Fishery Data Series No. 94-29

Creel, Escapement, and Stock Statistics for Coho Salmon on the Little Susitna River, Alaska, During 1993

by

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[1] This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-9, Job No. S-2-12.

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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 by boat anglers and a weir to estimate spawning escapement. Creel surveys were conducted at the Burma Road boat landing from 16 July through 2 September 1993 to estimate the effort for and the catch and harvest of coho salmon by boat anglers in the sport fishery. An estimated 11,051 coho salmon were harvested and an additional 1,260 coho salmon were caught and released during 26,613 boat angler-hours of effort. The contribution of hatchery-produced coho salmon to the sport harvest and escapement past the weir was estimated to be 28% and 29%, respectively. Returning hatchery coho salmon originated from 1992 smolt releases in Nancy Lake and in the mainstem Little Susitna River at Houston, Alaska; from a 1990 smolt release at Houston; and from two 1990 fry releases of Little Susitna River brood. Spawning escapement was 34,822 fish. Hook-and-release mortality was estimated to be 870 fish. Inriver exploitation (harvest plus hook-and-release mortality) by the boat angler sport fishery was estimated at 26%.

A total of 45,873 coho salmon were estimated in the Little Susitna River during 1993. The actual inriver return, however, was somewhat greater because of the unsurveyed harvest by shore anglers and by boat anglers who exited the fishery through landings other than Burma Road. An unknown number of fish also passed the counting weir after it was removed. Coho salmon are rarely observed to spawn downstream of the weir.

Hatchery releases of Little Susitna origin contributed an unknown harvest of coho salmon to the mixed-stock commercial fisheries of northern Cook Inlet.

KEY WORDS: coho salmon, *Oncorhynchus kisutch*, creel survey, escapement, age, sex, length, sport effort, sport harvest, sport catch, hatchery contribution, Little Susitna River, smolt, stocking, weir, hook-and-release mortality.

INTRODUCTION

The Little Susitna River (Figure 1) supports the second largest freshwater fishery for coho salmon *Oncorhynchus kisutch* in Alaska, second only to the Kenai River (Mills 1993). Road access to the lower reaches of the Little Susitna River improved with agricultural development in the area during the early 1980s. The harvest of, and corresponding fishing effort for, coho salmon in the lower 60 km of the Little Susitna River also increased in step with improvements in access. In response to the increases in harvest, the Little Susitna River has been stocked annually with coho salmon since 1982 (ADF&G 1981, Chlupach 1989).

The Alaska Department of Fish and Game (ADF&G), 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 the Little Susitna River to estimate the escapements of coho salmon. This weir was initially operated in 1986 and has been operated annually since 1988. A coho salmon management plan was adopted in 1990 and implemented in 1991. This management plan defines an escapement goal of 7,500 nonhatchery coho salmon for the Little Susitna River upstream of the Parks Highway bridge at river kilometer (rkm) 112 (ADF&G 1993). In this report, nonhatchery coho salmon are coho salmon that can not be identified to a specific release of hatchery fish based on marked to unmarked ratios or tagging information. The creel surveys and life history studies are summarized in a series of annual "Federal Aid in Sport Fish Restoration" reports published by ADF&G.

Data collected during this project are used to refine the management plan for hatchery and nonhatchery stocks of Little Susitna River coho salmon, and insure that the escapement goal of 7,500 nonhatchery coho salmon is attained.

Data collected during this project also aid in assessing the stocking program. The stocking program has contributed up to 75% (an estimated 10,660 fish) of the sport harvest (1989) and an inestimable number of additional angler-days to the sport fishery. Timely harvest, effort, and escapement information allowed maximum use of returning hatchery stock by the angling public. This program also optimized recreational opportunity and social and economic benefits to the citizens of Alaska.

The specific objectives for the 1993 portion of this evaluation were to:

1. Estimate the angling effort for and the catch and harvest of coho salmon above and below the weir at rkm 52 of the Little Susitna River by boat anglers exiting the fishery at Burma Road from 16 July through 2 September 1993 by 7-day periods, such that the early season (16 July to 5 August) and late season effort, catch, and harvest estimates are within ± 30% (for the early season) and ± 15% (for the late season) of the true values 90% of the time.

2. Estimate the age and sex compositions of the coho salmon harvested by the boat anglers exiting at Burma Road during the 16 July through 2 September 1993 period, such that the estimated proportions by age

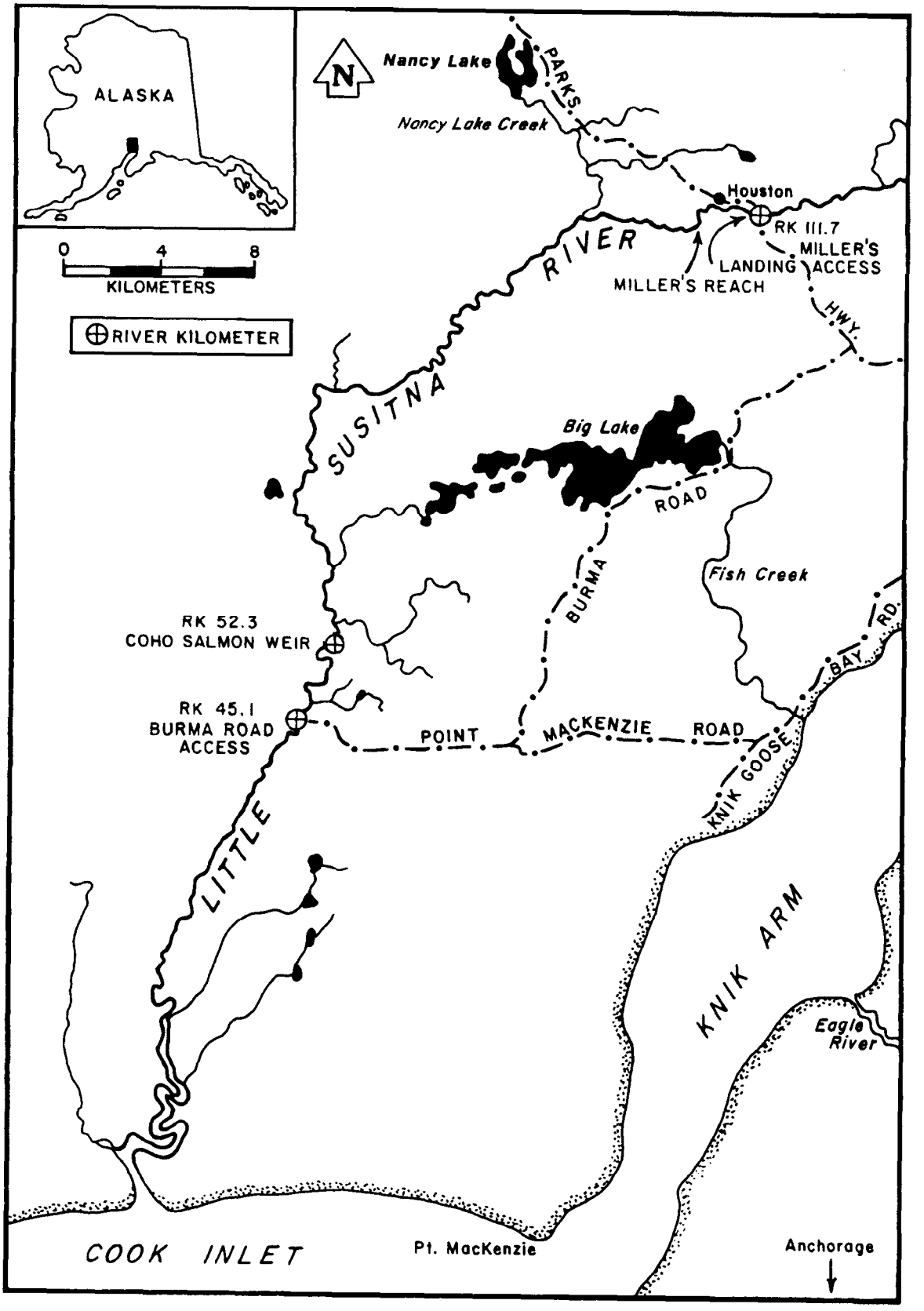

Figure 1. Little Susitna River study area.

class are within ± 5 percentage points of the true proportions 90% of the time.

3. Estimate the contribution of stocked coho salmon to the sport fishery of boat anglers exiting at Burma Road from 16 July through 2 September 1993 by 7-day periods, such that the total seasonal estimated contribution is within ± 25% of the true contribution 90% of the time and such that each 7-day period estimate is within either ± 300 fish or ± 50% of the true value 90% of the time.

4. Census the 1993 escapement of coho salmon in Little Susitna River past rkm 52.

5. Estimate the age and sex compositions of the coho salmon escapement past rkm 52, such that the estimated proportions by age class are within ± 5 percentage points of the true proportions 90% of the time.

6. Estimate the contribution of stocked coho salmon to the escapement past rkm 52 by 7-day periods, such that the total seasonal estimated contribution is within ± 20% of the true contribution 90% of the time and such that each 7-day period estimate is within either ± 300 fish or ± 50% of the true value 90% of the time.

In addition to the objectives listed above, two tasks were accomplished during the 1993 season. These were:

1. Release approximately 300,000 coho salmon smolt in the Little Susitna River drainage in 1993.

2. Collect and transport to the hatchery approximately 750,000 fertilized eggs from hatchery-produced coho salmon returning to the Little Susitna River (Nancy Lake) in 1993.

These tasks addressed the goal of continuing the ongoing enhancement activities associated with the goal of supporting the existing fishery.

The results of the 1993 program associated with these objectives and tasks are summarized in this report. Recommendations for future program planning are also developed.

METHODS

Creel Survey Design

Approximately 113 km of the Little Susitna River were open by regulation to salmon fishing during 1993 (ADF&G 1993)[1]. There were four defined access points to the fishery: (1) the Burma Road boat launch at rkm 45.1, (2) the boat launch at Miller's Landing in the city of Houston at rkm 111.7,

[1] A 458 meter reach of river was closed immediately downstream of the weir, and a 92 meter reach immediately upstream of the weir (rkm 52) was closed by emergency order.

(3) Miller's Reach at rkm 107.0, and (4) the Port of Anchorage (in the Municipality of Anchorage).

Only the Burma Road boat anglers were surveyed because previous research (Bartlett and Vincent-Lang 1989, Bartlett and Sonnichsen 1990, Bartlett and Bingham 1991) has shown that 80% to 90% of the catch and harvest for anglers exiting at Burma Road has been taken by boat anglers who represented 70% to 80% of the effort during fisheries for coho salmon. Boat anglers were defined as anglers who accessed their fishing site via a boat. This included anglers who used a boat to travel to a fishing site but fished from shore once they reached the site. A stratified-random, three-stage, direct-expansion creel survey was conducted to estimate boat angler effort in hours, and the coho salmon catch and harvest through the Burma Road boat landing.

The survey at Burma Road began on Friday, 16 July and continued through Thursday, 2 September. The survey was primarily stratified into 7-day periods. The four periods in which the major portion of the effort and harvest were anticipated (30 July through 26 August) were further divided into 5 weekday days (Tuesday, Wednesday, Thursday, Friday, and Monday) and 2 weekend days (Saturday and Sunday) for a total of eight weekend and weekday strata during this period. The division of strata in 7-day increments was designed to coincide with the coho salmon management plan which required a change from artificial lures only to bait or lures on 6 August, and to obtain estimates on a timely basis for inseason management decisions. Stratification by type of day (weekday versus weekend) within the anticipated peak strata was primarily directed at reducing bias within (and among) these 7-day periods, and secondarily at increasing the precision of our estimates, since the variance components associated with the survey were different between these two day types. The strata definitions, along with pertinent sampling information for the Burma Road boat creel survey, are summarized in Appendix A1.

The creel survey was a three-stage design, with the first stage being days; the second-stage units were periods within days; and the third-stage units were anglers within sampled periods. The length of the fishing day and the number of the daily periods changed with the decreasing length of daylight hours as the season progressed. The daily periods are presented in Appendix A2.

