**Fishery Data Series No. 00-15**

# Assessment of Coho Salmon from the Kenai River, Alaska, 1997

**by**

**Jamie A. Carlon**

**September 2000**

**Alaska Department of Fish and Game** **Division of Sport Fish**

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**Weights and measures (metric)**

| | |
|---|---|
| centimeter | cm |
| deciliter | dL |
| gram | g |
| hectare | ha |
| kilogram | kg |
| kilometer | km |
| liter | L |
| meter | m |
| metric ton | mt |
| milliliter | ml |
| millimeter | mm |

**Weights and measures (English)**

| | |
|---|---|
| cubic feet per second | $ft^3/s$ |
| foot | ft |
| gallon | gal |
| inch | in |
| mile | mi |
| ounce | oz |
| pound | lb |
| quart | qt |
| yard | yd |

Spell out acre and ton.

**Time and temperature**

| | |
|---|---|
| day | d |
| degrees Celsius | °C |
| degrees Fahrenheit | °F |
| hour (spell out for 24-hour clock) | h |
| minute | min |
| second | s |

Spell out year, month, and week.

**Physics and chemistry**

| | |
|---|---|
| all atomic symbols | |
| alternating current | AC |
| ampere | A |
| calorie | cal |
| direct current | DC |
| hertz | Hz |
| horsepower | hp |
| hydrogen ion activity | pH |
| parts per million | ppm |
| parts per thousand | ppt, ‰ |
| volts | V |
| watts | W |

**General**

| | |
|---|---|
| All commonly accepted abbreviations. | e.g., Mr., Mrs., a.m., p.m., etc. |
| All commonly accepted professional titles. | e.g., Dr., Ph.D., R.N., etc. |
| and | & |
| at | @ |
| Compass directions: | |
| east | E |
| north | N |
| south | S |
| west | W |
| Copyright | © |
| Corporate suffixes: | |
| Company | Co. |
| Corporation | Corp. |
| Incorporated | Inc. |
| Limited | Ltd. |
| et alii (and other people) | et al. |
| et cetera (and so forth) | etc. |
| exempli gratia (for example) | e.g., |
| id est (that is) | i.e., |
| latitude or longitude | lat. or long. |
| monetary symbols (U.S.) | $, ¢ |
| months (tables and figures): first three letters | Jan,...,Dec |
| number (before a number) | # (e.g., #10) |
| pounds (after a number) | # (e.g., 10#) |
| registered trademark | ® |
| trademark | ™ |
| United States (adjective) | U.S. |
| United States of America (noun) | USA |
| U.S. state and District of Columbia abbreviations | use two-letter abbreviations (e.g., AK, DC) |

**Mathematics, statistics, fisheries**

| | |
|---|---|
| alternate hypothesis | $H_A$ |
| base of natural logarithm | e |
| catch per unit effort | CPUE |
| coefficient of variation | CV |
| common test statistics | F, t, $\chi^2$, etc. |
| confidence interval | C.I. |
| correlation coefficient | R (multiple) |
| correlation coefficient | r (simple) |
| covariance | cov |
| degree (angular or temperature) | ° |
| degrees of freedom | df |
| divided by | ÷ or / (in equations) |
| equals | = |
| expected value | E |
| fork length | FL |
| greater than | > |
| greater than or equal to | ≥ |
| harvest per unit effort | HPUE |
| less than | < |
| less than or equal to | ≤ |
| logarithm (natural) | ln |
| logarithm (base 10) | log |
| logarithm (specify base) | $\log_2$, etc. |
| mideye-to-fork | MEF |
| minute (angular) | ' |
| multiplied by | x |
| not significant | NS |
| null hypothesis | $H_O$ |
| percent | % |
| probability | P |
| probability of a type I error (rejection of the null hypothesis when true) | α |
| probability of a type II error (acceptance of the null hypothesis when false) | β |
| second (angular) | " |
| standard deviation | SD |
| standard error | SE |
| standard length | SL |
| total length | TL |
| variance | Var |

*FISHERY DATA SERIES NO. 00-15*

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# ABSTRACT

The harvest of coho salmon *Oncorhynchus kisutch* of Kenai River origin in selected Upper Cook Inlet (UCI) fisheries was estimated in 1997 from the recoveries of harvested adults marked with coded wire tags (CWTs) and adipose finclips (AFCs). An estimated 1,236 (SE = 166) coho salmon of Kenai River origin were harvested by the Central District drift gillnet fishery and an estimated 2,093 (SE = 279) were harvested by the Central District eastside set gillnet fishery. Additional directed and incidental sampling indicated that the commercial harvest of this population by other fisheries was small. The estimated harvests represented 2% of the total drift gillnet harvest of 79,094 coho salmon and 11% of the total eastside set gillnet harvest of 19,688 coho salmon. Commercial harvest estimates are the fifth available for this population of coho salmon.

Adult coho salmon returning to the Kenai River were examined for adipose finclips and the presence of a CWT in 1997. This examination was necessary to estimate the proportion of the return bearing CWTs (a partial requirement for estimating commercial harvest in 1997) and as the recapture event in a mark-recapture experiment to estimate smolt abundance in 1996. The sport harvest, the catch of a department-operated fish wheel, and the escapement through the Russian River weir (tributary to the Kenai River) were examined. Although the tagged proportion returning to the Russian River varied significantly over weekly intervals ($P < 0.001$), the tagged proportions in the sport harvest ($P = 0.93$) and fish wheel catch ($P = 0.90$) did not. In addition, the tagged proportions did not differ significantly between the sport harvest and the fish wheel catch ($P = 0.88$) and the data from these two sources were combined to estimate an overall tagged proportion (0.182). An estimate of the 1996, drainage-wide smolt abundance (524,323; SE = 45,597) was based on the number of adult fish examined from these two inriver sources in 1997 (604 examined), the number that were observed to have an AFC (110), and the number of smolt marked and released with an AFC in 1996 (98,032).

A creel survey, limited to the lower 34 km of the Kenai River, was conducted in 1997. The purpose was to document the dynamics of the sport fishery under the Kenai River Coho Salmon Management Plan that was first in effect during the 1997 season. However, due to the anomalous fishing season and conservation measures, fishery dynamics in 1997 did not reflect the intent of the management plan. Harvest (2,782 fish; SE = 626), catch (3,089 fish; SE = 699), and effort (26,857 hours; SE = 3,754) were estimated by the creel survey. These parameters were also estimated separately for guided boat anglers, unguided boat anglers, and shore anglers.



Key words: coho salmon, *Oncorhynchus kisutch,* population assessment, sustained yield, contribution, commercial harvest, coded wire tag, Kenai River, smolt abundance, wild.


# INTRODUCTION

## BACKGROUND

Coho salmon *Oncorhynchus kisutch* spawn and rear in freshwater drainages of Upper Cook Inlet (UCI, Figure 1). As they return to spawn, adults are harvested annually in mixed-stock commercial and sport marine fisheries. Sport and personal use harvests also occur in fresh water. The largest sport harvests and the fifth largest commercial harvests of coho salmon in the state of Alaska occur in UCI (Figure 2).

In 1991, the Alaska Department of Fish and Game (ADF&G) initiated a program to assess the status of UCI coho salmon stocks (Meyer et al. *Unpublished*). Despite the importance of UCI coho salmon fisheries, no such program existed before 1991. A primary study component of the program involves the wild population of coho salmon from the Kenai River. This population was selected for assessment because of large inriver harvests and because the level of exploitation was unknown. These coho salmon support the largest freshwater sport harvest in the state (Mills 1979-1994; Howe et al. 1995-1996) and contribute an average of about one of every five coho salmon sport-harvested in Alaska. The population also contributes to commercial

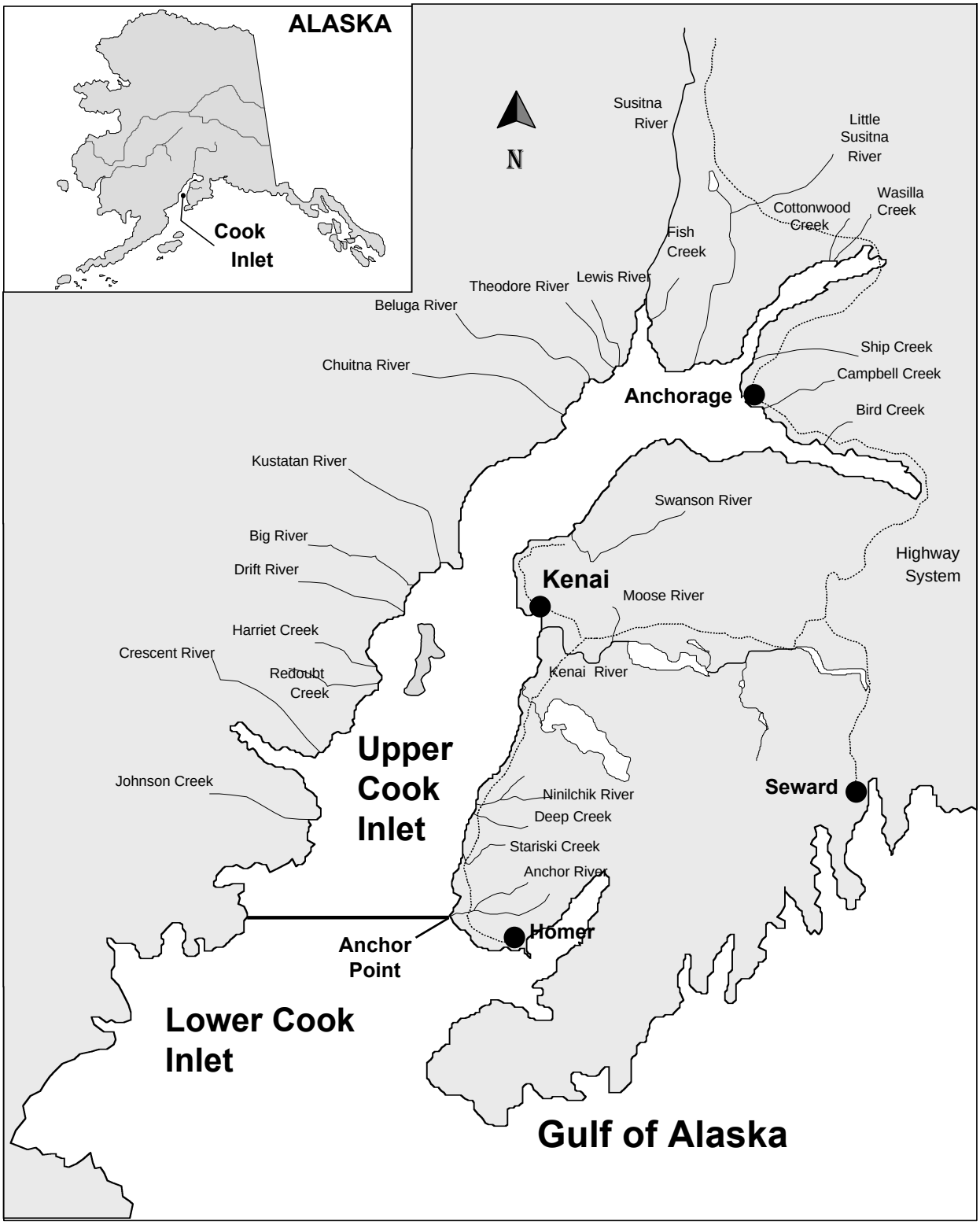



**Figure 1.-Schematic map of the Cook Inlet Basin with selected tributaries known to support coho salmon.**

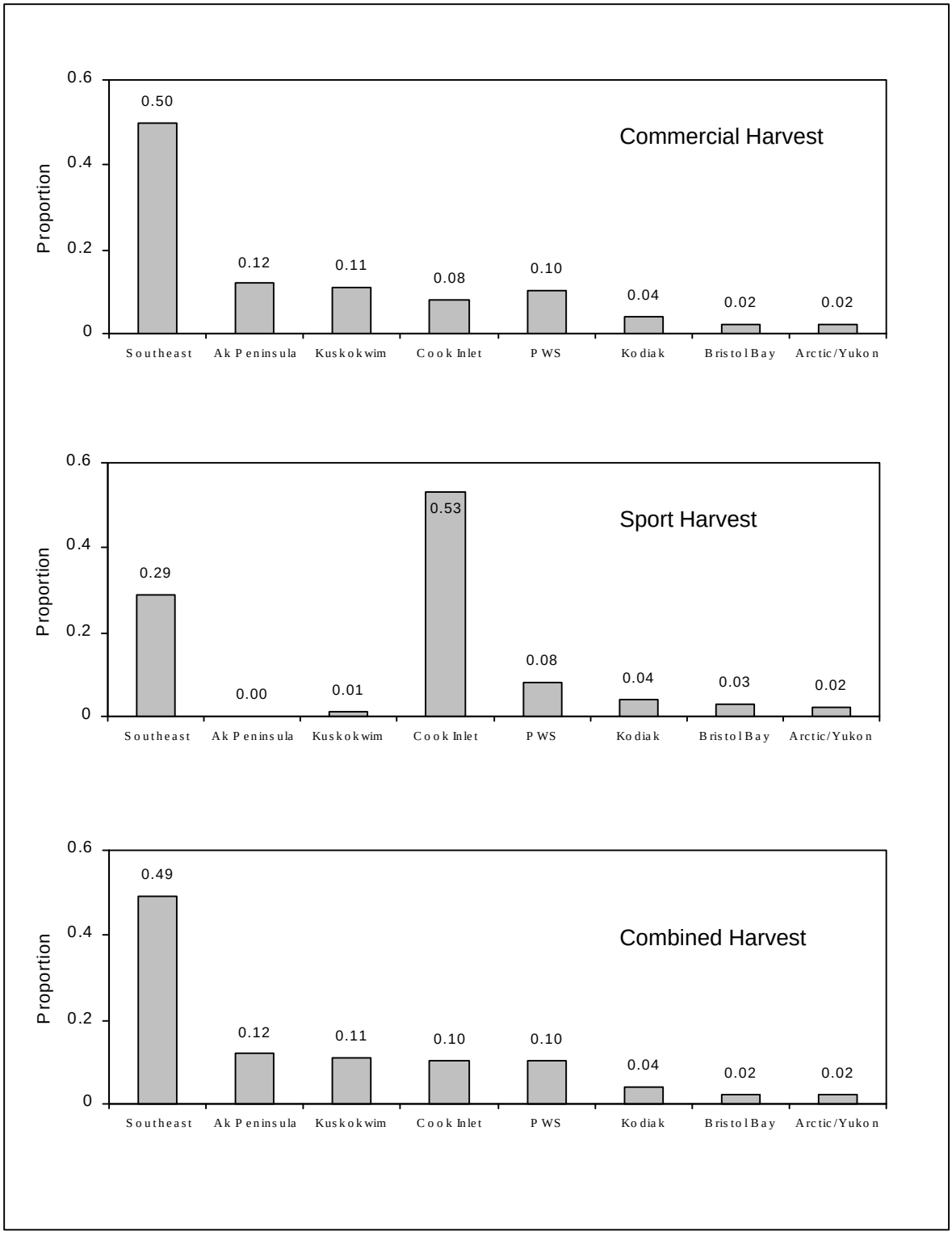



**Figure 2.-Average proportions by region of the statewide commercial and sport harvests of coho salmon, 1987-1996.**

marine fisheries in UCI and, to a lesser degree, to marine sport and inriver personal use fisheries which occur along migratory approach routes to the Kenai River.

