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HOOK AND RELEASE MORTALITY OF CHINOOK SALMON IN THE KENAI RIVER RECREATIONAL FISHERY[1]

By

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ABSTRACT

The widespread practice of hook and release fishing for chinook salmon *Oncorhynchus tshawytscha* in the Kenai River prompted the Alaska Department of Fish and Game to initiate a multi-year investigation of mortality associated with this fishing technique. Preliminary findings from the year of study are presented in this report. Short-term (1-5 day) hooking mortality for 100 chinook salmon that were caught and released in the Kenai River recreational fishery was assessed using radio telemetry. Biological and fishery variables were recorded for each of the late-run fish that were radio-tagged. Mortality was estimated to be 13 percent for males and 7 percent for females. Fates of radio-tagged fish were independent of fish lengths, but were significantly associated with sex. Due to small sample sizes, none of the variables recorded were found to significantly affect hooking mortality. Most mortality took place within 72 hours of release. Only 40 radio-tagged fish survived to spawn. Of those that did not survive, the majority were caught and retained in the recreational fishery and significantly more of these were females than males. Initial movements of radio-tagged fish occurred in both upstream and downstream directions. Movement occurred most frequently during the second half of the day. Upstream movements to spawning destinations were variable, and frequently punctuated by milling behavior. An average of 30 days elapsed between tagging and spawning and all but one tagged salmon selected mainstem spawning locations.

KEY WORDS: Kenai River, chinook salmon, *Oncorhynchus tshawytscha*, radio telemetry, transmitters, mortality, hook and release, angling variables.

INTRODUCTION

The Kenai River (Figure 1) is a glacial stream located in southcentral Alaska on the Kenai Peninsula. The river and its associated tributaries drain an area of approximately 5,700 square kilometers. The Kenai River supports the largest recreational harvest for chinook salmon *Oncorhynchus tshawytscha* in Alaska. The world record all-tackle chinook salmon (207.27 kg, 94 lbs) was taken from the Kenai River during 1985 and fish in excess of 154.35 kg (70 lbs) are not uncommon. Thus, the Kenai River enjoys a wide reputation for abundant catches of large chinook salmon. The estimated annual harvest of Kenai River chinook salmon from 1986 through 1989 has ranged from 16,383 to 29,100 and averaged 21,943 (Nelson 1990). Harvest and effort in this fishery have steadily increased since first estimated in 1974.

Angling for chinook salmon is restricted to the lower 80 km (50 miles) of mainstem river and is conducted primarily out of small outboard-powered boats by both guided and non-guided anglers. The fishery begins in early May and continues for 6 days each week until the season ends on 31 July. The return of adult chinook salmon (and the harvest) occurs in two distinct components, an early run and a late run. Fish caught prior to July 1 comprise the early run, while those caught after that date make up the late run. Early-run fish account for about 30% of the harvest and late-run fish make up the remaining 70%. Recent harvests have been taken in equal proportions by guided and non-guided anglers. The state has implemented regulations to manage the harvest in this fishery including establishment of escapement goals, a daily bag and possession limit of one fish, and a yearly bag and possession limit of two fish.

The voluntary practice of hook and release fishing for chinook salmon in the Kenai River has increased in recent years due to abundant returns, restrictive bag and possession limits, and selective harvesting for "trophy" sized fish. From 1986 through 1989, an estimated 38,268 chinook salmon (30% of the catch) were released by anglers (Table 1). In the early-run component of the 1988 fishing season, approximately 86% of the total chinook salmon return to the river was caught. The released component of that catch (5,440 fish) represented 67% of the estimated escapement. The ultimate fate of these hooked and released fish was unknown. Also in 1988, the Alaska Board of Fisheries directed the Alaska Department of Fish and Game (ADF&G) to manage the recreational fishery to achieve escapement goals of 9,000 early-run and 22,300 late-run chinook salmon. If these goals can not be projected during the season, ADF&G will reduce the time or area of the fishery, or require hook and release fishing only.

This study resulted from increased concern over the fate of hooked and released fish, the growth of this practice in the recreational fishery, and the need to evaluate the biological costs of hook and release fishing in anticipation of its use as a management tool. The goal of this study is to estimate the short-term (5 day) mortality associated with hook and release fishing for chinook salmon in the Kenai River and the affects of selected biological and fishing variables on mortality.

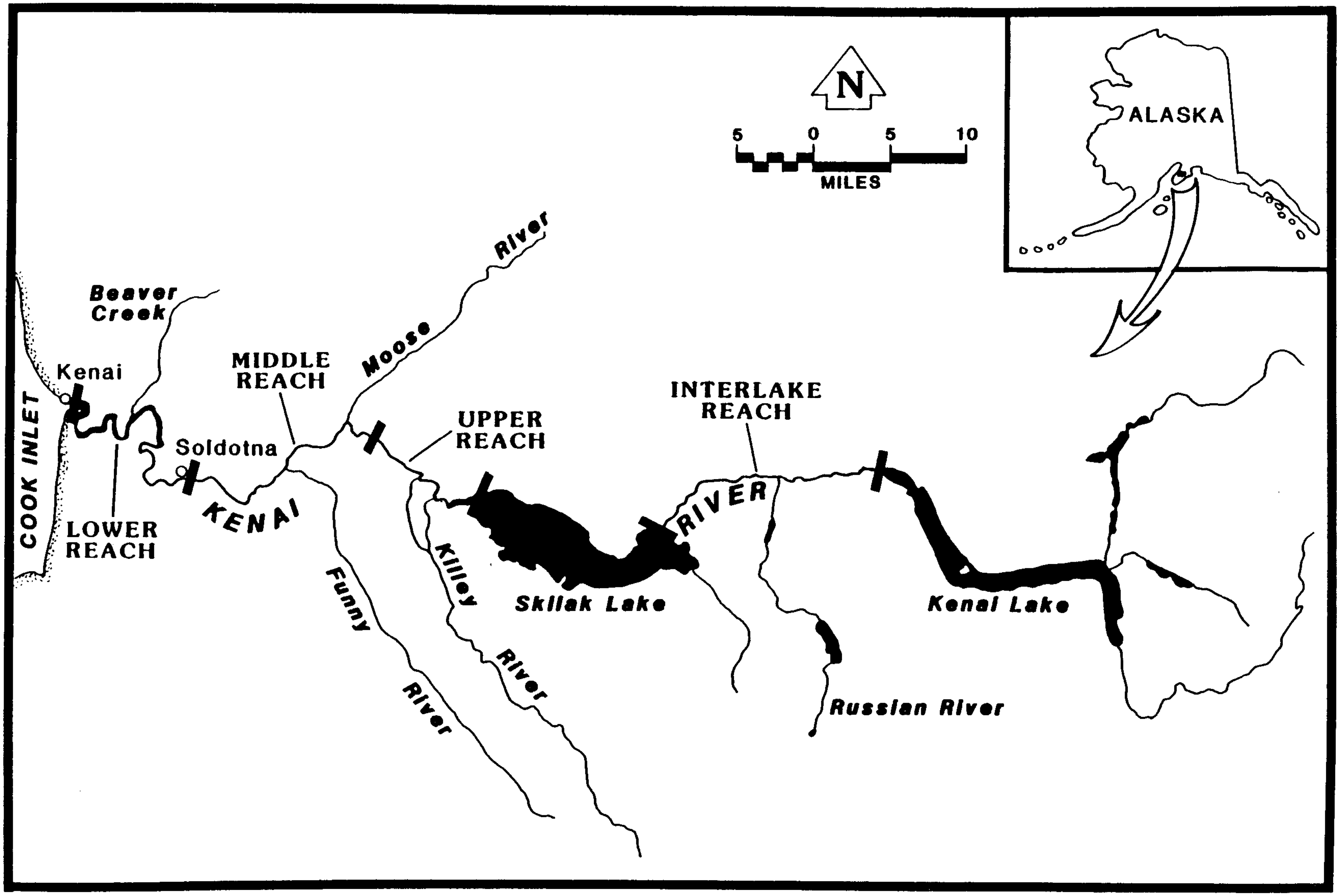

Figure 1. Map of the Kenai River Basin.

Table 1. Estimated escapements and numbers of chinook salmon that were caught, released, and retained in the Kenai River recreational fishery from 1986 through 1989.

Year	Run Component	Numbers of Chinook Salmon Caught	Numbers of Chinook Salmon Retained	Numbers of Chinook Salmon Released	Percent Released	Estimated Escapement[a]
1986	Early	12,120	7,570	4,550	38	19,519
	Late	15,400	9,040	6,360	41	48,559
	Both	27,520	16,610	10,910	40	68,078
1987	Early	19,340	13,430	5,910	31	12,362
	Late	16,790	12,250	4,540	27	52,787
	Both	36,130	25,680	10,450	29	65,149
1988	Early	17,040	11,600	5,440	32	8,133
	Late	23,240	17,500	5,740	25	34,496
	Both	40,280	29,100	11,180	28	42,629
1989	Early	9,901	7,256	2,645	27	10,736
	Late	12,210	9,127	3,083	25	19,908
	Both	22,111	16,383	5,728	26	30,644
All	Early	58,401	39,856	18,545	32	50,750
	Late	67,640	47,917	19,723	29	155,750
	Both	126,041	87,773	38,268	30	206,500

[a] Inriver return minus the sport harvest.

Our study used radio-telemetry to monitor the daily movements and estimate fates of chinook salmon that were caught and released in the recreational fishery. This report presents findings from the 1989 fishing season in which 100 late-run chinook salmon were caught, radio-tagged, and released. Biological and fishery variables were measured for each fish, and fates were established using a series of criteria based on telemetry signals and movement behavior. The findings presented in this report are preliminary. Additional data from tags deployed during the early and late runs in 1990 and the early run of 1991 will be used to evaluate chinook salmon hooking mortality in the Kenai River. Specific objectives for 1989 were to:

a. test the hypothesis that short term hook and release mortality for chinook salmon is not greater than 0.20;

b. estimate hook and release mortality;

c. estimate the effects that biological and fishery variables have on mortality rates;

d. estimate the duration of time tagged chinook salmon are susceptible to harvest in the lower Kenai River; and,

e. determine if chinook salmon destined for various spawning locations in the Kenai River drainage exhibit temporal differences in migratory timing through the lower river fishery.

METHODS

Data Collection and Procedures

Experimental Design and Assumptions:

The Kenai River presents several unique obstacles to conducting a hook and release study. The turbidity of the mainstem and tributaries prevents visual observations of study animals. The size and discharge of the mainstem precludes the operation of a weir for capturing or recovering fish and ADF&G personnel have failed to find suitable alternatives to gill net or hook and line sampling for capturing chinook salmon with minimum injury. The size of chinook salmon (often in excess of 23 kg) makes them difficult to handle and susceptible to injury when removed from the water. Due to these limitations, we chose to use radio telemetry to monitor the fates of individual fish. Thus, the mortality we estimate is a maximum value that includes the effects of handling and tagging.

There is evidence that hooking mortality is higher among salmon that are still feeding and in salt water than those that have entered fresh water to spawn (Parker et al. 1959, Vincent-Lang et al. In Press). We limited our tagging area to a 4.8 km (3 mile) reach of the lower Kenai River (Figure 2). Since radio transmitters do not propagate a signal in salt water, our tagging reach was located far enough upstream to allow for a 3 to 4 mile buffer area in which to identify tagged fish that moved downstream. We assumed that all

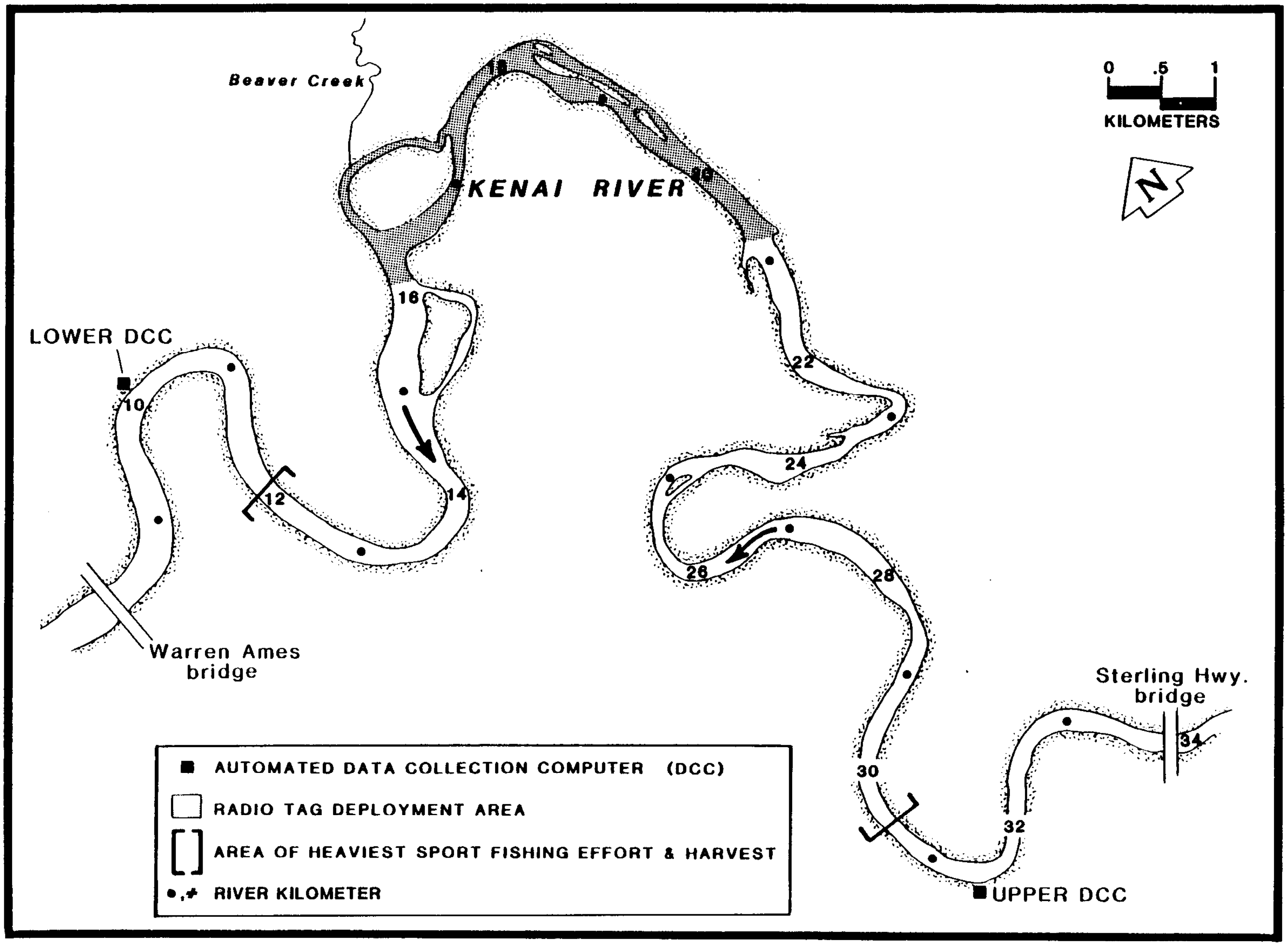

Figure 2. Map of the lower Kenai River delineating the area of greatest sport fishing harvest and effort, the boundaries of the tagging area and locations of the automated data collection computers.

chinook salmon captured within this reach responded similarly to angling and tagging.

A total of 100 late-run chinook salmon were angled, equipped with externally mounted radio transmitters, and released in the lower Kenai River. Our sample size was chosen to achieve the desired precision for objective b (±0.05, 80% of the time) using the binomial model (Cochran 1977). Tags were deployed systematically, and in equal weekly proportions (i.e. 25 tags each week during the 4 weeks of July). The fate of each radio-tagged fish was monitored daily for 5 consecutive days using aerial and ground tracking methods to test the hypothesis that short-term hook and release mortality is not greater than 0.20 (objective a). To estimate the duration that each radio-tagged fish was susceptible to harvest in the lower river recreational fishery, the number of days that each tagged fish spent between the time of release and passing an automated data logger (DCC) at river kilometer 30.6, or river mile 19 (rkm 30.6 or rm 19), was calculated (objective d). Fish that were alive following 5 days at-large and that survived the recreational fishery were relocated daily until spawning was indicated by the cessation of movement near the maximum distance penetrated upstream and radio transmitter signal modes[1]. The duration at-large, rates of movement, and estimated location of spawning were used to describe the spawning distribution of radio tagged chinook salmon (objective e).

Assumptions of this study were:

1. there is no tagging or natural mortality;

2. there is no tag loss; and,

3. tags that are removed by various fisheries or that we fail to relocate are a random subset of the total sample and do not bias the study results.

Telemetry Equipment:

Radio telemetry equipment used in this study was manufactured by Advanced Telemetry Systems, Inc., Isanti, Minnesota. Transmitters were encapsulated in electrical resin and measured approximately 20 mm by 70 mm with a 350 mm whip antenna. Each transmitter operated on a unique frequency between 48.000 MHz and 49.999 MHz separated by a minimum of 10 KHz. The minimum transmitter battery life was 85 days. Transmitters were equipped with mortality and activity options that altered their normal pulse rate of approximately one pulse per second. The mortality circuit, which doubled the pulse rate to 2 pulses per second, was triggered following 3 to 4 motionless hours. Subsequent movement reset the transmitter to the normal mode. Elevated levels of activity were indicated by a built in mercury switch that inserted additional pulses when the transmitter was moved vigorously. Thus, radio signals were transmitted in either normal, active, or mortality modes.

[1] The tags were able to transmit in several pulse rates, or modes, which designate different type of activity (normal, spawning, death). Explained more fully below.

Programmable scanning receivers and directional loop antennas were used to monitor radio transmissions. Daily flights in a PA-18 Supercub with an antenna mounted to the left wing jury struts were undertaken to relocate tagged chinook salmon. Flying was conducted at approximately 113 kph (70 mph) and 244 to 305 m (800 to 1000 ft) above the water column. A programmable receiver scanned available radio transmitter frequencies at 2 second intervals and the location of each fish was estimated to coincide with the point of maximum acoustic signal strength.

Two stationary automated data collection computers (DCC) were positioned along the banks of the lower Kenai River at rkm 10.5 and 30.6 (rm 6.5 and 19) (Figure 2). These DCC locations delineate boundaries of the reach in which approximately 84% of the effort and 90% of the harvest occurs in the chinook salmon recreational fishery (Hammarstrom 1989). Lead-acid batteries supplied field power to the DCC's and associated receivers which scanned each available frequency for 5 second intervals on a continuous basis. The frequencies, Julian date, time, and pulse rates of radios transmitting within range of the DCC's (usually less than 1.5 km) were stored electronically. These data were transferred to a microcomputer data base file on a weekly basis. DCC's were subject to extrinsic electronic interference, thus, aircraft relocation data were given priority when resolving discrepancies between the two data bases.