The survey schedule was designed to sample a maximum amount of time within the creel clerk's work-hours during the anticipated peak of effort and harvest. During these peak strata (6 August through 19 August), all weekdays and weekends were surveyed. During the first strata (16 July through 22 July) 4 days were randomly sampled without replacement (WOR). During strata 2, 3 and 4 (23 July through 5 August), 5 out of 7 days were randomly sampled WOR. During strata 9 and 10 (20 August through 26 August), 6 days were randomly sampled WOR; and during stratum 11 (27 August through 2 September), 2 days out of 7 were sampled WOR. In addition to the days not sampled within these strata, zero, 1 or 2 days were selected to inspect the harvest for adipose finclipped fish.

Two or three sample periods during each day were selected at random WOR and sampled. All boat anglers were interviewed as they exited the Burma Road access location, and as such, the third-stage sampling units were censused (and the design collapsed to a two-stage survey).

Creel Survey Data Collection

A standard Alaska Department of Fish and Game, short interview creel survey form was used to record the interview information from completed-trip boat anglers departing from the Burma Road boat landing. The following questions were asked of each interviewed boat angler:

1. the total time the angler fished,
2. the number and species of fish harvested (kept),
3. the number and species of fish released,
4. whether the angler had completed his/her trip (completed-trip interview) or not (incompleted-trip interview), and
5. whether the angler fished upstream or downstream of the weir.

Creel survey personnel maintained daily summaries of the number of anglers interviewed, the total daily effort in hours, and the number of coho salmon harvested and caught. Since all anglers were interviewed, the number of anglers interviewed was used as the count of anglers exiting the fishery (a "dummy" angler count data file is created for each date and period sampled for use by the analyses programs, see Appendix F).

Creel Survey Data Analysis

Angler interview and count mark-sense forms were visually checked for errors and corrected as necessary. Corrected forms were sent to Research and Technical Services (RTS) for optical scanning. Resultant data files and summary printouts were checked for errors and corrected as necessary. Corrected data files were sent back to RTS for archiving. Angler count and interview data files were then processed by Division of Sport Fish's creel survey computer programs and analyzed according to the procedures outlined below (archived data files and analysis programs are listed in Appendix F).

Angler Effort, Catch, and Harvest:

Procedures used to estimate effort, catch, and harvest for the Burma Road access site in 1993 were the same as those used in the 1991 and 1992 boat angler survey. The procedures are outlined in Appendix A3 and represent a three-stage direct expansion estimation approach. This approach involved the direct expansion of mean effort, catch, and harvest of anglers sampled within a period by the number of anglers exiting the fishery during the sampled period. Then the mean values of effort, catch, and harvest across periods sampled within each sampled day were expanded by the total number of periods in the day to obtain estimates of the daily statistics. Stratum estimates of these statistics were calculated by expanding mean values across days within each stratum by the total number of days within a stratum. Across strata estimates were obtained by summing the individual stratum estimates. Since all anglers counted were interviewed, the design collapses to a two-stage design; however, estimates were still obtained in a three-stage manner (and were equivalent).

Assumptions:

Assumptions necessary for the unbiased point and variance estimates of angler effort, catch, and harvest obtained by the procedures outlined above and in Appendix A3 include the following:

1. interviewed boat anglers were representative of the total boat angler population exiting at Burma Road,

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

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

With regard to assumption 1, boat anglers interviewed at the Burma Road survey site were assumed representative of all boat anglers exiting the fishery through that site only. With regard to assumption 2, not all boat anglers were able to remember the hours of fishing effort and tended to report a number of hours somewhere between the length of the trip and the actual number of hours spent fishing on the trip. Assumption 3 was in general valid because boats were generally not navigated on the river during hours of darkness.

Weir Census Design and Data Collection

A weir program was used to census the escapement of coho salmon past rkm 52. A floating weir was placed across the Little Susitna River at rkm 52 from 23 July through 12 September (Figure 1). The weir was a resistance-board design modified to pass boats. A live trap with a V-shaped entrance was placed on the upstream side of the weir. Spacing between the weir and live-trap pickets was 38 mm. This spacing allowed for the complete census of all but the smallest 0-ocean (jack) coho salmon. Data collected daily at the weir are listed in Appendix B.

Weir Data Analysis

Daily summaries of information collected at the weir were forwarded by telephone to the area office each weekday. Daily escapement data were entered into a computer spreadsheet for general summaries.

Biological Sampling Design and Data Collection

Age and sex compositions of coho salmon were estimated for the harvest by sampling during the creel survey, and for the escapement by sampling at the weir. Additionally, mean length-at-age by sex was also estimated for both the creel survey and escapement.

Hatchery coho salmon from smolt releases are almost exclusively age-1.1, while nonhatchery coho salmon and those from hatchery fry releases may be age-1.1, -2.1, or -3.1. Occasionally 0-ocean jacks of hatchery or nonhatchery origin are also encountered in the harvest. Age compositions may change over time as the contribution of hatchery and nonhatchery fish to the harvest or escapement changes or the age composition of the nonhatchery stock varies. A minimum

sample of 66 fish per 7-day period (462 fish total) both in the harvest and at the weir was attempted. When sampling fish at the weir, the sample was obtained by allowing the live trap to fill with the approximate number of coho salmon needed for the sample (10-15 fish per day). The entire contents of the trap were then sampled to eliminate selection or behavior biases inherent in subsampling fish.

Three scales for aging were collected from the left side of each sampled fish, two rows above the lateral line and on the diagonal row downward from the posterior insertion of the dorsal fin (Scarnecchia 1979). Scales were mounted on gum cards and impressed in cellulose acetate as described in Clutter and Whitesel (1956). Age determinations were made using a microfiche reader and recorded by the European method.

Sex composition of coho salmon has been shown to change over time inseason and between years. The sex of those fish randomly selected for age composition was recorded. Sex ratios were estimated on a 7-day stratum basis to coincide with the creel survey periods. Coho salmon were sexed based on external characteristics.

Biological Data Analysis

Estimates of sex and age composition (proportion) for the subsampled coho salmon were calculated for each stratum for the creel survey and at the weir. Information collected from the contiguous sets of sampling strata was grouped and chi-squared contingency table tests were conducted to evaluate the similarity of age compositions across grouped strata. Similarly, the proportion sampled of the estimated coho salmon harvested within each stratum was evaluated for adherence to proportional sampling. Since the age compositions did differ appreciably among strata and proportional sampling was not indicated, estimates of age composition (proportion) for the subsampled coho salmon were calculated for each stratum separately and then summed across all strata to estimate the total number of fish in the harvest or escapement in each age class. Complete details of the estimation procedure are presented in Appendix C.

Hatchery Contribution Design and Data Collection

The majority of the 1993 inriver return of hatchery coho salmon originated from two major 1992 hatchery releases in the Little Susitna River drainage at Nancy Lake and Houston (Appendix D1). Approximately 312,925 coho salmon smolt were released in 1992, of which approximately 38,786 (12%) had a coded wire tag (CWT) and adipose finclip (Appendix D1). To estimate the contribution of these stocked fish to the estimated 1993 sport harvest and the censused escapement (at rkm 52), all coho salmon harvested by boat anglers checked in the creel survey, and a portion of those passing upstream through the weir, were inspected for a missing adipose fin. Tallies by day of both the number of fish examined and the number of fish with a missing adipose fin were kept. Heads were collected from fish observed with a missing adipose fin. Only the heads from whole fish were collected from the harvest. Volunteer heads were not included in the estimate. Carcasses from fish killed at the weir were donated to various local charities.

Inseason estimation of the hatchery produced coho salmon passing upstream of rkm 52 was required to project the escapement of 7,500 nonhatchery coho salmon to the spawning grounds upstream of the Parks Highway Bridge (rkm 112) as provided by the coho salmon management plan. To project this escapement at the weir, an average expected harvest of 500 nonhatchery coho salmon upstream of the weir (Bartlett and Vincent-Lang 1989, Bartlett and Sonnichsen 1990, Bartlett and Bingham 1991) was added to the estimation of nonhatchery coho salmon passing upstream of the weir. Therefore, a goal of an estimated 8,000 nonhatchery coho salmon was established to pass upstream of the weir to satisfy escapement requirements. The proportion of nonhatchery coho salmon in the escapement was roughly estimated each weekday by expanding the number of fish observed with a missing fin by the marked to unmarked ratio (8:1) for the total smolt release. The cumulative of this rough estimate was used to estimate attainment of the escapement goal and to allow a bag limit increase to five coho salmon

Hatchery Contribution Data Analysis

Contribution to the Harvest:

The sampling procedure for estimating contribution of hatchery fish to the harvest was essentially the same as the creel survey program, with the additional sampling stage associated with inspecting each angler's creel. All fish in a sampled angler's creel were inspected, and as such, this final sampling stage was censused. The multi-stage nature of the sampling design was not utilized in estimating the contributions. It was assumed that the rate of contribution to the fishery did not vary substantially among sampling units within each stratum (or combined strata). Estimates of the contribution by CWT lot to each stratum of the fishery (or possibly within combined strata) were calculated according to the procedures outlined in Appendix D2.

These procedures essentially followed the approach outlined by Clark and Bernard (1987). The estimate of the variance and the standard error of these estimates were obtained via the bootstrap estimation approach (Efron 1982), since in the sampling program, the total harvest was estimated, via the creel survey. The equations presented in Clark and Bernard (1987) could not be used to estimate these variances due to the presence of sampling error in the estimates of total harvest. Estimates were obtained either separately for each stratum, or by select combinations of strata. Combination of strata could occur if either the relative contribution rate of each CWT release lot did not vary among the strata to be combined or if the sampling fractions (number inspected for adipose finclips versus the estimated harvest) were similar among the strata to be combined. As such, within any 7-day period with weekday versus weekend stratification, the contribution rate would be expected to be similar and might be combined prior to calculation of contributions. Combination of strata was only necessary (prior to data analysis) if insufficient numbers of coho salmon were inspected for adipose finclips or insufficient tags were decoded (regardless of tag code). Contingency table analyses comparing the sampling fractions among strata and comparing the marked (adipose finclipped) to unmarked ratios among strata were used to determine if strata could be combined.

Contribution to the Escapement:

A sample of coho salmon passing the weir was inspected for a missing adipose fin. The hatchery contribution to the escapement at the weir was estimated by the procedures outlined in Clark and Bernard (1987; equations [10], [14], and [15]). The procedures of Clark and Bernard (1987) could be followed in this case since the total escapement was not estimated, but was known. Chi-squared contingency table analyses were conducted on the weir data base to determine if contiguous 7-day periods could be combined if necessary (due to insufficient numbers sampled or adipose finclips observed). Estimates of the contribution by CWT lot to each stratum of the fishery were calculated according to the procedures outlined in Appendix D2.

Smolt Stocking

In May 1993, approximately 300,000 19-gram coho salmon smolt were released into the Little Susitna River drainage. Of the total released, approximately 132,000 smolt were released in Nancy Lake near the outlet of Lilly Creek and approximately 148,000 smolt were released in the mainstem river at Miller's Landing near Houston (Figure 1). Indicators of smolting, including behavior, color change, and blood sodium concentration, signaled the release.

The smolt originated from 830,000 eggs collected during a 1991 egg take in Nancy Lake. Embryos were incubated at the Fort Richardson hatchery. As fry, the smolt were divided into two groups and reared in separate raceways using standard hatchery techniques (ADF&G 1983).

Approximately 20,400 smolts (16%) of the Nancy Lake release and approximately 20,400 smolts (14%) of the Houston release were implanted with a coded wire tag and marked by clipping the adipose fin. Tag code 31-21-37 was assigned to both release lots. To determine CWT retention during tagging, 200 smolt tagged the previous day were scanned for a CWT during each day of the tagging operation. The final percent tag retention was determined from a 200 smolt sample from each release group just prior to release. Tag loss prior to release was estimated to be approximately 5% in both releases. Approximately 20,000 tagged fish were released at each site.

