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Creel and Escapement Statistics for Coho Salmon on the Little Susitna River, Alaska, During 1990

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Allen E. Bingham

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Alaska Department of Fish and Game

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ABSTRACT

Coho salmon *Oncorhynchus kisutch* returns to the Little Susitna River were assessed with a creel survey to estimate sport harvest and a weir to estimate spawning escapement. Creel surveys were conducted at the Burma Road boat landing from 16 July through 3 September 1990 and at Miller's Landing and Reach from 10 August through 3 September to estimate the effort for and catch and harvest of coho salmon by the sport fishery. An estimated 8,001 coho salmon were harvested and an additional 1,259 coho salmon were caught and released during 42,458 angler-hours of effort. The majority of the effort (39,866 hours) and harvest (7,318) occurred at the Burma Road survey site. Most of the harvested coho salmon were age 1.1. The contribution of hatchery-produced coho salmon to the sport harvest and escapement past the weir was estimated to be 30% and 24%, respectively, all of which originated from a 1989 smolt release in Nancy Lake.

A total of 22,311 coho salmon were estimated in the Little Susitna River during 1990. The actual inriver return, however, was somewhat greater than 22,311 because of the unsurveyed harvest by anglers who access the sport fishery through the Port of Anchorage. An unknown number of coho salmon are also harvested in the mixed-stock commercial fisheries of upper Cook Inlet. A total of 8,001 fish were harvested in the sport fishery: 6,800 fish below the weir and 1,201 fish above the weir. Spawning escapement was estimated at 14,310 fish. Coho salmon are not known to spawn downstream of the weir. Inriver exploitation by the sport fishery was estimated at 36%.

KEY WORDS: coho salmon, *Oncorhynchus kisutch*, creel survey, effort, harvest, catch, hatchery contribution, escapement, age, sex, length.

INTRODUCTION

The Little Susitna River (Figure 1) has had the highest sport fishery effort in the Matanuska-Susitna Valley since 1981 and currently supports the second largest freshwater coho salmon *Oncorhynchus kisutch* fishery in the state (Mills 1979-1990). The harvest of coho salmon in the Little Susitna River has increased 450% since 1977 (Figure 2). In response to large increases in effort and harvest, the Little Susitna River has been stocked annually with coho salmon since 1982 (ADFG 1981, Chlupach 1989).

The Alaska Department of Fish and Game (ADFG), Division of Sport Fish, began an annual creel survey of the sport fishery for coho salmon in the Little Susitna River in 1981. An annual life-history study of coho salmon in the Little Susitna River was begun in 1982. As part of this study, a weir was constructed in 1986 to estimate the escapements of coho salmon. These surveys and life history studies are summarized in a series of annual "Federal Aid to Sport Fish Restoration" reports published by the Alaska Department of Fish and Game.

The objectives of this report are to present:

1. estimates of angler effort, harvest (number kept), and catch (number kept plus number released) of coho salmon in the Little Susitna River sport fishery during 1990;

2. estimates of the spawning escapements of coho salmon to the Little Susitna River and to other selected northern Cook Inlet index streams during 1990;

3. estimates of the contribution of hatchery-reared coho salmon to the sport harvest and escapement during 1990; and

4. estimates of the age, sex, and length compositions of the coho salmon in the sport harvest and escapement in the Little Susitna River during 1990.

METHODS

Creel Surveys

Approximately 113 km of the Little Susitna River were open to salmon fishing by regulation during 1990 (ADFG 1990). There are three major access points to the fishery: (1) the Burma Road boat launch at river kilometer (rkm) 45.1, (2) the boat launch at Miller's Landing in the city of Houston at rkm 111.7, and (3) Miller's Reach at rkm 107.0. The Port of Anchorage (in the Municipality of Anchorage) is a fourth, but not a major, access to the sport fishery. Anglers exiting the sport fishery through the Port of Anchorage fish the tidal portion of the river from boats that are capable of crossing Knik Arm in adverse weather conditions.

An exception within the open area during 1990 was the emergency closure to sport fishing of a 6 km section of river between the Burma Road access and the

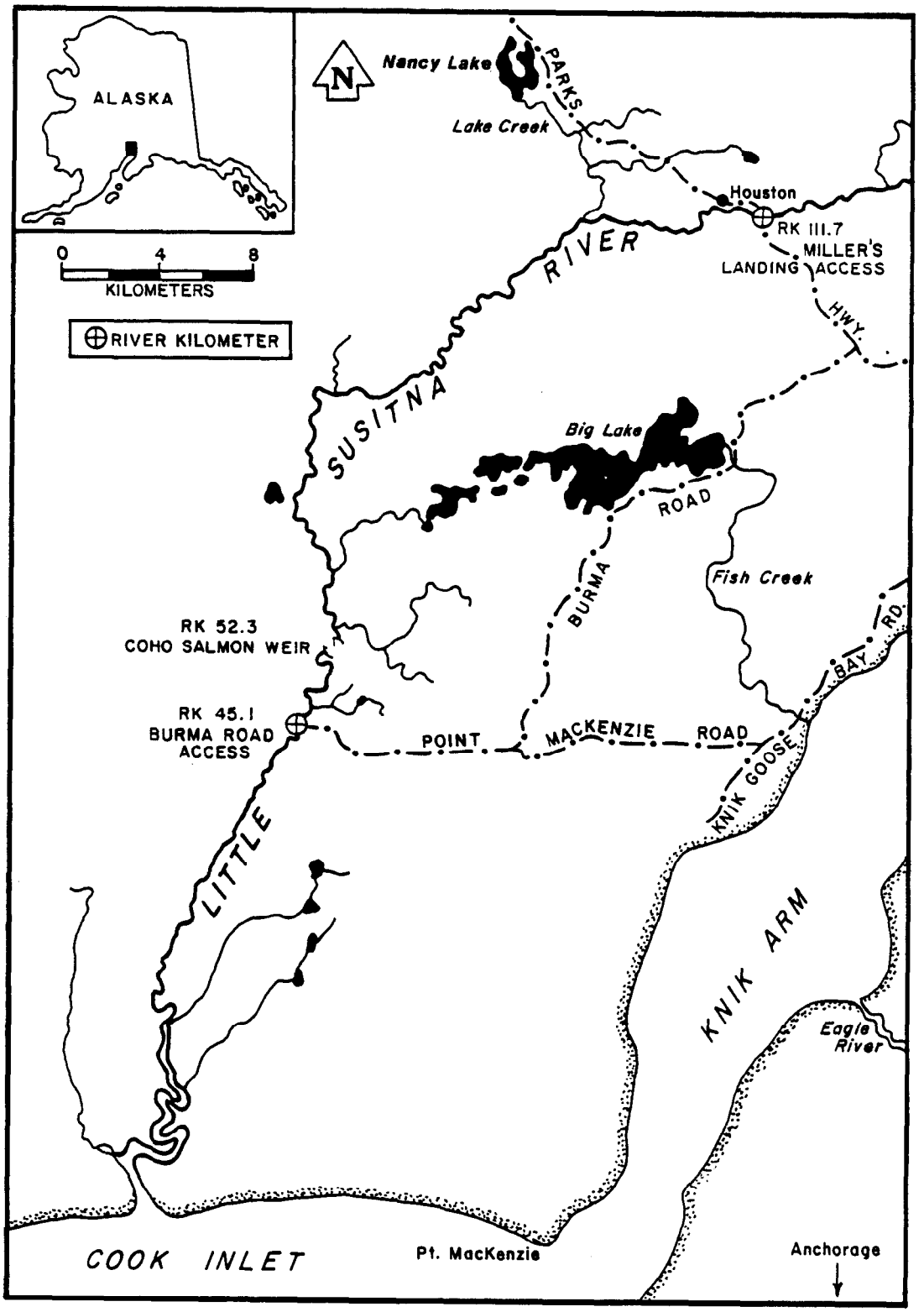

Figure 1. Map of the Little Susitna River.

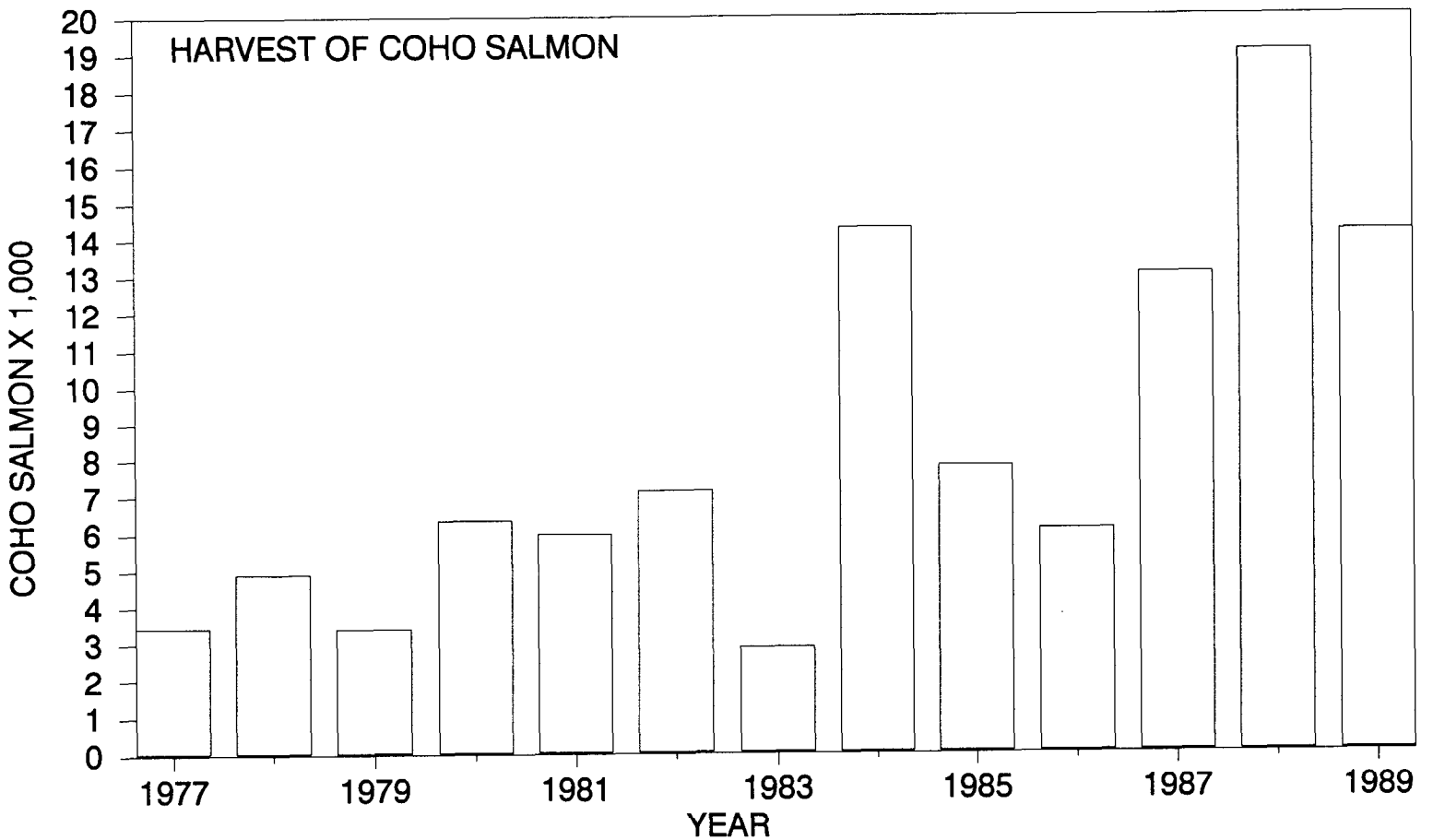

Figure 2. Estimated harvest of coho salmon from the Little Susitna River sport fishery (Statewide Harvest Survey by Mills 1979-1990).

weir from 2 August through noon 14 August. During 1990, daily bag and possession limits were three coho salmon of 406 mm (16 inches) or greater total length with the exception of an emergency order from 2 August through noon 14 August reducing the bag limit from three to one coho salmon. The open season for coho salmon was from 1 January through 31 December.

Creel surveys were used to estimate coho salmon harvest and catch by boat and shore anglers at the Burma Road access and by boat anglers at Miller's Landing and Miller's Reach. Boat anglers at all sites were surveyed via a direct expansion survey. Shore anglers at Burma Road were surveyed via a roving creel survey (Neuhold and Lu 1957).

Direct Expansion Creel Surveys:

Direct expansion surveys census all anglers exiting an access site during a sampling period. The information is then expanded to include periods not surveyed. Direct expansion surveys were conducted for boat anglers at the Burma Road and Miller's Landing and Miller's Reach access locations. Boat anglers are defined as anglers who accessed their fishing site via a boat. This includes anglers who used a boat to travel to a fishing site but fished from shore once they reached the site.

The direct expansion survey of coho salmon boat anglers exiting the sport fishery at Burma Road was conducted from 16 July through 3 September. From 16 July through 29 July, each fishing day at Burma Road was 16 hours long (0800-2359 hours) and consisted of four, 4-hour periods: (1) 0800 to 1159 hours, (2) 1200 to 1559 hours, (3) 1600 to 1959 hours, and (4) 2000 to 2359 hours. From 30 July through 19 August, each fishing day at Burma Road was 15 hours long (0730-2229 hours) and consisted of three, 5-hour periods: (1) 0730 to 1229 hours, (2) 1230 to 1729 hours, and (3) 1730 to 2229 hours. From 20 August through 3 September, each fishing day was reduced to 13.5 hours (0800-2130 hours) with three daily periods: (1) 0800 to 1229 hours, (2) 1230 to 1659 hours, and (3) 1700 to 2129 hours. The length of the fishing day was decreased as the season progressed because of the decreasing number of daylight hours available for survey.

A stratified, random sample design was used to develop the schedules for the direct expansion creel surveys. The Burma Road location was surveyed 3 days each Monday through Sunday. The days surveyed were selected by first choosing a day from Monday through Saturday not to sample and then adding the following day to allow the creel clerk 2 consecutive days off as required by union contract. Three days were then randomly chosen from the remaining 5 to conduct a direct expansion survey of boat anglers exiting through Burma Road. The roving creel survey of shore anglers fishing near Burma Road was conducted on the remaining 2 days. Due to this nonrandom selection of days to sample, our estimates are assumed to be biased to an unknown degree.

Past years' data (Bartlett and Vincent-Lang 1989, Bartlett and Sonnichsen 1990) have shown that 80% to 90% of the catch and harvest for anglers exiting at Burma Road is taken by boat anglers, who represent approximately 70% of the effort. For this reason, approximately three-fifths (i.e., 3 out of 5 working days) of the sampling effort were devoted to surveying the boat fishery.