Capture and Tagging:

Chinook salmon recreational fishermen were observed by a two-person crew working out of an outboard powered river boat in the lower Kenai River. The crew started a stopwatch when a fish strike was observed or an angler was seen setting a hook. The angler was subsequently asked if the fish was intended to be released and if we could place a radio transmitter on it. Fish that were volunteered in this manner were played to the angler's boat and placed in a landing net. The leader was cut and the fish and net were passed to the tagging boat without being removed from the water. The tagging crew started a second stopwatch, removed the tackle, noted the locations of injuries, and transferred the fish to a tagging cradle using a tail restraining loop. The cradle and loop, which immobilize the fish and keep it under water during processing, are described by Hammarstrom et al. 1985. Thus, none of the fish were removed from the water during their capture, transfer, or handling.

Radio transmitters were mounted on the right side of each fish beneath the anterior half of the dorsal fin. Each tag was securely fastened through the fish using two 7.6 cm nickle pins that were epoxied to the tags on one end and tied against 2.5 cm diameter plastic Petersen disks on the other end (Figure 3). Stainless hypodermic needles measuring 16 ga by 10.2 cm were used to shield the nickle pins and provide a sharp cutting surface for penetrating the skin of the chinook salmon. The needles were removed from the pins after penetrating through the skin; a single needle was used numerous times. When processing was complete, the tail loop was removed, and the fish was supported until it swam away under its own initiative.

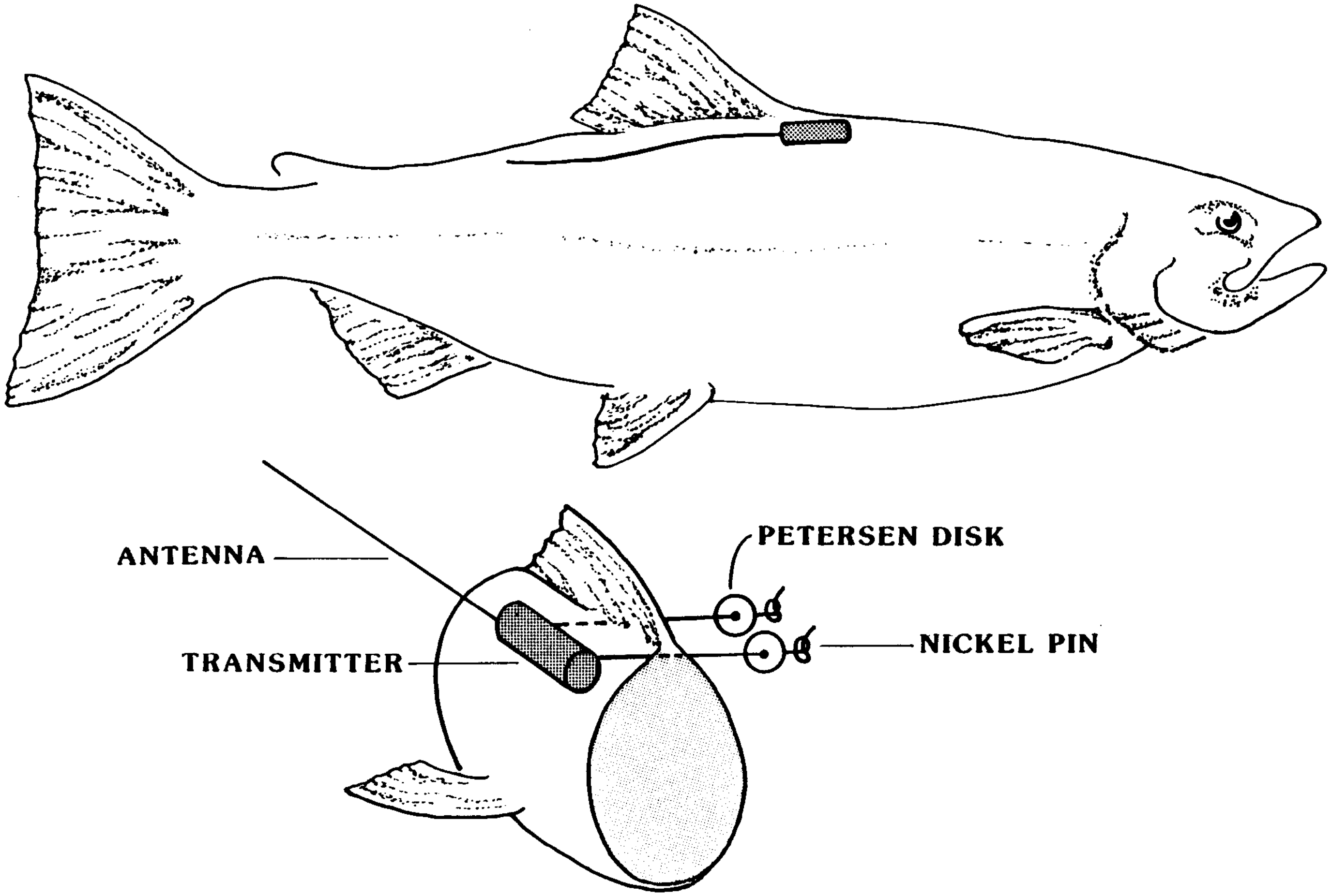

Figure 3. Schematic diagram of a salmon showing the attachment of a radio transmitter.

Biological and Fishery Variables:

Biological and fishery variables were recorded for each angling event. The biological variables were the size (millimeters) and sex of the fish, while the fishery variables defined the environmental conditions, fishing methods, and condition of fish at release (Table 2). Date, time, water temperature, catch and release locations, angler's name, and angling and tagging durations were recorded for each fish. Each event was assigned one of three fishing method classifications: back-bouncing, back-trolling, or drifting; and one of three terminal gears: artificial lure, bait, or lure/bait combination. The number and type of hooks and the presence of bleeding was noted. Classifications of anatomical hooking sites (Figure 4) adapted from Mongillo (1984) were recorded. The mid-eye to fork-of-tail length (measured to the nearest 10 mm) and sex (estimated from external characteristics) of tagged fish were recorded. The presence of sea lice *Lepeophtheirus salmonis*, gill net marks, fungus, other wounds, and fishing tackle were noted. Each fish was subjectively judged to be either vigorous or lethargic upon release.

<u>Dispositions of Tagged Fish</u>

Observed frequencies of dead and live radio-tagged fish, during the 5-day interval from release, were used to estimate hook and release mortality. Classifications for both 5-day and ultimate fates were used to describe the dispositions of all tagged fish. Tag recoveries from sport, commercial, and subsistence fisheries, interpretations of daily movement histories, and radio transmission modes were used to estimate fates. The following seven classifications defined 5-day fates:

1) survivor: fish that sustained upstream movement, transmitted radio signals in either normal or active modes, or were harvested after 5 days at-large;

2) mortality: fish that failed to move upstream from the intertidal area (rkm 19.3, rm 12), transmitted radio signals in the mortality mode, or tagged carcasses were recovered within 5 days of release (see discussion below);

3) sport harvest: fish tagged with transmitters that were recovered in the recreational fishery;

4) set net harvest: fish tagged with transmitters that were recovered in the east side Cook Inlet commercial set net fishery or in fish processing plants;

5) tag net harvest: fish tagged with transmitters that were recovered in ADF&G gill net studies conducted in the Kenai River;

6) education net harvest: fish tagged with transmitters that were recovered in the inriver Kenaitze Tribal education fishery;

7) drop-out: fish that returned to Cook Inlet and were not subsequently relocated;

Table 2. Biological, environmental, and fishing variables recorded for each chinook salmon angling event during 1989.

Variable	Explanation
SEX	Based on external characteristics.
LENGTH	Measurement from mid-eye to the fork of the tail (mm).
DATE	Recorded as month, day, and year.
TIME	Hour and minute of hook-up.
LOCATION	Location of hook-up to nearest 1.6 km.
WATER TEMPERATURE	Measured daily and recorded in degrees Celsius.
CAPTURE METHOD	1. Back-bouncing 2. Back-trolling 3. Drifting
TERMINAL GEAR	1. Artificial lure 2. Bait 3. Bait/lure combination
HOOK PLACEMENT	One of 12 anatomical locations, see Figure 4.
NUMBER OF HOOKS	Number of hooks (shanks) used in the terminal gear.
TYPE OF HOOKS	Recorded as either single or treble; determined by the number of points on each hook.
HOOKS REMOVED	Yes, if hooks removed; and, no, if hooks left in fish.
TIME PLAYED	Angling time in minutes and seconds from the initial strike until the fish was landed in a net.
TIME TAGGED	Handling time in minutes and seconds from placement in the net until tagged and released.
BLEEDING	Yes, if fish is bleeding; and, no, if fish is not bleeding.
LOCATION RELEASED	Location that fish is released.
CONDITION	Subjective judgement as to the condition of each fish upon release, and recorded as either vigorous or lethargic.

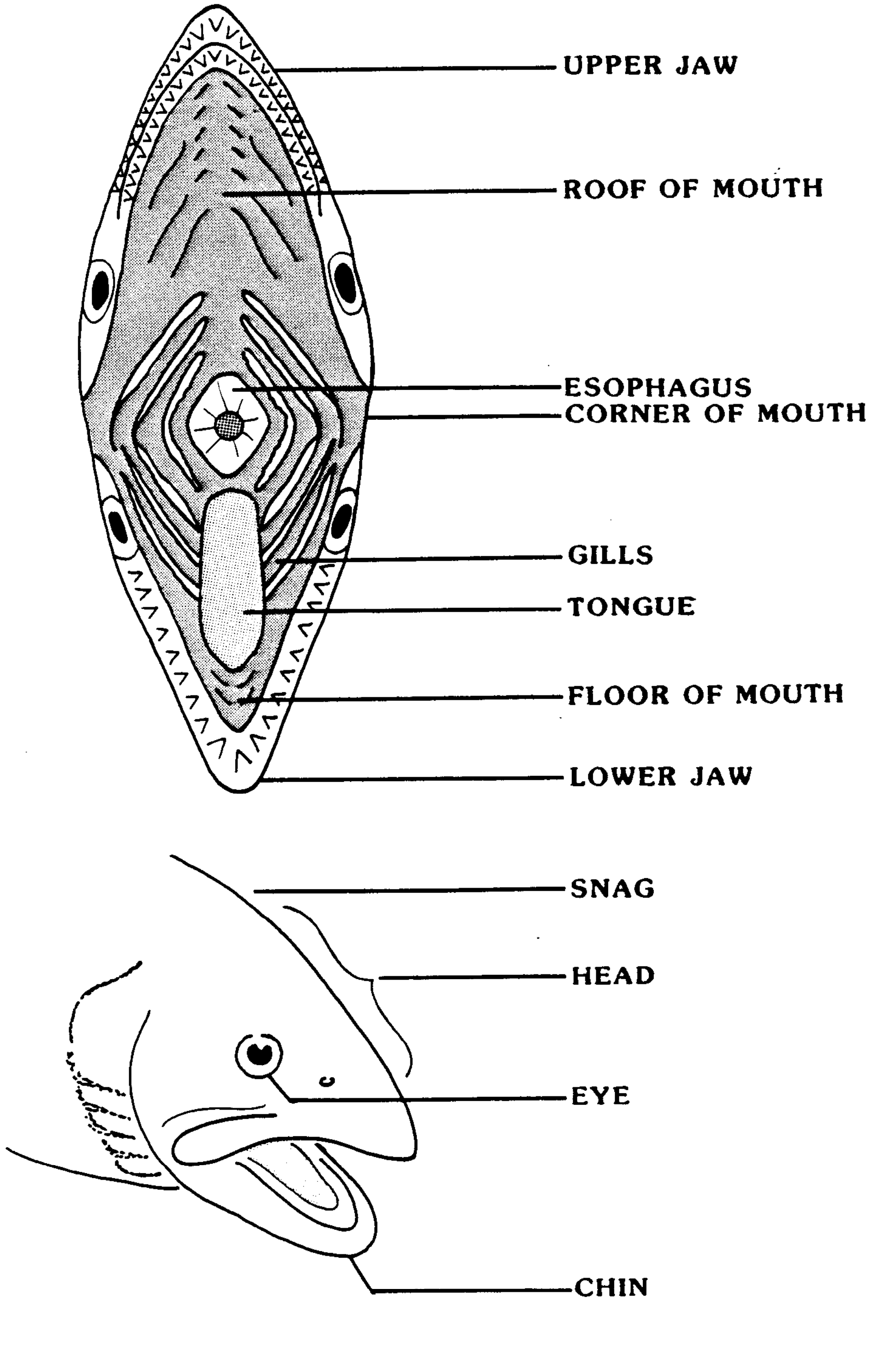

Figure 4. Diagrammatic view of a salmonid head illustrating hook injury locations adapted from Mongillo (1984).

8) uplost: fish that moved upstream but subsequently stopped transmitting a signal;

9) unknown: tagged fish that we failed to relocate.

The last seven fates represent fish that were removed from the study due to factors other than hook and release mortality.

Although we purposely limited the study objectives to address fates within 5 days of release, we also found it useful to assign ultimate fates to all fish, including those that survived more than 5 days. Dispositions of tagged fish that survived more than 5 days were as above with the exception of the first category (survivor), which becomes:

1) spawner: fish that held at destinations above the intertidal reach and transmitted signals in either normal or active modes.

The most difficult process in the determination of fate was that of estimating whether a fish had suffered hook and release mortality within 5 days of release. During the course of the study, it became apparent that the tag signals were not providing unambiguous evidence of this mortality. Therefore, we developed the following series of decision rules to allocate fates to the radio-tagged fish:

1. fish taken in the recreational or other fisheries were allocated to the appropriate fate;

2. if a carcass was recovered within 5 days, the fish was allocated to hook and release mortality;

3. if a fish consistently moved upstream at any time after the first 5 days, it was considered a survivor (irrespective of signal mode);

4. if a fish remained immobile, transmitted a mortality signal within 5 days, and continued to transmit in the mortality mode thereafter, then the fish was allocated to hook and release mortality (irrespective of location);

5. if a fish remained immobile within or below the tagging area (below rkm 19.3) within 5 days from release and during the remainder of the experiment, the fish was considered a hook and release mortality (irrespective of signal mode);

6. if a tag was not relocated after the fish was located below the lower DCC (rkm 10.5), the fish was a drop-out;

7. if the tag was not relocated after several days of upstream movement, the fish was up-lost; and,

8. if the tag was never relocated, the fate was unknown.

The first three rules were considered unambiguous. Relocation of a tag further and further upstream was considered proof of active movement. If a tag was collected from a fishery the fate was clearly defined. A carcass observed within 5 days of release was clearly categorized as a hook and release mortality, but in most cases where mortality was assigned, we found that the fish were categorized according to the fourth and fifth rules.

These rules (numbers 4 and 5) were necessary as the radio tag mortality signals did not provide a clear indication of mortality. A tag could be transmitting mortality signals, even while the fish was consistently relocated further and further upstream. A fish could transmit several days of mortality signals while remaining immobile, then suddenly move upstream with a normal signal. A stationary fish would transmit a mixture of mortality and normal signals. Therefore, the assumptions that were made in rules 4 and 5 were:

1. fish that disappear from the Kenai River were alive, a dead fish could not float out to sea;

2. there was no spawning below rkm 19.3 and fish observed to be stationary, or slowly moving downstream, in this area were dead irrespective of signal; and,

3. fish that were observed to be immobile above rkm 19.3 and had normal signals were considered survivors (in potential spawning areas).

Thus, location became crucial in our decision process. The most important assumption was that there is little spawning below rkm 19.3 (Burger et al. 1983) and a fish that does not migrate upstream of this point was assumed to be a mortality. Signal mode was of secondary importance for a fish relocated in this river reach. Above rkm 19.3, spawning could occur and a stationary fish could be on its spawning grounds. In this case, signal mode becomes the primary decision tool and only a consistent mortality signal will result in the fish being categorized as a dead fish.

Since this process leaves room for doubt, we divided the hook and release mortalities into "best-case" and "worst-case" categories. Only those fish defined as mortalities by rule 2 were considered "best-case" mortalities since we were certain of the fates for these fish, while those classified using rules 4 and 5 were "worst-case" mortalities.

In several cases, 5-day fates were not established until the end of the experiment. This was due to the stop-and-go behavior of many fish in the experiment.

<u>Data Analysis</u>

The assumption that censorship, i.e. removal from the experiment by factors other than hook and release mortality, is independent of biological and fishery variables was tested. Loglinear methods for categorical data (Agresti 1984) were used for the analysis of association in contingency tables of three or higher dimensions. These methods test whether there is interaction between any of the variables included, in particular between fate and the explanatory variables. The categorical procedure CATMOD in SAS (SAS 1987) was used to generate maximum-likelihood estimates for fitting loglinear models to the data. The size distributions of tagged fish removed by the sport, tag and set net fisheries were compared to the distribution of the total released sample using the non-parametric Kolmogorov-Smirnov statistic (Conover 1980). The null hypotheses tested were;

1. there is no association between sex, length and fate, where fate included the categories survivor, censored, or mortality;

2. there is no association between sex and length and the fishery variables;

3. there is no association between the fishery variables and fate; and,

4. there was no size selectivity in the various fisheries or censoring processes on the tagged population.

The first three null hypotheses were tested separately as sample sizes were not large enough to combine all of the categorical variables in one contingency table.

For this analysis the day of release was defined as day 1 of the experiment and the date of release was assumed not to have had an effect. In order to test the assumption that there was no change in censoring rates or mortality rates by actual date of release, a test of independence was carried out for fates by week of release. The null hypothesis that spawning destination does not differ by weekly interval of tagging was tested using chi-square contingency table analyses.

All statistical tests were conducted at the 90% (α=0.10) significance level unless otherwise noted.

Estimating Hook and Release Mortality:

The methods of survival analysis were used to estimate hook and release mortality (Cox and Oates 1984). For this analysis we defined hook and release mortality as a failure event and the time to that event was defined as the failure time. In this experiment censored individuals were those removed by a fate other than hook and release mortality e.g. the sport fishery. All fish still surviving 5 days after release were automatically censored, or removed from the experiment. This method computed the percent dying on each day of the experiment from all fish available on that day. The fish available were those available the previous day minus those dying and those censored the previous day.

The non-parametric Kaplan-Meier estimator was used to estimate the survivor function F(t), which is the probability of surviving to time t, and is estimated by (Cox and Oates 1984):

$$\hat{F}(t) = \prod_{j<t} (1-\hat{h}_j); \tag{1}$$

where:

$\hat{h}j$ is the hazard function or the probability of dying at time j, and is estimated by:

$$\hat{h}_j = \frac{d_j}{r_j}; \tag{2}$$

where,

d_j = number of individuals dying at time j; and

r_j = number available or alive just before time j.

The number alive just before time j, rj, includes those individuals censored at time j. The variance for the survivor function is estimated using Greenwood's formula (Cox and Oates 1984):

$$var(\hat{F}(t)) = \hat{F}(t)^2 \sum_{j<t} \frac{d_j}{r_j(r_j-d_j)}. \tag{3}$$

The Kaplan-Meier estimator can be stratified if the assumption of random censoring is found to be violated with respect to any of the biological or fishery variables. An estimate of total mortality (M_t) due to hook and release will then be estimated for the fish in this experiment as follows:

$$M_t = \sum_{i=1}^{s} n_i \; m_i; \tag{4}$$

where:

n_i = number of fish released in stratum i, i=1,..s;

m_i = estimate of total mortality in stratum i, and,

$$m_i = (1-\hat{F}_i); \tag{5}$$

where:

$\hat{F}_i$ = final estimate of survivor function, i.e. after 5 days.