Egg Collection

Approximately 790,000 eggs were collected from 211 female coho salmon in Nancy Lake by seining near the mouth of Lilly Creek in late September 1993. Ripeness was determined by physical examination of the fish. Ripe fish were killed by striking them on the head with a club. Milt from ten males was combined with eggs from five females in a 5 gallon plastic bucket. Water from Nancy Lake sufficient to cover the eggs was added to initiate fertilization. After 1 minute in the fertilization water, the eggs were rinsed, transferred to plastic bags, and placed in coolers to water harden for 45 to 90 minutes. The eggs were then iced, transported by truck to Fort Richardson hatchery, and placed into incubators.

All 438 coho salmon captured in the egg take were examined for a missing adipose fin. Heads were collected from all fish with a missing adipose fin and sent to the ADF&G tag lab in Juneau, Alaska for decoding. Egg collection field information was recorded in "Rite in Rain" notebooks and transferred to

standard hatchery production forms before being transported to the hatchery. Smolt from this egg collection are scheduled to be reared in the Fort Richardson hatchery and released into the Little Susitna River during the spring of 1995. They will return as adults during the summer of 1996.

RESULTS

Creel Statistics

A direct expansion creel survey was used to estimate the boat angler effort (in angler-hours) at the Burma Road access point to the Little Susitna River coho salmon sport fishery.

The number of boat anglers exiting the fishery at Burma Road during a surveyed period ranged from 0 to 164. Periods later in the fishing day were generally the busiest with respect to the number of anglers departing the fishery.

The total estimated effort during the coho salmon survey for all boat anglers exiting the sport fishery at Burma Road was 26,613 angler-hours (SE = 2,046) (Table 1). An estimated 1,210 (SE = 433) hours of this effort were spent fishing upstream of the weir (rkm 52). Hours of angler effort by 7-day periods for all boat anglers exiting the fishery at Burma Road ranged from 709 to 7,919. The highest estimated effort occurred from 6 August through 12 August. The lowest estimated 7-day effort was during the period from 27 August through 2 September.

The total estimated harvest of coho salmon by boat anglers exiting the fishery at Burma Road was 11,051 fish (SE = 779) (Table 2). An estimated 503 (SE = 115) coho salmon were harvested upstream of the weir (rkm 52). The estimated harvest of coho salmon by 7-day period for all boat anglers exiting the fishery at Burma Road ranged from 47 to 4,529. The highest number of fish for an estimated 7-day period was from 6 August through 12 August. The lowest estimated 7-day harvest was during the period from 16 July through 22 July.

The total estimated catch of coho salmon by boat anglers exiting the fishery at Burma Road was 12,311 fish (SE = 886) (Table 2). An estimated 651 (SE = 165) of these were caught upstream of the weir. The estimated catch of coho salmon by 7-day period for all boat anglers exiting the fishery at Burma Road ranged from 47 to 5,148. The highest number of fish estimated for a 7-day period was during the stratum from 6 August through 12 August. The lowest estimated 7-day catch was during the period from 16 July through 22 July.

Overall, boat anglers exiting the coho salmon sport fishery through Burma Road released about 10% of the coho salmon they caught (Table 3). Based on the 69% estimated mortality rate reported by Vincent-Lang et al. (1993) approximately 7% (870 fish) of the 12,311 coho salmon caught were estimated to have succumbed to hook-and-release mortality. The total mortality (hook-and-release mortality plus the harvest) was estimated to be about 97% of the catch.

Table 1. Estimated effort by boat anglers exiting the Little Susitna River coho salmon sport fishery through the Burma Road access in 1993.

Date	Estimated Effort (angler-hours)	SE	Relative Precision (α = 0.10)	90% Confidence Interval
716-722	941	206	36%	603 - 1,279
723-729	2,250	699	51%	1,105 - 3,396
730-805	3,431	598	29%	2,451 - 4,412
Early Total[a]	6,622	942	23%	5,078 - 8,168
806-812	7,919	980	20%	6,312 - 9,526
813-819	7,566	1,066	23%	5,817 - 9,315
820-826	3,796	962	42%	2,219 - 5,374
827-903	709	523	121%	0 - 1,567
Late Total[a]	19,990	1,816	15%	17,013 - 22,968
Total	26,613	2,046	13%	23,259 - 29,968

[a] See objective 1 for definition of terms.

Table 2. Estimated harvest and catch by boat anglers exiting the Little Susitna River coho salmon sport fishery at the Burma Road access, 1993.

Date	Estimated Harvest	SE	Relative Precision (α = 0.10)	90% Confidence Interval	Estimated Catch	SE	Relative Precision (α = 0.10)	90% Confidence Interval
7/16-7/22	47	14	50%	23 - 71	47	14	50%	23 - 71
7/23-7/29	333	95	47%	177 - 489	420	138	54%	194 - 646
7/30-8/05	974	186	31%	670 - 1,278	1,096	216	32%	742 - 1,450
Early Total[a]	1,354	209	25%	1,011 - 1,697	1,563	257	27%	1,142 - 1,984
8/06-8/12	4,529	463	17%	3,769 - 5,289	5,148	543	17%	4,257 - 6,039
8/13-8/19	3,846	482	21%	3,056 - 4,636	4,108	528	21%	3,242 - 4,974
8/20-8/26	1,154	310	44%	646 - 1,662	1,271	331	43%	729 - 1,813
8/27-9/02	168	144	140%	0 - 404	221	190	141%	0 - 533
Late Total[a]	9,697	751	13%	8,466 - 10,928	10,748	848	13%	9,357 - 12,139
Total	11,051	779	12%	9,773 - 12,329	12,311	886	12%	10,857 - 13,765

[a] See objective 1 for definition of terms.

Table 3. Summary of coho salmon released by boat anglers exiting the sport fishery through the Burma Road landing, 1993, with an estimate of the angling-induced mortality.

Dates	Catch	Harvest	Release	Percent Released	Released Fish Mortality[a] #fish	Released Fish Mortality[a] Percent[c]	Total Mortality[b] #fish	Total Mortality[b] Percent[c]	Effort[d]	Bag Limit
7/16-7/22	47	47	0	0.0%	0	0.0%	47	100.0%	941	3[e]
7/23-7/29	420	333	87	20.7%	60	14.3%	393	93.6%	2,250	3[e]
7/30-8/05	1,096	974	122	11.1%	84	7.7%	1,058	96.5%	3,431	3[e]
8/06-8/12	5,148	4,529	619	12.0%	427	8.3%	4,956	96.3%	7,919	3[f]
8/13-8/19	4,108	3,846	262	6.4%	181	4.4%	4,027	98.0%	7,566	5
8/20-8/26	1,271	1,154	117	9.2%	81	6.4%	1,235	97.2%	3,796	5
8/27-9/02	221	168	53	24.0%	37	16.5%	205	92.8%	709	5
Totals	12,311	11,051	1,260	10.2%	870	7.1%	11,921	96.8%	26,613	

[a] Mortality of released fish estimated at 69% from Vincent-Lang et al. (1993).

[b] Total mortality equals estimated released fish mortality plus the harvest.

[c] Estimated percent of catch.

[d] Effort in angler-hours.

[e] Artificial lure only required from 15 July through 5 August 1993.

[f] Bag limit downstream of the weir (rkm 52) changed from 3 to 5 coho salmon at 0001 hours 11 August.

Escapement Statistics

From 23 July through 12 September, 34,822 coho salmon, 26,554 chum salmon *O. keta*, 7,981 sockeye salmon *O. nerka*, and 483 pink salmon *O. gorbuscha* were passed through the weir at rkm 52 (Appendix E). Twenty-three chinook salmon *O. tshawytscha* were also passed but the count for this species was incomplete because the majority of the return passed the weir site prior to weir installation. An unknown number of sockeye salmon and chum salmon also passed the weir prior to its 23 July installation.

The counted escapement of coho salmon through the weir adjusted for the estimated harvest by sport anglers fishing upstream of the weir and exiting the sport fishery through Burma Road was 34,319 fish (SE = 115). A small but unknown number of coho salmon are also harvested near the mouth of Nancy Lake Creek. Fifty percent of the coho salmon had passed the weir (17,411 fish) through 11 August (Figure 2).

Coho salmon escapement through the weir in 1993, adjusted for the upstream harvest component, did not represent the entire escapement to the Little Susitna River. Although the weir remained fish-tight, flood waters prevented the passage of fish through the weir for several days beginning on 1 September (Appendix E). Several attempts were made to pass and count fish during the flood but few fish were moving upstream under the prevailing high-water flows. The weir was removed on 13 September during flood flows. Inspection of the river downstream of the weir for remaining fish was not possible due to the high and turbid water. Based on the daily counts for several days prior to 1 September and prior years' escapements, several hundred to several thousand fish could have remained downstream of the weir when it was removed.

Size, Sex, and Age Compositions

Scale samples of 348 coho salmon from the Burma Road sport harvest sample (3% of the estimated harvest) were usable and aged. Females and males represented 45% (SE = 5%) and 55% (SE = 5%) of the estimated harvest, respectively (Table 4). Age-1.1 coho salmon were the most abundant age group comprising 65% (SE = 5%) of the estimated harvest. The remaining harvest was comprised primarily of age-2.1 (35%, SE = 4%).

A total of 350 coho salmon from the escapement sample taken at the weir (1% of the estimated escapement) were usable and aged. Females and males represented 52% (SE = 5%) and 48% (SE = 5%) of the escapement, respectively (Table 5). Age 2.1 (53%, SE = 4%) and 1.1 (47%, SE = 4) were the only age groups in the escapement sample.

The age composition of fish sampled in the Burma Road harvest and escapement samples were significantly different ($\chi^2 = 11.6$, df = 1, $P < 0.001$). Age-1.1 fish dominated the harvest and age-2.1 fish dominated the escapement. Age-1.0 and -2.0 male jack coho salmon were only evident in the harvest samples.

There was a significant difference in the sex ratio of coho salmon from the Burma Road harvest and escapement age samples ($\chi^2 = 5.2$, df = 1, $P = 0.023$). Males dominated the harvest and females dominated the escapement.

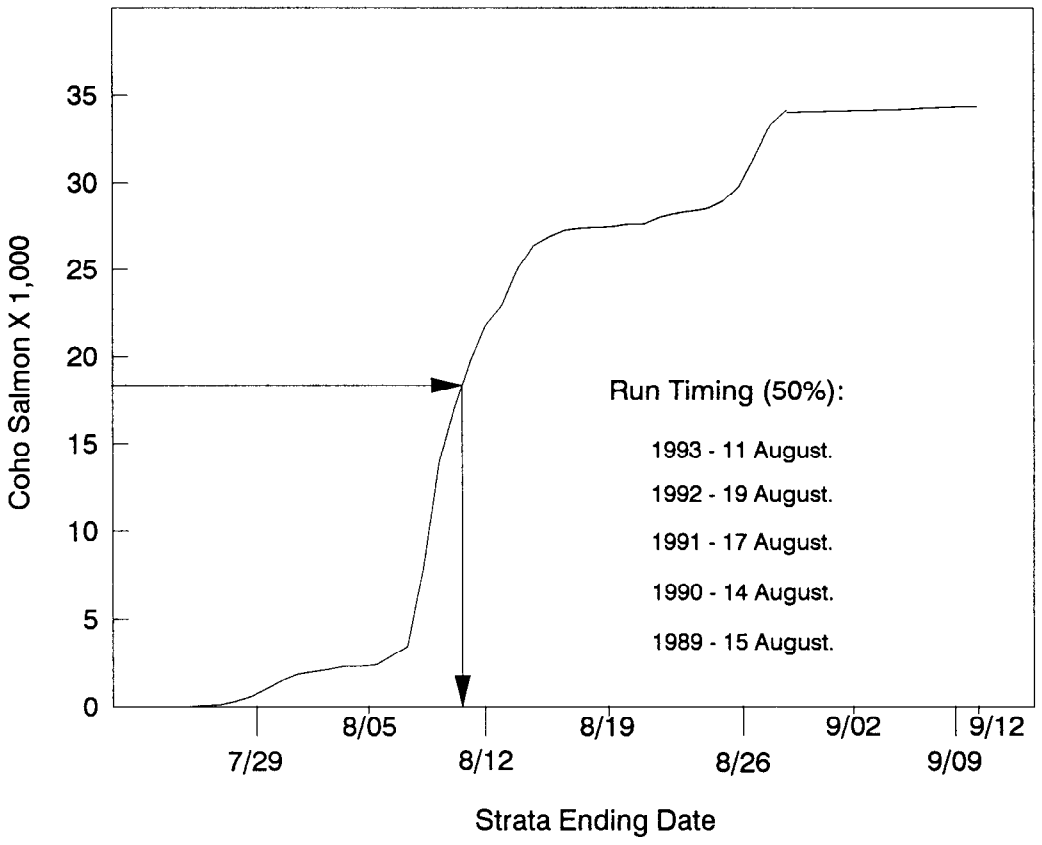

Figure 2. Cumulative escapement through the Little Susitna River weir (rkm 52) with the mid-point (50%) noted.