Periods surveyed were randomly selected within a day selected for survey. Two of four periods (1, 2, 3, and 4) or two of three periods (1, 2, and 3) were sampled. The entire period was surveyed.

At Miller's Landing and Miller's Reach, the creel survey of coho salmon boat anglers was conducted from 10 August through 3 September. It was divided into two strata: (1) 10 August through 19 August, and (2) 20 August through 3 September. The survey was designed for a 16-hour fishing day (0600-2200 hours). Fishing days were split into four, 4-hour survey periods: (1) 0600 to 0959 hours, (2) 1000 to 1359 hours, (3) 1400 to 1759 hours, and (4) 1800 to 2200 hours. The survey was split to survey anglers exiting the fishery at Miller's Landing boat launch and the Miller's Reach boat launch. Anglers exiting the fishery at both locations are known to be fishing the same area (near the mouth of Nancy Lake Creek).

The Miller's locations were surveyed 6 days in strata 1 and 10 days in strata 2. The locations to be surveyed were randomly selected first. The days to be surveyed were randomly selected second. The two periods to be sampled were then randomly chosen for each day surveyed. The entire period was surveyed.

The creel survey clerk was present at the selected location during the selected sample period. All boat anglers departing the fishery through the access site during the time sampled were interviewed by the survey clerk.

The following effort, catch, and harvest information were collected from each boat angler interviewed who had completed their trip: number of hours spent fishing, number of fish harvested (kept) and number of fish released by species, and guided or unguided angler. In addition, at Burma Road, the following information on the locations fished by the angler was collected: angler fished upstream and/or downstream of the boat launch at Burma Road, and angler fished upstream and/or downstream of the weir.

Harvest, catch, and effort were estimated using a 3-stage design. This design involved the direct expansion of sampled interview data by expansion factors dependent upon the number of anglers counted (third-stage units), sample periods (second-stage units), and days (first-stage units). Since all anglers counted were interviewed during 1990, the design collapses to a 2-stage design, however, estimates were still obtained in a 3-stage manner (and are equivalent).

The following procedures were used to estimate effort, catch, and harvest. First we estimated the mean angler effort over all completed-trip anglers interviewed within a sample:

$$\bar{e}_{hij} = \frac{\sum_{k=1}^{m_{hij}} e_{hijk}}{m_{hij}} ; \qquad (1)$$

where:

m_{hij} = the number of anglers interviewed during sample period j during day i within stratum h; and

e_{hijk} = the effort in hours expended by each angler interviewed.

Next, we expanded by the number of third-stage units (anglers counted) to obtain the estimated angler effort for each sample:

$$\hat{E}_{hij} = M_{hij}\,\bar{e}_{hij} \qquad (2)$$

where:

M_{hij} = the number of anglers counted during each sample period (note that this number equals m_{hij} during the 1990 survey).

Next we estimated the mean effort across periods sampled within each day:

$$\bar{\hat{E}}_{hi} = \frac{\sum_{j=1}^{p_{hi}} \hat{E}_{hij}}{p_{hi}}\ ; \qquad (3)$$

where:

p_{hi} = the number of periods sampled within each day.

The estimated angler effort for each day was then obtained as:

$$\hat{E}_{hi} = P_{hi}\,\bar{\hat{E}}_{hi}\ ; \qquad (4)$$

where:

P_{hi} = the number of sampling periods in the day.

Then we estimated the mean effort across days sampled within each stratum:

$$\bar{\hat{E}}_{h} = \frac{\sum_{i=1}^{d_h} \hat{E}_{hi}}{d_h}\ ; \qquad (5)$$

where:

d_h = the number of days sampled within each stratum.

Finally, we expanded by the number of days in each stratum (i.e., D_h) to obtain the stratum estimate of angler effort:

$$\hat{E}_h = D_h \bar{\hat{E}}_h \quad . \tag{6}$$

The variance for the estimated angler effort for each stratum was obtained by the three-stage variance equation (adapted from the approach outlined in: Cochran 1977, equation 11.24, page 303):

$$\begin{aligned} \hat{V}[\hat{E}_h] = & \left\{ (1 - f_{1h}) \frac{D_h^2}{d_h} s_{1h}^2 \right\} \\ & + \left\{ f_{1h} \frac{D_h^2}{d_h^2} \sum_{i=1}^{d_h} (1 - f_{2hi}) \frac{P_{hi}^2}{P_{hi}} s_{2hi}^2 \right\} \\ & + \left\{ f_{1h} \frac{D_h^2}{d_h^2} \sum_{i=1}^{d_h} f_{2hi} \frac{P_{hi}^2}{p_{hi}^2} \sum_{j=1}^{p_{hi}} (1 - f_{3hij}) \frac{M_{hij}^2}{m_{hij}} s_{3hij}^2 \right\} \end{aligned} \tag{7}$$

where: f_{1h}, f_{2hi}, and f_{3hij} are the sampling fractions for the first, second, and third sampling stages, respectively (i.e., $f_{1h} = d_h / D_h$, $f_{2hi} = p_{hi} / P_{hi}$, and $f_{3hij} = m_{hij} / M_{hij}$);

s_{1h}^2 = the among day variance for the total effort estimate;

$$= \frac{\sum_{i=1}^{d_h} (\hat{E}_{hi} - \bar{\hat{E}}_h)^2}{d_h - 1} ; \tag{8}$$

s_{2hi}^2 = the among period variance for each day sampled;

$$= \frac{\sum_{i=1}^{p_{hi}} (\hat{E}_{hij} - \bar{\hat{E}}_{hi})^2}{p_{hi} - 1} ; \text{ and} \tag{9}$$

s^2_{3hij} = the within sample variance for the effort estimate observed over all anglers interviewed during each sampled period;

$$= \frac{\sum_{j=1}^{m_{hij}} (e_{hijk} - \bar{e}_{hij})^2}{m_{hij} - 1} . \quad (10)$$

Estimates of catch and harvest of coho salmon and their variances were estimated similarly, by substituting the appropriate catch or harvest statistics in place of angler effort in equations 1 through 10, above.

Total angler effort, catch, or harvest across all strata (or select combinations of strata) and the associated variances were obtained by summing the corresponding stratum estimates (assuming independence). Standard errors were obtained by taking the square root of the variance estimates.

Estimates of catch per unit effort (CPUE), harvest per unit effort (HPUE), and their variances were obtained for the direct expansion surveys by the following standard procedures for estimating a stratified 3-stage mean. First, we weighted each interviewed angler's CPUE. The sample weights ensured that each angler's CPUE information is proportional to the angler effort at the time of the sample:

$$CPUE'_{hijk} = w_{hij} \frac{c_{hijk}}{e_{hijk}} ; \quad (11)$$

where:

$$w_{hij} = \frac{M_{hij}}{\bar{M}_{hi}} ; \quad (12)$$

$$\bar{M}_{hi} = \frac{\sum_{j=1}^{P_{hi}} M_{hij}}{P_{hi}} ; \text{ and} \quad (13)$$

c_{hijk} and e_{hijk} are the catch and effort of each interviewed angler.

Next, we obtained the weighted sample mean CPUE over all anglers interviewed:

$$\overline{CPUE}'_{hij} = \frac{\sum_{k=1}^{m_{hij}} CPUE'_{hijk}}{m_{hij}} . \quad (14)$$

The daily weighted mean CPUE was then estimated over all periods sampled in the day:

$$\overline{CPUE}'_{hi} = \frac{\sum_{j=1}^{Phi} \overline{CPUE}'_{hij}}{Phi} . \quad (15)$$

The weighted stratum CPUE was then obtained over all days sampled:

$$\overline{\overline{CPUE}}'_{h} = \frac{\sum_{i=1}^{d_h} \overline{CPUE}'_{hi}}{d_h} . \quad (16)$$

We obtained estimates of mean CPUE across all strata, or select combinations of strata, by weighting the individual stratum estimates by the relative size of each stratum in terms of the estimated number of angler-trips (following the approach explained in Cochran 1977, Equation 10.45, page 288), as follows:

$$\hat{CPUE} = \sum_{h=1}^{s} \hat{W}_h \overline{\overline{CPUE}}'_{h} \quad (17)$$

where:

$$\hat{W}_h = \frac{\hat{A}_h}{\hat{A}} ; \quad (18)$$

$\hat{A}_h$ = estimated number of angler-trips in the fishery within stratum *h*;

$$= D_h \bar{M}_h \quad (19)$$

$$\bar{M}_h = \frac{\sum_{i=1}^{d_h} \hat{M}_{hi}}{d_h} ; \quad (20)$$

$$\hat{M}_{hi} = P_{hi} \bar{M}_{hi} ; \quad (21)$$

$\hat{A}$ equals the sum of the estimated number of angler-trips across all strata; and all other terms are as defined above.

The variance of the across strata CPUE estimate was obtained by treating the estimated stratum weights as if they were constants (see Kish 1965, equations

2.8.5 and 2.8.7, pages 60 and 61), accordingly our variance estimate is only approximate:

$$\hat{V}[\overline{CPUE}] \approx \sum_{h=1}^{s} \hat{W}_h^2 \, \hat{V}[\overline{\overline{CPUE}}_h]' \; ; \tag{22}$$

where:

$\hat{V}[\overline{\overline{CPUE}}_h]'$ = estimated variance of the stratum estimates of the mean weight CPUE, obtained by the usual three-stage equation (see approach outlined by Cochran 1977, equation 10.15, page 278):

$$= \left\{ (1 - f_{1h}) \frac{s_{1h}^2}{d_h} \right\} + \left\{ \frac{f_{1h}}{d_h^2} \sum_{i=1}^{d_h} (1 - f_{2hi}) \frac{s_{2hi}^2}{p_{hi}} \right\} + \left\{ \frac{f_{1h}}{d_h^2} \sum_{i=1}^{d_h} \frac{f_{2hi}}{p_{hi}^2} \sum_{j=1}^{p_{hi}} (1 - f_{3hij}) \frac{s_{c3hij}^2}{m_{hij}} \right\} ; \tag{23}$$

where:

$$s_{1h}^2 = \frac{\sum_{i=1}^{d_h} (\overline{CPUE}_{hi}' - \overline{\overline{CPUE}}_h')^2}{d_h - 1} \; ; \tag{24}$$

$$s_{2hi}^2 = \frac{\sum_{j=1}^{p_{hi}} (\overline{CPUE}_{hij}' - \overline{CPUE}_{hi}')^2}{p_{hi} - 1} \; ; \tag{25}$$

$$s_{c3hij}^2 = \frac{\sum_{k=1}^{m_{hij}} (CPUE_{hijk}' - \overline{CPUE}_{hij}')^2}{m_{hij} - 1} \; ; \text{ and} \tag{26}$$

all other terms are as defined above.

Estimates of HPUE and its variance were obtained by substituting the appropriate harvest statistics in equations 11 through 26, above.

The assumptions necessary for unbiased point and variance estimates of angler effort, catch, harvest, CPUE, and HPUE obtained by the procedures outlined above are:

1. interviewed anglers accurately reported their hours of fishing effort and the number of coho salmon released;

2. no significant fishing effort occurred during the hours not included in the fishing day;

3. all anglers participating in the fishery exited the fishery through a surveyed access site; and

4. total daily angler effort, catch, and harvest does not vary within a weekly period.

Assumption 2, above, is in general valid. In regards to assumption 1, not all anglers are able to remember the hours of fishing effort and tend to report a number of hours somewhere between the length of the trip and the actual number of hours spent fishing on the trip. Regarding assumption 3, a portion of boat anglers fishing within the tidal reach of the Little Susitna River exit the fishery through the Port of Anchorage.

Assumption 4, is undoubtedly invalid, in that comparatively more anglers participate in the fishery on certain days of each week (e.g., Saturday). This assumption was necessitated by the non-random sampling procedure for selection of days to sample within each week. Since we chose 2 contiguous days off each week, we constrained our sampling of the remaining days such that not all days had an equal probability of selection. The degree of the bias due to this constraint is unknown, but would be expected to positively bias our estimates of catch, effort, and harvest[1].

Roving Creel Survey:

The effort, harvest, and catch by shore anglers fishing for coho salmon near the Burma Road access site were estimated using a roving creel survey (Neuhold and Lu 1957). The roving creel survey at Burma Road was conducted on the days of the week not selected for days off and for the direct expansion survey. A count of all shore anglers within 1.6 km upstream and 1.6 km downstream of the Burma Road survey location was conducted from a riverboat. Periods surveyed were randomly selected within a day selected for survey. The entire period was surveyed. Two angler counts were conducted during each survey period scheduled through 29 July. From 30 July through 3 September, one angler count was conducted for each survey period scheduled. Angler counts took 30 minutes to complete and were considered instantaneous. Shore anglers exiting the fishery at Burma Road were interviewed during the survey period time not used for the angler counts.

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[1] The daily sampling procedure resulted in an over-sampling of weekend days. The expected result would be that we would obtain mean daily values that are too high for some weeks, and hence our total estimates would be too high.

Angler effort, catch, and harvest, their associated variances, and standard errors were estimated for the roving creel survey using the following procedures. A systematic-random estimator was used to estimate angler effort on a sample by sample basis. Catch and harvest estimates for each sample were obtained by a ratio estimator: by combining the estimated effort (for the sample) with estimates of catch per unit effort (CPUE) and harvest per unit effort (HPUE) obtained from the angler interviews. The CPUE and HPUE estimates were obtained by the jackknife estimation approach (Efron 1982). The jackknife approach for estimating CPUE and HPUE was used since most other estimators are known to be biased (for use as ratio estimators, i.e., for expansion), and the jackknife estimate has been shown to be less biased and procedures exist for correcting some of this bias (as noted below) (see Cochran 1977, section 6.15, pages 174-177; and Smith 1980).

The following equations were not used to obtain estimates of CPUE or HPUE (and their variances) to describe individual angler catch or harvest rates. The CPUE and HPUE estimates presented here are only appropriate for expansion purposes (i.e., as used in a ratio estimation procedure).

The individual sample estimates of effort, catch, and harvest were then used in a stratified three-stage estimation approach to obtain total estimates, both within strata and across strata, as noted below.

The first step involved obtaining the jackknife estimated sample mean of CPUE (or HPUE) as follows:

$\overset{*}{CPUE}_{hijk}$ = the jackknifed CPUE for angler k in sample j within day i and stratum h;

$$= \frac{\sum_{\substack{o=1 \\ o \neq k}}^{m_{hij}} c_{hijo}}{\sum_{\substack{o=1 \\ o \neq k}}^{m_{hij}} e_{hijo}} ; \qquad (27)$$

where: c_{hijo} and e_{hijo} are the catch and effort of each interviewed angler; and m_{hij} equals the number of interviewed anglers in each sampled period.