The variance of M_t is estimated by:

$$V(M_t) = \sum_{i=1}^{s} n_i^2 \; V(m_i); \qquad (6)$$

and the variance of the stratum mortality, $V(m_i)$, is equal to the variance of the survivor function, F_i.

Explanatory Variables:

The influence of explanatory variables on hook and release mortality can be estimated using Cox's proportional hazards regression model which is described by (Cox and Oates 1984);

$$h(t,z) = w(z;b)\; ho(t); \qquad (7)$$

where: ho(t) is a baseline hazard function, in this case the Kaplan-Meier function. The function w(z;b) is a parametric shift function of the vector of explanatory variables, z, and the parametric vector b. The shift function will adjust the baseline hazard function dependent on the effect of the explanatory variables included in the model. Typically, w(z;b) is an exponential function (Steinberg and Colla 1988) and the hazard at time t is described by:

$$h(t,z) = ho(t)\; e(z;b).$$

The survival analysis was carried out using the SURVIVAL module of SYSTAT (Steinberg and Colla 1988).

RESULTS

A total of 100 chinook salmon were radio-tagged and released in the lower Kenai River from 5 July through 1 August 1988. The variables recorded for each fish caught are presented in Appendices A1 and A2. Eighty-six fish were volunteered by recreational anglers and 14 fish were captured by ADF&G personnel. The number of fish tagged per day ranged from 1 to 8 and averaged 5. All fish were caught between rkm 16.1 and 20.9 (rm 10 to 13) and released between rkm 14.5 and 19.3 (rm 9 to 12). Water temperature, recorded each fishing day, ranged from 8.3^o C to 15^o C and averaged 12^o C.

Radio-tagged fish ranged in length from 540 mm to 1,160 mm and averaged 919 mm. The male to female ratio was 1:1.3. Both the longest and shortest fish in our sample were males, however the average length of females (1,003 mm) was longer than that for males (854 mm). The length frequency distribution of radio-tagged fish was bimodal with length modes separated at 750 mm (Figure 5). The 14 fish taken by ADF&G personnel (mean length = 963 mm, 95% CI = 864-1,062 mm) were not significantly larger than the volunteer sample of tagged fish (919 mm, 95% CI = 882-955 mm) ($D=0.21$, $P=0.57$).

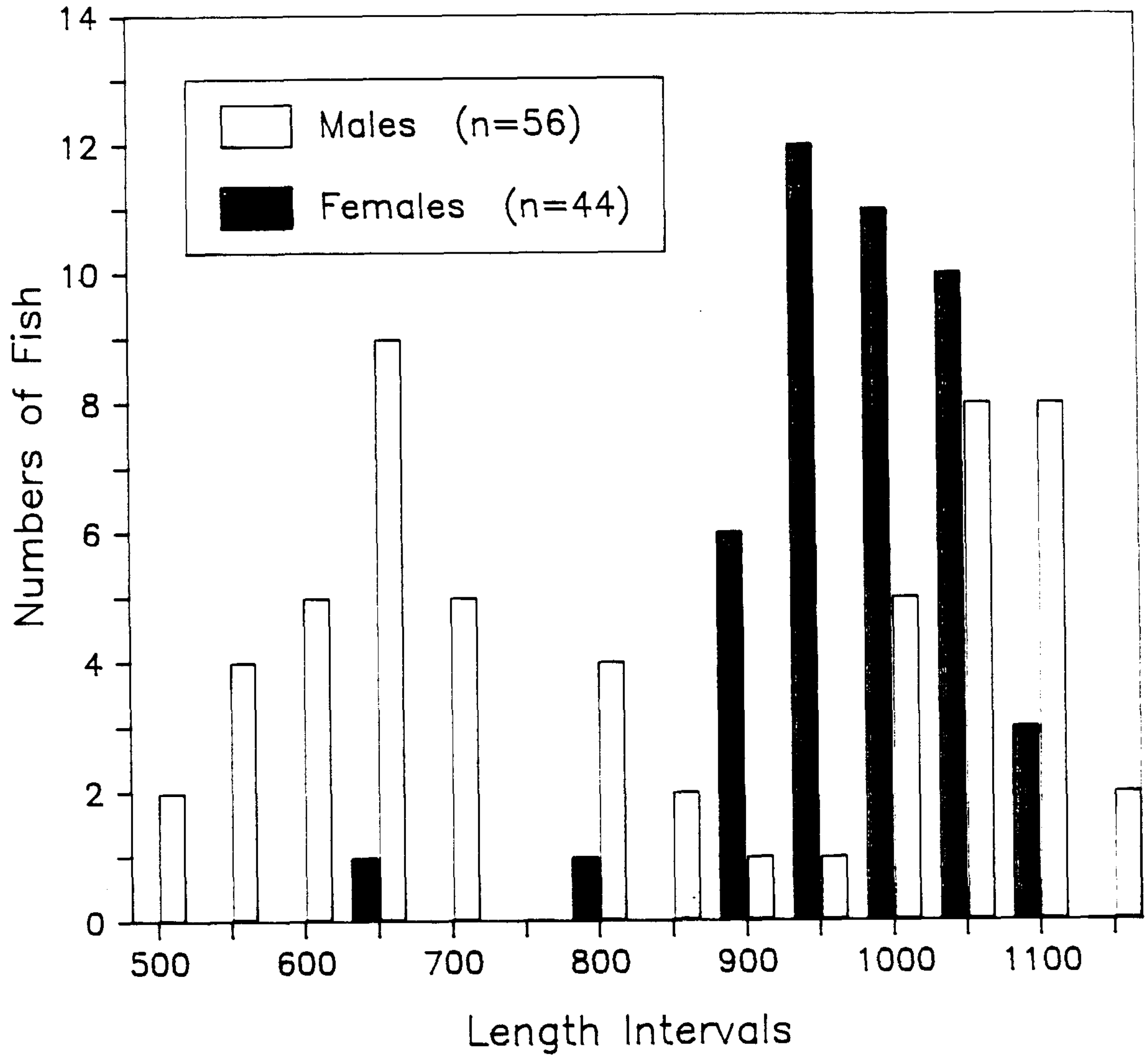

Figure 5. Length frequency distribution for 100 radio-tagged chinook salmon captured in the Kenai River late run recreational fishery during 1989.

Ninety-two of our fish were caught by drifting, while the remaining 8 were caught by back-trolling. Eighty-five chinook salmon were caught using a combination of bait and lure (primarily spin-n-glows and salmon eggs) and 15 were caught using unbaited artificial lures. No fish in our sample were caught on bait exclusively. Terminal gear with two hooks was responsible for capturing 99 of our sample fish with the one remaining fish caught using one-hook gear. Ninety-five fish were caught using single hooks and 6 were captured using treble hooks. The hooks were removed from 97 of our fish.

The duration of time fish were played (until put in the landing net) ranged from 37 seconds to 3,764 seconds (62 minutes) with a median time of 300 seconds (5 minutes). The tagging time (from netting until release) ranged from 184 seconds to 631 seconds with a median time of 300 seconds (5 minutes). Total cumulative handling time ranged up to 4,043 seconds (1.1 hour) with a median of 650 seconds and mean of 808 seconds.

Twelve anatomical classifications were used to define hooking injury locations. Hooking frequency was highest in the corner of the mouth (41%) followed by body snags (22%) and the lower jaw (13%). Sixty-four percent of all fish were hooked in one of 5 jaw locations, while 27% were snagged in either the head or body and 9% were hooked in the gills, eye, or tongue (Figure 6).

The presence of sea lice was noted on 79 fish. Thirteen fish were scarred from gill nets, 1 fish was spaghetti tagged in an unrelated Kenai River study, and 1 fish was carrying tackle from a previous hooking event. Ninety-two of 100 fish were judged to be vigorous upon release by the tagging crew.

<u>Five-day and Ultimate Fates</u>

There were 63 survivors at the end of 5 days and 9 mortalities which included 1 best-case and 8 worst-case classifications (Table 3). Twenty-eight fish were captured in a fishery within the first 5 days. Thirteen (46%) of these fish were removed in the recreational fishery followed by fish caught in the tag net, set net, and education net fisheries. Only one fish was unaccounted for at the end of 5 days.

The carcass of one hook and release mortality was recovered within 5 days of release resulting in a best-case (rule 2) classification. The "best-case" estimate of mortality was therefore 1 out of 63. Deaths of the remaining 8 mortalities were worst-case classifications defined by rules 4 and 5. Four of the worst-case mortalities made no upstream progress after release. The remaining four mortalities traveled an average of only 2.8 km (1.75 mi) above their respective release sites and only one fish traveled above rkm 19.3 (rm 12). No single variable stood out as a variable for the nine chinook salmon classified as hook and release mortalities (Table 4).

Nine classifications were used to describe ultimate fates. At the conclusion of the study, there were 40 spawners, 9 additional sport harvested fish, 3 additional set net fish and 1 additional tag net fish. Seven fish returned to Cook Inlet and were not subsequently relocated, while contact with three tagged fish in the vicinity of Skilak Lake was lost.

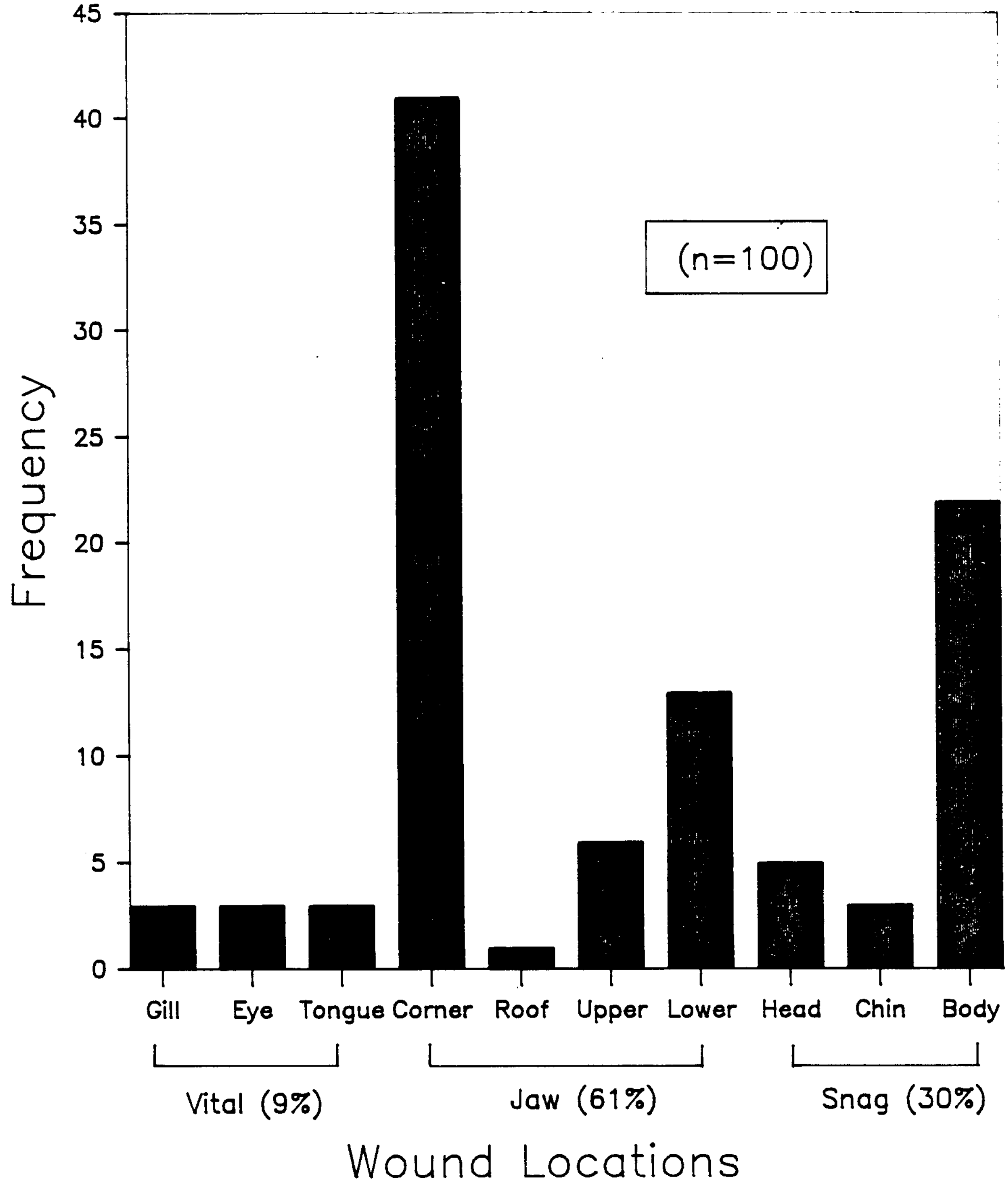

Figure 6. Distribution of hook injury locations from a sample of 100 chinook salmon captured in the Kenai River recreational fishery.

Table 3. Numbers of radio-tagged chinook salmon in each classification of 5-day and ultimate fates during the late run, 1989.

Five-Day Fates		Ultimate Fates	
		Spawner	40
Survivor	63	Mortality	9
Mortality	9	Sport Harvest	22
		Set Net	9
Sport Harvest	13	Tag Net	8
Set Net	6	Education Net	1
Tag Net	7	Drop Outs	7
Education Net	1	Uplost	3
Unknown	1	Unknown	1
Total	100	Total	100

Table 4. Biological and fishery variables recorded for each fish that was classified a hook and release mortality.

Variable	Fish Number 09	10	24	34	52	57	65	78	94
Date	07/07	07/07	07/11	07/13	07/20	07/20	07/22	07/26	07/29
Water Temp.(^{o}C)	10	10	11.7	12.8	14.4	14.4	13.3	12.8	12.8
Mid-eye Length (mm)	565	900	1150	1130	650	570	665	965	705
Sex	M	M	M	M	M	M	F	F	M
Fishing Method	Drift	Drift	Drift	Drift	Drift	Drift	Drift	Drift	Drift
Terminal Gear	Comb.[a]	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.
Angling Time (sec)	120	271	930	300	240	300	600	600	467
Tagging Time (sec)	414	560	340	249	366	414	215	405	330
No. Hooks	2	2	2	2	2	2	2	2	2
Hook Type	Single	Single	Single	Single	Single	Single	Single	Single	Single
Wound Location	Gill	Gill	Snag	Corner	Chin	Corner	Lower	Gill	Corner
Bleeding	No	Yes	No	No	No	No	Yes	Yes	No
Sea Lice	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Condition	Vig.[b]	Vig.	Vig.	Vig.	Vig.	Vig.	Vig.	Leth.[c]	Vig.

[a] Comb. = combined

[b] Vig. = vigorous

[c] Leth. = lethargic

Associations Between Fate and Biological Characteristics

Of the total 100 fish tagged and released, 56 were male and 44 were female. Nine fish were classified as mortalities, and of these, 7 were males and 2 were females (Table 5). The sample was divided into two length groups, above and below 750 mm, based on length frequencies (Figure 5). Of 26 small fish only 1 was female, while of 74 large fish 43 were female.

Females were significantly (P=0.001) larger than males (Figure 7). The tagged fish harvested in the sport fishery were not larger than the released population (P=0.11), although the sample sizes for the test were small (22 fish harvested). The length frequencies of fish taken in the other fisheries, set net and tag net, were not significantly different from the total sample; again the sample sizes were small. The length frequency of mortalities was not significantly different from that of the total sample (P=0.32).

Loglinear analysis was used to test the null hypothesis of independence between sex, length, and fate, where fate included the categories of survivor, censored individual, or mortality. The null hypothesis of independence was rejected for 5-day fates, and the final model chosen for this data set included significant interactions between sex and length and sex and fate (Table 6). Thus, length and fate were independent; in fact, small and large males suffered similar rates of censoring and mortality (Table 5), but sex and fate were not independent, significantly more males died than females. Overall, within the first 5 days after release, males suffered a 14% censoring rate, while females suffered a 45% censoring rate. A similar analysis on ultimate fates gave different results, in that no association was found between sex and fate, 43% of the males and 59% of the females were censored (Tables 3 and 5).

The difference in the results for 5-day and ultimate fates is due to differing censoring rates. Of the 22 fish that were ultimately taken in the sport harvest 10 were males and 12 were females, which is not a significant difference in overall harvest rates between sexes (Table 7). However, in the first 5 days after their release only 2 males were harvested of 10 total, but 11 of the 12 harvested females were taken within 5 days of release (Table 7). This difference in harvest rates between males and females was very significant (P<0.001). A similar comparison between sexes taken in the tag and set net fisheries before and after 5 days was not significant (P=0.8). So the sport harvest rate alone accounts for the difference in censoring rates between the sexes over time. While males had a higher hook and release mortality within 5 days of catch and release, females were removed in the sport fishery at a significantly higher rate over the same period. And, when all types of censoring are combined, more females were removed over the entire period of the experiment (P=0.1).

Associations Between Size, Sex, and Fishery Variables

In most cases, the fishery variables were independent of sex and length (Table 8), with the exception of handling time (P=0.005) and bleeding (P=0.06). Large fish were more likely to require a longer time to land and tag than small fish (Table 9) and in this regard, large males were more

Table 5. Fates of Kenai River chinook salmon by sex and size, 1989.

