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Stock Assessment of the Chinook Salmon Return to the Naknek River, Alaska, During 1992

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ABSTRACT

Drift gill nets were used to capture 1,068 adult chinook salmon *Oncorhynchus tshawytscha* in the lower Naknek River for marking as part of a mark-recapture experiment. Marked fish were recaptured during a creel survey of the sport fishery and during escapement surveys of the spawning grounds. Based on recovery data from the escapement surveys, an estimated 51,344 chinook salmon ≥ 635 millimeters entered the lower Naknek River from 5 June until 14 August. During the escapement recovery event in which 681 chinook salmon, 635 millimeters or greater in length, were examined, only 13 had been marked in the marking event. Due to this extremely low recapture rate, and a similarly low recapture rate during the sport fishery recovery event, a host of assumptions required for unbiased estimates of inriver abundance were not tested. Because these assumptions were not addressed and because the estimated inriver abundance minus the estimated sport harvest is nearly nine times as large as the total average historical escapement index, this estimate is believed to be biased high by an unknown amount.

An estimated 28,428 hours of effort were expended by recreational anglers fishing the lower Naknek River from 8 June through 31 July 1992. This estimate is 40% below the recent 4-year average (1988-1991) of 47,654 hours. Anglers caught (landed) and harvested (kept) an estimated 3,362 and 2,949 (88% harvested) chinook salmon, 156 and 156 (100% harvested) coho salmon *Oncorhynchus kisutch*, 456 and 413 (91% harvested) chum salmon *Oncorhynchus keta*, and 1,760 and 25 (1% harvested) rainbow trout *Oncorhynchus mykiss*. Age-1.4 (47%) and -1.3 (24%) chinook salmon dominated the harvest. An emergency order which prohibited fishing for chinook salmon in King Salmon Creek and Paul's Creek, as well as the waters surrounding their confluences with the Naknek River, took effect 1 June. These closures were enacted in an attempt to provide adequate chinook salmon escapement into these streams as well as to provide protection to a major milling area located at the confluence of King Salmon Creek and the Naknek River. The emergency order was only partially effective as both Paul's Creek and King Salmon Creek received below average escapements.

The spawning escapement index of chinook salmon, as determined by aerial survey counts of live fish in the four major spawning areas, was 2,621 fish which was well below the 1970-1991 average of 5,524 fish.

KEY WORDS: chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *Oncorhynchus kisutch*, chum salmon, *Oncorhynchus keta*, rainbow trout, *Oncorhynchus mykiss*, harvest, effort, creel survey, escapement index, Naknek River, inriver abundance estimate.

INTRODUCTION

The Naknek River (Figure 1) supports the largest chinook salmon *Oncorhynchus tshawytscha* sport fishery in southwestern Alaska. Adult chinook salmon first enter the Naknek River in late May. The majority of the run migrates through the lower section of river during a 4 to 5 week period beginning in mid-June, and abundance peaks in early July. Sport fishing effort in the Naknek River drainage has increased from 4,675 angler-days in 1977 to a recent 4-year average (1988-1991) of 15,246 angler-days which equates to about 17% of the total effort in southwest Alaska (Mills 1979-1992). Harvest in the sport fishery peaked in 1987 when anglers harvested an estimated 11,419 chinook salmon. Since 1988, regulatory and inseason emergency restrictions, along with reductions in effort during the chinook salmon fishery, have reduced the sport fish harvest to a recent 4-year average of approximately 3,700 chinook salmon (Coggins 1992). Currently, the management goal of the Naknek River chinook salmon sport fishery is to deliver an observed spawning escapement of 5,600 large fish on the spawning grounds.

Initial regulations for anglers seeking chinook salmon on the Naknek River during 1992 permitted a daily bag and possession limit, from 1 May to 31 July, of three chinook salmon, only one of which could be greater than 71 cm (28 in) in length (ADF&G 1992). On 20 May, the Department of Fish and Game, Division of Sport Fish, issued an emergency order that closed the waters of King Salmon and Paul's creeks, as well as the waters surrounding their confluences with the Naknek River (Figure 1), to fishing for chinook salmon from 1 June through 31 July. This action was in response to 4 consecutive years of below average escapements of chinook salmon observed in these systems. Bag limits of five other salmon in total (any of the following: sockeye *O. nerka*, chum *O. keta*, coho salmon *O. kisutch*, or pink *O. gorbuscha*) with no size limit, and one rainbow trout *O. mykiss* less than 45.7 cm (18 inches) in length, were also allowed. Only unbaited artificial lures were permitted in the Naknek River drainage from 1 March through 14 November. Fishing was prohibited above the Alaska Department of Fish and Game markers at Rapids Camp (Figure 1) from 10 April through 7 June, to protect spawning rainbow trout.

Naknek River chinook salmon are harvested in sport, commercial, and subsistence fisheries. However, the sport harvests have steadily declined since 1987. In recent years exploitation rates of Naknek River chinook salmon have been assumed to exceed 50% for all fisheries combined. In 1989 the exploitation rate was approximated to approach 80% (Coggins 1992). These apparent high exploitation rates have in part prompted the Division of Sport Fish to issue emergency order restrictions to insure adequate escapement of Naknek River chinook salmon. However, these approximate exploitation rates are questionable for three important reasons:

1. harvest estimates of the commercial fishery are comprised of fish caught in the Naknek-Kvichak district and include Naknek, Alagnak, and Kvichak River stocks in unknown proportions;

2. subsistence harvest is estimated from voluntary returns of permits with unknown biases due to unreturned permits; and

3. escapement is indexed through aerial surveys for which accuracy and precision are not estimated.

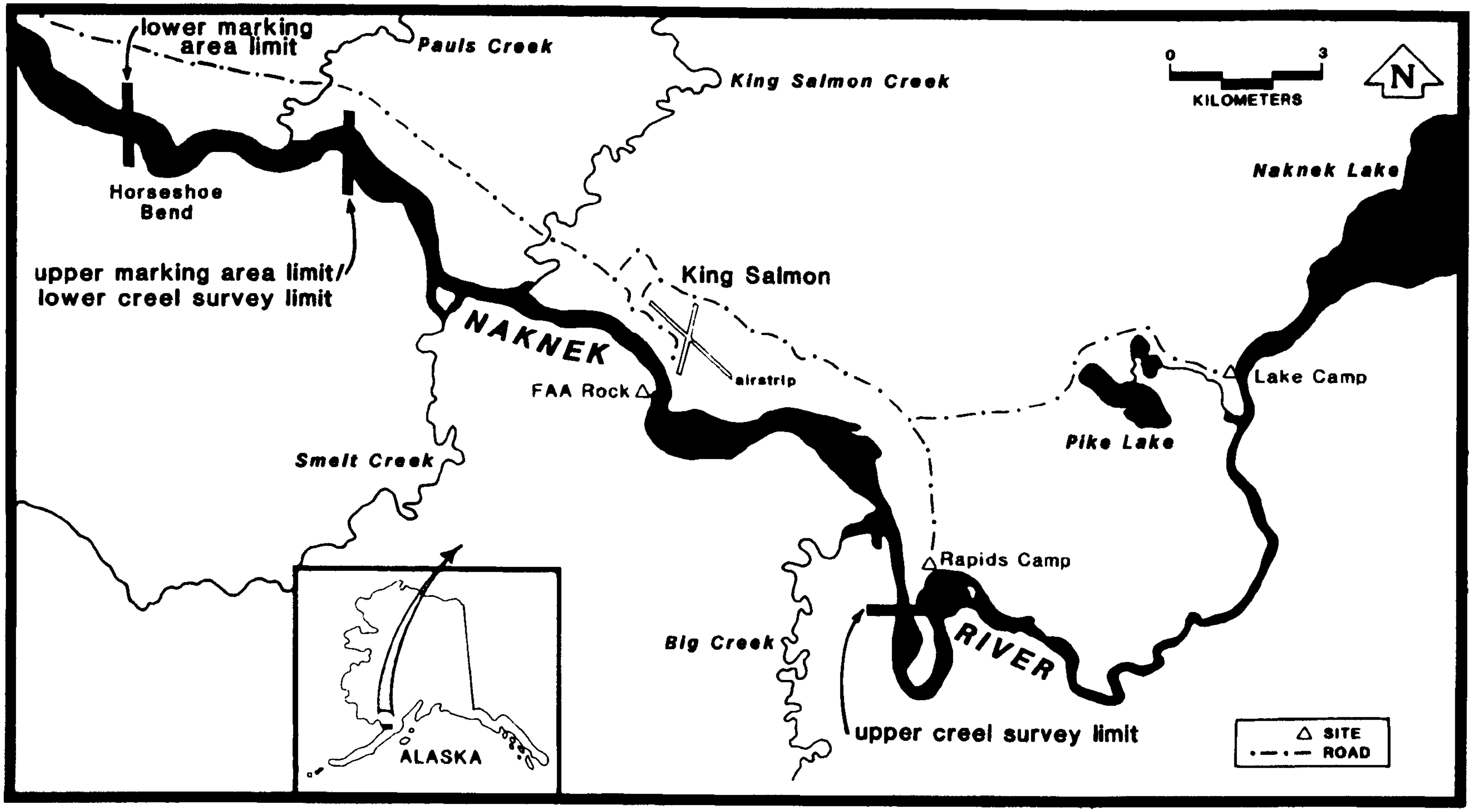

Figure 1. The lower Naknek River study site, 1992.

Due to the questionable accuracy of the available information used to estimate exploitation rates, there is a defined need for more refined stock assessment information.

To better estimate exploitation rate, a stock assessment program was proposed to assess all components of the Naknek River chinook salmon harvest (i.e., commercial, subsistence, and sport) and escapement. The feasibility of estimating the Naknek River component of the Bristol Bay commercial chinook salmon harvest was to be investigated through scale pattern analysis. The subsistence harvest was to be estimated by the Division of Subsistence through voluntary permit returns. The sport harvest was to be estimated through an onsite creel survey. Inriver abundance (total return minus the commercial and subsistence harvests) was to be estimated through a mark-recapture experiment. Finally, escapement (total return minus all harvest components) was to be estimated by subtracting the sport harvest from the inriver abundance. These estimates of harvest and escapement were to be used to estimate the exploitation rate of Naknek River chinook salmon.

The objectives of the 1992 Naknek River chinook salmon stock assessment program were:

Inriver Abundance

1. To estimate the number of chinook salmon entering the Naknek River from 8 June to 14 August.

2. To estimate the age, sex, and length compositions of chinook salmon entering the Naknek River.

Sport Fishery

3. To estimate angling effort (in angler-hours), during the 8 June to 31 July 1992 period.

4. To estimate catch (fish kept plus released) and harvest (fish kept only) of chinook salmon caught in the lower Naknek River sport fishery during the period 8 June to 31 July 1992.

5. To estimate the age, sex, and length composition of chinook salmon harvested by the sport fishery in the lower Naknek River.

Escapement

6. To estimate the total spawning escapement of the Naknek River chinook salmon stock.

7. To index by aerial survey the spawning escapement of chinook salmon in Paul's, King Salmon, and Big creeks and the mainstem of the Naknek River.

8. To estimate the age, sex, and length composition of the chinook salmon escapement into Paul's, King Salmon, and Big creeks and the mainstem of the Naknek River.

Total Return

9. To estimate the total return of chinook salmon to the Naknek River.

As a result of deficiencies with regard to specific project expectations such as mark recovery rate, gear selectivity, and sport fish harvest, not all of the above objectives were met. These deficiencies resulted in abandoning objectives two and nine, and significantly modifying objectives one and six. Objectives three, four, five, seven, and eight were successfully addressed as outlined above.

INRIVER ABUNDANCE ESTIMATION METHODS

Study Design

Marking:

The marking event commenced on 5 June and ended on 14 August. The majority of marking effort was concentrated from Paul's Creek to the lower end of the Horseshoe bend (Figure 1). Three marking crews conducted their operations according to a 7-day schedule based on periods of the day when tide levels offered the greatest probability of capturing chinook salmon. The tide series which continually offered the greatest probability of capturing chinook salmon occurred from high slack tide until low slack tide (i.e., the ebb tide). For crew safety, only daylight ebb tides were fished.

Marking was conducted from an outboard powered skiff from which two personnel used 19 cm stretched-mesh drift gill nets approximately 20 m long to capture chinook salmon. The nets were set by releasing one end near shore and rapidly backing the skiff toward the middle of the river channel. Once the net was fully deployed, it was allowed to drift downstream. The net was usually allowed to drift downstream until either a chinook salmon was caught, or until the net snagged on the river bottom.

When a chinook salmon became entangled in the net, the set was immediately ended and the chinook salmon retrieved from the net. A soft, braided line was looped around the fish's caudal peduncle to prevent the fish from escaping while the fish was untangled from the net. Frequently, to reduce stress imposed on the fish during processing, meshes were cut to reduce handling time. After the fish was untangled from the net, it was slipped into a rigid, foam-padded cradle for processing. The cradle was hung from the side of the skiff with its base slightly below the water line. With this method the fish was never removed from the water.

The condition of each captured chinook salmon was assessed prior to marking. Chinook salmon with deep scars, damaged gill filaments, and fish that were lethargic or required extended processing time were not marked. Fish were marked with individually numbered, 50 cm, Floy FT-4 plastic spaghetti tags. Each tag was inserted below the posterior insertion of the dorsal fin with a large needle and secured with an overhand knot. From 5 June until 6 July, the adipose fin was removed from marked chinook salmon as a secondary mark to estimate tag loss. However, beginning 7 July the secondary mark was switched to a caudal punch in hopes of reducing stress imposed during processing.

Each chinook salmon captured was sampled for length, sex, and age data. The mid-eye to fork-of-tail length (measured to the nearest millimeter) and the sex (identified from external characteristics) of all captured chinook salmon were recorded. Three scales were removed from the preferred area[1] and mounted on an adhesive-coated card. The adhesive-coated cards were pressed against acetate cards in a heated hydraulic press and the resulting scale impressions displayed on a microfiche projector (Clutter and Whitesel 1956) for age determination[2].

Catch and effort for each set with the gill net were recorded. Effort was measured as the number of minutes the net drifted before being retrieved, and catch as the number of chinook salmon caught. Captured chinook salmon were tallied according to six categories: (1) unmarked fish which were captured and marked; (2) unmarked fish which were captured but not marked because of poor condition; (3) unmarked fish which were captured and positively identified as chinook salmon but escaped before being processed; (4) previously marked fish which were recaptured and still retained their tag; (5) previously marked fish which were recaptured and had lost their tag; and (6) mortalities. Additionally, the number and species of fish caught other than chinook salmon were recorded.

Sport Fishery Mark Recovery:

The inriver sport fishery was designed to be the primary mechanism for mark recovery. A roving creel survey, which has been conducted on the Naknek River continually since 1986, was used to estimate the proportion of marked to unmarked fish harvested in the sport fishery. In addition to the two technicians historically employed by the Naknek River creel survey, an additional technician was employed solely to sample the sport fishery harvest. The creel survey is described in detail in the Creel Survey Methods section of this report.

All chinook salmon observed in the sport fishery harvest were sampled as described above for length, sex, and age data. They were also examined for the presence of a tag or a secondary mark. When present, the tag number and type of secondary mark were recorded.

Escapement Sampling Mark Recovery:

The spawning grounds of King Salmon Creek, Paul's Creek, Big Creek, and the mainstem Naknek River were accessed by jet-powered riverboat and surveyed for chinook salmon carcasses. The surveys took place during the second and third weeks of August and the first week of September.

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[1] Scales were collected from the left side of the body, at a point approximately two rows above the lateral line and on a diagonal line downward from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (INPFC 1958, Welander 1940).

[2] For salmon, the numeral preceding the decimal is the number of freshwater annuli, whereas the numeral following the decimal is the number of marine annuli (European method). Total age from brood year is the sum of the two numerals plus one.

All chinook salmon observed during the escapement surveys were sampled as described above for length, sex, and age data. They were also examined for the presence of a tag or a secondary mark. If either a tag or secondary mark was observed on a fish, the tag number and or type of secondary mark was recorded.

Data Analysis

There were three sets of data analyzed: (1) the chinook salmon marking data, (2) the sport harvest recovery data, and (3) the escapement recovery data. A two-sample closed mark-recapture estimator was used to estimate abundance for both sets of recovery data. Recovery data sets were not pooled due to differences in coverage of the population (e.g., all marked fish could be recaptured during the escapement recovery event). The assumptions necessary for the accurate estimation of abundance in a closed population using mark-recapture methods are (adapted from Seber 1982):

1. The population is closed, that is no additions or losses between sampling events (through recruitment, death, immigration, or emigration).

2. All fish have an equal capture probability in the first event or the second event; or marked fish mix completely with unmarked fish prior to the second event.

3. Marking does not affect capture probability in the second event.

4. Marks (tags) are not lost between events.

5. Marked fish can be recognized from unmarked fish.

The inriver population of chinook salmon in the lower Naknek River was obviously not a closed population. Both additions through immigration and losses through death and emigration were expected to occur. Since sampling occurred in the lower river, virtually all of the fish should be of Naknek River origin and, as such, an appreciable number of fish were not expected to migrate out of the system. Clearly, fish available to the recapture event in the fishery must first be available to the downstream marking event. Similarly, additions to the first event population through immigration would also have been available to the recapture event. As such, if fish were marked throughout the run, then all immigrants could have been viewed as newly catchable fish within the first event (i.e., no appreciable addition during the first event). Finally, since losses by death were assumed to affect both the marked and unmarked portion of the population (and ensured by careful handling of all fish during the first event), then the population abundance estimate would be valid for size of the population during the first event.

The collection of adult chinook salmon by drift gill nets was assumed to be size selective. Data from creel surveys during the last few years indicate that nearly all fish caught by anglers were retained (Dunaway and Bingham 1991, Coggins 1992). As such, retention of the catch of chinook salmon by the anglers was assumed to not be size selective. However hook and line sampling of the population may have had some degree of length bias. Data from the escapement survey was also expected to be length-biased. Previous studies suggest that larger fish carcasses are more likely to be "recaptured" than are smaller fish carcasses (Sykes and Botsford 1986). The severity of these possible biases was evaluated by conducting two Kolmogorov-Smirnov two-sample statistical tests for each set of recovery data. The first test compared the length frequency distribution of recaptured chinook salmon (sampled from the sport harvest or from the escapement survey) with those captured during the marking sample. The second test compared the length frequency distributions of chinook salmon captured during the marking sample with those sampled from the fishery or from the escapement surveys. The results of these two tests determined the methodology used to alleviate bias in abundance estimation (see Appendix A).

Concerning the second assumption, it was assumed that fish would not have an equal probability of capture in either event. Sampling effort remained consistent throughout the run in the face of large differences in daily abundance. However, sampling occurred daily during the marking and sport fishery recovery events. Conversely, the escapement surveys were conducted over a few days for each spawning ground site. Therefore, each fish had some positive probability of capture during each event. Since each fish could be identified with uniquely numbered tags, a stratified-in-time mark-recapture experiment was expected to be feasible. However, the numbers of recaptures in either recovery sample were so low (see Results section) that the data could not be post-stratified by period.