The initial goal of the Kenai River population assessment program was to determine if the exploitation rate imposed by existing fisheries is threatening sustained yield (Meyer et al. *Unpublished*). To achieve this goal, a series of annual exploitation and production rates would be needed. A decline in production that could be associated with increasing exploitation would signal the need for conservation actions. The initial research approach described by Meyer et al. (*Unpublished*) was to annually estimate: (1) the population-specific harvest in marine commercial fisheries, (2) the inriver sport and personal use harvests, and (3) the spawning escapement. The combination of these three components would provide the desired annual estimates of exploitation and adult production.

Estimates of commercial harvest have been made annually since 1993 through a coded wire tag (CWT) release and recovery program (Carlon and Hasbrouck 1994, 1996-1998). Inriver sport and personal use harvests are estimated annually by angler surveys (Hammarstrom 1977, 1978, and 1988-1992; Schwager-King 1993; Mills 1979-1994; Howe et al. 1995-1996). Spawning escapements have not been estimated, and therefore, total adult production and exploitation remain unknown.

The feasibility of using sonar technology to enumerate the return was tested in 1993 (Bendock and Vaught 1994). The authors concluded that the selected sonar equipment could not discern between coho salmon and sockeye salmon *O. nerka* at the selected site because of similarities in fish size. Radiotelemetry was used to determine if differences in migration patterns existed which could be interpreted by sonar. There was no useful separation in migration patterns of radio-tagged fish; migration routes of both species were distributed across the entire stream channel. The development of sonar technology to enumerate coho salmon was therefore discontinued based on these results.

Mark-recapture experiments have been considered as an alternative to sonar, but have not been initiated because we would have to assume that marked adults survive at a similar rate as unmarked adults. A recent handling study conducted in another UCI tributary (Little Susitna River) indicated that coho salmon that were captured with sport tackle and handled in intertidal waters were highly susceptible to stress; a mortality rate of 69% was measured in captured fish (Vincent-Lang et al. 1993).

In the absence of adult production estimates, an alternative production measure is being considered. Smolt abundance has been estimated since 1992 as ancillary information from the tag release and recovery procedures used to estimate commercial harvest. Annual smolt production is therefore being monitored as an alternative to adult production for assessing stock status. Monitoring the relationship between exploitation and smolt production may obviate costly and complex procedures to estimate adult escapements. However, consideration of adult studies has not been abandoned. Monitoring smolt production is considered a long-term approach which may not provide for a timely and informed conservation response due to the sizable nature of the harvest of the Kenai River population (Carlon and Hasbrouck 1996-1998). Alternative capture and handling methods are under consideration in companion studies to estimate adult production.

Although smolt abundance monitoring is considered a long-term approach to developing a sustained yield management objective, available estimates have illustrated a relative decline since 1993 (Carlon and Clark *Unpublished*). Although the cause of the decline is unknown, it has heightened the level of concern for the sustainability of recent harvest levels. A recent response to this concern was the development and adoption of the Kenai River Coho Salmon Management Plan (Appendix A1) by the Alaska Board of Fisheries. The plan was first in effect during the 1997 fishing season and is considered an interim management response to the resource concern. Assessment program data are therefore being reviewed annually for their utility in refining the interim management plan as well as for the original, long-term goal of defining a sustained yield objective for the resource and the fisheries it supports.

This report is the fifth in a series of published estimates of the commercial harvest and smolt abundance of coho salmon from the Kenai River. It documents commercial harvests in 1997 and smolt abundance in 1996. Estimates of total harvest will become available late in 1998 when the Statewide Harvest Survey provides estimates of the 1997 inriver sport and personal use harvests. These estimates, when combined with the commercial harvest estimates presented in this report, will represent the fifth consecutive annual estimate of total harvest for this population.

For the first time, this assessment report will also document methods and results of an onsite creel survey of the coho salmon fishery that occurred in the lower 34 kilometers of the Kenai River. The creel survey was conducted in 1997 to document the response of the fishery to the newly adopted management plan, to provide fishery dynamics information with which to refine the plan, and to provide managers with inseason harvest-rate data. The survey was a response to the recently identified resource concern and fulfilled the need for more immediate fishery information than provided by the Statewide Harvest Survey.

## STUDY AREA

Smolt were captured for marking in 1996 as they emigrated from the Moose River (Figure 3), a tributary to the Kenai River at Kenai River kilometer (rkm) 60.5. The 1997 creel survey was conducted in the lower 34 kilometers of the Kenai River. Anglers were interviewed at access locations to estimate harvest, effort, and the portion of the return bearing tags. The catch of coho salmon in a fish wheel at rkm 31 was also examined to determine the tagged portion of the return. A weir was operated on the Russian River (Kenai River tributary at rkm 118) throughout the duration of the coho salmon return. Samples of adults commercially harvested in the drift and eastside set gillnet fisheries of the Central District and the set gillnet fisheries of the Northern District were examined at processing locations located along the UCI coastline in 1997. The statistical area of examined harvests was recorded when possible (Figure 4).

## OBJECTIVES

The primary objectives of this study were:

1. to estimate the harvest of coho salmon of Kenai River origin in the eastside set gillnet and drift gillnet fisheries of the Central District of UCI in 1997;
2. to estimate the number of coho salmon smolt that emigrated from the Kenai River in 1996; and

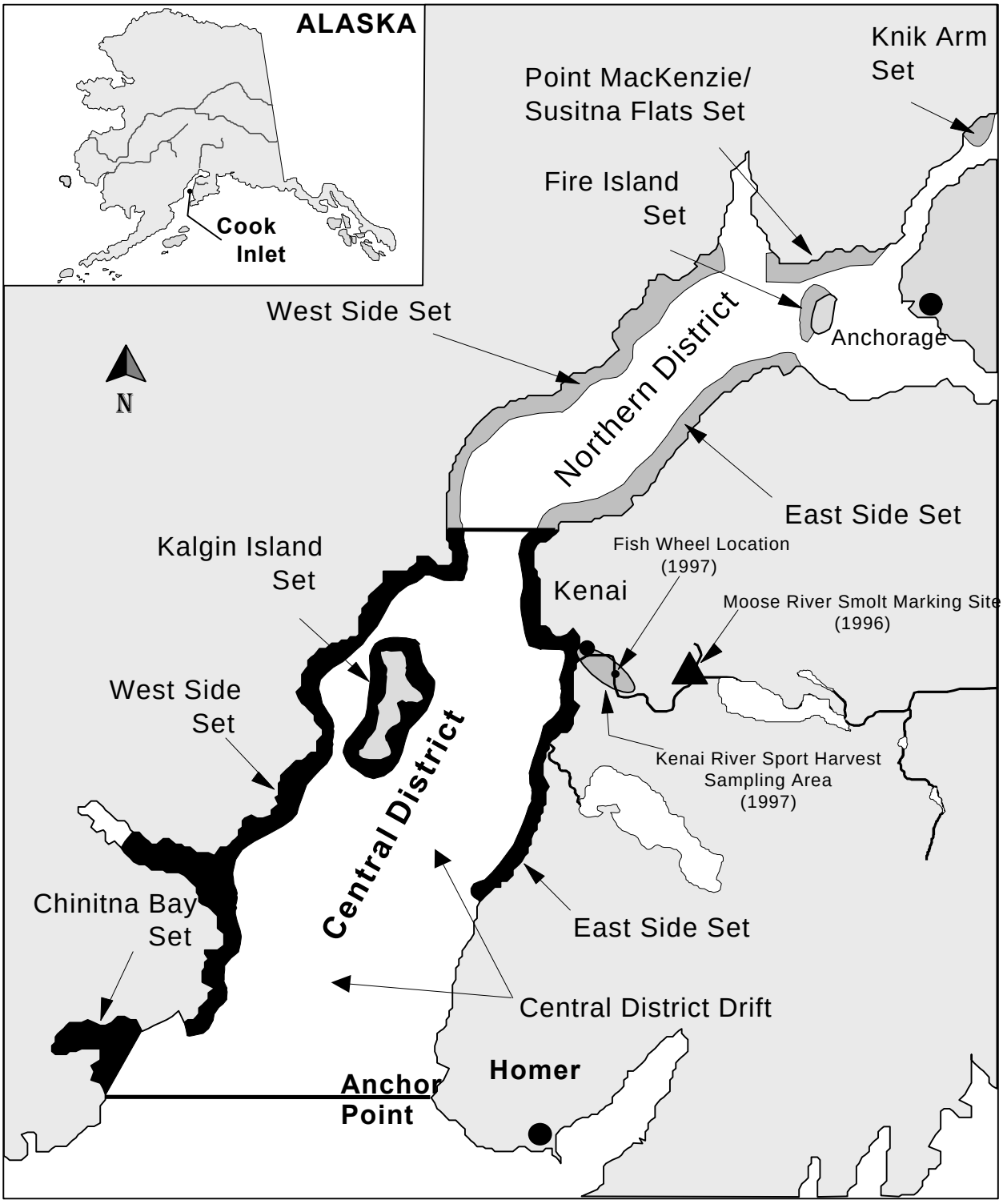



**Figure 3.-Schematic map of Upper Cook Inlet showing 10 commercial set gillnet and drift gillnet fishery areas, location at which marked coho salmon smolt were released in the Kenai River drainage in 1996, Kenai River fish wheel location in 1997, and river section in which the sport harvest was examined in 1997.**

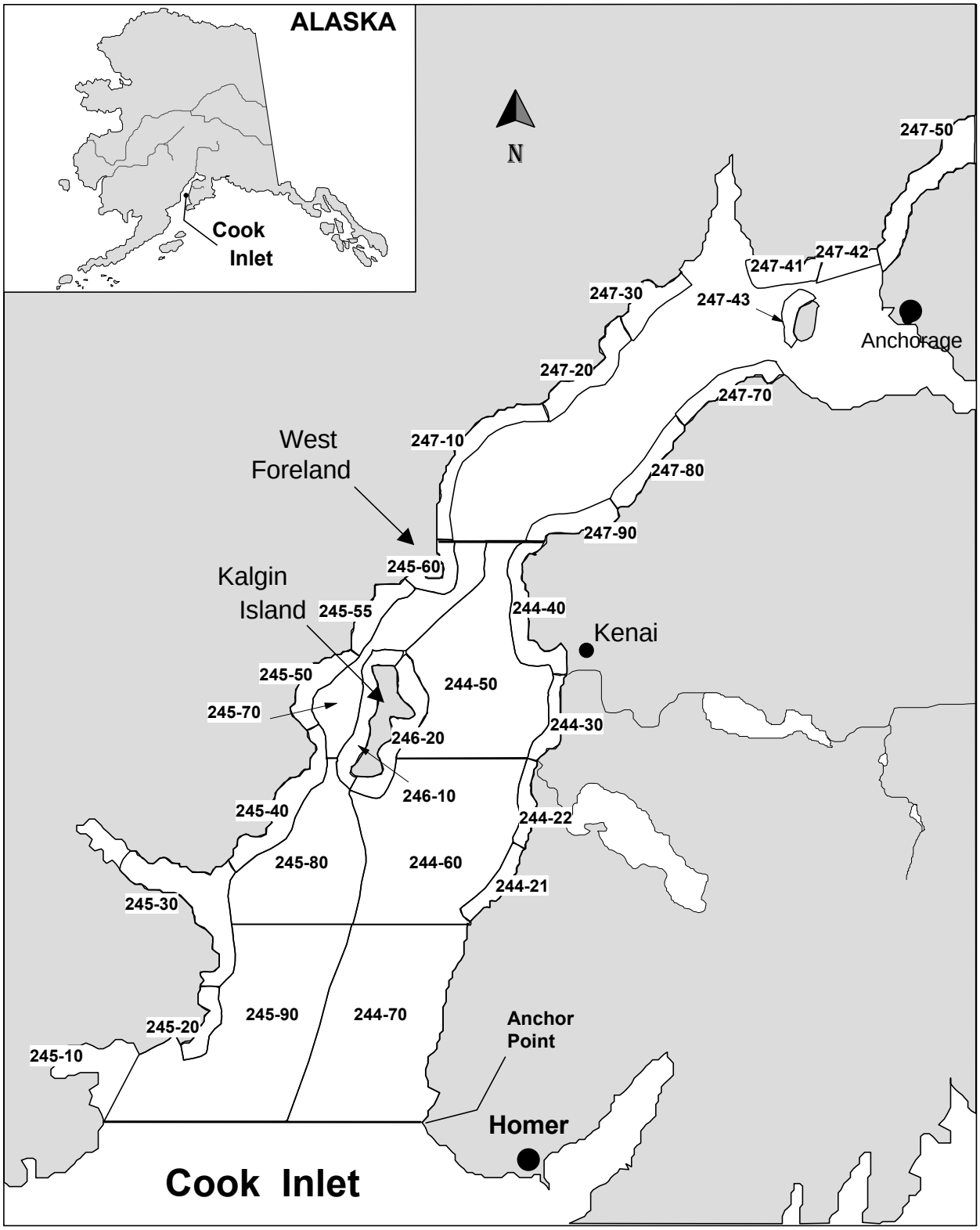



**Figure 4.-Schematic map of Upper Cook Inlet statistical areas.**

3. to estimate the harvest of coho salmon and effort expended by coho salmon anglers in the lower 34 kilometers of the Kenai River during August and September, 1997.