Sex and Fate		Survivor	Censor	Mortality	Total
Five day fates					
Male	Small	17	4	4	25
	Large	24	4	3	31
Female	Small	0	0	1	1
	Large	22	20	1	43
Ultimate fates					
Male	Small	11	10	4	25
	Large	14	14	3	31
Female	Small	0	0	1	1
	Large	15	24	1	43

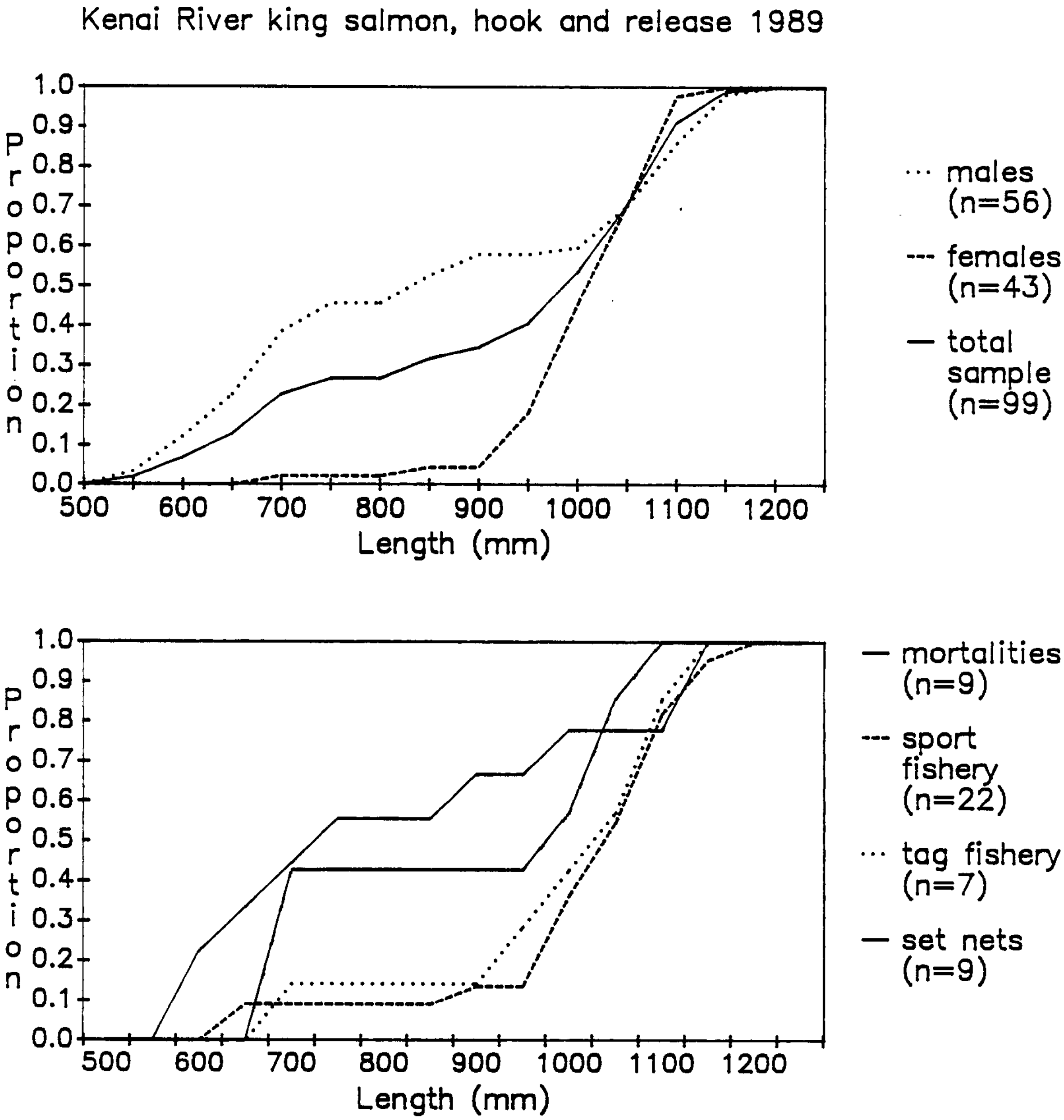

Figure 7. Cumulative length frequencies for Kenai River chinook salmon tagged in the hook and release experiment, 1989.

Table 6. Results of loglinear analysis of hook and release data for Kenai River chinook salmon, with sex, size, and fates as variables, 1989.

Hypothesis	df	χ^2	P-value
Five-day fates			
Independence	7	47.1	<0.001
All variables associated	2	4.8	0.09
Association between size and sex and sex and fate	4	7.0	0.13
Ultimate fate			
Independence between sex, length and fate[a]	6	6.5	0.37

[a] Sex and length interaction included to control for sample sizes.

Table 7. Censoring patterns for Kenai River chinook salmon, 1989.

a: Chinook salmon taken in fisheries within and after five days of release;

	Within 5 days	After 5 days	Total
Sport fishery			
Males	2	8	10
Females	11	1	12
Total	13	9	22
	$\chi^2 = 11.60$	P-value < 0.001	
Tag or set net fishery			
Males	6	2	8
Females	8	2	10
Total	14	4	18
	$\chi^2 = 0.06$	P-value = 0.80	

b: Censoring by sex over whole experiment, 1989.

	Censored	Not censored
Male	18	39
Female	22	23
	$\chi^2 = 2.73$	P-value = 0.10

Table 8. Tests for association between sex, size, and other variables measured in the Kenai River chinook salmon hook and release study, 1989.

H_0: No association between factor and sex or length[a]

Factor	df	χ^2	P-value
Hook location	6	7.92	0.240
Bait type	3	0.73	0.870
Condition	3	1.42	0.700
Handling time	2	12.7	0.005
Bleeding	3	7.3	0.060

[a] Sex-length interaction included in all models to control for sample sizes.

Table 9. Contingency table for sex and size with handling time and bleeding by 5-day fate for Kenai River chinook salmon, 1989.

H_o: Sex and size are independent of handling time and bleeding.

			Number of Fish			
Sex	Length	Handling time	Survives	Censored	Mortality	Total
Males	Small	<10 min	13	3	1	17
		>10 min	4	1	3	8
	Large	<10 min	5	1	1	7
		>10 min	19	3	2	24
Females	Small	<10 min	0	0	1	1
		>10 min	0	0	0	0
	Large	<10 min	12	4	0	16
		>10 min	10	15	1	25
		Bleeding	Survives	Censored	Mortality	Total
Males	Small	Y	4	0	0	4
		N	13	4	5	22
	Large	Y	0	0	1	1
		N	24	4	2	30
Females	Small	Y	0	0	1	1
		N	-	-	-	-
	Large	Y	4	0	1	5
		N	18	19	0	37

similar to large females than to small males. Of 26 small fish, 68% were handled for less than 10 minutes, but of 74 large fish only 24, or 32%, were handled less than 10 minutes (Table 9). Bleeding was found to be significant and fewer large males were bleeding when tagged and released (3%) than small males (18%), but 16% of the females released were bleeding (Table 9).

Associations Between Fishery Variables and Fate

Sample sizes were not large enough to test the hypothesis that fate was independent of the fishery variables using a loglinear model which included all of the variables. Therefore, initially the association of the fishery variables and the 5-day and ultimate fates was tested separately for each variable using a chi-square test for two dimensional tables. Fate was again defined as survival (past 5 days or to spawning), fish censored, and hook and release mortality. With the exception of hook location and bleeding, the chi-square tests were not significant (Table 10). Hook location was important in that all three gilled fish died. There were 11 fish bleeding at release, none were censored, i.e. taken in a fishery during the rest of the experiment, but 3 died. These two variables and handling time and condition at release, which had P-values less than 0.2 (Table 9) were included in a loglinear analysis of the association between fishery variables and fate and to test for interactions among all of these variables.

As fate was not independent of sex, the data were stratified by sex prior to testing for association between fishery variables and the fate of the fish. The model used to test the hypothesis of independence between the fishery variables and fate included interaction between handling time and bleeding with length for males. This model, which did not include any interactions between fate and the fishery variables, was not rejected for females or for males (Table 11).

Survival Analysis

Censoring:

The significant differences in fates between males and females (Table 6) necessitated that the data be stratified by sex for the purpose of estimating the survivor function. The reason for this difference in the rate of sport harvest between the sexes was the difference in censoring between the sexes, more particularly the difference in the pattern of harvest in the sport fishery. This difference was examined using survival analysis through estimation of the survivor function for the tagged population in the sport fishery. In this case, removal in the sport harvest constitutes the failure event for the individuals, removal in any other fishery, or due to hook and release mortality is now defined as censoring. The survivor functions (Figure 8) estimated for males and females are significantly different (χ^2=4.25, df=1, P=0.04). In the first 5 days after release, 58% of the females released had survived the sport fishery, while 84% of the males survived. Females were removed in the harvest at a much faster rate initially, although 20 days after release this difference had largely disappeared (Figure 8).

Table 10. Results of chi-square tests for two-way contingency tables of fishery variables versus fates for Kenai River chinook salmon, 1989.

Variable	Five-day fates			Ultimate fates		
	χ^2	df	P-value	χ^2	df	P-value
Handling time	3.4	2	0.19	4.2	2	0.12
Bait type	1.9	2	0.39	3.7	2	0.15
Hook placement	33.9	4	<0.001	32.2	4	<0.001
Bleeding	8.2	2	0.02	6.0	2	0.05
Condition	3.9	2	0.14	3.5	2	0.17
Number of hooks	0.6	2	0.74	1.0	2	0.62
Presence of lice	0.2	2	0.90	0.2	2	0.92

Table 11. Results for test of independence between fishery variables and fate by sex for Kenai River chinook salmon, 1989.

H_o: There is no association between 5-day fate and fishery variables.

Sex	df	χ^2	P-value
Males	133	60.9	1.00
Females	41	55.9	0.75

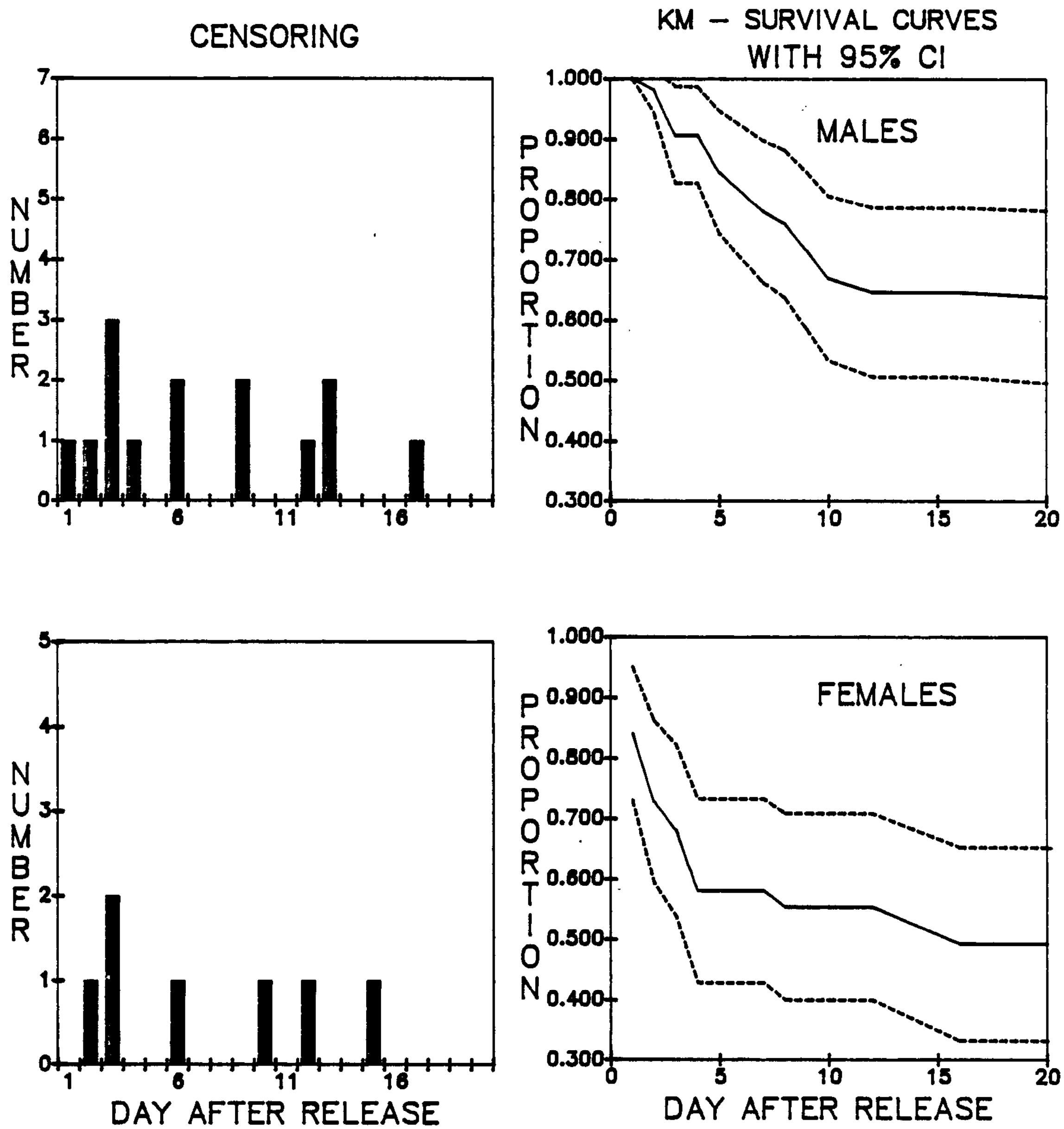

Figure 8. Distribution of censoring and Kaplan-Meier survival curves for sport harvested chinook salmon by sex, 1989.

Hook and Release Mortality:

Hook and release mortality was estimated using survival analysis with survivor functions estimated for the first 5 days after release. The distribution of censoring over the first 5 days of the experiment (Figure 9), shows the difference between males and females. The overall percent surviving was estimated to be 93% (95% CI = 84-100%) for females, while males had an estimated survival rate of 87% (95% CI = 78-96%). Two females died, both on the third day after release. Seven males died, 5 by the third day after release, and one on each subsequent day (Figure 9).

Although the comparison of these two survival estimates using a log-rank test (Cox and Oakes 1984) was not significant (χ^2=.86, df=1, P=.35), the data must be stratified due to the significantly different censoring pattern. Survival curves were estimated for small (total survival=83%) and large (total survival=90%) males (Figure 9), but these were not significant (χ^2=.40, df=1, P=0.53).

No explanatory variable was found to be significant when Cox's proportional hazard model was used, similar to the results obtained with the loglinear analysis. Sample sizes were too small to allow detection of any effects these variables may have on survival.

Thus the "best-case" estimate of the number of hook and release mortalities for 100 fish released was 1 out of 63 or 1.6 fish out of 100 released. The number expected to die in the "worst-case" scenario due to hook and release was estimated using the stratified estimates of mortalities. This estimation resulted in a total of 7.3 males (13% of 56 males released) and 3.1 females (7% of 44 females released) or a total of 10.4 out of 100 fish released.

Movement Behavior of Tagged Fish

Chinook salmon moved both upstream and downstream after tagging and release. A total of 93 fish were initially relocated within 48 hours of release. During this period, 12 fish (13%) were relocated within 0.5 km of their point of release, while 41 fish (44%) moved downstream and 40 fish (43%) moved upstream. Upstream migrants traveled a mean distance of 7.6 km during the initial relocation period and downstream migrants averaged 5.5 km. The maximum distance traveled by a radio-tagged fish during the first 24 hours was 21.4 km. The maximum distance traveled upstream during any 24 hour period was 33.8 km, while the maximum downstream distance was 37 km. Fish tagged during the first half of July exhibited a greater tendency to move downstream initially than those tagged during the latter half of the month. Only 40% of our sample was tagged during 5-14 July, yet these fish accounted for 65% of the initial downstream migrants. A chi-square contingency table analysis (Table 12) indicated that the direction of movement prior to initial relocation was not independent of bimonthly intervals of tagging (χ^2 = 19.051, df = 2, P < 0.005).

The number of days from release until the first record at the upper DCC (rkm 30.6) was calculated for each tagged fish to describe movement rates

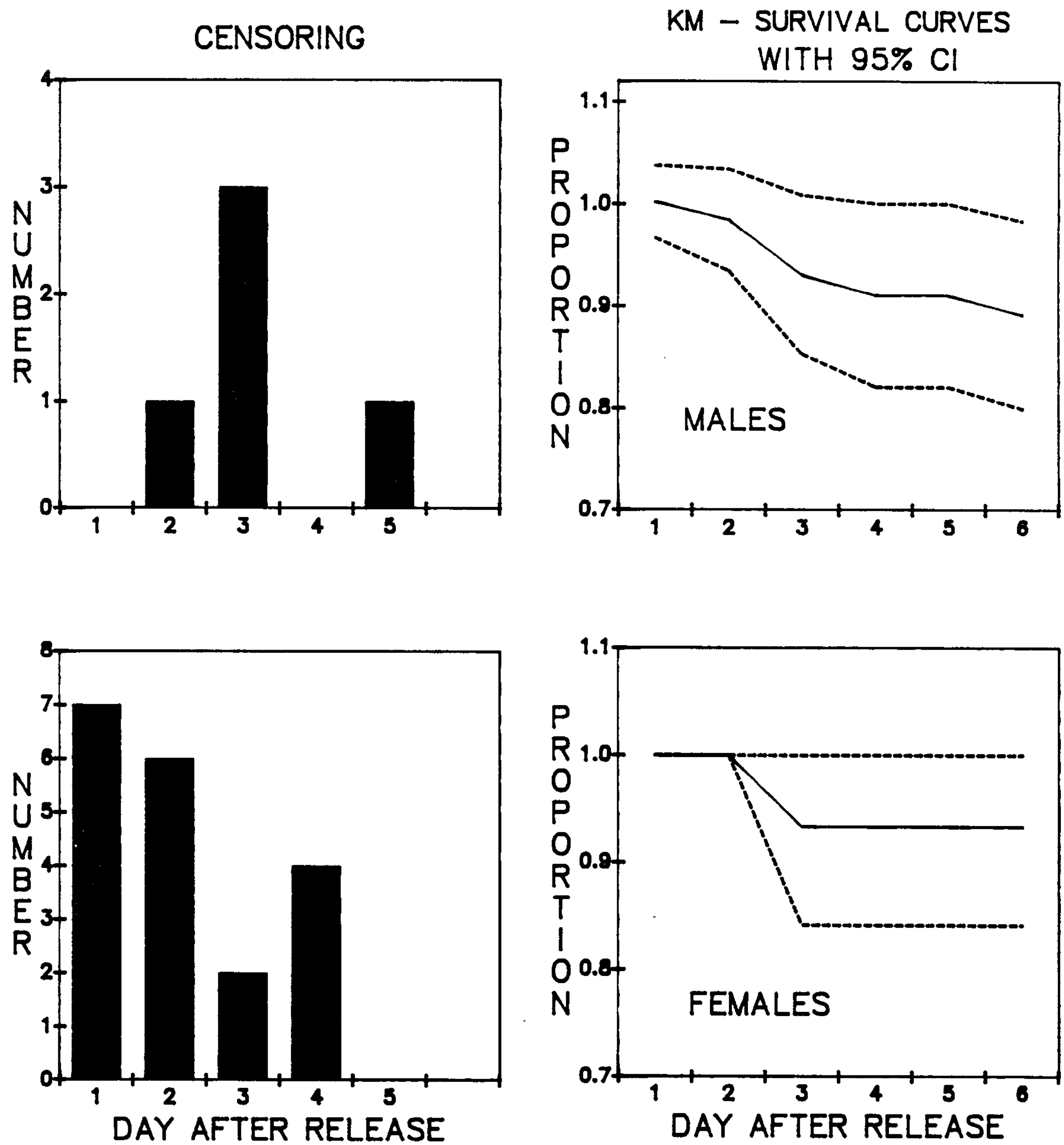

Figure 9. Distribution of chinook salmon censoring and Kaplan-Meier survival curves for 5-day mortalities by sex, 1989.

Table 12. Direction of movement upon initial relocation for 93 radio-tagged chinook salmon during bimonthly intervals, 1989.

H_o: Direction of movement is independent of bimonthly tagging intervals.

Interval	Direction of Movement			Total
	Down	Same	Up	
05 July to 14 July	27	3	8	38
15 July to 01 Aug.	14	9	32	55
Total	41	12	40	93

$\chi^2 = 19.051$ P-value < 0.005

through the lower river sport fishery. Data were available for 18 males and 19 females. The mean upstream distance traveled for all fish between the point of release and the DCC was 14.6 km. The duration of time required to travel this distance ranged from 0.9 days to 34.3 days with a median of 5.1 and an average of 6.9 days. Seventy-five percent of these 37 fish exited the fishery within 10 days of release (Figure 10). Females took slightly longer than males to exit the fishery with median times of 5.1 and 4.9 days, respectively.