Assumption 3 (marking does not affect capture probability) could not be directly tested. However, since different capture techniques were used for the first event (gill nets) and second events (hook and line by fishery or visual observation during escapement surveys) it seemed reasonable that marked and unmarked fish were equally likely to be captured during the two recovery events.

An auxiliary mark (clip the adipose fin or caudal fin punch) was used to estimate tag loss (fourth assumption). Careful examination of each fish sampled in the sport fishery by trained technicians and the presence of the double mark allowed for evaluation of the validity of the fifth assumption. However during the escapement recovery event, the deteriorated condition of the carcasses' caudal fins made it extremely difficult to recognize punches in the caudal fin. Therefore, evaluations of the fourth and fifth assumptions for recaptures during the escapement recovery were not possible.

Estimates of abundance using the marking data set along with the two recovery data sets were obtained with Chapman's modification of the Petersen estimator (see Seber 1982), by the following equation:

$\hat{N}$ = estimated abundance of inriver population of chinook salmon;

$$= \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1 ; \qquad (1)$$

where:

n_1 = number of chinook salmon captured, marked, and released during the marking event;

n_2 = number of chinook salmon inspected for marks during the recovery events (i.e., number of sampled chinook salmon from either the sport fishery or from the escapement surveys); and

m_2 = number of chinook salmon with marks observed during each one of the recovery events separately (= recaptures).

The variance of the abundance estimates (one for each type of recovery event), was obtained by the equation presented in Seber (1982):

$$\hat{V}[\hat{N}] = \frac{(n_1 + 1)\ (n_2 + 1)\ (n_1 - m_2)\ (n_2 - m_2)}{(m_2 + 1)^2\ (m_2 + 2)}\ . \qquad (2)$$

Estimates of abundance and their variances also were obtained for subsets of the full data sets due to the length selectivity observed in the marking data set (see Results section for details).

Bias of the Chapman-modified Petersen estimator was evaluated by the bootstrap resampling technique (Efron 1982). The estimate (obtained from equation 1, above) was bootstrapped 1,000 times using the capture histories of all fish in each mark-recovery data set. The procedure was as follows: (1) a capture history (i.e., fish caught during both marking and recovery events, fish caught only during the marking event, or fish caught only during the recovery event) was sampled at random with replacement from all available capture histories; (2) step 1 was repeated until a sample equivalent to the total number of fish in the capture histories was selected ($n_1 + n_2 - m_2$ times); (3) an abundance estimate was generated using equation 1, above, with the capture history data simulated in steps 1 and 2; (4) steps 1-3 were repeated a total of 1,000 times, with each estimated value of abundance saved; (5) a mean, variance, and sample standard deviation were calculated from the 1,000 simulated (bootstrapped) values generated with steps 1-4; (6) bias was estimated as the difference between the mean of the bootstrap replicates and the abundance estimate calculated from the original sampling data; and (7) the percentile method (Efron 1982) was used to obtain 90% confidence intervals from the 1,000 replicated values obtained in steps 1-4.

INRIVER ABUNDANCE ESTIMATION RESULTS

Marking operations began 5 June, with the first chinook salmon caught and marked on 7 June, and ended 14 August (Appendix B1). A total of 1,068 chinook salmon were marked. The sport recovery event began 8 June, and ended 31 July when the chinook salmon fishery was closed by regulation. The creel clerks examined a total of 1,318 chinook salmon (45% of the estimated harvest) of which 14 were marked. No secondary marks were observed without Floy tags (i.e., tag loss estimated at 0%). The escapement recovery events took place during the last two weeks of August and the first week in September. In total, 753 chinook salmon carcasses were examined during escapement sampling of which 13 were marked.

Creel Survey as the Recovery Event

We originally planned to estimate chinook salmon abundance into the Naknek River beyond the end of the sport fishing season (objective 1). This was to be accomplished by developing a model that related CPUE in the marking event to abundance estimates inriver. However, recoveries of marked fish occurred so infrequently that temporally stratified estimates were not possible, hence, development of the CPUE model was not possible. Since building a model to estimate abundance based on CPUE in the marking event was not possible and since the fishery terminated on 31 July, it was necessary to modify objective 1 such that the number of chinook salmon entering the Naknek River from 5 June until 21 July would be estimated.

The cutoff date of 21 July was determined by an analysis of the frequency distribution of recaptures by number of days "at large" (Figure 2). Fifty percent of recaptures occurred within 9 days of marking. Therefore, given a 9 day "at large" marking cutoff before the end of the recapture event, only fish marked before 22 July were included in the estimate of abundance. This decision was predicated on the requirement that all fish marked in the first event have an equal probability of being caught during the second event.

The smallest marked fish recaptured in the sport recovery event was 728 mm in length, indicating that both the marking and the sport recovery data sets should be truncated at about 725 mm. Visual inspection of the length frequency distributions of fish captured in the marking and sport recovery events supported this decision (Figure 3). Therefore, both the marking and the sport recovery data sets were edited to include only fish 725 mm and greater in length. As such the estimate of abundance is germane to chinook salmon 725 mm and greater in length entering the Naknek River from 5 June until 21 July.

The results of the Kolmogorov-Smirnov (K.S.) tests (see Appendix A for test procedure details) indicated that length selectivity did not occur in either event using the truncated data sets (Table 1). Visual inspection of the cumulative length frequency distribution curves of fish marked from 5 June until 21 July in the first event and fish recaptured in the second event (Figure 4), and fish captured from 5 June until 21 July in the first event and fish captured in the second event (Figure 5) confirmed the results of the K.S. tests. Therefore, the length compositions of fish marked from 5 June until 21 July in the first event and fish recaptured during the second event were not significantly different, and that the length compositions of fish captured from 5 June until 21 July in the first event and fish captured during the second event were not significantly different.

The nonstratified Chapman-modified Petersen estimator (Seber 1982) was selected to estimate the number of chinook salmon 725 mm and greater in length entering the Naknek River from 5 June until 21 July based on the sport recovery event. An inriver abundance of 46,464 (SE = 12,210) chinook salmon 725 mm in length or greater was estimated with a bootstrapped 90% confidence interval of 31,998 to 75,014 fish (Table 2).

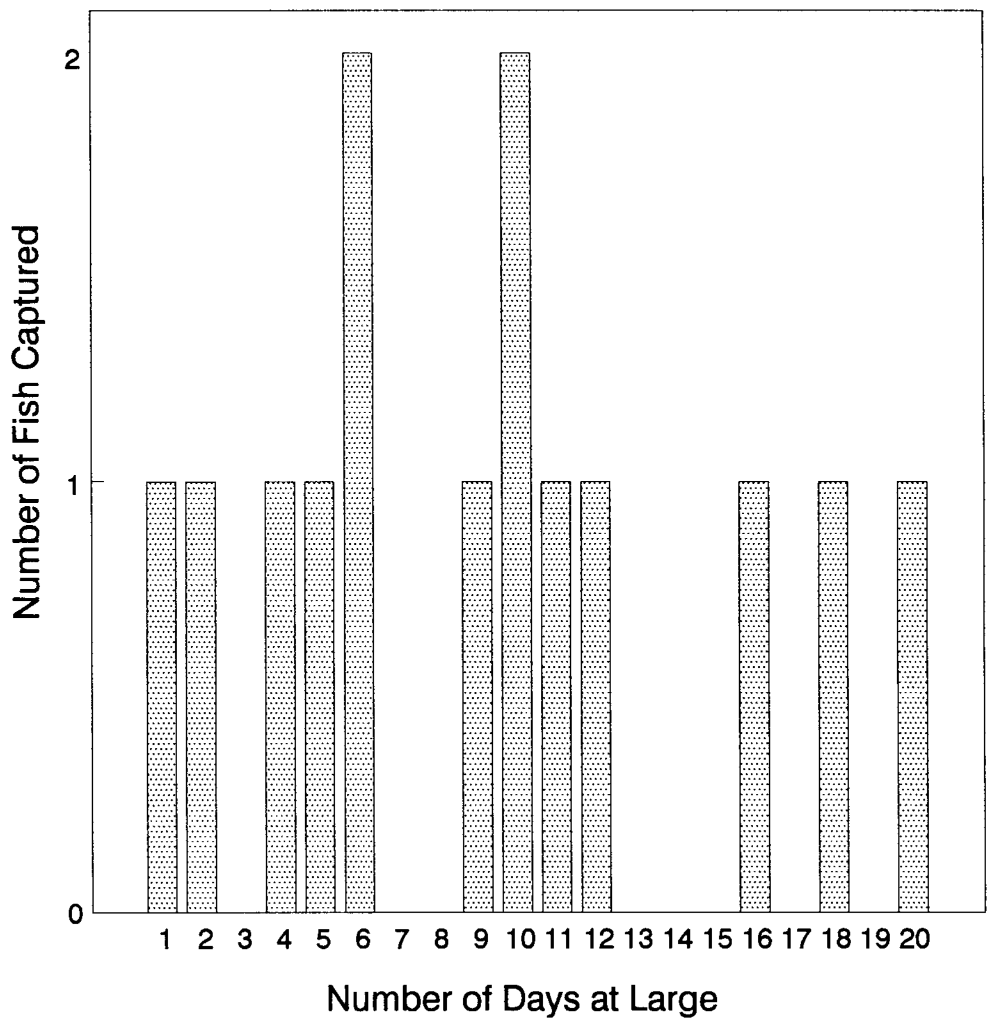
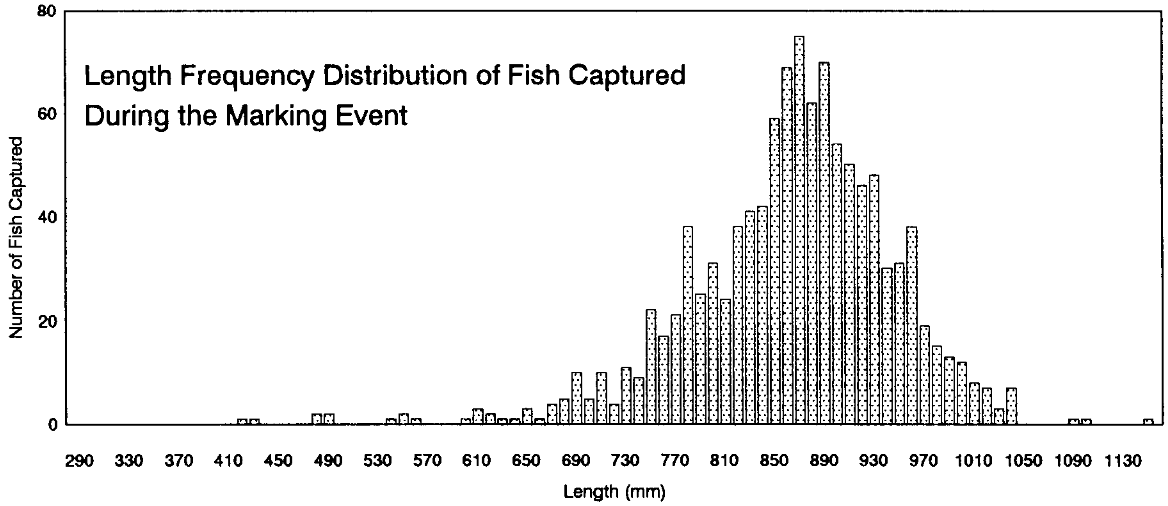
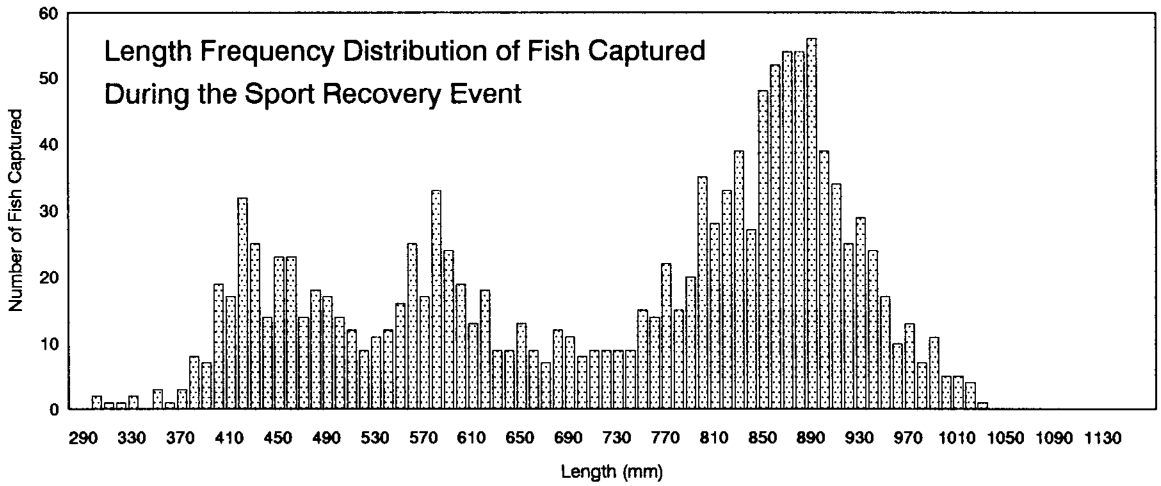


Figure 2. The frequency distribution of chinook salmon mark recaptures in the sport recovery event by "days at large".





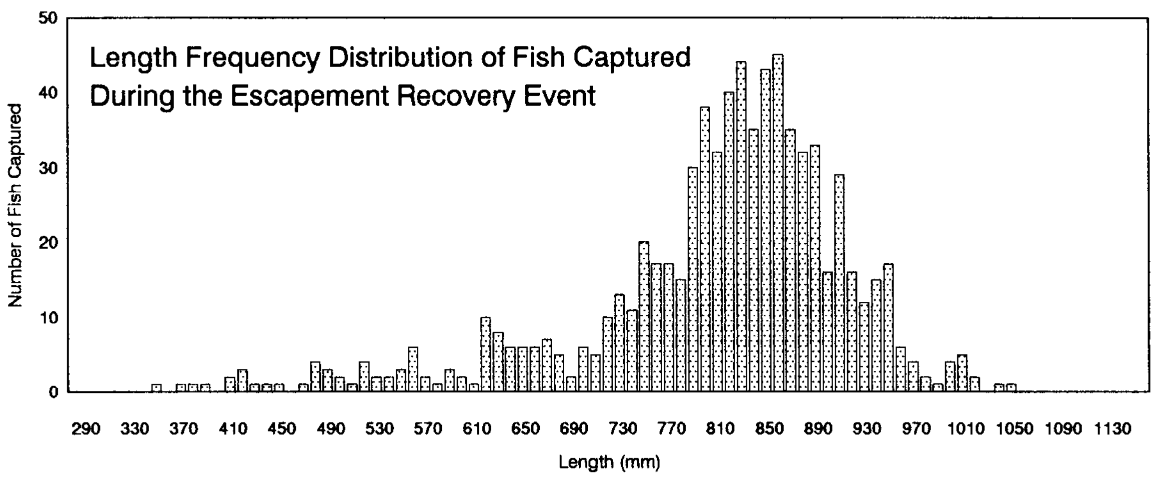


Figure 3. The length frequency distributions of chinook salmon captured in the marking, sport recovery, and escapement recovery events.

Table 1. Tests to detect size selectivity between the marking event and the sport recovery event in the Naknek River, 1992.

$H1_o$: The length compositions among fish marked during the first event (marking) and fish recaptured during the second event (sport recovery) are not significantly different.

Kolmogorov-Smirnov Test Applied to Samples A and B.

Sample A: The lengths of all fish ≥ 725 mm marked from 5 June until 21 July in the first event. N=798

Sample B: The lengths of all fish ≥ 725 mm recaptured during the second event. N=12

D = 0.1504
D+ = 0.1241
D- = 0.1504
Z = 0.5170

Probability of a greater D with a one-sided alternative hypothesis = 0.4570
Probability of a greater D with a two-sided alternative hypothesis = 0.9141

Conclusion: Fail to Reject $H1_o$.

$H2_o$: The length compositions among fish captured during the first event (marking) and fish captured during the second event (sport recovery) are not significantly different.

Kolmogorov-Smirnov Test Applied to Samples A and B.

Sample A: The lengths of all fish ≥ 725 mm captured from 5 June until 21 July in the first event. N=821

Sample B: The lengths of all fish ≥ 725 mm captured during the second event. N=755

D = 0.0410
D+ = 0.0260
D- = 0.0410
Z = 0.8132

Probability of a greater D with a one-sided alternative hypothesis = 0.2476
Probability of a greater D with a two-sided alternative hypothesis = 0.4952

Conclusion: Fail to reject $H2_o$

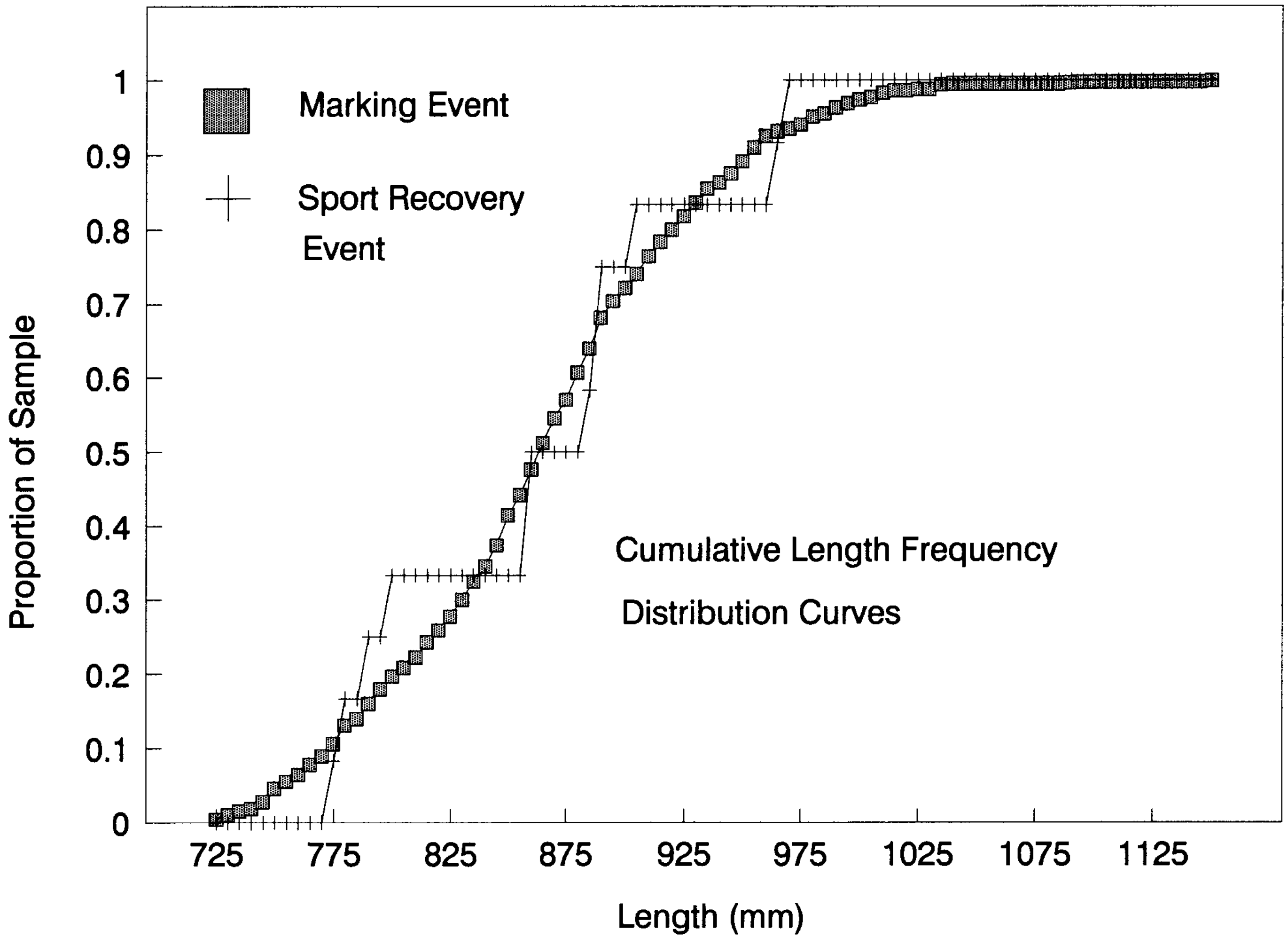


Figure 4. The cumulative length frequency distribution curves of chinook salmon marked in the marking event and recaptured in the sport recovery event.