Prerequisite objectives were:

1. to test the null hypothesis that the marked proportion remained constant over the duration of the return from August 1 through September 30, 1997; and, if constant,
2. to estimate the marked proportion of the adult population returning to the Kenai River from August 1 through September 30, 1997.

# METHODS

Assessment program methodology includes experimental design, data collection, and data analysis phases. Each phase is described as it applies to each primary objective.

## EXPERIMENTAL DESIGN AND ASSUMPTIONS

### Commercial Harvest Objective

Harvest from a population of salmon in a mixed-population fishery can be estimated by marking juveniles in fresh water and recovering marked adults in the fishery. Total harvest in the fishery and the fraction of fish in the population of interest bearing marks must be known or estimated. The number of marks recovered from the fishery can then be expanded into a population-specific harvest estimate to account for unmarked fish in the population and for the portion of the total harvest not examined.

To estimate commercial harvest of coho salmon bound for the Kenai River, a sample of juvenile coho salmon was captured from within the Kenai River drainage in 1996, marked with CWTs, and released. Total harvest of coho salmon in 1997 commercial fisheries was available from the Alaska Department of Fish and Game commercial fishery fish ticket database system. The marked fraction of the adult return to the Kenai River was estimated by examining a sample of the return in 1997.

An assumption of this methodology is that marked fish are a representative sample of the drainage-wide smolt emigration or of the subsequent adult return with respect to return timing (Clark and Bernard 1987). Marked fish must mix with unmarked fish in the population such that the fraction of marked fish remains constant throughout the adult return. A constant marked fraction measured from inriver samples implies such mixing and implies that the marked fraction estimated from inriver samples is an accurate estimate of the marked fraction of the population as it passed through commercial harvest areas prior to entering the river.

This assumption of mixing was evaluated by examining samples of coho salmon returning to the Kenai River and testing the hypothesis that the marked fraction did not change over time. Failure to reject this hypothesis confirms that marked fish mixed with unmarked fish between the marking and recovery events. Furthermore, failure to reject the hypothesis indicates that the marked fraction can best be estimated by pooling inriver samples over time.

Rejecting the hypothesis would indicate that marked fish were a biased sample of the population. Substantial bias would prohibit the estimation of commercial harvest because the marked fraction passing through commercial harvest areas would be unknown. However, if bias is minimal,

commercial harvest estimates may still be practical and valid for current research and management applications.

A final requirement for an accurate estimate of commercial harvest is accuracy of the estimated marked fraction. To estimate the marked fraction of the return, it must be assumed that the sport harvest from the lower 34 km section was representative of the return. This is likely a valid assumption because of the wide distribution of angler effort (both spatially and temporally) and because estimates of catch and harvest are nearly identical (Hammarstrom 1992; Schwager-King 1993) indicating that the sport fishery is nonselective. The validity of this assumption, however, has not been directly tested.

### Smolt Abundance Objective

All marking and recovery efforts associated with the objective of estimating commercial harvest also provided the data with which to estimate smolt abundance. The experimental design is a mark-recapture experiment. If all assumptions of the mark-recapture model are valid, the inriver examination of an adult return for marked fish yields an accurate estimate of the drainage-wide smolt abundance during the year in which adults were marked as smolt.

As with the model used to estimate commercial harvest, estimates of smolt abundance were considered accurate if mixing of marked smolt with unmarked smolt occurred between the marking and recovery years. This assumption was also tested by examining the inriver adult samples for temporal variations in the marked fraction. A constant marked fraction was considered an indication that smolt of all return timings were marked in proportion to their abundance.

In contrast to the commercial harvest model however, temporal variations in the marked fraction do not necessarily result in estimation inaccuracy. Mark-recapture models are inherently robust because bias in selecting individuals during the marking phase can be overcome by random selection of individuals during the recovery phase. In the case of the current experiment, bias in selection of individuals during both phases was considered minimal. Additional details of smolt model assumptions are described in the data analysis section.

A final noteworthy difference between the commercial harvest and smolt abundance experimental designs is that the mark of interest differs between experiments even though the recovery events are very similar. The commercial harvest estimate, as described in the previous section, relies on the proportion of the return that physically bears a CWT implanted in Kenai River smolt. Each tag of Kenai River origin is then expanded by the tagged proportion to account for untagged fish in the harvest. In contrast, the smolt abundance estimate relies on the AFC mark; recovery of the CWT itself is not necessary because all returning adults that are missing an adipose fin are assumed to have been marked as smolt emigrating from the Kenai River the previous year. Prior studies indicate that straying into the Kenai River of marked populations from other river systems is insignificant.

### Inriver Sport Harvest and Angler Effort Objective

A stratified multistage, roving-access creel survey was applied during the 1997 fishing season to estimate coho salmon catch, harvest, and effort in the Kenai River downstream of the Soldotna Bridge, rkm 34 (rm 21), to Cook Inlet, rkm 0 (rm 0). This river section was chosen because a

consistent majority (62%) of the mainstem harvest occurs there (Mills 1979-1994; Howe et al. 1995-1996). Harvest estimates were intended to serve as an interim index of the mainstem-wide harvest until such estimates become available through the Statewide Harvest Survey. The 1997 creel survey was therefore limited to this river section to avoid the unnecessary cost of conducting a river-wide survey.

Completed-trip angler interviews were conducted at access locations to estimate catch per unit effort (CPUE) and harvest per unit effort (HPUE). Angler counts were made from a roving boat to estimate effort. The catch and harvest were estimated as the product of estimated CPUE and HPUE and the estimated effort.

Estimates of coho salmon harvest and effort were stratified by type of day (Mondays, Tuesdays through Fridays, and weekends). Additionally, estimates were poststratified by type of angler (guided boat anglers, unguided boat anglers, and shore anglers). Total effort, catch, and harvest were estimated by summing the respective strata estimates.

It is not known if harvest rates in this fishery are proportional to abundance. Therefore, harvest rates are not considered essential to the long-term assessment approach at present. However, daily harvest rates were estimated to provide an inseason measure of fishery performance relative to past seasons. Catch rates and catch were also estimated as a relative measure of fishery performance for inseason management.

### 1997 Fishing Season

An unprecedented fishery scenario occurred in 1997. Weak and late returns of coho salmon to UCI resulted in exceptionally low harvests and curtailed fishing seasons.

At present, there is no official forecast of the UCI coho salmon return. However, a less rigorous "outlook" (Ruesch and Fox 1998) called for an average commercial harvest in 1997. Early inseason commercial harvests that were substantially below average forewarned of the potential for weak returns to UCI drainages. Sport angler interviews indicated that very few fish were harvested in the Kenai River during the first week of August and the harvest rate was nearly zero. In addition, weirs on several drainages in Cook Inlet indicated that the number of fish present in streams was far below average for early August. These inriver indications suggested weak returns to a wide geographical area and the sport fishing emergency order was issued for all Cook Inlet drainages.

Although conservation concerns could not be quantified for specific populations, continued harvesting of a potentially weak return was deemed imprudent due to a lack of quantifiable population status indicators for UCI populations in general. After the August 4 fishing period, all commercial fishing in UCI was closed for the remainder of the season by emergency order (Appendix A2). A second, inlet-wide emergency order (Appendix A3) restricted the sport fishing daily bag and possession limits to one fish and prohibited the use of bait. This emergency order applied to all flowing fresh waters of Cook Inlet after August 8.

In addition to these inseason management actions, the Kenai River sport fishery was operating under the newly adopted coho salmon management plan for the first time. The plan limited the inriver coho salmon season to July 1 through September 30. In addition, guided fishing was not permitted on Mondays downstream from the confluence of the Moose and Kenai rivers and guided fishing for coho salmon was not permitted on Mondays upstream from the confluence.

Finally, sport fishing guides could not fish while guiding clients. In the past, there were no such restrictions on fishing guides, and the fishing season was open from July 1 through December 31. The area open to fishing remained unchanged in the plan (river mouth upstream to the outlet of Kenai Lake – rkm 137 – and tributaries downstream from Kenai Lake).

## DATA COLLECTION

Data collection occurred during two calendar years. Mark release data were collected when smolt were captured and marked in 1996 and mark recovery data were collected in 1997 from commercial harvests and from inriver sources (sport harvest, rkm 31 fish wheel, and Russian River weir).

### Juvenile Marking in 1996

Juveniles were captured for marking in 1996 at a single location within the Kenai River drainage. Prior to 1994, juveniles were captured at a variety of locations (Carlon 1992, Carlon and Hasbrouck 1993). However, subsequent recoveries of adults marked as juveniles indicated that the Moose River was the only location that provided a suitable sample of smolt for marking (Carlon and Hasbrouck 1994). In addition to providing access to a sufficient number of smolt, the Moose River provided smolt that were representative of the entire Kenai River population with respect to adult return timing (Carlon and Hasbrouck 1994). Therefore, since 1994, juveniles have been marked only at the Moose River.

Observations and data collected during the marking of emigrants from the Moose River from 1992 through 1994, and subsequent recoveries of marked adults, indicate that smolt comprise nearly 100% of the annual springtime emigration from the Moose River. All CWTs recovered from marked adults returning to spawn in 1993 through 1995 had been implanted in juveniles emigrating from the Moose River the prior year (Carlon and Hasbrouck 1994-1998). The recovery of adults tagged two years prior to recovery has never occurred. CWTs implanted during all segments of the 1992 through 1995 emigrations have been recovered from adults the year following tagging. In addition, the similar behavior (mass downstream migration), appearance (silver skin pigmentation obscuring parr marks), migration timing (about May 20 through June 15), and narrow length distributions (Carlon 1992; Carlon and Hasbrouck 1993) are indications that most of the juvenile coho salmon emigrating from the Moose River each spring are smolt. Although juveniles shorter than 100 mm (fork length) were present during each emigration, these were not marked because they were substantially different in appearance (parr marks highly visible and substantially less silver skin pigmentation), there were very few of them (<100), and scale samples from fish shorter than 100 mm all exhibited only one annulus (most coho salmon of Kenai River origin undergo smoltification after 2 years in fresh water [Hammarstrom 1988-1992]).

Additional evaluation of smolt marking at the Moose River from 1992 through 1994 indicated that the date of arrival at the weir was independent of the eventual adult return timing (Carlon and Hasbrouck 1994, 1996, 1997). Therefore, as a cost-saving measure, an attempt was made to achieve the marking goal of 95,000 (Carlon *Unpublished*) as quickly as possible. When the marking goal was achieved on June 14, the weir was dismantled, and therefore, an emigration census was not made in 1996. Observations indicate that most smolt arriving at the weir were tagged through June 14, but the number passing after June 14 is unknown.

A weir with a trap was installed in the mainstem of the Moose River at rkm 7.5 to capture smolt for marking as they emigrated from overwintering lakes in the drainage. The weir was a total barrier to fish migration during the period May 18 through June 14, 1996. Virtually all smolt arriving at the weir were marked and released. Observations of smolt holding upstream of the weir indicated that migration timing was more protracted in 1996 than in prior years and most fish were marked within 2 days of arrival at the weir. This permitted the marking of all smolt captured during 1996 with the exception of several hundred fish that either escaped or died during capture or handling.

Fish captured in the weir trap throughout each day were partially immobilized by sedating with MS-222 to a level-two anesthesia (Yoshikawa et al. 1988), hand-sorted into one of three length groups, and transferred to instream holding pens. Buckets were used to transfer smolt from the holding pens to a marking facility located on the stream bank near the weir trap. For marking, fish were handled and marked following standard CWT application procedures (Moberly et al. 1977). Fish were sedated to a level-three anesthesia (Yoshikawa et al. 1988) and the adipose fin was excised with surgical scissors. All were then tagged with a Northwest Marine Technologies® Mark IV tag injector fitted with the optimal headmold for each length group. Fish ≤ 125 mm were tagged using a 30-per-pound headmold, those > 125 mm and ≤ 150 mm were tagged with a 20-per-pound headmold, and those > 150 mm were tagged with a 15-per-pound headmold. Headmolds were chosen to result in proper and precise tag placement in fish of each length group (Northwest Marine Technologies, Inc. 1990; Peltz and Hansen 1994). All marked fish were released to continue their downstream migration after recovering from anesthesia in an instream holding pen.

Groups of smolt were batch marked; a single tag code was applied to all individuals in the group. The number marked per group ranged from 3,797 to 11,902 depending on the number of tags per tag spool. This resulted in 12 tag code groups being released during the emigration.

Short-term survival and tag retention rates were estimated for juveniles marked during each tagging shift by detaining samples of about 200 marked fish in holding pens overnight. These rates were monitored as a quality control measure. Substantial decreases in survival or tag retention would identify the need to adjust capture, handling, or marking procedures. Survival and tag retention rates were also used to estimate the total number of smolt that survived tagging and retained tags after release.

## Estimating the Tagged Proportion of the 1997 Return

Three inriver sample sources were examined in 1997 to estimate the tagged proportion of the return. These were the sport harvest, the fish wheel catch at rkm 31, and the return of fish to the Russian River weir. Data from these sources were also examined to determine if the recovery of AFC fish could be used to estimate smolt abundance.

### Sport Fishery

In spite of the inseason and management plan restrictions, anglers did initially participate in the 1997 Kenai River sport fishery, but participation declined earlier than usual. The creel survey was conducted from August 2 through September 10, after which it was discontinued due to low angler participation and success rates.