The jackknife mean CPUE for each sample within each sampled day was then obtained as:

$$\overline{\overset{*}{CPUE}}_{hij} = \frac{\sum_{k=1}^{m_{hij}} \overset{*}{CPUE}_{hijk}}{m_{hij}} . \qquad (28)$$

Then the bias correction (adapted from Efron 1982, equation 2.8, page 6) was performed:

$$\overline{\overline{CPUE}}^{*\dagger}_{hij} = [m_{hij} (\overline{\overline{CPUE}}_{hij} - \overline{\overline{CPUE}}^{*}_{hij})] + [\overline{\overline{CPUE}}^{*}_{hij}] ; \quad (29)^2$$

where:

$$\overline{\overline{CPUE}}_{hij} = \frac{\sum_{o=1}^{m_{hij}} c_{hijo}}{\sum_{o=1}^{m_{hij}} e_{hijo}} . \quad (30)$$

The bias-corrected jackknife mean was then expanded by the estimated angler effort for the sample to obtain the estimated catch for each sampled period:

$$\hat{C}_{hij} = \hat{E}_{hij} \overline{\overline{CPUE}}^{*\dagger}_{hij} ; \quad (31)$$

where:

$\hat{E}_{hij}$ = estimated angler effort (in hours) for each sample;

$$= H_{hij} \bar{x}_{hij} ; \quad (32)$$

$\bar{x}_{hij}$ = mean angler count for each sampled period;

$$= \frac{\sum_{q=1}^{r_{hij}} x_{hijq}}{r_{hij}} ; \quad (33)$$

H_{hij} is the number of hours in each sampling period within each day; r_{hij} equals the total number of angler counts conducted for each sample; and x_{hijq} is the number of anglers counted fishing during each count.

The harvest for the sample was estimated similarly by substituting the appropriate harvest statistics into equations 27 to 33, above.

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[2] If the bias correction resulted in a negative value, then the uncorrected jackknife statistic was used instead of the bias corrected version in all following equations.

Estimates of angler effort, catch, and harvest for each day sampled were obtained as follows:

$\bar{\hat{Y}}_{hi}$ = mean of the sample estimates for each sampled day; in which Y represents E, C, or H for effort, catch, and harvest, respectively;

$$= \frac{\sum_{j=1}^{P_{hi}} \hat{Y}_{hij}}{P_{hi}} ; \qquad (34)$$

where:

$\hat{Y}_{hij}$ = estimated sample value for effort (E, as obtained from equation 32, above), catch or harvest (C or H, as obtained from equation 31, above).

The estimated daily effort, catch, and harvest were obtained by expanding by the number of sampling periods in the day:

$$\hat{Y}_{hi} = P_{hi}\, \bar{\hat{Y}}_{hi} . \qquad (35)$$

Similarly, we obtain mean estimates for each sampling stratum as follows:

$\bar{\hat{Y}}_{h}$ = mean of the daily estimates for stratum *h*; in which Y represents E, C, or H for effort, catch, and harvest, respectively;

$$= \frac{\sum_{i=1}^{d_h} \bar{\hat{Y}}_{hi}}{d_h} . \qquad (36)$$

The estimated stratum effort, catch, and harvest were obtained by expanding by the number of days in each stratum:

$$\hat{Y}_{h} = D_h\, \bar{\hat{Y}}_{h} . \qquad (37)$$

The variance of the estimated catch for each stratum was obtained by the three-stage variance equation (following the approach outlined by Cochran 1977), omitting the finite population correction factor (FPC) for the third stage units:

$$\hat{V}[\hat{C}_h] = \left[(1 - f_{1h}) \frac{D_h^2}{d_h} S_{1h}^2 \right] + \left[f_{1h} \frac{D_h^2}{d_h^2} \sum_{i=1}^{d_h} (1 - f_{2hi}) \frac{P_{hi}^2}{Phi} S_{2hi}^2 \right] + \left[f_{1h} \frac{D_h^2}{d_h^2} \sum_{i=1}^{d_h} f_{2hi} \frac{P_{hi}^2}{p_{hi}^2} \sum_{j=1}^{Phi} \frac{M_{hij}^2}{m_{hij}} \hat{V}[\hat{C}_{hij}] \right] ; \quad (38)$$

where:

$$S_{1h}^2 = \frac{\sum_{i=1}^{d_h} (\hat{C}_{hi} - \bar{\hat{C}}_h)^2}{d_h - 1} ; \quad (39)$$

$$S_{2hi}^2 = \frac{\sum_{j=1}^{Phi} (\hat{C}_{hij} - \bar{\hat{C}}_{hi})^2}{Phi - 1} ; \quad (40)$$

$\hat{V}[\hat{C}_{hij}]$ = the within period variance for the estimated sample catch, obtained by Goodman's (1960) formula for the variance of a product of independent random variates:

$$= \hat{E}_{hij}^2 s_{3hij}^{*2} + (\overline{CPUE}_{hij}^{*\dagger})^2 \hat{V}[\hat{E}_{hij}] - s_{3hij}^{*2} \hat{V}[\hat{E}_{hij}] ; \quad (41)$$

s_{3hij}^{*2} = jackknife estimate of the variance for the jackknifed sample mean CPUE (adapted from Efron 1982, equation 3.2, page 13);

$$= \frac{(m_{hij} - 1)}{m_{hij}} \sum_{k=1}^{m_{hij}} (CPUE_{hijk}^{*} - \overline{CPUE}_{hij}^{*})^2 ; \text{ and} \quad (42)$$

$\hat{V}[\hat{E}_{hij}]$ = estimated variance of the angler effort estimate for each sample, obtained by using the successive differences formula appropriate for systematic samples (adapted from Wolter 1985, equation 7.2.4, page 251);

$$= \frac{H_{hij}^2}{r_{hij}} \frac{\sum_{q=2}^{r_{hij}} \left[x_{hijq} - x_{hij(q-1)} \right]^2}{2\,(r_{hij} - 1)} . \qquad (43)$$

Variance estimates for the estimated harvest were obtained by replacing the appropriate harvest statistics (h's and H's) for the catch statistics (c's and C's) in equations 38 through 43, above.

Stratum estimates of the variance of the angler effort were obtained in a similar manner to those for catch and harvest. The primary difference occurs in the third major term in equation 38:

$$\hat{V}[\hat{E}_h] = \left[(1 - f_{1h}) \frac{D_h^2}{d_h} s_{1h}^2 \right] + \left[f_{1h} \frac{D_h^2}{d_h^2} \sum_{i=1}^{d_h} (1 - f_{2hi}) \frac{P_{hi}^2}{p_{hi}} s_{2hi}^2 \right] + \left[f_{1h} \frac{D_h^2}{d_h^2} \sum_{i=1}^{d_h} f_{2hi} \frac{P_{hi}^2}{p_{hi}^2} \sum_{j=1}^{p_{hi}} \hat{V}[\hat{E}_{hij}] \right] . \qquad (44)$$

The values for the terms in equation 44 were obtained by replacing the catch statistics (C's) by the appropriate effort statistics (E's), in equations 39 and 40 (equation 43 was used as is in the final term of equation 44).

Total angler effort, catch, or harvest across all strata (or select combinations of strata) and the associated variances were obtained by summing (assuming independence).

Angler CPUE and HPUE were estimated by the procedures noted below for the roving survey. The estimates obtained by these procedures are reflective of the individual rates experienced by anglers rather than the rates obtained by the harvest and effort estimation procedures (i.e., the jackknifed CPUE's and HPUE's used for expansion purposes)[3].

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[3] As obtained by equation 27 and 28, above.

The procedures used to obtain the CPUE and HPUE point and variance estimates for the roving survey were the same as those used for the direct expansion survey (i.e., equations 11 through 21) with the following noted exceptions. The sample weight used in equation 11 and calculated in equation 12 is replaced by:

$$w_{hij} = \frac{\bar{x}_{hij}}{\bar{\bar{x}}_{hi}} ; \tag{45}$$

where:

$\bar{x}_{hij}$ is as defined in equation 33, above; and

$$\bar{\bar{x}}_{hi} = \frac{\sum_{j=1}^{p_{hi}} \bar{x}_{hij}}{p_{hi}} . \tag{46}$$

The estimated number of angler-trips as used in equation 18 was calculated by the following equation (instead of equation 19, above) for the shore survey:

$$\hat{A}_h = \frac{\hat{E}_h}{\bar{\bar{e}}'_h} ; \tag{47}$$

where:

$\hat{E}_h$ = angler effort estimate (in angler-hours) obtained by the procedures outlined above (see equation 37);

$\bar{\bar{e}}'_h$ = mean of means weighted angler effort for completed-trip anglers interviewed within each stratum;

$$= \frac{\sum_{i=1}^{d_h} \bar{\bar{e}}'_{hi}}{d_h} ; \tag{48}$$

$$\bar{\bar{e}}'_{hi} = \frac{\sum_{j=1}^{p_{hi}} \bar{e}'_{hij}}{p_{hi}} ; \tag{49}$$

$$\bar{e}'_{hij} = \frac{\sum_{k=1}^{m_{hij}} e'_{hijk}}{m_{hij}} ; \quad (50)$$

$$e'_{hijk} = w_{hij}\, e_{chijk} ; \text{ and} \quad (51)$$

e_{chijk} equals the effort of each interviewed completed-trip angler.

The variance of the stratum and across strata CPUE estimates was also calculated using the procedures outlined for the direct expansion surveys (equations 22 through 26), with the exception being that the third stage finite population correction (FPC) factor is omitted for a roving type survey. That is, the "$(1 - f_{3hij})$" term in equation 23 was omitted. All other procedures in equations 22 through 26 were followed as is for the roving survey.

The assumptions necessary for unbiased point estimates of angler effort, catch, harvest, CPUE, and HPUE obtained by the procedures outlined above for the roving survey are:

1. catch rate and duration of fishing trip are independent (DiCostanzo 1956);

2. interviewed anglers accurately reported their hours of fishing effort and the number of coho salmon released;

3. catch and harvest rates of shore anglers exiting the fishery at Burma Road are representative of those for shore anglers counted during the roving creel survey;

4. no significant shore fishing effort occurs during the hours not surveyed; and

5. total daily angler effort, catch, and harvest does not vary within a weekly period.

We expect that assumption 1, above, is valid, and the sampling design as described ensures the validity of assumption 3. In regards to assumption 2, not all anglers are able to remember the hours of fishing effort and tend to report a number of hours somewhere between the length of the trip and the actual number of hours spent fishing on the trip. For assumption 4, some fishing effort from shore occurs after dark when angler counts are impossible to take but these same anglers tend to exit the fishery during the fishing day.

As noted above[4], assumption 5 is undoubtedly invalid. As noted above, the degree of the bias is unknown, but would be expected to positively bias our estimates of catch, effort, and harvest.

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[4] For the direct expansion creel surveys.

Additionally, we assume that our variance estimates are negatively biased. This negative bias is due to the inestimability of some of the terms in equations 23, 38, and 44, above. Specifically, the second major term in equations 23, 38, and 44 can not be estimated prior to the period starting on 30 July, since prior to this period only one period was sampled per surveyed day for the roving survey. During all later periods only one angler count was conducted per sampled period. Accordingly, the third major term in equation 44, and portions of equation 41, can not be estimated. The degree of the negative bias is unknown.

Escapement

A weir was constructed across the Little Susitna River at rkm 52. Daily and cumulative counts of five salmon species *Oncorhynchus* were recorded from 18 July through 9 September as the salmon passed through the weir and over a white flash panel. Salmon were counted during daylight hours when visibility was sufficient to identify the fish to species. The weir was closed to fish passage during hours of darkness. The total estimated escapement of coho salmon through the weir is the number counted through the weir less the estimated sport harvest upstream of the weir. The harvest upstream of the weir was estimated by sorting the interview files for anglers who fished upstream of the weir and applying the analysis for direct expansion creel surveys to this group.

Coho salmon spawning in index areas of selected Matanuska-Susitna Valley streams were counted either on foot or by canoe during peak spawning periods. Peak periods were identified through periodic inspections of spawning activity in streams which are easily monitored. When required by lighting conditions, surveyors wore Polaroid glasses while taking surveys. Live and dead fish were counted separately and recorded in field notebooks and permanent files.

Age, Sex, and Length Compositions

Coho salmon were sampled for age, sex, and length information from the fish passed at the weir and from the harvest exiting at the creel survey exit points. Scales were taken at the weir from 23 July through 6 September. The collection of scales at the weir was paced so that approximately 240 of the 480 total scale sets collected were collected by 14 August; the anticipated mid-point of the coho spawning migration through the weir. Scales were collected at the rate of from 6 to 59 scale sets per day depending upon the number of fish passing the weir on the specific day of collection. A minimum collection of ten sets on each day of collection was attempted.

Scales from the harvest were opportunistically collected by the creel survey clerk from 18 July through 31 August. The rate of collection varied from 1 to 63 sets per day as time and the number of fish examined allowed. A total of 659 scale sets were collected.

Three scales were collected from each fish and mounted on adhesive-coated cards (Clutter and Whitesel 1956). Impressions of scales were thermo-hydraulically made in cellulose acetate and the impressions were examined using a microfiche reader. Age was recorded using the European method (Koo 1962) where the numeral preceding the decimal is the number of freshwater

annuli and the numeral following the decimal is the number of marine annuli. Total age from brood is the sum of the two numerals plus one. Scales were aged and cross-checked by technicians experienced in ageing coho salmon scales. The mid-eye to fork-of-tail length of sampled fish was also recorded to the nearest 0.5 centimeter for each sampled fish. Sex was recorded for each sampled fish based on external characteristics.

In addition to fish included in the age, sex, and length data collection, the sex of each fish from the harvest inspected for a hatchery mark was also recorded. The sex of fish inspected for hatchery marks at the weir was not recorded because minimum handling of live fish and the quick passage of coho salmon through the weir was paramount.

Estimates of age composition (proportion) for the subsampled coho salmon were calculated for each stratum. Each proportion was calculated according to the following procedures:

$\hat{p}_{uh}$ = estimated proportion of the sampled coho salmon harvested or in the weir escapement samples that are age u within each stratum[5];

$$= \frac{n_{uh}}{n_h}; \qquad (52)$$

where: n_{uh} equals the number of the sampled coho salmon either harvested within each stratum for the creel survey or the number sampled from the weir that are age u; and n_h equals the total number of coho salmon sampled within each creel survey or weir stratum.

The variance of the estimated proportion of coho salmon harvested or in the weir escapement was estimated approximately by the standard equation for the variance of a binomial proportion (Cochran 1977, equation 3.8, page 52):

$$\hat{V}[p_{uh}] \approx \left(1 - \frac{n_h}{\hat{H}_h}\right) \frac{p_{uh}(1 - p_{uh})}{n_h - 1} \quad \text{or} \quad \left(1 - \frac{n_h}{N_h}\right) \frac{p_{uh}(1 - p_{uh})}{n_h - 1}; \qquad (53)$$

where:

$\hat{H}_h$ equals the estimated harvest of coho salmon in each stratum, obtained from equation 6 for the direct expansion surveys and equation 36 for the roving surveys; and N_h equals the number of coho salmon counted past the weir during each weir stratum.