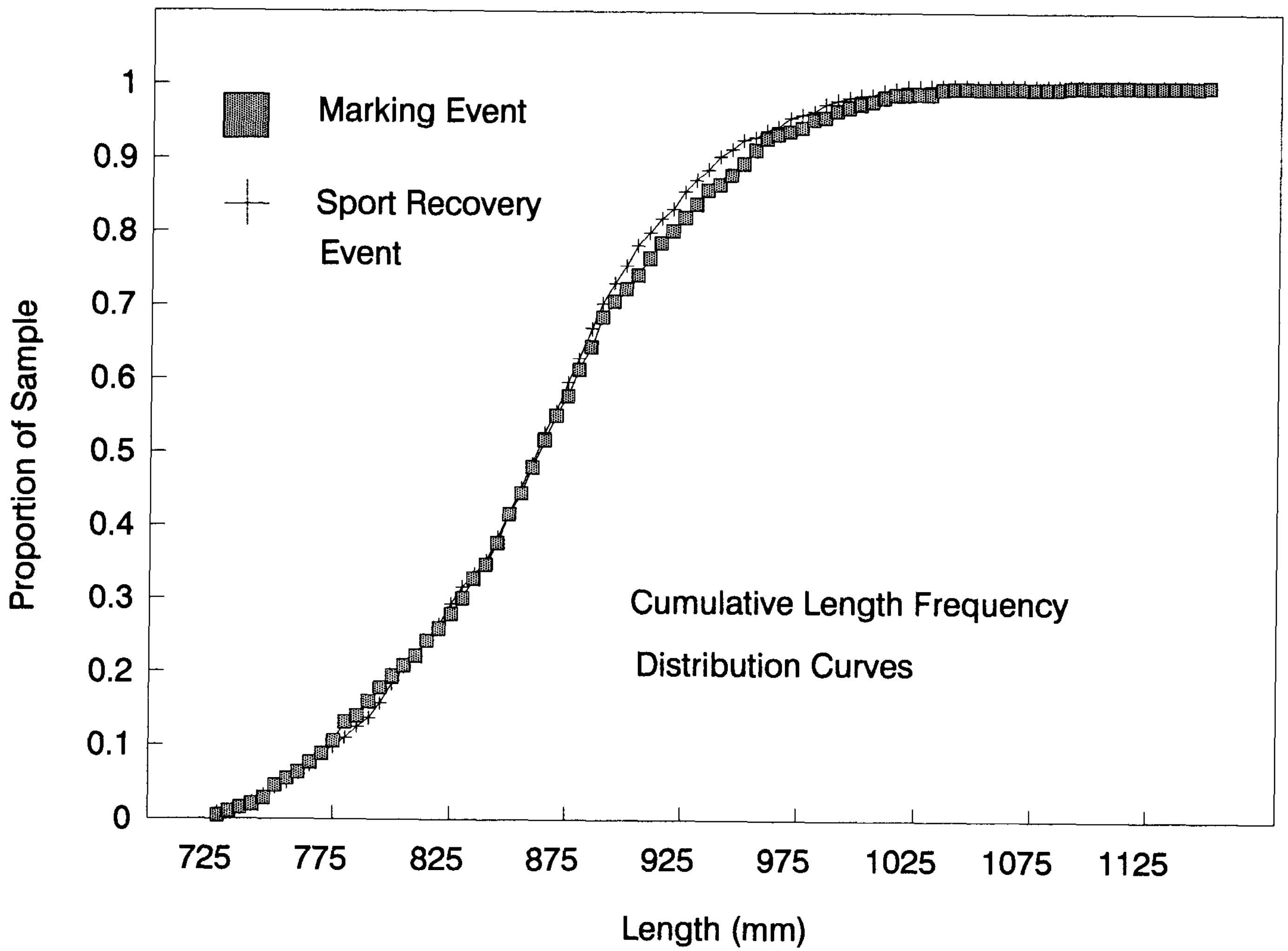


Figure 5. The cumulative length frequency distribution curves of chinook salmon captured in the marking event and captured in the sport recovery event.

Table 2. Estimation of abundance based on the sport recovery event of chinook salmon 725 mm and greater in length entering the Naknek River from 5 June until 21 July 1992.

Given:

$n_1 = 798$
$n_2 = 755$
$m_2 = 12$

Estimated Abundance:

Estimate of N from Chapman-modified Petersen estimator = 46,464
Estimate of N from mean of bootstrapped estimates = 49,565

Estimated Bias:

Estimate of bias of N from Chapman-modified Petersen estimator obtained from bootstrap resampling = 3,101

Standard Error:

Estimate from standard estimator for Chapman-modified Petersen estimate SE(N) = 12,210

Estimate from bootstrap resampling = 13,906

Percentile 90% bootstrap confidence interval of the estimated abundance:

Lower limit = 31,998   Upper limit = 75,014

Escapement Sampling as the Recovery Event

Since the estimate of inriver abundance based on the sport recovery event was constrained in time, an estimate based on the escapement recovery event was investigated. For the purposes of estimating abundance based on the escapement sampling event, the marking data set was not truncated after 21 July as all fish should have had adequate time to reach the spawning grounds before the escapement sampling event.

Given differences in length frequency distributions of fish captured in the marking and escapement recovery events (Figure 3), and that the smallest fish recaptured in escapement sampling event was 638 mm in length, the marking and escapement recovery data sets were truncated to include only fish 635 mm in length or greater. As such, the number of chinook salmon 635 mm and greater in length entering the Naknek River from 5 June until 14 August was estimated.

To determine whether the escapement recovery data (truncated to include only fish 635 mm or greater in length) from King Salmon Creek, Big Creek, and the mainstem Naknek River could be pooled, the marked to unmarked ratios among escapement areas were compared using a contingency table to evaluate the following hypothesis:

> H_o: The marked to unmarked ratios among escapement recovery event areas were not significantly different.

The contingency table indicated that H_o should not be rejected ($\chi^2 = 2.47$, df = 2, P = 0.29) inferring that the marked to unmarked ratios among the King Salmon Creek (0.0423), Big Creek (0.0131), and mainstem Naknek River (0.0217) escapement areas were not significantly different and that escapement recovery data from each area could be pooled.

The results of the K.S. test on the truncated escapement recovery data set indicated that the recovery event was not size selective, whereas the marking event was size selective (Table 3). Visual inspection of the cumulative length distribution curves of fish marked in the first event and fish recaptured in the second event (Figure 6), and fish captured in the first event and fish captured in the second event (Figure 7) confirmed the results of the K.S. tests. Additionally, there is a separation of the cumulative length frequency distributions of fish marked in the first event and fish captured in the escapement recovery event (Figure 7). Cumulative length frequency distributions of fish marked in the first event versus fish captured in the sport recovery event (Figure 5) have the same location. Furthermore, there is a slight shift to the left of the length frequency distribution of fish captured during the escapement recovery event in comparison to fish captured during the marking and sport recovery events (Figure 3). These observations indicate that carcasses sampled on the spawning grounds were generally smaller than live fish sampled in the marking or sport recovery events. One probable explanation of this phenomena is that tail erosion caused the average length of fish to decrease.

As per the procedures outlined in Appendix A, a nonstratified Chapman-modified Petersen estimator was again used to estimate abundance of chinook salmon 635 mm or greater in length entering the Naknek from 5 June until 14 August

Table 3. Tests to detect size selectivity between the marking event and the escapement recovery event in the Naknek River, 1992.

$H1_o$: The length compositions among fish marked during the first event (marking) and fish recaptured during the second event (escapement recovery) are not significantly different.

Kolmogorov-Smirnov Test Applied to Samples A and B.

Sample A: The lengths of all fish ≥ 635 mm marked during the first event.
N=1053

Sample B: The lengths of all fish ≥ 635 mm recaptured during the second event.
N=13

D = 0.2412
D+ = 0.0009
D- = 0.2412
Z = 0.8644

Probability of a greater D with a one-sided alternative hypothesis = 0.2192
Probability of a greater D with a two-sided alternative hypothesis = 0.4384

Conclusion: Fail to Reject $H1_o$.

$H2_o$: The length compositions among fish captured during the first event (marking) and fish captured during the second event (escapement recovery) are not significantly different.

Kolmogorov-Smirnov Test Applied to Samples A and B.

Sample A: The lengths of all fish ≥ 635 mm captured during the first event.
N=1081

Sample B: The lengths of all fish ≥ 635 mm captured during the second event.
N=681

D = 0.2196
D+ = 0.0009
D- = 0.2196
Z = 4.4885

Probability of a greater D with a one-sided alternative hypothesis ≤ 0.00005
Probability of a greater D with a two-sided alternative hypothesis ≤ 0.00005

Conclusion: Reject $H2_o$.

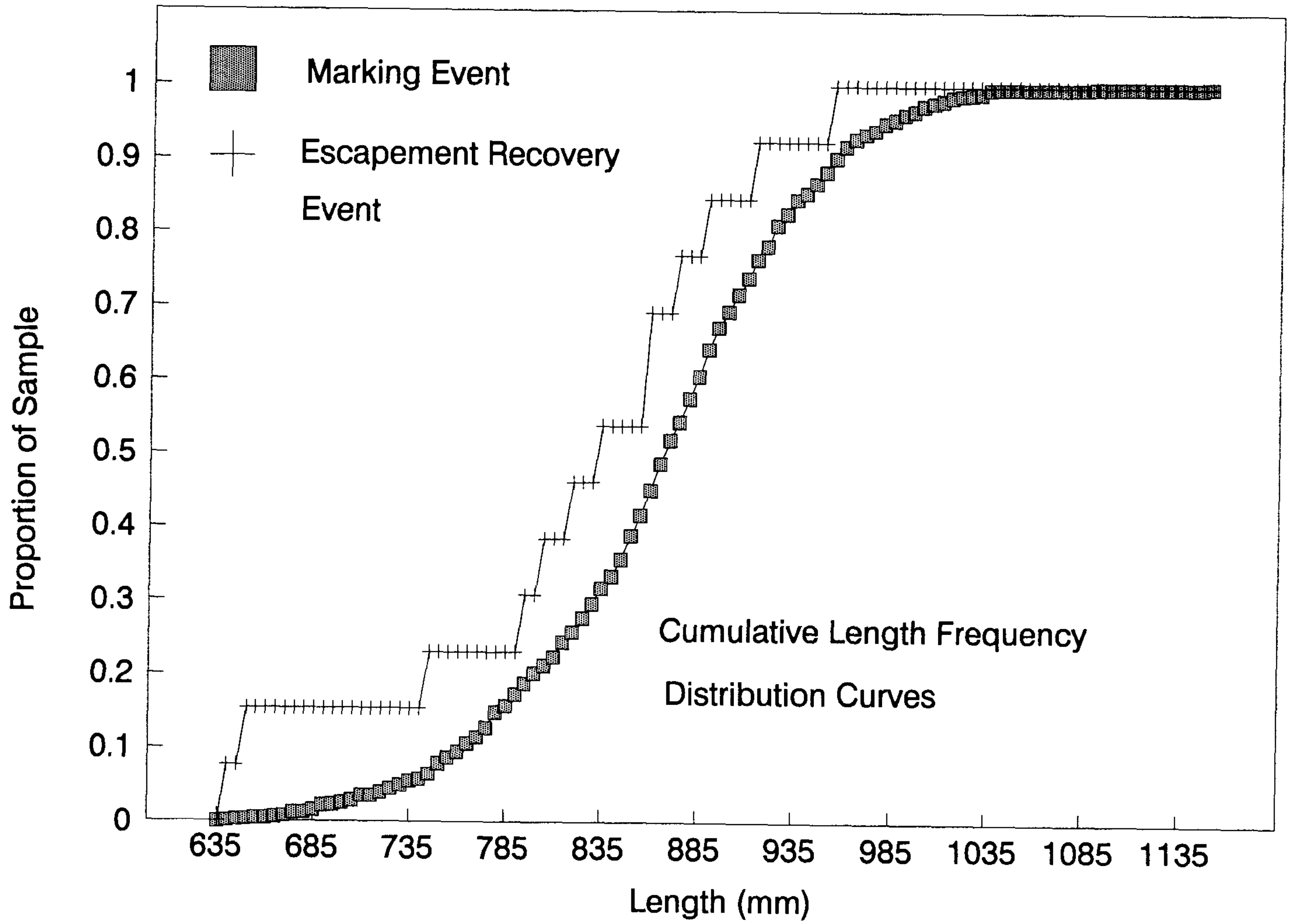


Figure 6. The cumulative length frequency distribution curves of chinook salmon marked in the marking event and recaptured in the escapement recovery event.

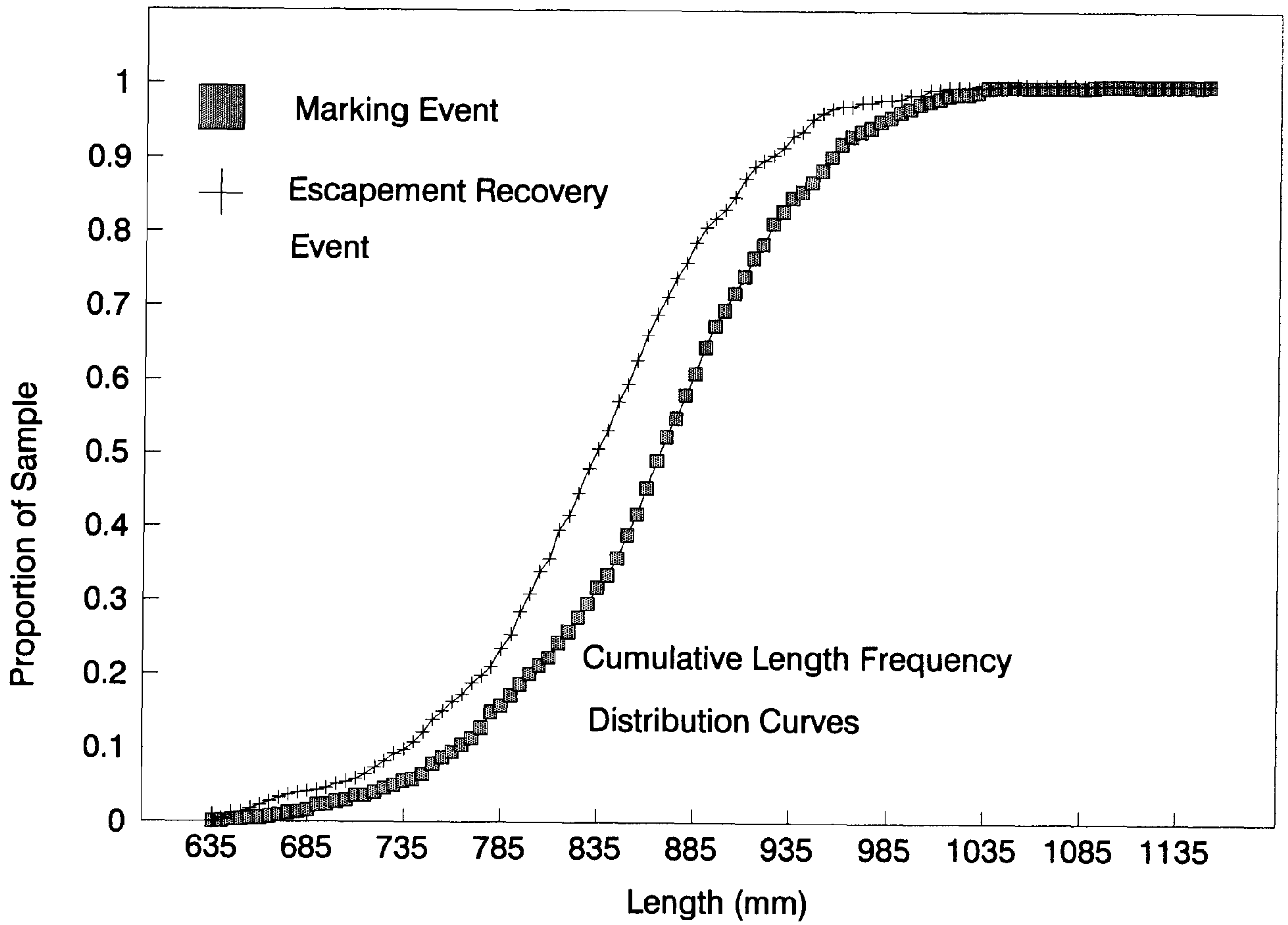


Figure 7. The cumulative length frequency distribution curves of chinook salmon captured in the marking event and captured in the escapement recovery event.

based on the escapement recovery event. An inriver abundance of 51,344 (SE = 13,906) fish 635 mm in length or greater was estimated with a bootstrapped 90% confidence interval of 35,871 to 88,896 (Table 4).

Comparison of the Marked to Unmarked Ratios Between the Sport and Escapement Recovery Events

To determine whether the marked to unmarked ratios were different among the sport recovery event and the pooled escapement recovery event, a contingency table test was used to evaluate the following hypothesis:

> H_o: The marked to unmarked ratios among the sport recovery event and the escapement recovery event were not significantly different.

The test indicated that H_o should not be rejected (χ^2 = 0.21, df = 1, P = 0.72) inferring that the marked to unmarked ratios among the sport recovery event (0.0159) and the escapement recovery event (0.0191) were not significantly different.

CREEL SURVEY METHODS

Study Design

A roving creel survey (Neuhold and Lu 1957) was conducted to count and interview anglers as well as sample the sport harvest in the lower Naknek River from 8 June until 31 July. A stratified three-stage random sampling design formed the basis for estimating effort (in angler-hours) and catch and harvest rates (fish per angler-hour). Angler counts were considered instantaneous counts and represent angler effort for the sample in which the counts were conducted. Angler interviews were used to estimate catch and harvest rates. Sampled days represented the first sampling stage; periods within days represented the second sampling stage; angler counts within periods represented the third sampling stage for the angler effort estimation, and angler interviews represented the third sampling stage for catch and harvest rate estimation.