Table 4. Estimated sex and age composition of coho salmon from the Little Susitna River Burma Road sport fishery harvest, 1993.

	Age Group					
	1.0	1.1	2.0	2.1	3.1	Total
Females:						
Estimated Harvest	0	3,332	0	1,669	0	5,001
SE	0	470	0	311	0	564
Percent	0	30	0	15	0	45
SE (%)	0	4	0	3	0	5
Males:						
Estimated Harvest	4	3,796	19	2,211	19	6,050
SE	4	507	19	367	19	627
Percent	<0.5	34	<0.5	20	<0.5	55
SE (%)	<0.5	4	<0.5	3	<0.5	5
Sexes Combined:						
Estimated Harvest	4	7,128	19	3,880	19	11,051
SE	4	748	19	511	19	843
Percent	<0.5	65	<0.5	35	<0.5	100
SE (%)	<0.5	5	<0.5	4	<0.5	

Table 5. Estimated sex and age composition of coho salmon from the Little Susitna River escapement through the weir (rkm 52), 1993.

	Age Group		
	1.1	2.1	Total
Females:			
Estimated Escapement	9,430	8,617	18,047
SE	1,201	1,228	1,717
Percent	27	25	52
SE (%)	3	4	5
Males:			
Estimated Escapement	7,053	9,721	16,775
SE	1,120	1,303	1,718
Percent	20	28	48
SE (%)	3	4	5
Sexes Combined:			
Estimated Escapement	16,483	18,339	34,822
SE	1,384	1,384	0
Percent	47	53	100
SE (%)	4	4	

The mean lengths in millimeters by sex of coho salmon from the Burma Road harvest (Table 6) and from the weir (Table 7) were compared with a two-tailed t-test ($\alpha = 0.05$). There were no significant differences between age-1.1 and -2.1 fish in the harvest and escapement samples. Age-1.0 and -2.0 males were not in the escapement because they pass between the live trap pickets and can not be captured for sampling at the weir.

Hatchery Contributions

Contribution to the Sport Fishery:

Of a total of 5,163 coho salmon examined from the Burma Road sport fishery, 205 had a missing adipose fin (Table 8). Of these, 158 heads were removed and sent to the CWT lab for processing. A total of 134 fish (85%) had CWT's present that could be decoded. Decodeable tags were recovered from seven hatchery releases: a 1991 smolt release from Little Susitna brood, two 1992 smolt releases from Little Susitna brood, and four 1990 fry releases from Nancy Lake (Appendix D3). Chi-square tests comparing the estimated sport harvest by boat anglers exiting through the Burma Road landing to the number of fish examined for a missing adipose fin and the number of fish observed with a missing adipose fin within the 11 strata indicated that significant differences ($\alpha = 0.05$) were present between strata. The hatchery contributions were, therefore, estimated separately and summed (with each respective variance) as 7-day strata for a total estimated hatchery contribution of 3,083 (SE = 289) fish to the sport harvest (Table 9). Based on these data, the estimated contribution of hatchery-produced coho salmon represents approximately 27.9% of the total estimated Burma Road boat angler harvest of 11,051 fish.

Eighty-six percent of the total 1993 estimated hatchery contribution of 3,083 fish to the Burma Road boat angler sport harvest originated from the two major 1992 smolt releases at Nancy Lake and Houston. The Nancy Lake release contributed 59% and the Houston release contributed 31% of the estimated total 2,662 (SE = 271) fish contributed from these two smolt releases. The remaining 14 originated from the four 1990 Nancy Lake fry releases (13%) and from the 1991 Houston smolt release (1%).

Contribution to the Escapement:

Of a total 4,872 (14%) coho salmon examined from the escapement (34,822 fish) past the weir, 187 were observed to have a missing adipose fin (Table 10). Escapement through the weir, the number of coho salmon inspected, and the number of missing adipose fins observed were grouped into 7-day periods to correspond with the date of regulation change starting on 6 August. The hatchery contribution for each 7-day period was then estimated separately and summed (with the respective variances) to produce the total estimated hatchery contribution through the weir. Coho salmon at the weir were killed to recover the CWT. Four tag codes were present in the escapement.

Based on these data, the hatchery contribution to the 34,822 coho salmon passing through the weir was estimated to be 10,211 (SE = 858) fish or about 29% of the escapement (Tables 11 and 12).

Table 6. Mean length of coho salmon by sex and age group sampled from the Little Susitna River Burma Road sport fishery, 1993.

	Age Group				
	1.0	1.1	2.0	2.1	3.1
Females:					
Mean Length (mm)[a]		571		579	
SE		3		4	
Sample Size		94		58	
Minimum		480		505	
Maximum		640		650	
Males:					
Mean Length (mm)[a]	470	579	400	587	570
SE		4		5	
Sample Size	1	117	1	76	1
Minimum	470	470	400	475	570
Maximum	470	660	400	660	570

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

Table 7. Mean length of coho salmon by sex and age group sampled from the escapement at the Little Susitna River weir, 1993.

	Age Group	
	1.1	2.1
Females:		
Mean Length (mm)[a]	570	575
SE	3	4
Sample Size	86	97
Minimum	490	470
Maximum	620	660
Males:		
Mean Length (mm)[a]	580	593
SE	5	4
Sample Size	83	84
Minimum	480	480
Maximum	670	655

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

Table 8. Little Susitna River Burma Road harvest coho salmon coded wire tag recovery summary by release and 7-day strata, 16 July through 2 September 1993.

Strata	Dates of Census	Heads W/CWT	Dec[a] CWT	Clips[b] Obser.	Heads To Lab	Harvest	Vari-ance	Number Inspected	Unique Code[c] 06	07	0405	0406	36	No[d] Tag	Total	Tagging[e] Proportion
1	716 - 722	1	1	1	1	47	196	35	1	0	0	0	0	0	1	
2	723 - 729	2	2	3	2	333	9,025	121	1	1	0	0	0	0	2	06 = 0.1213
3	730 - 805	14	14	20	14	974	34,596	454	9	2	1	2	0	0	14	07 = 0.1267
4	806 - 812	66	66	99	80	4,529	214,369	2,136	40	19	4	3	0	14	80	0405 = 0.1807
5	813 - 819	38	38	66	44	3,846	232,324	1,913	10	18	4	5	1	6	44	0406 = 0.1284
6	820 - 826	12	12	15	15	1,154	96,100	487	6	4	2	0	0	3	15	36 = 0.1821
7	827 - 902	1	1	2	2	168	20,736	17	0	1	0	0	0	1	2	
Totals		134	134	205	158	11,051	606,841	5,163	67	45	11	10	1	24	158	

[a] Number of heads found to have a decodeable coded wire tag.

[b] Number of adipose finclips observed in the inspected harvest.

[c] Released at: 06 = 1992 Nancy Lake smolt; 07 = 1992 Houston smolt; 0405 and 0406 = 1990 Nancy Lake fry; 36 = 1991 Houston smolt.

[d] Tag not found in head at decoding laboratory.

[e] For codes 06 and 07 the tagged fish released / total fish released. For remaining codes, total number marked / total number released.

Table 9. Little Susitna River hatchery coho salmon composition point estimate summary by release and 7-day strata of the sport harvest by Burma Road boat anglers, 16 July through 2 September 1993.

Date	716-722		723-729		730-805		806-812		813-819		820-826		827-902		Total	
Strata	1		2		3		4		5		6		7			
Harvest	47		333		974		4,529		3,846		1,154		168		11,051	
Tag Code[a]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]
06	11	9	34	30	227	80	936	164	249	79	117	55	0	0	1,574	209
%[d]	100		51		67		63		28		54				51	
07	0	0	33	30	48	37	426	95	428	108	75	41	78	73	1,088	173
%[d]	0		49		14		29		49		34		100		35	
0405	0	0	0	0	17	19	63	33	67	38	26	17	0	0	173	56
%[d]			0		5		4		8		12		0		6	
0406	0	0	0	0	48	37	66	37	117	57	0	0	0	0	231	77
%[d]	0		0		14		4		13		0		0		7	
36	0	0	0	0	0	0	0	0	17	19	0	0	0	0	17	19
%[d]	0		0		0		0		2		0		0		1	
Total	10	9	67	42	340	97	1,491	196	878	152	218	73	78	73	3,083	289
%[d]	<1		2		11		48		28		7		3		100	

[a] Release: 06 = 1992 Nancy Lake smolt; 07 = 1992 Houston smolt; 0405 and 0406 = 1990 Nancy Lake fry; 36 = 1991 Houston smolt.

[b] Contribution to the harvest for the indicated stratum.

[c] Standard error.

[d] Percent of stratum harvest.

Table 10. Little Susitna River weir coho salmon coded wire tag recovery summary by release and 7-day strata, 23 July through 12 September 1993.

Strata[a]	Dates of Census	Heads W/CWT	Dec[b] CWT	Clips[c] Obser.	Heads To Lab	Escape-ment	Vari-ance	Number Inspected	Unique Code[d] 06	07	0405	0406	No[e] Tag	Tag[f] Lost	Total	Tagging[g] Proportion
2	723 - 729	3	3	3	3	1,082	0	372	2	0	1	0	0	0	3	06 = 0.1213
3	730 - 805	3	3	7	3	1,386	0	473	1	2	0	0	0	0	3	07 = 0.1267
4	806 - 812	63	61	73	70	19,476	0	1,739	33	21	3	4	7	2	70	0405 = 0.1807
5	813 - 819	48	48	51	50	5,962	0	1,006	28	13	4	3	2	0	50	0406 = 0.1284
6	820 - 826	6	6	7	7	1,103	0	252	3	3	0	0	1	0	7	
7	827 - 902	32	32	45	43	5,666	0	934	13	16	1	2	11	0	43	
8	903 - 909	0	0	0	0	81	0	30	0	0	0	0	0	0	0	
9	910 - 916	1	1	1	1	66	0	66	0	1	0	0	0	0	1	
Totals		156	154	187	177	34,822	0	4,872	80	56	9	9	21	2	177	

[a] Strata are numbered to agree with the harvest strata.

[b] Number of heads found to have a decodeable coded wire tag.

[c] Number of adipose finclips observed in the inspected harvest.

[d] Released at: 06 = 1992 Nancy Lake smolt; 07 = 1992 Houston smolt; 0405 and 0406 = 1990 Nancy Lake fry.

[e] Tag not found in head at decoding laboratory.

[f] Tags lost at decoding lab.

[g] For codes 06 and 07 the tagged fish released / total fish released. For remaining codes, total number marked / total number released.

Table 11. Little Susitna River weir hatchery coho salmon composition point estimate summary by release and 7-day strata, 23 July through 16 September 1993.