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[5] Stratum refers to the sampling strata associated with the creel survey for the harvest age composition estimates, and to seasonal periods for the weir sampling (see Results section for further details).

The estimated proportion by age class (across all strata or select combinations of strata) was obtained by first estimating the number of coho salmon by age class in each stratum (for either the harvest or weir escapement):

$\hat{N}_{uh}$ = estimated number of fish harvested or in the escapement which are age class u;

$$= \hat{H}_h \hat{p}_{uh} \quad \text{or} \quad \hat{N}_h \hat{p}_{uh} . \tag{54}$$

The variance of the estimated number of fish harvested which are age class u, was obtained by Goodman's (1960) equation for the variance of the product of two random variates:

$$\hat{V}[\hat{N}_{uh}] = \hat{H}_h^2 \hat{V}[\hat{p}_{uh}] + \hat{p}_{uh}^2 \hat{V}[\hat{H}_h] - \hat{V}[\hat{p}_{uh}] \hat{V}[\hat{H}_h] ; \tag{55a}$$

where: $\hat{V}[\hat{H}_h]$ equals the variance of the estimated harvest for each stratum, which was obtained by equation 7 for the direct expansion surveys or equation 38 for the roving creel surveys.

Since the weir escapement counts are not estimated (i.e., known) then the estimated variance of the number of fish in the weir count which are age class u was obtained by the standard equation for the product of a constant and a random variate (see Kish 1965, equation 2.8.5, page 60):

$$\hat{V}[\hat{N}_{uh}] = N_h^2 \hat{V}[\hat{p}_{uh}] . \tag{55b}$$

Next we estimated the number of fish in the harvest or weir count in each age class by summing the numbers across strata:

$$\hat{N}_u = \sum_{h=1}^{s} \hat{N}_{uh} . \tag{56}$$

The variance of the estimated number of each age fish in the harvest or weir count was obtained by summing the corresponding variances (assuming independence, see Kish 1965, equation 2.8.7, page 61). Finally, the proportion of each age class across strata was obtained as follows:

$$\hat{p}_u = \frac{\hat{N}_u}{\hat{H}} \quad \text{or} \quad \frac{\hat{N}_u}{N} . \tag{57}$$

The variance of this estimate was obtained only approximately for the harvest using the usual estimator for the variance of a ratio of random variables, omitting the unestimable covariance term (see equation 15 on page 181 in Mood et al. 1974):

$$\hat{V}[p_u] \approx \left[\frac{\hat{N}_u}{\hat{H}} \right]^2 \left[\frac{\hat{V}[N_u]}{\hat{N}_u^2} + \frac{\hat{V}[H]}{\hat{H}^2} \right] . \quad (58a)$$

The variance of the estimated proportion of each age class in the weir count was obtained by the standard equation for the product of a constant and a random variate:

$$\hat{V}[p_u] = \frac{\hat{V}[N_u]}{N^2} . \quad (58b)$$

Estimates of mean length by age and sex group of coho salmon sampled from the sport harvest and from the weir escapement survey were calculated using the procedures outlined by Sokal and Rohlf (1981, Boxes 4.2 and 7.1, pages 56 and 139). Note, that although the harvest was sampled by a stratified multi-stage approach, we treated our samples of fish lengths as if collected by a simple random sampling program. Accordingly, both our estimates of mean length and its standard error are biased by an unknown amount. We assume that length at age does not vary substantially from stage to stage or stratum to stratum within each seasonal period, and as such, feel that the magnitude of this bias was small.

Age and length compositions were compared between the sport harvests at Burma Road and Miller's Landing and Reach and between the sport harvest and the escapement at the weir using contingency table tests (following the procedures outlined by Snedecor and Cochran 1980, section 11.10, pages 208-213). Mean length at age by sex was compared between the same paired groups using the Student's *t* test (Sokal and Rohlf 1981).

Hatchery Contributions

Adult coho salmon were expected to return to the Little Susitna River in 1990 from smolt stocked during 1989. Whole coho salmon harvested in the sport fishery and checked through the survey locations were examined for a missing adipose fin by the creel clerks. In addition, a portion of the coho salmon passed through the weir are examined for a missing adipose fin by weir technicians. On any given day of fish passage at the weir, an attempt to examine 20% of the previous day's passage was made. Salmon heads are not collected at the weir. Coho salmon observed to have a missing adipose fin when passed through the weir are assumed to contain a decodable coded-wire tag (CWT) implanted at the hatchery. The heads of fish having a missing adipose fin are bagged, labeled, frozen, and transferred to the Fisheries Rehabilitation, Enhancement, and Development (FRED) Division CWT lab for CWT removal and decoding.

At each creel survey location, the estimated harvest of fish and the number of fish inspected for a missing adipose fin in each stratum are compared with contingency table tests to determine if the proportions of inspected coho salmon at the survey locations are equal. If there are significant differences ($\alpha = 0.05$) in the proportions of inspected coho salmon, the contribution

in each stratum at each survey location is estimated separately. If they are not significant, the stratum and or locations can be pooled. At the weir, the number of fish passed in each stratum and the number of fish examined was compared with chi-square statistics ($\alpha = 0.05$) to test for possible grouping of strata prior to estimating the hatchery contribution.

The estimated contribution of a release to the sport fishery and its variance was calculated using the following procedures. These procedures essentially follow the approach outlined by Clark and Bernard (1987) as modified by Conrad and Larson (1987). Conrad and Larson's modification of Clark and Bernard's procedures entail the incorporation of the variance due to estimating the overall harvest (both untagged and tagged stocks).

Note, that in the procedures outlined, we ignored the multi-stage nature of our sampling programs. Our approach does incorporate the stratified nature of the program, however.

The first step involved estimating the contribution to each sampling stratum in the fishery of each particular tag code (using equation [10] from Clark and Bernard 1987):

$\hat{H}_{A_h}$ = estimated contribution of stocked fish from release associated with unique tag code *A* for fishery stratum *h*;

$$= \left[\frac{\hat{H}_h}{n_{2_h}} \right] \left[\frac{a_{1_h}}{a_{2_h}} \right] \left[\frac{m_{1_h}}{m_{2_h}} \right] \left[\frac{m_{a_h}}{\theta_A} \right] ; \qquad (59)$$

where:

$\hat{H}_h$ = the estimated harvest of all coho salmon within each stratum;

n_{2_h} = number of coho salmon inspected for missing adipose fins from the sampled harvest in each fishery stratum;

a_{1_h} = number of coho salmon with a missing adipose fin which were counted and marked with a head strap from each stratum;

a_{2_h} = number of coho salmon heads previously marked with a a head strap which arrived at the tag lab, from fish originally sampled from stratum *h*;

m_{1_h} = number of coded-wire tags which were detected in the coho salmon heads at the tag lab, from those sampled from stratum *h*;

m_{2_h} = number of coded-wire tags which were removed from the coho salmon heads and decoded, from coho salmon sampled from stratum *h*;

m_{a_h} = number of coded-wire tags dissected out of the coho salmon heads and decoded as the unique tag code *a*, originally sampled from stratum *h*; and

θ_A = proportion of a particular hatchery release which contains a coded-wire tag of the unique tag code *A*.

The variance of the above estimate was obtained following the approach proposed by Conrad and Larson (1987), in which the number of tags decoded as a unique tag code (*A*) and the total harvest estimate were treated as random variates, and all other terms in equation 57 were treated as constants (accordingly the approach first proposed by Goodman 1960 is used for the second major term in equation 58):

$$s^2_{H_{A_h}} \approx \left[\frac{1}{n_{2_h}} \frac{a_{1_h}}{a_{2_h}} \frac{m_{1_h}}{m_{2_h}} \frac{1}{\theta_A} \right]^2 \left[\hat{H}_h \, V[m_{A_h}] + m^2_{A_h} \hat{\hat{V}}[H_h] - V[m_{A_h}] \hat{\hat{V}}[H_h] \right] ; \quad (60)$$

where:

$\hat{\hat{V}}[H_h]$ = estimated variance of overall coho salmon harvest estimate for stratum *h*, obtained from creel survey sampling programs; and

$V[m_{A_h}]$ = variance of "random variate" m_{Ah}, approximated by the approach used by Clark and Bernard (1987; equation [12]);

$$\approx \frac{n_{2_h}(n_{2_h}-1)a_{2_h}(a_{2_h}-1)m_{2_h}(m_{2_h}-1)\hat{H}_{a_h}(\hat{H}_{a_h}-1)\theta_A^2}{\hat{H}_h(\hat{H}_h-1)a_{1_h}(a_{1_h}-1)m_{1_h}(m_{1_h}-1)} + \frac{n_{2_h}a_{2_h}m_{2_h}\hat{H}_{A_h}\theta_A}{\hat{H}_h a_{1_h} m_{1_h}} - \left[\frac{n_{2_h}a_{2_h}m_{2_h}\hat{H}_{A_h}\theta_A}{\hat{H}_h a_{1_h} m_{1_h}} \right]^2 . \quad (61)$$

The final step in calculating the variance of the contribution estimate for each tag code was to perform the following bias correction (Clark and Bernard 1987; equation [15]):

$$\hat{\hat{V}}[H_{A_h}] = \left[\frac{(\hat{H}_h-1)n_{2_h}(a_{1_h}-1)a_{2_h}(m_{1_h}-1)m_{2_h}}{\hat{H}_h(n_{2_h}-1)a_{1_h}(a_{2_h}-1)m_{1_h}(m_{2_h}-1)} \right] s^2_{H_{A_h}} . \quad (62)$$

In order to obtain the estimated contribution to the fishery across combinations of different tag codes and/or different strata, the following equations were used (as outlined by Clark and Bernard 1987, equation [16]):

$\hat{H}_C$ = estimated total contribution of a combination of tag codes and sampling strata;

$$= \sum_{h=1}^{s} \sum_{A=1}^{t} \hat{H}_{A_h} \qquad (63)$$

where:

s = the number of strata to be combined; and

t = the number of tag codes to be combined.

The variance of this combined estimate was obtained by (Clark and Bernard 1987, equation [17]):

$$\hat{V}[\hat{H}_C] = \left[\sum_{h=1}^{s} \sum_{a=1}^{t} \hat{V}[\hat{H}_{a_h}] \right] + \left[2 \sum_{h=1}^{s} \sum_{A=1}^{t} \sum_{B>A} \hat{cov}[\hat{H}_{A_h}, \hat{H}_{B_h}] \right] ; \qquad (64)$$

where:

$\hat{cov}[\hat{H}_{A_h}, \hat{H}_{B_h}]$ = estimated covariance between the estimated contributions for unique tag code *A* and *B* within stratum *h* (note that we assume that sampling was conducted independently between strata, therefore covariances are only needed for the within stratum values), obtained as outlined by Clark and Bernard (1987, equation [22]);

$$= \hat{H}_{A_h} \hat{H}_{B_h} \left[\frac{\hat{H}_h (n_{2_h}-1) a_{1_h} (a_{2_h}-1) m_{1_h} (m_{2_h}-1)}{(\hat{H}_h - 1) n_{2_h} (a_{1_h}-1) a_{2_h} (m_{1_h}-1) m_{2_h}} - 1 \right] . \qquad (65)$$

RESULTS

Creel Estimates

Burma Road Boat Anglers:

The number of boat anglers exiting the fishery at Burma Road during a surveyed period ranged from 0 to 95 (Appendix A1). Periods later in the fishing day were generally the busiest with respect to the number of anglers departing the fishery. Estimated angler effort during the survey for boat anglers exiting the fishery at Burma Road was 26,768 angler-hours (SE = 3,074) (Table 1).

Table 1. Estimated effort by boat anglers exiting the Little Susitna River coho salmon sport fishery through the Burma Road access in 1990.

Date	Estimated Effort[a]	SE	Rel. Pre.[b]	95% Confidence Interval
716-722	3,827	1,500	77%	886 - 6,768
723-729	9,746	1,608	32%	6,596 - 12,897
730-805	4,953	1,203	48%	2,595 - 7,310
806-812	1,608	927	113%	0 - 3,426
813-819	3,882	1,418	72%	1,103 - 6,660
820-826	2,217	525	46%	1,189 - 3,246
827-903	535	147	54%	247 - 823
Total	26,768	3,074	23%	20,743 - 32,792

[a] Angler-hours.

[b] Relative precision (α = 0.05).

Harvest rates by stratum of coho salmon for boat anglers exiting the fishery at Burma Road ranged from 0.027 to 0.708 fish per hour (Table 2). The highest harvest rate of coho salmon was during the stratum from 6 August through 12 August. Excluding the last stratum near the end of the sport fishery, the least amount effort was recorded during this stratum (Table 1). The estimated harvest of coho salmon by boat anglers exiting the fishery at Burma Road was 6,236 fish (SE = 805) (Table 3). An estimated 518 (SE = 122) of these fish were harvested upstream of the weir.

Catch rates by strata of coho salmon for boat anglers exiting the fishery at Burma Road ranged from 0.027 to 0.809 fish per hour (Table 2). The highest catch rate of coho salmon estimated was during the stratum from 6 August through 12 August. The estimated catch of coho salmon by boat anglers exiting the fishery at Burma Road was 7,329 fish (SE = 919) (Table 3). An estimated 986 (SE = 243) of these fish were caught upstream of the weir.

Boat anglers exiting the sport fishery through Burma Road who fished downstream of Burma Road released about 10% of the coho salmon they had caught (Table 4). Those fishing upstream of Burma Road and exiting through Burma Road released about 28% of the coho salmon they had caught. The total release by boat anglers exiting the fishery through Burma Road was about 15%.

Shore Anglers Near Burma Road:

The mean count per period of shore anglers in the area near Burma Road ranged from 2 to 46 (Appendix A2). Estimated shore angler effort during the survey was 13,098 angler-hours (SE = 1,970) (Table 5).

Harvest rates by stratum of coho salmon for shore anglers exiting the fishery at Burma Road ranged from 0.033 to 0.306 fish per hour (Table 6). The highest harvest rate of coho salmon estimated was during the stratum from 27 August through 3 September. The estimated harvest of coho salmon by shore anglers fishing near the Burma Road access site was 1,082 fish (SE = 244) (Table 7).

The range of catch rates by stratum for shore anglers fishing near Burma Road was also from 0.033 to 0.306 fish per hour. The estimated catch of coho salmon by shore anglers fishing near the Burma Road access site was 1,109 fish (SE = 227) (Table 7).