Preseason, the 54-day creel survey study period was divided into the following six temporal components: component 1 (6/8-6/21), component 2 (6/22-6/30), component 3 (7/1-7/7), component 4 (7/8-7/14), component 5 (7/15-7/21), and component 6 (7/22-7/31). These components were selected to coincide with shifts in angling effort and are similar to those used in previous surveys (Dunaway 1990, Dunaway and Bingham 1991, and Coggins 1992). For the six components of the survey, the angling day was considered to be 16 hours and was divided into four 4-hour sampling periods: A 0630-1029 hours, B 1030-1429 hours, C 1430-1829 hours, and D 1830-2229 hours.

Sampling intensity did not vary by temporal component. Analysis of previous creel survey data indicated that optimal allocation of sampling effort among the temporal components would call for varying amounts of effort (e.g., approximately 31% of the sampling effort should have been devoted to surveying the third temporal component, alone). However, the sampling intensity was not varied as the season progressed so that the fishery would be sampled consistently for estimation of marked to unmarked ratios for the mark-recapture portion of this project.

Table 4. Estimation of abundance based on the escapement recovery event of chinook salmon 635 mm and greater in length entering the Naknek River from 5 June until 14 August 1992.

Given:

n_1 = 1,053
n_2 = 681
m_2 = 13

Estimated Abundance:

Estimate of N from Chapman-modified Petersen estimator = 51,344
Estimate of N from mean of bootstrapped estimates = 55,502

Estimated Bias:

Estimate of bias of N from Chapman-modified Petersen estimator obtained from bootstrap resampling = 4,158

Standard Error:

Estimate from standard estimator for Chapman-modified Petersen estimate SE(N) = 13,033

Estimate from bootstrap resampling = 17,232

Percentile 90% bootstrap confidence interval of the estimated abundance:

Lower limit = 35,871 Upper limit = 88,896

A sampling trip consisted of a 4-hour shift, and a survey technician was responsible for two shifts per sampling day, which were selected at random from the four periods available. During three of the days sampled within each temporal component, four (of the possible four) angler counts were conducted within each sampled period. Angler interviews were conducted concurrently by the technician not conducting the angler counts. Accordingly, during these sampled days, two technicians were deployed on the river at the same time. Some additional days were sampled at random within each temporal component in which only one angler count (out of the four possible) was conducted within each sampled period. During the time not spent counting anglers, anglers were interviewed. During these additional days, only one technician was deployed on the river at a time. This sample design allowed estimation of all sampling stage components of variance.

Days for conducting the combined four-count and angler interview sample sessions were independently selected at random without replacement (WOR) during all temporal components. Days for conducting the remaining single count and angler interview sample sessions were selected at random WOR from the days not selected for the combined four-count samples. As noted above, within each sampled day, two sample periods were selected at random WOR from the available periods within each day. As before, a single count time was selected at random from one of the four possible 60 minute count times within each period for the samples with only one count.

Additionally, a third technician was deployed nonrandomly to sample the sport harvest. This technician's primary function was to examine as many sport harvested fish as possible for marks received during the mark-recapture portion of the project. This sampling occurred during periods B and C (described above) since these periods represent the hours of the day in which the majority of anglers exit the fishery (Minard and Brookover 1988, Minard 1989, Dunaway 1990, Dunaway and Bingham 1991, Coggins 1992).

Data Collection

Angler Effort, Catch, and Harvest:

Sampling consisted of angler counts, obtaining catch, harvest, and effort information from anglers who have completed fishing (completed-trip interviews), and collecting age, sex and length information from harvested fishes. During sample sessions with only one technician, a single count was conducted and anglers were interviewed during the remaining time in each period. Since all anglers were not necessarily interviewed with equal probability during the entire 4-hour period, the estimates were likely biased by an unknown amount. This bias was expected to be rather minor as catch and harvest rates presumably did not vary significantly within a 4-hour period. During combined angler count-interview sample sessions conducted by two technicians, nearly all completed-trip anglers were interviewed as they exited surveyed access locations in the fishery during each sampled 4-hour period. Completed trip anglers who exited the fishery more than once during the day were asked to report their entire day's effort, catch, and harvest.

Biological Composition:

Sport harvested chinook salmon encountered during the angler interview portion of the creel survey were sampled as described above in Inriver Abundance Estimation Methods.

Data Analysis

Angler Effort, Catch, and Harvest:

Angler effort, catch, and harvest, their associated variances, and standard errors were estimated for the creel survey using the following procedures. A 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 appropriate since most other estimators were known to be biased for use as ratio estimators (i.e., for expansion). Also, the jackknife estimate has been shown to be less biased and procedures existed for correcting some of this bias (see Cochran 1977, section 6.15, pages 174-177; and Smith 1980).

The individual sample estimates of effort, catch, and harvest were then used in a stratified three-stage estimation approach (Cochran 1977) to obtain total estimates, both within temporal components and across temporal components, as described in Coggins (1992, in Appendix A1 of that report).

The assumptions necessary for unbiased point and variance estimates of angler effort, catch, and harvest obtained by the study design outlined above included the following:

1. interviewed anglers accurately reported their hours of fishing effort (for unbiased catch and harvest estimates) and the number of fish by species released (for unbiased catch estimates);

2. interviewed anglers were representative of the total angler population;

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

4. no significant fishing effort occurred in the areas not covered by the survey.

The assumption that interviewed anglers reported their catch and effort accurately as noted has been supported by verification work done in previous years' surveys on the Naknek River. Results have indicated that most anglers, to the best of their ability, report accurate effort and catch information as long as the time between completion of the day's fishing and the interview is not too long. For this study, interviews were conducted immediately following the day's fishing when anglers were most likely to remember when they started fishing (so total fishing time could be calculated by the creel clerk), and how many fish they caught. The harvest of chinook salmon is not an estimate on the part of the angler, but since it is the observed number of fish in the angler's possession, it is considered to have no error associated with its reporting.

Interviews occurred at approximately five locations on the lower Naknek River, all of which were in sight of each other. It was incumbent upon the creel clerk to ensure an even distribution of interview effort between these locations so that assumption two would not be violated. That interviewed anglers were representative of the total angler population was likely true since the interviews were collected proportional to the number of anglers exiting the fishery at the various locations. Department creel clerks ensured that interviews were distributed such that a representative selection of anglers across all exit sites was made.

Past surveys, conducted by ADF&G, have shown that there is no significant sport fishing effort occurring in hours and locations not covered by this season's survey in the lower portion of the Naknek River. Assumptions three and four are considered validated based on previous work.

Biological Composition:

Estimates of mean length (and associated standard error) by age group of chinook salmon sampled from the sport harvest were calculated using the procedures outlined by Sokal and Rohlf (1981, Boxes 4.2 and 7.1, pages 56 and 139).

Estimates of age composition (percent) for the subsampled chinook were calculated for each temporal component. Estimates of proportion of fish harvested by age class across all temporal components were obtained by a weighted mean procedure. Complete details of the estimation procedures are presented in Appendix C.

CREEL SURVEY RESULTS

Angler Effort, Catch, and Harvest Estimates

The creel survey on the lower Naknek River was conducted from 8 June to 31 July. Total angler effort in the lower Naknek River was estimated to be 28,428 angler-hours (SE = 1,457), with peak effort estimates during the chinook salmon fishery occurring in late June and early July (Table 5 and Appendix D1). An estimated 3,362 chinook salmon (SE = 268) were caught (landed) in the study area, of which 2,949 (SE = 233) (88%) were harvested (Table 6 and Appendix D2). An estimated 156 coho salmon (SE = 46) were caught and harvested (Table 7 and Appendix D3). Anglers are estimated to have also caught 456 and kept 413 chum salmon (Table 8 and Appendix D4). Additionally, a catch of 1,760 rainbow trout, and harvest of 25, were estimated for the lower Naknek River (Table 9 and Appendix D5).

Biological Composition Estimates

Approximately 64% (SE = 1%) of the 1,297 chinook salmon sampled from the sport harvest were males (Table 10). The majority of the harvest was age 1.4 (46%, SE = 1%). Age 1.3 comprised 24% (SE = 1%) of the harvest. Data collected

Table 5. Estimated angler effort by temporal component for the sport fishery in the lower Naknek River, 8 June to 31 July 1992.

Temporal Component	Days Sampled	Effort (angler-hours)	SE	90% Confidence Interval Lower		Upper	RP[a]
1 (6/08-6/21)	13	3,379	438	2,658	--	4,100	21.3%
2 (6/22-6/30)	7	6,678	726	5,484	--	7,872	17.9%
3 (7/01-7/07)	5	6,233	742	5,012	--	7,454	19.6%
4 (7/08-7/14)	5	5,284	721	4,098	--	6,470	22.4%
5 (7/15-7/21)	5	3,298	436	2,581	--	4,015	21.7%
6 (7/22-7/31)	9	3,556	378	2,935	--	4,177	17.5%
Season Total	44	28,428	1,457	26,032	--	30,824	8.4%

[a] Relative precision of 90% confidence interval.

Table 6. Estimated catch and harvest of chinook salmon by the sport fishery in the lower Naknek River, 8 June to 31 July 1992.

	Catch[a]					Harvest					
Temporal Component and Date	Estimate	SE	90% Confidence Interval Lower	Upper	RP[b]	Estimate	SE	90% Confidence Interval Lower	Upper	RP[b]	Percent of Catch Harvested
1 (6/08-6/21)	312	52	227 -	397	27.2%	294	47	216 -	372	26.5%	94%
2 (6/22-6/30)	781	135	559 -	1,003	28.4%	751	128	540 -	962	28.1%	96%
3 (7/01-7/07)	549	122	349 -	749	36.5%	501	122	300 -	702	40.1%	91%
4 (7/08-7/14)	685	152	435 -	935	36.5%	562	115	373 -	751	33.6%	82%
5 (7/15-7/21)	520	87	377 -	663	27.5%	416	62	314 -	518	24.5%	80%
6 (7/22-7/31)	515	75	391 -	639	24.1%	425	60	326 -	524	23.4%	83%
Season Total	3,362	268	2,920 -	3,804	13.1%	2,949	233	2,566 -	3,332	13.0%	88%

[a] Catch = total fish kept + total fish released.

[b] Relative precision of 90% confidence interval.

Table 7. Estimated catch and harvest of coho salmon by the sport fishery in the lower Naknek River, 8 June to 31 July 1992.

Temporal Component and Date	Catch[a] Estimate	SE	90% Confidence Interval Lower	Upper	RP[b]	Harvest Estimate	SE	90% Confidence Interval Lower	Upper	RP[b]	Percent of Catch Harvested
1 (6/08-6/21)	0	0	0 -	0	---	0	0	0 -	0	---	---
2 (6/22-6/30)	0	0	0 -	0	---	0	0	0 -	0	---	---
3 (7/01-7/07)	0	0	0 -	0	---	0	0	0 -	0	---	---
4 (7/08-7/14)	0	0	0 -	0	---	0	0	0 -	0	---	---
5 (7/15-7/21)	0	0	0 -	0	---	0	0	0 -	0	---	---
6 (7/22-7/31)	156	46	80 -	231	48.4%	156	46	80 -	231	48.4%	100%
Season Total	156	46	80 -	231	48.4%	156	46	80 -	231	48.4%	100%

[a] Catch = total fish kept + total fish released

[b] Relative precision of 90% confidence interval.

Table 8. Estimated catch and harvest of chum salmon by the sport fishery in the lower Naknek River, 8 June to 31 July 1992.

	Catch[a]					Harvest					
Temporal Component and Date	Estimate	SE	90% Confidence Interval Lower	Upper	RP[b]	Estimate	SE	90% Confidence Interval Lower	Upper	RP[b]	Percent of Catch Harvested
1 (6/08-6/21)	9	6	0 -	19	114.5	9	6	0 -	19	114.5	100%
2 (6/22-6/30)	261	93	109 -	413	58.4%	239	83	102 -	376	57.3%	92%
3 (7/01-7/07)	60	19	28 -	92	52.8%	60	19	28 -	92	52.8%	100%
4 (7/08-7/14)	92	31	40 -	144	56.1%	84	31	33 -	135	60.2%	91%
5 (7/15-7/21)	28	11	10 -	46	63.1%	15	7	3 -	27	77.1%	54%
6 (7/22-7/31)	6	5	0 -	14	125.4%	6	5	0 -	14	125.4%	100%
Season Total	456	101	291 -	621	36.3%	413	92	263 -	563	36.4%	91%

[a] Catch = total fish kept + total fish released

[b] Relative precision of 90% confidence interval.

Table 9. Estimated catch and harvest of rainbow trout by the sport fishery in the lower Naknek River, 8 June to 31 July 1992.

	Catch[a]					Harvest					
Temporal Component and Date	Estimate	SE	90% Confidence Interval Lower	Upper	RP[b]	Estimate	SE	90% Confidence Interval Lower	Upper	RP[b]	Percent of Catch Harvested
1 (6/08-6/21)	465	167	190	- 740	59.2%	0	0	0	- 0	--	0%
2 (6/22-6/30)	532	343	0	- 1,097	106.2%	0	0	0	- 0	--	0%
3 (7/01-7/07)	274	154	21	- 527	92.4%	0	0	0	- 0	--	0%
4 (7/08-7/14)	387	211	41	- 733	89.5%	23	18	0	- 53	130.1%	6%
5 (7/15-7/21)	89	69	0	- 202	127.3%	0	0	0	- 0	--	0%
6 (7/22-7/31)	13	7	1	- 25	91.7%	2	2	0	- 6	192.5%	15%
Season Total	1,760	468	991	- 2,529	43.7%	25	18	0	- 55	120.7%	1%

[a] Catch = total fish kept + total fish released.

[b] Relative precision of 90% confidence interval.

Table 10. Estimated harvest by age and sex class, age composition (percent), and mean lengths (millimeters) of chinook salmon sampled from the Naknek River sport harvest, 1992.

	Age Group						
	UNKNOWN	1.1	1.2	1.3	1.4	1.5	TOTAL[a]
FEMALES							
Estimated Harvest		3	3	205	832	22	1,065
SE[b]		2	3	26	70	6	75
Percent		<0.5	<0.5	7	28	1	36
SE[c]		<0.5	<0.5	1	1	<0.5	1
Sample Size		1	1	74	316	9	401
Mean Length	848	345	599	784	865	901	849
SE[d]	11			7	3	23	3
Sample Size	55	1	1	74	316	9	456
MALES							
Estimated Harvest		256	563	501	543	21	1,884
SE[b]		28	56	52	49	6	95
Percent		9	19	17	18	1	64
SE[c]		1	1	1	1	<0.5	1
Sample Size		98	211	191	209	8	717
Mean Length	630	411	511	688	867	977	650
SE[d]	17	4	4	8	6	24	6
Sample Size	124	98	211	191	209	8	841
ALL SAMPLES							
Estimated Harvest		259	566	706	1,375	43	2,949
SE[b]		28	56	68	109	9	233
Percent		9	19	24	46	2	100
SE[c]		1	1	1	1	<0.5	
Sample Size		99	212	265	525	17	1,118
Mean Length	697	410	511	714	866	937	720
SE[d]	14	3	4	6	3	19	5
Sample Size	179	99	212	265	525	17	1,297

[a] Includes both aged and unaged fish.
[b] Standard error of harvest estimates.
[c] Standard error of age composition estimates.
[d] Standard error of length estimates.

from the sport harvest of chinook salmon yielded a mean length of 720 mm (SE = 5 mm, n = 1,297). The largest chinook salmon sampled measured 1,027 mm (42 in) in length.

SPAWNING ESCAPEMENT METHODS

Study Design and Data Analysis

One of the original objectives was to estimate the total spawning escapement of the Naknek River chinook salmon stock (objective 6). The estimate of spawning escapement was to be obtained by subtraction of the estimated sport harvest from the estimated inriver return. However, since the estimate of inriver abundance included only chinook salmon ≥ 635 mm in length, it was necessary to alter objective 6 such that the estimate of spawning escapement included only fish ≥ 635 mm in length. Accordingly, the estimate of sport harvest was stratified to include only fish ≥ 635 mm in length.

Since all fishing mortality other than sport harvest occurred prior to the chinook salmon immigrating to the area associated with the inriver abundance, the result of this subtraction should closely approximate the spawning escapement. Any natural mortality that occurred after the population passed the sport fishery was not accounted for and resulted in an unknown positive bias to our estimate of escapement. Mortality from hook and release effects is believed to be minimal due to the prohibition of bait in the sport fishery and the observed consumptive nature of this fishery (Coggins 1992).

The estimated spawning escapement was obtained by subtracting the harvest of chinook salmon that were ≥ 635 mm from the inriver population estimate obtained from the escapement recovery data set (also germane to fish ≥ 635 mm). As such the resultant spawning escapement estimate was only for chinook salmon that were ≥ 635 mm. The estimated harvest for fish ≥ 635 mm was calculated according to the procedures outlined in Appendix C, with one category defined as fish ≥ 635 mm. The variance of the estimated spawning escapement was simply the sum of the variance of the estimated harvest and the variance of the estimated inriver abundance (all for fish ≥ 635 mm). The standard error was calculated as the square root of the variance.

SPAWNING ESCAPEMENT RESULTS

The inriver estimate of chinook salmon ≥ 635 mm in length was 51,344. The sport fish harvest of chinook salmon ≥ 635 mm in length was estimated to be 1,891 (SE = 148). Subtraction of the sport fish harvest from the inriver estimate yields a total spawning escapement estimate of 49,453 (SE = 13,034).

ESCAPEMENT SURVEY METHODS

Study Design

Since 1967, the Alaska Department of Fish and Game has conducted aerial surveys to index the escapement of chinook salmon into selected spawning areas of the Naknek River drainage. Counts of live and dead chinook salmon were made from fixed wing aircraft by an observer wearing Polaroid sunglasses. Surveys were confined to the Paul's, King Salmon, and Big Creek drainages as well as the mainstem of the Naknek River. The planned escapement survey dates for each area were as follows:

King Salmon Creek	25 July-2 August
Paul's Creek	28 July- 4 August
Big Creek	8-18 August
Mainstem Naknek River	15-22 August

Age and size composition of the chinook salmon escapement into Paul's, King Salmon, and Big creeks and the mainstem of the Naknek River was estimated from samples collected from carcasses on the spawning grounds. Sampling took place during the second and third weeks of August and the first week in September. The spawning areas were accessed by jet-powered riverboat.

Data Collection and Reduction

For each flight the date, weather conditions, and type of aircraft was recorded and a subjective assessment of survey visibility conditions (Excellent, Good, Fair, or Poor) was made and recorded. At the end of each flight, the number of chinook salmon observed was tallied by stream. The peak survey count over a series of flights was considered the peak index for that system.

Biological data collected from carcasses on the spawning grounds included length, sex, and age information. Sex was determined visually from external characteristics, including the presence or absence of a kype, distention of the abdomen, the presence or absence of an ovipositer, and if necessary internal inspection for retained eggs or milt sacs. Length was measured from the eye orbit to fork-of-tail to the nearest millimeter. Three scales were collected from each carcass for age analysis. The presence of tags (and tag number), secondary marks, or tag scars was noted.

Data Analysis

Biological data collected during the escapement survey were processed similar to the samples taken from the harvest, except data were not stratified nor was the finite population correction factor (FPC) applied. The variances were estimated directly from the sample data (i.e., using equations C.1 and C.9, Appendix C, without the FPC).