Movement of tagged fish past the upper DCC occurred predominantly during the second half of the day. Seventy-eight percent of the tagged fish passed the upper DCC between the hours of 12 noon and 12 midnight. Forty-six percent of these fish passed between the hours of 6:00 p.m. and midnight, while only 3% were recorded between midnight and 6:00 a.m. (Figure 11).

Spawning Destinations

A total of 40 out of 100 radio-tagged fish were ultimately classified as spawners. The sample of spawning fish was comprised of 15 females and 25 males that ranged in length from 560 mm to 1,130 mm and averaged 910 mm. The mean handling time for this group was 775 seconds (12.9 minutes). Thirty-two fish (80%) in this group had sea lice when tagged, and 39 (98%) were judged to be vigorous upon release.

The date and location of spawning for each fish was estimated using daily movement histories and radio signal modes. We assumed that spawning took place at the maximum upstream distance penetrated by each fish where holding behavior was noted and that completion of spawning coincided with the onset of consecutive radio signals in the mortality mode. Using these criteria, the mean and median number of elapsed days between the release of each fish and the completion of spawning was 30.4 and 30.5 respectively (range = 14 to 53 days). Males were at large an average of 29 days while females averaged 33 days. Spawners tagged during the first half of July were at-large an average of 35 days, while those tagged during the remainder of July survived an average of 27 days. We inferred that spawning took place in the mainstem between the upper intertidal reach (rkm 19.3) and the confluence of the Russian River (rkm 122.3). The termination of spawning activity, evidenced by consecutive mortality signals or downstream movement from upper destinations, was first noted on 4 August and continued through 11 September with peak frequencies occurring in the second half of August.

Mainstem destinations were selected for spawning by 39 out of 40 fish. The remaining fish spawned near the confluence of Skilak Glacier Creek and Skilak Lake. Fifteen fish (38%) spawned in the middle river reach, followed by 11 (28%) in the lower reach, 7 (18%) in the interlake reach, and 6 (15%) in the upper reach (Figure 12). A chi-square contingency table analysis indicated that distributions of spawners among the four mainstem river reach classifications were independent of weekly tagging intervals ($\chi^2 = 6.955$, df = 9, $P > 0.10$).

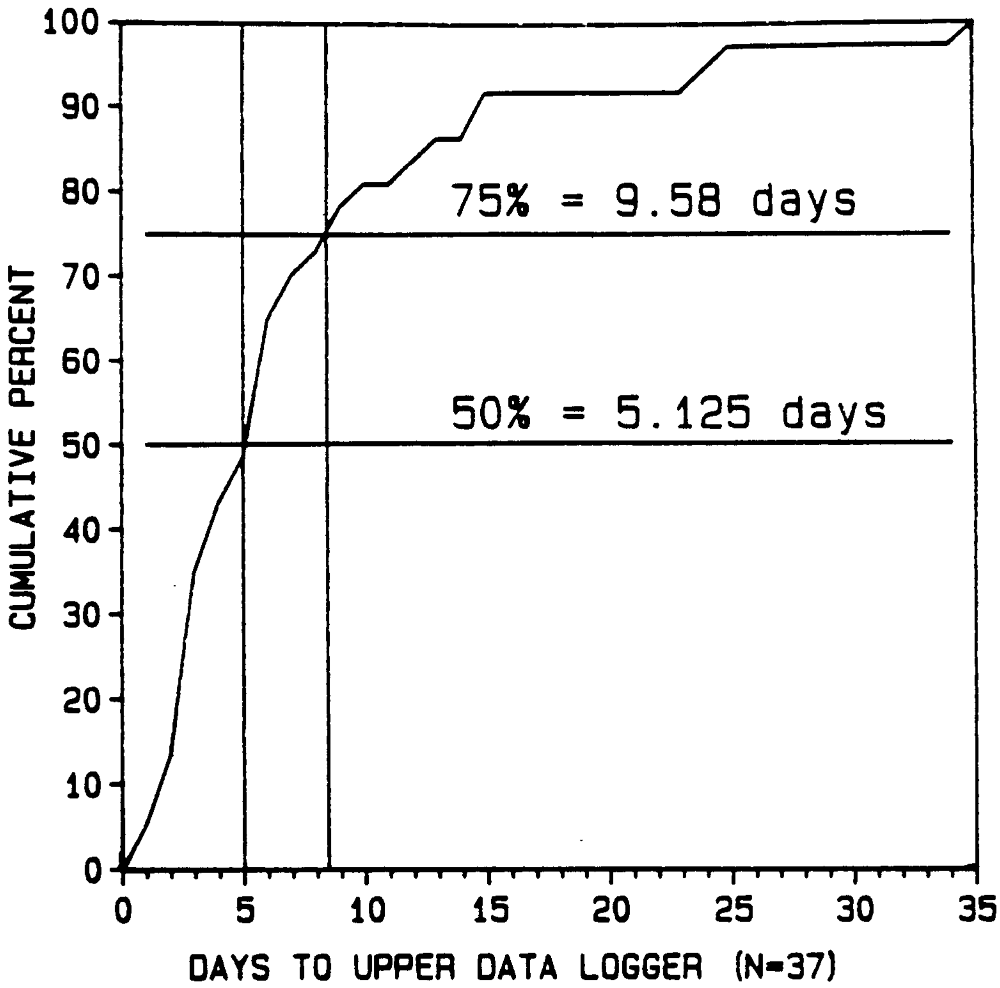

Figure 10. Duration of time for radio-tagged chinook salmon to exit the sport fishery from point of release to the upper data collection computer located at river kilometer 30.6 (river mile 19).

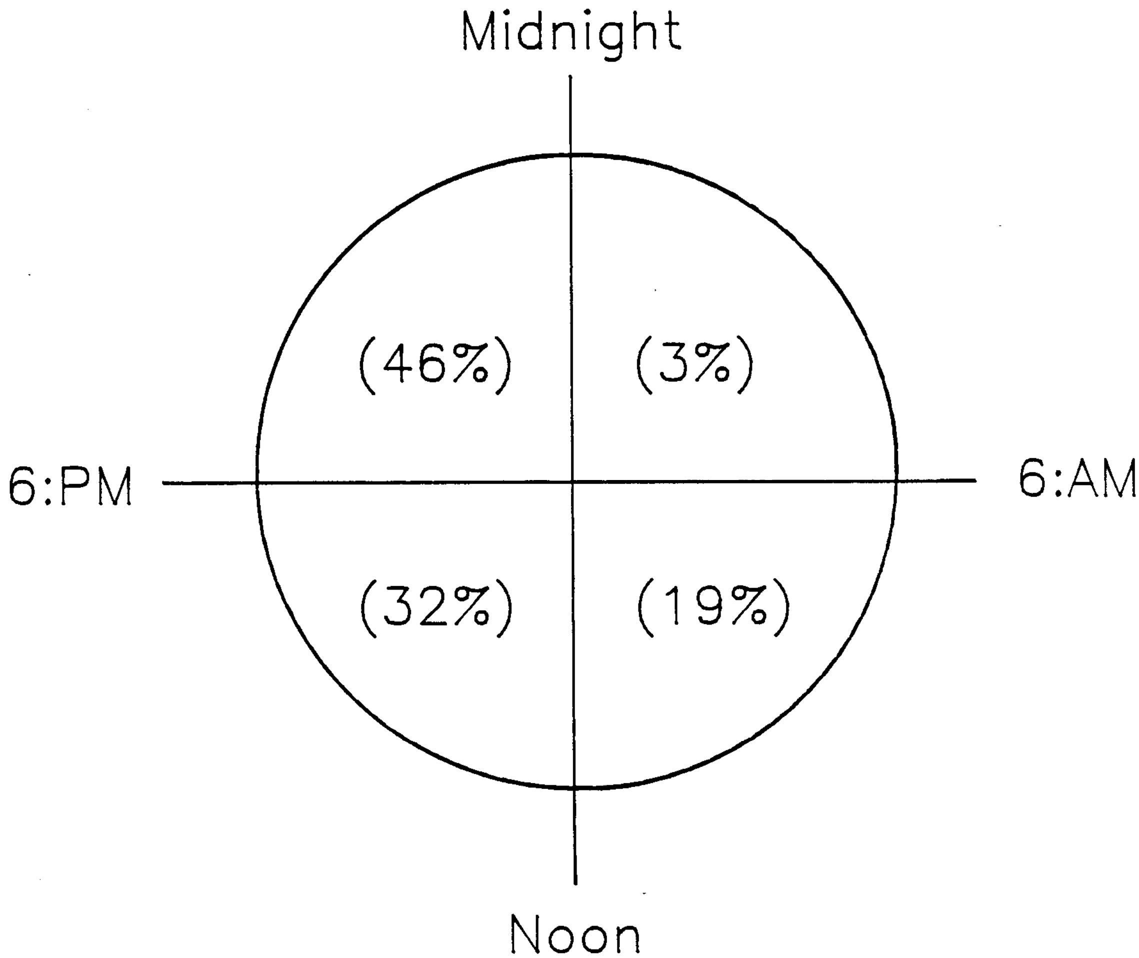

Figure 11. The proportions of radio-tagged chinook salmon moving during quarter-day intervals based on the times of initial contact at the upper data collection computer.

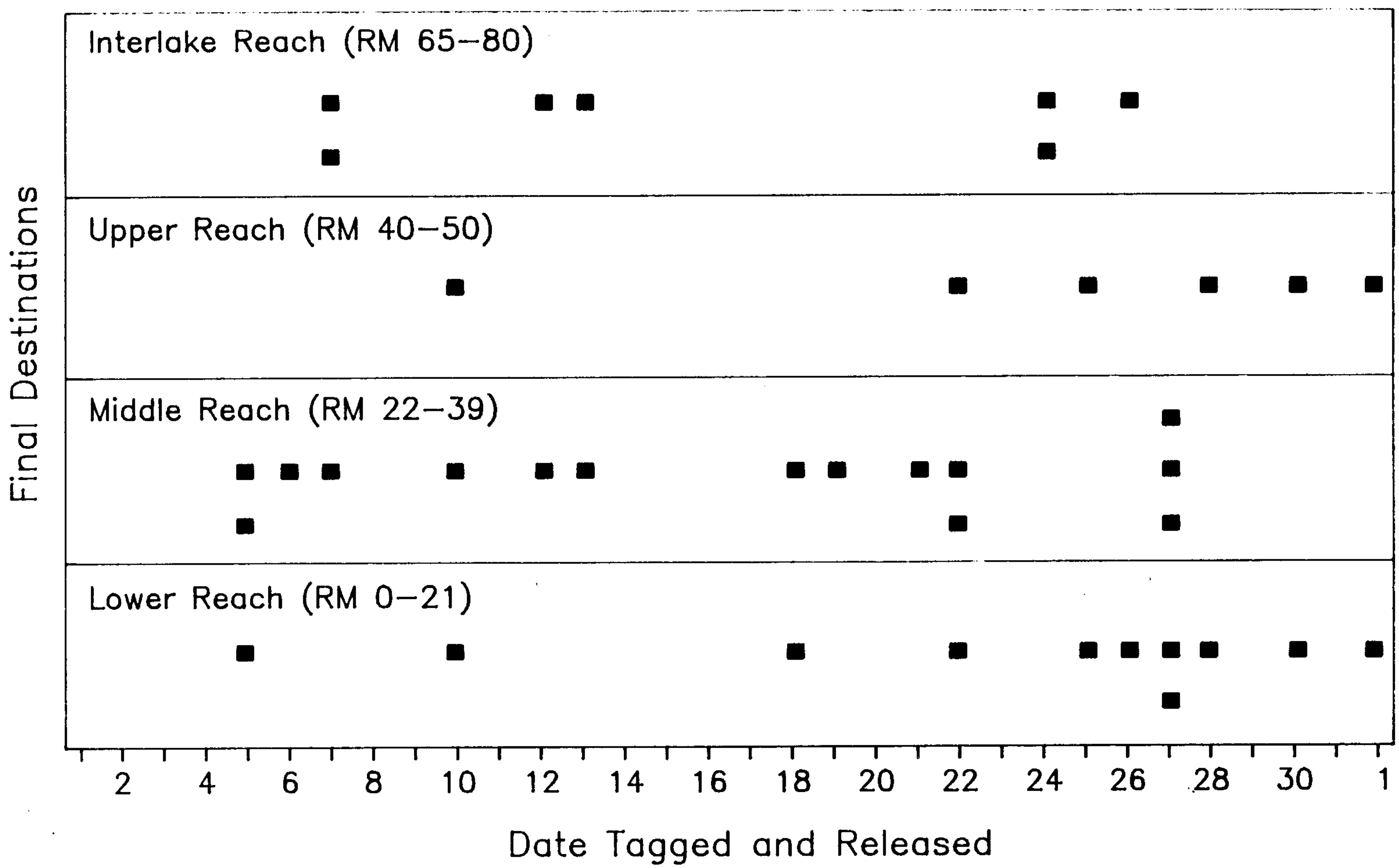

Figure 12. Tagging dates and spawning destinations for 39 radio-tagged chinook salmon in the Kenai River.

Exposure to the Recreational Fishery

All of the chinook salmon used in this study were hooked and released at least once, and 22 of these fish (the sport harvested component) were angled at least twice. We confirmed additional hook and release events for 7 fish. One of these fish had tackle in its jaw from a previous event when we caught and tagged it, and the others were caught, released, and reported to us by recreational anglers. Three of these multiple recaptures survived to spawn, while one each of the remaining fish was a sport harvest, drop-out, set net, and tag net fate. A fish that was caught and radio-tagged on 27 July had been captured by gill net and spaghetti tagged on 12 July and was carrying sport tackle from an interim hooking event. This fish was judged to have survived and spawned in the lower Kenai River during mid August.

The Cook Inlet commercial set gill net fishery for salmon opened on 1 July. On 14 July, we tagged a chinook salmon that was scarred by a previous encounter with gill nets and subsequent to that date, 13 tagged salmon (21%) had similar gill net injuries.

Thus, prior to entering our study as hooked and released fish, many salmon experienced recent angling or netting events which may have influenced their ultimate fate. It was only possible to reconstruct fishery histories based on the most obvious and gross verification (tackle, scars, wounds) of those events.

Those fish that moved past the data logger at rkm 30.6 spent on the average 5-7 days in the lower reach, which was where 16, or 73%, of the 22 sport harvested fish were caught (Figure 13). However, 28% of the survivors spawned below rkm 33.8, which is in the major sport fishery area.

DISCUSSION

Hook and Release Mortality

The hook and release mortality rates estimated in this study were significantly smaller then the 20% tolerance level established at the beginning of the study (α=0.2). The hook and release mortality rate was estimated to be 13% (±6%) for males and 7% (±6%) for females, and an estimated 10% (±8%) in total suffered hook and release mortality, assuming the worst case scenario. This estimated worst-case rate of hook and release mortality for Kenai River chinook salmon is lower than mortality rates in sport fisheries reported for many other species (Mongillo 1984, Vincent-Lang et al. In Press, Warner and Johnson 1978). Wertheimer (1988) and Loftus et al (1988) reported mortality rates of 24.5% and 20.5% for sub-legal and legal length chinook salmon captured using commercial troll gear in salt water. These rates also exceeded our worst-case estimate.

In this study, the data were stratified by sex as the mortality rates were significantly higher for males than for females. No other variables were found to have a significant effect, but sample sizes were small. There were

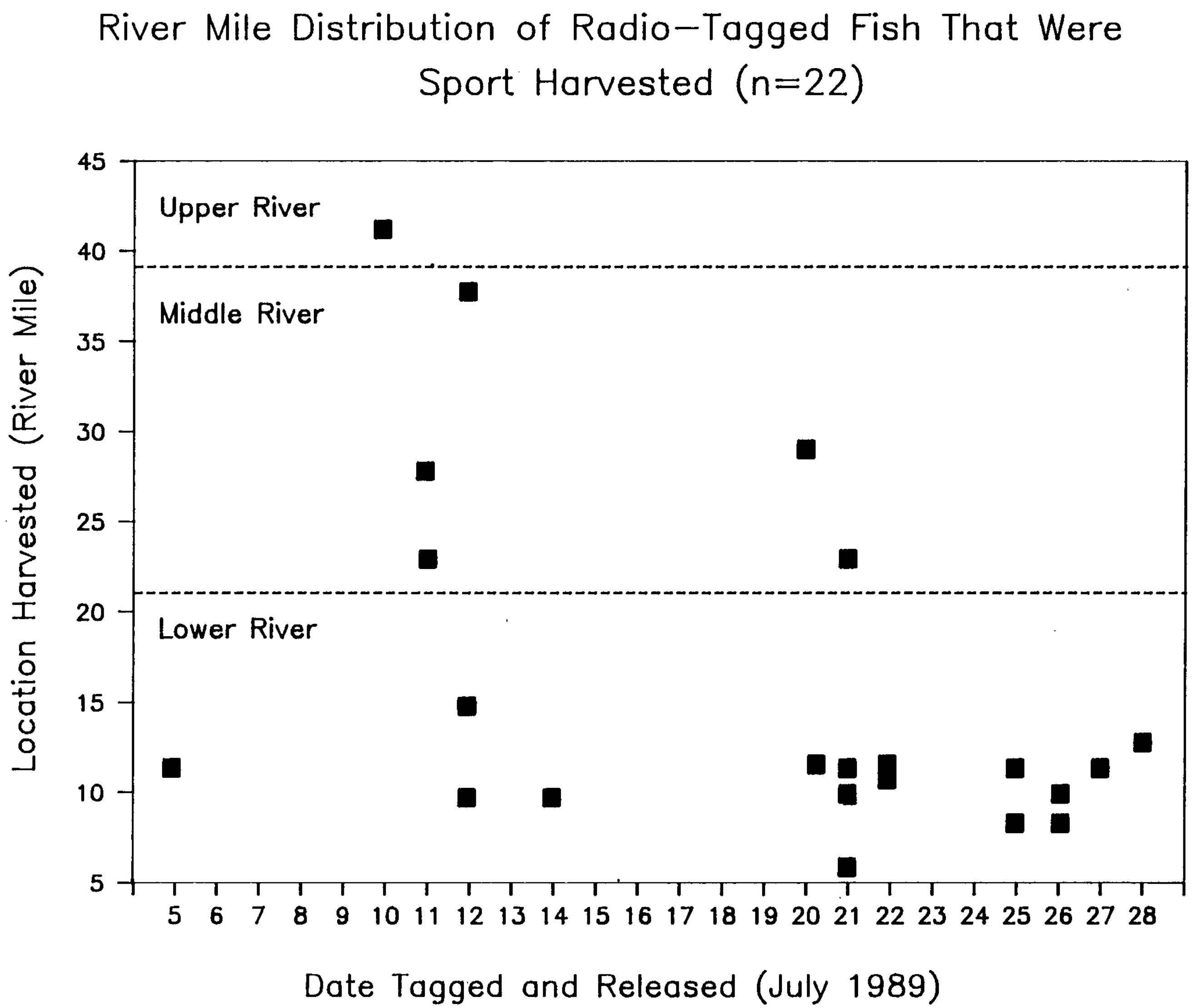

Figure 13. Distributions of sport harvested fish by location and date tagged.

indications that fish sizes, hook location, and bleeding were affecting mortality rates, but these results were not conclusive due to small sample sizes.

