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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. Findings from four hook-and-release experiments, conducted during 1989 to 1991, are presented in this report.

Short-term (1-5 d) hooking mortality for 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 226 early-run and 220 late-run fish that were tagged during the study. The average mortality was 7.6% for all experiments combined, and ranged from 10.6% in 1989 to 4.0% in 1991. In all experiments, small males suffered the highest mortality when compared to large males and females. Most mortality took place within 72 h of release. The distribution of fishery variables differed among runs, largely due to management regulations, but no relationship was found associating these variables with the fates of radio-tagged fish. The survival of chinook salmon that were injured in the gills or bleeding was significantly reduced; however, the frequency of gilled and bleeding fish was small in all experiments.

Initial movements of radio-tracked fish occurred in both upstream and downstream directions. Late-run salmon that moved downstream to Cook Inlet returned to the river at a significantly lower rate than early-run fish. 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 33 days elapsed between tagging and spawning. Most (81%) early-run fish that were radio tracked spawned in tributary streams with peak spawning occurring in mid-July, while most (96%) late-run fish that were radio tracked spawned in the mainstem with peak activity in mid-August. Spawner destinations within each run were independent of weekly entry times.

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 fishery for chinook salmon *Oncorhynchus tshawytscha* in Alaska. The world record all-tackle chinook salmon (42.6 kg, 94 lbs) was taken from the Kenai River during 1985 and fish in excess of 31.8 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 1991 has ranged from 7,740 to 30,259 and averaged 17,408 (Nelson *In press*). Harvest and effort in this fishery have grown dramatically 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 1 July 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 restrictive regulations to manage the harvest in this fishery including minimum 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. Between 1986 and 1991, an estimated 48,280 chinook salmon (32% of the catch) were released by anglers (Table 1). In the early-run component of the 1988 fishing season, over 90% of the total chinook salmon return to the river was caught. The released component of that catch (5,946 fish) represented 73% of the estimated escapement. The 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, harvest is reduced by restricting the time or area of the fishery, or reducing the bag limit to zero by requiring hook-and-release fishing only. Weak returns of adult chinook salmon in both the early and late runs prompted ADF&G to implement mandatory hook-and-release fishing, for the first time as a regulatory mechanism, during the 1990 fishing season. Releasing fish was again required during the 1991 early run due to continuing weak returns of adult salmon.

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 when used as a management tool. The goal of this multi-year study was to estimate the short-term (5 d) mortality associated with hook-and-release fishing for

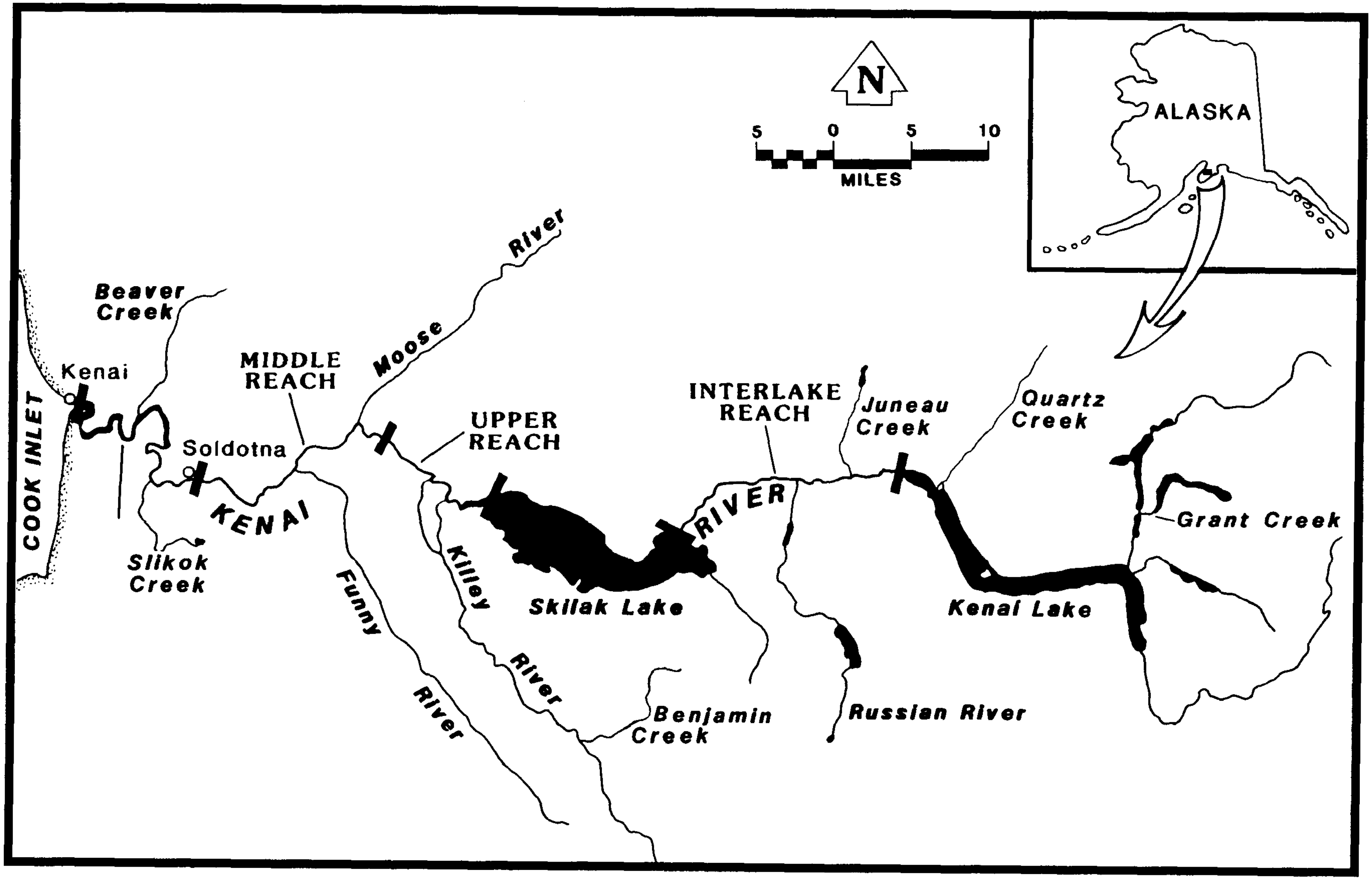


Figure 1. Map of the Kenai Peninsula showing the Kenai River Basin.

Table 1. Estimated escapements and numbers of chinook salmon that were caught, released, and retained in the Kenai River recreational fishery during 1986 through 1991.

Year	Run Component	Numbers of Chinook Salmon Caught	Retained	Released	Percent Released	Estimated Escapement[a]
1986	Early	12,117	7,561	4,556	38	19,519
	Late	15,331	9,004	6,327	41	48,559
	Both	27,448	16,565	10,883	40	68,078
1987	Early	19,119	13,281	5,838	31	12,362
	Late	16,701	12,237	4,464	27	52,787
	Both	35,820	25,518	10,302	29	65,149
1988	Early	18,693	12,747	5,946	32	8,133
	Late	23,238	17,512	5,726	25	34,496
	Both	41,931	30,259	11,672	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
1990	Early[b]	4,973	1,735	3,238	65	8,656
	Late[b]	8,637	6,247	2,390	28	25,770
	Both	13,610	7,982	5,628	41	34,426
1991	Early[b]	3,716	891	2,825	76	9,922
	Late	8,091	6,849	1,242	15	27,943
	Both	11,807	7,740	4,067	34	37,865
All	Early	68,519	43,471	25,048	37	69,328
	Late	84,208	60,976	23,232	28	209,463
	Both	152,727	104,447	48,280	32	278,791

[a] Inriver return minus the sport harvest.

[b] Release of catch mandatory for all or part of run.

chinook salmon in the Kenai River and the affects of selected biological and fishing variables on mortality.

Our study used radio telemetry to monitor the daily locations and estimate fates of chinook salmon that were caught and released in the recreational fishery. This report presents findings from 447 tagged and released chinook salmon of which 101 early-run fish were fitted with transmitters (tagged) during 1991, 125 early-run and 120 late-run fish were tagged during 1990 (Bendock and Alexandersdottir 1991), and 100 late-run salmon were tagged during 1989 (Bendock and Alexandersdottir 1990). Biological and fishery variables were measured for each fish, and fates were established using a matrix of criteria based on telemetry signals and movement behavior. Information is also presented on the movement behaviors and spawning destinations of chinook salmon. Specific objectives for this study were to:

1. test the hypothesis that short-term hook-and-release mortality for chinook salmon is less than or equal to 0.20;

2. estimate hook-and-release mortality;

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

4. estimate the length of time tagged chinook salmon are vulnerable to harvest in the lower Kenai River; and

5. 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, while the size and discharge of the river precludes operation of a weir for capturing or recovering fish. ADF&G personnel have failed to find good alternatives to gill net or hook-and-line for capturing chinook salmon. Since chinook salmon (often in excess of 23 kg) are difficult to handle and susceptible to injury when removed from the water, we chose radio telemetry to monitor the fates of individual fish. The mortality we estimate includes effects of handling and tagging.

There is some evidence that hooking mortality (M) 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). Consequently, we usually limited the area where fish were captured and fitted with radio transmitters to a 4.8 km (3 mi) reach of the lower Kenai River (Figure 2). We assumed that all chinook salmon captured within this reach responded similarly to angling and tagging. However, we extended the upper limit to river kilometer (rkm) 23 for

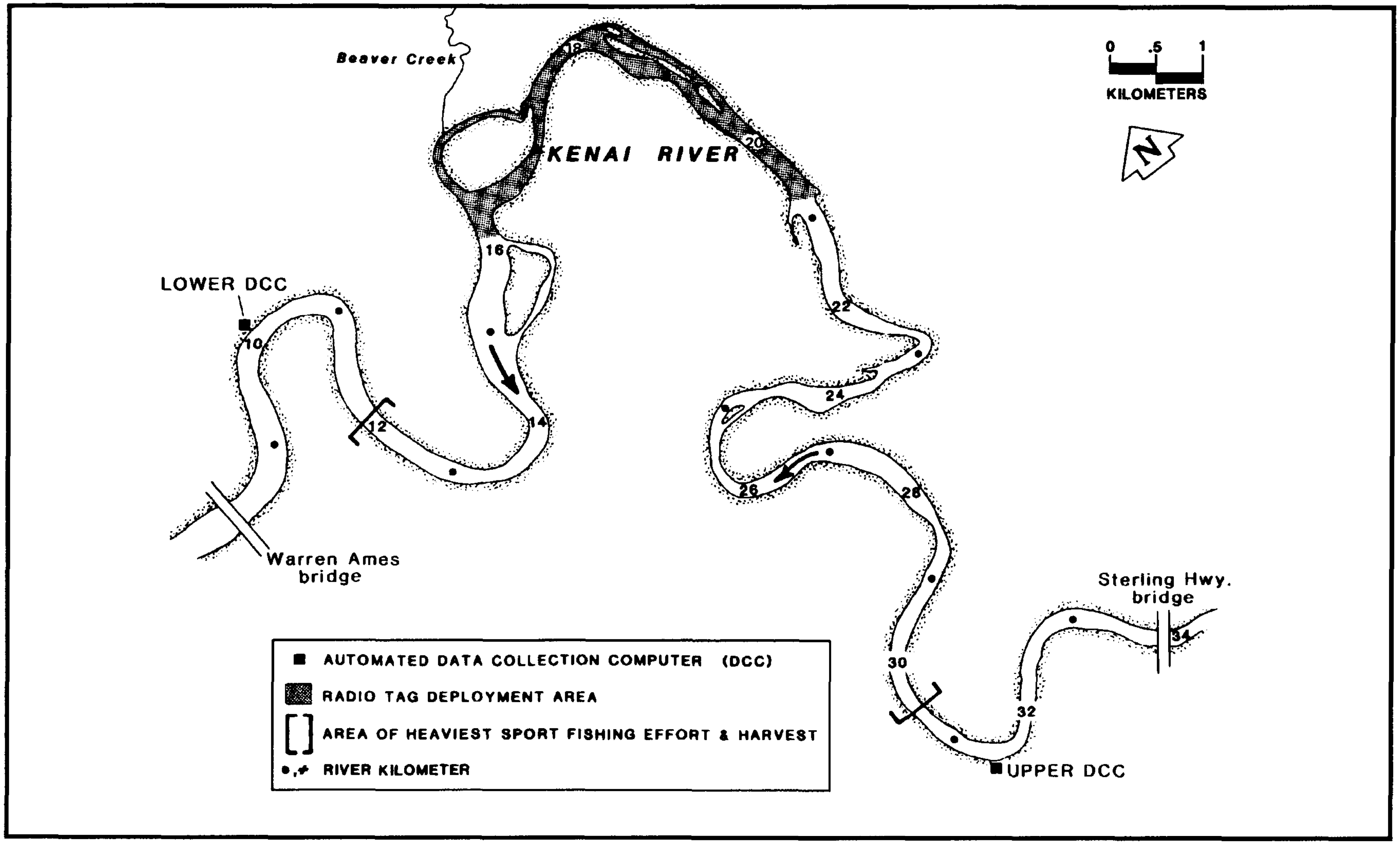


Figure 2. Map of the lower Kenai River delineating the area of greatest sport fishing harvest and effort, the boundaries of the tagging area and locations of the automated data collection computers.

collecting sufficient numbers of early-run fish because few anglers fished low in the river prior to mid-June. Since radio transmitters do not propagate a signal in salt water, our tagging reach was located far enough upstream to allow for a 5 to 6 km buffer area in which to track fish that moved downstream.

A total of 226 early-run chinook salmon and 221 late-run chinook salmon were angled, equipped with externally mounted radio transmitters, and released in the lower Kenai River. 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 less than or equal to 0.20 (Objective 1). A sample of size ≥ 100 was chosen prior to the 1989 study in order to achieve a desired precision for Objective 2 (M ± 0.05 for 80% confidence) using the binomial model (Cochran 1977). However, results in 1989 indicated that male and female chinook salmon differed in their fates after release. Sample size goals were thus increased to ≥ 120 to allow for stratification by sex in the experiment. Assuming 60 fish are successfully tracked, a difference of 0.10 in mortality can be detected at an alpha (α) level of 0.10 with a power ($1-\beta$) equal to 0.66. The 80% upper confidence interval for an estimated mortality of 0.20 would be 0.27 at this sampling level.

To estimate the duration that each radio-tagged fish was vulnerable to harvest in the lower river, the number of days that each tracked fish spent between the time of release and passing an automated data collecting computer (DCC) at rkm 31.3 (rm 19.5) was calculated (Objective 4). Fish that were alive following 5 days at large and that survived the recreational fishery were located daily until spawning was indicated (cessation of movement near the maximum distance penetrated upstream and radio-transmitter signal modes) to collect data for objectives 4 and 5. The duration at large, rates of movement, and estimated location of spawning were used to describe temporal differences in migratory timing of spawners (Objective 5).

Assumptions of this study were:

1. there was no tagging or natural mortality;

2. there was no tag loss; and

3. tags that were removed by various fisheries or that we failed to locate were a random subset of the total sample and did 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, measured approximately 20 mm X 70 mm, and had a 350 mm wire antenna. Each transmitter operated on a unique frequency between 48.000 MHz and 49.999 MHz. All frequencies were separated by a minimum of 10 KHz. The minimum transmitter battery life was 85 days. Transmitters used in this study were equipped with mortality and activity sensors (Eiler 1990) that altered the normal pulse rate of approximately one pulse per second. The mortality circuits doubled the pulse rate to 2 pulses per second, following 3 to 4 h of no motion. Subsequent movement reset the transmitter to the normal mode. Elevated levels of activity were indicated by inserting additional pulses as the transmitter moved vigorously. Thus, radio signals were transmitted in either normal, active, or mortality modes.

Programmable scanning receivers and directional loop antennas were used to monitor radio transmissions. Salmon were tracked daily using a PA-18 Supercub with an antenna mounted to the left wing jury struts. Flying was conducted at approximately 70 mph and 800 to 1,000 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 as the point of maximum acoustic signal strength.

Two stationary automated data collection computers (DCC's) 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 locations delineate boundaries of the river in which approximately 84% of the effort and 90% of the harvest occurs in the chinook salmon recreational fishery (Hammarstrom 1989). Receivers, powered by lead-acid batteries, scanned each available frequency for 5 second intervals on a continuous basis. Frequencies, Julian date, time, and pulse rates of radios transmitting within range of a DCC (usually less than 1.6 km) were stored electronically. These data were transferred to a microcomputer database file on a weekly basis via an RS-232 interface. Since DCC's are subject to extrinsic electronic interference, aircraft location data were given priority when resolving discrepancies of location between databases.

Capture and Tagging:

Chinook salmon 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 (Hammarstrom et al. 1985). No 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 (3 in) nickle pins that were epoxied to the radio transmitters on one end and tied against 2.5 cm (1 in) diameter plastic Petersen disks on the other end (Figure 3). Stainless steel hypodermic needles measuring 16 ga by 100 mm (4 in) were used to shield the nickle pins and provide a sharp cutting surface for penetrating the skin of the salmon. The needles were removed from the pins after penetrating through the skin and were re-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.

