

Between-day variance, s_{Bj}^2, was estimated as follows:

$$s_{Bj}^2 = [\sum_{i=1}^{D_j} (\bar{x}_{ij} - \bar{x}_j)^2]/(d_j - 1). \qquad [A2]$$

Results

The crew-day interactions were significant for seven of the eighteen comparisons (Appendix Table A2). Interaction terms are difficult to interpret and the presence of significant interaction nullifies any tests of the main-effects (Kleinbaum and Kupper 1978). The day effect was significant ($P < 0.05$) in all analyses where the interaction effect was not significant ($P > 0.05$). The crew effect was significant ($P < 0.01$) in four of the eleven analyses with no significant interaction effect.

The results of the nonparametric tests for differences among-crews for the eight statistics having two sources of variation were similar to those of the two-factor ANOVA. Only one significant difference ($P < 0.05$) was found for the comparison of data collected during two-crew, three-crew, or four-crew tides (Appendix Table A3). The difference occurred in the TOTSETS variable for the tides when three crews operated.

Discussion

There was no evidence of gear competition between crews on days when all four crews operated as was found in 1986 (Conrad and Larson 1987). Therefore, we used all effort and catch data in the regression analyses.

Since there were no significant among-crew differences for the effort and catch statistics from tides when three or fewer crews worked (Appendix Table A3), data were pooled for all crews. Because crews were not a significant source of variation, a two-stage sample design was used to estimate the variance of the statistics measured by set.

Appendix Table A2. Results of the two-factor analyses of variance for the effort and catch statistics having three sources of variation: set, crew, and day. Analyses performed for tides when only two crews worked, tides when only three crews worked, and tides when all four crews worked. (** = significant $P \leq 0.01$, * = significant $0.01 < P \leq 0.05$, and NS = not significant $P > 0.05$).

Statistic[1]	Two Crews Int[2]	Day	Crew	Three Crews Int[2]	Day	Crew	Four Crews Int[2]	Day	Crew
MNDUR3	**	**	**	**	**	**	NS	**	**
MNCAT3	**	**	NS	NS	**	NS	NS	**	NS
CPUE	**	**	*	NS	**	**	NS	**	NS
MNLNCPUE3	*	**	NS	NS	**	**	NS	**	NS
MNDUR=03	NS	**	NS	NS	**	NS	NS	**	NS
MNDUR>03	**	**	**	**	**	**	NS	**	**

[1] Statistics defined in Table 1.

[2] Day-crew interaction.

[3] Transformed by natural logarithm to equalize variances.

Appendix Table A3. Results of the non-parametric tests for related samples of effort and catch statistics having two sources of variation: crew and day. Analyses performed for tides when only two crews worked, tides when only three crews worked, and tides when all four crews worked. (** = significant $P \leq 0.01$, * = significant $0.01 < P \leq 0.05$, and NS = not significant $P > 0.05$).

Statistic[1]	Two Crews	Three Crews	Four Crews
TOTSETS	NS	*	NS
TOTEFF	NS	NS	NS
TOTCAT	NS	NS	NS
CPUE	NS	NS	NS
TOTEFF=0	NS	NS	NS
%EFF>0	NS	NS	NS
SETS>0	NS	NS	NS
%SETS>0	NS	NS	NS

[1] Statistics defined in Table 1.