Shore anglers exiting the sport fishery through Burma Road who fished downstream of Burma Road released about 2% of the coho salmon they had caught (Table 4). Those fishing upstream of Burma Road and exiting through Burma Road released about 5% of the coho salmon they had caught. The total release by shore anglers exiting the fishery through Burma Road was about 2.4%.

Miller's Landing and Reach:

The number of boat anglers exiting the fishery at Miller's Landing and Reach during a surveyed period ranged from 0 to 17 (Appendix A3). Periods later in the fishing day were generally the busiest with respect to the number of anglers departing the fishery. Estimated angler effort during the survey for boat anglers exiting the fishery at Miller's was 2,592 angler-hours (SE = 750) (Table 8).

Table 2. Estimated harvest and catch rates by boat anglers exiting the Little Susitna River coho salmon sport fishery through the Burma Road access in 1990.

Date	HPUE[a]	SE	CPUE[b]	SE
716-722	0.0269	0.0096	0.0269	0.0095
723-729	0.3930	0.0651	0.4302	0.0726
730-805	0.2652	0.0441	0.3119	0.0454
806-812	0.7079	0.2024	0.8088	0.2226
813-819	0.3607	0.0586	0.4388	0.0616
820-826	0.5054	0.1648	0.6305	0.1906
827-903	0.3926	0.2575	0.6348	0.4509
Total	0.3467	0.3314	0.4053	0.0134

[a] Harvest rate per angler-hour.

[b] Catch rate per angler-hour.

Table 3. Estimated harvest and catch of coho salmon by boat anglers exiting the Little Susitna River sport fishery through the Burma Road access in 1990.

Date	Estimated Harvest	SE	Rel.[a] Pre.	95% Confidence Interval	Estimated Catch	SE	Rel.[a] Pre.	95% Confidence Interval
716-722	126	66	103%	0 - 256	126	66	103%	0 - 256
723-729	2,805	455	32%	1,913 - 3,697	3,052	463	30%	2,144 - 3,960
730-805	1,229	485	77%	277 - 2,180	1,428	496	68%	456 - 2,400
806-812	280	145	101%	0 - 564	361	169	92%	0 - 691
813-819	1,036	392	74%	268 - 1,804	1,358	562	81%	257 - 2,459
820-826	669	152	45%	370 - 967	865	167	38%	538 - 1,191
827-903	92	50	107%	0 - 191	140	90	126%	0 - 316
Total	6,236	805	25%	4,659 - 7,813	7,329	919	25%	5,528 - 9,130

[a] Relative Precision (a = 0.05).

Table 4. Estimated percent of Little Susitna River coho salmon released by location and type of fishery in 1990.

Location	Type of Fishery	Harvest	Catch	Coho Released	% Catch Released
Burma down[a]	Boat	4,858	5,416	558	10%
Burma up[b]	Boat	1,378	1,913	535	28%
Miller's[c]	Boat	683	822	139	17%
Burma down[a]	Shore	844	859	15	2%
Burma up[b]	Shore	238	250	12	5%

[a] Downstream of the Burma Road boat launch to saltwater.

[b] Upstream of the Burma Road boat launch excluding Miller's Landing and Reach.

[c] Anglers exiting through Miller's Landing and Reach.

Table 5. Estimated effort by shore anglers sport fishing for coho salmon near the Little Susitna River Burma Road access in 1990.

Date	Estimated Effort[a]	SE	Rel. Pre.[b]	95% Confidence Interval
716-722	914	453	97%	25 - 1,802
723-729	3,843	1,660	85%	590 - 7,096
730-805	2,929	379	25%	2,186 - 3,672
806-812	1,792	416	46%	976 - 2,607
813-819	2,787	718	51%	1,379 - 4,195
820-826	549	295	105%	0 - 1,127
827-903	285	49	34%	188 - 382
Total	13,098	1,970	29%	9,236 - 16,959

[a] Angler-hours.

[b] Relative precision (α = 0.05).

Table 6. Estimated harvest and catch rates by shore anglers fishing for coho salmon in the Little Susitna River near the Burma Road access in 1990.

Date	HPUE[a]	SE	CPUE[b]	SE
716-722	0.0333	0.0300	0.0333	0.0300
723-729	0.0446	0.0253	0.0484	0.0222
730-805	0.0838	0.0422	0.0838	0.0422
806-812	0.1955	0.0430	0.1955	0.0430
813-819	0.0090	0.0032	0.0090	0.0032
820-826	0.0500	0.0435	0.0500	0.0435
827-903	0.3056	0.1839	0.3056	0.1839
Total	0.0748	0.0137	0.0757	0.0134

[a] Harvest per angler-hour.

[b] Catch per angler-hour.

Table 7. Estimated harvest and catch of coho salmon by shore anglers fishing near the Little Susitna River Burma Road access in 1990.

Date	Estimated Harvest	SE	Rel. Pre.[a]	95% Confidence Interval	Estimated Catch	SE	Rel. Pre.[a]	95% Confidence Interval
716-722	61	56	179%	0 - 171	61	56	179%	0 - 171
723-729	339	197	114%	0 - 725	367	174	93%	25 - 709
730-805	227	88	76%	54 - 400	227	88	76%	54 - 400
806-812	273	79	56%	119 - 427	273	79	56%	119 - 427
813-819	60	35	115%	0 - 129	60	35	115%	0 - 129
820-826	42	37	171%	0 - 114	42	37	171%	0 - 114
827-903	79	35	86%	11 - 147	79	35	86%	11 - 147
Total	1,082	244	44%	603 - 1,560	1,109	227	40%	665 - 1,553

[a] Relative precision (a = 0.05).

Table 8. Estimated effort by boat anglers exiting the Little Susitna River coho salmon sport fishery through the Miller's Landing and Reach accesses in 1990.

Miller's Reach:

Date	Estimated Effort[a]	SE	Rel. Pre.[b]	95% Confidence Interval
810-819	54	49	178%	0 - 150
820-903	637	198	61%	249 - 1,025
Total	691	204	58%	291 - 1,091

Miller's Landing:

Date	Estimated Effort[a]	SE	Rel. Pre.[b]	95% Confidence Interval
810-819	1,242	443	70%	375 - 2,109
820-903	659	570	170%	0 - 1,777
Total	1,901	722	74%	486 - 3,316
Grand Total	2,592	750	58%	1,122 - 4,062

Miller's Landing and Reach Combined:

Date	Estimated Effort[a]	SE	Rel. Pre.[b]	95% Confidence Interval
810-819	1,296	445	67%	423 - 2,169
820-903	1,296	604	91%	113 - 2,479
Total	2,592	750	57%	1,122 - 4,062

[a] Angler-hours.

[b] Relative precision (α = 0.05).

Harvest rates per angler hour by stratum of coho salmon for boat anglers exiting the fishery at Miller's Landing and Reach ranged from 0.361 (SE = 0.1483) to 0.698 (SE = 0.2608) fish per hour (Table 9). The highest harvest rate of coho salmon estimated was by anglers exiting the fishery during the second stratum from 20 August through 3 September. The estimated harvest of coho salmon by boat anglers exiting the fishery at Miller's was 683 fish (SE = 210) (Table 10).

Catch rates per angler hour of coho salmon for boat anglers exiting the fishery at Miller's ranged from 0.425 (SE = 0.1732) to 0.947 (SE = 0.3143) fish per hour (Table 9). The highest catch rate of coho salmon estimated was also by anglers exiting the fishery during the second stratum from 20 August through 3 September. The estimated catch of coho salmon by boat anglers exiting the fishery at Burma Road was 822 fish (SE = 244) (Table 10).

Anglers exiting the sport fishery in the Miller's Reach and Landing area released about 17% (139 fish) of the coho salmon they caught (Table 4).

Summary:

Total effort was estimated at 42,458 angler-hours (SE = 3,727). A total of 8,001 coho salmon (SE = 867) were harvested from a total of 9,260 caught (SE = 978). Boat anglers exiting the fishery through the Burma Road access site were responsible for the majority of the angler effort (63%), coho salmon harvest (78%), and coho salmon catch (79%). Shore anglers fishing near Burma Road were the next largest component of the fishery. These shore anglers were responsible for 31% of the angler effort, 14% of the coho salmon harvest, and 12% of the coho salmon catch. Anglers exiting the fishery at the Miller's access site had 6% of the effort, 9% of the harvest, and 9% of the catch.

Catch and harvest rates for guided and unguided anglers exiting the sport fishery through the Burma Road access were estimated (Table 11). Both CPUE and HPUE for guided anglers were three to four times greater than for unguided anglers.

Escapement

From 18 July through 9 September 15,511 coho salmon; 3,224 chum salmon *O. keta*; and 7,604 pink salmon *O. gorbuscha* were passed through the weir at rkm 52. (Appendix A4). Forty-five chinook salmon *O. tshawytscha* and 1,045 sockeye salmon *O. nerka* were also passed but the counts for these species are incomplete because high spring runoff prevented the weir from being installed until after the majority of the fish of these species were upstream of the weir site.

The estimated escapement of coho salmon through the weir adjusted for the estimated harvest of coho salmon by sport anglers fishing upstream of the weir and exiting the sport fishery through Burma Road and Miller's Landing and Reach was 14,310 fish (SE = 314). Fifty percent of the coho salmon passage through the weir occurred prior to 14 August (Figure 3).

Coho escapement through the weir, adjusted for the upstream harvest component, in 1990 represents almost the entire escapement to the Little Susitna River.

Table 9. Estimated harvest and catch rates by boat anglers exiting the Little Susitna River coho salmon sport fishery through the Miller's Landing and Reach accesses in 1990.

Miller's Reach:

Date	HPUE[a]	SE	CPUE[b]	SE
810-819	0.0000	0.0000	0.0000	0.0000
820-903	0.6111	0.0752	0.7084	0.1237
Total	0.4919	0.0608	0.5701	0.0995

Miller's Landing:

Date	HPUE[a]	SE	CPUE[b]	SE
810-819	0.4303	0.1767	0.5059	0.2063
820-903	0.7983	0.5534	1.2210	0.6601
Total	0.5801	0.2484	0.7970	0.2953
Grand Total	0.5478	0.1591	0.7138	0.1905

Miller's Landing and Reach Combined:

Date	HPUE[a]	SE	CPUE[b]	SE
810-819	0.3612	0.1483	0.4249	0.1732
820-903	0.6983	0.2608	0.9470	0.3143
Total	0.5476	0.1587	0.7137	0.1903

[a] Harvest rate per angler-hour.

[b] Catch rate per angler-hour.

Table 10. Estimated harvest and catch of coho salmon by boat anglers exiting the Little Susitna River sport fishery through Miller's Landing and Reach accesses in 1990.

Miller's Reach:

Date	Estimated Harvest	SE	Rel. Pre.[a]	95% Confidence Interval	Estimated Catch	SE	Rel. Pre.[a]	95% Confidence Interval
810-819	0	0	0%	0 - 0	0	0	0%	0 - 0
820-903	205	74	71%	59 - 350	256	101	77%	59 - 453
Total	205	74	71%	59 - 350	256	101	77%	59 - 453

Miller's Landing:

Date	Estimated Harvest	SE	Rel. Pre.[a]	95% Confidence Interval	Estimated Catch	SE	Rel. Pre.[a]	95% Confidence Interval
810-819	324	155	94%	21 - 627	348	147	83%	59 - 637
820-903	154	121	155%	0 - 391	218	166	150%	0 - 543
Total	478	196	80%	93 - 862	566	222	77%	130 - 1,001
Grand Total	683	210	60%	271 - 1,094	822	244	58%	343 - 1,300

Miller's Landing and Reach Combined:

Date	Estimated Harvest	SE	Rel. Pre.[a]	95% Confidence Interval	Estimated Catch	SE	Rel. Pre.[a]	95% Confidence Interval
810-819	324	155	94%	21 - 627	348	147	83%	59 - 637
820-903	359	142	78%	81 - 638	474	194	80%	94 - 854
Total	683	210	60%	271 - 1,094	822	243	58%	344 - 1,300

[a] Relative precision (a = 0.05).

Table 11. Harvest and catch rates by stratum of guided and unguided coho salmon anglers exiting the sport fishery through the Little Susitna River Burma Road access in 1990.

Date	HPUE[a]	SE	CPUE[b]	SE
Guided Anglers:				
716-722[c]				
723-729	0.85615	0.195038	0.89533	0.19032
730-805	0.75569	0.217876	1.93168	1.18793
806-812	0.62554	0.248797	1.16667	0.14721
813-819	0.56589	0.155563	0.94714	0.45248
820-826	1.36476	0.507809	1.65653	0.52049
827-903	0.13333	0.027203	0.43333	0.04764
Sub-total	0.878356	0.141082	1.243823	0.245846
Unguided Anglers:				
716-722	0.02692	0.00949	0.02692	0.00949
723-729	0.33210	0.05857	0.37051	0.06935
730-805	0.25049	0.03795	0.28011	0.04159
806-812	0.74202	0.23435	0.82613	0.25288
813-819	0.34101	0.06380	0.39729	0.07014
820-826	0.36253	0.13468	0.44939	0.18442
827-903	0.46699	0.31628	0.74477	0.53900
Sub-total	0.309051	0.031938	0.357000	0.038821

[a] Harvest per angler-hour.

[b] Catch per angler-hour.

[c] No guided anglers exited at access site during sampled periods.