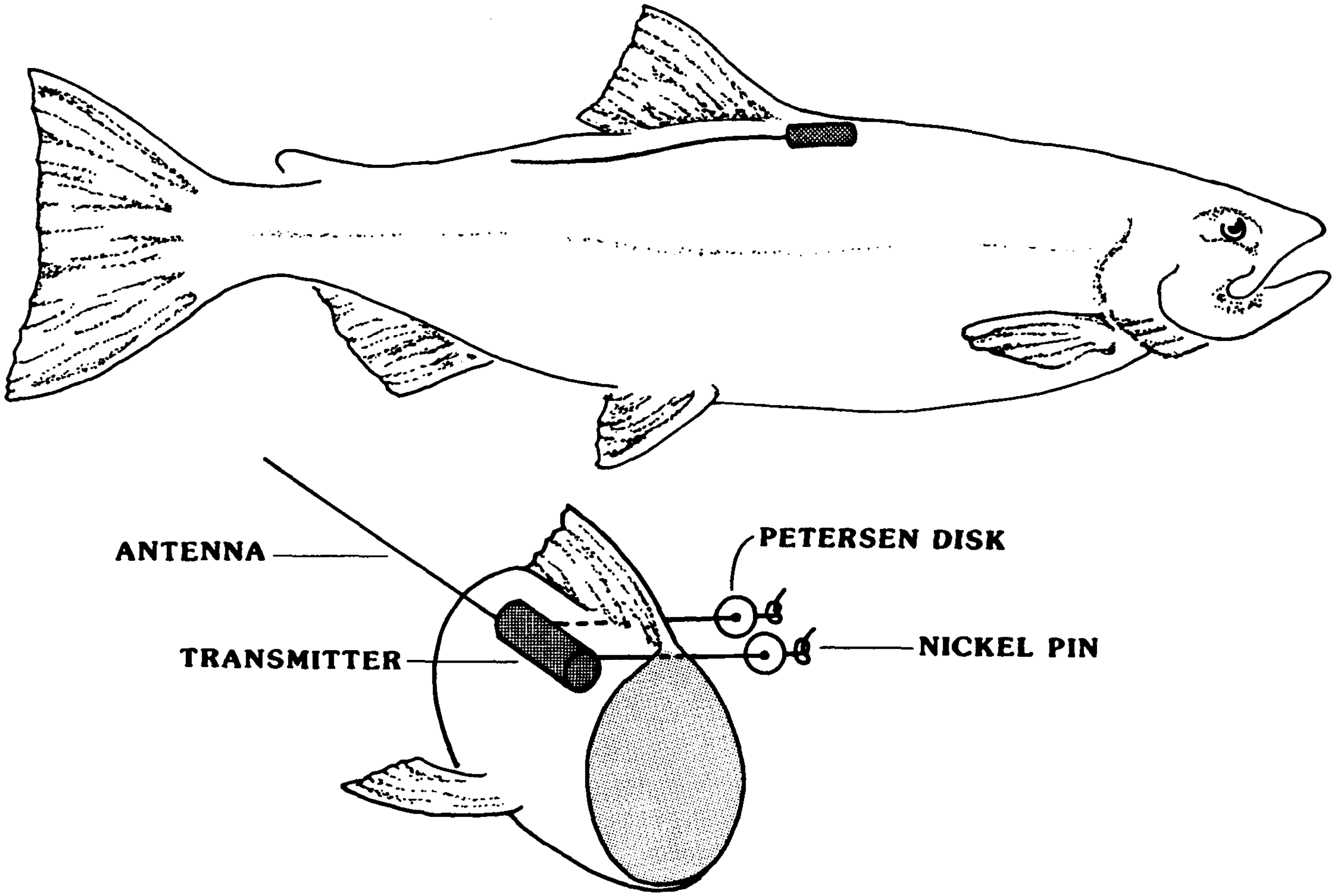


Figure 3. Schematic diagram of a salmon showing the attachment of a radio transmitter.

Biological and Fishery Variables:

Biological and fishery variables were recorded for each angling event. The biological variables were the mid-eye-to-fork length (in 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.

Dispositions of Tagged Fish

Observed frequencies of dead and alive 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 nine classifications defined 5-day fates:

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

2. mortality: a fish that failed to move upstream from the intertidal area (rkm 19.3, rm 12), transmitted radio signals in the mortality mode, or was recovered as a carcass 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 eastside Cook Inlet commercial set net fishery or 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 through 1991.

Variable	Explanation
SEX	Estimation based on external characteristics.
LENGTH	Measurement (mm) from mid-eye to the fork of tail.
DATE	Recorded as mm/dd/yy.
TIME	Hour and minute of hook-up.
LOCATION	River mile location of hook-up.
WATER TEMPERATURE	Measured daily and recorded in degrees Celsius.
ANGLING 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 and 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 is 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	River mile location that fish is released.
CONDITION	Subjective judgement as to the condition of each fish upon release, and recorded as either vigorous or lethargic.

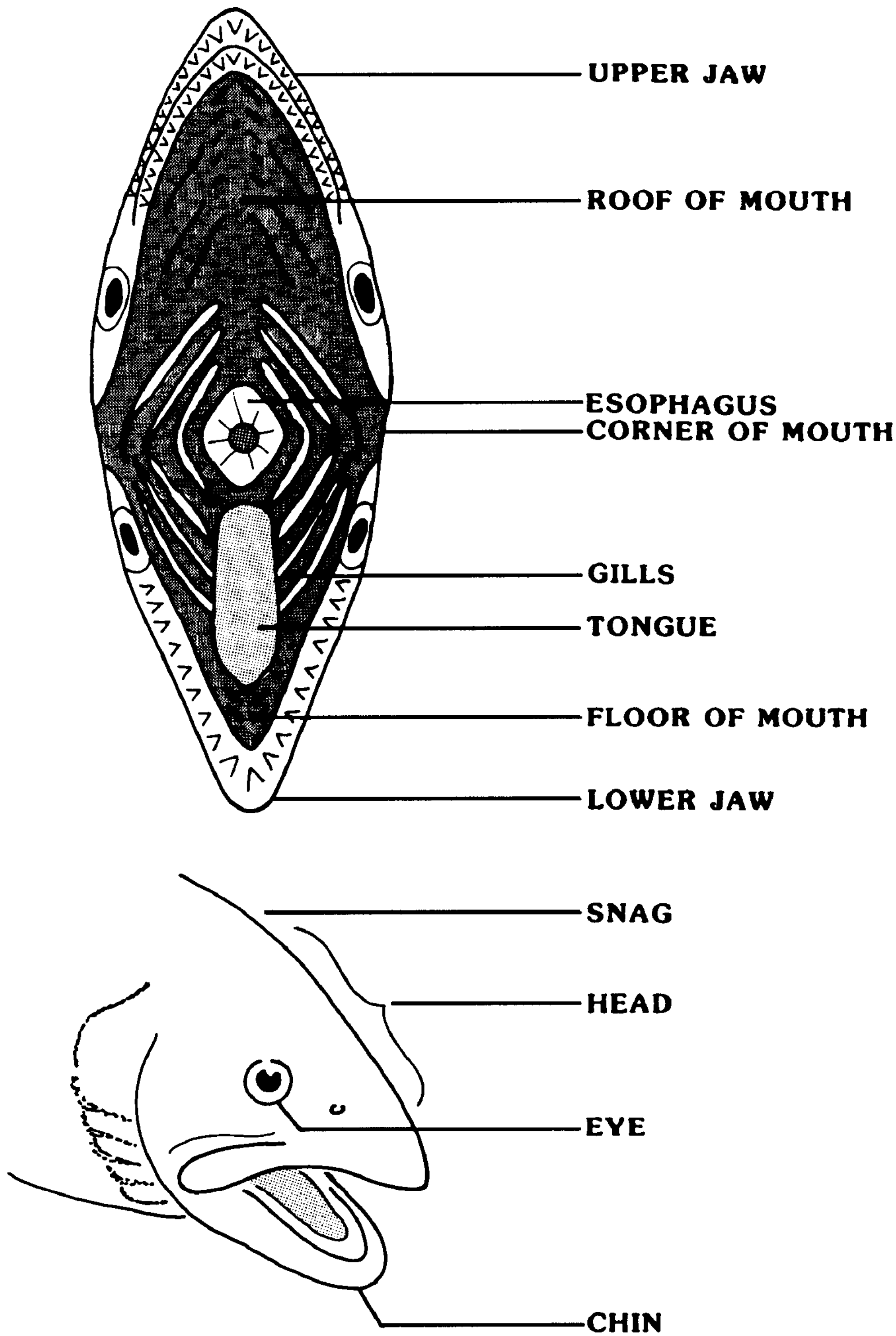


Figure 4. Diagrammatic view of a salmonid head illustrating hook injury locations adapted from Mongillo (1984).

8. uplost: fish that moved upstream but subsequently stopped transmitting a signal,

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

Fates of fish that survived more than 5 days, or the ultimate fates of fish were as above except that the first category (survivors) becomes:

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

The 5-day fates defined in this experiment fall into three groupings. Within the first 5 days the radio-tagged fish either survived (fate 1), suffered hook-and-release mortality (fate 2), or were removed from the experiment by a fishery or other unknown causes (fates 3-9). Chinook salmon removed from the experiment within the first 5 days by some means other than hook-and-release mortality were classified as censored fish.

Ultimate fates were assigned to the salmon at the end of the season, and include spawners, subsequent hook-and-release mortalities, or mortalities classified after 5 days, harvested fish, drop-outs, and uplost fish.

Mortalities:

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 in 1989, it became apparent that transmitter signals provided ambiguous evidence of mortality. Therefore, the following decision rules were developed to help determine fate 2:

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

2b. if a fish consistently moves upstream at any time during and after the first 5 days, it is considered a survivor (irrespective of signal mode);

2c. if a fish remains immobile, transmits a mortality signal within 5 days, and continues to transmit in the mortality mode thereafter, the fish is considered a hook-and-release mortality irrespective of river mile location;

2d. if a fish remains immobile below rkm 19.3 within 5 days from release and remains immobile thereafter, the fish is considered a hook-and-release mortality irrespective of signal mode;

The first two rules (2a and 2b) are unambiguous: tracking a signal further and further upstream is considered proof of survival. Rules 2c and 2d are necessary because transmitter mortality signals did not provide a clear indication of mortality. We observed mortality signals even while fish were consistently located further and further upstream. A fish could also transmit several days of mortality signals while remaining immobile, then suddenly move upstream with a normal signal and stationary fish could transmit a mixture of mortality and normal signals. Assumptions that we made in rules 2c and 2d were:

1. fish that disappear from the Kenai River are alive, a dead fish cannot float out to sea;

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

3. fish that were observed to be immobile above rkm 19.3 and had normal signals were considered survivors.

Thus, location became crucial in our decision process. The most important assumption is that there is no spawning below rkm 19.3 (Burger et al. 1983) and a fish that does not migrate upstream of this point is 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.

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.

Data Analysis

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. 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 hypothesis of no association among the categorical fishery variables, biological variables and fate were tested using chi-square statistics (Snedecor and Cochran 1967). The null hypotheses tested were:

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

2. there was no association between sex, length, and the fishery variables,

3. there was 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 to not affect censoring or mortality rates. In order to test these assumptions, 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% ($\alpha = 0.10$) 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). We define hook-and-release mortality as a failure event and the time to that event the failure time for this analysis. Censored individuals are those removed by a fate other than hook-and-release mortality (e.g. the sport fishery). All fish still surviving 5 days after release are automatically censored, or removed from the experiment. This method computes the percent dying on each day of the experiment from all fish available on that day. The fish available are 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),

$$\hat{F}(t) = \sum_{j<t} (1-\hat{\lambda}_j) \tag{1}$$

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

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

and,

d_j = number of individuals dying at time j,

r_j = number available or alive just before time j.

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

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

The Kaplan-Meier estimator can be stratified and an estimate of total mortality (M_t) due to hook-and-release is estimated for the fish in this experiment as follows,

$$\hat{M}_t = \sum_{i=1}^{s} n_i \; m_i \tag{4}$$

where,

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

$\hat{m}_i$ = estimate of total mortality in stratum i, and

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

where,

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

The variance of $\hat{M}_t$ is estimated by,

$$V(\hat{M}_t) = \sum_{i=1}^{s} n_i^2 \ V(m_i) \tag{6}$$

and the variance of the stratum mortality, $V(\hat{m}_i)$, is equal to the variance of the survivor function, F_i.

A chi-square statistic computed using the log-rank method is used to test the hypothesis that the survivor functions do not differ among strata (Kalbfleisch and Prentice 1980).

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):

$$\lambda(t,z) = w(z;b) \ \lambda_o(t) \tag{7}$$

where $\lambda_o(t)$ 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 covariates, z, and the parametric vector b. The shift function will adjust the baseline hazard function dependent on the effect of the covariates 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:

$$\lambda(t,z) = \lambda_o(t) \ e^{(z;b)}. \tag{8}$$

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

Comparison of Experiments:

Four hook-and-release experiments have been conducted during the following intervals: the late run in 1989, the early and late runs in 1990, and the early run in 1991. A comparison of these four experiments was made using the Kaplan-Meier non-parametric model and the log-rank chi-square statistic (Kalbfleisch and Prentice 1980). The experiments were entered into the models as strata in order to test for significant differences among the experiments. The effect of fishery and biological variables was estimated for the combined experiments using Cox's proportional hazard model.

RESULTS

Retention of chinook salmon in the recreational fishery was prohibited during most of the 1991 early run. In order to achieve the optimum early-run escapement goal for Kenai River chinook salmon, restrictions implemented from 6 through 27 June included a prohibition on the use of bait and a requirement to limit terminal tackle to single-hook artificial lures only. Consequently, a "catch-and-release" fishery occurred throughout most of our 1991 tagging experiment.

A total of 101 early-run chinook salmon were fitted with radio transmitters and released in the lower Kenai River from 28 May through 29 June 1991. Variables recorded for each tagged fish and angling event are presented in Appendix A and are summarized in Table 3. The number of fish tagged per day ranged from 0 to 13. All fish were caught between rkm 16 and 23.2 (rm 10 to 14.5) and released between rkm 14.5 and 23.2 (rm 9 to 14.5). Daily location records for each fish tagged during 1991 are shown in Appendix B.

Associations Between Size, Sex, and Fishery Variables

Tagged fish ranged in length from 460 mm to 1,165 mm and averaged 871.8 mm (SE = 14.0). Fifty-three (53) males averaging 836.3 mm (SE = 23.8) and 48 females averaging 911.0 mm (SE = 11.0) were tagged and released. Chi-square statistics were used to test the null hypothesis of independence between size and sex groups and fates. Three groups were defined, small and large males and females. The sample for males was divided into two groups, smaller and larger than 750 mm, based on length frequencies for the 1989 (Bendock and Alexandersdottir 1990) and 1990 (Bendock and Alexandersdottir 1991) experiments. In 1991, nearly all females (47 of 48) were over 750 mm, while 18 males (35% of 53) were under 750 mm (Table 4).

We tested the hypothesis that the distribution of fishery variables is independent of sex and size groups of tagged fish. The chi-square statistic was significant ($\alpha = 0.05$) for four variables: hook type ($p = 0.028$), number of hooks ($p < 0.001$), date of capture ($p = 0.003$), and angling time ($p = 0.03$). A higher proportion of large males (88.6%) and females (91.7%) were taken on single hooks than small males (66.7%), and a higher proportion of large males (89.6%) and females (85.7%) were taken on one hook compared to small males (44.4%). During the last half of May, 27.8% of the small males were captured compared to only 3% and 2% of the large males and females, respectively. Large males and females also took longer to land (play) with 20% of the large males and 6.2% of the females taking over 4 minutes, while all small males were landed in less than 4 minutes.

Table 3. Summary values for selected biological and fishery variables, 1989-1991.

Variable	1989 Late Run (n=100)	1990 Early Run (n=125)	1990 Late Run (n=120)	1991 Early Run (n-101)	All (n=446)
Sex					
Male	56	69	89	53	267
Female	44	56	31	48	179
Mean Length (mm)					
Male	854	904	704	836	819
Female	1003	936	957	911	948
Guided Angler					
Yes	n/a	96	66	72	234
No	n/a	29	54	29	112
Angling Method					
Back-troll	8	125	26	101	260
Drift	92	0	91	0	183
Back-bounce	0	0	3	0	3
Terminal Gear					
Bait	0	0	0	0	0
Artificial Lure	15	125	23	101	264
Bait/Lure Combo.	85	0	97	0	182
Hook Type					
Single	94	122	106	87	409
Treble	6	3	14	14	37
Number Hooks					
One	1	119	9	81	210
Two	99	6	111	20	236
Hook Location					
Gill, Eye, Tongue	9	8	1	6	24
Jaw, Snag	91	117	119	95	422
Hooks Removed					
Yes	97	112	112	93	414
No	3	13	8	8	32
Bleeding					
Yes	11	26	15	18	70
No	89	99	105	83	376
Sea Lice					
Yes	79	93	101	84	357
No	21	32	19	17	89
Condition					
Vigorous	91	120	116	100	427
Lethargic	9	5	4	1	19
Mean Handling Time (minutes)	17.0	14.8	14.8	14.7	15.3

Table 4. Five-day fates for size and sex categories of tagged and released chinook salmon during the early run, 1991.

Sex	Size	Censored	Mortality	Survivor	Total
Male	Small	1 (5.6%)[a]	2 (11.1%)	15 (83.3%)	18 (17.8%)[b]
	Large	1 (2.9%)	0	34 (97.1%)	35 (34.6%)
Female	All	1 (2.1%)	2 (4.2%)	45 (93.7%)	48 (47.5%)
	Total	3 (3.0%)[b]	4 (4.0%)	94 (93.1%)	101

[a] Percent of fish in size-sex group
[b] Percent of total fish tagged and released

Five-day and Ultimate Fates

During 1991, 94 (93%) fish were still alive at the end of 5 days, four fish were classified as hook-and-release mortalities, and three (3%) fish were censored from the tagged population (Table 5). Seven classifications were used to describe the final fate for these early run fish. Six (5.9%) fish were ultimately classified as mortalities, 5 (4.9%) were harvested by sport fishermen, tagging net and uplost classifications accounted for 4 (3.9%) fish each, 3 (2.9%) fish dropped out of the river, and the fates of 2 (1.9%) fish were unknown (Table 5). The remaining 77 fish or 76% of the tagged population were estimated to survive and spawn.

Associations Between Fishery Variables and Fate

Of four hook-and-release mortalities during 1991, two were small males and two were females (Table 4). No large males died within 5 days of release. One fish in each size-sex group was censored due to capture in the ADF&G gill net fishery.

Only two of the fishery variables were significantly related to 5-day fates: hook location and whether or not a fish was bleeding (Table 6). Fish hooked in the gills or vital areas (eye and tongue) had higher mortality rates than fish hooked in the jaws or snagged. Bleeding fish during the 1991 experiment had a 100% mortality rate.

Survival Analysis

The Kaplan-Meyer estimate of survival for hooked-and-released chinook salmon 5 days after release is 96% (n = 101, SE = 2.0%) for 1991 early-run fish (Table 7). Survival for small males was 0.885 and for females was 0.958, while no large males died. Survival among the three size-sex groups was not significantly different (Table 7).

Comparison of Experiments 1989-1991

Our investigation has included four hook-and-release experiments: 1 in 1989 (Bendock and Alexandersdottir 1990), 2 in 1990 (Bendock and Alexandersdottir 1991), and 1 in 1991. Over the period of these four experiments, we have radio tagged and released a total of 446 chinook salmon. Of these, 31 fish died, 40 were censored, and 375 fish survived the first 5 days after release (Table 5). In 1989, an estimated survival of 89.4% for released chinook salmon is compared to 91.2% and 94.1% for the early and late runs respectively in 1990, and 96.0% for the 1991 early run (Figure 5).

The stratified Kaplan-Meier estimates of survival for these four experiments were not significantly different (χ^2 = 4.8, df = 3, p = 0.19). However, the distribution of the three size and sex groups and censoring patterns differed significantly over the four experiments (Figure 6). During the late run in 1990, small males represented 54.2% of the total tagged population but only 13% to 26% for the other three experiments (Table 8). In addition, there is an evident difference in hook-and-release mortality among the size-sex groups (Figure 6). In all experiments, small males suffer the highest mortality rate (9.2% to 17.6%), while large males suffer the lowest (0% to 9.7%).

Table 5. Five-day and final fates for 446 chinook salmon that were tagged and released in the Kenai River during 1989 through 1991.