Computerized data files used to generate these analyses are listed in Appendix E.

ESCAPEMENT SURVEY RESULTS

Aerial surveys of the Naknek River drainage chinook salmon spawning areas were conducted on 1 August (Paul's Creek), 9 August (King Salmon Creek), 18 August (Big Creek), and 27 August (mainstem Naknek River). These surveys counted a total escapement of 2,621 fish (Table 11). Approximately 825 fish (37%) were observed spawning in Big Creek. Another 1,550 fish or nearly 52% of the total escapement were counted in the mainstem Naknek River.

Table 11. Unexpanded aerial escapement counts of chinook salmon in the Naknek River drainage, 1970-1992.[a]

Year	Mainstem Naknek	Paul's Creek	King Salmon Creek	Big Creek	Total
1970	3,060	NC[b]	260	825	4,145
1971	1,639	52	704	490	2,885
1972	351	156	1,224	1,060	2,791
1973	1,315	NC[b]	115	1,106	2,536
1974	NC[b]	91	495	860	NC[b]
1975	2,250	144	279	779	3,452
1976	5,950	31	180	970	7,131
1977	4,830	NC[b]	1,860	NC[b]	NC[b]
1978	NC[b]	NC[b]	NC[b]	NC[b]	NC[b]
1979	NC[b]	NC[b]	NC[b]	NC[b]	NC[b]
1980	300	17	NC[b]	30	NC[b]
1981	2,890	NC[b]	591	790	4,271
1982	5,360	340	980	1,930	8,610
1983	2,860	290	460	4,220	7,830
1984	790	400	385	3,420	4,995
1985	590	NC[b]	NC[b]	NC[b]	NC[b]
1986	2,200	73	102	1,542	3,917
1987	2,800	7	290	1,353	4,450
1988	7,380	150	600	3,600	11,730
1989	1,700	50	100	860	2,710
1990	4,500	150	350	2,000	7,000
1991	1,655	121	275	2,340	4,391
All Years					
Average	2,759	138	514	1,565	4,976[c]
Percent[d]	55%	3%	10%	31%	
1992	1,550	88	158	825	2,621
Percent	59%	3%	6%	31%	

[a] Unpublished data, ADF&G Sport Fish and Commercial Fisheries Divisions aerial survey files, King Salmon and Dillingham, Alaska.

[b] No counts made.

[c] Calculated as the sum of the averages of the individual spawning areas.

[d] Percent of the sum of averages (4,976 in this case).

Over 73% of the 43 chinook salmon sampled from the Paul's Creek escapement were males (Table 12). The predominant age class was age 1.4 (44.7%) with age 1.2 and 1.3 each contributing 23.7%. The 83 chinook salmon sampled from the King Salmon creek escapement contained 65.8% males and 34.2% females (Table 13). The predominant age classes, 1.4 and 1.3, accounted for 65.8% and 20.5% respectively. Over 60% of the 338 chinook salmon sampled from the Big Creek escapement were males (Table 14). Age-1.4 fish contributed 73.8% of the escapement and age-1.3 fish contributed 17.3%. The 286 chinook salmon sampled from the mainstem of the Naknek River contained 52.6% males and 47.4% females (Table 15). The predominant age class was 1.4 (83.3%) with age 1.3 contributing 11.4%.

DISCUSSION

Inriver Abundance

In 1992, a total of 51,344 chinook salmon 635 mm in length or greater were estimated to have entered the Naknek River from 5 June until 14 August, based on mark recoveries from the escapement recovery event.

The low number of recaptured fish observed in the both the sport harvest recovery and the escapement recovery prevented an in-depth analysis of the assumptions associated with use of the Chapman-modified Petersen estimator. Additionally, the tests used to evaluate assumptions, such as size selectivity, had very little statistical power. Therefore, given the small sample sizes, the probability of making a Type II error[3] was high. Accordingly, it was not too surprising that the tests indicated no need to stratify according to length, and also indicated that marking rates were similar among recovery data sets (e.g., the sport recovery and escapement recovery data sets).

The limitations of the mark and recovery data sets precluded evaluating the assumption of a closed population in terms of losses out of the system through emigration from the river. However, a total of nine voluntary tag returns from the Naknek-Kvichak district commercial fisheries and two voluntary tag returns from the Naknek River subsistence fishery (Appendix B2) indicate that substantial numbers of chinook salmon available for marking may have exited the system. Note, however, that disproportionate numbers of marked fish may have left the system due to the effect of handling and marking.

During the sport recovery, tag loss was evaluated to be at an undetectable rate, but again with so few recaptures the probability of observing a tag loss was expected to be minimal. Tag loss could not be similarly evaluated for the escapement recovery events, due to the decomposed condition of chinook salmon carcasses during this event. Additionally, the probability of tag loss during this recovery event would be expected to be greater than for the sport recovery due to tags falling out of rotting carcasses.

The assumption that marking does not affect capture probability could not be directly tested. It had been assumed that since three different capture techniques were used for the first event (gill nets) or second events (hook

[3] A Type II error refers to the probability of failing to reject the null hypothesis given that a stated alternative hypothesis is true.

Table 12. Age composition (percent) and mean lengths (millimeters) of chinook salmon sampled during the Paul's Creek carcass survey, 1992.

	Age Group					
	UNKNOWN	1.1	1.2	1.3	1.4	TOTAL[a]
FEMALES						
Percent				5.3	21.1	26.3
SE[b]				3.67	6.70	7.24
Sample Size				2	8	10
Mean Length	843			706	800	787
SE[c]				7.00	18.16	18.12
Sample Size	1			2	8	11
MALES						
Percent		7.9	23.7	18.4	23.7	73.7
SE[b]		4.43	6.99	6.37	6.99	7.24
Sample Size		3	9	7	9	28
Mean Length	582	362	497	729	878	653
SE[c]	79.20	8.51	19.41	16.31	17.51	33.72
Sample Size	4	3	9	7	9	32
ALL SAMPLES						
Percent		7.9	23.7	23.7	44.7	100.0
SE[b]		4.43	6.99	6.99	8.17	
Sample Size		3	9	9	17	38
Mean Length	634	362	497	724	841	687
SE[c]	80.52	8.51	19.41	12.95	15.65	26.94
Sample Size	5	3	9	9	17	43

[a] Includes both aged and unaged fish.

[b] Standard error of age composition estimates.

[c] Standard error of length estimates.

Table 13. Age composition (percent) and mean lengths (millimeters) of chinook salmon sampled during the King Salmon Creek carcass survey, 1992.

	Age Group					
	UNKNOWN	1.1	1.2	1.3	1.4	TOTAL[a]
FEMALES						
Percent		1.4	1.4	5.5	26.0	34.2
SE[b]		1.37	1.37	2.68	5.17	5.59
Sample Size		1	1	4	19	25
Mean Length	819	411	532	761	818	788
SE[c]	11.37			15.85	14.31	18.83
Sample Size	5	1	1	4	19	30
MALES						
Percent		2.7	8.2	15.1	39.7	65.8
SE[b]		1.92	3.24	4.22	5.77	5.59
Sample Size		2	6	11	29	48
Mean Length	782	402	500	692	880	771
SE[c]	70.05	13.50	38.01	21.11	11.22	22.71
Sample Size	5	2	6	11	29	53
ALL SAMPLES						
Percent		4.1	9.6	20.5	65.8	100.0
SE[b]		2.34	3.47	4.76	5.59	
Sample Size		3	7	15	48	73
Mean Length	800	405	505	710	856	777
SE[c]	34.04	8.29	32.44	17.73	9.80	15.96
Sample Size	10	3	7	15	48	83

[a] Includes both aged and unaged fish.

[b] Standard error of age composition estimates.

[c] Standard error of length estimates.

Table 14. Age composition (percent) and mean lengths (millimeters) of chinook salmon sampled during the Big Creek carcass survey, 1992.

	Age Group						
	UNKNOWN	1.1	1.2	1.3	1.4	1.5	TOTAL[a]
FEMALES							
Percent			0.8	3.6	34.3	1.2	39.9
SE[b]			0.57	1.19	3.02	0.70	3.12
Sample Size			2	9	85	3	99
Mean Length	823		620	744	834	860	823
SE[c]	8.21		6.00	14.34	6.51	19.60	5.53
Sample Size	38		2	9	85	3	137
MALES							
Percent		0.4	4.8	13.7	39.5	1.6	60.1
SE[b]		0.40	1.37	2.19	3.11	0.80	3.12
Sample Size		1	12	34	98	4	149
Mean Length	803	496	583	710	855	969	801
SE[c]	20.79		14.26	13.31	7.20	22.98	8.95
Sample Size	52	1	12	34	98	4	201
ALL SAMPLES							
Percent		0.4	5.6	17.3	73.8	2.8	100.0
SE[b]		0.40	1.47	2.41	2.80	1.05	
Sample Size		1	14	43	183	7	248
Mean Length	811	496	589	717	846	922	810
SE[c]	12.49		12.67	11.09	4.95	26.18	5.80
Sample Size	90	1	14	43	183	7	338

[a] Includes both aged and unaged fish.

[b] Standard error of age composition estimates.

[c] Standard error of length estimates.

Table 15. Age composition (percent) and mean lengths (millimeters) of chinook salmon sampled during the mainstem Naknek River carcass survey, 1992.

	Age Group						
	UNKNOWN	1.1	1.2	1.3	1.4	1.5	TOTAL[a]
FEMALES							
Percent				3.9	42.1	1.3	47.4
SE[b]				1.29	3.28	0.76	3.31
Sample Size				9	96	3	108
Mean Length	805			750	821	851	813
SE[c]	11.12			16.48	4.49	9.02	4.33
Sample Size	28			9	96	3	136
MALES							
Percent		0.4	1.8	7.5	41.2	1.8	52.6
SE[b]		0.44	0.87	1.74	3.27	0.87	3.31
Sample Size		1	4	17	94	4	120
Mean Length	843	473	590	693	858	937	829
SE[c]	18.19		46.71	17.20	6.27	30.49	8.32
Sample Size	30	1	4	17	94	4	150
ALL SAMPLES							
Percent		0.4	1.8	11.4	83.3	3.1	100.0
SE[b]		0.44	0.87	2.11	2.47	1.14	
Sample Size		1	4	26	190	7	228
Mean Length	825	473	590	713	839	900	821
SE[c]	11.03		46.71	13.55	4.06	24.03	4.84
Sample Size	58	1	4	26	190	7	286

[a] Includes both aged and unaged fish.

[b] Standard error of age composition estimates.

[c] Standard error of length estimates.

and line by fishery or visual observation during escapement surveys), then it seemed reasonable that marked fish were equally likely to be captured during the two recovery events. However, if chinook salmon captured in the first event were more likely to back out of the system or die prior to the recovery events, then the assumption that marking does not affect capture probability was invalid. Again, little or no data were available to directly assess this assumption.

The inability to evaluate the assumptions necessary for unbiased abundance estimates, combined with the likely types of deviations from the assumptions (i.e., tag loss, smaller probability of marked fish being caught/observed in the recovery event either from stress-related behavior or mortality) results in the conclusion that the estimate of abundance was biased high (i.e., the inriver population was less than the estimate).

Creel Survey

The creel survey data from the 1986-1989 creel surveys (Minard 1987, Minard and Brookover 1988, Minard 1989, Dunaway 1990) were reanalyzed using temporal components comparable[4] to those used in the 1990 and 1991 creel surveys (Dunaway and Bingham 1991, Coggins 1992) (Table 16). The 1992 lower Naknek River creel survey documented an angler effort level during the chinook salmon fishery which is the lowest observed in the last 7 years and represents a reduction, from the 1986-1991 average estimate, of 38%. However, the 1992 effort estimate is comparable to the 1991 effort estimate of 28,814. The chinook salmon catch and harvest estimates for 1992 lagged well behind the 1986 to 1991 average estimate in each temporal component of the survey. However, once again, the 1992 estimates of total catch and total harvest were not significantly or appreciably different from those documented in 1991. Finally, the 1992 sport harvest estimate represents the lowest harvest since 1981 (Table 17 and Figure 8) Paddock (1968-1970), Siedelman (1971-1974), Gwartney (1975, 1976, 1979, 1980), Gwartney and Russell (1977), Minard (1987 and 1989), Minard and Brookover (1988), Dunaway (1990), Dunaway and Bingham (1991), Coggins (1992), and Mills (1977-1991). Comparisons between onsite surveys and statewide mail surveys have a high degree of correlation (Figure 8).

Spawning Escapement

The spawning escapement estimate is believed to be biased high and have a high degree of imprecision for the same reasons the inriver abundance estimate is biased high and has a high degree of imprecision. Additionally, the spawning escapement estimate of 49,453 is nearly nine times as large as the total average historical escapement index of 5,254.

Escapement Survey

The 1992 aerial escapement surveys of Paul's Creek, King Salmon Creek, Big Creek, and the mainstem Naknek River counted an estimated 2,621 chinook salmon spawning in these systems. This estimate represents a 49% reduction from the

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[4] The reanalysis of the 1986-1989 data (corresponding to the 1990 and 1991 temporal components) produced different estimates than appear in the original reports.

Table 16. Historical estimates of effort (angler-hours), catch, and harvest from creel surveys conducted on the lower Naknek River chinook salmon sport fishery.[a]

Temporal[b] Component	1986 Estimate	1986 SE[c]	1987 Estimate	1987 SE[c]	1988 Estimate	1988 SE[c]	1989 Estimate	1989 SE[c]	1990 Estimate	1990 SE	1991 Estimate	1991 SE	86-91 Average	1992 Estimate	1992 SE	1992 Accumulated Estimate
Fishing Effort (Angler-Hours)																
1	3,996		4,193		9,734		7,655		7,623	830	2,940	612	6,024	3,379	438	3,379
2	10,350		8,401		17,241		16,949		11,480	1,592	6,456	905	11,813	6,678	726	10,057
3	9,781		11,195		11,110		11,613		7,392	938	7,190	1,058	9,714	6,233	742	16,290
4	9,597		10,416		9,366		7,665		5,076	535	4,010	408	7,688	5,284	721	21,574
5	2,604		6,334		8,671		6,006		4,294	547	3,791	777	5,283	3,298	436	24,872
6	3,906		5,902		10,396		5,745		3,787	304	4,427	370	5,694	3,556	378	28,428
Total	40,234		46,441		66,518		55,633		39,652	2,186	28,814	1,794	46,215	28,428	1,457	
Catch Estimates																
1	741		309		248		413		655	206	93	29	410	312	52	312
2	877		2,682		1,081		1,037		1,373	396	517	96	1,261	781	135	1,093
3	2,339		3,432		961		908		901	188	1,246	291	1,631	549	122	1,642
4	2,377		2,546		724		830		484	131	506	79	1,245	685	152	2,327
5	549		1,859		1,014		609		493	127	520	124	841	520	87	2,847
6	860		1,621		1,314		444		359	105	735	135	889	515	75	3,362
Total	7,743		12,449		5,342		4,241		4,265	528	3,617	367	6,276	3,362	268	
Harvest Estimates																
1	670		309		248		413		650	206	93	29	397	294	47	294
2	816		2,414		947		976		1,284	327	503	93	1,157	751	128	1,045
3	1,976		2,636		724		802		864	176	1,153	289	1,356	501	122	1,546
4	2,118		2,495		642		798		138	39	488	77	1,113	562	115	2,108
5	443		1,615		758		602		180	69	431	101	672	416	62	2,524
6	845		1,178		1,229		433		134	49	447	94	711	425	60	2,949
Total	6,868		10,647		4,548		4,024		3,250	434	3,115	343	5,409	2,949	233	

[a] This table was produced by partitioning and reanalyzing portions of the original data that correspond to the temporal components used in 1991. The reanalysis was completed only for the portions of each survey that occurred between 1 June and 31 July: estimates presented here may differ from those in the original reports.

[b] Temporal components for the 1986 - 1991 surveys: 1 (6/1-6/21); 2 (6/22-6/30); 3 (7/1-7/7); 4 (7/8-7/14); 5 (7/15-7/21); 6 (7/22-7/31). Temporal components for the 1992 survey: 1 (6/8-6/21); 2 (6/22-6/30); 3 (7/1-7/7); 4 (7/8-7/14); 5 (7/15-7/21); 6 (7/22-7/31).

[c] Standard error terms for the 1986-1989 studies were not available at the time of this reporting.

Table 17. Estimates of chinook salmon commercial, subsistence, and sport harvest plus escapement for the Naknek River fishery, 1970-1992.

	Harvest				
Year	Commercial[a]	Subsistence	Sport	Total	Escapement[b] Index
1970	19,037	300	2,730	22,067	4,145
1971	10,254	200	2,417	12,871	2,885
1972	2,262	400	1,668	4,330	2,791
1973	951	600	1,000	2,551	2,536
1974	480	1,000	1,700	3,180	—
1975	964	700	427	2,091	3,452
1976	4,064	900	800	5,764	7,131
1977	4,373	1,300	1,005	6,678	—
1978	6,930	1,200	2,406	10,536	—
1979	10,415	1,200	2,669	14,284	—
1980	7,517	1,500	2,729	11,746	—
1981	11,048	1,000	2,581	14,629	4,271
1982	12,425	1,100	3,264	16,789	8,610
1983	9,942	1,000	3,545	14,487	7,830
1984	9,198	900	4,524	14,622	4,995
1985	5,891	1,179	5,038	12,108	—
1986	3,552	1,295	6,462	11,309	3,917
1987	5,000	1,289	11,419	17,708	4,450
1988	6,677	1,057	5,380	13,114	11,730
1989	6,463	970	3,879	11,312	2,710
1990	3,749	985	3,250	7,984	7,000
1991	4,528	1,009	3,115	8,652	4,391
All Years					
Average	6,624	958	3,273	10,855	5,178
Percent	61%	9%	30%		
1987 to 1991					
5 Year Avg	5,283	1,062	5,409	11,752	6,056
Percent	45%	9%	46%		
1992	5,429	947	2,949	9,325	2,621
Percent	58%	10%	32%		

[a] Naknek/Kvichak district harvests likely consisting of Naknek, Alagnak, and Kvichak River stocks. The above reported harvests of Naknek River stocks are therefore considered maximums.

[b] Actual raw count made from fixed wing aerial surveys.