Date	723-729		730-805		806-812		813-819		820-826		827-902		903-909		910-916		Total	
Strata	2		3		4		5		6		7		8		9			
Escapement	1,082		1,386		19,476		5,962		1,103		5,666		81		66			
Tag Code[a]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]
06	48	33	56	56	3,282	553	1,395	257	108	61	680	185	0	0	0	0	5,569	643
%[d]	75		34		56		61		51		42		0		0		55	
07	0	0	108	64	1,999	427	620	169	104	59	802	195	0	0	8	7	3,641	506
%[d]	0		66		34		27		49		50		0		100		36	
0405	16	16	0	0	200	115	134	66	0	0	35	35	0	0	0	0	385	138
%[d]	25		0		3		6		0		2		0		0		4	
0406	0	0	0	0	376	186	141	81	0	0	99	69	0	0	0	0	616	214
%[d]	0		0		7		6		0		6		0		0		6	
Total	64	33	164	85	5,857	732	2,290	325	212	85	1,616	280	0	0	7	7	10,211	858
%[d]	1		2		57		22		2		16		0		<1		100	

[a] Release: 06 = 1992 Nancy Lake smolt; 07 = 1992 Houston smolt; 0405 and 0406 = 1990 Nancy Lake fry.

[b] Contribution to escapement.

[c] Standard error.

[d] Percent of stratum harvest.

Table 12. Contribution of hatchery-origin coho salmon to the estimated sport harvest and escapement past the Little Susitna River weir from 1986 through 1993.

	Total[a]		Hatchery[a]		
Year	Estimate	SE	Estimate	SE	Percent
Harvest:					
1986	5,812	--[b]	107	30.5	1.8
1987	13,202	442.1	3,460	509.7	26.2 ± 7.8
1988	12,759	405.0	6,468	571.9	50.7 ± 9.3
1989	14,150	746.3	10,660	1,275.2	75.0 ± 19.3
1990	8,001	866.8	2,393	478.0	29.9 ± 13.3
1991	14,079	1,297.0	6,584	1,205.7	46.8 ± 18.8
1992	8,739	674.0	1,482	188.7	17.0 ± 4.9
1993	11,051	779.0	3,083	288.8	27.9 ± 4.3
Escapement:					
1986[c]					
1987[d]					
1988	21,438	--[e]	4,764	1,076.3	22.2 ± 9.8
1989	15,855	--[e]	7,191	757.6	45.9 ± 9.4
1990	15,511	--[e]	3,791	449.0	24.4 ± 5.7
1991	39,241	--[e]	8,375	592.9	21.4 ± 3.0
1992	21,182	--[e]	2,468	279.0	11.5 ± 2.6
1993	34,822	--[e]	10,211	857.6	29.4 ± 4.0

[a] 1986 through 1990 data were taken from Federal Aid annual reports.

[b] Standard error not reported.

[c] No tagged fish reported.

[d] No weir in place.

[e] Measured without error.

Estimated Hatchery Contribution:

The combined hatchery contribution to the sport harvest and escapement of the Little Susitna River was estimated to be 13,294 (SE = 905) coho salmon or about 28% of the total estimated return to the river excluding those harvested by unsurveyed anglers. Hatchery coho salmon from Little Susitna River releases of Little Susitna River broods are also caught in Cook Inlet commercial fisheries (Hoffmann and Waltemyer *Unpublished*). An inspection program to find coho salmon with coded wire tags in selected commercial harvests of the central and northern Cook Inlet commercial fisheries was conducted in 1993. The results of this program, with estimated proportions of individual hatchery stocks, will be released in a separate report.

Stocking and Egg Collection

All 438 coho salmon used in the 1993 egg take were inspected for a missing adipose fin. Fish from the 1992 Nancy Lake smolt release (code 31-20-06) comprised an estimated 75% of the inspected coho salmon. Fish from the 1990 Nancy Lake fry releases comprised 15% and marked fish without tags comprised 10%. No fish from the 1992 Houston smolt release were observed.

The 1993 brood of coho salmon eggs was collected from sexually mature fish in Nancy Lake near the mouth of Lilly Creek. At an estimated 76% egg to smolt survival in the hatchery, approximately 600,400 smolt are expected to result from the 790,000 eggs taken in 1993. Approximately 150,000 smolt will be released into the Little Susitna River in 1995. The remainder will be utilized in other stocking programs. A minimum of 40,000 Little Susitna River released smolt (27%) will be tagged with one tag code prior to release.

DISCUSSION

All the objectives, tasks and schedules of the 1993 program were completed. Precision levels associated with the objectives were met in most cases.

The 1993 coho salmon sport fishing season (mid-July through early September) was the third season in which the Little Susitna River was managed in accordance with the Little Susitna River coho salmon management plan. This plan requires the escapement of at least 7,500 nonhatchery coho salmon to the mainstem river upstream of the Parks Highway bridge. The 1993 calendar year was also the first year that only artificial lures were allowed from 15 July through 5 August. The bag and possession limit was also changed from a one coho salmon bag limit, which was in effect until 6 August during the 1991 and 1992 calendar years, to a three fish limit.

Previous researchers (Bartlett and Vincent-Lang 1989; Bartlett and Sonnichsen 1990; Bartlett and Bingham 1991; Bartlett 1992) observed a separation in the proportional timing of hatchery and nonhatchery stocks with the majority of the hatchery stock entering the river later in the season. The bag and possession limit prior to 6 August of one coho salmon was an effort to preserve the earlier timing of the nonhatchery stock. Data reported by Bartlett and Bingham (1993) suggested that the proportional timing of coho salmon stocks were again distinct during the 1992 return but that unnecessarily large numbers of early arriving coho salmon had been lost to

hook-and-release mortality during the 1991 and 1992 seasons. The one coho salmon bag limit that was in effect during 1991 and 1992, combined with the high hook-and-release mortality associated with use of bait (Vincent-Lang et al. 1993), was believed to be the primary cause of the loss of fish.

The proportional timing of the nonhatchery stock and the hatchery stock was only slightly temporally separated (top graph of Figure 3) during the early strata of the 1993 season. A visual comparison of the cumulative percent escapement curves to the mean of past years (center and bottom graphs of Figure 3) indicates that both stocks entered the river at their normal timing but increased to full run strength a few days earlier than observed in past years (also see Figure 2). There are several possible causes for this observation. One may be in the percent reduction of 1993 angling mortality as compared to past years. Approximately 16% (2,806 fish) and 18% (2,103 fish) of the catch during 1991 and 1992, respectively, were lost to angling mortality (Bartlett 1992, Bartlett and Bingham 1993) while in 1993 only 7% (870 fish) were lost. This reduction alone potentially added approximately 2,000 fish to the escapement.

A second possible cause could have been the arrival of rain showers earlier in the 1993 season than was observed during the past several seasons. Rain in early August had the effect of raising water levels several inches. Rising water, along with slight turbidity, prompts Little Susitna River coho salmon to accelerate their upstream migration. This facet of salmon behavior is very evident at the counting weir.

Projection of the escapement goal of 7,500 nonhatchery coho salmon upstream of the Parks Highway bridge (rkm 112) can allow an increase in the bag limit downstream of the weir (and within a 0.4 km radius of the confluence of Nancy Lake Creek with the Little Susitna River) from three to five fish. The nonhatchery escapement goal has been estimated inseason for the past 3 years the management plan has been in place. During 1991 and 1992 the goal was met on 13 August and the bag limit was increased by emergency order shortly afterward (Bartlett 1992, Bartlett and Bingham 1993). In 1993 the goal was met 3 days earlier on 10 August and the bag limit was increased to 5 fish on 11 August. The earlier attainment of the goal was consistent with the timing curves of Figure 3.

A relatively low hook-and-release mortality of coho salmon through 5 August (compared to the past two seasons) was observed during the 1993 season. The mortality estimate is based on studies by Vincent-Lang et al. (1993) which indicate that the mortality of hooked-and-released coho salmon in the intertidal waters of the Little Susitna River is as high as 69%. This mortality in the intertidal waters is attributed by Vincent-Lang et al. (1993) chiefly to hooking in the gills or gullet and associated bleeding. Bait was the only terminal gear used during their study. The angling mortality observed during 1993 is probably less than the estimate of 870 fish because only artificial lures were allowed in the Little Susitna River from 15 July until 6 August. Fish hooked on artificial lures and released probably have a lower mortality associated with gill and gullet bleeding than fish hooked with bait.

Bartlett and Bingham (1993) speculated that the initial impact of the new artificial lure only regulation would be a reduction in catch rates as anglers learned new techniques and areas to fish. In 1992, approximately 0.32 coho

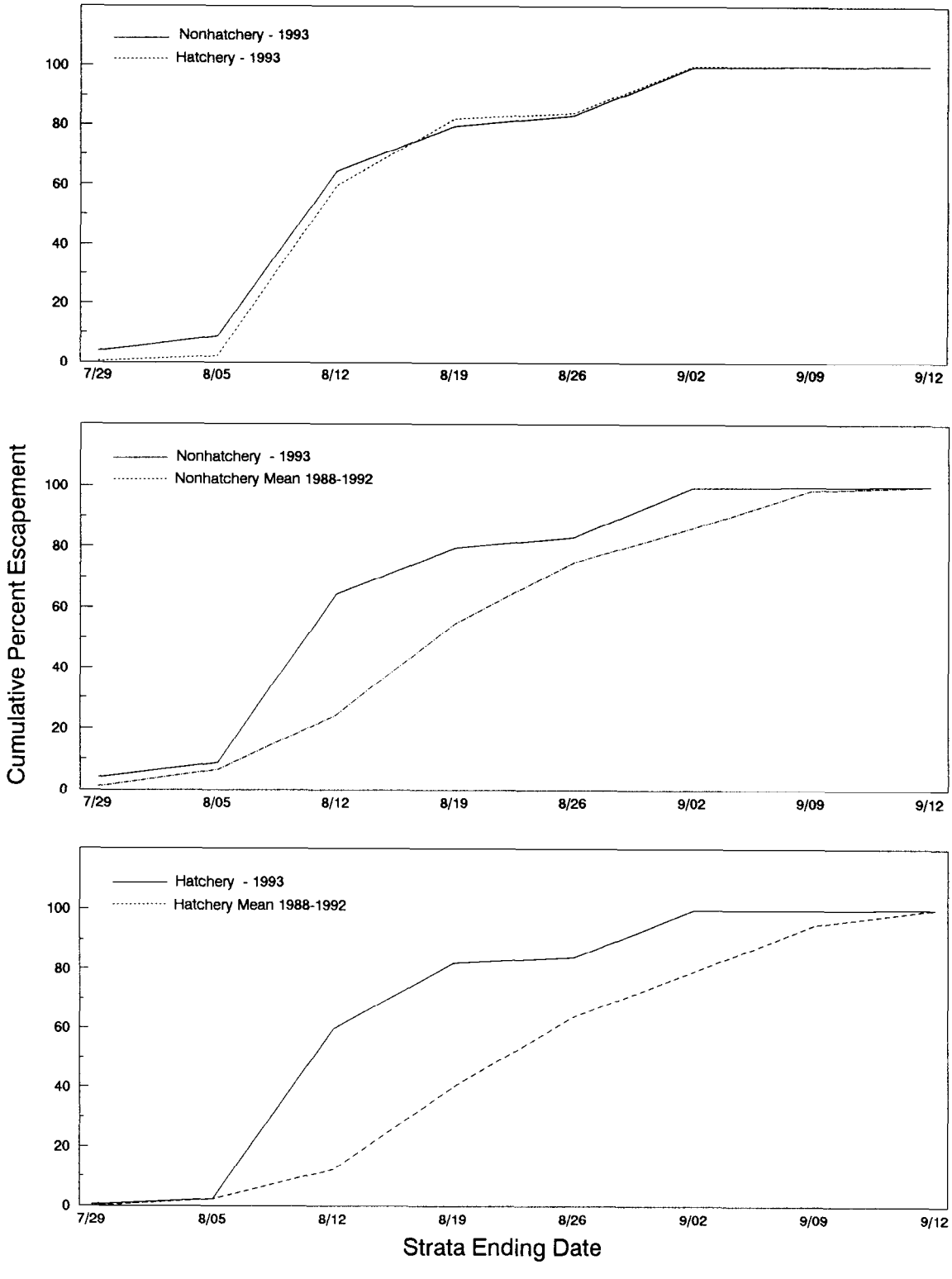

Figure 3. Proportion of timing of estimated 1993 and 1988-1992 hatchery and nonhatchery coho salmon stocks through the Little Susitna River weir (rkm 52).

salmon per angler-hour of effort were caught, primarily with bait, during the early season strata. In 1993 approximately 0.23 to 0.24 coho salmon per angler-hour of effort were caught during the same strata using artificial lures. Twenty-three percent more coho salmon had also passed through the weir during the early (through 5 August) 1993 strata than they did in 1992. This point suggests that coho salmon were more abundant in the reach of river downstream of the weir during 1993 than they were in 1992. The above discussion strongly suggests that, even with higher numbers of coho salmon in the river, the catch of coho salmon per angler-hour on artificial lures in 1993 was lower than that on bait in 1992.