Fates	1989 Late Run (n=100)	1990 Early Run (n=125)	1990 Late Run (n=120)	1991 Early Run (n=101)	All (n=446)
Five-Day Fates					
Survivor	63	112	106	94	375
Mortality	9	11	7	4	31
Sport Harvest	13	1	3	0	17
Set Net	6	0	1	0	7
Tag Net	7	1	1	3	12
Sub Net	1	0	0	0	1
Drop Out	0	0	2	0	2
Unknown	1	0	0	0	1
Final Fates					
Survivor	40	94	71	77	282
Mortality	9	15	7	6	37
Sport Harvest	22	9	12	5	48
Set Net	9	0	5	0	14
Tag Net	7	2	6	4	19
Sub Net	1	0	0	0	1
Drop Out	7	3	11	3	24
Up Lost	3	2	8	4	17
Unknown	2	0	0	2	4

Table 6. Fishery variables[a] and fates for radio-tracked Kenai River chinook salmon released during the early run, 1991.

Variable	df	χ^2	p-value	Comments
Hook Location	6	40.3	<0.001	Gilled = 3, 1 mortality Jaw/Snag = 95, 1 mortality Eye/Tongue = 3, 2 mortalities
Bleeding	2	20.0	<0.001	Bleeding = 4, 4 mortalities Not Bleeding = 83, 0 morts.
Hook Type	2	1.5	0.48	
Number of Hooks	2	0.4	0.80	
Sea Lice	2	0.2	0.90	
Hook Removal	2	1.9	0.39	
Handling Time	2	2.1	0.36	
Guided/Unguided	2	2.2	0.33	
Period of Run	4	2.3	0.68	2-week periods, 15 May to 30 June

[a] All other fishery variables did not have sufficient sample sizes to test the hypothesis of independence between the variable and fate.

Table 7. Results of survival analysis by size and sex categories of radio-tracked chinook salmon released during the early run, 1991.

Group	Survival	SE	95% Confidence Interval
Small Males	0.885	0.076	0.736 - 1.000
Large Males	1.000	na	
Females	0.958	0.029	0.900 - 1.000
Ho: There is no difference in survival among size-sex groups			
$\chi^2 = 3.87$	df = 2	p = 0.144	
All Fish	0.960	0.020	0.921 - 0.999

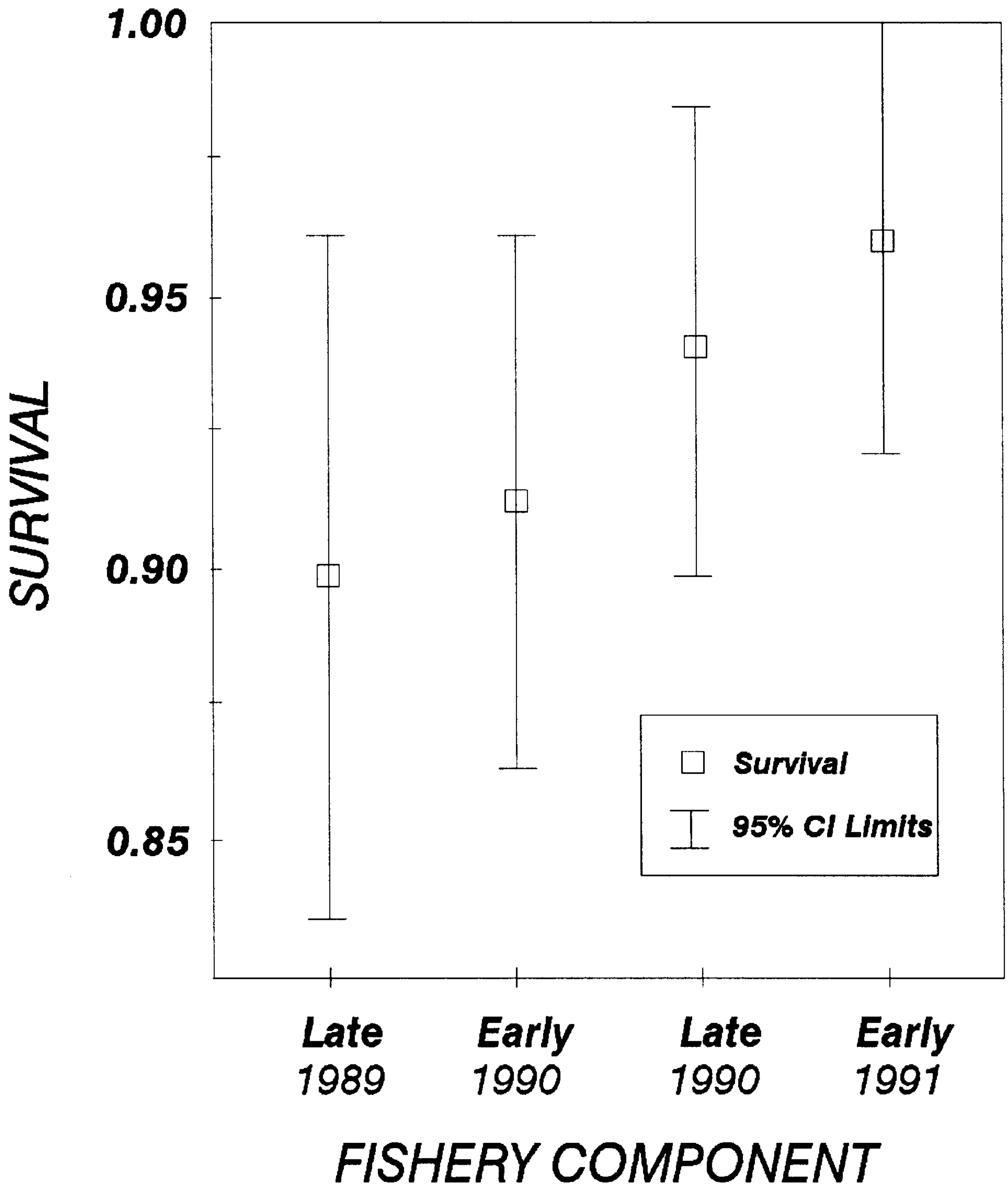
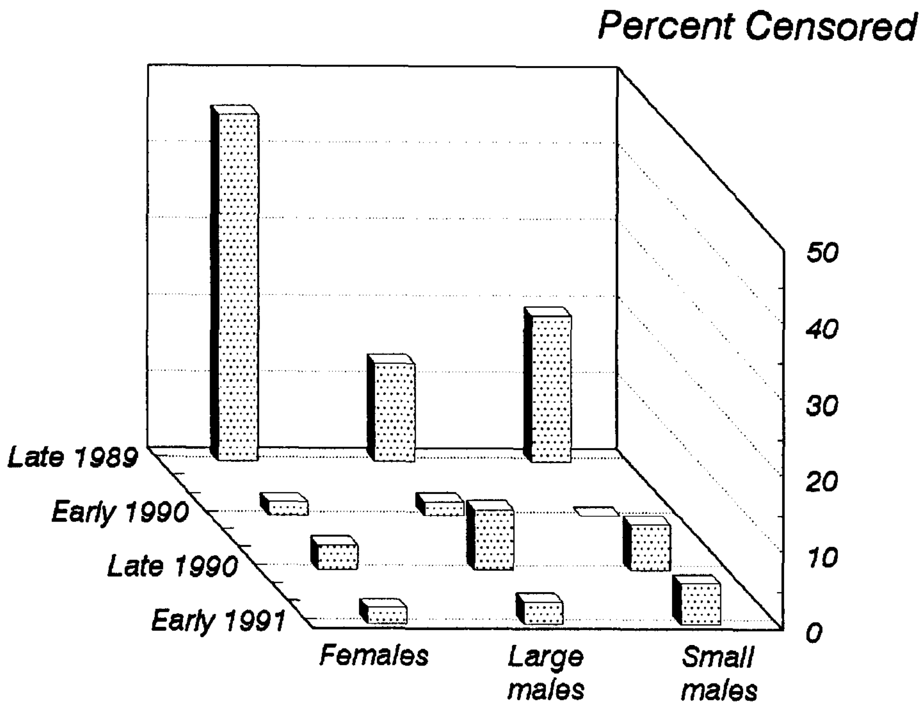


Figure 5. Estimates of survival with 95% confidence intervals for radio-tracked chinook salmon in hook and release experiments in the Kenai River, 1989-1991.



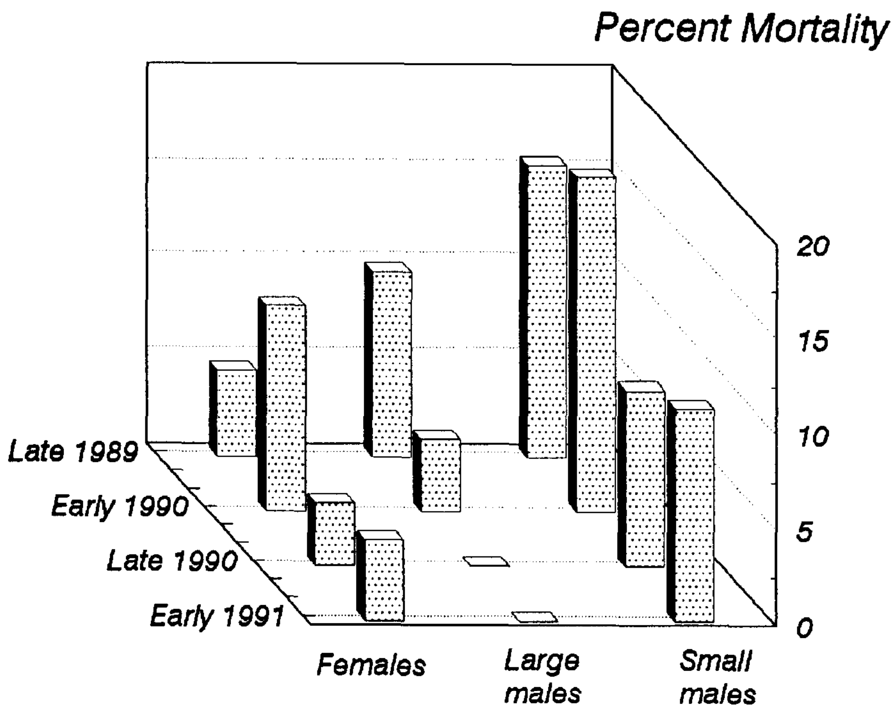


Figure 6. Distribution of percent mortality and percent censoring by experiment and sex-size group for radio-tracked chinook salmon, 1989-1991.

Table 8. Distribution of sex and size groups for radio-tracked Kenai River chinook salmon over four experiments during 1989-1991.

Run/Year	Small Males	Large Males	Females	Total
Late 1989	25 (25.0%)	31 (31.0%)	44 (44.0)	100
Early 1990	17 (13.6%)	52 (41.6%)	56 (44.8%)	125
Late 1990	65 (54.2%)	25 (20.8%)	30 (23.3%)	120
Early 1991	18 (17.8%)	35 (34.6%)	48 (47.5%)	101
All	125 (28.0%)	143 (32.1%)	178 (39.9%)	446

The rate of censoring was different for the late run in 1989 compared to the other experiments (Figure 6). In 1989, a total of 29 (28.7%) fish were censored within 5 days of release. Thirteen fish were harvested in the sport fishery and 14 were harvested in ADF&G gill net or commercial set net fisheries. Most of the censored fish (20) were females (Figure 6), and 11 of these were removed in the sport fishery. This high rate of censoring was not repeated in the 1990 or 1991 experiments. Thus, survival analysis data were separated into two groups, 1989 data and 1990-1991 data, and were further stratified by sex and size due to apparent differences in mortality rates.

Late Run 1989:

The overall Kaplan-Meier survival estimate for 1989 was 0.894 (SE = 0.033). Survival was 0.829 (SE = 0.078) for small males, 0.901 (SE = 0.054) for large males, and 0.935 (SE = 0.044) for females (Table 9). While the censoring pattern for 1989 was unusual, the estimates of survival among the three size-sex groups are not significantly different ($p = 0.48$).

Early and Late Run 1990 and Early Run 1991:

There was little censoring in any of these three experiments and no significant difference in censoring among sex-size groups (Figure 6). Stratified Kaplan-Meier estimates of survival within each sex-size group for each experiment were not significantly different (Table 9). Thus, data for the three experiments were combined and stratified only by sex and size. The Kaplan-Meier survival estimates were significantly different ($\chi^2 = 7.56$, df = 2, $p = 0.02$) at 0.889 (SE = 0.032) for small males, 0.981 (SE = 0.013) for large males, and 0.932 (SE = 0.022) for females (Table 9).

Explanatory Variables:

Cox's proportional hazard model was applied to the combined data with experiments and size-sex as strata. Hook location was a significant explanatory variable for the 1989 late run experiment, while hook location and bleeding were significant ($p < 0.01$) variables in the 1990-1991 data (Table 10). Survival of fish hooked in the gills, eye, or tongue (vital areas) was also compared to fish hooked in the jaw or snagged (Table 11). The survival of fish that were bleeding or were hooked in vital areas decreased significantly: of 48 fish bleeding on release, 12 (25%) died, while of 276 fish not bleeding only 10 (4%) died (Table 11). Similarly, of 15 fish hooked in vital areas, 8 or 53% died while only 14 (4%) of the remaining 319 fish that were hooked in the jaw or snagged died (Table 11). Values for each of these variables for all fish classified as hook-and-release mortalities are shown in Table 12.

<u>Movement Behavior of Tagged Fish 1989-1991</u>

Initial Direction of Movement:

Chinook salmon moved both upstream and downstream following release. Most tagged (81%) fish were located from the air within 24 h of release but some were not located for 48 h (18%) or 72 h (1%). The chi-square statistic was not significant for differences in direction of movement by time of initial contact, so these data were combined for further analysis. Upon initial

Table 9. Results of survival analysis by size and sex categories of radio-tracked chinook salmon released in the Kenai River, 1989-1991.

Stratum		Survival	SE	95% C. I.	χ^2	df	p-value
<u>1989:</u>	Females	0.935	0.044	0.849-1.000			
	Large males	0.901	0.054	0.795-1.000	1.47[a]	2	0.48
	Small males	0.829	0.078	0.676-0.982			
<u>1990-1991:</u>							
Females	Early 1990	0.893	0.041	0.813-0.973			
	Late 1990	0.966	0.034	0.899-1.000	2.49[b]	2	0.28
	Early 1991	0.958	0.029	0.901-1.000			
Large males	Early 1990	0.961	0.027	0.908-1.000			
	Late 1990	1.000	na				
	Early 1991	1.000	na				
Small males	Early 1990	0.824	0.092	0.643-1.000			
	Late 1990	0.907	0.036	0.836-0.977	0.77[b]	2	0.68
	Early 1991	0.885	0.076	0.736-1.000			
Females	Total	0.932	0.022	0.889-0.975			
Large males	Total	0.981	0.013	0.955-1.000	7.56[c]	2	0.02
Small males	Total	0.889	0.032	0.826-0.952			

[a] Null hypothesis: There is no difference among sex-size classes in 1989.

[b] Null hypothesis: There is no difference among experiments within a sex size class.

[c] Null hypothesis: There is no difference among sex-size groups for combined experiments 1990-1991.

Table 10. Results of Cox's proportional hazard model for radio-tracked Kenai River chinook salmon, 1989-1991.

Stratum	Parameter	Estimate	SE	95% C. I. Lower	95% C. I. Upper	T-stat	p-value
Late 1989	Hook loc[a]	3.71	0.914	1.918	5.503	4.06	< 0.001
Combined 1990-1991	Hook loc[a]	2.08	0.634	0.838	3.326	3.28	< 0.001
	Bleeding[b]	1.35	0.494	0.382	2.319	2.73	0.030

[a] Hook locations: 1-jaw/snag, 2-gill/vital
[b] Bleeding: 1-yes, 2-no

Table 11. Distribution of explanatory variables by sex-size groups and fates for radio-tracked Kenai River chinook salmon, 1989-1991.

Size-Sex	Variable	Censored Number	(%)	Mortalities Number	(%)	Survivors Number	(%)
	Hook Location						
Small males:	Gill/Vital	1	(11)	4	(44)	4	(44)
	Jaw/Snag	8	(7)	11	(10)	94	(83)
Large males:	Gill/Vital			1	(20)	4	(80)
	Jaw/Snag	8	(6)	4	(3)	129	(91)
Females:	Gill/Vital			6	(60)	4	(40)
	Jaw/Snag	23	(14)	5	(3)	140	(83)
	Bleeding						
Small males:	Not bleed.	9	(9)	8	(8)	83	(83)
	Bleeding			7	(32)	15	(68)
Large males:	Not bleed.	7	(5)	3	(2)	119	(92)
	Bleeding	1	(6)	2	(12)	14	(82)
Females:	Not bleed.	23	(16)	5	(3)	119	(81)
	Bleeding			6	(19)	25	(81)

Table 12. Listing of radio-tracked salmon classified as hook-and-release mortalities, 1989-1991.

Tag Number	Date	Size	Sex	Hook Location	Hook Removal	Bleeding
9-89	7 07 89	Small	M	Gill	Y	N
10-89	7 07 89	Large	M	Gill	Y	Y
24-89	7 11 89	Large	M	Snag	Y	N
34-89	7 13 89	Large	M	Jaw	Y	N
52-89	7 20 89	Small	M	Snag	Y	N
57-89	7 20 89	Small	M	Jaw	Y	N
65-89	7 22 89	Large	F	Jaw	Y	Y
78-89	7 26 89	Large	F	Gill	N	Y
94-89	7 29 89	Small	M	Jaw	Y	N
1-90	5 22 90	Large	M	Jaw	Y	N
45-90	6 12 90	Large	F	Gill	N	Y
48-90	6 12 90	Large	F	Jaw	Y	N
55-90	6 13 90	Large	F	Eye/Tongue	N	N
61-90	6 14 90	Large	F	Jaw	N	N
63-90	6 14 90	Large	F	Jaw	N	N
67-90	6 15 90	Large	M	Jaw	Y	Y
86-90	6 21 90	Small	M	Gill	Y	Y
91-90	6 22 90	Small	M	Jaw	Y	N
122-90	6 30 90	Large	F	Gill	Y	Y
123-90	6 30 90	Small	M	Jaw	Y	N
131-90	7 05 90	Small	M	Gill	Y	Y
135-90	7 05 90	Small	M	Jaw	Y	N
149-90	7 06 90	Small	M	Jaw	Y	Y
150-90	7 07 90	Small	M	Jaw	Y	Y
157-90	7 10 90	Large	F	Jaw	Y	N
166-90	7 12 90	Small	M	Jaw	Y	N
214-90	7 18 90	Small	M	Jaw	Y	Y
263-91	6 06 91	Large	F	Eye/Tongue	Y	Y
267-91	6 06 91	Large	F	Eye/Tongue	N	Y
319-91	6 18 91	Small	M	Jaw	Y	Y
345-91	6 28 91	Small	M	Gill	Y	Y

contact, 77 fish (18%) were relocated within 0.8 km (0.5 mi) of their point of release, while 165 fish (40%) moved downstream and 176 fish (42%) moved upstream. Fish moving upstream traveled a mean distance of 5.3 km (3.3 mi) during the initial relocation period and downstream fish averaged 5.6 km (3.5 mi). The maximum distance traveled by a radio-tracked fish during this initial period was 21 km for both downstream and upstream swimmers respectively.