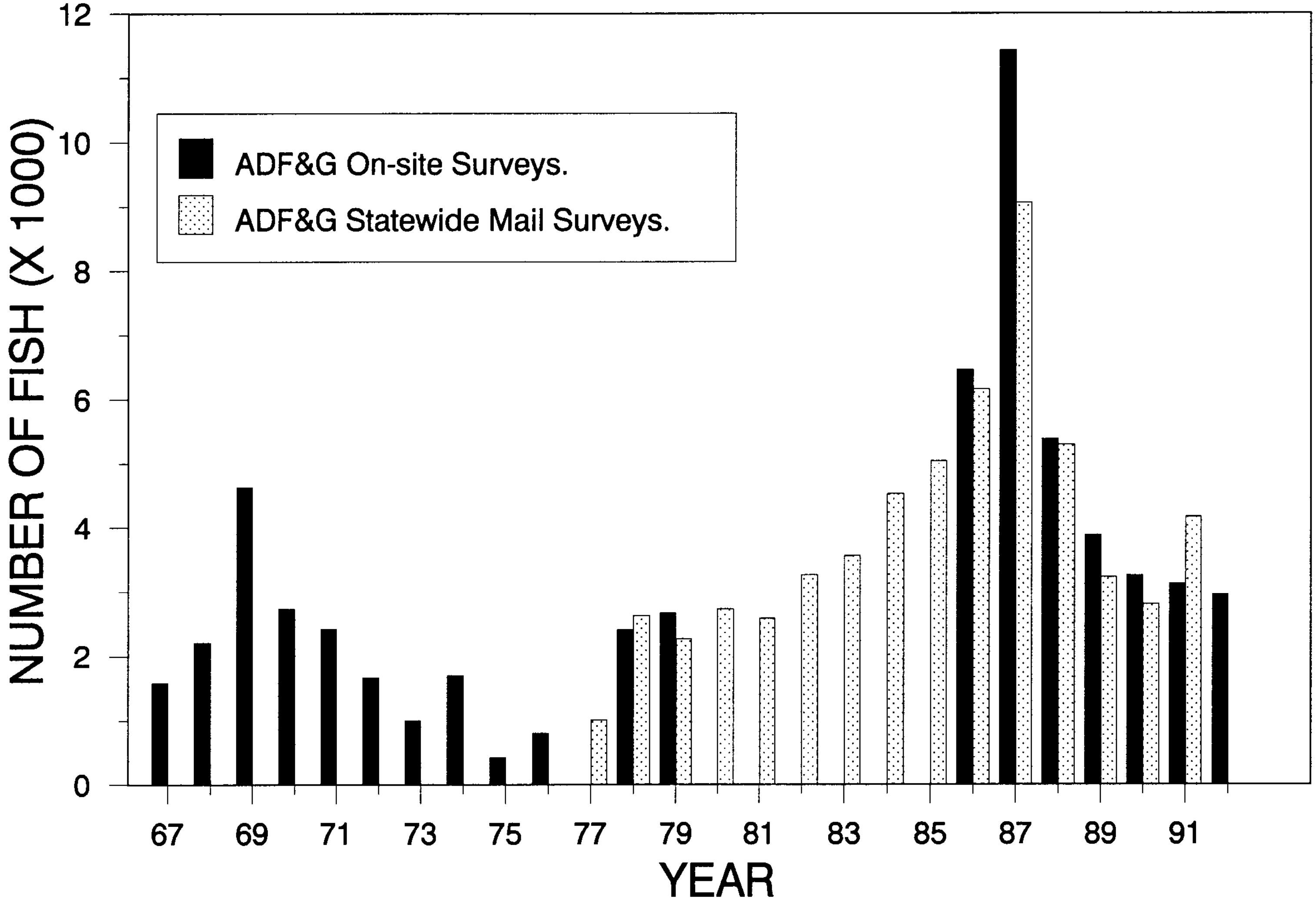

Figure 8. Estimated harvest of chinook salmon by the sport fishery in the Naknek River, 1967-1992.

1970-1991 average estimate of 5,178. However, the aerial escapement surveys of King Salmon Creek, Big Creek, and the mainstem Naknek River, which cumulatively account for approximately 97% of the total escapement, are believed to be biased low as they were conducted after the peak of spawning due to high water levels.

RECOMMENDATIONS

The following recommendations relate to the use of the mark-recapture results from this project, and to the design of any future studies of this system:

1. Due to biases, the inriver abundance and escapement estimates should not be used for short or long-term management decisions related to these stocks of chinook salmon.

2. Prior to implementing future mark-recapture experiments for these stocks of chinook salmon, future studies should be designed to reduce sources of bias found during this study (e.g., evaluate different marking and/or recovery techniques, larger sample sizes, etc.).

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APPENDIX A: MARK-RECAPTURE PROCEDURES

Appendix A. Detection of size-selectivity in mark-recapture sampling and its effects on estimation of size composition.

Results of Hypothesis Tests (Kolmogorov-Smirnov two sample) on Lengths of Fish Marked during the First Event and Recaptured during the Second Event	Results of Hypothesis Tests (K-S) on Lengths of Fish Captured during the First Event and Captured during the Second Event
Case I:[a]	
"Accept" H_o	"Accept" H_o
There is no size-selectivity during either sampling event.	
Case II:[b]	
"Accept" H_o	Reject H_o
There is no size-selectivity during the second sampling event but there is during the first.	
Case III:[c]	
Reject H_o	"Accept" H_o
There is size-selectivity during both sampling events.	
Case IV:[d]	
Reject H_o	Reject H_o
There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.	

[a] Case I: Calculate one unstratified abundance estimate, and pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition.

[b] Case II: Calculate one unstratified abundance estimate, and only use lengths, sexes, and ages from the second sampling event to estimate proportions in compositions.

[c] Case III: Completely stratify both sampling events, and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data.

[d] Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Also, calculate a single estimate of abundance without stratification.

Case IVa: If the stratified and unstratified abundance estimates for the entire population are dissimilar, discard the unstratified estimate. Only use the lengths, ages, and sexes from the second sampling event to estimate proportions in composition, and apply formulae to correct for size bias to data from the second event.

Case IVb: If the stratified and unstratified abundance estimates for the entire population are similar, discard the estimate with the larger variance. Only use the lengths, ages, and sexes from the first sampling event to estimate proportions in compositions, and do not apply formulae to correct for size bias.

APPENDIX B: MARK-RECAPTURE SUMMARY DATA

Appendix B1. Results of the marking and sport recovery events in the lower Naknek River by day from 5 June until 14 August 1992.

DATE	Daily Marked	Cumulative Marked	Daily Sampled	Cumulative Sampled
05-Jun	0	0	0	0
06-Jun	0	0	0	0
07-Jun	1	1	0	0
08-Jun	1	2	0	0
09-Jun	1	3	8	8
10-Jun	2	5	12	20
11-Jun	1	6	5	25
12-Jun	0	6	9	34
13-Jun	1	7	4	38
14-Jun	0	7	16	54
15-Jun	8	15	16	70
16-Jun	3	18	10	80
17-Jun	18	36	10	90
18-Jun	6	42	8	98
19-Jun	4	46	16	114
20-Jun	5	51	24	138
21-Jun	4	55	6	144
22-Jun	22	77	20	164
23-Jun	18	95	9	173
24-Jun	19	114	9	182
25-Jun	10	124	26	208
26-Jun	6	130	34	242
27-Jun	15	145	33	275
28-Jun	47	192	41	316
29-Jun	32	224	51	367
30-Jun	37	261	60	427
01-Jul	28	289	38	465
02-Jul	33	322	28	493
03-Jul	20	342	24	517
04-Jul	15	357	13	530
05-Jul	20	377	62	592
06-Jul	25	402	45	637
07-Jul	32	434	19	656
08-Jul	31	465	25	681
09-Jul	27	492	39	720
10-Jul	27	519	35	755
11-Jul	17	536	10	765
12-Jul	17	553	36	801
13-Jul	31	584	44	845
14-Jul	25	609	51	896

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DATE	Daily Marked	Cumulative Marked	Daily Sampled	Cumulative Sampled
15-Jul	34	643	37	933
16-Jul	29	672	21	954
17-Jul	25	697	35	989
18-Jul	48	745	35	1024
19-Jul	29	774	29	1053
20-Jul	37	811	19	1072
21-Jul	39	850	23	1095
22-Jul	29	879	11	1106
23-Jul	24	903	12	1118
24-Jul	28	931	37	1155
25-Jul	15	946	11	1166
26-Jul	24	970	44	1210
27-Jul	24	994	31	1241
28-Jul	11	1005	34	1275
29-Jul	10	1015	5	1280
30-Jul	4	1019	24	1304
31-Jul	4	1023	14	1318
01-Aug	7	1030	0	1318
02-Aug	5	1035	0	1318
03-Aug	6	1041	0	1318
04-Aug	3	1044	0	1318
05-Aug	6	1050	0	1318
06-Aug	4	1054	0	1318
07-Aug	4	1058	0	1318
08-Aug	5	1063	0	1318
09-Aug	0	1063	0	1318
10-Aug	0	1063	0	1318
11-Aug	1	1064	0	1318
12-Aug	0	1064	0	1318
13-Aug	3	1067	0	1318
14-Aug	1	1068	0	1318

Appendix B2. Mark releases, recaptures and voluntary returns by day for the Naknek River, 1992.

Date of Release	Number Marked	Daily[a] Recaptures	Daily[b] Returns
05-Jun			
06-Jun			
07-Jun	1		
08-Jun	1		
09-Jun	1		
10-Jun	2		
11-Jun	1		
12-Jun			
13-Jun	1		
14-Jun			
15-Jun	8		
16-Jun	3		
17-Jun	18		
18-Jun	6		
19-Jun	4	1	
20-Jun	5		
21-Jun	4		
22-Jun	22		
23-Jun	18		
24-Jun	19		
25-Jun	10		
26-Jun	6		
27-Jun	15		
28-Jun	47		
29-Jun	32		1(CF)
30-Jun	37		
01-Jul	28		
02-Jul	33		
03-Jul	20		
04-Jul	15		
05-Jul	20		
06-Jul	25		
07-Jul	32		1(CF)
08-Jul	31		
09-Jul	27	1	1(CF)
10-Jul	27		
11-Jul	17		1(SF)
12-Jul	17	1	
13-Jul	31		
14-Jul	25		3(1-SF,2-CF)
15-Jul	34		

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Date of Release	Number Marked	Daily[a] Recaptures	Daily[b] Returns
16-Jul	29		1(SF)
17-Jul	25	2	
18-Jul	48		
19-Jul	29	2	
20-Jul	37		1(SUB)
21-Jul	39		
22-Jul	29		
23-Jul	24		1(CF)
24-Jul	28		
25-Jul	15	2	
26-Jul	24	2	
27-Jul	24		1(CF)
28-Jul	11	2	1(CF)
29-Jul	10		
30-Jul	4		
31-Jul	4	1	1(SUBF)
01-Aug	7		1(CF)
02-Aug	5		
03-Aug	6		
04-Aug	3		
05-Aug	6		
06-Aug	4		1(SF)
07-Aug	4		
08-Aug	5		
09-Aug			
10-Aug			
11-Aug	1		
12-Aug			
13-Aug	3		
14-Aug	1		

[a] Marks recovered by the creel survey from fish recaptured in the sport fishery.

[b] Voluntary returns of marks from fish recaptured in: SF = Sport Fishery, CF = Commercial Fishery, and SUB = Subsistence Fishery.

APPENDIX C: CREEL SURVEY PROCEDURES

Appendix C. Estimation equations for the age composition in proportions and in numbers for the fish harvested in the chinook salmon sport fishery in Naknek River, 1992.

Estimates of the percentage of chinook salmon by age class and sex, as well as the apportioned abundances by these classifications were calculated in the following manner:

$$\hat{p}_{ut} = \frac{n_{ut}}{n_t} ; \qquad (C.1)$$

where:

n_{ut} = the number of chinook salmon classified as category *u* (where the types of categories were the various age classes for age composition or male/female for the sex composition estimates) that were in temporal component *t*; and

n_t = the number of chinook salmon sampled for age or sex composition within temporal component *t*.

The next step involved estimating the harvest of each category (age class or sex) within each temporal component:

$$\hat{N}_{ut} = \hat{p}_{ut} \hat{N}_t ; \qquad (C.2)$$

where:

$\hat{N}_t$ = the estimated harvest of chinook salmon within temporal component *t*.

Next the harvest of chinook salmon in each category over all temporal components was estimated as:

$$\hat{N}_u = \sum_{t=1}^{s} \hat{N}_{ut} ; \qquad (C.3)$$

where: *s* represent the temporal components.

Next the proportion of chinook salmon in each category was estimated as:

$$\hat{p}_u = \frac{\hat{N}_u}{\hat{N}} ; \qquad (C.4)$$

-continued-

where:

$\hat{N}$ = the total estimated harvest of chinook salmon over all temporal components;

$$= \sum_{u=1}^{c} \hat{N}_u \text{ ; and} \quad \text{(C.5)}$$

c = the number of categories (age groups or sex groups).

The percentage in each age group was found as the above proportions times 100%.

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

$$\hat{V}[\hat{p}_u] \approx \left[\frac{\hat{N}_u}{\hat{N}} \right]^2 \left[\frac{\hat{V}[\hat{N}_u]}{\hat{N}_u^2} + \frac{\hat{V}[\hat{N}]}{\hat{N}^2} - \frac{2\,\hat{V}[\hat{N}_u]}{\hat{N}_u\,\hat{N}} \right] ; \quad \text{(C.6)}$$

where:

$\hat{V}[\hat{N}_u]$ = the estimated variance for the estimated harvest of chinook salmon over all temporal components, obtained as the sum of variances of the components;

$$= \sum_{t=1}^{s} \hat{V}[\hat{N}_{ut}] \text{ ;} \quad \text{(C.7)}$$

$\hat{V}[\hat{N}_{ut}]$ = estimated variance for the estimated harvest for each category within temporal component, obtained from Goodman's (1960) formula for the variance of the product of random variates:

$$= \hat{p}_{ut}^2\,\hat{V}[\hat{N}_t] + \hat{N}_t^2\,\hat{V}[\hat{p}_{ut}] - \hat{V}[\hat{N}_t]\,\hat{V}[\hat{p}_{ut}] \text{ ;} \quad \text{(C.8)}$$

$\hat{V}[\hat{N}_t]$ = estimated variance for the estimated harvest of chinook salmon within each temporal component;

-continued-

$\hat{V}[\hat{p}_{ut}]$ = estimated variance for the estimated proportion of each category within each temporal component, obtained from the standard equation for the variance of a binomial parameter (adapted from equation 3.8 in Cochran 1977, page 52);

$$= \left[1 - \frac{n_t}{\hat{N}_t} \right] \left[\frac{\hat{p}_{ut} (1 - \hat{p}_{ut})}{(n_t - 1)} \right] ; \text{ and} \qquad \text{(C.9)}$$

$\hat{V}[\hat{N}]$ = estimated variance of the total estimate of harvest, which for use with these procedures was equated to the sum of the individual harvest for each category[1];

$$= \sum_{u=1}^{c} \hat{V}[\hat{N}_u] \ . \qquad \text{(C.10)}$$

Variances in terms of percentages were obtained by multiplying the variance estimates for the proportions by the square of 100%. Standard errors were obtained by taking the square root of the variance estimates.

[1] This formula for estimating the total harvest estimate variance was used so that the covariance term in equation C.6, above, was approximated by the variance of the individual components.

APPENDIX D: CREEL SURVEY SUMMARY DATA

Appendix D1. Angler counts in the lower Naknek River sport fishery, 1992.

Temporal Components	Date	Time Periods A 0630 1029	B 1030 1429	C 1430 1829	D 1830 2230
1	08-Jun		0.75[a]	2.25[a]	
1	09-Jun	5	6		
1	10-Jun	7.5[a]			10.25[a]
1	11-Jun		2		14
1	12-Jun				
1	13-Jun		13		1
1	14-Jun		31[a]	39.5[a]	
1	15-Jun	2			29
1	16-Jun	10	2		
1	17-Jun	0	8		
1	18-Jun		14	23	
1	19-Jun	3	9		
1	20-Jun	20		35	
1	21-Jun		73	32	
2	22-Jun				
2	23-Jun		34	9	
2	24-Jun				
2	25-Jun	23	55		
2	26-Jun		62.5[a]		21.75[a]
2	27-Jun		58.5[a]	72.75[a]	
2	28-Jun	24	77		
2	29-Jun			82.25[a]	52.5[a]
2	30-Jun	42			35
3	01-Jul				
3	02-Jul			46.25[a]	30.75[a]
3	03-Jul		78	102	
3	04-Jul	65.25[a]	82.75[a]		
3	05-Jul				
3	06-Jul		42		21
3	07-Jul		42.25[a]	46.25[a]	

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Temporal Components	Date	Time Periods A 0630 1029	B 1030 1429	C 1430 1829	D 1830 2230
4	08-Jul				
4	09-Jul			77.25[a]	28.75[a]
4	10-Jul		25	80	
4	11-Jul	37[a]	76.5[a]		
4	12-Jul				
4	13-Jul		66		18
4	14-Jul	37[a]			26.25[a]
5	15-Jul	25.5[a]	28.25[a]		
5	16-Jul				
5	17-Jul		50		17
5	18-Jul		16	50	
5	19-Jul	20.5[a]	50.5[a]		
5	20-Jul				
5	21-Jul			18.25[a]	18.5[a]
6	22-Jul		26	21	
6	23-Jul	11.75[a]	24[a]		
6	24-Jul		38		15
6	25-Jul				
6	26-Jul	17	45		
6	27-Jul		18.5[a]	40[a]	
6	28-Jul	0	27		
6	29-Jul		17	27	
6	30-Jul			27.25[a]	22.5[a]
6	31-Jul	0			23

[a] Values reflect the average of four separate in-period counts.

Appendix D2. Summary of daily angler effort (angler-hours), catch, and harvest for chinook salmon in the sport fishery in the lower Naknek River, 1992.