Catch rates dramatically increased with the addition of bait as legal terminal gear. Boat anglers caught approximately 0.54 coho salmon per angler-hour of effort in 1993 compared to approximately 0.25 coho salmon per hour during the same later strata during 1992. In 1993 there were also approximately 40% more coho salmon in the river during this period than there were in 1992. There were also approximately 8,700 fewer hours of effort during these strata in 1993 than there were in 1992.

The percent estimated hatchery contribution to the harvest and the escapement in 1993 was similar to several other years (Table 12). The estimated number of hatchery coho salmon in the escapement, however, was the highest on record. The nonhatchery portion of this year's return originated from the 1989 and 1990 brood years. The hatchery portion originated primarily from the two 1992 smolt releases of 1990 Nancy Lake brood and the two 1990 fry releases of 1989 Nancy Lake brood.

Returning hatchery fish from the smolt releases are almost exclusively age-1.1 while the nonhatchery stock and returning fish from the fry releases are mixed age-1.1 and -2.1. Accurate estimation of the ratio of age-1.1 to age-2.1 nonhatchery fish in the escapement is not possible because of the presence of unmarked hatchery fish in the age sample. It can however, be roughly approximated. Only one pure, nonhatchery age sample from the Little Susitna River coho escapement is known to exist (Bartlett and Bingham 1991). This 1978 sample was comprised of 42% age-1.1 and 57% age-2.1 fish. Based on this one sample it would seem that the nonhatchery escapement could be comprised of up to roughly one-half age-1.1 fish.

The number of age-1.1 fish (169) in the 1993 escapement age sample minus the estimated 26.5% hatchery contribution of the two smolt releases (45 fish) suggests the number of nonhatchery age-1.1 fish in the escapement age sample was roughly 124 fish. The same argument for the age-2.1 fish produces a rough estimate of 133 nonhatchery fish for a total of 257 nonhatchery fish of both age groups. The 48% age-1.1 and 52% age-2.1 nonhatchery fish in the 1993 sample approximates the split by age of 42% age-1.1 and 57% age-2.1 in prehatchery Little Susitna coho salmon stock as reported by Bartlett and Bingham (1991).

Applying the results of this argument to the estimated 1993 nonhatchery escapement of 24,611 coho salmon, there were roughly 12,297 age-2.1 and 11,813 age-1.1 nonhatchery coho salmon in the 1993 escapement. Applying this argument one step farther, an estimated parent-year return of 8,664 nonhatchery fish in 1989 produced 12,297 nonhatchery age-2.1 fish in 1993 for a ratio of 1.4 fish per spawner. Similarly, the 1990 parent-year of 11,720

nonhatchery fish would have produced a 1993 return of 11,813 nonhatchery age-1.1 fish for a rough estimated ratio of 1.0 fish per spawner. The actual production per spawner can not be estimated because the exploitation of Little Susitna River stocks in the various fisheries, commercial, subsistence and sport, is also unknown.

The proportion of smolt released at Houston and Nancy Lake in 1992 was 53% and 47%, respectively. The total proportion inriver return estimated by tag code was 46% for the Houston release and 54% for the Nancy Lake release. This suggests the Nancy Lake release had better survival than did the Houston release. Similar findings were reported in 1992 (Bartlett and Bingham 1993). This observation supports the decision to release future stockings only in Nancy Lake.

A total of 21 coho salmon in the escapement CWT inspection sample had a clipped adipose fin but had no tag (Table 10). This observed tag loss of 11.9% approximates the 11.4% tag loss in the two smolt releases as reported by the hatchery prior to release. This observation suggests that, at least for the smolt releases, shedding of tags took place in the hatchery prior to release. Tag loss up to release within the fry releases is not recorded at the hatchery but undoubtedly takes place after release and would represent a small but unknown portion of the total number of missing tags from the escapement sample.

A CWT was not found in six of the 60 fish (10%) with a missing adipose fin in the egg-take sample. The 1992 Nancy Lake smolt release comprised 75% of the inspected fish while the 1990 fry releases comprised 15%. The observed percent tag loss in the egg take is similar to the tag loss of approximately 11% reported at release.

RECOMMENDATIONS

Based on the data contained in this report and on the discussion, the following is recommended:

1. End the creel survey for coho salmon on the Little Susitna River. Sport fishing activity related to coho salmon through the Burma Road access has become reasonably anticipatory. For example, the fish enter the river and fishery at approximately the same time annually, and the high and low points in the effort and catch occurs during the same strata weeks every year. Inseason estimates derived from the creel survey are only relative to the actual strength and progress of the coho salmon migration. Information adequate for inseason management could be acquired by frequent onsite visits by staff and daily reports from the counting weir.

2. Combined with frequent onsite visits to gather the inseason management information above, daily inspect a large portion of the harvest to estimate hatchery contribution. Inspection times would be scheduled to intercept the highest number of boat anglers. Use this estimate of hatchery fish to estimate the percent hatchery contribution to the harvest using the 1994 harvest estimate subsequently reported in the SWHS.

3. End the collection of age, sex and length data from the harvest. Collect this data only from the escapement at the weir.

4. Consider marking all 150,000 smolt in the 1995 release with adipose finclips and coded wire tags to allow for the possibility of retaining additional (bonus) hatchery fish caught upstream of the weir in the 1996 daily bag limit.

ACKNOWLEDGEMENTS

The author thanks all the staff who participated in the collection of the data used in this report, and particularly Allen Bingham who contributed much of the statistical design and Lori Restad who collected and summarized the creel survey and hatchery contribution data, and aged the coho salmon scales; and G. Mike Chartrand who directed the operation of the Little Susitna River weir. Appreciation is also given to Research and Technical Services staff, especially Donna Buchholz who processed all mark-sense forms and provided electronic data files. Keith Webster, who provided invaluable biometric support and editing prior to his untimely death, will be sorely missed. Thanks to Larry Peltz and Andy Hoffmann for their contribution of results related to their respective programs and Doug McBride who provided supervisory guidance, reviewed the draft report, and contributed editorial comment. Lastly, thanks are also extended to Margaret Leonard and Gwyn Alexander for editing this report and preparing it for publication.

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APPENDIX A

Appendix A1. Definition of sampling strata for the 1993 Little Susitna River creel survey of the Burma Road boat angler fishery.

Week[a]	Stratum	Date	Number of Days Per Stratum	Number of Days Sampled	Number of Periods Per Day	Number of Periods Sampled Per Day[b]
1	1	16-22 July	7	4	5	0,2,3
2	2	23-29 July	7	4	5	0,2
3 WD	3	30 July and 2-5 August	5	2	5	0,2,3
WE	4	31 July and 1 August	2	2	5	3
4 WD	5	6 and 9-12 August	5	5	5	2,3
WE	6	7-8 August	2	2	5	3
5 WD	7	13 and 16-19 August	5	5	5	2,3
WE	8	14-15 August	2	2	5	2
6 WD	9	20 and 23-26 August	5	3	4	0,2
WE	10	21-22 August	2	2	4	2
7	11	27 August-2 September	7	4	3	0,2

[a] WD denotes weekday; WE denotes weekend.

[b] Multiple listing of periods indicate the number of periods (0, 2 or 3) that were sampled within each day within the stratum.

Appendix A2. Definition of sampling periods within days for the 1993 Little Susitna River creel survey of the Burma Road boat angler fishery.

Weeks	Strata	Time of Season	Sample Period	Time of Day
1-5	1-8	16 July to 19 August	A	0400-0759
			B	0800-1159
			C	1200-1559
			D	1600-1959
			E	2000-2359
6	9-10	20 August to 26 August	A	0500-0859
			B	0900-1259
			C	1300-1659
			D	1700-2059
7	11	27 August to 2 September	A	0700-1059
			B	1100-1459
			C	1500-1859

Appendix A3. Estimation equations for angler effort for, and catch and harvest of, coho salmon in the 1993 Burma Road boat angler sport fishery in Little Susitna River.

The following procedures were used to estimate effort, catch, and harvest in the 1993 survey. The procedures as outlined below represent a three-stage direct expansion estimation approach. This approach 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, the design collapsed to a two-stage design, however estimates were still obtained in a three-stage manner (and were equivalent).

First the mean angler effort over all completed-trip anglers interviewed within a sampled period was obtained:

$$\bar{e}_{hij} = \frac{\sum_{k=1}^{m_{hij}} e_{hijk}}{m_{hij}}; \qquad \text{(A3.1)}$$

where: m_{hij} equals the number of anglers interviewed during sample period j during day i within stratum h; and e_{hijk} equals the effort in hours expended by each angler interviewed.

Next, the number of third-stage units (anglers counted) was used to expand this mean to obtain the estimated angler effort for each sample:

$$\hat{E}_{hij} = M_{hij}\,\bar{e}_{hij}; \qquad \text{(A3.2)}$$

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

Next the mean effort across periods sampled within each day was calculated:

$$\bar{\hat{E}}_{hi} = \frac{\sum_{j=1}^{p_{hi}} \hat{E}_{hij}}{p_{hi}}; \qquad \text{(A3.3)}$$

where: p_{hi} equals the number of periods sampled within each day.

-continued-

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

$$\hat{E}_{hi} = P_{hi} \bar{\hat{E}}_{hi} \; ; \qquad \text{(A3.4)}$$

where: P_{hi} equals the number of sampling periods in the day.

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

$$\bar{\hat{E}}_h = \frac{\sum_{i=1}^{d_h} \hat{E}_{hi}}{d_h} \; ; \qquad \text{(A3.5)}$$

where: d_h equals the number of days sampled within each stratum.

Finally, this mean daily value was expanded by the number of days in each stratum (i.e., D_h) to obtain the stratum estimate of angler effort:

$$\hat{E}_h = D_h \bar{\hat{E}}_h \; . \qquad \text{(A3.6)}$$

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):

$$\hat{V}[\hat{E}_h] = \left[(1 - f_{1h}) \frac{D_h^2}{d_h} S_{1h}^2 \right] + \left[f_{1h} \frac{D_h^2}{d_h^2} \sum_{i=1}^{d_h} (1 - f_{2hi}) \frac{P_{hi}^2}{p_{hi}} S_{2hi}^2 \right] + \left[f_{1h} \frac{D_h^2}{d_h^2} \sum_{i=1}^{d_h} f_{2hi} \frac{P_{hi}^2}{p_{hi}^2} \sum_{j=1}^{p_{hi}} (1 - f_{3hij}) \frac{M_{hij}^2}{m_{hij}} s_{3hij}^2 \right] ; \qquad \text{(A3.7)}$$

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 $f_{3hij} = m_{hij} / M_{hij}$);

-continued-

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

$$= \frac{\sum_{i=1}^{d_h} (\hat{E}_{hi} - \bar{\hat{E}}_h)^2}{d_h - 1} ; \quad \text{(A3.8)}$$

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

$$= \frac{\sum_{i=1}^{p_{hi}} (\hat{E}_{hij} - \bar{\hat{E}}_{hi})^2}{p_{hi} - 1} ; \text{ and} \quad \text{(A3.9)}$$

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

$$= \frac{\sum_{j=1}^{m_{hij}} (e_{hijk} - \bar{e}_{hij})^2}{m_{hij} - 1} . \quad \text{(A3.10)}$$

Note, that since all anglers were expected to be interviewed in these surveys, then all $f_{3hij} = 1$, and the third major term in equation A3.7 is equal to zero.