The null hypothesis that the initial direction of movement is independent of sex, bleeding, presence of sea lice, time played and total handling time was not rejected (Table 13). The hypothesis was not accepted for three variables: run timing ($p = 0.004$), bait ($p = 0.004$), and fishing method ($p = 0.003$) (Table 13). Two associations were made with run timing. First, within each run, a larger proportion of fish moved upstream initially during the second half compared to the first half. Secondly, more late-run fish moved upstream initially than early-run fish.

Fish caught on artificial lures were less likely to be located upstream initially than those caught on a bait-lure combination. Fish caught by drifting were also more likely to be found upstream initially, compared to those caught by back trolling. It should be noted, however, that both the fishing method and the choice of terminal gears are related since the preferred terminal gears for back trolling are artificial lures and the preferred gears for drifting are bait-lure combinations. In addition, restrictions in place to manage the fishery may also dictate the kinds of terminal gears used, and thereby influence fishing method.

Reversions to Cook Inlet:

A total of 67 fish (15%) returned to Cook Inlet after being tagged and released above rkm 16 (rm 10) during 1989-1991. There was no significant difference between proportions of early-run (14%) and late-run (16%) fish that returned to Cook Inlet. The subsequent return of these fish to spawn in fresh water, however, was dependant upon run timing with significantly more early-run fish returning than late-run fish ($\chi^2 = 22.6$, $df = 1$, $p < 0.005$). Increased numbers of fish harvested in set nets and classified as drop outs during the late runs accounted for the different rates of return to fresh water. Most (77%) early-run reversions to Cook Inlet ultimately returned to the Kenai River, while most (81%) late-run fish did not return.

Movements Through the Lower River Sport Fishery:

Holding or milling behavior was observed for most radio-tagged fish. Few fish migrated directly to a spawning destination following release and many spent a week or longer milling in the intertidal zone before initiating upstream movement.

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 through the lower river sport fishery. Data were available for 138 early-run and 70 late-run fish during the four experiments (Table 14). The mean upstream distance traveled for all tagged fish between the point of release and the DCC was 11.9 km. The duration of time required to travel this distance ranged from 0.9 days to 37.1 days with a median of 6.2 and an average

Table 13. Results for tests of independence between fishing variables and initial direction of movement for radio-tracked Kenai River chinook salmon, 1989-1991.

H_o: Initial direction of movement is independent of variable.

Variable	df	χ^2	P-value
Sex	2	1.339	0.51
Bleeding	2	2.302	0.32
Sea Lice	2	0.783	0.68
Time Played	6	4.540	0.60
Total Time	8	10.540	0.23
Run Timing	2	10.984	0.004
Bait	2	10.922	0.004
Method	2	11.673	0.003

Table 14. Statistics for travel times of radio-tracked chinook salmon between points of release and the upper data collecting computer (rkm 30.6), 1989-1991.

Statistic	1989 Late Run	1990 Early Run	1990 Late Run	1991 Early Run	All
n	37	80	33	58	208
Mean Distance (km)	14.6	10.8	14.3	10.5	11.9
Min (days)	0.9	0.9	1.0	2.2	0.9
Max (days)	34.3	19.5	27.1	37.1	37.1
Mean (days)	7.0	7.8	8.8	10.7	8.4
Median (days)	5.1	6.5	5.1	9.8	6.2
Rate (km/day)	2.10	1.38	1.63	0.98	1.42

of 8.4 days. Seventy-five percent of these fish transited the lower river within 12 days of release while 50% spent nearly 6 days before reaching the data logger (Figure 7). The mean rate of movement for early-run fish (1.2 km/d) was lower than that for late-run fish (1.9 km/d). Movement of tagged fish past the upper DCC occurred predominantly during the second half of the day. Sixty-four percent of the tagged fish passed the upper DCC between the hours of 12 noon and 12 midnight (Figure 8).

Spawning Destinations for Radio-Tracked Fish 1989-1991

The date and river mile of spawning for each radio-tracked 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. A total of 282 fish (172 early run and 112 late run) were classified as spawners. Radio-tracked fish in the early run were distributed primarily to tributary destinations, while radio-tracked fish in the late run remained in the mainstem ($\chi^2 = 158$, df = 1, $p < 0.001$) (Table 15, Figure 9).

Early Run:

Radio-tracked early-run spawners distributed to both tributary (81%) and mainstem (19%) final destinations (Figure 10). Destinations were related to weekly entry times for early-run fish ($\chi^2 = 38.3$, df = 9, $p < 0.005$) with most Killey and Funny river spawners entering the river in the first half of the early run and most other tributary and mainstem spawners entering during the second half. The Killey (58%) and Funny rivers (30%) were the most extensively used tributary destinations, while the middle section (13%) was the most extensively used mainstem river reach (Table 15). The hypothesis that spawner distribution is independent of calendar year (1990 vs. 1991) was rejected for early-run fish ($\chi^2 = 9.8$, df = 3, $p < 0.01$). A larger proportion of radio-tracked fish spawned in the mainstem during 1990 compared to 1991 (27% vs. 9%), and a lower proportion returned to the Killey River drainage (46% vs. 64%).

Completion of early-run spawning activity, as evidenced by consecutive mortality signals or downstream movement from maximum upper locations, occurred from 24 June through 23 August with peak spawning in mid-July. Median spawning dates were 15, 17, 22, and 19 July for Funny River, Killey River, Benjamin Creek, and mainstem spawners, respectively.

Late Run:

Mainstem destinations were selected for spawning by 107 (96%) out of 112 radio-tracked late-run fish. Forty-four fish (39%) spawned in the lower mainstem river reach, followed by 37 (33%) in the middle reach, 15 (13%) in the upper reach, and 11 (10%) in the interlake reach (Table 15). Distributions of spawners among the four mainstem river reach classifications were independent of weekly entry times ($\chi^2 = 2.8$, df = 9, $p > 0.05$). Mainstem spawning destinations were also independent of calendar year for late-run fish ($\chi^2 = 5.2$, df = 4, $p > 0.25$). Radio-tracked late-run fish spawned in the lower, middle, upper, and interlake reaches of the mainstem in nearly equal proportions during 1989 and 1990 with most fish utilizing the lower and middle

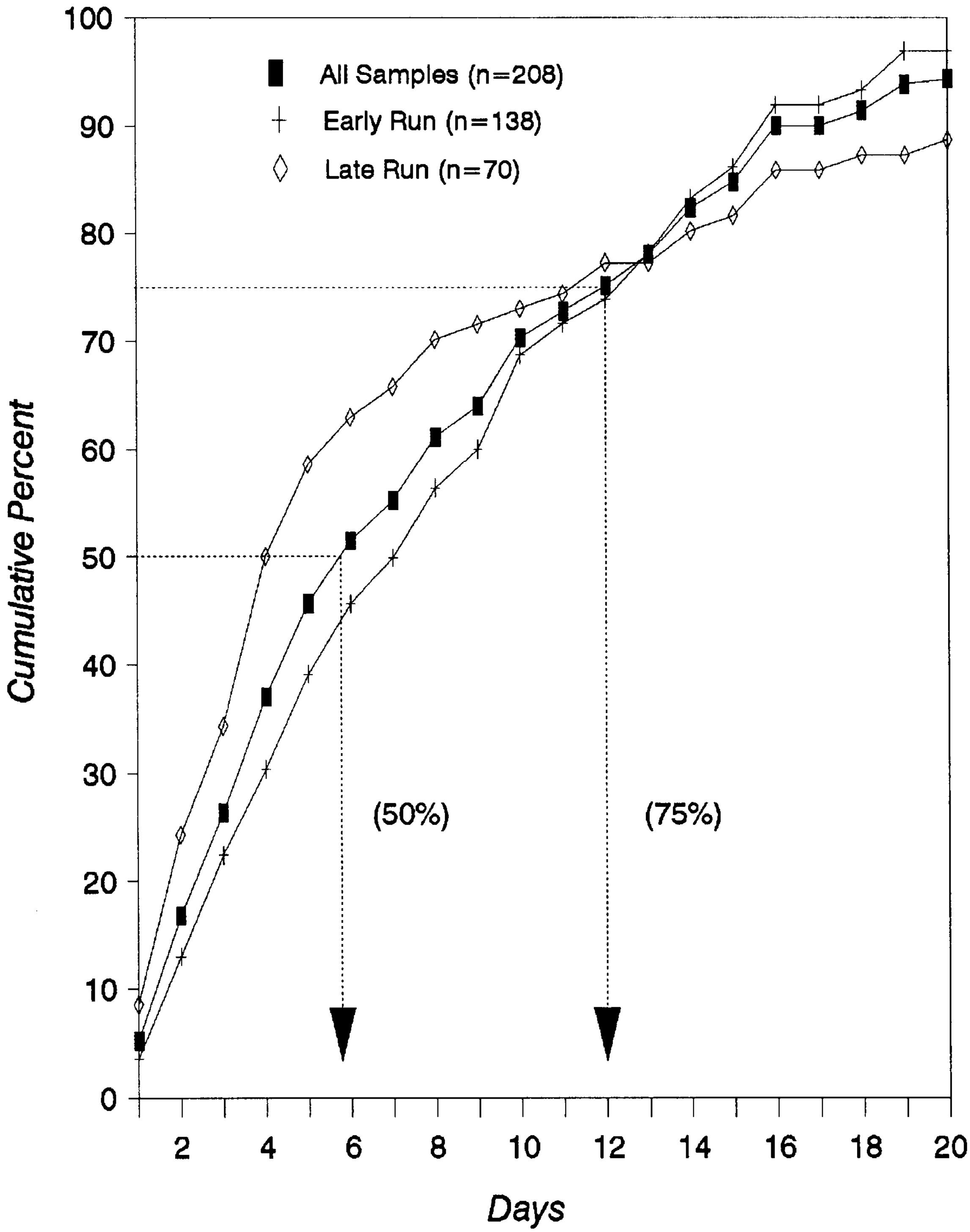


Figure 7. Duration of time for radio-tracked chinook salmon to exit the sport fishery from point of release to the upper data collection computer located at river kilometer 30.6, 1989-1991.

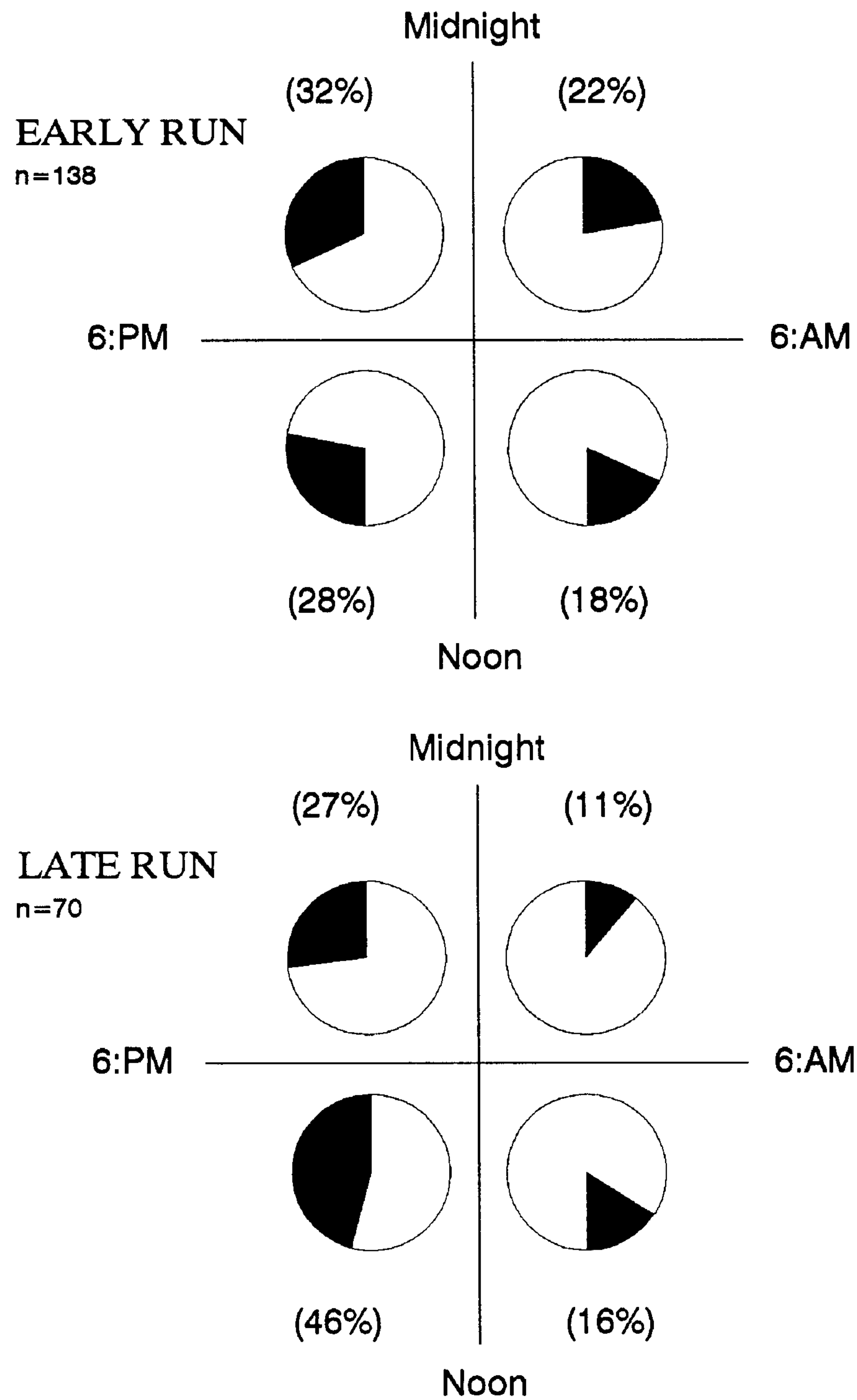


Figure 8. Proportions of radio-tracked chinook salmon moving during quarter-day intervals based on the times of initial contact at the upper data collection computer, 1989-1991.

Table 15. Spawning distributions by location or river reach for early- and late-run radio-tracked chinook salmon, 1989-1991.

Destination	1989 Late Run	1990 Early Run	1990 Late Run	1991 Early Run	All
TRIBUTARIES:					
Slikok Creek	0	1	1	2	4
Funny River	0	19	0	16	35
Killey River	0	39	0	28	67
Benjamin Creek	0	4	1	21	26
Skilak Lake	1	2	0	0	3
Juneau Creek	0	1	1	1	3
Russian River	0	0	1	0	1
Quartz Creek	0	1	0	2	3
Grant Creek	0	1	0	0	1
MAINSTEM:					
Lower	11	8	33	1	53
Middle	15	10	22	5	52
Upper	6	3	9	1	19
Interlake	6	5	4	0	15
Totals	39	94	72	77	282

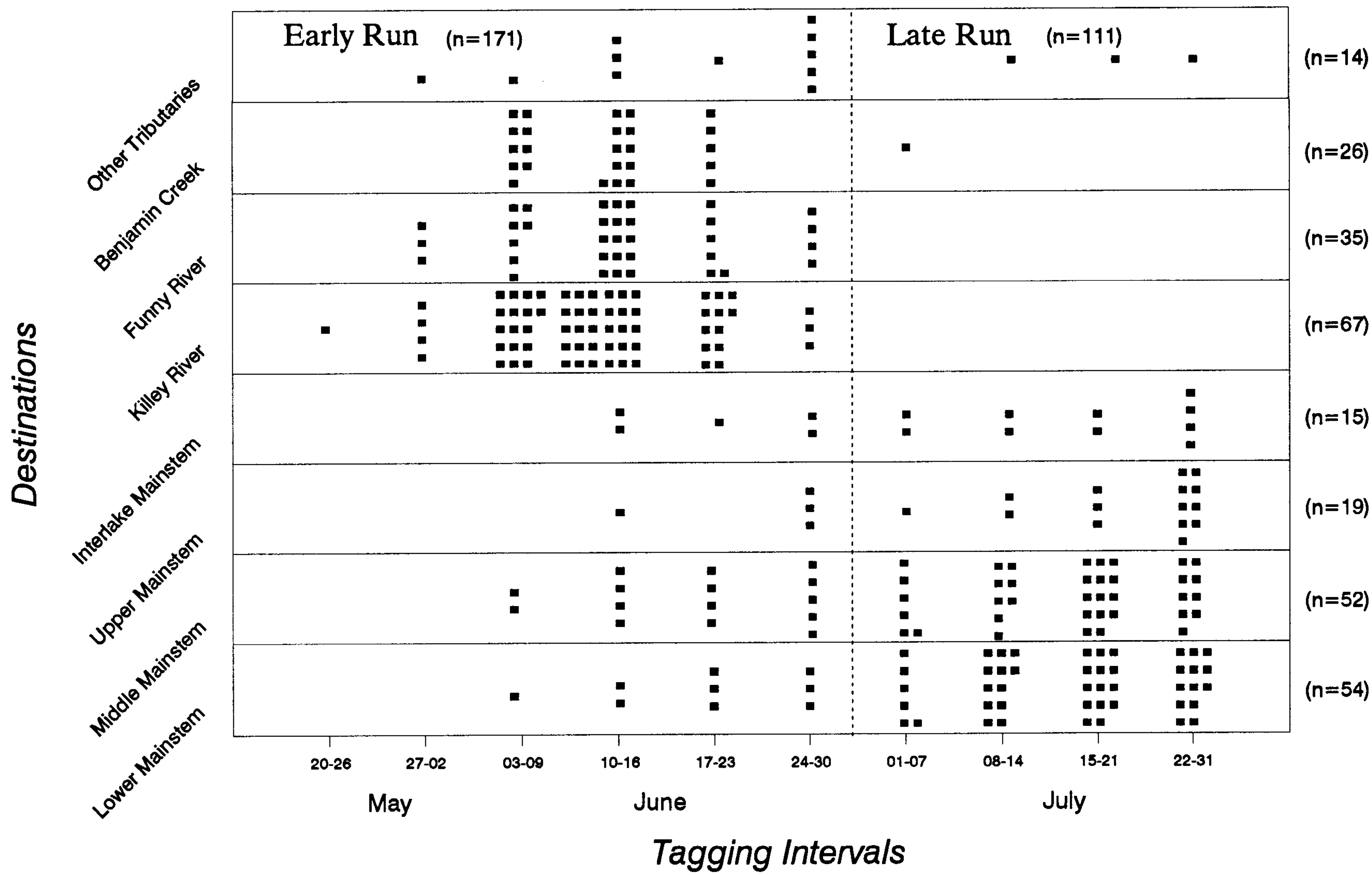


Figure 9. Spawning destinations for 282 radio-tracked chinook salmon by weekly intervals of capture and release, 1989-1991.