Since mortality results from damage to vital organs such as the gills (Wydoski 1977), our lower mortality rate may be explained by the low incidence of hook injuries to these areas in our samples. Chinook salmon, in the lower Kenai River, are typically caught by anglers fishing from drifting boats, and using two single hooks in a terminal gear that combines bait with a lure. The use of bait has been shown to significantly increase hook and release mortality (Clapp and Clark 1989, Payer et al. 1989, Shetter and Allison 1958, Stringer 1967). Warner and Johnson (1978) observed significantly higher mortality in fish that bled after hooking (86%) compared to fish that were not bleeding (15%). Vincent-Lang et al. (In Press) found that coho salmon hooked in the gills had significantly higher mortality rates compared to salmon hooked in other locations. But the methods and terminal gears used to capture chinook salmon in the Kenai River recreational fishery usually result in superficial hook wounds to the mouth, even though 85% of our sample was caught using bait. Ninety-one percent of our catch was hooked in the jaw or snagged. Six of these fish died, resulting in a mortality rate of 6.6%. Only three salmon were hooked in the gills and all of these fish died. The cessation of feeding, poor water clarity, and practice of drift-fishing with large baited lures may all contribute to the low incidence of lethal hook injuries in the Kenai River chinook salmon fishery. In addition, anglers cannot by regulation remove a fish from the water if that fish is to be released, which contributes to good handling of fish prior to release.

We estimated mortality at the end of a 5-day interval following release. Most of the mortalities (7 out of 9) had taken place within 3 days of release. Several investigators have concluded that hook and release mortality occurs within a short time period after release and that delayed mortality may be insignificant (Marnell and Hunsaker 1970, Mongillo 1984, Stringer 1967). Parker et al. (1959) observed the highest mortality rate for troll-caught salmon 2-3 hours after hooking and concluded that 97% of the mortality occurred within 6 hours.

Sample Design and Assumptions

Our survival analysis showed significant differences between males and females in their fates after release, with females being retaken in the fisheries at a faster rate, and males suffering higher hook and release mortality. The number of fish caught and released again in the sport fishery could not be estimated. This may be more frequent for males, as small fish are not generally kept and there were more small males among our tagged sample of released chinook salmon.

These results indicate that all analyses will have to be stratified by sex. The basic assumption that is necessary in all of the above analyses is that the rate of censoring (removal from the experiment) is a random process, independent of other characteristics of the sample. However, our findings indicate that censoring in the form of sport harvest is not independent of sex. The same may also be the case for size of fish, but this will not be clear until larger sample sizes have been tagged.

The extent of chinook salmon spawning locations in the mainstem Kenai River is not well documented. Thus, our assumption that little spawning takes place below rkm 19.3 may not be valid. The lowest spawning location observed by Burger et al. (1983) was at rkm 19. The tagging reach (between kilometers 16.1 and 20.9 or miles 10 and 13) is influenced by tides to the extent that velocity decreases and depth increases at high tide; however it is above the influence of salinity. High turbid water conditions during the fall of 1989 precluded our attempts to recover the carcasses of radio-tagged fish that did not penetrate above rkm 19.3. If spawning does occur below rkm 19.3, our estimate of mortality may be overestimated.

<u>Chinook Salmon Movements</u>

Initial Behavior:

Radio telemetry has been successfully used to study a variety of fish in fresh water including chinook salmon in the Kenai River (Burger et al. 1985), Columbia River (Liscom et al. 1978, Gray and Haynes 1979), and Skagit River (Granstrand and Gibson 1980). These studies collected information on movement rates and timing, habitat selection, or distribution. An implicit assumption in these studies is that the behavior of tagged fish is not significantly altered by the use and attachment of radio transmitters. We found no evidence of a consistent pattern of behavior that could be ascribed to our radio tags or handling procedures. Upon release, some tagged salmon continued upstream movements, while others moved downstream or remained in place. Six (27%) fish were caught in the sport fishery and retained on the same day they were tagged and released. Recreational and commercial fishermen that harvested radio-tagged fish indicated that these salmon were vigorous when taken, and that there were no apparent injuries associated with the tags. Gray and Haynes (1979) concluded that travel times and numbers of returning fish did not differ significantly between externally radio-tagged salmon and a control group. However, our estimate of hook and release mortality, derived from the behavior of radio-tagged salmon, is assumed to be a maximum value that includes any additional effects from handling or tagging.

The maximum upstream distance (33.8 km) traveled by a radio-tagged chinook salmon during 24 hours in this study is slightly further than that reported for migrating chinook salmon in other studies using telemetry. Maximum distances reported for 24 hour movements have ranged from 17 km on the Skagit River (Granstrand and Gibson 1980) to 29.1 km for the Kenai River (Burger et al. 1983). Burger et al. (1983) also reported that early-run chinook salmon in the Kenai River migrated at a significantly faster daily rate than late-run fish. Our observation that most diel movement of chinook salmon occurs during the evening between 1800 and 2400 hours is also supported by the findings of Burger et al. (1983).

Numerous investigations using telemetry to describe movement behaviors have shown downstream as well as upstream movements following the release of tagged fish. Fifty three (53%) of our tagged fish either remained in place or had moved downstream up to 17 km when first relocated but significantly more moved down during the first half of July compared to the latter half. This behavior may result from a weak affinity for upstream movement by fish that are not fully adapted to their freshwater environment. Similar downstream movements for tagged chinook salmon have been reported by Liscom et al. (1978) and Eiler (In Press). All of these studies except Liscom et al. (1978) captured salmon in or near the intertidal reaches of rivers where fish were first entering fresh water. The Alaska Department of Fish and Game (1983) observed in the Susitna River that the farther upstream salmon were radio-tagged, the less likely they were to exhibit downstream movement after tagging. It is possible that the motivation for salmon to maintain upstream positions increases with sexual maturation, as this response increased in the latter half of the experiment.

Dropouts:

All of the chinook salmon that were classified as drop-outs spent a minimum of 5 days at-large in the Kenai River before reverting to Cook Inlet and thus were considered survivors for the mortality estimate. These fish may have been strays from adjacent drainages, or may have been captured in Cook Inlet but unreported. Drop-out fish penetrated a maximum upstream distance of 41.8 km in the Kenai River. Burger et al. (1983) and Eiler (1989) reported both temporary and permanent reversions of radio-tagged fish to salt water. We observed both gradual and abrupt downstream movements of tagged fish following substantial upstream travel. Nine fish that we recovered from commercial gill nets in Cook Inlet spent from 2 to 25 days at large in the Kenai River before moving back to salt water. These fish had penetrated from 16.1 to 37 km upstream. Two other tagged salmon that returned to salt water re-entered the Kenai River and eventually spawned in the middle and upper reaches.

Spawning Destinations

Holding or milling behavior of radio tagged salmon was observed both en route to, and near spawning destinations. An average duration of approximately 1 month transpired between tagging and spawning, but few fish migrated directly to their respective spawning destinations during this period. Lower river spawners frequently milled for one to several weeks in the upper intertidal reach before migrating the remaining few miles to a spawning site. Several fish that did not move for up to 10 days in the lower river were subsequently sport harvested and reported to be in excellent condition. Another fish held in the vicinity of rkm 16.1 for 34 days before moving upstream to spawn near rkm 20.8. Fish that eventually spawned in the interlake reach commonly held for prolonged periods in the lower, middle, or upper river reaches. Thus, movement patterns, without additional knowledge of ultimate upstream destinations, may be poor indicators of spawning locations. Prolonged holding in a localized area before continued upstream movement has been reported by Eiler (1989) Granstrand and Gibson (1980), and Burger et al. (1983). Liscom et al. (1978) reported that tributary spawners in the Columbia River often overshoot their intended target streams then spend from 6 to 38 days milling near their confluence before entering to spawn. Similar behaviors were observed for chinook salmon spawning in tributaries to the Susitna River (Alaska Department of Fish and Game 1983). The variability we observed in movement rates for chinook salmon between the point of release and the upper DCC may be explained, in part, by the tendency of chinook salmon to hold for prolonged periods or temporarily back downstream, and because fish spawning in the vicinity of the DCC spent their entire stream life en route to that location.

Mainstem spawning destinations were selected by 39 out of 40 tagged fish. The selection of mainstem habitats (versus tributary) for late run spawning, the peak spawning time, and the lower limit for spawning that we observed are consistent with the findings of Burger et al. (1985). The majority (79%) of chinook salmon we tagged had entered the river within a few days of capture based on the presence of sea lice (Cheng 1964), yet the average elapsed time that we observed between tagging and spawning (30 days) was considerably shorter than the 52 day interval reported for chinook salmon in the Skagit River (Granstrand and Gibson 1980).

Only one of 149 chinook salmon that were radio tagged during the late run in the Kenai River chose a tributary destination for spawning during five studies (Figure 14). The highest frequency of spawning in our study occurred in the middle reach followed by the lower reach, interlake reach, and upper reach. Hammarstrom et al. (1985) observed relatively uniform proportions of use among mainstem reaches, while Burger et al. (1983) observed the highest use in the upper reach during 1979, and the lower reach during 1980 and 1981. We do not know if homing occurs to specific mainstem spawning reaches, or if variability in use occurs in response to seasonal environmental conditions or intraspecific factors. However, the disproportionately high sport fishing harvest that occurs in the lower 32 km (Hammarstrom 1989) likely targets on lower-river spawners.

RECOMMENDATIONS

1. The mortality experiment should be repeated again for the late run, and twice for the early run of chinook salmon in the Kenai River.

2. The study design should include post-stratification of the released fish by sex due to significant differences in the results between males and females.

3. The sample sizes should be increased as resources will permit to account for this stratification.

4. The carcasses of radio-tagged fish that do not penetrate upstream of rkm 19.3 should be recovered and examined to confirm that there is no spawning in the lower river.

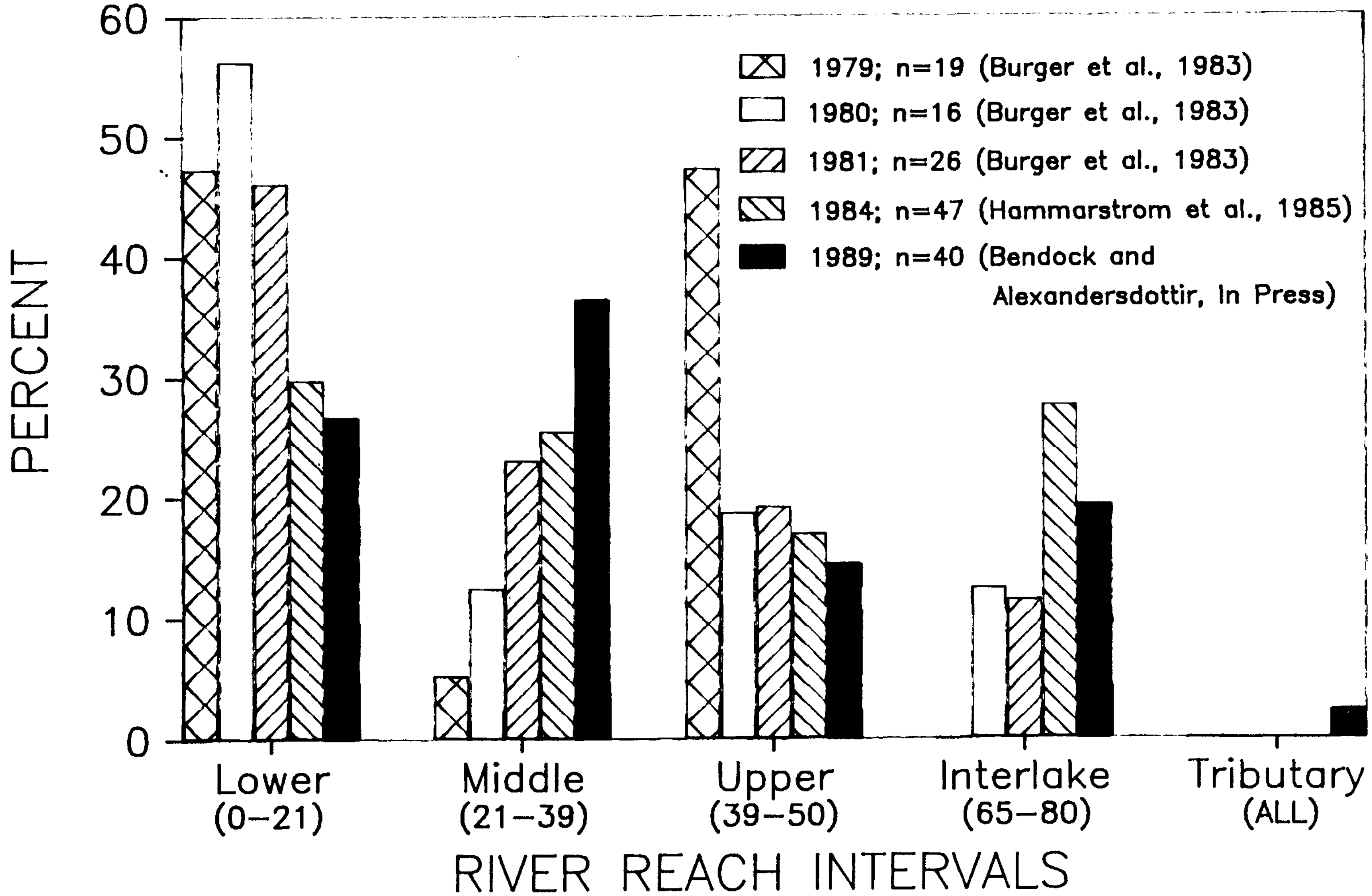

Figure 14. Spawning destinations by river reach intervals for 149 radio-tagged late run chinook salmon in the Kenai River during 1979, 1980, 1981, 1984, and in 1989.

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LITERATURE CITED

Agresti, A. 1984. Analysis of ordinal categorical data. John Wiley and Sons, Inc. New York, New York.

Alaska Department of Fish and Game. 1983. Adult anadromous fisheries studies, Phase II, Volume 2. Susitna Hydro Aquatic Studies, 2207 Spenard Road, Anchorage, Alaska, USA.

Burger, C. V., D. B. Wangaard, R. L. Wilmot, and A. N. Palmiso. 1983. Salmon investigations in the Kenai River, Alaska, 1979-1981. U.S. Fish and Wildlife Service, National Fisheries Research Center, Alaska Field Station, Anchorage, Alaska, USA. 178 pp.

Burger, C. V., R. L. Wilmot, and D. B. Wangaard. 1985. Comparison of spawning areas and times for two runs of chinook salmon (*Oncorhynchus tshawytscha*) in the Kenai River, Alaska. Can. J. Fish. Aquat. Sci. 42:693-700.

Cheng, T. 1964. The biology of animal parasites. W. B. Saunders Company, Philadelphia, PA., USA. 727 pp.

Clapp, D. F. and R. D. Clark, Jr. 1989. Hooking mortality of smallmouth bass caught on live minnows and artificial spinners. N. Am. J. Fish. Management. 9:81-85.

Cochran, W. G. 1977. Sampling techniques. John Wiley and Sons, New York, New York, USA.

Conover, W. J. 1980. Practical non-parametric statistics. John Wiley and Sons, Inc. New York, New York.

Cox, D. R. and D. Oakes. 1984. Analysis of survival data. Chapman and Hall, Ltd. New York, New York.

Eiler, J. H. In press. Use of radio telemetry for studying fish in large turbid rivers. Proceedings of the Tenth International Symposium on Biotelemetry.

Gray, R. H., and J. M. Haynes. 1979. Spawning migration of adult chinook salmon (*Oncorhynchus tshawytscha*) carrying external and internal radio transmitters. J. Fish. Res. Board Can. 36:1060-1064.

Granstrand, R. L., and J. D. Gibson. 1980. First year Skagit River spring chinook radio-tracking study. Skagit System Cooperative, LaConner, Washington, USA. 18 pp.

Hammarstrom, S. 1989. Angler effort and harvest of chinook salmon and coho salmon by the recreational fisheries in the lower Kenai River, 1988. Alaska Department of Fish and Game, Fishery Data Series No. 100. 98 pp.

Hammarstrom, S., L. Larson, M. Wenger, and J. Carlon. 1985. Kenai Peninsula chinook and coho salmon studies. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Performance Report, 1984-1985, Project F-9-17, Volume 26:60-149. Juneau, Alaska, USA.

Liscom, K. L., L. C. Stuehrenberg, and G. E. Monan. 1978. Radio tracking studies of spring chinook salmon and steelhead trout to determine specific areas of loss between Bonneville and John Day dams, 1977. Final Report. National Marine Fisheries Service, NOAA, Seattle, Washington, USA. 33 pp.

Loftus, A. J., W. Taylor, and M. Keller. 1988. An evaluation of lake trout (*Salvelinus namaycush*) hooking mortality in the upper Great Lakes. Can. J. Fish and Aquat. Sci. 45(8):1473-1479.

Marnell, L. F. and D. H. Hunsaker II. 1970. Hooking mortality of lure caught cutthroat trout (*Salmo clarki*) in relation to water temperature, fatigue and reproductive maturity of released fish. Trans. Am. Fish. Soc. 99 (4):684-686.

Mongillo, P. E. 1984. A summary of salmonid hooking mortality. Fish Management Division, Washington Department of Game. Olympia, Washington. 46 pp.

Nelson, D. 1990. Kenai Peninsula management report, 1989. Alaska Department of Fish and Game, Sport Fish Division, Soldotna, Alaska 99669. 180 pp.

Parker, R. R., E. C. Black and P. A. Larkin. 1959. Fatigue and mortality in troll-caught Pacific salmon (*Oncorhynchus*). J. Fish. Res. Bd. Canada, 16 (4):429-448.

Payer, R. D., R. B. Pierce, and D. L. Pereira. 1989. Hooking mortality of walleyes caught on live and artificial baits. N. Am. J. Fish. Management. 9:188-192.

SAS Institute Inc. 1987. SAS/STAT guide for personal computers. Version 6 Edition. Cary, NC. SAS Institute Inc. 1028 pp.

Shetter, D. S. and L. N. Allison. 1955. Comparison of mortality between fly-hooked and worm-hooked trout in Michigan streams. Michigan Dept. Conservation, Inst. Fish Res., Misc. Publ. No. 9. Lansing, Michigan. 44 pp.

Steinberg, D. and D. Colla. 1988. SURVIVAL: A supplementary module for SYSTAT. Evanston, IL. SYSTAT, Inc. 154 pp.

Stringer, G. E. 1967. Comparative hooking mortality using three types of terminal gear on rainbow trout from Pennask Lake, British Columbia. The Canadian Fish-Cult. 39:17-21.

Vincent-Lang, D., M. Alexandersdottir, D. McBride, and K. Hepler. In Press. Mortality of coho salmon caught and released in the sport fishery in the Little Susitna River, Alaska. Submitted for publication to: N. Am. J. Fish. Management.