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 A3.1 through A3.10, 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.

APPENDIX B

Appendix B. Summary information collected and recorded at the Little Susitna River coho salmon weir, 1993.

The following summary information was collected at the Little Susitna River coho salmon weir and called in daily to the Palmer office.

1. The number of salmon (by species) passed upstream of the weir (the number of salmon observed to pass back over the weir after release were subtracted from the daily count of adult salmon passing through the weir and continuing upstream),

2. the number of coho salmon examined for a missing adipose fin,

3. the number of coho salmon observed to have a missing adipose fin,

4. the number of coho salmon heads collected,

5. the number of coho salmon sampled for age and sex composition at the weir, and

6. any other pertinent factors that may have affected the efficiency of the weir to accurately census the passage of coho salmon upstream of rkm 52.

APPENDIX C

Appendix C. Estimation equations for the age composition in proportions and in numbers for the fish harvested in the Burma Road boat angler coho salmon sport fishery and the escapement through the weir (rkm 52), in the Little Susitna River, 1993.

Estimates of the proportion and apportioned abundance of coho salmon by sex and age class were calculated with the sampling strata grouped into temporal components or strata to describe 7-day periods in the fishery. The first step in obtaining these estimates was to calculate the proportions of each age class of fish harvested in each stratum of the sport fishery or the escapement through the weir:

$\hat{p}_{uh}$ = estimated proportion of the sampled coho salmon harvested or in the spawning escapement samples that are age u within each stratum[1] or combined strata;

$$= \frac{n_{uh}}{n_h}; \qquad \text{(C1.1)}$$

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

The variance of the estimated proportion of coho salmon harvested or in the escapement was estimated approximately by the standard equation for the variance of a binomial proportion (Cochran 1977, equation 3.8, page 52) (where the first term on the right-hand-side of the ≈ sign is for the harvest survey and the second term, after the "or" is for the escapement-weir survey):

$$\hat{V}[\hat{p}_{uh}] \approx \left(1 - \frac{n_h}{\hat{H}_h}\right) \frac{p_{uh}(1 - p_{uh})}{n_h - 1} \text{ or } \left(1 - \frac{n_h}{N_h}\right) \frac{p_{uh}(1 - p_{uh})}{n_h - 1} . \qquad \text{(C1.2)}$$

where: $\hat{H}_h$ equals the estimated harvest of coho salmon in each stratum or combined strata, obtained from equation A3.6; and N_h equals the number of coho salmon counted past the weir during each weir stratum or combined strata period.

-continued-

[1] Stratum refers to the sampling strata associated with the creel surveys for the harvest age composition estimates. The escapement sampling program is also stratified by 7-day periods, matching up to the creel survey periods.

The estimated proportion by age class (across all strata or across combined strata) was obtained by first estimating the number of coho salmon by age class in each stratum or combined strata:

$\hat{N}_{uh}$ = estimated number of fish harvested which are age class u, within stratum h (with the first term for the creel survey and the second term for the escapement-weir survey);

$$= \hat{H}_h \hat{p}_{uh} \quad \text{or} \quad N_h \hat{p}_{uh} . \tag{C1.3}$$

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

$$\hat{V}[\hat{N}_{uh}] = \hat{H}_h^2 \hat{V}[\hat{p}_{uh}] + \hat{p}_{uh}^2 \hat{V}[\hat{H}_h] - \hat{V}[\hat{p}_{uh}] \hat{V}[\hat{H}_h] ; \tag{C1.4a}$$

where: $\hat{V}[\hat{H}_h]$ equals the variance of the estimated harvest for each stratum, obtained by equation A3.7.

The variance of the estimated number of fish in the escapement past the weir which are age class u, within stratum h, was obtained simply by the usual equation for the product of a constant and a random variate:

$$\hat{V}[\hat{N}_{uh}] = N_h^2 \hat{V}[\hat{p}_{uh}] . \tag{C1.4b}$$

Next the number of fish in the harvest or in the escapement in each age class over all strata was obtained by summing the numbers across strata:

$$\hat{N}_u = \sum_{h=1}^{s} \hat{N}_{uh} . \tag{C1.5}$$

The variance of the estimated number of each age fish in the harvest or in the escapement 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 all strata was obtained as follows (with the first term for the harvest survey and the second term for the escapement-weir survey):

$$\hat{p}_u = \frac{\hat{N}_u}{\hat{H}} \quad \text{or} \quad \frac{\hat{N}_u}{N} ; \tag{C1.6}$$

-continued-

where: $\hat{H}$ equals the estimated total abundance of coho salmon over all sex and age groupings over all strata; and N equals the total number of coho salmon counted past the weir.

The percentage of each age group was derived by multiplying the above proportions by 100%.

The variance of the estimated proportion of coho salmon in each category for the harvest survey was calculated approximately using the Delta Method (see Seber 1982, section 1.3.3, pages 7-9) by:

$$\hat{V}[\hat{p}_u] \approx \left[\frac{\hat{N}_u}{\hat{H}}\right]^2 \left[\frac{\hat{V}[N_u]}{\hat{N}_u^2} + \frac{\hat{V}[H]}{\hat{H}^2} - \frac{2\,\hat{V}[N_u]}{\hat{N}_u\,\hat{H}}\right]. \qquad \text{(C1.7a)}$$

The corresponding variance estimate for the escapement survey at the weir was obtained by the standard equation for a ratio of a random variate to a constant:

$$\hat{V}[\hat{p}_u] = \frac{\hat{V}[\hat{N}_u]}{N^2}. \qquad \text{(C1.7b)}$$

APPENDIX D

Appendix D1. Summary of coho salmon smolt stocked in the Little Susitna River from eggs taken at Nancy Lake and incubated at Fort Richardson hatchery from 1983-1993.

Brood Year	Number of Eggs Incubated	Release						Dominant Return Year
		Site	Year	Size(g)	Number	Number Marked	Tag Code	
1983	56,000	Nancy Lake	1985	17.1	54,394	12,151		1986
1984	594,000	Nancy Lake	1986	17.2	580,065	24,401	31-17-30	1987
1985	552,000	Houston	1987	19.0	98,156	7,950	31-17-45	1988
		Nancy Lake		19.2	203,011	16,700	31-17-45	
		1987 Release Year Total			301,167	24,650		
1986	495,400	Nancy Lake	1988	20.1	446,016	24,628	31-17-61	1989
1987	537,877	Houston	1989	18.5	49,349	3,581	31-18-32	1990
		Nancy Lake		20.8	305,548	22,050	31-18-32	
		1989 Release Year Total			354,897	25,631		
1988	462,000	Houston	1990	20.8	106,242	15,679	31-19-17	1991
		Nancy Lake		20.8	202,114	29,541	31-16-01	
		1990 Release Year Total			308,356	45,220		
1989	530,315	Houston	1991	23.4	88,675	16,151	31-19-36	1992
		Nancy Lake		22.9	189,087	30,207	31-19-35	
		1991 Release Year Total			277,762	46,358		
1990	590,015	Houston	1992	24.1	154,466	19,564	31-20-07	1993
		Nancy Lake		23.4	158,459	19,222	31-20-06	
		1992 Release Year Total			312,925	38,786[a]		
1991	833,883	Houston	1993	18.1	148,282	20,312	31-21-37	1994
		Nancy Lake		20.2	131,591	19,930	31-21-37	
		1993 Release Year total			279,873	40,242[a]		
1993	790,000	1994						1995

[a] Total number of tagged smolt released.

Appendix D2. Estimation equations for the hatchery contribution of stocked coho salmon to the Burma Road boat angler coho salmon sport fishery and escapement through the weir (rkm 52) in the Little Susitna River, 1993.

The notation used in the following equations essentially follows that used by Clark and Bernard (1987), with additional subscripts used to denote individual stratum (or combined strata). The first step involved estimating the contribution to each stratum (or combined strata) in the fishery of each particular tag code (using equation [10] from Clark and Bernard (1987):

$\hat{n}_{1Ah}$ = estimated contribution of stocked fish from release associated with unique tag code *A* for fishery stratum *h*;

$$= \left[\frac{\hat{N}_h}{n_{2h}} \right] \left[\frac{a_{1h}}{a_{2h}} \right] \left[\frac{m_{1h}}{m_{2h}} \right] \left[\frac{m_{cAh}}{\theta_A} \right] ; \qquad \text{(D2.1)}$$

where: $\hat{N}_h$ equals the estimated harvest of all coho salmon within each stratum; n_{2h} is the number of coho salmon inspected for missing adipose fins from the sampled harvest in each fishery stratum; a_{1h} equals the number of coho salmon with a missing adipose fin which were counted and marked with a head strap from each stratum; a_{2h} equals the number of coho salmon heads previously marked with a head strap which arrived at the tag lab, from fish originally sampled from stratum *h*; m_{1h} equals the number of coded wire tags which were detected in the coho salmon heads at the tag lab, from those sampled from stratum *h*; m_{2h} is the number of coded wire tags which were removed from the coho salmon heads and decoded, from coho salmon sampled from stratum *h*; m_{cAh} is the 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 equals the proportion of a particular hatchery release which contains a coded wire tag of the unique tag code *A*.

Estimates of across strata (or initially combined strata) contributions by tag code, as well as by combined tag codes were obtained by summing the estimates across the strata and tag codes, as appropriate.

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Bootstrapping (Efron 1982) was used to calculate the variance of the contribution estimate. The components of variance for the contribution estimate included components from the harvest estimation procedure (i.e., the creel survey) and the harvest sampling program. Estimated harvest was considered normally distributed and its variance was calculated in closed form (see equation A3.7, hence no simulation was involved). The bootstrap resampling primarily involved estimation of the variance due to the CWT sampling program. Equation D2.1 was first divided into three components (in the following presentation subscripts denoting strata and particular tag codes were dropped):

$$N \left[\frac{m_1}{m_2} \frac{a_1}{a_2} \frac{m_c}{n_2} \right] \theta .$$

The first component (N) was harvest as estimated from the creel survey, and the third component (θ) was obtained from the tag lab data base and was assumed to be known for the hatchery tag codes. The second component $[(m_1/m_2)(a_1/a_2)(m_c/n_2)]$ corresponds to statistics garnered through harvest sampling (and lab work); for convenience, M was defined as the result of the arithmetic operations in this second component. Each of these three components is the product of three distinct and independent programs.

The bootstrap was used to simulate the variation in the second component by resampling data from the harvest sampling program. Each fish counted in the harvest sampling program was placed into one of the following six categories depending on its progress through the program:

1. adipose fin was present, therefore head was not retained;
2. adipose fin was missing, either the head was strapped and sent to lab, but never arrived, or the head was not strapped or sent to the lab[1];
3. head arrived at lab, but contained no CWT;
4. head contained a CWT, but tag was not decoded;
5. tag was decoded, but did not carry the appropriate code; and
6. tag did carry the appropriate code.

-continued-

[1] Sometimes heads can not be cinch strapped even though an adipose finclip is detected, since anglers sometimes cut off the fish's head.