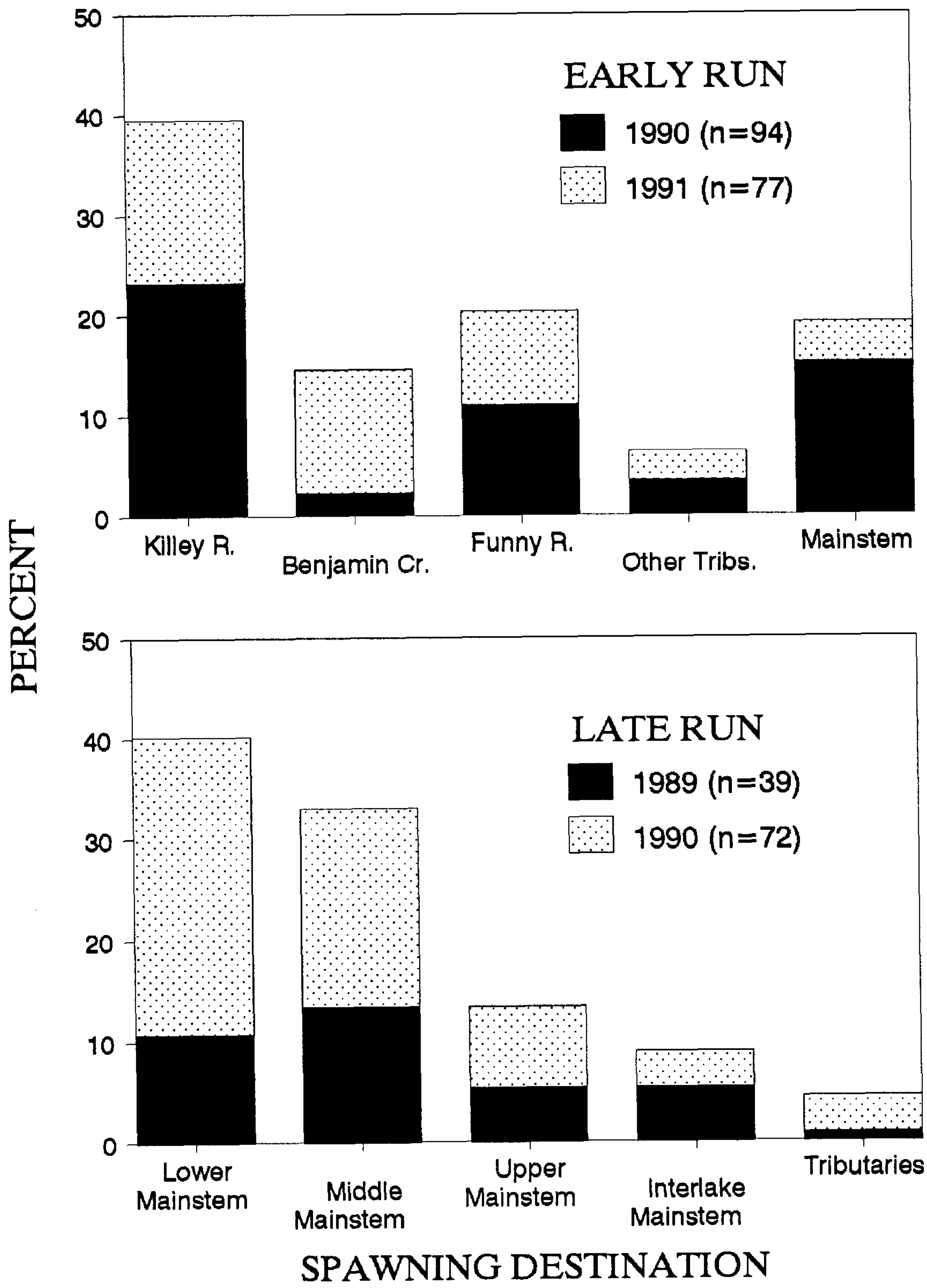


Figure 10. Spawning destinations for 282 radio-tracked chinook salmon by location or river reach for early and late runs, 1989-1991.

reaches (Figure 10). Completion of late-run spawning activity, evidenced by consecutive mortality signals or downstream movement from maximum upper locations, occurred from 24 July through 11 September with a median spawning date of 17 August. Median spawning date for radio-tracked fish was earliest for the lower reach (10 August), latest for the upper reach (25 August), and intermediate for the middle and interlake reaches (16 and 22 August, respectively).

Stream Life of Tagged Fish:

The duration of time between tagging and death (stream life) was calculated for 282 fish that were judged to have spawned (Table 16). Mean stream life was 33 days (SE = 0.609) and ranged from 8 to 67 days. Stream life was significantly longer for tributary spawners (mean = 35.1 d, SE = 0.7428) and consequently for early-run fish, than for mainstem spawners (mean = 30.3 d, SE = 0.9846). Fish that spawned in Benjamin Creek had the longest stream life (41.5 d) and mainstem spawners had the shortest (30.5 d).

Chinook salmon tracked to small tributaries such as Slikok, Juneau, and Quartz creeks spent a larger proportion of their stream life in the mainstem than fish utilizing the Funny and Killey rivers or Benjamin Creek. Tagged fish utilizing small tributaries expended 91% of their average stream life in the mainstem, while fish utilizing Benjamin Creek, Killey, and Funny rivers expended 58% in the mainstem. Consequently, radio-tracked chinook salmon spent an average of only 5.9 days in small tributaries compared to 13.3 days in the larger tributaries.

DISCUSSION

Hook-and-Release Mortality

Hook-and-release mortality was found to be significantly smaller than a management tolerance level of 20% established at the outset of this study. Further, hook-and-release mortality estimated in this study includes the effect of handling and tagging which cannot be subtracted. For the four experiments, mortality after 5 days was estimated at 10.6%, 8.8%, 5.9% and 4.0% for the late 1989 run, the early 1990, the late 1990, and the early 1991 runs. The average mortality for the combined experiments was 7.6%. The 95% confidence intervals for these four estimates were well above the 80% tolerance level that we established (Figure 5).

Although the four experiments did differ in several areas, including the size and sex distributions, the rate and pattern of censoring and the distribution of fishery variables, the effect of being hooked and released (i.e. survival) in the Kenai River was the same for all experiments. The only factors that significantly affected mortality were hooking location and bleeding. A chinook salmon that was gilled had a significantly reduced chance of surviving compared to a salmon that was not gilled. However, the frequency of chinook salmon that were hooked in the gills was small in all four experiments (Figure 11), thus the overall effect of this factor was minimal.

There are consistent differences in mortality among size-sex groups throughout the experiments. Mortality is highest for small males, ranging from 9.2% to

Table 16. Stream life statistics for radio-tracked chinook salmon categorized by run timing and spawning location.

Category	n	Stream Life (Days)				
		Min.	Max.	Avg.	Median	SE
Early Run	171	12	67	35.1	35	0.743
Late Run	111	8	56	30.3	30	0.985
Mainstem	140	8	60	30.5	30	0.918
Killey River	67	20	56	36.1	36	1.016
Benjamin Cr.	26	31	60	41.5	40	1.271
Funny River	35	17	67	31.4	31	1.625
Other Tribs	14	18	45	36.2	37	1.884
All	282	8	67	33.2	33	0.609

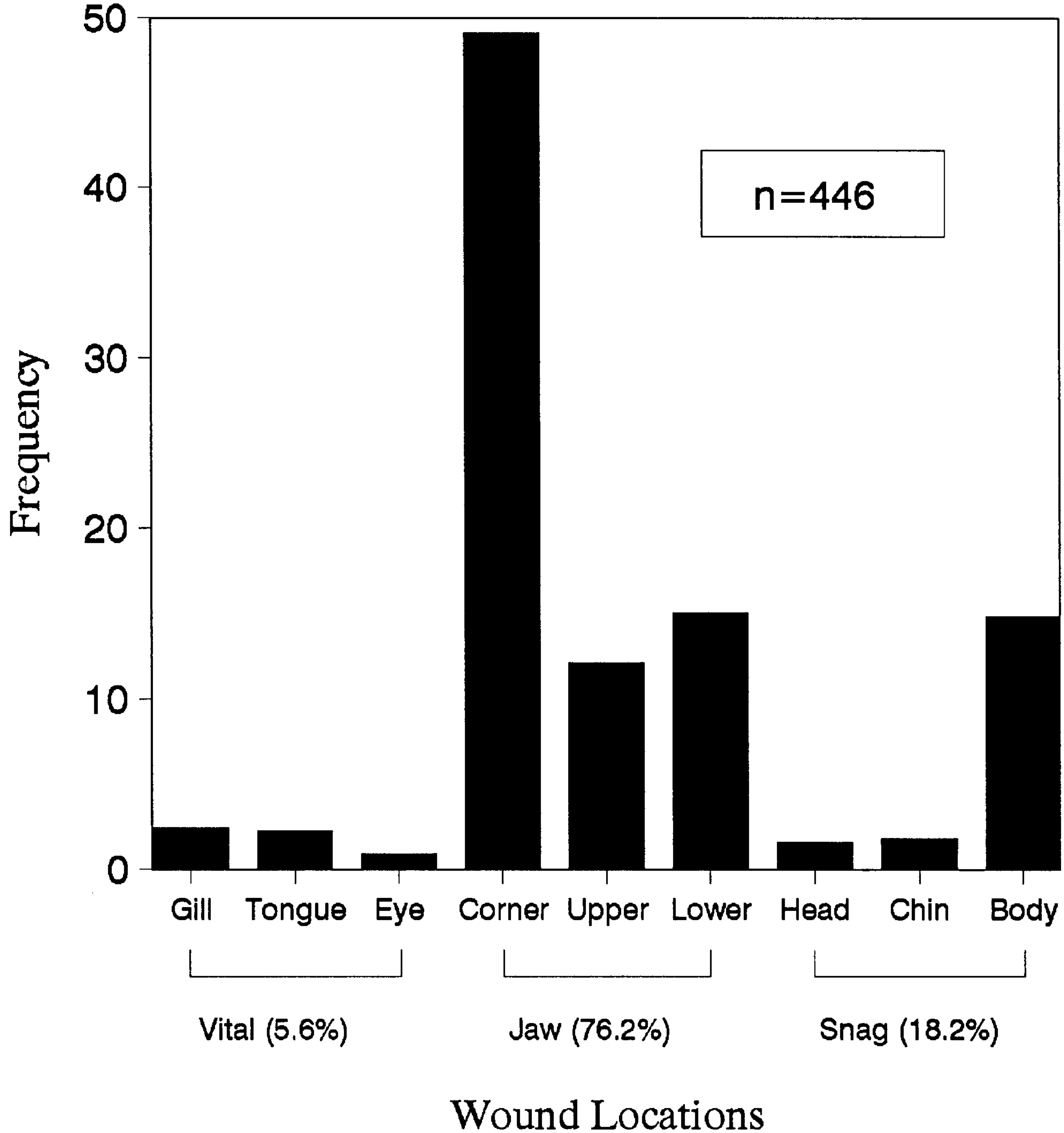


Figure 11. Distribution of hooking wounds for 446 chinook salmon that were caught and released in the Kenai River recreational fishery, 1989-1991.

17.6% (Figure 6). For large males, estimates range from 0 to 9.7%, and for females, estimates range from 3.3% to 10.7%.

The censoring pattern was very different for the late run in 1989 compared to any of the other experiments. In 1989, females were retained in the recreational fishery at a higher rate than males, and the overall level of censoring was higher in this experiment than in the 1990 (Bendock and Alexandersdottir 1990) or 1991 experiments. The reason for this difference cannot be determined, and although it does affect the analysis of the data, it did not lead to significantly different results among the experiments. During the late run, a larger number of salmon backed out of the Kenai River after release without subsequently returning, compared to the early run. Some of these late-run fish were taken in the setnet commercial fishery, while others were never relocated (dropouts). However, most of these removals occurred after 5 days of release. In 1990, all three early run dropouts were still in the river and were classified survivors 5 days after release, while during the late run only three out of 16 such removals occurred within 5 days of release. Since most of these fish can be classified as survivors with respect to the 5-day hook-and-release experiment, we can assume negligible affect on the estimate of hook-and-release mortality. There were proportionately more small males caught and released during the late run in 1990 than during the early 1990 run or the late 1989 run, due to the age composition of that run. The distribution of fishery variables differed among the runs, largely due to management regulations, but no relationship was found associating these fishery variables with fate.

Chinook Salmon Movements

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), Skagit River (Granstrand and Gibson 1980), and Taku River (Eiler 1990). 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 salmon 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 transmitters or handling procedures. Upon release, some tagged salmon continued upstream movement, while others moved downstream or remained in place. Eight fish were re-caught in the sport fishery and retained on the same day they were tagged and released. Anecdotal evidence from both 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.

The maximum upstream distance (34 km) traveled by a radio-tracked chinook salmon during 24 h in this study is slightly further than that reported in other studies using telemetry. Maximum distances reported for 24 h movements have ranged from 17 km on the Skagit River (Granstrand and Gibson 1980) to 29 km for the Kenai River (Burger et al. 1983). Burger et al. (1983) reported that early-run chinook salmon in the Kenai River migrated at a significantly higher daily rate than late-run fish, however, we found the mean rate of movement for early-run fish that moved through the lower Kenai River to be less than that of late-run fish. Our observation that most diel movement of chinook salmon occurs during the second half of the day between 1200 and 2400 hours is 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. The majority (58%) of our tagged fish either remained in place or had moved downstream when first relocated compared to 53% reported by Burger et al. (1983) in the initial 48 h. This behavior may be in response to capture and handling stress, and/or may result from a weak affinity for upstream movement by fish not fully adapted to their freshwater environment. Similar downstream movements for tagged chinook salmon have been reported by Liscom et al. (1978) and Eiler (1990). 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. ADF&G (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, since more of our tagged fish moved upstream initially during the latter half of each run.

Spawning Destinations

Holding or milling behavior of radio-tracked salmon was observed both enroute to, and near spawning destinations. An average of approximately 1 month transpired between tagging and spawning, and few fish migrated directly to their respective spawning destinations during this period. Lower Kenai River spawners frequently milled for one to several weeks in the upper intertidal reach before migrating the remaining few kilometers 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. One fish held in the vicinity of rkm 16 for 34 days before moving upstream to spawn near rkm 21. Fish that eventually spawned in the interlake reach commonly held for prolonged periods in the lower, middle, or upper river reaches. Early-run fish often entered tributaries such as Beaver Creek or the Funny River for one or more days before continuing up the mainstem to a final destination. Tributaries spawners often milled for extended periods in the mainstem at or below their destination confluence. This behavior was particularly evident for Funny River spawners which held along the south bank between rkm 45 to 48 (rm 28-30) and Slikok Creek spawners which held in "College Hole" below rkm 25. Thus, movement patterns without 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 (1990), 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 the confluence before entering it to spawn. Similar behaviors were observed for chinook salmon spawning in tributaries to the Susitna River (ADF&G 1983). The variability we observed in movement rates for 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 enroute to that location.

Based on the presence of sea lice, the majority (80%) of chinook salmon we tagged had entered the river within a few days of capture (McLean et al. 1990). The average elapsed time between tagging and spawning (33 days) is considerably shorter than the 52 day interval reported for chinook salmon in the Skagit River (Granstrand and Gibson 1980). Most (81%) early run fish spawned in tributaries, while most (96%) late run fish spawned in the mainstem Kenai River. The selection of spawning destinations, peak spawning periods, and the lower river kilometer limit for spawning that we observed for radio-tracked fish are consistent with the findings of Burger et al. (1983).

Spawning locations for radio-tracked chinook salmon in the Kenai River have been described in three separate investigations (Figure 12). Experimental designs used in these studies did not accommodate deploying transmitters in proportion to fish abundance. However, the distribution of final destinations for radio-tracked fish in these studies may provide insight into the spawning distributions for Kenai River chinook salmon. Based on the combined findings from these investigations, radio-tracked fish in the early run spawn primarily in the Killey River drainage (58%), followed by the Funny River (19%), mainstem (16%), and other tributaries (7%) (Figure 12). Radio-tracked fish in the late run spawn primarily in the lower river (40%), middle river (26%), upper river (19%), interlake reach (13%), and in tributaries (2%). The distribution of spawners among river reaches varied between investigations. Only 2.5% of the early run fish tagged by Burger et al. (1983) spawned in the mainstem compared to 19% in our study. During the late run, 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. The fraction of early-run spawners that utilized Benjamin Creek in our study varied from 4% in 1990 to 28% in 1991. We do not know if homing occurs to specific spawning reaches, or if variability in use occurs in response to seasonal environmental conditions or intraspecific factors that affect production. However, the disproportionately high sport fishing harvest that occurs in the lower 32 river kilometers (Hammarstrom 1989) likely targets on lower-river spawners.

Implications for Fishery Management

The chinook salmon recreational fishery is managed in two distinct components (early and late) with separate management objectives for each run (McBride and Hammarstrom 1990). The Cook Inlet commercial gill net fishery is not prosecuted during the early run, but harvests late run chinook salmon in salt water. Hydroacoustic assessment (sonar) is used to estimate total inriver return. The sonar facility is located at rkm 13.6 in the intertidal zone of the river.

Findings on the movements of radio-tracked chinook salmon that have been caught and released may explain anecdotal reports of salmon with sport tackle occurring in Cook Inlet commercial catches. Caught and released fish backed down to Cook Inlet during both the early and late runs; however most of the early-run fish returned to fresh water, while most late-run fish were either caught in set gill nets or disappeared from the study. If salmon backed down to Cook Inlet in response to hooking events, it is possible that mandatory catch and release fishing during a late run conservation shortfall may result in higher gill net mortalities, due to sustained high catch rates in the lower river recreational fishery.