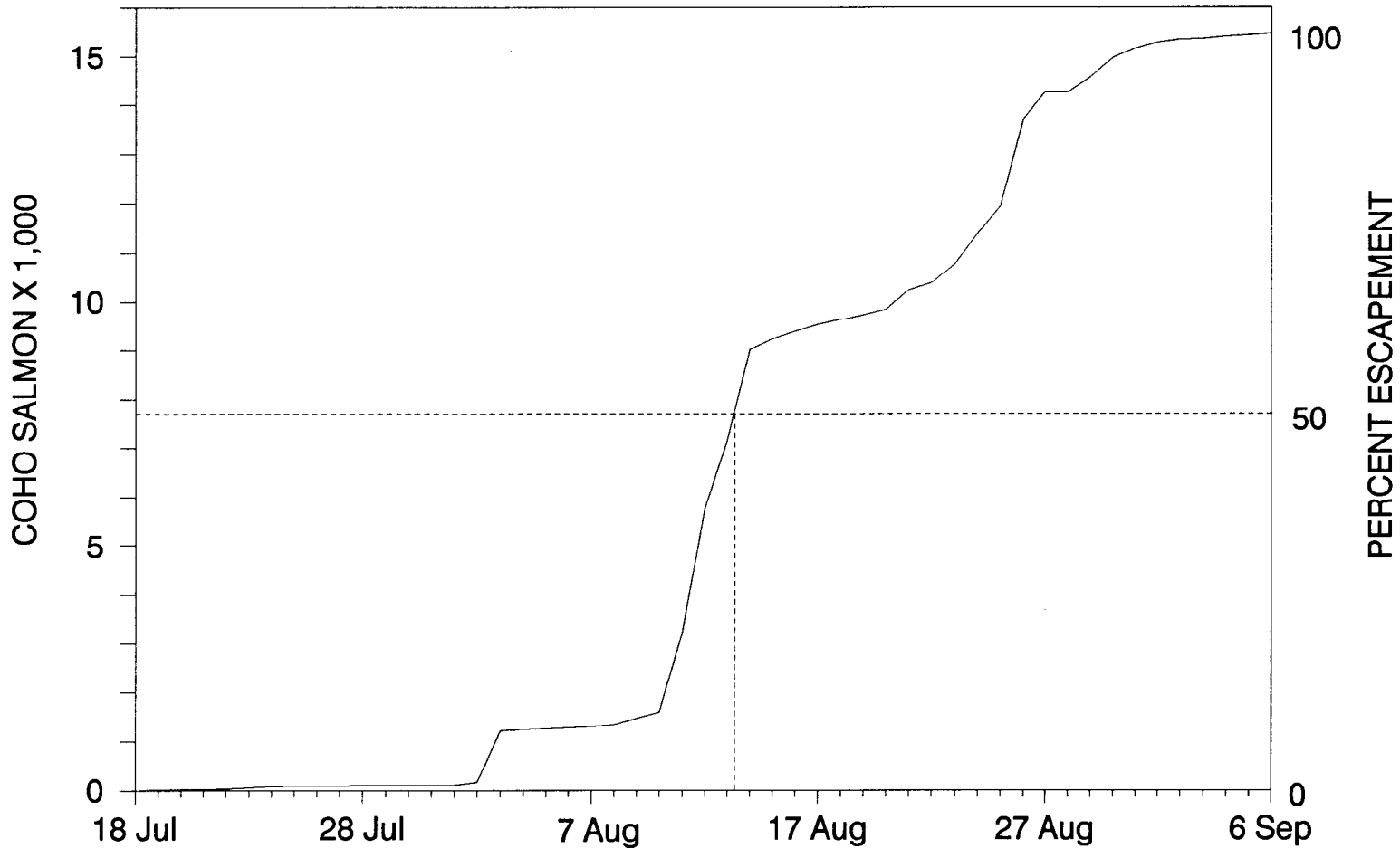

Figure 3. Cumulative escapement of coho salmon through the Little Susitna River weir, 1990.

It is doubtful that more than a few fish passed the weir after it was removed and the unestimated harvest upstream of the weir is believed minimal. Coho salmon are also not known to spawn downstream of the weir. An aerial count of coho salmon escapement to index areas on the Little Susitna River was not conducted during 1990 because the weir remained in place during most of the adult migration.

Counts of coho salmon in the index areas of other Matanuska-Susitna Valley streams ranged from 6 to 599 fish (Table 12). Water clarity and other visibility factors affecting the accuracy of the counts were very good.

Age, Sex, and Length Compositions

A total of 491 coho salmon from the Burma Road sport harvest were sexed and their scales aged. Males and females represented 47% (SE = 0.0647) and 53% (SE = 0.0762) of the estimated harvest, respectively (Table 13). Age-1.1 coho salmon were the most abundant age group comprising 58% of the estimated harvest (SE = 0.1085). The remaining harvest was comprised of age groups 1.0, 2.1, and 3.1.

A total of 377 coho salmon from the escapement past the weir were sexed and their scales aged. Males and females represented 67% and 33% of the escapement, respectively (Table 14). Age-1.1 coho salmon were the most abundant age group as they comprised 66% of the escapement. The remaining escapement was comprised of age groups 2.1 and 3.1. Age composition was not significantly different ($\alpha = 0.05$) between the Burma Road harvest and the escapement ($\chi^2 = 5.8$ with 2 degrees of freedom). There was however, a higher proportion of females in the Burma Road harvest than in the escapement ($\chi^2 = 18.3$ with 1 degree of freedom).

The sex ratios of coho sampled for age, sex, and length composition in the Burma Road harvest at the weir were tabulated by weekly, Monday through Sunday, strata. Within these samples, males dominated the samples collected at the weir through the stratum ending 12 August (Appendix A5). Males dominated the harvest samples during the first two strata and females dominated thereafter.

The sex of 1,284 coho salmon harvested at Burma Road was noted when they were inspected for hatchery marks (Appendix A5). Males were more abundant in the first strata group (16 July through 5 August) while females were more abundant in the remaining strata (23 July through 3 September).

Mean lengths at age of male and female coho salmon sampled from the Burma Road sport harvest and at the weir (Tables 15 and 16) were not significantly different at $\alpha = 0.05$ (Appendix A6).

A total of 57 coho salmon from the Miller's Landing sport harvest were sexed and their scales aged. Males and females represented 44% (SE = 0.1888) and 56% (SE = 0.1550) of the estimated harvest, respectively (Table 17). Age-1.1 coho salmon were the most abundant age group comprising 53% (SE = 0.2361) of the estimated harvest. Age group 2.1 comprised the remainder of the estimated harvest. Age and sex composition were significantly different ($\alpha = 0.05$) between the Miller's Landing and Reach harvest and the coho salmon passing the

Table 12. Escapement counts[a] of coho salmon for selected Matanuska-Susitna Valley streams, 1984-1990.

Stream	Year						
	1990	1989	1988	1987	1986	1985	1984
Little Susitna River	14,310[c]	15,232[bc]	20,491	4,865	1,038[d]	3,540	20,991
Spring (Wasilla) Creek	38	67	82	110	141	150	NS[d]
Yellow Creek	146	226	110	58	20	65	0
McRoberts Creek	599	597	1,911	667	439	662	NS[d]
Spring (Flats) Creek	12	39	30	42	147	81	90
Cottonwood Creek	167	147	293	360	121	334	935
Wasilla Creek	36	NS[e]	NS[e]	251	NS[e]	248	628
Rabideux Creek	20	20	230	50[f]	NS[e]	82	480
Birch Creek	36	180	63	46	25	30	236
Question Creek	41	31	337	149	NS[e]	89	60
Answer Creek	6	66	160	10	NS[e]	9	57
Total	15,411	16,605	23,707	6,608	1,931	5,290	23,477

[a] Aerial and/or foot surveys unless otherwise noted.

[b] Minimum estimate. Flood overtopped weir, 8-27-89.

[c] Weir count minus estimated harvest above weir.

[d] Incomplete survey.

[e] Not surveyed.

[f] Poor survey conditions.

Table 13. Estimated sex and age composition of coho salmon from the Little Susitna River Burma Road sport fishery harvest in 1990.

	Age Group				
	1.0	1.1	2.1	3.1	Total
Females:					
Number Estimated		2,377	1,458	31	3,866
Proportion		0.325	0.199	0.004	0.528
SE		0.0642	0.0413	0.0030	0.0766
Males:					
Number Estimated	39	1,882	1,435	96	3,452
Proportion	0.005	0.257	0.196	0.013	0.471
SE	0.0037	0.0512	0.0398	0.0057	0.0652
Sexes Combined:					
Number Estimated	39	4,259	2,893	127	7,318
Proportion	0.005	0.583	0.394	0.017	1.000
SE	0.0038	0.1085	0.0754	0.0068	

Table 14. Estimated sex and age composition of coho salmon from the Little Susitna River escapement through the weir in 1990.

	Age Group			
	1.1	2.1	3.1	Total
Females:				
Number Estimated	3,682	1,339	43	5,064
Proportion	0.238	0.087	0.003	0.328
SE	0.2379	0.0865	0.0028	0.2532
Males:				
Number Estimated	6,539	3,833	43	10,415
Proportion	0.422	0.248	0.003	0.673
SE	0.4225	0.2476	0.0028	0.4897
Sexes Combined:				
Number Estimated	10,221	5,173	85	15,479[a]
Proportion	0.660	0.334	0.006	1.000
SE	0.6603	0.3342	0.0055	

[a] Total includes only fish passed during sampled strata.

Table 15. Mean length of coho salmon by sex and age group sampled from the Little Susitna River Burma Road sport fishery in 1990.

	Age Group			
	1.0	1.1	2.1	3.1
Females:				
Mean Length (cm)[a]		56.3	58.4	59.8
SE		3.9	3.2	22.5
Sample Size		134	89	2
Minimum		40.5	47.0	40.5
Maximum		64.5	64.5	62.0
Males:				
Mean Length (cm)[a]	30.0	57.2	59.6	59.2
SE		4.8	4.9	14.1
Sample Size	1	103	79	6
Minimum	30.0	44.5	47.5	53.5
Maximum	30.0	67.5	67.5	63.0

[a] Mid-eye to fork of tail.

Table 16. Mean length of coho salmon by sex and age group sampled from the escapement at the Little Susitna River weir in 1990.

	Age Group		
	1.1	2.1	3.1
Females:			
Mean Length (cm)[a]	59.1	59.2	63.0
SE	4.0	6.8	
Sample Size	88	30	1
Minimum	44.5	52.0	63.0
Maximum	68.0	68.0	63.0
Males:			
Mean Length (cm)[a]	60.2	61.8	59.0
SE	2.9	3.3	
Sample Size	160	97	1
Minimum	41.0	52.0	59.0
Maximum	67.0	69.5	59.0

[a] Mid-eye to fork of tail.

Table 17. Estimated sex and age composition of coho salmon from the Little Susitna River, Miller's Landing and Reach sport fishery harvest in 1990.

	Age Group		
	1.1	2.1	Total
Females:			
Number Estimated	179	203	382
Proportion	0.262	0.297	0.559
SE	0.1259	0.1407	0.1888
Males:			
Number Estimated	182	119	301
Proportion	0.267	0.174	0.441
SE	0.1268	0.0892	0.1550
Sexes Combined:			
Number Estimated	361	322	683
Proportion	0.529	0.471	1.000
SE	0.2361	0.2158	

weir. There was a higher proportion of age-2.1 females in the Miller's Landing and Reach harvest than there was in the escapement (χ^2 = 4.32 with 1 degree of freedom).

Mean lengths at age of male and female coho salmon sampled from the Miller's Landing and Reach sport harvest (Table 18) were not significantly different at α = 0.05 from those sampled from the Burma Road sport harvest and at the weir (Appendix A6).

Hatchery Contributions

Out of a total of 1,660 coho salmon examined from the Burma Road sport fishery, 35 had a missing adipose fin. Of these, 32 had their heads removed and sent to the FRED Division CWT lab for processing. A total of 28 fish had coded-wire tags which were present and could be decoded. All decodable tags were from the 1989 Nancy Lake smolt release. Chi-square tests comparing the estimated harvest to the number of fish examined for marks between weekly strata was not significant (α = 0.05) for the weeks between 30 July and 26 August (Appendix A7). These weeks were pooled. Estimates for four recovery periods were then calculated separately and combined for a total estimate.

Based on these data, the estimated contribution of hatchery-produced coho salmon to the sport harvest in the Little Susitna River through Burma Road during 1990 was 1,927 fish (SE = 392) (Table 19). This represents 27% of the total harvest of coho salmon through the Burma Road access site.

A total of 68 coho salmon from the Miller's Landing and Reach sport fishery were examined for a missing adipose fin. Of these, three were observed to have a missing adipose fin, two had heads which were removed and sent to the FRED Division CWT lab for processing. Both heads had decodable coded-wire tags from the 1989 Nancy Lake smolt release. Based on these data the estimated contribution of hatchery-produced coho salmon to the sport harvest in the Little Susitna River through Miller's Landing during 1989 was 421 fish (SE = 273) (Table 19). This represents 62% of the total harvest of coho salmon through the Miller's Landing access site.

A total of 3,747 coho salmon from the escapement past the weir were examined for a missing adipose fin, of which 76 were observed to have a missing adipose. Chi-square tests comparing the passage at the weir to the number of fish examined for marks between weekly strata was significant (α = 0.05) for all weeks except from 20 August through 2 September (χ^2 = 3.55 with 1 df). These weeks were pooled. Estimates for five recovery periods were then calculated separately and combined for a total estimate.

Based on these data, the hatchery contribution to the 15,511 coho salmon passing through the weir was estimated to be 3,791 fish (SE = 449) or about 24% (Table 19). No heads were collected from coho salmon passing through the weir. We assume, however, based on tag decoding information obtained from the sport fishery recoveries, that these fish originate from the 1989 Nancy Lake smolt release.

Table 18. Mean length of coho salmon by sex and age group sampled from the Little Susitna River Miller's Landing and Reach sport fishery in 1990.

	Age Group	
	1.1	2.1
Females:		
Mean Length (cm)[a]	54.5	59.2
SE	12.9	6.5
Sample Size	15	17
Minimum	43.5	54.5
Maximum	60.5	63.0
Males:		
Mean Length (cm)[a]	60.1	65.0
SE	8.9	30.7
Sample Size	15	10
Minimum	54.5	56.0
Maximum	67.0	83.5

[a] Mid-eye to fork of tail.

Table 19. Contribution of hatchery-origin coho salmon[a] to the sport harvest and escapement past the Little Susitna River weir in 1990.

Location	Total		Hatchery		
	Harvest	SE	Harvest	SE	Percent
Fishery					
Burma Road	7,318	841.0	1,927	392.1	27.0
Miller's	683	210.0	421	272.9	61.6
Total	8,001	866.8	2,393	478.0	29.9
Weir	15,511	--[b]	3,791	449.0	24.4

[a] From hatchery-reared smolts released at Nancy Lake in 1989.

[b] Measured without error.

DISCUSSION

The estimated 42,458 angler-hours of effort in 1990 was the lowest estimated effort on the Little Susitna River for coho salmon since 1983 and down 38% from 1989 (Bentz 1983-1986, Bartlett and Conrad 1988, Bartlett and Vincent-Lang 1989, Bartlett and Sonnichsen 1990). The low effort may be related to two factors: first, the water temperature and flow conditions of the river during the coho salmon spawning migration; and second, in-season management restrictions. Extremely low and warm water stalled the upstream movement of coho salmon until about 11 August (Figure 3). Many of these fish were concentrated in pools and resting areas in a 6 km reach of river below the weir where they were highly visible and excessively vulnerable to the sport fishery. An emergency closure of this 6 km of reach was effective from 0001 hours on 2 August through 1200 hours on 14 August. A reduction of the bag limit from three coho to one coho on the remainder of the river was also ordered. This emergency order coincided with the traditional peak of the coho salmon fishery in the 6 km reach.

Public reaction to the emergency order was evident from the effort estimates by surveyed stratum (Table 1). The estimated effort during the stratum enclosed by the emergency order period was sharply reduced relative to the preceding and following strata. Engel (1990) estimated that during the emergency order period, effort was reduced by about 70% and the harvest of coho salmon was estimated to have been reduced by about 80%. If the harvest had not been restricted by emergency order, an additional harvest of about 4,500 coho salmon may have been realized.