As part of the angler interview process, harvested coho salmon were examined for an AFC. The number of fish examined and the number with an AFC were recorded by each technician. If a fish had an AFC, the fish head was removed (with the angler's permission) so that the CWT could be recovered. All data, including the number of coho salmon examined, the number with an AFC, and the number of heads recovered, were recorded on an ADF&G Coded Wire Tag and Otolith Processing Laboratory (Tag Lab) Coded Wire Tag Sampling Form. Coho salmon heads were shipped to the Tag Lab in Juneau, Alaska where the CWTs were removed, decoded, data keypunched, and archived. The raw data are accessible via the World Wide Web at URL http://tagotoweb.adfg.state.ak.us.

**Fish Wheel**

Due to the weak return and minimal sport harvest in 1997, the desired sample of 800 fish every 2 weeks could not be examined in the creel survey. To supplement the number of fish examined for an AFC, the catch of a fish wheel was examined. The fish wheel is operated annually at rkm 31 by the Commercial Fisheries Division (CFD). The primary purpose of operating the fish wheel is to estimate species proportions for application to sonar counts. It is typically operated through the sockeye salmon return, which is nearly complete in early August. In 1997, Division of Sport Fish personnel continued operation of the fish wheel through September 17 to increase the number of coho salmon examined for a mark and to provide relative catch rate information for management purposes during the weak return.

The fish wheel was operated and its catch was examined for species composition every day from July 1 through September 17. All coho salmon captured were examined for an AFC from August 15 through September 16 (the last day on which coho salmon were caught). A sample of the fish found to have an AFC were checked with an electronic tag detection wand for the presence of an embedded CWT.

**Russian River Weir**

Supplemental information was also sought at the Russian River, a tributary to the Kenai River at approximately rkm 118. Sockeye, coho, and chinook *O. tshawytscha* salmon spawn in the drainage annually. The Russian River supports an intense, directed sport fishery for sockeye salmon and the return is managed for an escapement goal. A weir is used to census that escapement and is usually operated until about mid-September, the approximate end of the sockeye salmon return. In 1997, weir operation was extended through October 6 to enumerate later-returning coho salmon and to examine the Russian River segment of the population for marked fish. Fish were not sacrificed for CWT retrieval nor were they detained to check for the presence of a CWT with a tag detection wand. Fish were simply counted and visually examined for AFCs as they passed through the weir.

The Russian River weir is the only existing facility in the Kenai River drainage that permits enumeration of coho salmon, but escapements have been enumerated there only twice before 1997 (Marsh 1995; Nelson 1983). An escapement count at the Russian River weir was therefore deemed valuable during the 1997 return because of the conservation concern that developed.

## Commercial Harvest in 1997

Upper Cook Inlet commercial fisheries typically harvest coho salmon between late June and early September. The fisheries are managed primarily for sockeye salmon through various

combinations of time and area restrictions. Fishery management guidelines for all species are described in the Upper Cook Inlet Salmon Management Plan; 1997 management actions are documented by Ruesch and Fox (1998).

Fisheries selected for sampling during 1997 included the drift gillnet and the eastside set gillnet fisheries of the Central District and the set gillnet fisheries of the Northern District. These areas historically account for most of the UCI harvest (Ruesch and Fox 1995). Northern District fisheries typically harvest less than 200 coho salmon of Kenai River origin (Carlon and Hasbrouck 1994, 1996, 1997), but were sampled to estimate the harvest of hatchery-produced coho salmon stocked in Northern District streams (Cyr et al. 1999). Harvests in other UCI commercial fisheries were sampled incidentally throughout the season.

In 1997, both the drift gillnet and eastside set gillnet fishing seasons opened on June 27. The harvest in both fisheries was examined through the last fishing period on August 4, as were the harvests in Northern District fisheries. After the August 4 fishing period, all commercial fishing in UCI was closed for the remainder of the season by emergency order.

Until commercial fisheries were closed, harvested coho salmon were examined at processing plants, buying stations, and aboard tenders throughout UCI to recover CWTs from AFC fish. Sampling personnel roved among commercial processing locations (main plants and buying stations) and recorded daily totals of the number of coho salmon examined and the number that had an AFC. Heads were collected from AFC fish, frozen, and later shipped to the Tag Lab for retrieval of the embedded CWT. Date sold (date harvested), statistical area of harvest when available, and processor was also recorded. In general, the statistical area was known for set gillnet harvests. Drift gillnet harvests were typically a mixture of fish from multiple statistical areas. All tag recovery data were keypunched and archived by the Tag Lab. The raw data are accessible via the World Wide Web at URL http://tagotoweb.adfg.state.ak.us.

### Inriver Sport Harvest and Effort in 1997

Angler counts and interviews were conducted on the Kenai River downstream of the Soldotna Bridge. Two technicians, operating a boat, were primarily responsible for the angler counts and two technicians, operating automobiles, were primarily responsible for angler interviews. The count technicians collected angler interviews when time permitted.

Angler counts were made as the boat was driven through the survey area during scheduled count times. The following data were recorded during each count: (1) number of unguided power boats; (2) number of unguided drift boats; (3) number of guided power boats; (4) number of guided drift boats; (5) number of unguided anglers in power boats; (6) number of unguided anglers in drift boats; (7) number of guided anglers in power boats (excluding the guide); (8) number of guided anglers in drift boats (excluding the guide); and (9) number of shore anglers.

Interview technicians conducted completed-trip angler interviews at scheduled access locations and times. An attempt was made to interview all anglers exiting the fishery during the time surveyed. If more anglers exited the fishery than could be interviewed, care was taken to avoid interview bias toward successful or unsuccessful anglers. The following data were recorded for each interviewed angler: (1) boat or shore angler (if boat, powered or non-powered); (2) guided or unguided angler; (3) total hours fished; (4) coho salmon harvest (number retained), and (5) coho salmon released.

## DATA ANALYSIS

Several steps were required to achieve the objectives of estimating smolt production and commercial harvest of coho salmon of Kenai River origin. These were: (1) estimate the number of smolt marked in 1996 that survived the marking process, (2) test the hypothesis that the proportion of tagged adults observed inriver in 1997 did not change over time, (3) estimate the marked proportion of the adult return in 1997, and (4) estimate smolt production in 1996 and commercial harvest for the two Central District commercial fisheries of interest in 1997.

In addition, creel survey analyses were performed to estimate harvest, catch, harvest and catch rates, and angler effort for the 1997 inriver sport fishery.

### Juvenile Marking in 1996

Short-term mortality and CWT loss were estimated to determine the total number of viable, AFC and CWT smolt released in 1996. Short-term survival and CWT retention for smolt marked during each shift were estimated from a random sample of about 200 AFC smolt that were detained in holding pens for 18 to 24 hours after marking. Short-term survival rate $(s_k)$ for smolt marked and released during marking shift k was estimated as the fraction of smolt that survived detainment.

Short-term CWT retention rate $(b_k)$ for smolt that were marked during a shift and that survived was estimated as the fraction of surviving smolt that had retained their tags.

The total number of smolt marked with a CWT during each shift k $(m'_k)$ was adjusted to account for short-term survival and tag retention as:

$$\hat{m}_k = m'_k \hat{s}_k \hat{b}_k . \qquad (1)$$

The total number of smolt marked with a CWT at the Moose River in 1996 was estimated by summing the $m'_k$ over all shifts. This was required to determine when the goal of releasing 95,000 tagged fish was achieved. The total number of smolt marked with an AFC was likewise estimated by summing the $\hat{m}_k$ over all shifts. Note that this was the estimated number of smolt released with a mark during the release event of the mark-recapture experiment to estimate smolt abundance.

### Estimating the Tagged Proportion of the 1997 Return

Estimating the commercial harvest of coho salmon of Kenai River origin in 1997 required estimating the proportion (θ) of the return bearing CWTs. This proportion was unknown at the time of smolt marking in 1996, but was estimated when adults returned in 1997 by examining fish from three different sampling sources. These sources were the inriver sport harvest, the catch of coho salmon in the fish wheel at rkm 31, and the return of fish to the weir on the Russian River.

Estimation of θ was a four-step process. The first step involved estimating the proportion $(y_{gi})$ of fish examined in each of the sampling sources g that had an AFC during each weekly interval i. The second step involved estimating the proportion $(c_{gi})$ of the AFC fish in each sample source g during each weekly interval i that carried a CWT implanted at the Moose River

in 1996. The third step involved estimating the proportion ($\theta_{gi}$) of fish examined in sampling source g during weekly interval i that carried a CWT implanted at the Moose River in 1996. This proportion was estimated as the product of $(y_{gi})$ and $(c_{gi})$. The fourth step involved a battery of hypothesis tests to determine if samples could be combined over weekly intervals and among sample sources to provide a single estimate of $\theta$ for the 1997 return that carried CWTs implanted at the Moose River in 1996.

Fish were not sacrificed to retrieve CWTs from fish wheel-caught adults, nor from adults examined at the Russian River weir due to the conservation concerns associated with the weak return in 1997. However, a CWT detection wand was used to check for the presence of a CWT in a sample of AFC fish recovered at the fish wheel to determine the tagged proportion $(c_{gi})$ of that sample. Because all CWTs recovered from the sport harvest originated from the Moose River in 1996, we assumed that all fish having a CWT at the fish wheel and all AFC fish observed at the Russian River weir were marked at the Moose River in 1996.

For each sampling source g, a chi-square statistic was then used to test the hypothesis that the proportion of fish carrying a Moose River tag did not change among weekly intervals ($\alpha = 0.05$). Failure to reject the hypothesis would indicate that the tagged proportion did not change over time and that an overall estimate of the tagged proportion ($\theta_g$) in the return could be made by pooling data over weekly intervals.

A chi-square statistic ($\alpha = 0.05$) was then used to compare the resultant overall estimates of the tagged proportion ($\theta_g$) among sampling sources to determine if sample data could be combined among sources to provide a more precise estimate of the overall tagged proportion in the 1997 return.

### Estimating the 1996 Smolt Emigration

Marking smolt in 1996 and inriver sampling of marked adults in 1997 also provided data to estimate the number of smolt that emigrated from the Kenai River in 1996. The mark used to estimate smolt abundance was the AFC as opposed to the presence of a CWT which was used to estimate commercial harvest. The model used to estimate smolt abundance was the Chapman modified Lincoln-Petersen model (Seber 1982):

$$\hat{N} = \frac{(M+1)(C+1)}{(R+1)} - 1, \tag{2}$$

where:

M = the number of smolt marked with an AFC and surviving to emigrate in 1996,

C = the number of adult coho salmon examined for an AFC in the 1997 return sample, and

R = the number of adult coho salmon in the 1997 sample that had an AFC.

The variance was estimated by:

$$\hat{V}(\hat{N}) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}. \tag{3}$$

This model produces unbiased estimates of abundance if:

1. adult coho salmon examined for AFCs were a random sample of the 1997 inriver return, or the AFC sample of smolt were a random sample of the drainage-wide smolt emigration in 1996, or marked and unmarked fish mixed during the interim;
2. all juveniles marked with an AFC at the Moose River in 1996 were actually smolt;
3. survival and catchability were the same for AFC and unmarked individuals;
4. adipose fins were not regenerated between the mark and recovery events;
5. there was no natural loss of adipose fins between marking and recovery; and
6. fish were correctly categorized for the presence or absence of an adipose fin when examined at each inriver sampling source.

Independence between adult return timing and time of tagging as smolt would indicate that mixing of marked with unmarked fish occurred after tagging. Too few CWTs were recovered during 1997 to test for independence. However, the return timing of marked adults and the time of smolt marking were independent for the 1993-1996 returns (Carlon and Hasbrouck 1994, 1996-1998), indicating that mixing did occur. Additional analyses indicated that smolt that emigrate from the Moose River are representative of the entire Kenai River population with respect to return timing. Also, the sample of sport-caught fish examined should be representative if not random because of the wide spatial and temporal distribution of the fishing effort.

The remaining five assumptions are also probably valid. Previous experience and observations indicate that most juveniles marked at the Moose River each year are smolt (assumption 2) (Carlon and Hasbrouck 1997). Short-term survival of marked smolt has been nearly 100% during all smolt-marking events at the Moose River (assumption 3) (Carlon and Hasbrouck 1994, 1996-1998), although long-term survival and catchability assumptions remain untested for this wild population. For hatchery-produced coho salmon marked with AFCs and CWTs and released in a western Kenai Peninsula drainage system, the smolt-to-adult survival was no different than that of unmarked coho salmon (Vincent-Lang 1993). Regeneration of adipose fins probably occurs (assumption 4). The frequency of regeneration is unknown, but probably negligible. No quantitative study has been carried out to estimate the occurrence of naturally missing adipose fins in the Kenai River drainage (assumption 5). However, of the 1 million coho salmon juveniles handled for tagging since 1991, less than 100 were missing the adipose fin. Naturally missing adipose fins appear to be a rare occurrence in coho salmon in the Kenai River drainage. If this phenomenon was common, it would result in differences between short-term and long-term tag retention rates (a fish with a naturally missing adipose fin would be identified as an individual that lost its CWT). The short-term and long-term tag retention rates have been nearly identical (Carlon and Hasbrouck 1994, 1996-1998).

## Commercial Harvest in 1997

Estimates of commercial harvest of coho salmon of Kenai River origin were stratified by date (fishing period). The eastside set gillnet harvest was additionally stratified by statistical area. The drift gillnet harvest was not stratified by area because sampled fish were often a mixture of the harvest from more than one statistical area. The total harvest of Kenai River coho salmon in each fishery was estimated by summing estimates of each stratum. Because strata were

considered independent, the variance of total harvest was calculated by summing stratum variances. The Commercial Fish Ticketing System managed by the CFD provided the commercial harvest by fishery, date, and statistical area.