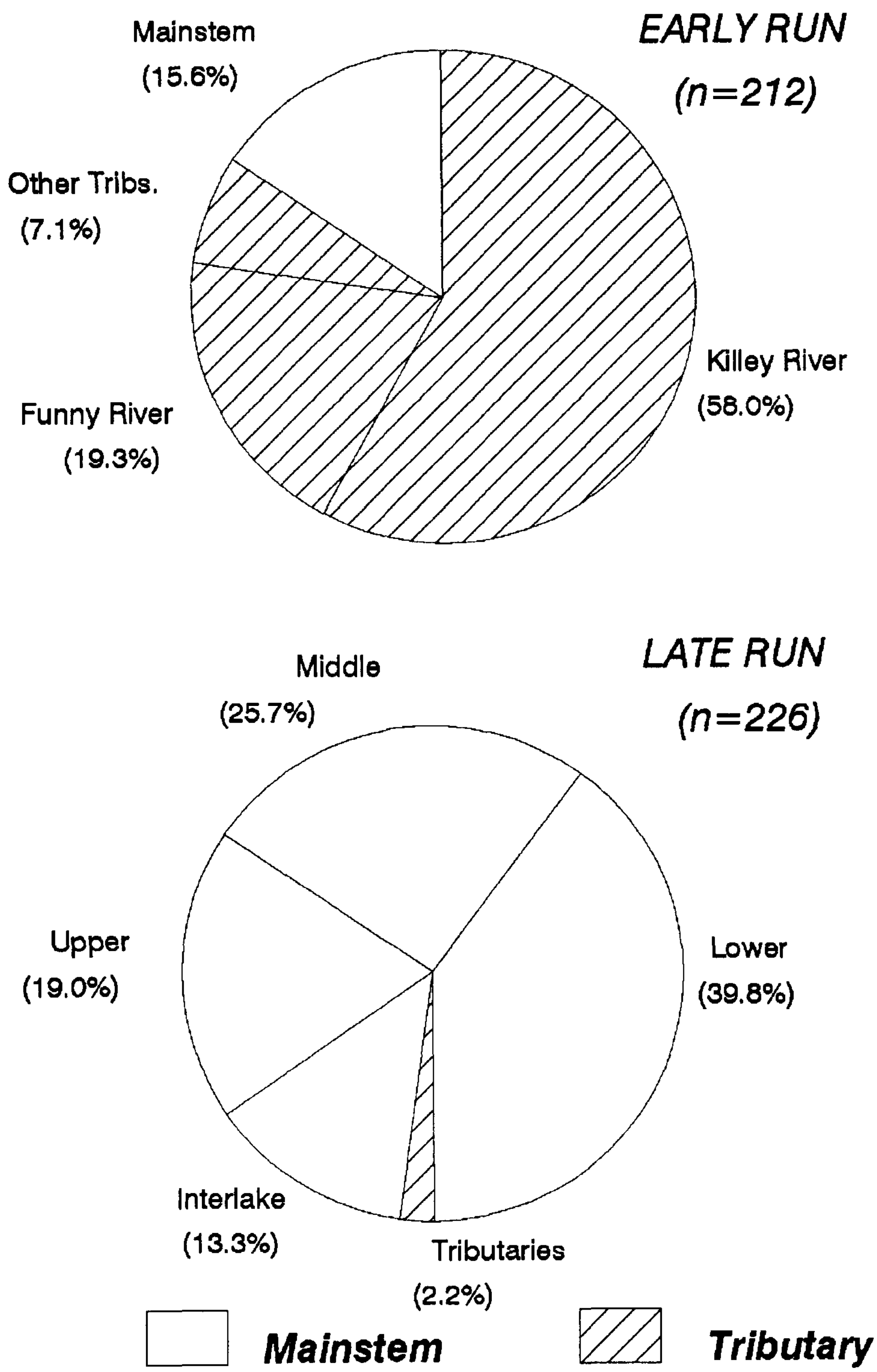


Figure 12. Spawning destinations for 438 radio tracked chinook salmon by location or river reach, 1979 to 1991 (Burger et al. 1983, Hammarstrom et al. 1985, Bendock and Alexandersdottir 1990 and 1991).

Salmon that back downstream and possibly return upstream a second time, or mill in the lower Kenai River, may result in multiple sonar counts which can affect the accuracy of the inriver return estimate. Other studies have shown that salmon may return to salt water after being handled in fresh water (S. Hammarstrom, Alaska Department of Fish and Game, personal communication; J. Eiler, National Marine Fisheries Service, personal communication), and there is abundant anecdotal evidence of these movements based on the presence of sportfishing tackle (hooks and lures) on salmon caught in Cook Inlet gill net fisheries.

The slow exodus of early-run fish from the reach of river open to fishing makes them vulnerable to harvest throughout much of the late run. Since early-run fish can not be physically distinguished from late run fish, additional closures in the fishery may be necessary to protect them from harvest during the late run in years of a conservation shortfall.

All of the chinook salmon used in this study were hooked and released at least once, and 48 of these fish (the sport harvested component) were hooked at least twice. Anglers reported additional hook-and-release events for 18 fish during the 3 years of study; thus, at least 15% of the fish in this study were hooked multiple times. Of fish that were released more than once, the proportion that spawned was half of the overall rate, while the proportion of drop outs was three times higher. Additional hooking events and subsequent injuries may explain the abrupt downstream movements we observed in some fish that had penetrated several kilometers upstream. Furthermore, as catch rates increase in the sport fishery, mortality may also increase due to cumulative injury from multiple hooking events.

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APPENDIX A

DETAILED CAPTURE AND RELEASE INFORMATION FOR EACH CHINOOK SALMON TAGGED DURING 1991

Appendix A. Detailed capture and release information for each chinook salmon tagged during 1991[a].

No.	Date Rele.	Water Temp.	River Mile	Time of Day	Seconds Played	Seconds To Tag	Method	Gear	#1 Hook Injury	#2 Hook Injury	Numb Hooks	Type Hook	Hook Removed	Length (mm)	Sex	Bleed-ing?	Where	Sea Lice	Condi-tion	RM Rele	Guided	5 Day Fate	Final Fate
246	5/28/91	45	14.0	847	209	299	BT	AL	U		2	T	Y	690	M	N		N	V	14.0	Y	S	SP
247	5/28/91	45	13.0	940	203	227	BT	AL	S		2	T	Y	750	M	N		N	V	12.8	Y	S	SP
248	5/28/91	45	13.0	1010	154	174	BT	AL	L		2	S	Y	610	M	N		Y	V	13.0	N	S	TA
249	5/28/91	45	14.3	1236	240	215	BT	AL	S		2	T	Y	745	F	N		Y	V	14.0	Y	S	SP
250	5/28/91	45	14.3	1246	240	237	BT	AL	S	I	2	T	Y	715	M	N		Y	V	14.0	Y	S	SP
251	5/29/91	44	13.3	744	290	196	BT	AL	U	K	2	T	Y	755	M	N		Y	V	13.3	Y	S	SP
252	5/30/91	44	14.0	715	180	260	BT	AL	S		2	S	Y	460	M	N		Y	V	14.0	Y	S	UP
253	6/01/91	46	14.5	650	179	266	BT	AL	F		2	S	N	800	M	N		N	V	14.3	Y	S	SP
254	6/04/91	47	12.5	730	1173	234	BT	AL	S		2	T	Y	995	F	N		Y	V	11.8	Y	S	SP
255	6/04/91	47	12.5	832	254	213	BT	AL	K	S	2	T	Y	880	F	N		Y	V	12.0	Y	S	SP
256	6/04/91	47	11.3	942	322	226	BT	AL	S		2	T	Y	980	F	N		Y	V	11.0	Y	S	SP
257	6/04/91	47	10.5	1003	152	202	BT	AL	L	S	2	T	Y	800	M	N		Y	V	10.5	Y	S	FA
258	6/05/91	46	14.3	650	200	196	BT	AL	U	T	2	S	Y	795	M	N		Y	V	14.0	Y	S	SP
259	6/05/91	46	14.5	741	450	187	BT	AL	K	S	2	S	Y	705	M	Y	I	Y	V	14.3	Y	S	SP
260	6/05/91	46	14.5	807	135	196	BT	AL	L	U	2	T	Y	760	M	N		Y	V	14.5	Y	S	SP
261	6/05/91	46	14.5	1146	93	268	BT	AL	K	S	2	T	Y	710	M	Y		N	V	14.3	N	S	SP
262	6/06/91	45	14.8	712	154	200	BT	AL	K		1	S	Y	850	F	N		Y	V	14.3	Y	S	SP
263	6/06/91	45	14.8	817	210	765	BT	AL	T		1	S	Y	910	F	Y	T	Y	L	14.3	Y	M	M
264	6/06/91	45	14.8	903	634	249	BT	AL	L		1	S	Y	1115	M	N		N	V	14.5	N	S	SP
265	6/06/91	45	14.5	941	230	246	BT	AL	K		1	S	Y	805	M	N		Y	V	14.3	Y	S	SP
266	6/06/91	45	11.0	1057	600	257	BT	AL	R		1	S	Y	1020	M	Y	R	Y	V	10.5	Y	S	SP
267	6/06/91	45	14.8	1227	521	220	BT	AL	T		1	S	N	820	F	Y	T	Y	V	14.3	Y	M	M
268	6/06/91	45	13.0	1309	209	233	BT	AL	F		1	S	Y	1035	M	N		Y	V	12.8	Y	S	SP

-continued-

Appendix A. (Page 2 of 5).

No.	Date Rele.	Water Temp.	River Mile	Time of Day	Seconds Played	Seconds To Tag	Method	Gear	#1 Hook Injury	#2 Hook Injury	Numb Hooks	Type Hook	Hook Removed	Length (mm)	Sex	Bleed-ing?	Where	Sea Lice	Condi-tion	RM Rele	Guided	5 Day Fate	Final Fate
269	6/06/91	45	14.3	1344	1980	362	BT	AL	R		1	S	Y	1050	M	N		Y	V	13.0	Y	S	SP
270	6/07/91	46	15.0	734	651	251	BT	AL	K		1	S	Y	1070	M	N		N	V	14.3	Y	S	SP
271	6/07/91	46	14.8	805	132	242	BT	AL	U		1	S	Y	750	M	N		Y	V	14.3	Y	S	SP
272	6/07/91	46	13.3	1011	320	189	BT	AL	K		1	S	Y	830	F	N		Y	V	13.0	Y	S	H
273	6/07/91	46	12.5	1128	276	217	BT	AL	U		1	S	Y	750	M	N		Y	V	12.3	Y	S	SP
274	6/07/91	46	14.5	1210	137	181	BT	AL	K		1	S	Y	900	F	N		Y	V	14.3	Y	S	SP
275	6/07/91	46	12.5	1242	400	241	BT	AL	K		1	S	Y	940	F	N		Y	V	12.0	N	S	SP
276	6/07/91	46	12.5	1256	60	257	BT	AL	L		1	S	Y	820	M	N		Y	V	12.3	N	S	SP
277	6/08/91	46	14.5	652	372	275	BT	AL	K		1	S	Y	1085	M	N		N	V	14.5	Y	S	SP
278	6/08/91	46	15.5	703	324	231	BT	AL	K		1	S	Y	795	M	N		Y	V	15.3	Y	S	SP
279	6/08/91	46	15.5	741	160	207	BT	AL	L		1	S	Y	1000	F	N		Y	V	14.3	Y	S	SP
280	6/12/91	49	13.5	654	193	200	BT	AL	U		1	S	Y	995	F	N		Y	V	13.0	N	S	M
281	6/12/91	49	13.0	707	120	211	BT	AL	K		1	S	Y	820	F	N		N	V	12.8	Y	S	SP
282	6/12/91	49	13.5	737	283	218	BT	AL	K		1	S	Y	975	F	N		Y	V	12.8	Y	S	SP
283	6/12/91	49	13.5	743	600	210	BT	AL	L		1	S	Y	830	M	N		N	V	12.8	Y	S	SP
284	6/12/91	49	13.3	750	600	199	BT	AL	S		1	S	Y	970	F	N		Y	V	12.5	N	S	SP
285	6/12/91	49	12.0	804	600	148	BT	AL	L		1	S	Y	740	M	N		Y	V	11.8	Y	S	SP
286	6/12/91	49	11.5	818	276	186	BT	AL	K		1	S	Y	915	F	N		Y	V	10.8	N	S	SP
287	6/12/91	49	11.5	824	209	219	BT	AL	R		1	S	Y	950	F	N		Y	V	11.0	Y	S	SP
288	6/12/91	49	11.5	852	196	213	BT	AL	K		1	S	Y	915	F	N		Y	V	11.0	Y	S	FA
289	6/12/91	49	12.0	930	485	230	BT	AL	R		1	S	Y	960	F	N		Y	V	11.3	Y	S	SP
290	6/13/91	49	13.3	701	110	282	BT	AL	L		1	S	N	970	M	N		Y	V	13.0	Y	S	SP
291	6/13/91	50	13.0	711	170	175	BT	AL	U		1	S	Y	920	M	Y	U	Y	V	12.8	Y	S	SP

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Appendix A. (Page 3 of 5).

No.	Date Rele.	Water Temp.	River Mile	Time of Day	Seconds Played	Seconds To Tag	Method	Gear	#1 Hook Injury	#2 Hook Injury	Numb Hooks	Type Hook	Hook Removed	Length (mm)	Sex	Bleed-ing?	Where	Sea Lice	Condi-tion	RM Rele	Guided	5 Day Fate	Final Fate
292	6/13/91	50	13.3	724	105	179	BT	AL	K		1	S	Y	965	F	N		Y	V	13.0	N	S	SP
293	6/13/91	50	12.5	808	770	235	BT	AL	L		1	S	Y	1095	M	N		Y	V	11.8	N	S	SP
294	6/13/91	50	12.0	836	231	180	BT	AL	U		1	S	Y	815	M	N		Y	V	11.8	Y	S	SP
295	6/13/91	50	13.0	857	300	169	BT	AL	L		1	S	Y	875	F	N		Y	V	12.8	Y	S	SP
296	6/13/91	50	12.3	915	376	277	BT	AL	K		1	S	Y	910	F	N		N	V	11.5	Y	S	SP
297	6/13/91	50	12.5	946	600	259	BT	AL	U		1	S	Y	815	M	N		Y	V	12.0	N	S	SP
298	6/13/91	50	12.3	1000	120	190	BT	AL	K		1	S	Y	855	F	Y	K	Y	V	12.0	Y	S	SP
299	6/13/91	50	12.0	1008	215	213	BT	AL	K		1	S	Y	825	M	N		Y	V	11.8	Y	S	H
300	6/13/91	50	11.5	1018	168	192	BT	AL	U		1	S	Y	910	F	N		Y	V	11.0	N	S	SP
301	6/13/91	50	13.3	1058	284	297	BT	AL	U		2	S	Y	995	F	N		Y	V	12.8	Y	S	SP
302	6/13/91	50	13.3	1110	204	186	BT	AL	L		2	S	Y	680	M	N		Y	V	12.8	N	S	SP
303	6/15/91	50	14.3	651	214	184	BT	AL	K		1	S	Y	860	F	N		Y	V	14.0	Y	TA	TA
304	6/15/91	50	14.5	712	269	193	BT	AL	K		1	S	Y	630	M	N		Y	V	14.3	Y	S	SP
305	6/15/91	50	14.0	746	300	215	BT	AL	K		1	S	Y	1045	F	Y	I	N	V	13.8	N	S	SP
306	6/15/91	50	13.3	826	300	270	BT	AL	T		1	S	N	925	F	N		Y	V	13.0	Y	S	SP
307	6/15/91	50	13.0	841	480	202	BT	AL	K		1	S	Y	1015	F	N		Y	V	12.8	N	S	SP
308	6/15/91	50	12.8	854	637	222	BT	AL	U		1	S	Y	1035	M	N		Y	V	12.3	Y	S	SP
309	6/15/91	50	13.0	902	600	179	BT	AL	L		1	T	Y	815	M	N		Y	V	12.3	N	S	SP
310	6/15/91	50	12.8	921	420	184	BT	AL	G		1	S	N	845	M	Y	G	Y	V	12.5	Y	S	SP
311	6/15/91	50	13.0	949	300	230	BT	AL	K		1	S	Y	795	M	Y	K	Y	V	12.8	N	S	SP
312	6/15/91	50	14.5	1212	163	321	BT	AL	K		1	S	Y	910	F	N		Y	V	14.3	N	S	UP
313	6/18/91	50	14.5	637	480	268	BT	AL	L		1	S	N	890	F	N		Y	V	14.3	Y	S	DR
314	6/18/91	50	14.5	653	156	171	BT	AL	K		1	S	Y	945	F	Y	K	Y	V	14.3	Y	S	SP

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Appendix A. (Page 4 of 5).

No.	Date Rele.	Water Temp.	River Mile	Time of Day	Seconds Played	Seconds To Tag	Method	Gear	#1 Hook Injury	#2 Hook Injury	Numb Hooks	Type Hook	Hook Removed	Length (mm)	Sex	Bleed-ing?	Where	Sea Lice	Condi-tion	RM Rele	Guided	5 Day Fate	Final Fate
315	6/18/91	50	13.3	717	142	232	BT	AL	K		1	S	Y	555	M	N		Y	V	13.0	Y	S	SP
316	6/18/91	50	13.0	727	189	195	BT	AL	L		1	S	Y	945	F	N		Y	V	12.8	Y	S	SP
317	6/18/91	50	13.0	731	345	168	BT	AL	K		1	S	Y	1025	M	N		Y	V	12.3	Y	S	SP
318	6/18/91	50	13.3	751	178	195	BT	AL	K		1	S	Y	960	F	N		Y	V	13.0	Y	S	SP
319	6/18/91	50	13.0	813	85	332	BT	AL	K		1	S	Y	535	M	Y	K	N	V	12.8	N	M	M
320	6/18/91	50	13.0	839	310	243	BT	AL	U		1	S	Y	865	F	N		Y	V	12.8	Y	S	SP
321	6/18/91	50	12.0	905	174	181	BT	AL	K		1	S	Y	720	M	N		Y	V	11.8	Y	S	M
322	6/18/91	50	12.0	917	215	170	BT	AL	U		1	S	Y	860	M	Y	U	Y	V	11.8	N	TA	TA
323	6/19/91	48	13.0	721	270	196	BT	AL	L		1	S	Y	905	F	N		Y	V	12.5	N	S	SP
324	6/19/91	48	13.0	746	350	235	BT	AL	G		1	S	N	1060	M	Y	G	N	V	12.3	N	S	SP
325	6/19/91	48	13.0	804	139	195	BT	AL	L		1	S	Y	970	F	N		Y	V	12.5	N	S	UP
326	6/19/91	48	12.0	902	229	263	BT	AL	L		1	S	Y	860	M	N		Y	V	11.5	N	S	SP
327	6/19/91	48	12.5	1009	380	210	BT	AL	K		1	S	Y	1065	M	N		Y	V	12.0	N	S	SP
328	6/19/91	48	11.3	1114	225	194	BT	AL	K		1	S	Y	925	F	Y	K	Y	V	11.0	Y	S	DR
329	6/19/91	48	11.5	11.3	450	185	BT	AL	K		1	S	Y	940	F	N		N	V	11.3	Y	S	SP
330	6/19/91	48	11.3	1148	157	143	BT	AL	U		1	S	Y	800	M	N		N	V	10.8	Y	S	SP
331	6/19/91	48	11.5	1158	917	213	BT	AL	K		1	S	Y	970	F	N		Y	V	10.5	Y	S	DR
332	6/22/91	50	13.0	750	181	211	BT	AL	K		1	S	Y	925	F	N		Y	V	12.8	Y	S	SP
333	6/22/91	50	13.3	758	900	211	BT	AL	K		1	S	Y	890	F	N		Y	V	13.0	Y	S	SP
334	6/22/91	50	13.0	926	254	188	BT	AL	U		1	S	Y	1035	M	N		Y	V	12.5	N	S	SP
335	6/22/91	50	12.0	955	129	230	BT	AL	K		1	S	Y	800	F	Y	G	Y	V	11.5	Y	S	SP
336	6/22/91	50	13.0	1143	237	334	BT	AL	U		1	S	Y	730	M	Y	U	Y	V	12.5	N	S	H
337	6/22/91	50	13.0	1202	227	168	BT	AL	K		1	S	Y	885	F	N		Y	V	12.5	N	S	UP

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Appendix A. (Page 5 of 5).