A multinomial, empirical density distribution with six cells was created with the data from the harvest sampling program. Respective to the categories above, the probabilities of drawing a single sample from this distribution were calculated from the original data as follows:

$$\frac{n_2 - a_1}{n_2} \quad \frac{a_1 - a_2}{n_2} \quad \frac{a_2 - m_1}{n_2} \quad \frac{m_1 - m_2}{n_2} \quad \frac{m_2 - m_c}{n_2} \quad \frac{m_c}{n_2} .$$

The bootstrap technique began by drawing with replacement a sample of size n_2 from the empirical distribution according to the probabilities based on the original data. Once such a sample was drawn (call it sample b), the result was tallied to obtain a new set of statistics $\{a^*_1, a^*_2, m^*_1, m^*_2, m^*_c\}_b$ and a value of M_b. A large number (say B numbers) of M_b were so generated, their values were used as an empirical distribution with mean and variance. These statistics were calculated as:

$$V[\bar{M}] = \frac{\sum_{b=1}^{B} (M_b - \bar{M})^2}{B - 1} \quad \text{with} \quad \bar{M} = \frac{\sum_{b=1}^{B} M_b}{B} . \qquad \text{(D2.2)}$$

Then the variance of the contribution estimate was estimated as:

$$\hat{V}[\hat{n}_1] = \theta^{-2} \left(\hat{V}[\bar{M}] \hat{N}^2 + \hat{V}[\hat{N}] M^2 - \hat{V}[\bar{M}] \hat{V}[\hat{N}] \right) . \qquad \text{(D2.3)}$$

Estimates of the variance of across strata contributions by tag code, as well as by combined tag codes were obtained by summing the variances across the strata and tag codes, as appropriate. The resulting estimates of variance were assumed to be conservative in that the covariances among contribution estimates by tag code within each sampling stratum were assumed to be negative (Clark and Bernard 1987).

Standard errors (SE's) were obtained as the square root of the appropriate variance.

Appendix D3. Little Susitna River drainage coho salmon fry release summary from 1982-1990.

Release Location	Date	Size(g)	Total Number	Number Tagged	Tag Code
Little Susitna River	6/22/82	0.4	2,950		
Nancy Lake	6/15/83	0.5	23,652	1,880	B4-07-13
	6/16/83	0.5	80,124	4,605	B4-07-13
	6/17/83	0.6	79,251	2,622	B4-07-13
	6/22/83	0.7	67,815	5,278	B4-07-13
	6/23/83	0.7	15,666	6,450	B4-07-13
	Total		266,508	20,835	B4-07-13
Nancy Lake	6/14/84	1.0	171,194	4,026	B4-14-11
	6/15/84	0.9	164,280	5,174	B4-14-11
	6/19/84	0.9	90,742	631	B4-14-11
	Total		436,047	9,831	B4-14-11
Nancy Lake	6/18/85	0.3	127,000	10,000	B4-15-08
	5/31/85	0.3	164,600		
Horseshoe Lake	6/20/85	0.3	140,000		
	6/21/85	0.3	79,000		
	6/05/85	0.3	229,600		
	6/03/85	0.3	85,000		
Crooked Lake	6/12/85	0.3	68,000		
	6/21/85	0.3	164,000		
Butterfly Lake	6/25/85	0.3	119,000		
Delyndia Lake	6/25/85	0.3	49,000		
	Total	Nancy L.	291,600	10,000	B4-15-08
		All Others	933,600		
Nancy Lake	6/26/86	1.0	211,255	10,300	B3-11-15
	6/27/86	1.0	105,015		
	Total	Nancy L.	316,270	10,300	B3-11-15

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Release Location	Date	Size(g)	Total Number	Number Tagged	Tag Code
Horseshoe Lake	5/11/88	16.4	15,725		
Horseshoe Lake	6/23/88	0.7	450,000		
Crooked Lake	7/01/88	1.0	105,000		
	7/05/88	1.3	151,000		
Nancy Lake	7/05/88	1.3	174,126	3,126	B3-02-02
	7/07/88	0.7 - 1.3	1,708,939	8,939	B3-02-02
East Papoose L	7/06/88	1.0	172,000		
West Papoose L	7/06/88	1.0	164,000		
Butterfly Lake	7/06/88	1.0	141,000		
Delyndia Lake	7/06/88	1.0	141,000		
Hock Lake	7/06/88	1.0	72,000		
Yohn Lake	7/06/88	1.0	46,000		
My Lake	7/06/88	1.0	58,000		
		Nancy L.	1,883,065	12,065	B3-02-02
		All Others	1,515,725		
	1988 Total		3,398,790		
Horseshoe Lake	7/28/89	1.4	8,400		
Horseshoe Lake	6/19/90	1.0	344,000		
Crooked Lake	6/20/90	1.0	78,000		
Nancy Lake	6/28/90	1.1	155,619	11,619	13-01-01-04-05
	7/06/90	1.5	65,305	28,305	13-01-01-04-05
	7/13/90	1.7	28,722	10,722	13-01-01-04-06
	7/23/90	2.0	223,681	21,681	13-01-01-04-06
My Lake	6/29/90	1.1	23,000		
Yohn Lake	6/29/90	1.1	26,000		
Butterfly Lake	6/29/90	1.1	90,000		
Hock Lake	6/29/90	1.1	40,000		
Delyndia Lake	6/29/90	1.1	89,000		
		Nancy L.	220,924	39,924	13-01-01-04-05
			252,403	32,403	13-01-01-04-06
		All Others	690,000		
	1990 Total		1,163,327		

APPENDIX E

Appendix E. Daily and cumulative counts by salmon species through the Little Susitna River weir, 23 July through 12 September 1993.

	Coho Salmon		Sockeye Salmon		Chum Salmon		Pink Salmon		Chinook Salmon	
Date	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.
23-Jul[a]	0	1	39	77	82	192	0	121	0	0
24-Jul	63	1	570	77	905	192	7	121	1	1
25-Jul	36	37	342	1,056	1,126	1,162	8	129	0	1
26-Jul	63	100	979	2,598	970	3,641	1	130	0	1
27-Jul	244	344	1,542	4,140	2,479	6,120	17	147	0	1
28-Jul	315	659	759	4,899	2,716	8,836	20	167	1	2
29-Jul	423	1,082	707	5,606	1,282	10,118	42	209	2	4
30-Jul	497	1,579	268	5,874	884	11,002	19	228	1	5
31-Jul	346	1,925	211	6,085	238	11,240	15	243	0	5
01-Aug	145	2,070	50	6,135	150	11,390	4	247	0	5
02-Aug	157	2,227	231	6,366	591	11,981	8	255	0	5
03-Aug	151	2,378	103	6,469	522	12,503	5	260	2	7
04-Aug	40	2,418	81	6,550	665	13,168	12	272	1	8
05-Aug	50	2,468	61	6,611	602	13,770	15	287	1	9
06-Aug	551	3,019	169	6,780	959	14,729	28	315	1	10
07-Aug	517	3,536	275	7,055	1,212	15,941	16	331	0	10
08-Aug	4,429	7,965	159	7,214	1,890	17,831	44	375	1	11
09-Aug	6,100	14,065	196	7,410	1,306	19,137	11	386	0	12
10-Aug	3,054	17,119	180	7,590	1,325	20,462	15	401	3	15
11-Aug	2,812	19,931	112	7,702	1,321	21,783	19	420	5	20
12-Aug	2,013	21,944	62	7,764	1,457	23,240	30	450	1	21
13-Aug	1,082	23,026	60	7,824	1,063	24,303	13	463	1	22
14-Aug	2,479	25,505	80	7,904	1,114	25,417	10	473	0	22
15-Aug	1,323	26,828	12	7,916	249	25,666	5	478	0	22
16-Aug	530	27,358	14	7,930	162	25,828	1	479	0	22
17-Aug	382	27,740	14	7,944	147	25,975	0	479	0	22
18-Aug	127	27,867	24	7,968	130	26,105	4	483	1	23
19-Aug	39	27,906	0	7,968	49	26,154	0	483	0	23
20-Aug	18	27,924	1	7,969	52	26,206	0	483	0	23
21-Aug	139	28,063	1	7,970	54	26,260	0	483	0	23
22-Aug	26	28,089	0	7,970	26	26,286	0	483	0	23
23-Aug	402	28,491	1	7,971	13	26,299	0	483	0	23
24-Aug	192	28,683	0	7,971	15	26,314	0	483	0	23
25-Aug	169	28,852	0	7,971	24	26,338	0	483	0	23
26-Aug	157	29,009	0	7,971	27	26,365	0	483	0	23
27-Aug	379	29,388	2	7,973	36	26,401	0	483	0	23
28-Aug	876	30,264	3	7,976	45	26,446	0	483	0	23
29-Aug	1,677	31,941	1	7,977	60	26,506	0	483	0	23
30-Aug	1,829	33,770	0	7,977	11	26,517	0	483	0	23
31-Aug	905	34,675	0	7,977	12	26,529	0	483	0	23

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Appendix E. (Page 2 of 2).

Date	Coho Salmon		Sockeye Salmon		Chum Salmon		Pink Salmon		Chinook Salmon	
	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.
01-Sep[b]										
02-Sep[b]										
03-Sep[b]										
04-Sep[b]										
05-Sep[b]										
06-Sep	12	34,687	0	7,977	0	26,529	0	483	0	23
07-Sep[b]										
08-Sep	23	34,710	0	7,977	2	26,531	0	483	0	23
09-Sep	46	34,756	3	7,980	4	26,535	0	483	0	23
10-Sep	31	34,787	1	7,981	1	26,536	0	483	0	23
11-Sep	26	34,813	0	7,981	17	26,553	0	483	0	23
12-Sep[c]	9	34,822	0	7,981	1	26,554	0	483	0	23

[a] Weir in place and fish tight on 23 July 1993.

[b] Weir closed due to flood.

[c] Weir removed on 13 September 1993.

APPENDIX F

Appendix F. Computer data files and analysis programs developed for the coho salmon creel survey and escapement studies on the Little Susitna River, 1993.

Data Files[a]

K004BSL3.DTA	Burma Road angler interview data file for anglers interviewed during the artificial lure only strata, 15 July-5 August 1993;
K004BST3.DTA	Burma Road angler interview data file for anglers interviewed during the bait allowed strata, 6 August-2 September 1993;
K004BCX3.DTA	Burma Road angler count data file for anglers fishing upstream of the ADF&G weir;[b]
K004BCY3.DTA	Burma Road angler count data file for anglers fishing downstream of the ADF&G weir;[b]
K004BCZ3.DTA	Burma Road angler count data file for all anglers;[b]
K004DBA3.DTA	Weir site biological data file;
K004BBA3.DTA	Creel survey at Burma Road boat launch biological data file;

Analysis Programs[c]

LSU.EXE	Research and Technical Services (RTS) program for preprocessing Burma road boat launch mark-sense angler interview data files;
UCSP92.EXE	RTS program to analyze raw data files from direct-expansion and roving creel surveys and generate estimates of angler effort, catch, and harvest;
DRA31LSU.RD	RTS report descriptive file for stage 1 of a stratified-random, three-stage, direct-expansion creel survey;
DRA32LSU.RD	RTS report descriptive file for stage 2 of a stratified-random, three-stage, direct-expansion creel survey;
DRA33LSU.RD	RTS report descriptive file for stage 3 of a stratified-random, three-stage, direct-expansion creel survey;
SFXTAB.EXE	RTS program used to cross-tabulate biological data files and produce either "discrete" or "continuous" tables of age, sex, length, and weight data;
MENU91.BAT	Series of RTS programs used to generate listing, frequency, and litho code reports from raw data;
LSUBSS92.WK1	Lotus 1-2-3® worksheet used to apportion coho salmon harvest estimates by sex and age, within and across all temporal components;
LSUWSS92.WK1	Lotus 1-2-3® worksheet used to apportion coho salmon weir escapement estimates by sex and age, within and across all temporal components.

[a] Data files are archived with the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services Unit, 333 Raspberry Road, Anchorage, Alaska 99518. Contact Gail Heineman or Donna Buchholz (267-2369) for copies of the files and descriptions of the file format.

[b] Angler count files only contain dummy records for each date and period sampled (number of anglers interviewed from interview files equals the number of exiting anglers).

[c] Analysis programs are maintained by the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services Unit, 333 Raspberry Road, Anchorage, Alaska 99518. Contact Allen Bingham (267-2369) for copies of the programs.