Commercial harvest of coho salmon of Kenai River origin was estimated; total harvest, number examined for marks, and number of CWTs recovered were considered known. The proportion of the return bearing marks was estimated by sampling the inriver sport harvest, the fish wheel catch, and the return of adults to the Russian River. The harvest of coho salmon of Kenai River origin in each commercial fishery stratum i was estimated by (Bernard and Clark 1996):

$$\hat{r}_i = N_i \hat{\theta}^{-1} \left( \frac{m_i}{\lambda_i n_i} \right) = N_i \hat{\theta}^{-1} \hat{p}_i , \tag{4}$$

where:

$N_i$ = total number of coho salmon harvested in stratum i,

$\theta$ = proportion of the 1997 Kenai River return marked with CWTs,

$m_i$ = number of decoded CWTs recovered in commercial fishery stratum i,

$n_i$ = number of fish harvested during stratum i and examined for an AFC,

$\lambda_i = \frac{a_i' t_i'}{a_i t_i}$ = the decoding rate of CWTs for marked fish recovered from stratum i,

$a_i$ = number of heads collected in stratum i from fish with an AFC,

$a'_i$ = number of heads collected in stratum i that arrive at the Tag Lab,

$t_i$ = number of heads in stratum i with CWTs detected, and

$t'_i$ = number of CWTs found and decoded.

This estimator is statistically unbiased when sampling is from a simple random or pseudo-random process (Clark and Bernard 1987). When the proportion marked is estimated, the large-sample approximation of the variance of commercial harvest is (Bernard and Clark 1996):

$$\hat{V}(\hat{r}_i) = \hat{r}_i^2 \left[ G(\hat{p}_i) + G(\hat{\theta}^{-1}) - G(\hat{p}_i) G(\hat{\theta}^{-1}) \right] , \tag{5}$$

where:

$$G(\hat{p}_i) = \frac{1 - \lambda_i \phi_i \hat{\theta}}{m_i},$$

$$\phi_i = \frac{n_i}{N_i}, \text{ and}$$

$$G\left(\hat{\theta}^{-1}\right) = \frac{v(\hat{\theta}^{-1})}{\hat{\theta}^{-2}}.$$

Although the number of fish harvested is estimated by commercial processors as a product of pounds purchased and average weight per fish, the overall variance of the number harvested is considered small because the entire harvest is weighed. Therefore, the number of coho salmon harvested by fishery was considered a known constant, not an estimate. The variance component associated with estimated average weight is not known and is not included in the variance associated with 1997 harvest estimates. The extent of this variance component could be measured in the future based on data collected by ADF&G harvest sampling personnel.

Harvest estimates were based on sample data pooled among processors. Bias associated with this pooling is probably small because of the similarity of the marked proportion among intensively sampled processors in 1997 (Figure 5) and in prior years (Carlon and Hasbrouck 1997, 1998). The proportion bearing 1996 Moose River tags was no greater than 0.004 for intensively sampled processors of the drift harvest that processed a substantial number of fish (>3,000). Among intensively sampled processors of the eastside set gillnet harvest that processed a substantial number of fish (>1,500), the proportion ranged from 0.02 to 0.04. Therefore, pooling data among processors in 1997 should improve precision of harvest estimates without introducing significant bias.

The harvest occurring on unsampled dates was accounted for by combining the harvest on the unsampled date with the harvest occurring on the nearest sampled date. Accounting for unsampled dates in this way allows for comparisons of total harvest estimates among years regardless of unsampled dates.

### Inriver Sport Harvest in 1997

All analyses were stratified by day-of-week (weekdays, weekend days, Mondays) and poststratified by angler type (guided boat anglers, unguided boat anglers, and unguided shore anglers). Estimates were calculated by poststratum and stratum first, then summed to estimate seasonal totals (Appendix B).

## RESULTS

### JUVENILE MARKING IN 1996

Smolt were marked with CWTs and AFCs as they emigrated from the Moose River during May 21 through June 15, 1996 (Appendix A4). An estimated 98,032 of the 98,138 marked smolt survived the marking process based on the estimated short-term survival rate (99.9%). Of the marked smolt that survived, 97,744 retained CWTs based on the estimated short-term tag retention rate (99.7%). The weir was removed on June 16 after the marking goal of 95,000 was achieved and the remaining CWTs in the last tag lot were expended.

### TAGGED PROPORTION OF THE 1997 RETURN

### Sport Fishery in 1997

From August 2 through September 10, 1997, 317 sport-harvested coho salmon were examined (Table 1 and Appendix A5). Of these, 57 (18%) were missing an adipose fin. Heads were recovered from 34 (60%) of the 57 adipose-clipped adults observed. Of the 34 heads processed at the Tag Lab, all contained a tag implanted at the Moose River in 1996. No coho salmon were examined after September 7 due to minimal or nonexistent daily harvests. The creel survey was discontinued after September 10.

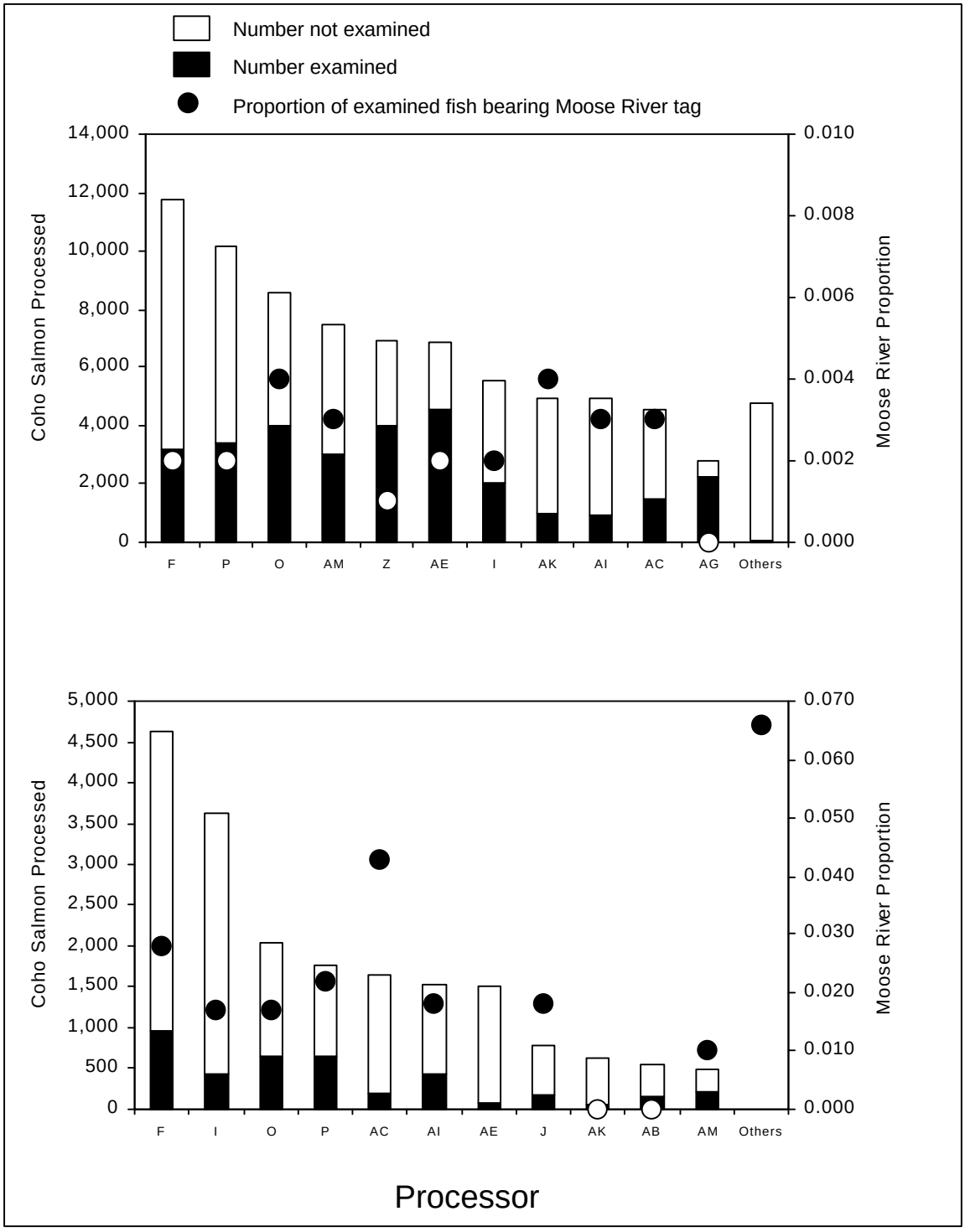



**Figure 5.-Number of coho salmon harvested and processed in 1997 in the Central District drift gillnet fishery (top) and the Central District eastside set gillnet fishery (bottom) of Upper Cook Inlet by commercial processor (total of shaded and unshaded bars), number examined (shaded bars), and proportion of examined fish that were originally marked at the Moose River in 1996 (dots).**

**Table 1.-Sources of coho salmon adults recovered at random from the Kenai River sport harvest by week, August 2 through September 7, 1997, from a fish wheel at river kilometer 31 by week, August 15 through September 16, 1997, and sources combined.**

| Weekly Period | Number Examined | Marked Fish Observed | $y_i$ [a] | Marked Fish Checked for a Coded Wire Tag [b] | Source = Moose R. 1996 | $c_i$ [c] | $Theta_i$ | Coded Wire Tag Missing or Not Detected [d] |
|---|---|---|---|---|---|---|---|---|
| **Sport Harvest** | | | | | | | | |
| 8/01-8/07 | 43 | 9 | 0.209 | 2 | 2 | 1.000 | 0.209 | 0 |
| 8/08-8/14 | 77 | 14 | 0.182 | 1 | 1 | 1.000 | 0.182 | 0 |
| 8/15-8/21 | 57 | 8 | 0.140 | 7 | 7 | 1.000 | 0.140 | 0 |
| 8/22-8/28 | 89 | 15 | 0.169 | 14 | 14 | 1.000 | 0.169 | 0 |
| 8/29-9/04 | 37 | 8 | 0.216 | 7 | 7 | 1.000 | 0.216 | 0 |
| 9/05-9/11 [e] | 14 | 3 | 0.214 | 3 | 3 | 1.000 | 0.214 | 0 |
| Total | 317 | 57 | 0.180 | 34 | 34 | 1.000 | 0.180 | 0 |
| **Fish Wheel (rkm 31)** | | | | | | | | |
| 8/15-8/21 | 122 | 25 | 0.205 | 25 | 24 [g] | 0.960 | 0.197 | 1 |
| 8/22-8/28 | 104 | 18 | 0.173 | 10 | 10 [g] | 1.000 | 0.173 | 0 |
| 8/29-9/04 | 18 | 2 | 0.111 | 1 | 1 [g] | 1.000 | 0.111 | 0 |
| 9/05-9/11 | 38 | 7 | 0.184 | 5 | 5 [g] | 1.000 | 0.184 | 0 |
| 9/12-9/18 [f] | 5 | 1 | 0.200 | 1 | 1 [g] | 1.000 | 0.200 | 0 |
| Total | 287 | 53 | 0.185 | 42 | 41 | 0.976 | 0.180 | 1 |
| **Sources Combined** | | | | | | | | |
| 8/01-8/07 | 43 | 9 | 0.209 | 2 | 2 | 1.000 | 0.209 | 0 |
| 8/08-8/14 | 77 | 14 | 0.182 | 1 | 1 | 1.000 | 0.182 | 0 |
| 8/15-8/21 | 179 | 33 | 0.184 | 32 | 31 | 0.969 | 0.179 | 1 |
| 8/22-8/28 | 193 | 33 | 0.171 | 24 | 24 | 1.000 | 0.171 | 0 |
| 8/29-9/04 | 55 | 10 | 0.182 | 8 | 8 | 1.000 | 0.182 | 0 |
| 9/05-9/11 | 52 | 10 | 0.192 | 8 | 8 | 1.000 | 0.192 | 0 |
| 9/12-9/18 | 5 | 1 | 0.200 | 1 | 1 | 1.000 | 0.200 | 0 |
| Total | 604 | 110 | 0.182 | 76 | 75 | 0.987 | 0.180 | 1 |

[a] Proportion of examined fish that were found with an adipose clip mark.

[b] Sport-caught fish were checked by dissecting the head and physically recovering the tag. Fish wheel-caught fish were checked with a tag detection wand before being released alive.

[c] Proportion of marked fish recovered that were originally marked at the Moose River in 1996 or proportion of marked fish in which a coded wire tag was detected with a tag detection wand.

[d] Missing in the case of sport-caught fish and not detected in the case of fish wheel-caught fish.

[e] Sport fishing effort and harvest were minimal during this weekly period due to low angler success rates and inseason fishing restrictions. The creel survey was discontinued after September 10.

[f] Fish wheel operation was discontinued during this weekly period after September 16 due to declining catch.

[g] All adipose-clipped fish are assumed to be of Moose River origin because all tags recovered from sport-caught fish were of Moose River origin.

The weekly tagged proportion ranged from 0.140 to 0.216, but did not vary significantly among weekly periods ($\chi^2 = 1.38$, df = 5, P = 0.93).

### Fish Wheel in 1997

The fish wheel was operated during a portion of each day from July 1 through September 17. Coho salmon, which were first caught on August 6, were not examined for adipose fin status until August 15.

From August 15 through September 16, 287 coho salmon were captured and examined (Table 1 and Appendix A6). Of these, 53 (18%) were missing an adipose fin. The tag detection wand was used to check 42 of the adipose-clipped fish and a tag was detected in all but one fish.

The weekly tagged proportion ranged from 0.111 to 0.200, but did not vary significantly among weekly periods ($\chi^2 = 0.85$, df = 4, P = 0.93).

### Russian River in 1997

The Russian River weir was operational from June 9 through October 6, but the first coho salmon did not arrive at the weir until August 13 (Table 2 and Appendix A7). Between August 13 and October 6, 4,104 coho salmon were passed through the weir and all were examined for adipose fin status. Of these, 675 (16%) were missing an adipose fin.

The weekly proportion of fish missing an adipose fin ranged from 0.094 to 0.292 and varied significantly among weekly periods ($\chi^2 = 64.73$, df = 6, P < 0.001). The weekly variation was characterized by a general increasing trend.

### Estimated Tagged Proportion

The estimated tagged proportion ($\hat{\theta}$) of the 1997 adult coho salmon return to the Kenai River was 0.180 [$V(\hat{\theta}^{-1}) = 0.3692$]. This estimate was based on the pooled data from the sport fishery and fish wheel sample sources. The data from these two sources were pooled because temporal variation in the tagged proportion was not detected at either source and because the proportions estimated from each source did not differ significantly from one another ($\chi^2 = 0.002$, df = 1, P = 0.96). In addition, the variation among weekly proportions was less than in previous years (Figure 6).