No.	Date Rele.	Water Temp.	River Mile	Time of Day	Seconds Played	Seconds To Tag	Method	Gear	#1 Hook Injury	#2 Hook Injury	Numb Hooks	Type Hook	Hook Removed	Length (mm)	Sex	Bleed-ing?	Where	Sea Lice	Condi-tion	RM Rele	Guided	5 Day Fate	Final Fate
338	6/25/91	50	14.0	700	600	229	BT	AL	L		1	S	Y	1005	M	N		N	V	13.3	Y	S	H
339	6/25/91	50	13.0	721	150	259	BT	AL	U		1	S	Y	590	F	N		Y	V	12.5	Y	S	SP
340	6/25/91	50	12.0	826	120	222	BT	AL	K		1	S	Y	905	F	N		Y	V	11.5	Y	S	SP
341	6/25/91	50	14.3	1157	1200	321	BT	AL	S		1	S	Y	1165	M	N		Y	V	12.8	Y	S	SP
342	6/27/91	48	12.0	806	1321	390	BT	AL	K		1	S	N	1115	M	N		N	V	10.3	Y	S	H
343	6/27/91	48	13.3	1028	600	242	BT	AL	U		1	S	Y	885	F	N		Y	V	13.0	Y	S	SP
344	6/27/91	48	13.3	1110	360	302	BT	AL	U		1	S	Y	920	F	N		Y	V	13.0	Y	S	SP
345	6/28/91	48	13.0	650	120	364	BT	AL	G	S	2	T	Y	610	M	Y	G	Y	V	12.5	Y	M	M
346	6/29/91	48	12.0	915	50	314	BT	AL	L		2	T	Y	530	M	N		Y	V	11.8	N	TA	TA

a

Fishing Method
BB - Back Bounce
BT - Back Troll
DR - Drift

Terminal Gear
AL - Artificial lure
CO - Combination bait and lure

Hook Injuries
C - Chin
F - Floor of mouth
G - Gill
H - Head(snag)
I - Eye
K - Corner of mouth
L - Lower jaw
R - Roof of mouth
S - Snag
T - Tongue
U - Upper jaw

Type of Hook
S - Single
T - Treble

Condition
L - Lethargic
V - Vigorous

Fates
H - Sport Harvest
M - Mortality
S - Survivor
DR - Fish dropped out to Cook Inlet and did not return
FA - Tag Failure
SE - Caught in commercial set net
SP - Spawner
SU - Caught in subsistence net fishery
TA - Caught in ADF&G tagging crew's net
UN - Unknown
UP - Lost signal after fish moved upstream

APPENDIX B

MOVEMENT RECORDS FOR EARLY RUN CHINOOK SALMON
THAT WERE TAGGED DURING 1991

Appendix B. Movement records for early-run chinook salmon that were tagged during 1991.

			River Mile Locations By Date and [Final Fates]																							
No.	Date Tagged	RM Tagged	5/29	5/30	5/31	6/02	6/03	6/04	6/05	6/06	6/07	6/08	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/18	6/19	6/20	6/21	6/22	6/24	6/25
246	5/28/91	14.0	13.0	14.5	16.0	21.0	20.0	17.0	18.0	22.0	21.0	21.0	21.0	19.0	21.0	27.0	46.0	48.0	KIL	KIL		KIL		KIL		KIL
247	5/28/91	12.8	14.5	14.5	17.0	16.0	17.0	18.0	19.0	21.0	21.0	21.0	19.0	19.0	19.0	19.0	19.0	20.0	19.0	19.0	19.0	22.0	27.0	30.0	30.0	30.0
248	5/28/91	13.0	10.0	10.0	10.0	10.0	10.0	9.0	9.0	[caught by tagging crew at RM 8.3 on 6/06/91]																
249	5/28/91	14.0	14.5	9.0	6.5	12.0	12.0	7.0	9.0	OUT	6.5	13.0	11.5	6.5	5.0	OUT	3.0	6.0	12.0	4.0	6.5	8.0		10.0	10.0	
250	5/28/91	14.0	13.0	14.5	16.0	16.0	14.5	14.5	14.5	14.5	17.0	21.0	14.5	16.0	16.0	16.0	17.0	22.0	22.0	22.0	20.0	22.0	26.0	27.0	27.0	30.0
251	5/29/91	13.3		13.0	8.5	16.0	16.0	16.0	17.0	17.0	17.0	17.0	16.0	16.0	17.0	19.0	26.0	29.0	30.0	FUN		FUN		FUN	FUN	FUN
252	5/30/91	14.0			7.0	18.0	20.0	24.0	24.0	21.0	21.0	21.0	17.0	18.0	16.0	[tag failure]										
253	6/01/91	14.3				11.0	11.0	11.0	7.0	8.0	11.5	12.0	13.0	11.5	12.0	12.0	12.0	16.0	9.0	9.0	12.0	14.5	27.0	36.0	44.0	KIL
254	6/04/91	11.8							14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	16.0	14.5	14.5	16.0	19.0	25.0	30.0	28.0	18.0	14.5
255	6/04/91	12.0							11.5	11.5	11.5	12.0	11.5	11.0	11.5		11.0	16.0	16.0	10.0	10.0	11.5	12.0	12.0	12.0	12.0
256	6/04/91	11.0							12.0	6.0	11.5	14.0	15.0	16.0	16.0	18.0	16.0	19.0	19.0	19.0	20.0	19.0	21.0	22.0	22.0	22.0
257	6/04/91	10.5							14.5	14.5	17.0	18.0	20.0	25.0	26.0	26.0	34.0	36.0	[tag failure]							
258	6/05/91	14.0								12.0	12.0	12.0	12.0	13.0	13.0	16.0	19.0	19.0	19.0	19.0	19.0	21.0	30.0	36.0	44.0	KIL
259	6/05/91	14.3								14.5	14.5	14.5	14.5	14.5	20.0	20.0	24.0	24.0	24.0	24.0	24.0	22.0	22.0	22.0	22.0	22.0
260	6/05/91	14.5								16.0	17.0	20.0	19.0	19.0	21.0	25.0	25.0	25.0	19.0	19.0	19.0	25.0	36.0	44.0		KIL
261	6/05/91	14.3								14.5	13.0	14.5	14.0	16.0	20.0	21.0	25.0	28.0	FUN	FUN		FUN		FUN	FUN	FUN
262	6/06/91	14.3									17.0	21.0	19.0	19.0	21.0	19.0	19.0	21.0	21.0	23.0	25.0	26.0	30.0	34.0	36.0	36.0
263	6/06/91	14.3									11.5	12.0	11.5	11.5	11.5	[hook-and-release mortality]										
264	6/06/91	14.5									16.0	16.0	16.0	16.0	16.0	16.0	16.0	18.0	23.0	28.0	30.0	36.0	36.0	36.0	44.0	44.0
265	6/06/91	14.3									14.5	17.0	17.0	18.0	18.0	20.0	25.0	26.0	26.0	30.0	31.0	29.0	30.0	FUN	FUN	FUN
266	6/06/91	10.5									19.0	21.0	20.0	23.0	26.0	27.0	30.0	23.0	36.0	36.0	36.0	36.0	46.0	KIL	KIL	KIL
267	6/06/91	14.3									10.0	10.0	10.0	10.0	10.0	[hook-and-release mortality]										
268	6/06/91	12.8									14.5	18.0	14.5	14.0	14.5	14.5	14.5	16.0	19.0	19.0	23.0	23.0	26.0	30.0	30.0	36.0
269	6/06/91	13.0									16.0	20.0	24.0	25.0	25.0	26.0	25.0	25.0	25.0	25.0	28.0	28.0	32.0	36.0	46.0	46.0
270	6/07/91	14.3										14.5	14.5	14.5	14.5	14.5	18.0	19.0	19.0	19.0	25.0	26.0	29.0	30.0	36.0	44.0
271	6/07/91	14.5										14.5	12.0	7.0	8.0		4.5	4.0	OUT	OUT	OUT	3.0	OUT	8.0		12.0
272	6/07/91	13.0										12.0	12.0	11.5	12.0		10.0	10.0	10.0	8.0	5.0	11.5	12.0	14.5	12.0	10.0
273	6/07/91	12.3										13.0	14.5	18.0	20.0	18.0	19.0	23.0	19.0	19.0	24.0	24.0	36.0	36.0	34.0	30.0
274	6/07/91	13.3										14.5	17.0	18.0	18.0	18.0	19.0	19.0	19.0	17.0	17.0	17.0	26.0	27.0	36.0	36.0
275	6/07/91	12.0										8.0	1.0	2.0	5.0		6.5	7.0	OUT	OUT	4.0	4.0		14.5	25.0	30.0
276	6/07/91	12.3										14 5	14.5	14.5	14.5	17.0	19.0	21.0	19.0	19.0	27.0	28.0	30.0	30.0	31.0	FUN
277	6/08/91	14.5											14.5	14.5	16.0	14.5	17.0	19.0	19.0	19.0	20.0	26.0	29.0	36.0	30.0	30.0
278	6/08, 91	15.3											17.0	20.0	22.0	25.0	27.0	26.0	26.0	26.0	26.0	26.0	30.0	34.0	44.0	KIL
279	6/08/91	14.5											14.5	14.5	14.5	18.0	18.0	19.0	20.0	25.0	28.0	28.0	40.0	44.0	44.0	44.0
280	6/12/91	13.0															5.0	3.0	7.5	0.0	OUT	4.0		19.0	24.0	29.0
281	6/12/91	12.8														10.0	12.0	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	10.0
282	6/12/91	12.8														10.0	11.5	10.0	10.0	10.0	2.0	6.0		6.0	13.0	14.5
283	6/12/91	12.8														11.5	11.5	14.5	14.5	13.0	17.0	17.0	19.0	20.0	22.0	27.0
284	6/12/91	12.5														11.5	8.0	8.0	6.5	6.5	7.0	6.5	11.5	17.0	22.0	22.0
285	6/12/91	11.8															8.5	10.0	10.0	10.0	4.0	11.0		9.0		9.0
286	6/12/91	10.8															10.0	14.5	18.0	18.0	16.0	21.0	21.0	28.0	30.0	30.0
287	6/12/91	11.0														12.0	14.5	14.5	14.5	16.0	16.0	16.0	14.5	18.0	22.0	22.0
288	6/12/91	11.0														13.0	14.5	14.5	14.5	16.0	[Tag Failure]					
289	6/12/91	11.3														13.0	14.5	18.0	21.0	25.0	30.0	33.0	40.0	42.0	40.0	44.0
290	6/13/91	13.0															9.0	11.5	9.0	5.0	7.0	4.0	OUT	13.0	23.0	26.0
291	6/13/91	12.8															12.0	17.0	7.5	OUT	OUT	4.0		8.5	10.0	12.0

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Appendix B. (Page 2 of 9).

No.	Date Tagged	RM Tagged	5/29	5/30	5/31	6/02	6/03	6/04	6/05	6/06	6/07	6/08	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/18	6/19	6/20	6/21	6/22	6/24	6/25		
292	6/13/91	13.0															12.0	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5		
293	6/13/91	11.8															12.0	13.0	11.5	1.0	8.5	9.0	9.0	11.0	OUT	2.0		
294	6/13/91	11.8															12.0	15.0	6.5	7.0		7.0		14.5	23.0	28.0		
295	6/13/91	12.8															18.0	18.0	21.0	21.0	19.0	22.0	26.0	28.0	27.0	28.0		
296	6/13/91	11.5															18.0	18.0	22.0	20.0	19.0	23.0	29.0	30.0	FUN	FUN		
297	6/13/91	12.0															12.0	13.0	14.5	14.5	14.5	16.0	16.0	17.0	14.5	21.0		
298	6/13/91	12.0															8.0	8.0	11.0	12.0	14.5	16.0	18.0	24.0	19.0	30.0		
299	6/13/91	11.8															6.5	9.0	7.5	8.0	OUT	11.5		13.0		11.5		
300	6/13/91	11.0															12.0	17.0	12.0	12.0	12.0	16.0	14.5	14.5	14.5	17.0		
301	6/13/91	12.8															14.5	14.5	16.0	16.0	16.0	19.0	22.0	26.0	26.0	30.0		
302	6/13/91	12.8															7.0	6.0	7.0	6.5	6.0	11.5	10.0	17.0	28.0	30.0		
303	6/15/91	14.0																	7.0	BEV	[caught by tagging crew on 6/19]							
304	6/15/91	14.3																	10.0	6.5	5.0	5.0		OUT	17.0	22.0		
305	6/15/91	13.8																	12.0	12.0	12.0	12.0	12.0	14.5	22.0	22.0		
306	6/15/91	13.0																	14.5	16.0	18.0	22.0	25.0	25.0	27.0	28.0		
307	6/15/91	12.8																	OUT	0.0	5.0	8.5	12.0	16.0	18.0	22.0		
308	6/15/91	12.3																	14.5	16.0	16.0	16.0	19.0	25.0	24.0	21.0		
309	6/15/91	12.3																	OUT	OUT	6.0	OUT		7.0	6.0	25.0		
310	6/15/91	12.5																	7.0	12.0	17.0	14.5	14.5	18.0	19.0	22.0		
311	6/15/91	12.8																	14.5	19.0	23.0	23.0	19.0	19.0	22.0	28.0		
312	6/15/91	14.3																	12.0	12.0	12.0	12.0	19.0	27.0	35.0	36.0		
313	6/18/91	14.3																			14.5	14.5	17.0	17.0	20.0	21.0		
314	6/18/91	14.3																			12.0	12.0	14.5	14.5	20.0	22.0		
315	6/18/91	13.0																			OUT	OUT		OUT	OUT	4.0		
316	6/18/91	12.8																			12.0	14.5	14.5	19.0	22.0	22.0		
317	6/18/91	12.3																			10.0	12.0	12.0	19.0	22.0	22.0		
318	6/18/91	13.0																			14.5	18.0	18.0	19.0	23.0	23.0		
319	6/18/91	12.8																			12.0	11.0		11.0	11.0	11.0		
320	6/18/91	12.8																			12.0	12.0	10.0	10.0	11.5	10.0		
321	6/18/91	11.8																			7.0	12.0		10.0	11.0	3.0		
322	6/18/91	11.8																			10.0	[caught by tagging crew on 6/20]						
323	6/19/91	12.5																				16.0		4.0	3.0	4.0		
324	6/19/91	12.3																				13.0		12.0	20.0	26.0		
325	6/19/91	12.5																				17.0	17.0	19.0	22.0	22.0		
326	6/19/91	11.5																				OUT		5.0	OUT	10.0		
327	6/19/91	12.0																				12.0	14.5	18.0	22.0	22.0		
328	6/19/91	11.0																				12.0	10.0	10.0	11.5	11.5		
329	6/19/91	11.3																				10.0	10.0	10.0	18.0	18.0		
330	6/19/91	10.8																				12.0	12.0	11.5	14.5	14.5		
331	6/19/91	10.5																				12.0	12.0	10.0	12.0	12.0		
332	6/22/91	12.8																							14.5	14.5		
333	6/22/91	13.0																							17.0	2.0		
334	6/22/91	12.5																							12.0	21.0		
335	6/22/91	11.5																							12.0	14.5		
336	6/22/91	12.5																							14.5	21.0		
337	6/22/91	12.5																							12.0	6.0		

River Mile Locations By Date and [Final Fates]

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			River Mile Locations Bv Date and [Final Fates]																									
No.	Date Tagged	RM Tagged	5/29	5/30	5/31	6/02	6/03	6/04	6/05	6/06	6/07	6/08	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/18	6/19	6/20	6/21	6/22	6/24	6/25		
338	6/25/91	13.3																										
339	6/25/91	12.5																										
340	6/25/91	11.5																										
341	6/25/91	12.8																										
342	6/27/91	10.3																										
343	6/27/91	13.0																										
344	6/27/91	13.0																										
345	6/28/91	12.5																										
346	6/29/91	11.8																										