A total of 22,311 coho salmon were accounted for in the Little Susitna River during 1990. The actual inriver return is somewhat greater than this due to fishing effort by anglers who access the sport fishery through the Port of Anchorage and were not surveyed during 1990. This estimate is based on an estimated escapement of 14,310 coho salmon above the weir, an estimated sport harvest of 1,201 coho salmon above the weir, and an estimated sport harvest of 6,800 coho salmon below the weir. Based on a total estimated sport harvest of 8,001, this represents a minimum inriver exploitation rate by the sport fishery of about 36%. It is not possible to estimate the total return or exploitation of Little Susitna River stock as an unknown number of coho salmon are harvested in the mixed-stock commercial fisheries of upper Cook Inlet.

When compared to the statewide harvest estimations reported by Mills (1979-1990), the estimated harvest of 8,001 coho salmon is the tenth largest in the 14 year recorded history (1977-1989) of the fishery (Figure 2). As previously noted, the actual harvest would be higher than 8,001 because of unsurveyed portions of the sport fishing effort through the Port of Anchorage. These anglers would historically add from 3% to 5% to the estimated harvest (Bentz 1983-1987; Bartlett and Conrad 1988). The unsurveyed anglers were accounted for in a 1990 statewide coho salmon harvest estimation for the Little Susitna River.

Hooking mortality and a small number of salmon that pass upstream after the weir is removed also add to the uncounted number of coho salmon in the return. Studies by Vincent-Lang et al. (*Unpublished*) show that the mortality of hooked and released coho salmon in the intertidal waters of the Little Susitna River

is as high as 69%. A 69% mortality of the released fish (Table 4) would comprise about 6% (395 fish) of the total catch of coho salmon by anglers fishing downstream of the Burma Road access.

Coho salmon originating from hatchery smolt releases are, with rare exception, age-1.1 fish while the age composition of the wild stock is comprised of mostly age-1.1 and 2.1-fish. In recent years, the percent of age-1.1 fish in the escapement has exceeded the estimated hatchery component by about twofold (Bartlett and Vincent-Lang 1989, Bartlett and Sonnichsen 1990). Greater than a twofold difference was again noted in 1990 when an estimated 27% of the coho salmon that passed the weir originated from 1989 stocking efforts while 66% of those sampled for age composition at the weir were aged as 1.1. What percent of wild stock age-1.1 coho that could be considered "normal" to Little Susitna River is unknown because only one age composition record for pure Little Susitna River wild coho salmon escapement is known to exist. This sample, collected from the spawning escapement in 1978, contains 81 readable sets of scales of which 42% were aged as 1.1- and 57% as 2.1-coho salmon. The percent of age-1.1 coho salmon in this sample does indicate, however, that age-1.1 estimates up to 42% higher than the estimated age-1.1 hatchery component are possible.

Variation in harvest timing between the Little Susitna River hatchery and naturally-spawned stocks was reported by Bartlett and Vincent-Lang (1990). This study determined that the hatchery stock enter the river and are harvested proportionally later than the naturally-spawned stock. Differential harvest timing was also observed in 1990 (Figure 4). Extreme low and warm water, combined with the emergency order restricting effort and harvest, are believed to have disrupted the separation of stocks as reported by Bartlett and Vincent-Lang to some degree during the 1990 season. The reason for the separation of stocks is unknown but may have roots in the timing and other factors of the brood stock when originally selected.

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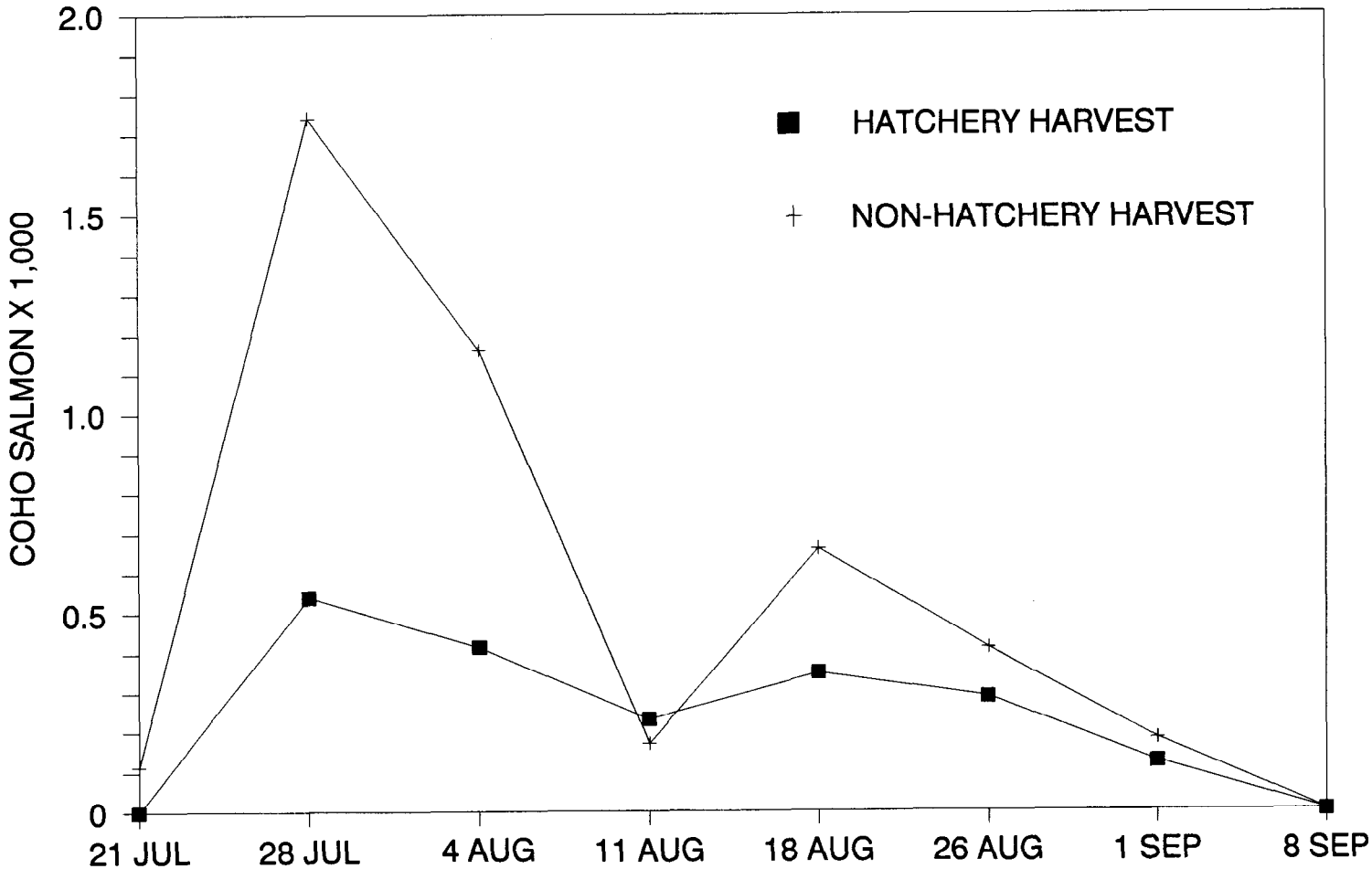

Figure 4. Timing of hatchery and non-hatchery coho salmon in the Burma Road sport fishery, Little Susitna River, 1990.

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APPENDIX A

Appendix A1. Effort, harvest and catch summaries of Little Susitna River, Burma Road coho salmon boat anglers by day and period, 1990.

Date	Period[a]	Sample Size[b]	Mean[c] Effort	Effort[d] Variance	Est.[e] Effort	Mean Harvest	Harvest[d] Variance	Est.[e] Harvest	Mean Catch	Catch[d] Variance	Est.[e] Catch
719	2	10	3.30	1.7333	33.00	0.00	0.0000	0	0.00	0.0000	0
719	4	7	2.79	3.1548	19.50	0.43	1.2857	3	0.43	1.2857	3
720	2	38	4.05	3.3620	154.00	0.08	0.0747	3	0.08	0.0747	3
720	3	24	5.00	8.3913	120.00	0.04	0.0417	1	0.04	0.0417	1
722	1	8	11.88	59.7679	95.00	0.38	0.2679	3	0.38	0.2679	3
722	3	74	5.39	7.8805	398.50	0.23	0.4534	17	0.23	0.4534	17
725	1	26	5.13	38.7912	133.50	3.00	9.0400	78	3.04	9.0785	79
725	2	42	6.70	16.2690	281.50	1.88	1.6684	79	2.40	8.3444	101
727	2	75	5.55	13.8863	416.00	2.31	1.1344	173	2.48	1.9827	186
727	3	83	5.72	18.6475	474.50	1.12	1.6682	93	1.16	1.8654	96
728	2	63	4.82	2.6073	303.50	2.25	1.3538	142	2.41	1.8269	152
728	4	95	5.05	10.2663	479.50	0.38	0.7059	36	0.42	0.7996	40
801	1	68	4.73	5.7346	321.50	1.96	1.7144	133	2.03	1.9096	138
801	2	76	5.78	2.8960	439.00	1.38	1.7591	105	1.59	2.6447	121
802	2	54	4.13	4.3178	223.00	0.76	0.4127	41	0.85	0.9210	46
802	3	31	4.74	4.8478	147.00	0.48	0.2581	15	0.81	2.7613	25
804	1	17	2.94	2.6526	50.00	0.59	0.2574	10	0.59	0.2574	10
804	2	46	5.10	24.1624	234.50	1.02	0.9995	47	1.48	3.0551	68
810	1	4	2.00	0.0000	8.00	1.00	0.0000	4	1.25	0.2500	5
810	3	0	0.00	0.0000	0.00	0.00	0.0000	0	0.00	0.0000	0
811	1	13	1.79	3.2692	23.25	0.92	0.4103	12	1.31	2.2308	17
811	3	12	6.25	4.5682	75.00	0.42	0.2652	5	0.92	1.9015	11
812	1	9	1.72	1.8194	15.50	0.78	0.1944	7	0.78	0.1944	7
812	3	79	4.28	9.4593	337.75	0.66	0.2535	52	0.80	0.8046	63
813	1	0	0.00	0.0000	0.00	0.00	0.0000	0	0.00	0.0000	0
813	2	16	3.78	5.3323	60.50	0.63	0.2500	10	0.69	0.2292	11
816	1	8	4.13	1.5536	33.00	2.38	0.8393	19	2.38	0.8393	19
816	3	92	4.24	7.3865	389.75	1.07	1.4902	98	1.29	3.5723	119
817	2	67	6.04	5.6463	404.50	1.64	1.8394	110	2.66	10.5925	178
817	3	58	3.81	3.6372	221.25	1.02	1.2804	59	1.05	1.4534	61
820	1	10	3.20	1.8444	32.00	0.00	0.0000	0	0.00	0.0000	0
820	2	26	3.58	2.1138	93.00	1.50	1.7800	39	2.42	3.6938	63
822	2	34	4.26	6.9278	145.00	0.88	1.1979	30	1.09	1.7193	37
822	3	29	6.03	8.0345	175.00	1.93	1.2094	56	1.97	1.1773	57
826	1	2	1.00	0.0000	2.00	0.00	0.0000	0	0.00	0.0000	0
826	3	29	6.43	34.0486	186.50	2.28	2.2069	66	3.10	5.9532	90
828	1	0	0.00	0.0000	0.00	0.00	0.0000	0	0.00	0.0000	0
828	2	8	3.50	1.5714	28.00	0.00	0.0000	0	0.00	0.0000	0
829	1	0	0.00	0.0000	0.00	0.00	0.0000	0	0.00	0.0000	0
829	3	14	2.95	1.4056	41.25	1.14	2.1319	16	2.00	6.9231	28
830	1	2	2.00	0.0000	4.00	0.00	0.0000	0	0.00	0.0000	0
830	2	15	4.03	2.2310	60.50	0.47	0.5524	7	0.47	0.5524	7

[a] Periods:

716-729		730-819		820-903	
1	0800-1159	1	0730-1229	1	0800-1229
2	1200-1559	2	1230-1729	2	1230-1659
3	1600-1959	3	1730-2229	3	1700-2129
4	2000-2359				

[b] Number of anglers interviewed exiting the fishery during this period.

[c] Angler-hours.

[d] Variance of the mean value during this period.

[e] Estimated.

Appendix A2. Summary of Little Susitna River, Burma Road coho salmon shore angler statistics by period and day, 1990.

Date	Period[a]	Hours/ Period	Counts/ Period	Mean Count/ Period	Count Var.[b]	Est.[c] Effort	Est. Effort Var.[d]	Inter- views/ Period	Mean Jack[e] HPUE[f]	HPUE[f] Jack[e] Var.[b]	Est. Harvest/ Period	Harvest Var.[d]	Mean Jack[e] CPUE[g]	CPUE[g] Jack[e] Var.[b]	Est. Catch/ Period	Est. Catch Var.[d]
718	3	6.00	2	3.0	2.0	18.00	36	6	0.0000	0.0000	0	0.0000	0.0000	0.0000	0	0.0000
721	1	6.00	2	11.5	0.5	69.00	9	6	0.0848	0.0093	6	44.0280	0.0848	0.0093	6	44.0280
726	1	6.00	2	15.0	128.0	90.00	2,304	11	0.0581	0.0004	5	10.2605	0.0871	0.0016	8	26.7001
729	3	6.00	2	46.0	32.0	276.00	576	37	0.0981	0.0012	27	98.6115	0.0981	0.0012	27	98.6115
803	2	3.25	1	32.0	-	104.00	-	23	0.0559	0.0007	6	7.6316	0.0559	0.0007	6	7.6316
803	4	3.25	1	25.0	-	81.25	-	40	0.0175	0.0001	1	0.9249	0.0175	0.0001	1	0.9249
805	2	3.25	1	12.0	-	39.00	-	14	0.1963	0.0043	8	6.5127	0.1963	0.0043	8	6.5127
805	3	3.25	1	34.0	-	110.50	-	13	0.1001	0.0004	11	4.9605	0.1001	0.0004	11	4.9605
806	2	3.25	1	23.0	-	74.75	-	17	0.1762	0.0025	13	13.8670	0.1762	0.0025	13	13.8670
806	5	3.25	1	17.0	-	55.25	-	15	0.0469	0.0010	3	2.9624	0.0469	0.0010	3	2.9624
809	2	3.25	1	10.0	-	32.50	-	11	0.2375	0.0079	8	8.3446	0.2375	0.0079	8	8.3446
809	3	3.25	1	13.0	-	42.25	-	-	-	-	-	-	-	-	-	-
818	3	3.25	1	46.0	-	149.50	-	53	0.0286	0.0004	4	9.5750	0.0286	0.0004	4	9.5750
818	5	3.25	1	16.0	-	52.00	-	28	0.0000	0.0000	0	0.0000	0.0000	0.0000	0	0.0000
819	1	3.25	1	17.0	-	55.25	-	-	-	-	-	-	-	-	-	-
819	3	3.25	1	19.0	-	61.75	-	21	0.0209	0.0004	1	1.4550	0.0209	0.0004	1	1.4550
821	3	4.75	1	2.0	-	9.50	-	13	0.0000	0.0000	0	0.0000	0.0000	0.0000	0	0.0000
823	1	4.75	1	9.0	-	42.75	-	10	0.0935	0.0043	4	7.8001	0.0935	0.0043	4	7.8001
827	1	4.75	1	2.0	-	9.50	-	2	0.5000	0.2500	5	22.5625	0.5000	0.2500	5	22.5625
831	2	4.75	1	3.0	-	14.25	-	3	0.1306	0.0153	2	3.1086	0.1306	0.0153	2	3.1086

[a] Periods:

716-729		730-819		820-903	
1	0500-1059	1	0600-0914	1	0645-1129
2	1100-1659	2	0915-1229	2	1130-1614
3	1700-2259	3	1230-1544	3	1615-2059
		4	1545-1859		
		5	1900-2214		

[b] Variance of mean value during this period.
[c] Estimated angler-hours.
[d] Variance of estimated value.
[e] Jack knife.
[f] Harvest rate per angler-hour.
[g] Catch rate per angler-hour.