Data collected at the Russian River sample source were not pooled with the other two sources to estimate the overall tagged proportion in the return because of the temporal trend in the marked proportion observed at the weir in 1997. Although the overall marked (adipose-clipped) proportion measured at the Russian River (16%) did not differ significantly ($\chi^2 = 0.98$, df = 1, P = 0.32) from the pooled estimate of 18% (sport fishery and fish wheel sample sources), the trend indicated that marked fish returning to the Russian River may not be representative of the entire Kenai River population with respect to return timing. Because the estimated tagged proportion must be based on a representative sample of fish to accurately estimate commercial harvest, the Russian River data were excluded when estimating the tagged proportion of the 1997 return.

### Smolt Estimate in 1996

Because of the temporal consistency in the adipose-clipped proportions, the smolt estimate was based on data collected from both the inriver sport harvest and the fish wheel sample sources.

**Table 2.-Summary of coho salmon adults counted and examined for a missing adipose fin at the Russian River weir by week, August 1 through October 6, 1997.**

| Weekly Period | Weir Count | Number Examined | Marked Fish Observed | $y_i$ [a] |
|---|---|---|---|---|
| 8/08-8/14 [b] | 7 | 7 | 0 | 0.000 |
| 8/15-8/21 | 117 | 117 | 11 | 0.094 |
| 8/22-8/28 | 351 | 351 | 36 | 0.103 |
| 8/29-9/04 | 1,033 | 1,033 | 126 | 0.122 |
| 9/05-9/11 | 1,740 | 1,740 | 296 | 0.170 |
| 9/12-9/18 | 687 | 687 | 167 | 0.243 |
| 9/19-9/25 | 136 | 136 | 30 | 0.221 |
| 9/26-10/2 | 24 | 24 | 7 | 0.292 |
| 10/3-10/6 [c] | 9 | 9 | 2 | 0.222 |
| Total | 4,104 | 4,104 | 675 | 0.164 |

[a] Proportion of examined fish that were found with an adipose clip mark.

[b] The first coho salmon arrived at the weir on August 13, 1997.

[c] Weir operation was discontinued after October 6 due to the passage of coho salmon in numbers less than 1% of the cumulative total to date.

The Russian River weir data were not used to estimate smolt abundance because of the temporal change in the marked proportion that was detected as described above.

Based on the number of smolt that survived and were released with an adipose clip at the Moose River in 1996 (98,032), the number of adult coho salmon examined for adipose fin status in the Kenai River sport harvest and the fish wheel catch in 1997 (604), and the number of adults in the sample that were missing an adipose fin (110), an estimated 534,323 (SE = 45,597) smolt emigrated from the Kenai River in 1996.

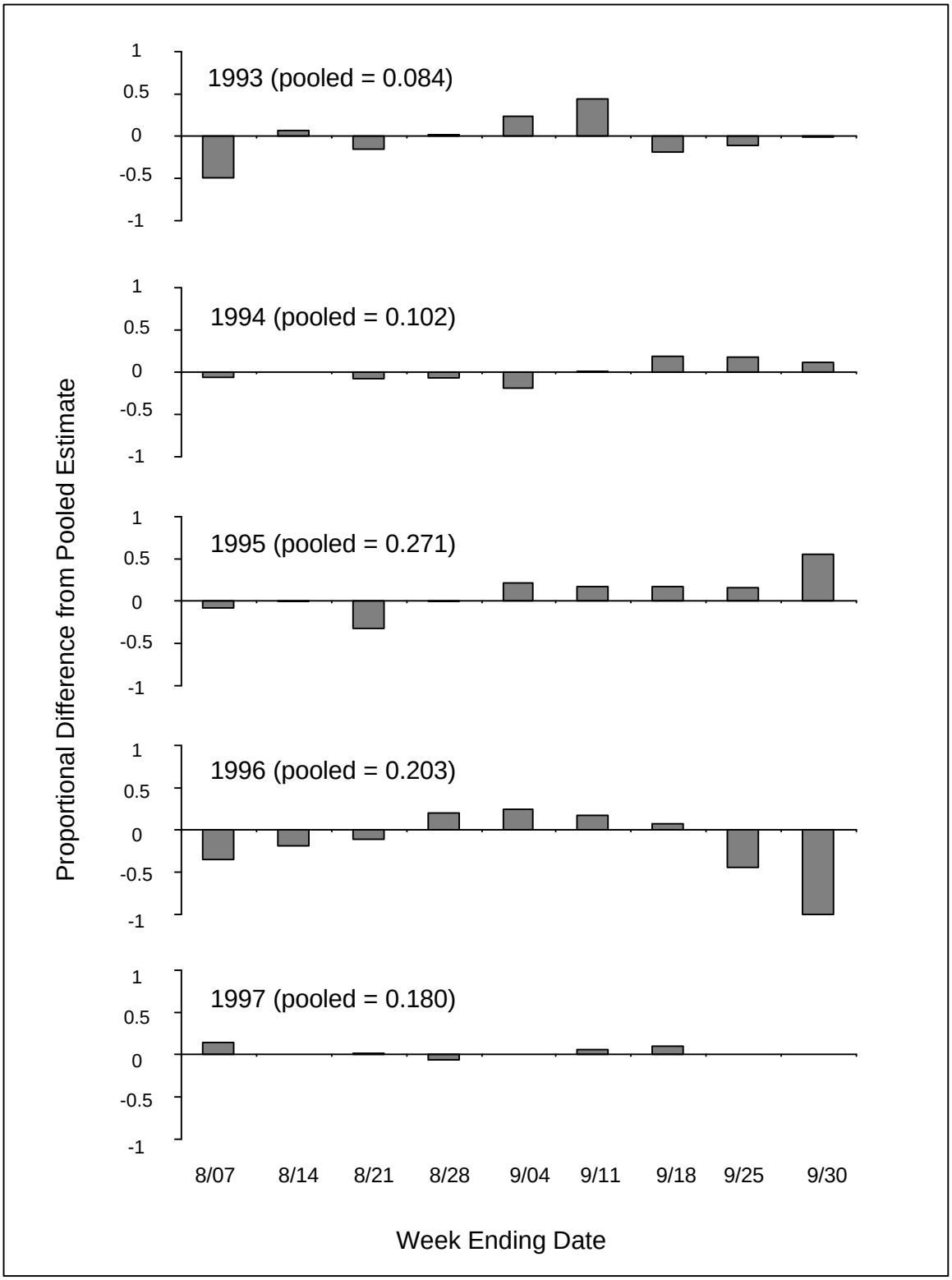



**Figure 6.-Difference between weekly estimates of the marked proportion of the return of coho salmon to the Kenai River and the pooled, seasonal estimate, 1993-1997 (difference is expressed as a proportion of the seasonal estimate).**

## COMMERCIAL HARVEST IN 1997

General inlet-wide sampling is summarized to add perspective and to document the recovery of marked coho salmon of Kenai River origin in other areas of Cook Inlet. Commercial fishery sampling is summarized in detail for the target fisheries of the Central District (drift and eastside set). Additional details of 1997 Northern District sampling efforts and recoveries of hatchery-produced coho salmon are documented in a companion report (Cyr et al. 1999).

### Inlet-Wide Fisheries

During the abbreviated 1997 fishing season, 152,836 coho salmon were harvested in commercial fisheries of UCI (Table 3). This harvest was 39% less than the average of the last 10 years (Ruesch and Fox 1998) and the lowest since 1973. About 75% of the 1997 UCI commercial harvest was taken in Central District fisheries (Figure 7). The greatest harvest occurred in the drift gillnet fishery of the Central District (52%), followed by the set gillnet fishery on the west side of the Northern District (17%), and the Central District eastside set gillnet fishery (13%). The other seven fisheries accounted for 18% of the total harvest.

Of the inlet-wide harvest, 65,460 fish (43%) were examined for adipose clips. Adipose-clipped fish were found in all sampled fisheries (except for the Kalgin Island set gillnet fishery where a small, incidental sample of 98 fish was examined on a single day). Exact fishery or statistical area of harvest could not be identified for 6,822 examined fish (Appendix A8); these fish were mixed among statistical areas prior to being delivered to processing/sampling locations. They were not used to calculate harvest estimates.

The remaining 58,638 examined fish were positively assigned to fishery strata (Appendix A9) and were used to calculate harvest estimates. Of these, 2,617 (4%) were missing the adipose fin, and heads were collected from all but 12. Of the 2,605 heads recovered, 181 (7%) had no tag, one was lost before it could be decoded, and one was not decodable, resulting in a total of 2,422 decodable tags. All of the decodable tags originated from UCI releases of hatchery-produced smolt or from the 1996 tagging and release of wild smolt in the Kenai River drainage.

Of the 2,422 decodable tags recovered from adults commercially harvested in known fishery strata, a total of 159 (7%) was originally released in smolt emigrating from the Kenai River drainage. All 159 were originally implanted in smolt emigrating from the Moose River in 1996. Most (95%) were recovered from Central District fisheries with only five Moose River tags recovered from known Northern District fisheries.

### Central District Drift Gillnet Fishery

The Central District drift gillnet fishery harvest was sampled during most fishing periods between June 27 and August 4 (Figure 8, Appendix A9). Overall, 38% of the harvest was examined (Table 3). The harvest occurring on days not sampled accounted for 1% of the total harvest.

The first recoveries of fish tagged at Moose River occurred on July 20, 23 days after the first fishing period. Coho salmon marked at the Moose River were recovered on all but 5 sampled days between July 20 and August 4. Of the 29,830 fish examined in this fishery, 0.2% had been marked as smolt at the Moose River in 1996.

**Table 3.-Summary of harvest, sampling effort, and recovery of coded wire tags (CWT) from adipose-less coho salmon harvested in Upper Cook Inlet commercial fisheries in 1997.**

| Gillnet Fishery | Harvest | Number Examined | Percent of Harvest Examined | Adipose Clips Found | Heads Recovered | Missing CWT or Unreadable | Heads with Decodable CWT [a] | Number from cohort marked at Moose R. in 1996 |
|---|---|---|---|---|---|---|---|---|
| | | | | **CENTRAL DISTRICT** | | | | |
| Drift | 79,094 | 29,830 | 38 | 1,193 | 1,186 | 91 | 1,095 | 66 |
| East Side Set (by Statistical Area) | | | | | | | | |
| 244-21 | 1,504 | 371 | 25 | 25 | 23 | 0 | 23 | 16 |
| 244-22 | 3,037 | 607 | 20 | 38 | 37 | 2 | 35 | 15 |
| 244-30 | 3,883 | 842 | 22 | 25 | 25 | 0 | 25 | 14 |
| 244-40 | 11,244 | 2,237 | 20 | 142 | 141 | 7 | 134 | 43 |
| East Side Set Total | 19,668 | 4,057 | 21 | 230 | 226 | 9 | 217 | 88 |
| Kalgin Is. Set | 8,905 | 98 | 1 | 0 | 0 | 0 | 0 | |
| West Side Set | 7,789 | 505 | 6 | 5 | 5 | 0 | 5 | 0 |
| Chinitna Bay Drift | 11 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Mixed East Side Set Stat. Areas [b] | | 224 | | 10 | 10 | 2 | 8 | 1 |
| Mixed Drift/East Side Set [c] | | 771 | | 27 | 27 | 1 | 26 | 1 |
| Mixed West Side/Kalgin Is. Set [d] | | 2,092 | | 27 | 27 | 2 | 25 | 2 |
| **Central District Total** | 115,467 | 37,577 | 33 | 1,492 | 1,481 | 105 | 1,376 | 158 |
| | | | | **NORTHERN DISTRICT** | | | | |
| West Side Set | 26,302 | 15,164 | 58 | 132 | 131 | 22 | 109 | 2 |
| East Side Set | 2,219 | 1,661 | 75 | 107 | 107 | 10 | 97 | 2 |
| Fire Is. Set | 3,748 | 2,274 | 61 | 366 | 366 | 20 | 346 | 0 |
| Pt. MacKenzie/Su Flats Set | 4,983 | 5,049 | 101 | 584 | 584 | 31 | 553 | 1 |
| Knik Arm Set | 117 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Mixed West/East Side Set [e] | | 2,529 | | 112 | 112 | 9 | 103 | 4 |
| Mixed Su Flats/Fire Is. Set [f] | | 73 | | 5 | 5 | 1 | 4 | 0 |
| Mixed Pt. MacKenzie/Fire Is. Set [g] | | 1,133 | | 123 | 122 | 5 | 117 | 0 |
| **Northern District Total** | 37,369 | 27,883 | 75 | 1,429 | 1,427 | 98 | 1,329 | 9 |
| **Grand Total** | 152,836 | 65,460 | 43 | 2,921 | 2,908 | 203 | 2,705 | 167 |

[a] Includes marked fish released in the Kenai River and at other Cook Inlet release locations.

[b] Examined fish were from a mixture harvested from among Central District eastside setnet fishery statistical areas.

[c] Examined fish were from a mixture harvested in the Central District drift and eastside setnet fisheries.

[d] Examined fish were from a mixture harvested in the Central District westside set and Kalgin Island setnet fisheries.

[e] Examined fish were from a mixture harvested in the Northern District west- and eastside setnet fisheries.

[f] Examined fish were from a mixture harvested in the Su Flats statistical area and the Fire Island setnet fishery.

[g] Examined fish were from a mixture harvested in the Pt. MacKenzie statistical area and the Fire Island setnet fishery.