Warner, K. and P. R. Johnson. 1978. Mortality of landlocked Atlantic salmon (*Salmo salar*) hooked on flies and worms in a river nursery area. Trans. Am. Fish. Soc. 107(6):772-775.

Wertheimer, A. 1988. Hooking mortality of chinook salmon released by commercial trollers. N. Am. J. Fish. Management. 8:346-355.

Wydoski, R. S. 1977. Relation of hooking mortality and sublethal hooking stress to quality fishery management. In: Proceedings of a national symposium on catch and release fishing. Humboldt University, Arcata. Humboldt, California. pp. 43-97.

APPENDIX A

Appendix A1. Movements of radio-tagged chinook salmon identified via aerial flights in July 1989. (Movements of fish in August and September are in Appendix A2.)

No.	Date Tagged	RM Tagged	7/06	7/07	7/08	7/09	7/10	7/11	7/12	7/13	7/14	7/15	7/16	7/17	7/18	7/19	7/20	7/21	7/23	7/25	7/26	7/27	7/28	7/30	[Ultimate Fate]
1	7/05/89	11.0	10.5	10.5	10.5	10.5	14.5	18	16	3.5	3.5			2	2.5	3.5	3.5			3					[caught in east side set net on north beach, tag found in sand on 8/11]
2	7/05/89	11.3	9	9	10	9.5	10	10	10	11.5	12	11.5	14.5	13	13	14	12.5	13	11.5	12	12	17	14.5	19	
3	7/05/89	10.0	6.5	6.5	12.5	21	27	28	27	27	27	27	27	27	27	27	28	27	27	28	29	29	29	32	
4	7/05/89	11.0	19.5	27	27	32.5	34	38	40.5	43.5	45	46	46												[uplost - tag failure or unreported harvest?]
5	7/05/89	11.0	2.5	9.5	11.5	11.5	13	14.5	16	17	19	19	19	19	20	17	17	17	11.5	13	15	16	13		
6	7/05/89	10.5																							[harvested in sport fishery same day as tagged]
7	7/06/89	12.3		23	24	29	29	30.5	29	29	28	29.5	29	31	27	27	29	28	29	29	29	29	29	32	
8	7/07/89	10.8			7.5	13	15	17	20	20	20	20	25	25	25	25	27	27	34	36	36	37	37	37	
9	7/07/89	10.5			6.5	4	4	4	4		3	1	1	3	5	5	4	4	4						[hook-and-release mortality]
10	7/07/89	9.5			6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6	6	6								[hook-and-release mortality]
11	7/07/89	10.0			14.5	14	14	17	19	20	19	21	21	20	20	21	21	21	28	29	36	41	42	68	
12	7/07/89	9.3			6.5	13	13	14.5	17	20	20	31	31	31	27.5	27	27	28				28			
13	7/10/89	11.3						10	10.5	14.5	15	10	10	10	10	10	10	11	10	10	10	10	10	10	
14	7/10/89	9.8						6.5	4	3	8	11.5	14.5	21	18	21	23		3.5						[east side set net on 7/25/89]
15	7/10/89	9.8						6.5	6.5	18.5	18.5	17	22	23	23	25	24	26	26	26	23	24	24	24	
16	7/10/89	9.8																							[tag failure magnet left attached]
17	7/10/89	9.5						2	2		0		-0.5	6.5	9	15	18	20	24	26	26	26	26	26	
18	7/10/89	11.0						6	3.5																[caught by tagging crew at mi 6.5 on 7/12/89]
19	7/10/89	10.8						6.5																	[east side set net, mi 11 K-Beach, on 7/13/89]
20	7/10/89	10.5						9	9	24	27.5		29	37											[harvested in sport fishery mi 41 on 7/18/89]
21	7/11/89	10.3							?	?	?	?	?	?											[east side set net off K-Beach on 7/18/89]
22	7/11/89	9.8							13	17	18	27	27	27	27	27	26	27	27	27					[harvested in sport fishery at mi 26 on 7/26/89]
23	7/11/89	10.8							7	8	7	7	7	8	8										[caught by tagging crew at mi 7 on 7/20/89]
24	7/11/89	9.5							9	10	10	11.5	10	10	10	10	11	10	10	11	11	12	8.5	11.5	
25	7/11/89	9.8							5.5	3.5	5.5	14.5	17	23	24	24	18	23							[harvested in sport fishery at mi 23 on 7/22/89]
26	7/12/89	11.3								6	6	7.5	7.5	7.5											[harvested in sport fishery at mi 10 on 7/18/89]
27	7/12/89	9.8								23	36	46	47	49	49	49		49	49	49	49	49	49	58	
28	7/12/89	9.8								6.5															[east side set net off K-Beach on 7/15/89]
29	7/12/89	9.0								5	0	3													[tag net: caught and released by tag crew at mi 7 on 7/13/89, subsequently assumed to be dead at mi 3.5]
30	7/12/89	10.8								23	26	36													[harvested in sport fishery at mi 37.5 on 7/15/89]
31	7/12/89	9.5																							[harvested in sport fishery at mi 15 on 7/13/89]
32	7/12/89	9.8								5	7	0	2	23	26	27	28	28	27	28	28	30	28	27	
33	7/13/89	10.8																							[caught by tagging crew at mi 9.3 on 7/13/89]
34	7/13/89	10.5									8.5	10	9	8	8	8	8.5	8.5	8	8	78	6.5		6.5	
35	7/13/89	10.5																							[east side set net off K-Beach on 7/14/89]
36	7/13/89	10.5									9	16	17	22	23	27	28	28	32	32	36	37	31	27	
37	7/13/89	10.5									10.5														[harvested in "educational net" at mi 5 on 7/15/89]
38	7/13/89	10.0									6	8	20	23	26	26	26	26	26	26	27	27	27	28	
39	7/14/89	10.0										12.5													[caught by tagging crew at mi 8 on 7/16/89]
40	7/14/89	10.5										9.5	9.5	10	10	10	10	10							[harvested in sport fishery at mi 10 on 7/22/89]
41	7/17/89	9.8													8	7.5	7	11	4	4	4	3.3		2	[drop-out after 7/28/89]
42	7/17/89	11.0																							[unknown?? no movement data]
43	7/18/89	11.3														10	11	12	17		LDCC				[drop-out after 7/26/89]
44	7/18/89	10.8														14.5	15	13	11.5	9	11	11	11	12	
45	7/18/89	9.5														12	13	12.5	15	19	20	23	23	23	
46	7/18/89	10.8														19	27	32	41	41	41	41	42	46	
47	7/19/89	12.3															12	12	15	23	26	23	11		[drop-out after 7/28/89]
48	7/19/89	12.3																							[caught by tagging crew at mi 6.4 on 7/20/89]
49	7/19/89	9.8															5	17	24	26	26	26	26	26	
50	7/20/89	11.0																20	20						[east side set net off K-Beach on 7/24/89]

-Continued-

Appendix A1. (page 2 of 2)

River Mile Locations By Date

No.	Date Tagged	RM Tagged	7/06	7/07	7/08	7/09	7/10	7/11	7/12	7/13	7/14	7/15	7/16	7/17	7/18	7/19	7/20	7/21	7/23	7/25	7/26	7/27	7/28	7/30	[Ultimate Fate]
51	7/20/89	10.5																11.5	6.5	4	4	4	4.5	[drop-out after 7/28/89]	
52	7/20/89	10.8																11.5	10	10	10	10		[hook-and-release mortality]	
53	7/20/89	10.3																10	10	14		[drop-out after 7/25/89]			
54	7/20/89	10.5																10.5	13	22		[drop-out after 7/25/89]			
55	7/20/89	10.5																22	26	28		[harvested in sport fishery at mile 29 on 7/26/89]			
56	7/20/89	10.5																13	12	11.5	12		[harvested in sport fishery at mile 12 on 7/27/89]		
57	7/20/89	10.0																13	11	11	11	11	11	11	
58	7/21/89	11.3																	18	22	20	23	23	23	
59	7/21/89	11.0																	20	23	26	28	28	28	
60	7/21/89	11.3																[harvested in sport fishery at mi 11.3 on 7/21/89]							
61	7/21/89	11.3																	[harvested in sport fishery at mi 10 on 7/22/89]						
62	7/21/89	10.0																	9	6.5	6.5		[caught & released 7/25/89 at mi 6.5; harvested in sport fishery at mi 6 on 7/27/8		
63	7/21/89	10.8																	23	33	38	45	53	56	
64	7/22/89	10.5																	14.5	11.5	7.5	3	2	2	
65	7/22/89	10.5																	9.5						
66	7/22/89	11.0																	12	13	13	14.5	17	18	
67	7/22/89	10.5																	[harvested in sport fishery at mi 11.3 on 7/22/89]						
68	7/22/89	11.0																	14.5	6	3	2	5	4.5	
69	7/22/89	11.0																	10	8	3	3.5	7	4.5	
70	7/22/89	10.5																		[harvested in sport fishery at mi 11 on 7/24/89]					
71	7/24/89	10.0																		6.5	10	11	17	8	
72	7/24/89	9.8																		14.5	21	21	24	38	
73	7/25/89	11.0																			13	13	[harvested in sport fishery at mi 11.0 on 7/28/89]		
74	7/25/89	9.5																			11	11.5	12.5	14.5	
75	7/25/89	9.5																		[harvested in sport fishery at mi 8.5 on 7/25/89]					
76	7/25/89	11.0																			11.5	11.5	12	12	
77	7/26/89	10.0																				[harvested in sport fishery at mi 10 on 7/27/89]			
78	7/26/89	9.5																				10			
79	7/26/89	9.3																				15	15	18	
80	7/26/89	9.3																				10		17	
81	7/26/89	10.0																				13	11.5	12	
82	7/26/89	10.0																				[harvested in sport fishery at mi 8.5 on 7/27/89]			
83	7/27/89	11.0																					10.5	4.5	
84	7/27/89	10.0																					6	8	
85	7/27/89	10.8																					12	15	
86	7/27/89	10.8																					17	10	
87	7/27/89	10.5																				[harvested in sport fishery at mi 11.2 on 7/27/89]			
88	7/27/89	10.8																					9.5	22	
89	7/27/89	9.8																					12	28	
90	7/28/89	11.0																						18	
91	7/28/89	11.3																						17	
92	7/28/89	9.8																						[harvested in sport fishery at mi 13 on 7/30/89]	
93	7/28/89	9.8																						11	
94	7/29/89	10.8																						11	
95	7/29/89	9.5																						[caught & released at mi 9.25 on 7/29/89; tag net at mi 6.8 on 7/29/89]	
96	7/30/89	11.0																							
97	7/30/89	10.5																							
98	7/30/89	10.5																							
99	7/30/89	9.3																							
100	8/01/89	9.5																							
101	8/01/89	12.3																							

Appendix A2. Movements of radio-tagged chinook salmon identified via aerial flights in August and September 1989. (Movements of fish in July are in Appendix A1.)

No.	Date Tagged	RM Tagged	8/01	8/03	8/04	8/06	8/07	8/10	8/11	8/13	8/15	8/17	8/18	8/22	8/24	8/25	8/28	8/31	9/04	9/07	9/11	9/15	9/24	[Ultimate Fate]
			River Mile Locations By Date																					
1	7/05/8	11.0																						
2	7/05/8	11.3	23	14	14	14.5	14.5	20	22	23	23	13	13	13	13	13	13	12	12	12	12	12	12	[spawner middle river]
3	7/05/8	10.0	31	31	31	31	31	30	30	31	25	25	23	19	19	19	19	18	17	17	17	15	15	[spawner middle river]
4	7/05/8	11.0																						
5	7/05/8	11.0	15	16		17		8	10	10	9.5	9.5	9.5	10.5	10	10	10	10	10	9.5	9.5	9.5	9.5	[spawner lower river]
6	7/05/8	10.5																						
7	7/06/8	12.3	30	29	30	31	31	31	31	31	31	31	31	31	31	31	31	28	28	28	28	28	28	[spawner middle river]
8	7/07/8	10.8	36	37	37	37	37	37	36	36	37	37	37	37	37	37	37	37	37	37	37	36	36	[spawner middle river]
9	7/07/8	10.5																						
10	7/07/8	9.5																						
11	7/07/8	10.0	70	72	72	72		74		73	70	70	70	70		70	70	70	70	68	68	68	68	[spawner interlake reach]
12	7/07/8	9.3			47			69				74	[spawner interlake reach]											
13	7/10/8	11.3	10								13	13	13	12	12	12	12	12	12	12	12	12	12	[spawner lower river]
14	7/10/8	9.8																						
15	7/10/8	9.8	24	24	25	25	25	22	22	21	21	21	21	21	21	21	21	21	21	21	21	21	21	[spawner middle river]
16	7/10/8	9.8																						
17	7/10/8	9.5	26	28	28	28	44	47	47	48	48	47	48	48	48	48	47	47	47	48	48	48	48	[spawner upper river]
18	7/10/8	11.0																						
19	7/10/8	10.8																						
20	7/10/8	10.5																						
21	7/11/8	10.3																						
22	7/11/8	9.8																						
23	7/11/8	10.8																						
24	7/11/8	9.5	9	9	9	9	9	9	9	9	9	9	9	9	[hook-and-release mortality]									
25	7/11/8	9.8																						
26	7/12/8	11.3																						
27	7/12/8	9.8	58	63	65	67		74		74	74	74	74	74		73	71	71	74	74	74	72	72	[spawner interlake reach]
28	7/12/8	9.8																						
29	7/12/8	9.0																						
30	7/12/8	10.8																						
31	7/12/8	9.5																						
32	7/12/8	9.8	27	27	27	28	28	28	28	28	28	28	28	27	27	27	27	27	26	26	26	24	23	[spawner middle river]
33	7/13/8	10.8																						
34	7/13/8	10.5	7	8	8	8	8	7.5	6.5	6.5	6.5	6.5	6.5	6.5	[hook-and-release mortality]									
35	7/13/8	10.5																						
36	7/13/8	10.5		27	27	26	26	26	26	26	26	26	26	26	26	26	26	25	19	19	19	19	19	[spawner middle river]
37	7/13/8	10.5																						
38	7/13/8	10.0	28	29	29	44	44	66		65	66	60	73	68		68	68	67	67	67	67	67	67	[spawner interlake reach]
39	7/14/8	10.0																						
40	7/14/8	10.5																						
41	7/17/8	9.8																						
42	7/17/8	11.0																						
43	7/18/8	11.3																						
44	7/18/8	10.8	11	11.5	11.5	12	10.5	9	7	6.5	5	5	[spawner lower river]											
45	7/18/8	9.5	22	22	24	23	24	24	24	24	25	26	21	20	20	20	20	20	20	20	20	20	20	[spawner middle river]
46	7/18/8	10.8	47	50	49	50	49	65		60	53	62	65	65		65	65	65	65	65	65	65	65	[spawn at the outlet of Skilak Glacier]
47	7/19/8	12.3																						
48	7/19/8	12.3																						
49	7/19/8	9.8	26	26	27	26	26	26	26	26	26	26	27	26	26	25	26	26	26	26	26	25	25	[spawner middle river]
50	7/20/8	11.0																						

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Appendix A2. (page 2 of 2)

No.	Date Tagged	RM Tagged	8/01	8/03	8/04	8/06	8/07	8/10	8/11	8/13	8/15	8/17	8/18	8/22	8/24	8/25	8/28	8/31	9/04	9/07	9/11	9/15	9/24	[Ultimate Fate]
			River Mile Locations By Date																					
51	7/20/8	10.5	12	11.5	11	12	12	6	5	6	6	6		4.5	4	4	4	5	5	5	5	6	6	[hook-and-release mortality]
52	7/20/8	10.8	21	21	21	23	21	21	20	20	21	21		21	21	21	21	21	21	21	21	21	[unreported sport fish harvest, tag found in river near cleaning table at mi 21]	
53	7/20/8	10.3	31	31	33	36	37	37	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	[spawner middle river]
54	7/20/8	10.5																						
55	7/20/8	10.5																						
56	7/20/8	10.5																						
57	7/20/8	10.0	69	73	68	[uplost - either tag failure or poached after 8/4/89]																		
58	7/21/8	11.3		5	5	5	6		2.5	9	11.5	14.5	14.5	18	18	18	23	23	23	16	16	16	16	[spawner middle river]
59	7/21/8	11.0						3	3	3	2.5	2.5	[hook-and-release mortality]											
60	7/21/8	11.3	15	10.5	6.5	25	31	48	48	48	47	47	47	47	47	47	44	44	43	44	43	43	43	[spawner upper river]
61	7/21/8	11.3																						
62	7/21/8	10.0		10	10.5	9.5	9.5	8	9.5	9.5	9.5	9	9	9	8	9	9	9	9	9	7.5	7.5	7.5	[spawner lower river]
63	7/21/8	10.8	14.5	15	16	21	21	27	34	30	31	31	31	30	30	28	28	28	28	28	28	28	28	[spawner middle river]
64	7/22/8	10.5																						
65	7/22/8	10.5	8	7	7	7	6	6	9	13	14.5	23	38	66		68	66	66	66	66	66	65	65	[spawner interlake reach]
66	7/22/8	11.0	40	41	41	41	41	40	40	40	48	66	66	73		72	72	71	73	73	73	72	72	[spawner interlake reach]
67	7/22/8	10.5																						
68	7/22/8	11.0	10.5	11.5	11	11	12	10	10	10.5	10	10	11.5	6.5	6	5	4	4	4	4	4	4	4	[spawner lower river]
69	7/22/8	11.0																						
70	7/22/8	10.5	11	10	11.5	19	24	39	44	43	43	43	43	43	43	43	40	40	41	41	41	41	41	[spawner upper river]
71	7/24/8	10.0																						
72	7/24/8	9.8	5	5	5	5	5	[hook-and-release mortality]																
73	7/25/8	11.0					LDCC	[drop-out after 8/7/89]																
74	7/25/8	9.5	13	14	14	15	8.5	10.5	10.5	13.5	14.5	15	8	24	37	48	74	76	75	75	75	74	74	[spawner interlake reach]
75	7/25/8	9.5	11	11	11	11	12	11.5	11.5	11.5	11	11	11	11	11	11	11	11	11	11	11	11	11	[spawner lower river]
76	7/25/8	11.0																						
77	7/26/8	10.0	23	23	23	25	23	28	28	28	27	28	28	27	26	26	27	27	27	27	27	26	26	[spawner middle river]
78	7/26/8	9.5	17	18	18	19	19	22	22	24	26	26	26	27	27	27	26	26	26	26	28	26	27	[spawner middle river]
79	7/26/8	9.3	14.5	15	17	17	17	17	17	18	14.5	14.5	14.5	14	14	13	13	13.5	13	13	13	13	13	[spawner lower river]
80	7/26/8	9.3	10	10	10			10	10	10	12	12	11	10		10	[spawner lower river]							
81	7/26/8	10.0																						
82	7/26/8	10.0	29	28	29	29	30	36	36	36	36	43	48	63	[uplost after 8/22/89 - tag failure?]									
83	7/27/8	11.0	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	31	31	31	31	31	31	[spawner middle river]
84	7/27/8	10.0	27	27	28	32	32	32	32	32	34	36	36	43	42	43	44	43	42	42	41	41	41	[spawner upper river]
85	7/27/8	10.8	[caught & released at mi 10.7 on 7/28/89; east side set net off K-Beach on 8/1/89]																					
86	7/27/8	10.8																						
87	7/27/8	10.5	14.5	18	17	24	6.5	12	14.5	13	19	20	19	16	16	16	16	16	15	15	15	15	15	[spawner lower river]
88	7/27/8	10.8	12	10.5	10.5	10	10	10	10	10	10	10	7	7	7	7	7	7	4	4	4	4	4	[hook-and-release mortality (net marks and fungus)]
89	7/27/8	9.8																						
90	7/28/8	11.0	8.5	11.5	17.5	28	31	37	41	42	42	42	42	42	41	41	41	41	40	40	40	40	40	[spawner upper river]
91	7/28/8	11.3	13		13	13	13	13	13	13	10.5	12.5	12	11	11	9.5	10.5	10.5	10.5	10.5	10.5	10	10	[spawner lower river]
92	7/28/8	9.8		[east side set net along north beach on 8/3/89]																				
93	7/28/8	9.8	[caught by tagging crew at mi 9.1 on 8/1/89]																					
94	7/29/8	10.8		10.5	10.5	15	15	20	17	18	14.5	14.5	14.5	13	13	13	13	13	13	13	13	13	13	[spawner lower river]
95	7/29/8	9.5		15	14.5	19	21	25	24	32	34	49	50	40	36	37	37	25	23	23	16	[spawner upper river]		
96	7/30/8	11.0																						
97	7/30/8	10.5	13		13	13	13	13	13	13	10.5	12.5	12	11	11	9.5	10.5	10.5	10.5	10.5	10.5	10	10	[spawner lower river]
98	7/30/8	10.5		[east side set net along north beach on 8/3/89]																				
99	7/30/8	9.3	[caught by tagging crew at mi 9.1 on 8/1/89]																					
100	8/01/8	9.5		10.5	10.5	15	15	20	17	18	14.5	14.5	14.5	13	13	13	13	13	13	13	13	13	13	[spawner lower river]
101	8/01/8	12.3		15	14.5	19	21	25	24	32	34	49	50	40	36	37	37	25	23	23	16	[spawner upper river]		

APPENDIX B

Appendix B1. Detailed tagging and recapture information for each radio-tagged chinook salmon[a].