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No.	Date Tagged	RM Tagged	6/26	6/27	6/28	6/29	7/01	7/03	7/05	7/06	7/08	7/09	7/12	7/15	7/17	7/18	7/19	7/20	7/21	7/23	7/24	7/25	7/26	7/27	7/28	7/29	7/30	7/31
			River Mile Locations By Date and [Final Fates]																									
246	5/28/91	14.0		KIL	KIL		KIL	KIL		KIL		KIL	KIL	KIL	[spawner Killey River]													
247	5/28/91	12.8	FUN	FUN	FUN		FUN	FUN		FUN	FUN	FUN	FUN	FUN	[spawner Funny River]													
248	5/28/91	13.0																										
249	5/28/91	14.0						19.0	19.0	19.0	SLI	SLI	SLI	SLI	SLI	[spawner Slicok Creek]												
250	5/28/91	14.0	44.0	44.0	44.0	44.0	48.0	KIL		KIL		KIL	KIL	KIL	KIL	[spawner Killey River]												
251	5/29/91	13.3			FUN		FUN	[spawner Funny River]																				
252	5/30/91	14.0																										
253	6/01/91	14.3			KIL		KIL	KIL		KIL		KIL	KIL	KIL	[spawner Killey River]													
254	6/04/91	11.8	12.0	12.0	10.0	10.0	28.0	36.0		44.0	KIL	KIL	KIL	KIL		KIL	[spawner Killey River]											
255	6/04/91	12.0	8.5	10.0	11.5	13.0	15.0	19.0		29.0	29.0	27.0	FUN	FUN	FUN		FUN				FUN		FUN			FUN		
256	6/04/91	11.0	22.0	20.0	22.0	22.0	25.0	42.0		44.0	KIL	KIL	KIL	KIL	[spawner Killey River]													
257	6/04/91	10.5																										
258	6/05/91	14.0			KIL		KIL	KIL		KIL		KIL	KIL	KIL	KIL	[spawner Killey River]												
259	6/05/91	14.3	25.0	28.0	27.0	30.0	44.0	KIL		KIL		KIL	KIL	KIL			KIL	[spawner Killey River]										
260	6/05/91	14.5			KIL		KIL	KIL		KIL		KIL	KIL	KIL	[spawner Killey River]													
261	6/05/91	14.3			FUN		FUN	FUN		FUN	FUN	FUN	FUN	FUN	[spawner Funny River]													
262	6/06/91	14.3	36.0	36.0	36.0	36.0	36.0	44.0		46.0	KIL	KIL	KIL	KIL	[spawner Killey River]													
263	6/06/91	14.3																										
264	6/06/91	14.5	44.0	46.0	46.0	46.0	KIL	KIL		KIL		KIL	KIL	KIL	[spawner Killey River]													
265	6/06/91	14.3			FUN		FUN	FUN		FUN	FUN	FUN	FUN	FUN	[spawner Funny River]													
266	6/06/91	10.5			KIL		KIL	KIL		KIL		KIL	KIL	KIL	[spawner Killey River]													
267	6/06/91	14.3																										
268	6/06/91	12.8	44.0	44.0	44.0	44.0	KIL	KIL		KIL		KIL	KIL	KIL	KIL	[spawner Killey River]												
269	6/06/91	13.0	46.0	46.0	46.0	46.0	KIL	KIL		KIL		BEN	BEN	BEN	BEN	[spawner Benjamin Cr.]												
270	6/07/91	14.3	44.0	44.0	KIL		KIL	KIL		BEN		BEN	BEN	BEN	[spawner Benjamin Cr.]													
271	6/07/91	14.5	27.0	30.0	36.0	44.0		KIL		BEN		BEN	BEN	BEN	BEN	[spawner Benjamin Cr.]												
272	6/07/91	13.0	9.0	11.5	10.0	10.0	11.5	[harvested at RM 14 on 7/02/91]																				
273	6/07/91	12.3	44.0	44.0	44.0	KIL	KIL	KIL		KIL		KIL	KIL	KIL	KIL		KIL				KIL	[spawner Killey River]						
274	6/07/91	13.3	36.0	43.0	44.0	43.0	44.0	44.0		KIL		KIL	KIL	BEN	BEN		BEN				BEN		BEN			BEN		
275	6/07/91	12.0	46.0	44.0	47.0	47.0	KIL	KIL		KIL		KIL	KIL	KIL	[spawner Killev River]													
276	6/07/91	12.3			FUN		FUN	FUN		FUN		FUN	FUN	FUN	[spawner Funny River]													
277	6/08/91	14.5	36.0	44.0	KIL		KIL	KIL		BEN		BEN	BEN	BEN	[spawner Benjamin Cr.]													
278	6/08/91	15.3			KIL		KIL	KIL		BEN		BEN	BEN	BEN	BEN	[spawner Benjamin Cr.]												
279	6/08/91	14.5	44.0	44.0	44.0	44.0	KIL	KIL		BEN		BEN	BEN	BEN	BEN		BEN				BEN		BEN			BEN		
280	6/12/91	13.0	30.0	36.0	41.0	44.0	44.0	44.0		44.0	44.0	44.0	[Mortality at RM 44 beginning 7/03]															
281	6/12/91	12.8	11.5	10.0	10.0		17.0	39.0		46.0	46.0	46.0	KIL	KIL	KIL		KIL				KIL		KIL	[spawner Killey River]				
282	6/12/91	12.8	14.5	14.5	14.5	19.0	19.0	26.0		36.0	36.0	44.0	KIL	KIL	KIL		KIL				KIL		KIL			KIL		
283	6/12/91	12.8	29.0	30.0	36.0	36.0	44.0	44.0		KIL		KIL	KIL	KIL	KIL		KIL				KIL	[spawner Killey River]						
284	6/12/91	12.5	22.0	25.0	27.0	29.0	36.0	44.0		44.0	KIL	LIL	KIL	BEN	BEN		BEN		BEN		[spawner Benjamin Cr.]							
285	6/12/91	11.8	10.0	10.0	12.0							42.0	42.0	41.0	41.0	[Spawner upper river]												
286	6/12/91	10.8	FUN		FUN		FUN	FUN		FUN	FUN	FUN	FUN	FUN	[spawner Funny River]													
287	6/12/91	11.0	22.0	25.0	28.0	30.0	30.0	36.0		44.0	KIL	KIL	KIL	KIL	KIL		KIL				KIL		KIL			KIL		
288	6/12/91	11.0																										
289	6/12/91	11.3	44.0	44.0	44.0	44.0	44.0	46.0		KIL		KIL	BEN	BEN	BEN		BEN				BEN	[spawner Benjamin Cr.]						
290	6/13/91	13.0	30.0	30.0	30.0	30.0	36.0	44.0		44.0	46.0	46.0	KIL	KIL	BEN		BEN	[spawner Benjamin Cr.]										
291	6/13/91	12.8	10.0	10.0	10.0	10.0	12.0	19.0		FUN	FUN	FUN		FUN	[spawner Funny River]													

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River Mile Locations By Date and [Final Fates]

No.	Date Tagged	RM Tagged	6/26	6/27	6/28	6/29	7/01	7/03	7/05	7/06	7/08	7/09	7/12	7/15	7/17	7/18	7/19	7/20	7/21	7/23	7/24	7/25	7/26	7/27	7/28	7/29	7/30	7/31
292	6/13/91	13.0	14.5	14.5	20.0	22.0	30.0	36.0		44.0	44.0	KIL	KIL	BEN	BEN		BEN				BEN		BEN	[spawner Benjamin Cr.]				
293	6/13/91	11.8	6.5	7.0	6.5	6.5	16.0	23.0	26.0	27.0	28.0	28.0	28.0	36.0	43.0		40.0				35.0		35.0	[Spawner upper river]				
29[illegible]	6/13/91	11.8	FUN		FUN		FUN	FUN		FUN	FUN	FUN	FUN	FUN	[spawner Funny River]													
295	6/13/91	12.8	29.0	30.0	30.0	30.0	36.0	36.0		46.0	46.0	46.0	KIL	BEN	BEN		BEN				BEN		BEN	[spawner Benjamin Cr.]				
296	6/13/91	11.5			FUN		FUN	FUN		FUN	FUN	FUN	FUN	FUN	[spawner Funny River]													
297	6/13/91	12.0	19.0	18.0	19.0	19.0	21.0	28.0		29.0	30.0	30.0	FUN	FUN	FUN		FUN	[spawner Funny River]										
298	6/13/91	12.0	30.0	30.0	30.0	30.0	39.0	SKI		69.0		77.0	KEN	QTZ	QTZ		QTZ	[spawner Quartz Cr.]										
299	6/13/91	11.8	9.0	[illegible]	10.0	10.0		19.0	19.0	19.0	[poached at RM 19 on 7/08]																	
300	6/13/91	11.0	19.0	20.0	19.0	20.0	24.0	29.0		30.0	FUN	FUN	FUN	FUN	FUN	[spawner Funny River]												
301	6/13/91	12.8	30.0	30.0	30.0	30.0	30.0	36.0		42.0	44.0	46.0	46.0	46.0	KIL		KIL	[spawner Killey River]										
302	6/13/91	12.8	30.0	FUN	FUN		FUN	FUN		FUN	FUN	FUN	FUN	FUN	FUN		FUN				FUN	[spawner Funny River]						
303	6/15/91	14.0																										
304	6/15/91	14.3	30.0	36.0	46.0	46.0	KIL	KIL		KIL		KIL	KIL	KIL	KIL	[spawner Killey River]												
305	6/15/91	13.8	28.0	28.0	28.0	22.0	[illegible]	36.0		44.0	KIL	KIL	KIL	KIL	[spawner Killey River]													
306	6/15/91	13.0	30.0	34.0	34.0	36.0	44.0	44.0		44.0	44.0	KIL	KIL	KIL	KIL	[spawner Killey River]												
307	6/15/91	12.8	30.0	34.0	42.0	KIL	KIL	KIL		KIL		KIL	KIL	KIL	[spawner Killey River]													
308	6/15/91	12.3	36.0	36.0	36.0	36.0	44.0	46.0		46.0	46.0	46.0	KIL	BEN	BEN		BEN			BEN	[spawner Benjamin Cr.]							
309	6/15/91	12.3	19.0	25.0	29.0	29.0	36.0	36.0		36.0	44.0	KIL	KIL	BEN	BEN	[spawner Benjamin Cr.]												
310	6/15/91	12.5	22.0	24.0	22.0	22.0	28.0	36.0		44.0	46.0	KIL	KIL	BEN	BEN		BEN				BEN		BEN			BEN		
311	6/15/91	12.8	29.0	35.0	36.0	35.0	36.0	34.0		36.0	43.0	44.0	KIL	KIL	BEN		BEN				BEN		BEN			BEN		
312	6/15/91	14.3	36.0	36.0	36.0	36.0	44.0	[uplost after 7/01/91]																				
313	6/18/91	14.3	22.0	22.0	22.0	22.0	23.0	26.0	28.0	30.0	30.0	8.5	[drop out after 7/09/91]															
314	6/18/91	14.3	25.0	26.0	30.0	30.0	44.0	44.0		KIL		KIL	BEN	BEN	BEN		BEN				BEN		BEN			BEN		
315	6/18/91	13.0	OUT	8.5	8.0	10.0	11.5	17.0	19.0	25.0	28.0	39.0	33.0	KIL	KIL		KIL				BEN		BEN	[spawner Benjamin Cr.]				
316	6/18/91	12.8	22.0	22.0	26.0	28.0	30.0	41.0		46.0	46.0	46.0	KIL	KIL	KIL		KIL				KIL		KIL			KIL		
317	6/18/91	12.3	22.0	22.0	22.0	22.0	22.0	30.0		30.0	30.0	36.0	36.0	SKI	70.0		75.0				JUN		JUN			JUN		
318	6/18/91	13.0	23.0	27.0	[illegible]	27.0	28.0	30.0		36.0	36.0	44.0	44.0	KIL	KIL		KIL				BEN		BEN			BEN		
319	6/18/91	12.8	11.0	[hook-and-release mortality]																								
320	6/18/91	12.8	6.0	10.0	10.0	10.0	12.0	20.0	24.0	24.0	24.0	21.0	24.0	24.0	24.0		22.0				22.0		22.0			22.0		
321	6/18/91	11.8	4.0	4.0	4.0	4.0	4.0	[mortality (after 5 days)]																				
322	6/18/91	11.8																										
323	6/19/91	12.5	4.0	4.0	4.0	16.0	29.0	36.0		44.0	44.0	KIL	KIL	KIL	KIL		KIL				KIL		KIL			KIL		
324	6/19/91	12.3	30.0	30.0	30.0	30.0	30.0	30.0		29.0	FUN	FUN	FUN	FUN	[spawner Funny River]													
325	6/19/91	12.5	22.0	19.0	21.0	19.0	21.0	22.0		19.0	[uplost after 7/06/91]																	
326	6/19/91	11.5	10.0	12.0	11.0	11.0	10.0	22.0		44.0	46.0	46.0	44.0	BEN	BEN		BEN	[spawner Benjamin Cr.]										
327	6/19/91	12.0	26.0	26.0	29.0	30.0	44.0	KIL		KIL		KIL	KIL	KIL	KIL		KIL	[spawner Killey River]										
328	6/19/91	11.0	7.0	12.0	14.5	19.0	32.0	36.0		34.0	46.0	46.0	28.0	[drop out after 7/12/91]														
329	6/19/91	11.3	23.0	24.0	20.0	26.0	24.0	34.0		30.0	FUN	FUN	FUN	FUN	[spawner Funny River]													
330	6/19/91	10.8	22.0	20.0	26.0	42.0	KIL	KIL		KIL		KIL	KIL	KIL	[spawner Killey River]													
331	6/19/91	10.5	11.5	12.0	11.0	11.0	11.5	[drop out after 7/01/91]																				
332	6/22/91	12.8	16.0	17.0	21.0	26.0	28.0	28.0	28.0	28.0	30.0	29.0	FUN	FUN	FUN	[spawner Funny River]												
333	6/22/91	13.0	6.5	8.0	8.0	10.0	10.0	12.0		36.0	36.0	36.0	36.0	KIL	KIL		KIL				BEN		BEN			BEN		
334	6/22/91	12.5	26.0	30.0	30.0		21.0	36.0		44.0	KIL	KIL	KIL	KIL	KIL		KIL	[spawner Killey River]										
335	6/22/91	11.5	14.5	12.0	12.0	12.0	14.5	14.5	17.0	19.0	18.0	19.0	19.0	19.0	17.0		18.0				17.0		16.0	[spawner lower river]				
336	6/22/91	12.5	22.0	16.0	11.5	10.0	10.0	11.5		13.0	11.5	[harvested at RM 14.5 on 7/09/91]																
337	6/22/91	12.5	7.0		6.0	10.0	11.5	12.0		18.0	19.0	18.0	19.0	[uplost after 7/12/91]														

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No.	Date Tagged	RM Tagged	6/26	6/27	6/28	6/29	7/01	7/03	7/05	7/06	7/08	7/09	7/12	7/15	7/17	7/18	7/19	7/20	7/21	7/23	7/24	7/25	7/26	7/27	7/28	7/29	7/30	7/31
			River Mile Locations By Date and [Final Fates]																									
338	6/25/91	13.3	14.5	14.5	22.0	20.0	20.0	27.0	[fish poached at RM 36 on 7/05/91]																			
339	6/25/91	12.5	10.0	9.0	9.0	9.0	11.5	12.0	17.0	20.0	22.0	20.0	21.0	21.0	21.0	[spawner middle river]												
340	6/25/91	11.5	10.0	10.0	11.5	10.0	10.0	17.0	17.0	24.0	24.0	24.0	30.0	30.0	30.0	[spawner middle river]												
341	6/25/91	12.8	14.5	19.0	18.0	19.0	21.0	25.0	28.0	30.0	36.0	36.0	36.0	36.0	36.0		36.0				36.0		36.0			36.0		
342	6/27/91	10.3			12.0	10.0	10.0	11.5		12.0	12.0	12.0	10.0	[harvested at RM 10 on 7/13/91]														
343	6/27/91	13.0			15.0	17.0	17.0	16.0	18.0	19.0	21.0	25.0	18.0	SLI	19.0		19.0				19.0		21.0			SLI		
344	6/27/91	13.0			16.0	18.0	23.0	27.0	27.0	27.0	28.0	28.0	30.0	44.0	49.0		51.0				69.0		76.0			QTZ		
345	6/28/91	12.5				9.0	9.0	5.0	[hook-and-release mortality]																			
346	6/29/91	11.8					4.0	[caught by tagging crew at RM 7.1 on 7/02/91]																				

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No.	Date Tagged	RM Tagged	River Mile Locations By Date and [Final Fates] 8/01	8/02	8/03	8/04	8/05	8/06	8/07	8/08	8/09	8/10
246	5/28/91	14.0										
247	5/28/91	12.8										
248	5/28/91	13.0										
249	5/28/91	14.0										
250	5/28/91	14.0										
251	5/29/91	13.3										
252	5/30/91	14.0										
253	6/01/91	14.3										
254	6/04/91	11.8										
255	6/04/91	12.0	[spawner Funny River]									
256	6/04/91	11.0										
257	6/04/91	10.5										
258	6/05/91	14.0										
259	6/05/91	14.3										
260	6/05/91	14.5										
261	6/05/91	14.3										
262	6/06/91	14.3										
263	6/06/91	14.3										
264	6/06/91	14.5										
265	6/06/91	14.3										
266	6/06/91	10.5										
267	6/06/91	14.3										
268	6/06/91	12.8										
269	6/06/91	13.0										
270	6/07/91	14.3										
271	6/07/91	14.5										
272	6/07/91	13.0										
273	6/07/91	12.3										
274	6/07/91	13.3	BEN	[spawner Benjamin Cr.]								
275	6/07/91	12.0										
276	6/07/91	12.3										
277	6/08/91	14.5										
278	6/08/91	15.3										
279	6/08/91	14.5	BEN	[spawner Benjamin Cr.]								
280	6/12/91	13.0										
281	6/12/91	12.8										
282	6/12/91	12.8	KIL	[spawner Killey River]								
283	6/12/91	12.8										
284	6/12/91	12.5										
285	6/12/91	11.8										
286	6/12/91	10.8										
287	6/12/91	11.0	KIL	[spawner Killey River]								
288	6/12/91	11.0										
289	6/12/91	11.3										
290	6/13/91	13.0										
291	6/13/91	12.8										

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No.	Date Tagged	RM Tagged	8/01	8/02	8/03	8/04	8/05	8/06	8/07	8/08	8/09	8/10
			River Mile Locations By Date and [Final Fates]									
292	6/13/91	13.0										
293	6/13/91	11.8										
294	6/13/91	11.8										
295	6/13/91	12.8										
296	6/13/91	11.5										
297	6/13/91	12.0										
298	6/13/91	12.0										
299	6/13/91	11.8										
300	6/13/91	11.0										
301	6/13/91	12.8										
302	6/13/91	12.8										
303	6/15/91	14.0										
304	6/15/91	14.3										
305	6/15/91	13.8										
306	6/15/91	13.0										
307	6/15/91	12.8										
308	6/15/91	12.3										
309	6/15/91	12.3										
310	6/15/91	12.5	BEN	[spawner Benjamin Cr.]								
311	6/15/91	12.8	BEN	[spawner Benjamin Cr.]								
312	6/15/91	14.3										
313	6/18/91	14.3										
314	6/18/91	14.3	BEN	[spawner Benjamin Cr.]								
315	6/18/91	13.0										
316	6/18/91	12.8	[spawner Killey River]									
317	6/18/91	12.3	[spawner Juneau Cr.]									
318	6/18/91	13.0	[spawner Benjamin Cr.]									
319	6/18/91	12.8										
320	6/18/91	12.8	22.0	[spawner middle river]								
321	6/18/91	11.8										
322	6/18/91	11.8										
323	6/19/91	12.5	[spawner Killey River]									
324	6/19/91	12.3										
325	6/19/91	12.5										
326	6/19/91	11.5										
327	6/19/91	12.0										
328	6/19/91	11.0										
329	6/19/91	11.3										
330	6/19/91	10.8										
331	6/19/91	10.5										
332	6/22/91	12.8										
333	6/22/91	13.0	BEN	[spawner Benjamin Cr.]								
334	6/22/91	12.5										
335	6/22/91	11.5										
336	6/22/91	12.5										
337	6/22/91	12.5										

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No.	Date Tagged	RM Tagged	8/01	8/02	8/03	8/04	8/05	8/06	8/07	8/08	8/09	8/10
			River Mile Locations By Date and [Final Fates]									
338	6/25/91	13.3										
339	6/25/91	12.5										
340	6/25/91	11.5										
341	6/25/91	12.8	36.0	[spawner middle river]								
342	6/27/91	10.3										
343	6/27/91	13.0	SLI	[spawner Slikok Cr.]								
344	6/27/91	13.0	QTZ	[spawner Quartz Cr.]								
345	6/28/91	12.5										
346	6/29/91	11.8										