Temporal Component[a]	Date	Period[b]	Number of Counts	Mean Angler Count	Anglers Interviewed	Estimates by Period: Effort		Catch		Harvest	
						Estimate	Variance	Estimate	Variance	Estimate	Variance
01	920608	B	4	0.75	8	3.0	3.33	0.00	0.00	0.00	0.00
01	920608	C	4	2.25	16	9.0	6.67	0.00	0.00	0.00	0.00
01	920609	A	1	5.00	1	20.0	0.00	5.00	0.00	5.00	0.00
01	920609	B	1	6.00	6	24.0	0.00	2.20	1.83	2.20	1.83
01	920610	A	4	7.50	4	30.0	30.67	0.00	0.00	0.00	0.00
01	920610	D	4	10.25	15	41.0	89.33	0.85	0.75	0.00	0.00
01	920611	B	1	2.00	5	8.0	0.00	0.80	0.24	0.80	0.24
01	920611	D	1	14.00	8	56.0	0.00	0.00	0.00	0.00	0.00
01	920613	B	1	13.00	20	52.0	0.00	1.01	0.98	1.01	0.98
01	920613	D	1	1.00	3	4.0	0.00	0.00	0.00	0.00	0.00
01	920614	B	4	31.00	21	124.0	226.00	23.74	33.64	21.63	30.34
01	920614	C	4	39.50	24	158.0	86.00	10.23	13.29	10.23	13.29
01	920615	A	1	2.00	0	8.0	0.00	0.00	0.00	0.00	0.00
01	920615	D	1	29.00	14	116.0	0.00	15.19	26.44	15.19	26.44
01	920616	A	1	10.00	10	40.0	0.00	3.16	9.32	3.16	9.32
01	920616	B	1	2.00	10	8.0	0.00	1.54	0.28	1.54	0.28
01	920617	A	1	0.00	0	0.0	0.00	0.00	0.00	0.00	0.00
01	920617	B	1	8.00	5	32.0	0.00	9.31	5.42	9.31	5.42
01	920618	B	1	14.00	18	56.0	0.00	1.06	1.17	1.06	1.17
01	920618	C	1	23.00	20	92.0	0.00	9.94	9.56	9.94	9.56
01	920619	A	1	3.00	4	12.0	0.00	0.75	0.56	0.75	0.56
01	920619	B	1	9.00	8	36.0	0.00	2.00	1.72	2.00	1.72
01	920620	A	1	20.00	0	80.0	0.00	0.00	0.00	0.00	0.00
01	920620	C	1	35.00	19	140.0	0.00	13.66	43.99	10.91	24.49
01	920621	B	1	73.00	22	292.0	0.00	10.21	30.44	10.21	30.44
01	920621	C	1	32.00	10	128.0	0.00	5.40	9.43	5.40	9.43
02	920623	B	1	34.00	21	136.0	0.00	7.90	16.51	7.90	16.51
02	920623	C	1	9.00	25	36.0	0.00	4.59	2.26	3.58	0.92
02	920625	A	1	23.00	4	92.0	0.00	0.00	0.00	0.00	0.00
02	920625	B	1	55.00	33	220.0	0.00	4.68	6.82	4.68	6.82
02	920626	B	4	62.50	51	250.0	263.33	30.39	43.49	30.39	43.49
02	920626	D	4	21.75	21	87.0	99.33	4.77	7.98	4.77	7.98
02	920627	B	4	58.50	48	234.0	801.33	50.57	114.43	43.15	81.31
02	920627	C	4	72.75	77	291.0	1142.00	19.94	17.38	19.94	17.38
02	920628	A	1	24.00	14	96.0	0.00	22.57	38.50	22.57	38.50
02	920628	B	1	77.00	17	308.0	0.00	50.40	335.31	50.40	335.31
02	920629	C	4	82.25	40	329.0	1617.33	37.82	74.83	37.82	74.83
02	920629	D	4	52.50	30	210.0	54.00	30.69	72.27	27.30	62.10
02	920630	A	1	42.00	10	168.0	0.00	30.58	216.84	30.58	216.84
02	920630	D	1	35.00	22	140.0	0.00	8.92	18.35	8.92	18.35

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Temporal Component[a]	Date	Period[b]	Number of Counts	Mean Angler Count	Anglers Inter-viewed	Estimates by Period: Effort Estimate	Effort Variance	Catch Estimate	Catch Variance	Harvest Estimate	Harvest Variance
03	920702	C	4	46.25	49	185.0	758.00	14.85	13.88	13.45	10.50
03	920702	D	4	30.75	28	123.0	59.33	15.52	14.77	14.30	13.52
03	920703	B	1	78.00	17	312.0	0.00	60.54	200.71	60.54	200.71
03	920703	C	1	102.00	44	408.0	0.00	22.83	61.30	14.46	23.05
03	920704	A	4	65.25	12	261.0	1684.00	0.00	0.00	0.00	0.00
03	920704	B	4	82.75	94	331.0	574.67	12.49	10.26	12.49	10.26
03	920706	B	1	42.00	40	168.0	0.00	21.03	24.15	21.03	24.15
03	920706	D	1	21.00	29	84.0	0.00	11.48	18.88	7.64	5.94
03	920707	B	4	42.25	22	169.0	112.67	28.81	67.52	26.41	45.83
03	920707	C	4	46.25	37	185.0	342.67	8.53	7.52	8.53	7.52
04	920709	C	4	77.25	57	309.0	825.33	8.70	11.72	7.27	9.68
04	920709	D	4	28.75	61	115.0	217.33	11.84	6.96	10.11	5.83
04	920710	B	1	25.00	25	100.0	0.00	25.00	16.67	20.00	10.42
04	920710	C	1	80.00	50	320.0	0.00	37.19	33.03	29.45	32.27
04	920711	A	4	37.00	11	148.0	730.67	7.89	66.11	7.89	66.11
04	920711	B	4	76.50	57	306.0	311.33	20.95	27.03	20.95	27.03
04	920713	B	1	66.00	47	264.0	0.00	41.16	38.23	37.04	28.93
04	920713	D	1	18.00	26	72.0	0.00	6.64	3.56	5.71	3.48
04	920714	A	4	37.00	8	148.0	730.67	71.56	477.83	51.23	418.25
04	920714	D	4	26.25	21	105.0	310.00	13.73	12.00	11.14	7.56
05	920715	A	4	25.50	4	102.0	152.00	41.30	378.63	27.60	150.38
05	920715	B	4	28.25	33	113.0	30.00	15.29	13.00	15.29	13.00
05	920717	B	1	50.00	36	200.0	0.00	21.19	16.25	21.19	16.25
05	920717	D	1	17.00	27	68.0	0.00	6.80	3.40	6.80	3.40
05	920718	B	1	16.00	26	64.0	0.00	12.32	4.15	9.82	4.78
05	920718	C	1	50.00	11	200.0	0.00	15.70	13.88	15.70	13.88
05	920719	A	4	20.50	0	82.0	1079.33	0.00	0.00	0.00	0.00
05	920719	B	4	50.50	52	202.0	262.00	19.83	23.64	16.32	15.97
05	920721	C	4	18.25	31	73.0	49.33	21.86	26.73	15.13	8.06
05	920721	D	4	18.50	22	74.0	180.00	11.42	15.30	4.53	5.04
06	920722	B	1	26.00	16	104.0	0.00	8.04	12.76	8.04	12.76
06	920722	C	1	21.00	16	84.0	0.00	14.92	30.98	8.01	3.99
06	920723	A	4	11.75	11	47.0	65.33	0.00	0.00	0.00	0.00
06	920723	B	4	24.00	16	96.0	53.33	11.63	75.38	11.63	75.38
06	920724	B	1	38.00	28	152.0	0.00	21.02	28.02	16.14	20.44
06	920724	D	1	15.00	19	60.0	0.00	5.44	9.18	4.53	6.43
06	920726	A	1	17.00	0	68.0	0.00	0.00	0.00	0.00	0.00
06	920726	B	1	45.00	38	180.0	0.00	21.20	24.04	19.70	18.53
06	920727	B	4	18.50	20	74.0	263.33	16.07	21.35	12.58	16.73
06	920727	C	4	40.00	42	160.0	92.67	33.16	20.14	24.70	12.10
06	920728	A	1	0.00	0	0.0	0.00	0.00	0.00	0.00	0.00
06	920728	B	1	27.00	31	108.0	0.00	20.51	40.39	15.85	17.59

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Appendix D2. (Page 3 of 3).

Temporal Component[a]	Date	Period[b]	Number of Counts	Mean Angler Count	Anglers Inter-viewed	Estimates by Period: Effort Estimate	Effort Variance	Catch Estimate	Catch Variance	Harvest Estimate	Harvest Variance
06	920729	B	1	17.00	22	68.0	0.00	5.56	4.48	5.56	4.48
06	920729	C	1	27.00	13	108.0	0.00	10.69	20.52	10.69	20.52
06	920730	C	4	27.25	29	109.0	75.33	24.25	22.71	19.19	13.45
06	920730	D	4	22.50	39	90.0	22.67	11.07	12.39	8.06	6.45
06	920731	A	1	0.00	0	0.0	0.00	0.00	0.00	0.00	0.00
06	920731	D	1	23.00	29	92.0	0.00	7.08	6.10	7.08	6.10

[a] Temporal Components: 1 (6/08-6/21); 2 (6/22-6-30); 3 (7/01-7/07); 4 (7/08-7/14); 5 (7/15-7/21); 6 (7/22-7/31).

[b] Daily periods for temporal components 1-6: A (0630-1029); B (1030-1429); C (1430-1829); D (1830-2230).

Appendix D3. Summary of daily angler effort (angler-hours), catch, and harvest for coho salmon in the sport fishery in the lower Naknek River, 1992.

Temporal Component[a]	Date	Period[b]	Number of Counts	Mean Angler Count	Anglers Interviewed	Effort Estimate	Effort Variance	Catch Estimate	Catch Variance	Harvest Estimate	Harvest Variance
01	920608	B	4	0.75	8	3.0	3.33	0.00	0.00	0.00	0.00
01	920608	C	4	2.25	16	9.0	6.67	0.00	0.00	0.00	0.00
01	920609	A	1	5.00	1	20.0	0.00	0.00	0.00	0.00	0.00
01	920609	B	1	6.00	6	24.0	0.00	0.00	0.00	0.00	0.00
01	920610	A	4	7.50	4	30.0	30.67	0.00	0.00	0.00	0.00
01	920610	D	4	10.25	15	41.0	89.33	0.00	0.00	0.00	0.00
01	920611	B	1	2.00	5	8.0	0.00	0.00	0.00	0.00	0.00
01	920611	D	1	14.00	8	56.0	0.00	0.00	0.00	0.00	0.00
01	920613	B	1	13.00	20	52.0	0.00	0.00	0.00	0.00	0.00
01	920613	D	1	1.00	3	4.0	0.00	0.00	0.00	0.00	0.00
01	920614	B	4	31.00	21	124.0	226.00	0.00	0.00	0.00	0.00
01	920614	C	4	39.50	24	158.0	86.00	0.00	0.00	0.00	0.00
01	920615	A	1	2.00	0	8.0	0.00	0.00	0.00	0.00	0.00
01	920615	D	1	29.00	14	116.0	0.00	0.00	0.00	0.00	0.00
01	920616	A	1	10.00	10	40.0	0.00	0.00	0.00	0.00	0.00
01	920616	B	1	2.00	10	8.0	0.00	0.00	0.00	0.00	0.00
01	920617	A	1	0.00	0	0.0	0.00	0.00	0.00	0.00	0.00
01	920617	B	1	8.00	5	32.0	0.00	0.00	0.00	0.00	0.00
01	920618	B	1	14.00	18	56.0	0.00	0.00	0.00	0.00	0.00
01	920618	C	1	23.00	20	92.0	0.00	0.00	0.00	0.00	0.00
01	920619	A	1	3.00	4	12.0	0.00	0.00	0.00	0.00	0.00
01	920619	B	1	9.00	8	36.0	0.00	0.00	0.00	0.00	0.00
01	920620	A	1	20.00	0	80.0	0.00	0.00	0.00	0.00	0.00
01	920620	C	1	35.00	19	140.0	0.00	0.00	0.00	0.00	0.00
01	920621	B	1	73.00	22	292.0	0.00	0.00	0.00	0.00	0.00
01	920621	C	1	32.00	10	128.0	0.00	0.00	0.00	0.00	0.00
02	920623	B	1	34.00	21	136.0	0.00	0.00	0.00	0.00	0.00
02	920623	C	1	9.00	25	36.0	0.00	0.00	0.00	0.00	0.00
02	920625	A	1	23.00	4	92.0	0.00	0.00	0.00	0.00	0.00
02	920625	B	1	55.00	33	220.0	0.00	0.00	0.00	0.00	0.00
02	920626	B	4	62.50	51	250.0	263.33	0.00	0.00	0.00	0.00
02	920626	D	4	21.75	21	87.0	99.33	0.00	0.00	0.00	0.00
02	920627	B	4	58.50	48	234.0	801.33	0.00	0.00	0.00	0.00
02	920627	C	4	72.75	77	291.0	1142.00	0.00	0.00	0.00	0.00
02	920628	A	1	24.00	14	96.0	0.00	0.00	0.00	0.00	0.00
02	920628	B	1	77.00	17	308.0	0.00	0.00	0.00	0.00	0.00
02	920629	C	4	82.25	40	329.0	1617.33	0.00	0.00	0.00	0.00
02	920629	D	4	52.50	30	210.0	54.00	0.00	0.00	0.00	0.00
02	920630	A	1	42.00	10	168.0	0.00	0.00	0.00	0.00	0.00
02	920630	D	1	35.00	22	140.0	0.00	0.00	0.00	0.00	0.00

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Appendix D3. (Page 2 of 3).

Temporal Component[a]	Date	Period[b]	Number of Counts	Mean Angler Count	Anglers Inter-viewed	Estimates by Period: Effort Estimate	Effort Variance	Catch Estimate	Catch Variance	Harvest Estimate	Harvest Variance
03	920702	C	4	46.25	49	185.0	758.00	0.00	0.00	0.00	0.00
03	920702	D	4	30.75	28	123.0	59.33	0.00	0.00	0.00	0.00
03	920703	B	1	78.00	17	312.0	0.00	0.00	0.00	0.00	0.00
03	920703	C	1	102.00	44	408.0	0.00	0.00	0.00	0.00	0.00
03	920704	A	4	65.25	12	261.0	1684.00	0.00	0.00	0.00	0.00
03	920704	B	4	82.75	94	331.0	574.67	0.00	0.00	0.00	0.00
03	920706	B	1	42.00	40	168.0	0.00	0.00	0.00	0.00	0.00
03	920706	D	1	21.00	29	84.0	0.00	0.00	0.00	0.00	0.00
03	920707	B	4	42.25	22	169.0	112.67	0.00	0.00	0.00	0.00
03	920707	C	4	46.25	37	185.0	342.67	0.00	0.00	0.00	0.00
04	920709	C	4	77.25	57	309.0	825.33	0.00	0.00	0.00	0.00
04	920709	D	4	28.75	61	115.0	217.33	0.00	0.00	0.00	0.00
04	920710	B	1	25.00	25	100.0	0.00	0.00	0.00	0.00	0.00
04	920710	C	1	80.00	50	320.0	0.00	0.00	0.00	0.00	0.00
04	920711	A	4	37.00	11	148.0	730.67	0.00	0.00	0.00	0.00
04	920711	B	4	76.50	57	306.0	311.33	0.00	0.00	0.00	0.00
04	920713	B	1	66.00	47	264.0	0.00	0.00	0.00	0.00	0.00
04	920713	D	1	18.00	26	72.0	0.00	0.00	0.00	0.00	0.00
04	920714	A	4	37.00	8	148.0	730.67	0.00	0.00	0.00	0.00
04	920714	D	4	26.25	21	105.0	310.00	0.00	0.00	0.00	0.00
05	920715	A	4	25.50	4	102.0	152.00	0.00	0.00	0.00	0.00
05	920715	B	4	28.25	33	113.0	30.00	0.00	0.00	0.00	0.00
05	920717	B	1	50.00	36	200.0	0.00	0.00	0.00	0.00	0.00
05	920717	D	1	17.00	27	68.0	0.00	0.00	0.00	0.00	0.00
05	920718	B	1	16.00	26	64.0	0.00	0.00	0.00	0.00	0.00
05	920718	C	1	50.00	11	200.0	0.00	0.00	0.00	0.00	0.00
05	920719	A	4	20.50	0	82.0	1079.33	0.00	0.00	0.00	0.00
05	920719	B	4	50.50	52	202.0	262.00	0.00	0.00	0.00	0.00
05	920721	C	4	18.25	31	73.0	49.33	0.00	0.00	0.00	0.00
05	920721	D	4	18.50	22	74.0	180.00	0.00	0.00	0.00	0.00
06	920722	B	1	26.00	16	104.0	0.00	0.00	0.00	0.00	0.00
06	920722	C	1	21.00	16	84.0	0.00	0.00	0.00	0.00	0.00
06	920723	A	4	11.75	11	47.0	65.33	0.00	0.00	0.00	0.00
06	920723	B	4	24.00	16	96.0	53.33	0.00	0.00	0.00	0.00
06	920724	B	1	38.00	28	152.0	0.00	0.00	0.00	0.00	0.00
06	920724	D	1	15.00	19	60.0	0.00	0.00	0.00	0.00	0.00
06	920726	A	1	17.00	0	68.0	0.00	0.00	0.00	0.00	0.00
06	920726	B	1	45.00	38	180.0	0.00	16.64	79.91	16.64	79.91
06	920727	B	4	18.50	20	74.0	263.33	1.15	1.32	1.15	1.32
06	920727	C	4	40.00	42	160.0	92.67	12.31	37.15	12.31	37.15
06	920728	A	1	0.00	0	0.0	0.00	0.00	0.00	0.00	0.00
06	920728	B	1	27.00	31	108.0	0.00	0.00	0.00	0.00	0.00

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Temporal Component[a]	Date	Period[b]	Number of Counts	Mean Angler Count	Anglers Inter-viewed	Estimates by Period: Effort Estimate	Effort Variance	Catch Estimate	Catch Variance	Harvest Estimate	Harvest Variance
06	920729	B	1	17.00	22	68.0	0.00	0.00	0.00	0.00	0.00
06	920729	C	1	27.00	13	108.0	0.00	5.29	13.27	5.29	13.27
06	920730	C	4	27.25	29	109.0	75.33	11.37	24.34	11.37	24.34
06	920730	D	4	22.50	39	90.0	22.67	2.99	3.04	2.99	3.04
06	920731	A	1	0.00	0	0.0	0.00	0.00	0.00	0.00	0.00
06	920731	D	1	23.00	29	92.0	0.00	3.83	3.24	3.83	3.24

[a] Temporal Components: 1 (6/08-6/21); 2 (6/22-6-30); 3 (7/01-7/07); 4 (7/08-7/14); 5 (7/15-7/21); 6 (7/22-7/31).

[b] Daily periods for temporal components 1-6: A (0630-1029); B (1030-1429); C (1430-1829); D (1830-2230).

Appendix D4. Summary of daily angler effort (angler-hours), catch, and harvest for chum salmon in the sport fishery in the lower Naknek River, 1992.

Temporal Component[a]	Date	Period[b]	Number of Counts	Mean Angler Count	Anglers Interviewed	Estimates by Period: Effort Estimate	Effort Variance	Catch Estimate	Catch Variance	Harvest Estimate	Harvest Variance
01	920608	B	4	0.75	8	3.0	3.33	0.00	0.00	0.00	0.00
01	920608	C	4	2.25	16	9.0	6.67	0.00	0.00	0.00	0.00
01	920609	A	1	5.00	1	20.0	0.00	0.00	0.00	0.00	0.00
01	920609	B	1	6.00	6	24.0	0.00	0.00	0.00	0.00	0.00
01	920610	A	4	7.50	4	30.0	30.67	0.00	0.00	0.00	0.00
01	920610	D	4	10.25	15	41.0	89.33	0.00	0.00	0.00	0.00
01	920611	B	1	2.00	5	8.0	0.00	0.40	0.16	0.40	0.16
01	920611	D	1	14.00	8	56.0	0.00	0.00	0.00	0.00	0.00
01	920613	B	1	13.00	20	52.0	0.00	0.00	0.00	0.00	0.00
01	920613	D	1	1.00	3	4.0	0.00	0.00	0.00	0.00	0.00
01	920614	B	4	31.00	21	124.0	226.00	2.11	4.81	2.11	4.81
01	920614	C	4	39.50	24	158.0	86.00	0.00	0.00	0.00	0.00
01	920615	A	1	2.00	0	8.0	0.00	0.00	0.00	0.00	0.00
01	920615	D	1	29.00	14	116.0	0.00	0.00	0.00	0.00	0.00
01	920616	A	1	10.00	10	40.0	0.00	1.58	2.33	1.58	2.33
01	920616	B	1	2.00	10	8.0	0.00	0.00	0.00	0.00	0.00
01	920617	A	1	0.00	0	0.0	0.00	0.00	0.00	0.00	0.00
01	920617	B	1	8.00	5	32.0	0.00	0.00	0.00	0.00	0.00
01	920618	B	1	14.00	18	56.0	0.00	0.00	0.00	0.00	0.00
01	920618	C	1	23.00	20	92.0	0.00	0.00	0.00	0.00	0.00
01	920619	A	1	3.00	4	12.0	0.00	0.00	0.00	0.00	0.00
01	920619	B	1	9.00	8	36.0	0.00	0.00	0.00	0.00	0.00
01	920620	A	1	20.00	0	80.0	0.00	0.00	0.00	0.00	0.00
01	920620	C	1	35.00	19	140.0	0.00	0.00	0.00	0.00	0.00
01	920621	B	1	73.00	22	292.0	0.00	0.00	0.00	0.00	0.00
01	920621	C	1	32.00	10	128.0	0.00	0.00	0.00	0.00	0.00
02	920623	B	1	34.00	21	136.0	0.00	0.00	0.00	0.00	0.00
02	920623	C	1	9.00	25	36.0	0.00	0.25	0.07	0.25	0.07
02	920625	A	1	23.00	4	92.0	0.00	0.00	0.00	0.00	0.00
02	920625	B	1	55.00	33	220.0	0.00	3.13	4.69	3.13	4.69
02	920626	B	4	62.50	51	250.0	263.33	9.24	18.29	9.24	18.29
02	920626	D	4	21.75	21	87.0	99.33	0.00	0.00	0.00	0.00
02	920627	B	4	58.50	48	234.0	801.33	8.88	17.77	7.40	15.58
02	920627	C	4	72.75	77	291.0	1142.00	0.87	0.75	0.87	0.75
02	920628	A	1	24.00	14	96.0	0.00	4.97	11.56	4.97	11.56
02	920628	B	1	77.00	17	308.0	0.00	36.10	128.65	28.95	124.08
02	920629	C	4	82.25	40	329.0	1617.33	30.38	145.29	30.38	145.29
02	920629	D	4	52.50	30	210.0	54.00	1.70	3.02	1.70	3.02
02	920630	A	1	42.00	10	168.0	0.00	6.01	39.20	6.01	39.20
02	920630	D	1	35.00	22	140.0	0.00	0.00	0.00	0.00	0.00

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Appendix D4. (Page 2 of 3).