No.	Date Rele.	Water Temp.	River Mile	Time of Day	Seconds Played	Seconds To Tag	Fishing Method	Terminal Gear	#1 Hook Injury	#2 Hook Injury	Number Hooks	Type of Hooks	Hook Removed	Length (mm)	Sex	Bleed-ing?	Where	Sea Lice	Condi-tion	RM Rele	5 Day Fate	Ultimate Fate
1	7/05/89	48	12.5	1040	1443	439	DR	AL	S		2	S	Y	1090	M	N		N	L	11	S	SET NET
2	7/05/89	48	11.5	1130	189	392	DR	CO	U		2	S	Y	685	M	N		Y	V	11.25	S	SP
3	7/05/89	48	10.5	1300	412	631	BT	AL	K		2	T	Y	1020	M	N		Y	L	10	S	SP
4	7/05/89	48	11.3	1320	531	347	DR	CO	K	L	2	S	Y	1040	F	Y	K	Y	L	11	S	ULOST
5	7/05/89	48	11.3	1335	94	276	DR	CO	U	C	2	S	Y	590	M	Y	U	Y	V	11	S	SP
6	7/05/89	48	11.5	1425	483	340	DR	CO	K	C	2	S	Y	1030	F	N		Y	V	10.5	H	H
7	7/06/89	47	12.8	900	316	265	BT	AL	L	U	2	T	Y	1060	F	N		Y	V	12.25	S	SP
8	7/07/89	50	11.3	1040	120	360	DR	CO	L	H	2	S	Y	705	M	N		Y	V	10.75	S	SP
9	7/07/89	50	11.0	1109	120	414	DR	CO	G		2	S	Y	565	M	N		N	V	10.5	M	M
10	7/07/89	50	10.0	1249	271	560	DR	CO	G	S	2	S	Y	900	M	Y	G	Y	V	9.5	M	M
11	7/07/89	50	11.5	1341	2280	300	BT	CO	S		2	S	Y	1040	M	N		Y	V	10	S	SP
12	7/07/89	50	10.0	1540	970	297	DR	AL	H	S	2	S	Y	1130	M	N		Y	V	9.25	S	SP
13	7/10/89	53	11.5	733	123	326	DR	CO	I	S	2	S	Y	685	M	Y	I	Y	V	11.25	S	SP
14	7/10/89	53	10.0	1010	205	185	DR	CO	H	H	2	S	Y	940	F	Y	H	N	V	9.75	S	SET NET
15	7/10/89	53	10.0	1035	635	184	DR	CO	K	U	2	S	Y	1005	F	Y	U	Y	V	9.75	S	SP
16	7/10/89	53	10.0	1600	93	393	DR	CO	C	C	2	S	Y	560	M	N		N	V	9.75	MAGNET	MAGNET
17	7/10/89	53	10.0	1655	593	280	DR	CO	K		2	S	Y	1100	M	N		Y	V	9.5	S	SP
18	7/10/89	53	11.3	1750	156	330	DR	CO	L	R	2	S	Y	1050	M	N		N	V	11	TAG NET	TAG NET
19	7/10/89	53	11.0	1835	215	250	DR	CO	K		2	S	Y	1035	F	N		Y	V	10.75	SET NET	SET NET
20	7/10/89	53	11.0	1957	331	294	DR	CO	K		2	S	Y	1160	M	N		Y	V	10.5	S	H
21	7/11/89	53	11.3	730	100	330	DR	CO	L	S	2	S	Y	940	F	N		Y	V	10.25	S	SET NET
22	7/11/89	53	10.8	740	460	220	BT	CO	T	L	2	S	Y	1075	F	Y	T	Y	V	9.75	S	H
23	7/11/89	53	11.3	1025	435	255	DR	CO	K	H	2	S	Y	855	M	N		Y	V	10.75	S	TAG NET
24	7/11/89	53	10.0	1125	930	340	DR	CO	S	S	2	S	Y	1150	M	N		Y	V	9.5	M	M
25	7/11/89	53	10.0	1242	242	230	DR	CO	S		2	S	Y	870	M	N		Y	V	9.75	S	H
26	7/12/89	53	11.5	700	300	320	BT	CO	U		1	T	Y	1060	M	N		Y	L	11.25	S	H
27	7/12/89	53	10.0	800	270	379	DR	CO	K	K	2	S	Y	845	M	N		Y	V	9.75	S	SP
28	7/12/89	53	10.0	909	270	220	DR	AL	K		2	S	Y	1040	F	N		Y	V	9.75	SET NET	SET NET
29	7/12/89	53	10.0	950	879	272	DR	CO	S	H	2	S	Y	1055	F	N		Y	V	9	TAG NET	TAG NET
30	7/12/89	53	11.3	1111	640	263	DR	AL	S		2	S	Y	980	F	N		Y	V	10.75	H	H

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Appendix B1. (page 2 of 4)

No.	Date Rele.	Water Temp.	River Mile	Time of Day	Seconds Played	Seconds To Tag	Fishing Method	Terminal Gear	#1 Hook Injury	#2 Hook Injury	Number Hooks	Type of Hooks	Hook Removed	Length (mm)	Sex	Bleeding?	Where	Sea Lice	Condition	RM Rele	5 Day Fate	Ultimate Fate
31	7/12/89	53	10.0	1200	920	248	DR	CO	K	S	2	S	Y	1080	F	N		Y	V	9.5	H	H
32	7/12/89	53	10.0	1230	297	265	DR	AL	S		2	S	Y	1085	M	N		Y	V	9.75	S	SP
33	7/13/89	55	11.0	820	480	217	DR	CO	S		2	S	Y	920	F	N		Y	V	10.75	TAG NET	TAG NET
34	7/13/89	55	11.3	830	300	249	DR	CO	K		2	S	Y	1130	M	N		Y	V	10.5	M	M
35	7/13/89	55	10.8	910	540	240	DR	CO	S		2	S	Y	960	F	N		Y	V	10.5	SET NET	SET NET
36	7/13/89	55	11.3	950	600	255	DR	CO	K		2	S	Y	1020	F	N		Y	V	10.5	S	SP
37	7/13/89	55	11.3	1015	380	266	DR	CO	S	S	2	S	Y	1100	F	N		Y	V	10.5	SUB NET	SUB NET
38	7/13/89	55	11.3	1127	1767	253	DR	CO	S		2	S	Y	1025	M	N		Y	V	10	S	SP
39	7/14/89	59	10.5	811	300	264	BT	CO	L	K	2	T	Y	695	M	N		Y	V	10	TAG NET	TAG NET
40	7/14/89	59	11.3	930	705	315	DR	CO	H		2	S	Y	1030	M	N	X	Y	L	10.5	S	H
41	7/17/89	55	10.0	957	129	379	DR	CO	K		2	S	Y	680	M	N		Y	V	9.75	S	DROP OUT
42	7/17/89	57	12.0	1536	288	208	DR	CO	K		2	S	Y	1070	F	N		Y	V	11	UNKNOWN	UNKNOWN
43	7/18/89	55	11.5	736	120	550	DR	CO	K		2	S	Y	540	M	N		N	L	11.25	S	DROP OUT
44	7/18/89	55	11.0	852	120	355	DR	CO	K		2	S	Y	630	M	N		N	V	10.75	S	SP
45	7/18/89	55	10.0	911	180	347	DR	CO	K		2	S	Y	660	M	Y	K	N	V	9.5	S	SP
46	7/18/89	55	11.3	1130	572	296	DR	CO	H	S	2	S	Y	930	F	N		Y	V	10.75	S	SP
47	7/19/89	57	13.0	750	259	300	BT	CO	H	U	2	T	Y	990	F	N		N	L	12.25	S	DROP OUT
48	7/19/89	57	13.0	805	170	263	BT	CO	S	C	2	T	Y	970	F	N		N	V	12.25	TAG NET	TAG NET
49	7/19/89	57	10.0	1056	145	280	DR	AL	K		2	S	Y	695	M	Y	K	Y	V	9.75	S	SP
50	7/20/89	58	11.3	800	120	390	DR	CO	K		2	S	Y	700	M	N		Y	V	11	SET NET	SET NET
51	7/20/89	58	11.0	825	90	415	DR	CO	I	C	2	S	Y	540	M	N		Y	V	10.5	S	DROP OUT
52	7/20/89	58	11.3	843	240	366	DR	CO	C	K	2	S	Y	650	M	N		Y	V	10.75	M	M
53	7/20/89	58	11.3	918	600	312	DR	CO	K		2	S	Y	725	M	N		Y	V	10.25	S	DROP OUT
54	7/20/89	58	11.0	950	177	260	DR	CO	K		2	S	Y	930	F	N		Y	V	10.5	S	DROP OUT
55	7/20/89	58	11.0	958	900	290	DR	CO	S		2	S	Y	995	M	N		Y	V	10.5	S	H
56	7/20/89	58	11.0	1015	360	290	DR	CO	K		2	S	Y	645	M	N		Y	V	10.5	S	H
57	7/20/89	58	10.8	1024	300	414	DR	CO	K		2	S	Y	570	M	N		N	V	10	M	M
58	7/21/89	54	11.8	730	37	372	DR	CO	K		2	S	Y	645	M	N		Y	V	11.25	S	H
59	7/21/89	54	11.5	747	177	252	DR	CO	U		2	S	Y	815	M	N		Y	V	1100	S	SP
60	7/21/89	54	11.5	908	900	239	DR	CO	K		2	S	Y	980	F	N		Y	V	11.25	H	H
61	7/21/89	54	11.5	841	106	305	DR	CO	K		2	S	Y	1030	F	N		N	V	11.25	H	H

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Appendix B1. (page 3 of 4)

No.	Date Rele.	Water Temp.	River Mile	Time of Day	Seconds Played	Seconds To Tag	Fishing Method	Terminal Gear	#1 Hook Injury	#2 Hook Injury	Number Hooks	Type of Hooks	Hook Removed	Length (mm)	Sex	Bleed-ing?	Where	Sea Lice	Condi-tion	RM Rele	5 Day Fate	Ultimate Fate
62	7/21/89	54	11.0	923	1403	312	DR	CO	T		2	S	Y	1105	M	N		Y	V	10	S	H
63	7/21/89	54	11.3	1050	283	336	DR	CO	C		2	S	Y	1060	F	N		Y	L	10.75	S	ULOST
64	7/22/89	56	11.0	855	450	371	DR	CO	R		2	S	Y	1025	F	N		Y	V	10.5	S	SP
65	7/22/89	56	11.5	910	600	215	DR	CO	L	C	2	S	Y	665	F	Y	C	Y	V	10.5	M	M
66	7/22/89	56	11.5	945	173	360	DR	CO	K	C	2	S	Y	845	F	N		Y	V	11	S	SP
67	7/22/89	56	11.0	1000	399	275	DR	CO	C		2	S	Y	995	F	N		Y	V	10.5	H	H
68	7/22/89	56	11.5	1045	200	250	DR	CO	S	S	2	S	Y	1070	M	N		Y	V	11	S	SP
69	7/22/89	56	11.5	1115	118	235	DR	CO	U	L	2	S	Y	630	M	N		Y	V	11	S	SP
70	7/22/89	56	11.0	1210	427	240	DR	CO	K		2	S	Y	1120	M	N		Y	V	10.5	H	H
71	7/24/89	55	10.3	900	137	204	DR	CO	K	U	2	S	Y	1005	F	N		N	V	10	S	SP
72	7/24/89	55	10.0	950	186	258	DR	CO	L		2	S	Y	1075	F	N		Y	V	9.75	S	SP
73	7/25/89	53	12.3	705	711	360	DR	CO	S		2	S	Y	1080	F	N		N	V	11	H	H
74	7/25/89	53	10.0	837	285	284	DR	CO	K		2	S	Y	945	F	N		N	V	9.5	S	SP
75	7/25/89	53	10.3	1030	1050	437	DR	CO	K	T	2	S	N	1110	F	N		Y	V	950	H	H
76	7/25/89	53	11.5	1130	900	245	DR	AL	T	R	2	S	Y	720	M	N		Y	V	11	S	SP
77	7/26/89	55	13.0	748	3764	279	DR	CO	S		2	S	Y	1090	M	N		N	V	10	H	H
78	7/26/89	55	11.3	850	600	405	DR	CO	G	T	2	S	N	965	F	Y	G	Y	L	9.5	M	M
79	7/26/89	55	10.0	856	1200	274	DR	AL	K	S	2	S	Y	1100	M	N		N	V	9.25	S	DROP OUT
80	7/26/89	55	10.0	930	1001	358	DR	AL	U		2	S	Y	980	F	N		Y	V	9.25	S	SP
81	7/26/89	55	10.5	1140	900	256	DR	CO	K		2	S	Y	1030	M	N		Y	V	10	S	SP
82	7/26/89	55	11.3	1205	1320	240	DR	CO	S		2	S	Y	960	F	N		Y	V	10	H	H
83	7/27/89	53	11.5	715	600	315	DR	AL	K		2	S	Y	830	M	N		Y	V	11	S	SP
84	7/27/89	53	11.3	730	300	442	DR	CO	K		2	S	Y	1100	F	N		Y	V	10	S	SP
85	7/27/89	53	11.3	800	200	330	DR	AL	S	L	2	S	Y	625	M	N		N	V	10.75	S	SP
86	7/27/89	53	11.3	1015	120	396	DR	CO	S		2	S	Y	560	M	N		N	V	10.75	S	SP
87	7/27/89	53	11.3	1020	420	241	DR	CO	S		2	S	Y	1070	F	N		Y	V	10.5	H	H
88	7/27/89	53	11.3	1100	225	290	DR	CO	L	K	2	S	Y	830	M	N		Y	V	10.75	S	ULOST
89	7/27/89	53	10.0	1240	465	270	DR	CO	L	K	2	S	Y	965	F	N		Y	V	9.75	S	SP
90	7/28/89	54	11.5	720	224	239	DR	CO	S	C	2	S	Y	1030	F	N		Y	V	11	S	SP
91	7/28/89	54	11.5	730	81	382	DR	CO	I		2	S	Y	665	M	N		Y	V	11.25	SET NET	SET NET
92	7/28/89	54	10.0	940	199	428	DR	AL	K		2	S	Y	1015	F	N		Y	V	9.75	H	H

-Continued-

Appendix B1. (page 4 of 4)

No.	Date Rele.	Water Temp.	River Mile	Time of Day	Seconds Played	Seconds To Tag	Fishing Method	Terminal Gear	#1 Hook Injury	#2 Hook Injury	Number Hooks	Type of Hooks	Hook Removed	Length (mm)	Sex	Bleed-ing?	Where	Sea Lice	Condi-tion	RM Rele	5 Day Fate	Ultimate Fate
93	7/28/89	54	10.0	1100	242	312	DR	CO	K	C	2	S	Y	975	F	N		N	V	9.75	S	SP
94	7/29/89	55	11.3	654	467	330	DR	CO	K		2	S	Y	705	M	N		Y	V	10.75	M	M
95	7/29/89	55	10.0	755	475	317	DR	AL	S		2	S	Y	1080	F	N		Y	V	9.5	TAG NET	TAG NET
96	7/30/89	52	11.5	815	608	376	DR	CO	L	I	2	S	N	1065	M	N		Y	V	11	S	SP
97	7/30/89	52	11.5	845	1020	350	DR	CO	K	S	2	S	Y	1070	M	N		N	V	10.5	S	SP
98	7/30/89	52	11.3	908	300	306	DR	CO	L		2	S	Y	690	M	N		Y	V	1050	SET NET	SET NET
99	7/30/89	52	11.3	1130	998	321	DR	CO	K		2	S	Y	1110	M	N		N	V	9.25	TAG NET	TAG NET
100	8/01/89	49	10.0	1220	406	309	DR	CO	L	L	2	S	Y	1130	M	N		Y	V	9.5	S	SP
101	8/01/89	49	12.8	1546	225	244	DR	CO	L	U	2	S	Y	990	F	N		Y	V	12.25	S	SP

a

Fishing Method

BT = Back troll

Dr = Drift

Terminal Gear

AL = Artificial lure

CO = Combination bait and lure

Hook Injuries

C = Chin
G = Gill
H = Head (snag)
I = Eye
K = Corner of mouth
L = Lower jaw
R = Roof of mouth
S = Snag
T = Tounge
U = Upper jaw

Type of Hook

S = Single

T = Treble

Condition

L = Lethargic

V = Vigourous

5 Day Fate

H = Sport Harvest
M = Mortality
S = Survior
MAGNET = Magnet left on tag - fate unknown
SET NET = Caught in commercial set net
TAG NET = Caught in ADF&G tagging crew's net

Ultimate Fate

H = Sport Harvest
M = Mortality
SP = Spawner
DROP OUT = Fish dropped out to Cook Inlet and did not return
MAGNET = Magnet left on tag - fate unknown
SET NET = Caught in commercial set net
TAG NET = Caught in ADF&G tagging crew's net
ULOST = Lost signal after fish moved upstream