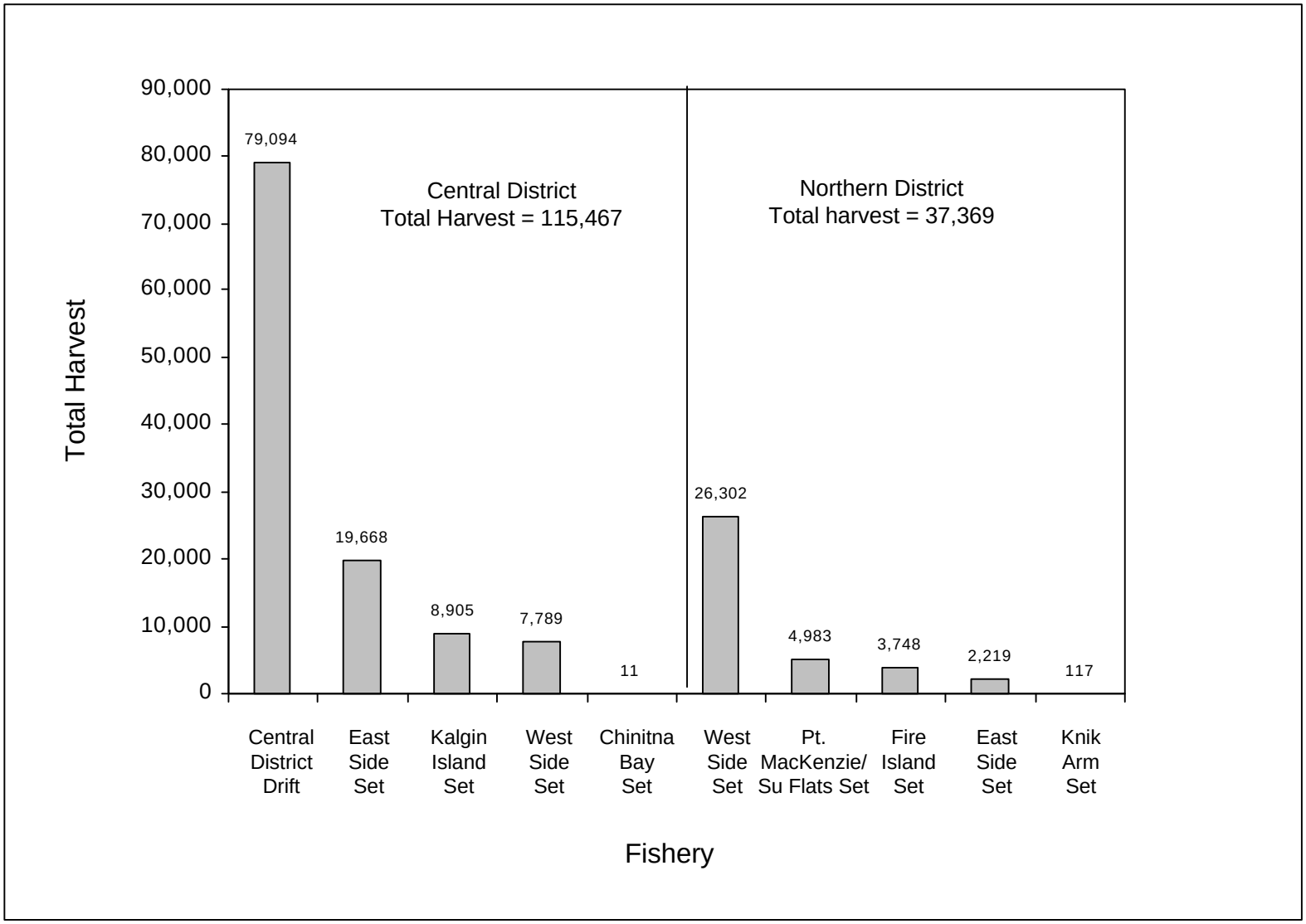
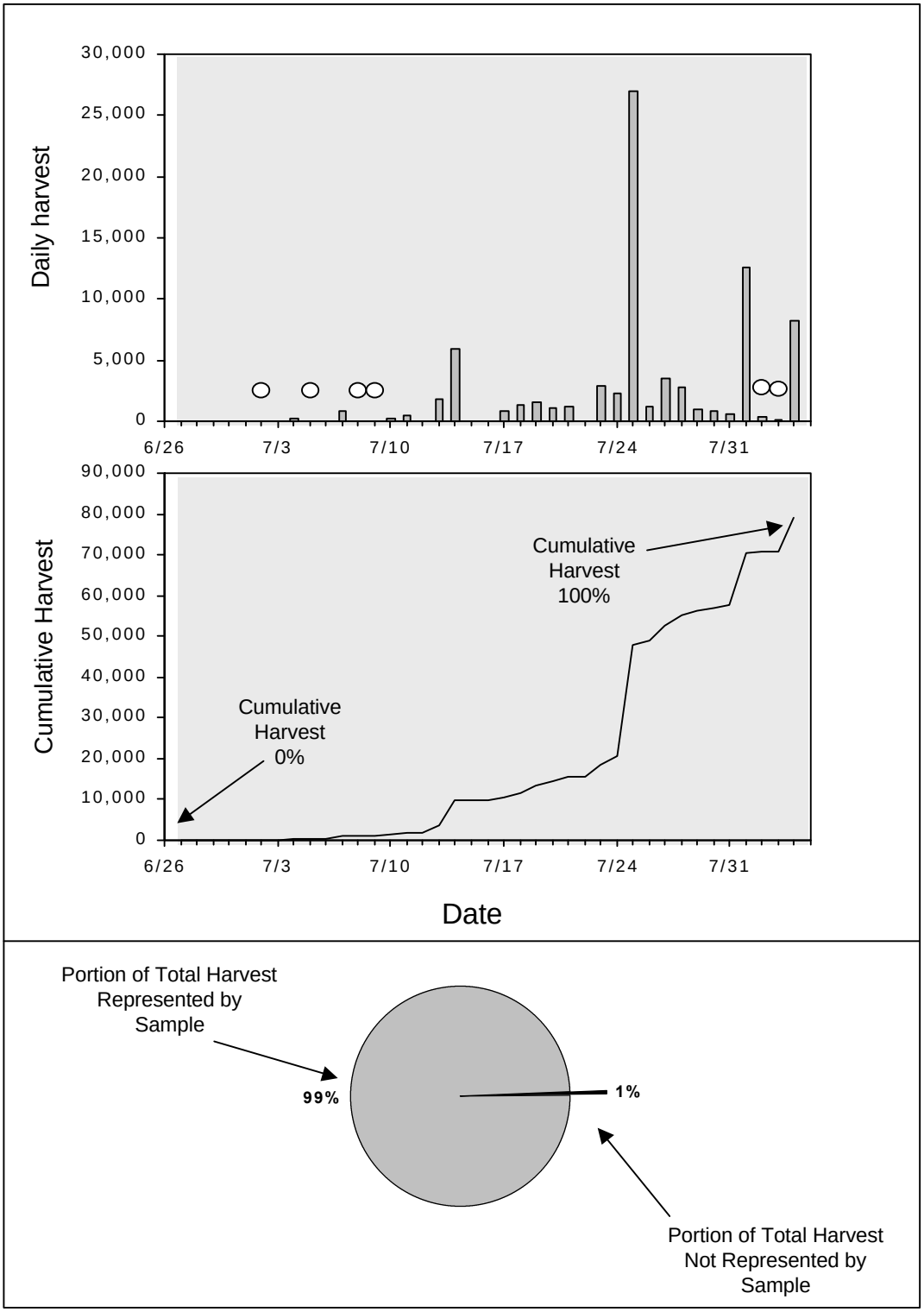



**Figure 7.-Coho salmon harvest in 10 Upper Cook Inlet commercial fishery areas in 1997.**




Note: Shaded region represents the time period during which the harvest was examined.

**Figure 8.-Coho salmon harvest and sampling performance occurring in the Upper Cook Inlet Central District drift gillnet fishery in 1997.**

### Central District Eastside Set Gillnet Fishery

The Central District eastside set gillnet fishery harvest was sampled during most fishing periods between July 5 and the last day of the fishery on August 4 (Figure 9, Appendix A9). Overall, 21% of the harvest was examined (Table 3). The harvest occurring on days not sampled accounted for 2% of the total harvest. Among statistical areas, small portions of the harvest (0% to 1.7%) were not examined early in the season (Figure 10). The portion of the harvest occurring on days not sampled ranged from 2% to 40% among statistical areas.

Coho salmon marked at the Moose River in 1996 were recovered from all four statistical areas in 1997. The first recovery of Moose River tags occurred on July 21 in statistical area 244-22, on July 23 in statistical area 244-30, and on July 25 in statistical areas 244-21 and 244-40. The portions of fish examined in 1997 that had been marked as smolt at the Moose River in 1996 were 4.3%, 1.7%, and 1.9% for statistical areas 244-21, 244-22, 244-30, and 244-40, respectively.

### Commercial Harvest Estimates

An estimated 1,236 (SE = 166) coho salmon of Kenai River origin were harvested by the drift gillnet fishery and 2,093 (SE = 279) by the eastside set gillnet fishery, for a total of 3,329 (SE = 325) during 1997 (Tables 4 and 5). Coho salmon of Kenai River origin comprised 2% of the total drift gillnet harvest and 11% of the total eastside set gillnet harvest in 1997.

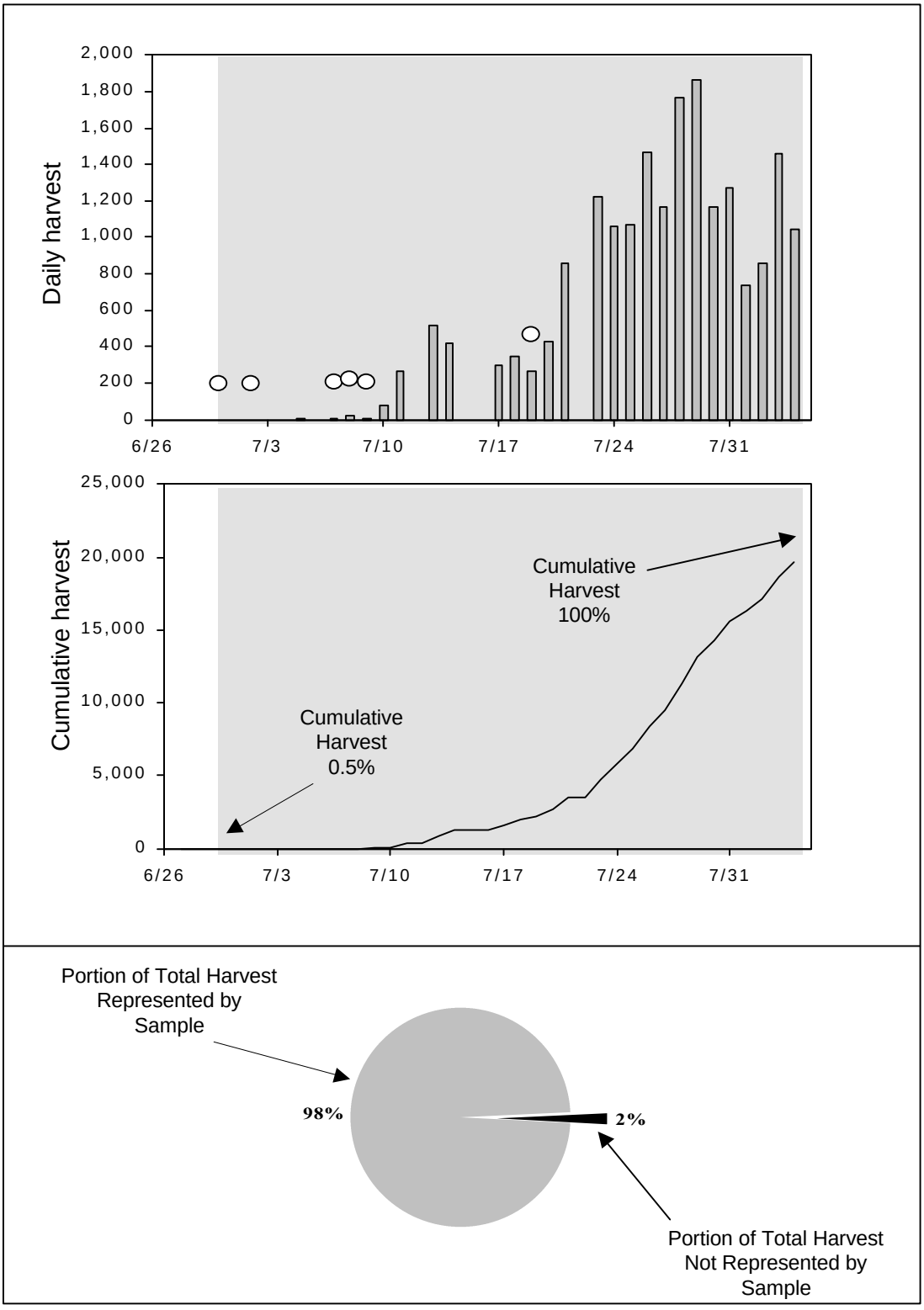
The harvest occurring in the drift gillnet fishery before the first coho salmon from the Kenai River were detected on July 12 represented 17% (13,369 coho salmon) of the total harvest. Virtually all (99%) of the harvest of coho salmon of Kenai River origin occurred during an 11-day period between July 25 and the last open fishing period on August 4. There was a temporal increase in the portion of the harvest comprising Kenai River fish (Figure 11). The greatest proportional contribution (4%) and the greatest absolute harvest occurred during the first 4 days of August (the last four fishing periods).

The harvest occurring in the eastside set gillnet fishery before the first coho salmon from the Kenai River were detected on July 21 represented 14% (2,681 coho salmon) of the total harvest. Among statistical areas, there was a consistent increasing temporal trend in the portion of the harvest made up of coho salmon of Kenai River origin (Figure 12), and the greatest absolute harvest occurred during the first 4 days of August (the last four fishing periods).

From the southernmost statistical area to the northernmost, there was an increasing geographical trend in total coho salmon harvest and a general decreasing trend in the portion of the harvest composed of coho salmon from the Kenai River (Figure 13). The result was a similar absolute harvest of Kenai River-bound coho salmon among statistical areas (all < 1,000).