Appendix A3. Effort, harvest, and catch summaries by day and period of Little Susitna River Miller's Landing and Reach coho salmon boat anglers, 1990.

Survey Location	Date	Period[a]	Sample Size[b]	Mean[c] Effort	Effort Var.[d]	Est.[e] Effort	Mean Harvest	Harvest Var.[d]	Est.[e] Harvest	Mean Catch	Catch Var.[d]	Est.[e] Catch
Miller's Reach	811	1	0									
Miller's Reach	811	4	0									
Miller's Reach	815	3	0									
Miller's Reach	815	4	3	3.00	0.0000	9.00	0.00	0.0000	0	0.00	0.0000	0
Miller's Reach	816	1	0									
Miller's Reach	816	2	0									
Miller's Reach	821	1	0									
Miller's Reach	821	2	0									
Miller's Reach	823	3	6	5.00	1.2000	30.00	1.33	2.2667	8	1.33	2.2667	8
Miller's Reach	823	4	0									
Miller's Reach	827	2	0									
Miller's Reach	827	3	4	5.00	0.0000	20.00	2.00	0.6667	8	2.00	0.6667	8
Miller's Reach	828	1	0									
Miller's Reach	828	3	7	4.50	0.1667	31.50	1.86	1.8095	13	2.71	0.2381	19
Miller's Reach	903	3	8	2.25	3.0714	18.00	0.38	0.2679	3	0.63	0.2679	5
Miller's Reach	903	4	0									
Miller's Landing	810	3	4	5.25	2.2500	21.00	0.50	0.3333	2	1.00	0.6667	4
Miller's Landing	810	4	1	2.50	0.0000	2.50	0.00	0.0000	0	0.00	0.0000	0
Miller's Landing	814	1	0									
Miller's Landing	814	4	9	7.06	22.3403	63.50	1.67	1.7500	15	1.89	2.6111	17
Miller's Landing	818	2	10	5.60	6.1556	56.00	1.80	1.9556	18	1.80	1.9556	18
Miller's Landing	818	4	17	3.76	4.3474	64.00	1.12	1.8603	19	1.12	1.8603	19
Miller's Landing	822	1	0									
Miller's Landing	822	3	16	6.13	0.5167	98.00	1.31	1.5625	21	1.81	5.4958	29
Miller's Landing	826	1	0									
Miller's Landing	826	2	2	1.50	0.0000	3.00	0.00	0.0000	0	0.50	0.5000	1
Miller's Landing	830	3	0									
Miller's Landing	830	4	2	1.00	0.0000	2.00	1.50	0.5000	3	2.00	2.0000	4
Miller's Landing	831	1	0									
Miller's Landing	831	4	0									
Miller's Landing	901	1	0									
Miller's Landing	901	2	0									

[a] Periods: 1 0600-0959
2 1000-1359
3 1400-1759
4 1800-2200

[b] Number of anglers interviewed exiting the fishery during this period.

[c] Angler-hours.

[d] Variance of the mean value during this period.

[e] Estimated.

Appendix A4. Daily and cumulative salmon counts, Little Susitna River weir, 1990.

Date	Coho		Sockeye		Chum		Pink		Chinook	
	Daily	Cum.[a]	Daily	Cum.[a]	Daily	Cum.[a]	Daily	Cum.[a]	Daily	Cum.[a]
718	4	4	0	0	9	9	0	0	5	5
719	10	14	5	5	12	21	0	0	2	7
720	3	17	4	9	13	34	1	1	1	8
721	5	22	48	57	48	82	4	5	0	8
722	9	31	183	240	145	227	18	23	0	8
723	21	52	95	335	236	463	12	35	0	8
724	17	69	37	372	433	896	29	64	3	11
725	15	84	49	421	409	1,305	14	78	0	11
726	5	89	78	499	531	1,836	8	86	0	11
727	0	89	38	537	86	1,922	6	92	2	13
728	6	95	17	554	42	1,964	5	97	0	13
729	0	95	5	559	30	1,994	2	99	0	13
730	0	95	3	562	0	1,994	5	104	0	13
731	3	98	4	566	38	2,032	16	120	0	13
801	4	102	0	566	12	2,044	27	147	0	13
802	61	163	12	578	17	2,061	159	306	0	13
803	1,060	1,223	126	704	232	2,293	1,060	1,366	1	14
804	27	1,250	23	727	48	2,341	1,024	2,390	0	14
805	23	1,273	29	756	40	2,381	313	2,703	0	14
806	21	1,294	31	787	37	2,418	386	3,089	1	15
807	24	1,318	37	824	24	2,442	722	3,811	18	33
808	42	1,360	46	870	55	2,497	459	4,270	1	34
809	129	1,489	46	916	124	2,621	1,009	5,279	2	36
810	119	1,608	21	937	40	2,661	412	5,691	3	39
811	1,620	3,228	22	959	27	2,688	782	6,473	4	43
812	2,540	5,768	31	990	32	2,720	467	6,940	2	45
813	1,399	7,167	3	993	54	2,774	232	7,172	0	45
814	1,861	9,028	9	1,002	32	2,806	280	7,452	0	45
815	215	9,243	10	1,012	59	2,865	48	7,500	0	45
816	159	9,402	7	1,019	33	2,898	23	7,523	0	45
817	127	9,529	8	1,027	46	2,944	21	7,544	0	45
818	99	9,628	2	1,029	41	2,985	31	7,575	0	45
819	105	9,733	1	1,030	46	3,031	7	7,582	0	45
820	128	9,861	1	1,031	8	3,039	1	7,583	0	45
821	377	10,238	3	1,034	18	3,057	6	7,589	0	45
822	141	10,379	1	1,035	22	3,079	0	7,589	0	45
823	396	10,775	1	1,036	17	3,096	3	7,592	0	45
824	617	11,392	0	1,036	31	3,127	3	7,595	0	45
825	556	11,948	0	1,036	18	3,145	4	7,599	0	45
826	1,765	13,713	1	1,037	40	3,185	2	7,601	0	45
827	554	14,267	0	1,037	11	3,196	1	7,602	0	45
828	0	14,267	0	1,037	0	3,196	0	7,602	0	45
829	311	14,578	1	1,038	1	3,197	0	7,602	0	45
830	400	14,978	5	1,043	5	3,202	2	7,604	0	45
831	191	15,169	0	1,043	2	3,204	0	7,604	0	45
901	139	15,308	0	1,043	6	3,210	0	7,604	0	45
902	60	15,368	0	1,043	2	3,212	0	7,604	0	45
903	6	15,374	0	1,043	1	3,213	0	7,604	0	45
904	44	15,418	0	1,043	3	3,216	0	7,604	0	45
905	26	15,444	2	1,045	6	3,222	0	7,604	0	45
906	44	15,488	0	1,045	1	3,223	0	7,604	0	45
907	9	15,497	0	1,045	0	3,223	0	7,604	0	45
908	4	15,501	0	1,045	1	3,224	0	7,604	0	45
909	10	15,511	0	1,045	0	3,224	0	7,604	0	45

[a] Cumulative.

Appendix A5. Sex ratios of coho salmon in the Little Susitna River sport fishery and escapement, 1990.

Examined for ad-clips in the creel survey at Burma Road.

Date	Males	Females	M:F [a] Ratio	M:F [b] Ratio
716-722	11	16	1:1.45	1:0.73
723-729	246	142	1:0.58	
730-805	166	150	1:0.90	
806-812	45	61	1:1.36	1:1.60
813-819	101	183	1:1.81	
820-826	58	79	1:1.36	
827-903	9	17	1:1.89	
Total	636	648	1:1.02	

Examined for age, sex, and length in the creel survey at Burma Road.

Date	Males	Females	M:F [a] Ratio	M:F [c] Ratio
716-722	8	3	1:0.38	1:0.71
723-729	96	71	1:0.74	
730-805	50	66	1:1.32	
806-812	24	46	1:1.92	1:1.65
813-819	25	52	1:2.08	
820-826	16	26	1:1.63	
827-903	3	5	1:1.67	
Total	222	269	1:1.21	

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Examined for age, sex, and length at the weir.

Date	Males	Females	M:F [a] Ratio	M:F [d] Ratio
723-729	16	0	1:0.00	1:0.28
730-805	7	1	1:0.14	
806-812	69	18	1:0.26	
813-819	111	39	1:0.35	
820-826	18	27	1:1.50	1:1.11
827-902	33	21	1:0.64	
903-909	4	13	1:3.25	
Total	258	119	1:0.46	

Examined for age, sex, and length in the creel survey at Miller's Landing and Reach.

Date	Males	Females	M:F [a] Ratio
810-821	11	17	1:1.55
822-903	14	15	1:1.07
Total	25	32	1:1.28

[a] Ratio by stratum.

[b] Ratio by grouped strata, 716-805 and 806-903.

[c] Ratio by grouped strata, 716-729 and 730-903.

[d] Ratio by grouped strata, 716-812 and 813-903.

Appendix A6. Mean length comparisons of Little Susitna River coho salmon by location and age, 1990.

Location	Age	Mean[a] Length	SE	Sample Size	t-statistic[b]	df[c]
Weir	1.1	59.8	2.39	248	0.348	373
	2.1	61.2	3.12	127		
Weir	1.1	59.8	2.39	248	0.045	248
	3.1	61.0	20.00	2		
Weir	2.1	61.2	3.12	127	0.008	127
	3.1	61.0	20.00	2		
Burma Road	1.1	56.7	3.01	237	0.508	403
	2.1	58.9	2.91	168		
Burma Road	1.1	56.7	3.01	237	0.157	243
	3.1	59.3	11.18	8		
Burma Road	2.1	58.9	2.91	168	0.029	174
	3.1	59.3	11.18	8		
Burma Road	1.1	56.7	3.01	237	0.802	483
Weir	1.1	59.8	2.39	248		
Burma Road	2.1	58.9	2.91	168	0.534	293
Weir	2.1	61.2	3.12	127		
Burma Road	3.1	59.3	11.18	8	0.069	8
Weir	3.1	61.0	20.00	2		

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Location	Age	Mean[a] Length	SE	Sample Size	t-statistic[b]	df[c]
Burma Road	1.1	56.7	3.01	248	0.066	265
MLR[d]	1.1	57.3	9.31	30		
Burma Road	2.1	58.9	2.91	168	0.281	193
MLR[d]	2.1	61.4	12.97	27		
Weir	1.1	59.8	2.39	248	0.329	276
MLR[d]	1.1	57.3	9.31	30		
Weir	2.1	61.2	3.12	127	0.022	152
MLR[d]	2.1	61.4	12.97	27		

[a] Mid-eye to fork of tail in centimeters.

[b] Two-tailed test (α = 0.05).

[c] Degrees of freedom.

[d] Miller's Landing and Reach.

Appendix A7. Strata as grouped for hatchery contribution estimates according to the ratio between the estimated harvest and the number of coho salmon examined for hatchery marks in the Burma Road sport fishery, 1990.

Date	Estimated Harvest	Number Examined	P[a]	χ^{2}[b]	df[c]	Significant?
716-722	187	19	0.10	5.59	1	Yes
723-729	3,144	566	0.18	58.69	4	Yes
730-805	1,456	401	0.28			
806-812	553	146	0.26	0.66	3	No
813-819	1,096	316	0.29			
820-826	711	198	0.28			
827-803[d]	171	14	0.08			
Total	7,318	1,660				

[a] Proportion of the estimated harvest examined for the hatchery mark.

[b] Chi-square statistic (0.05) for grouped strata.

[c] Degrees of freedom.

[d] Stratum not included in chi-square tests.

APPENDIX B

Appendix B1. Little Susitna River 1990 creel survey effort, catch, harvest, catch rate, and harvest rate, input data, analysis, and output files.

Fishery/Creel Survey Description	Input Data[a] Files	Effort, Catch, and Harvest Estimates		CPUE/HPUE Estimates	
		SAS Program	SAS Output Files	SAS Program	SAS Output Files
1. Burma Road boat anglers:					
a. All areas combined	LSCOAS90.DTA	LSCOAS90.SAS	LSCOAS90.LST & LOG	LSU90BCS.SAS/	LSU90BCS.LST & LOG/
b. Downstream of Burma Rd.	LSCODS90.DTA	LSCODS90.SAS	LSCODS90.LST & LOG		
c. Between Burma Rd. & weir	LSCOBS90.DTA	LSCOBS90.SAS	LSCOBS90.LST & LOG		
d. Upstream of weir	LSCOUS90.DTA	LSCOUS90.SAS	LSCOUS90.LST & LOG		
2. Burma Road shore anglers:					
a. All areas combined	LSCOS90.DTA LSCCOUNT.DTA	LSU90SHS.SAS	LSU90SHS.LST & LOG	LSU90CSS.SAS/ LSU90HSS.SAS	LSU90CSS.LST & LOG/ LSU90HSS.LST & LOG
b. Split by area above & below Burma Rd.	LSCOS90.DTA LSCCOUNT.DTA	LSU90SSS.SAS	LSU90SSS.LST & LOG		
3. Miller's Landing & Reach boat anglers,	MILCOB90.DTA	MILCOB90.SAS	MILCOB90.LST & LOG	LSU90MCS.SAS/	LSU90MCS.LST & LOG/

[a] Archived files.