Temporal Component[a]	Date	Period[b]	Number of Counts	Mean Angler Count	Anglers Inter-viewed	Estimates by Period: Effort Estimate	Effort Variance	Catch Estimate	Catch Variance	Harvest Estimate	Harvest Variance
03	920702	C	4	46.25	49	185.0	758.00	4.98	5.35	4.98	5.35
03	920702	D	4	30.75	28	123.0	59.33	2.35	2.78	2.35	2.78
03	920703	B	1	78.00	17	312.0	0.00	4.94	26.02	4.94	26.02
03	920703	C	1	102.00	44	408.0	0.00	0.00	0.00	0.00	0.00
03	920704	A	4	65.25	12	261.0	1684.00	0.00	0.00	0.00	0.00
03	920704	B	4	82.75	94	331.0	574.67	0.00	0.00	0.00	0.00
03	920706	B	1	42.00	40	168.0	0.00	2.33	2.68	2.33	2.68
03	920706	D	1	21.00	29	84.0	0.00	0.00	0.00	0.00	0.00
03	920707	B	4	42.25	22	169.0	112.67	4.80	10.76	4.80	10.76
03	920707	C	4	46.25	37	185.0	342.67	1.89	1.83	1.89	1.83
04	920709	C	4	77.25	57	309.0	825.33	10.13	35.00	10.13	35.00
04	920709	D	4	28.75	61	115.0	217.33	4.00	5.00	4.00	5.00
04	920710	B	1	25.00	25	100.0	0.00	1.00	1.00	1.00	1.00
04	920710	C	1	80.00	50	320.0	0.00	9.09	25.79	9.09	25.79
04	920711	A	4	37.00	11	148.0	730.67	0.00	0.00	0.00	0.00
04	920711	B	4	76.50	57	306.0	311.33	3.00	9.01	3.00	9.01
04	920713	B	1	66.00	47	264.0	0.00	5.46	7.25	2.73	3.75
04	920713	D	1	18.00	26	72.0	0.00	0.00	0.00	0.00	0.00
04	920714	A	4	37.00	8	148.0	730.67	0.00	0.00	0.00	0.00
04	920714	D	4	26.25	21	105.0	310.00	0.00	0.00	0.00	0.00
05	920715	A	4	25.50	4	102.0	152.00	0.00	0.00	0.00	0.00
05	920715	B	4	28.25	33	113.0	30.00	0.99	1.06	0.99	1.06
05	920717	B	1	50.00	36	200.0	0.00	1.40	1.99	1.40	1.99
05	920717	D	1	17.00	27	68.0	0.00	0.00	0.00	0.00	0.00
05	920718	B	1	16.00	26	64.0	0.00	2.45	1.85	0.81	0.68
05	920718	C	1	50.00	11	200.0	0.00	0.00	0.00	0.00	0.00
05	920719	A	4	20.50	0	82.0	1079.33	0.00	0.00	0.00	0.00
05	920719	B	4	50.50	52	202.0	262.00	2.32	2.72	1.15	1.37
05	920721	C	4	18.25	31	73.0	49.33	0.44	0.20	0.00	0.00
05	920721	D	4	18.50	22	74.0	180.00	0.00	0.00	0.00	0.00
06	920722	B	1	26.00	16	104.0	0.00	0.00	0.00	0.00	0.00
06	920722	C	1	21.00	16	84.0	0.00	0.00	0.00	0.00	0.00
06	920723	A	4	11.75	11	47.0	65.33	0.00	0.00	0.00	0.00
06	920723	B	4	24.00	16	96.0	53.33	0.00	0.00	0.00	0.00
06	920724	B	1	38.00	28	152.0	0.00	0.00	0.00	0.00	0.00
06	920724	D	1	15.00	19	60.0	0.00	0.00	0.00	0.00	0.00
06	920726	A	1	17.00	0	68.0	0.00	0.00	0.00	0.00	0.00
06	920726	B	1	45.00	38	180.0	0.00	0.00	0.00	0.00	0.00
06	920727	B	4	18.50	20	74.0	263.33	0.00	0.00	0.00	0.00
06	920727	C	4	40.00	42	160.0	92.67	0.00	0.00	0.00	0.00
06	920728	A	1	0.00	0	0.0	0.00	0.00	0.00	0.00	0.00
06	920728	B	1	27.00	31	108.0	0.00	0.00	0.00	0.00	0.00

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Temporal Component[a]	Date	Period[b]	Number of Counts	Mean Angler Count	Anglers Inter-viewed	Estimates by Period: Effort Estimate	Effort Variance	Catch Estimate	Catch Variance	Harvest Estimate	Harvest Variance
06	920729	B	1	17.00	22	68.0	0.00	0.00	0.00	0.00	0.00
06	920729	C	1	27.00	13	108.0	0.00	0.00	0.00	0.00	0.00
06	920730	C	4	27.25	29	109.0	75.33	0.00	0.00	0.00	0.00
06	920730	D	4	22.50	39	90.0	22.67	2.00	2.02	2.00	2.02
06	920731	A	1	0.00	0	0.0	0.00	0.00	0.00	0.00	0.00
06	920731	D	1	23.00	29	92.0	0.00	0.77	0.63	0.77	0.63

[a] Temporal Components: 1 (6/08-6/21); 2 (6/22-6-30); 3 (7/01-7/07); 4 (7/08-7/14); 5 (7/15-7/21); 6 (7/22-7/31).

[b] Daily periods for temporal components 1-6: A (0630-1029); B (1030-1429); C (1430-1829); D (1830-2230).

Appendix D5. Summary of daily angler effort (angler-hours), catch, and harvest for rainbow trout in the sport fishery in the lower Naknek River, 1992.

Temporal Component[a]	Date	Period[b]	Number of Counts	Mean Angler Count	Anglers Inter-viewed	Estimates by Period: Effort Estimate	Effort Variance	Catch Estimate	Catch Variance	Harvest Estimate	Harvest Variance
01	920608	B	4	0.75	8	3.0	3.33	3.30	4.09	0.00	0.00
01	920608	C	4	2.25	16	9.0	6.67	14.12	18.65	0.00	0.00
01	920609	A	1	5.00	1	20.0	0.00	0.00	0.00	0.00	0.00
01	920609	B	1	6.00	6	24.0	0.00	1.10	1.20	0.00	0.00
01	920610	A	4	7.50	4	30.0	30.67	0.00	0.00	0.00	0.00
01	920610	D	4	10.25	15	41.0	89.33	0.87	0.75	0.00	0.00
01	920611	B	1	2.00	5	8.0	0.00	0.00	0.00	0.00	0.00
01	920611	D	1	14.00	8	56.0	0.00	48.83	470.15	0.00	0.00
01	920613	B	1	13.00	20	52.0	0.00	8.53	64.18	0.00	0.00
01	920613	D	1	1.00	3	4.0	0.00	0.00	0.00	0.00	0.00
01	920614	B	4	31.00	21	124.0	226.00	4.22	19.22	0.00	0.00
01	920614	C	4	39.50	24	158.0	86.00	45.68	414.53	0.00	0.00
01	920615	A	1	2.00	0	8.0	0.00	0.00	0.00	0.00	0.00
01	920615	D	1	29.00	14	116.0	0.00	0.00	0.00	0.00	0.00
01	920616	A	1	10.00	10	40.0	0.00	4.35	6.99	0.00	0.00
01	920616	B	1	2.00	10	8.0	0.00	0.25	0.07	0.00	0.00
01	920617	A	1	0.00	0	0.0	0.00	0.00	0.00	0.00	0.00
01	920617	B	1	8.00	5	32.0	0.00	0.00	0.00	0.00	0.00
01	920618	B	1	14.00	18	56.0	0.00	1.06	1.17	0.00	0.00
01	920618	C	1	23.00	20	92.0	0.00	4.37	4.15	0.00	0.00
01	920619	A	1	3.00	4	12.0	0.00	0.00	0.00	0.00	0.00
01	920619	B	1	9.00	8	36.0	0.00	0.00	0.00	0.00	0.00
01	920620	A	1	20.00	0	80.0	0.00	0.00	0.00	0.00	0.00
01	920620	C	1	35.00	19	140.0	0.00	0.00	0.00	0.00	0.00
01	920621	B	1	73.00	22	292.0	0.00	60.50	2021.11	0.00	0.00
01	920621	C	1	32.00	10	128.0	0.00	18.85	163.70	0.00	0.00
02	920623	B	1	34.00	21	136.0	0.00	0.00	0.00	0.00	0.00
02	920623	C	1	9.00	25	36.0	0.00	1.26	0.56	0.00	0.00
02	920625	A	1	23.00	4	92.0	0.00	173.78	383.14	0.00	0.00
02	920625	B	1	55.00	33	220.0	0.00	10.81	60.38	0.00	0.00
02	920626	B	4	62.50	51	250.0	263.33	0.00	0.00	0.00	0.00
02	920626	D	4	21.75	21	87.0	99.33	6.38	15.88	0.00	0.00
02	920627	B	4	58.50	48	234.0	801.33	4.43	11.17	0.00	0.00
02	920627	C	4	72.75	77	291.0	1142.00	6.92	19.71	0.00	0.00
02	920628	A	1	24.00	14	96.0	0.00	0.00	0.00	0.00	0.00
02	920628	B	1	77.00	17	308.0	0.00	0.00	0.00	0.00	0.00
02	920629	C	4	82.25	40	329.0	1617.33	0.00	0.00	0.00	0.00
02	920629	D	4	52.50	30	210.0	54.00	1.68	3.02	0.00	0.00
02	920630	A	1	42.00	10	168.0	0.00	0.00	0.00	0.00	0.00
02	920630	D	1	35.00	22	140.0	0.00	1.78	3.15	0.00	0.00

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Appendix D5. (Page 2 of 3).

Temporal Component[a]	Date	Period[b]	Number of Counts	Mean Angler Count	Anglers Inter-viewed	Estimates by Period: Effort Estimate	Effort Variance	Catch Estimate	Catch Variance	Harvest Estimate	Harvest Variance
03	920702	C	4	46.25	49	185.0	758.00	50.20	659.32	0.00	0.00
03	920702	D	4	30.75	28	123.0	59.33	1.15	1.44	0.00	0.00
03	920703	B	1	78.00	17	312.0	0.00	0.00	0.00	0.00	0.00
03	920703	C	1	102.00	44	408.0	0.00	0.00	0.00	0.00	0.00
03	920704	A	4	65.25	12	261.0	1684.00	0.00	0.00	0.00	0.00
03	920704	B	4	82.75	94	331.0	574.67	46.50	353.49	0.00	0.00
03	920706	B	1	42.00	40	168.0	0.00	0.00	0.00	0.00	0.00
03	920706	D	1	21.00	29	84.0	0.00	0.00	0.00	0.00	0.00
03	920707	B	4	42.25	22	169.0	112.67	0.00	0.00	0.00	0.00
03	920707	C	4	46.25	37	185.0	342.67	0.00	0.00	0.00	0.00
04	920709	C	4	77.25	57	309.0	825.33	86.91	697.29	1.45	2.10
04	920709	D	4	28.75	61	115.0	217.33	8.65	27.16	0.58	0.32
04	920710	B	1	25.00	25	100.0	0.00	0.00	0.00	0.00	0.00
04	920710	C	1	80.00	50	320.0	0.00	0.00	0.00	0.00	0.00
04	920711	A	4	37.00	11	148.0	730.67	0.00	0.00	0.00	0.00
04	920711	B	4	76.50	57	306.0	311.33	1.49	2.25	0.00	0.00
04	920713	B	1	66.00	47	264.0	0.00	0.00	0.00	0.00	0.00
04	920713	D	1	18.00	26	72.0	0.00	0.96	0.43	0.00	0.00
04	920714	A	4	37.00	8	148.0	730.67	40.24	423.03	6.36	44.04
04	920714	D	4	26.25	21	105.0	310.00	0.00	0.00	0.00	0.00
05	920715	A	4	25.50	4	102.0	152.00	0.00	0.00	0.00	0.00
05	920715	B	4	28.25	33	113.0	30.00	0.00	0.00	0.00	0.00
05	920717	B	1	50.00	36	200.0	0.00	0.00	0.00	0.00	0.00
05	920717	D	1	17.00	27	68.0	0.00	0.00	0.00	0.00	0.00
05	920718	B	1	16.00	26	64.0	0.00	24.43	290.08	0.00	0.00
05	920718	C	1	50.00	11	200.0	0.00	0.00	0.00	0.00	0.00
05	920719	A	4	20.50	0	82.0	1079.33	0.00	0.00	0.00	0.00
05	920719	B	4	50.50	52	202.0	262.00	3.44	6.96	0.00	0.00
05	920721	C	4	18.25	31	73.0	49.33	0.45	0.20	0.00	0.00
05	920721	D	4	18.50	22	74.0	180.00	0.00	0.00	0.00	0.00
06	920722	B	1	26.00	16	104.0	0.00	0.00	0.00	0.00	0.00
06	920722	C	1	21.00	16	84.0	0.00	0.00	0.00	0.00	0.00
06	920723	A	4	11.75	11	47.0	65.33	0.00	0.00	0.00	0.00
06	920723	B	4	24.00	16	96.0	53.33	0.00	0.00	0.00	0.00
06	920724	B	1	38.00	28	152.0	0.00	0.00	0.00	0.00	0.00
06	920724	D	1	15.00	19	60.0	0.00	2.77	2.53	0.00	0.00
06	920726	A	1	17.00	0	68.0	0.00	0.00	0.00	0.00	0.00
06	920726	B	1	45.00	38	180.0	0.00	0.00	0.00	0.00	0.00
06	920727	B	4	18.50	20	74.0	263.33	0.00	0.00	0.00	0.00
06	920727	C	4	40.00	42	160.0	92.67	0.00	0.00	0.00	0.00
06	920728	A	1	0.00	0	0.0	0.00	0.00	0.00	0.00	0.00
06	920728	B	1	27.00	31	108.0	0.00	0.94	0.89	0.00	0.00

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			Number	Mean	Anglers	Estimates by Period					
						Effort		Catch		Harvest	
Temporal Component[a]	Date	Period[b]	of Counts	Angler Count	Inter-viewed	Estimate	Variance	Estimate	Variance	Estimate	Variance
06	920729	B	1	17.00	22	68.0	0.00	0.00	0.00	0.00	0.00
06	920729	C	1	27.00	13	108.0	0.00	0.00	0.00	0.00	0.00
06	920730	C	4	27.25	29	109.0	75.33	0.00	0.00	0.00	0.00
06	920730	D	4	22.50	39	90.0	22.67	2.01	1.99	0.98	1.02
06	920731	A	1	0.00	0	0.0	0.00	0.00	0.00	0.00	0.00
06	920731	D	1	23.00	29	92.0	0.00	0.00	0.00	0.00	0.00

[a] Temporal Components: 1 (6/08-6/21); 2 (6/22-6-30); 3 (7/01-7/07); 4 (7/08-7/14); 5 (7/15-7/21); 6 (7/22-7/31).

[b] Daily periods for temporal components 1-6: A (0630-1029); B (1030-1429); C (1430-1829); D (1830-2230).

APPENDIX E: ARCHIVING INFORMATION

Appendix E. Computer files used to produce this report.

Data Files

R007AIZ2.DTA	Naknek R. angler interviews 8 June-31 July 1992.
R007ACZ2.DTA	Naknek R. angler counts 8 June-31 July 1992.
R007ABA2.DTA	Naknek R. chinook salmon 1992 marking data.
R007ABB2.DTA	Naknek R. chinook salmon sport harvest biological data.
R007ABC2.DTA	Naknek R. chum salmon sport harvest biological data.
R007ABD2.DTA	Naknek R. coho salmon sport harvest biological data.
R007ABE2.DTA	Naknek R. chinook salmon escapement biological data.
R1550BA2.DTA	Paul's Creek chinook salmon escapement biological data.
R1430BA2.DTA	King Salmon Creek chinook salmon escapement biological data.
R1960BA2.DTA	Big Creek chinook salmon escapement biological data.

Analysis Programs

KS2.EXE	Program to calculate Kolmogorov-Smirnov 2-sample test on length data.
PETERBT.EXE	Program to conduct bootstrap resampling of capture history data and calculate Chapman-modified Petersen population abundance estimates.
UCSP92.EXE	Universal creel survey program: effort, catch, and harvest estimate program.
R007AC02.DTD	UCSP92 interview data control file.
R007AI02.DTD	UCSP92 count data control file.
BRA31NAK.RD	UCSP92 report table 1 descriptive file.
BRA32NAK.RD	UCSP92 report table 2 descriptive file.
BRA33NAK.RD	UCSP92 report table 3 descriptive file.
BRA31NAK.DB	UCSP92 table 1 data descriptive file.
BRA32NAK.DB	UCSP92 table 2 data descriptive file.
BRA33NAK.DB	UCSP92 table 3 data descriptive file.
R007AC02.STB	UCSP92 count data header file.
R007AI02.STB	UCSP92 interview data header file.
BBXPEXE	A series of programs that uses biological data files to produce tables of mean lengths and weights by sex and age group for a species.
CC91	A program which produces frequency reports from raw data.
NAKKSH92.WK1	A Lotus 1-2-3 (tm) worksheet which weights chinook salmon age data by temporal component.

These 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 99518-1519. Contact Gail Heineman or Donna Buchholz (267-2369) for copies of the files and descriptions of the file formats.