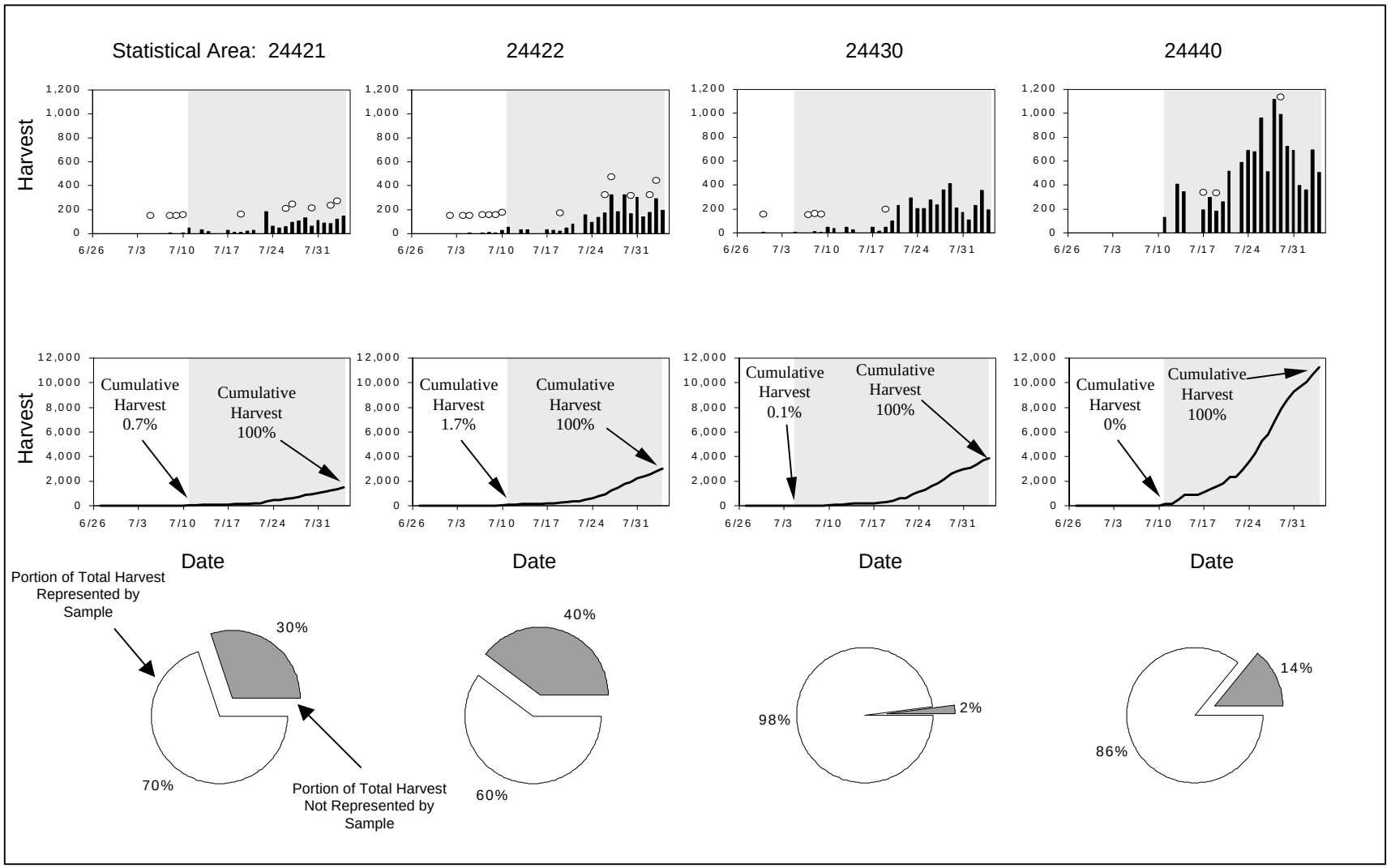
## INRIVER SPORT HARVEST IN 1997

An estimated 2,782 (SE = 626) coho salmon were harvested from the lower 34 km of the Kenai River by sport anglers in 1997. Estimated catch was 3,089 (SE = 699) coho salmon; estimated effort was 26,857 hours (SE = 3,754) (Table 6). The sample data and statistics upon which the estimates are based are archived in Appendix A10 (angler counts) and Appendix A11 (angler interviews). Because of declining angler participation, the survey was discontinued after September 10 and estimates of harvest, catch, and effort were not made by month.




Note: Shaded region represents the time period during which the harvest was examined.

**Figure 9.-Coho salmon harvest and sampling performance occurring in the Upper Cook Inlet Central District eastside set gillnet fishery in 1997.**




Note: Shaded region represents the time period during which the harvest was examined.

**Figure 10.-Coho salmon harvest and sampling performance occurring in the Upper Cook Inlet Central District eastside set gillnet fishery by statistical area in 1997.**

**Table 4.-Estimated harvest, and associated variance, of coho salmon of Kenai River origin in the commercial drift gillnet fishery of the Central District of Upper Cook Inlet during selected time intervals, 1997.**

| Interval | Total Harvest | Estimated Harvest of Coho Salmon of Kenai River Origin | Percent Contribution to Total Harvest | Variance of Harvest Estimate | Relative Precision |
|---|---|---|---|---|---|
| 6/27 - 7/10 | 1,480 | 0 | 0.0% | 0 | |
| 7/11 - 7/17 | 8,973 | 0 | 0.0% | 0 | |
| 7/18 - 7/24 | 10,371 | 13 | 0.1% | 156 | 188.3% |
| 7/25 - 7/31 | 36,948 | 342 | 0.9% | 4,714 | 39.3% |
| 8/01 - 8/04 | 21,322 | 881 | 4.1% | 22,779 | 33.6% |
| Total | 79,094 | 1,236 | 1.6% | 27,649 | 26.4% |

# DISCUSSION

## SMOLT ABUNDANCE

### History

The record of estimated smolt abundance has become an important element of the population assessment program for Kenai River coho salmon. The complete record, since 1992, has been cited by the department as the basis for recommending conservation actions. Recommendations were based on a relative decline in smolt abundance and were presented to the Alaska Board of Fisheries (BOF) in the spring of 1997. At that time a management plan was developed, adopted into regulation, and was first implemented during the 1997 fishing season.

Although the smolt abundance record was the impetus for developing the plan, the record of estimates, relative to one another, was not originally intended to be applied in this manner. Therefore, the management plan is precautionary in nature because it is not known if the decline is harvest induced, natural, or a combination of both. It is too early to determine if the decline is harvest induced because only one ordered pair of total harvest and subsequent smolt production is available (1993 parent year harvest [Carlon and Hasbrouck 1994] and 1996 smolt abundance). Natural factors influencing freshwater production are unknown and unmeasured. Despite the lack of a quantified explanation for the decline in smolt abundance, a precautionary fishery management plan is probably a prudent response. Lack of an explanation should not be cause for postponing conservation actions, especially in light of the harvest potential of existing fisheries.

Smolt abundance estimates have been the sole population assessment "barometer" since 1995, when smolt abundance was identified as an alternative to assessing population status from a record of adult abundance. Scrutinizing a record of harvest and resulting smolt abundance was acknowledged as a long-term endeavor, but was favored because of the lack of success in

**Table 5.-Total harvest and estimated harvest, with associated variance, of coho salmon of Kenai River origin in the eastside set gillnet fishery of Upper Cook Inlet by statistical area and selected time intervals, 1997.**

| Interval | Total Harvest | Estimated Harvest | Variance | R.P.[a] |
|---|---|---|---|---|
| | | **244-21** | | |
| 6/27 - 7/11 | 56 | 0 | 0 | |
| 7/12 - 7/17 | 70 | 0 | 0 | |
| 7/18 - 7/24 | 319 | 0 | 0 | |
| 7/25 - 7/31 | 614 | 137 | 3,085 | 79.5% |
| 8/01 - 8/04 | 445 | 231 | 5,504 | 62.9% |
| Total [c] | 1,504 | 368 | 8,589 | 49.4% |
| | | **244-22** | | |
| 6/27 - 7/11 | 103 | 0 | 0 | |
| 7/12 - 7/17 | 98 | 0 | 0 | |
| 7/18 - 7/24 | 425 | 30 | 428 | 135.2% |
| 7/25 - 7/31 | 1,609 | 191 | 7,303 | 87.7% |
| 8/01 - 8/04 | 802 | 279 | 13,527 | 81.7% |
| Total [c] | 3,037 | 500 | 21,258 | 57.2% |
| | | **244-30** | | |
| 6/27 - 7/11 | 112 | 0 | 0 | |
| 7/12 - 7/17 | 122 | 0 | 0 | |
| 7/18 - 7/24 | 888 | 28 | 757 | 192.6% |
| 7/25 - 7/31 | 1,871 | 79 | 3,967 | 156.3% |
| 8/01 - 8/04 | 890 | 203 | 3,977 | 60.9% |
| Total [c] | 3,883 | 310 | 8,701 | 59.0% |
| | | **244-40** | | |
| 6/27 - 7/11 | 133 | 0 | 0 | |
| 7/12 - 7/17 | 1,241 [b] | 0 | 0 | |
| 7/18 - 7/24 | 2,244 [b] | 0 | 0 | |
| 7/25 - 7/31 | 5,673 | 551 | 34,014 | 65.6% |
| 8/01 - 8/04 | 1,953 | 364 | 5,245 | 39.0% |
| Total [c] | 11,244 | 915 | 39,259 | 42.4% |
| | | **Total** | | |
| 6/27 - 7/11 | 404 | 0 | 0 | |
| 7/12 - 7/17 | 1,531 | 0 | 0 | |
| 7/18 - 7/24 | 3,876 | 58 | 1,185 | |
| 7/25 - 7/31 | 9,767 | 958 | 48,369 | 45.0% |
| 8/01 - 8/04 | 4,090 | 1,077 | 28,253 | 30.6% |
| Total [c] | 19,668 | 2,093 | 77,807 | 26.1% |

[a] Relative precision of estimated harvest = 100 x (1.96 x standard error of estimate)/estimate for 95% confidence.

[b] For statistical area 244-40, period is 7/12-7/18 and 7/19-7/24 due to unsampled days crossing the period margin dates. Effect on comparisons among periods and statistical areas is minor because minimal harvests occurred during these periods.

[c] Totals are rounded to nearest whole number.

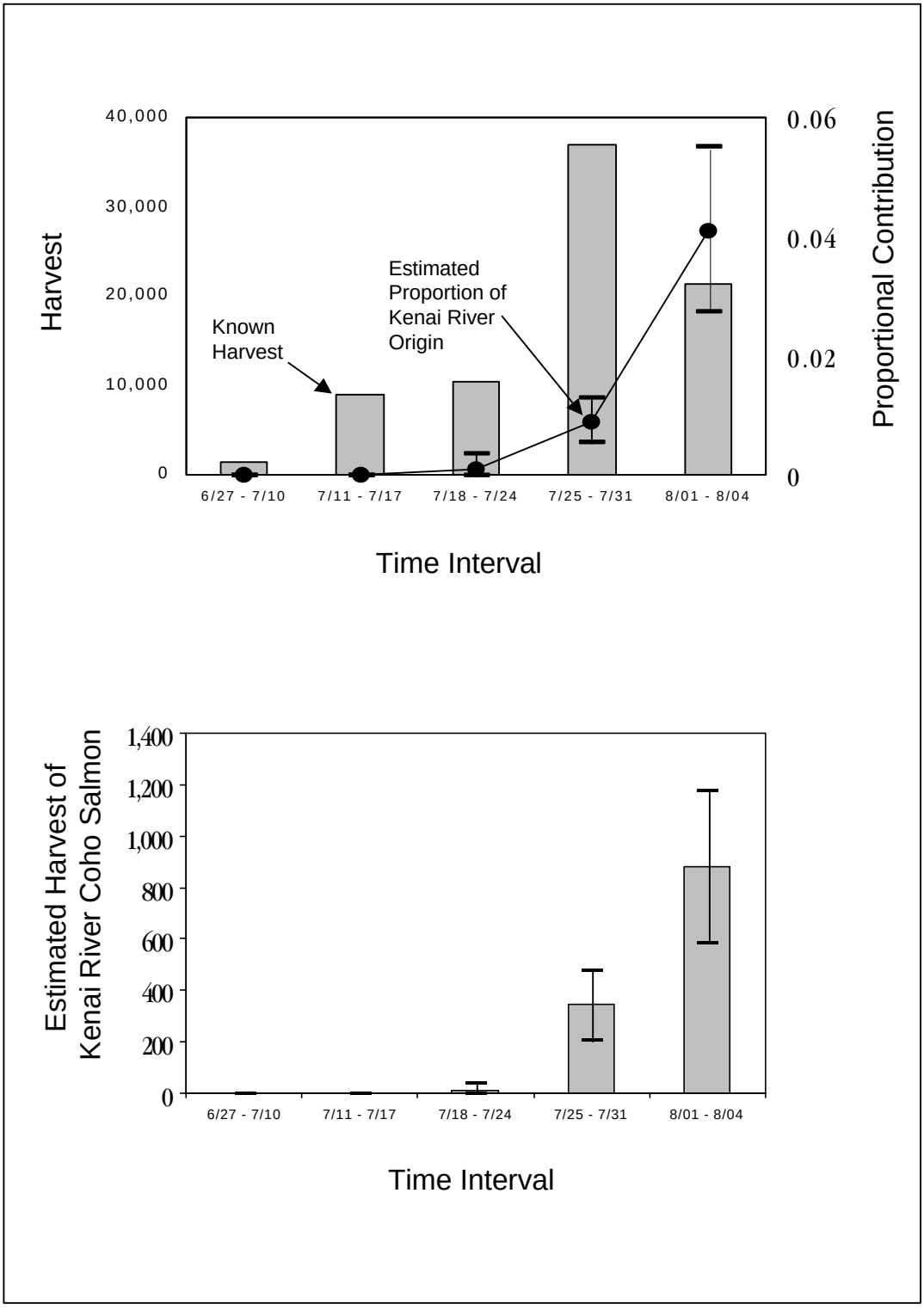



**Figure 11.-Temporal trend in proportional contribution of Kenai River coho salmon to the total harvest (top) and trend in absolute contribution (bottom) occurring in the drift gillnet fishery of the Central District of Upper Cook Inlet, 1997.**

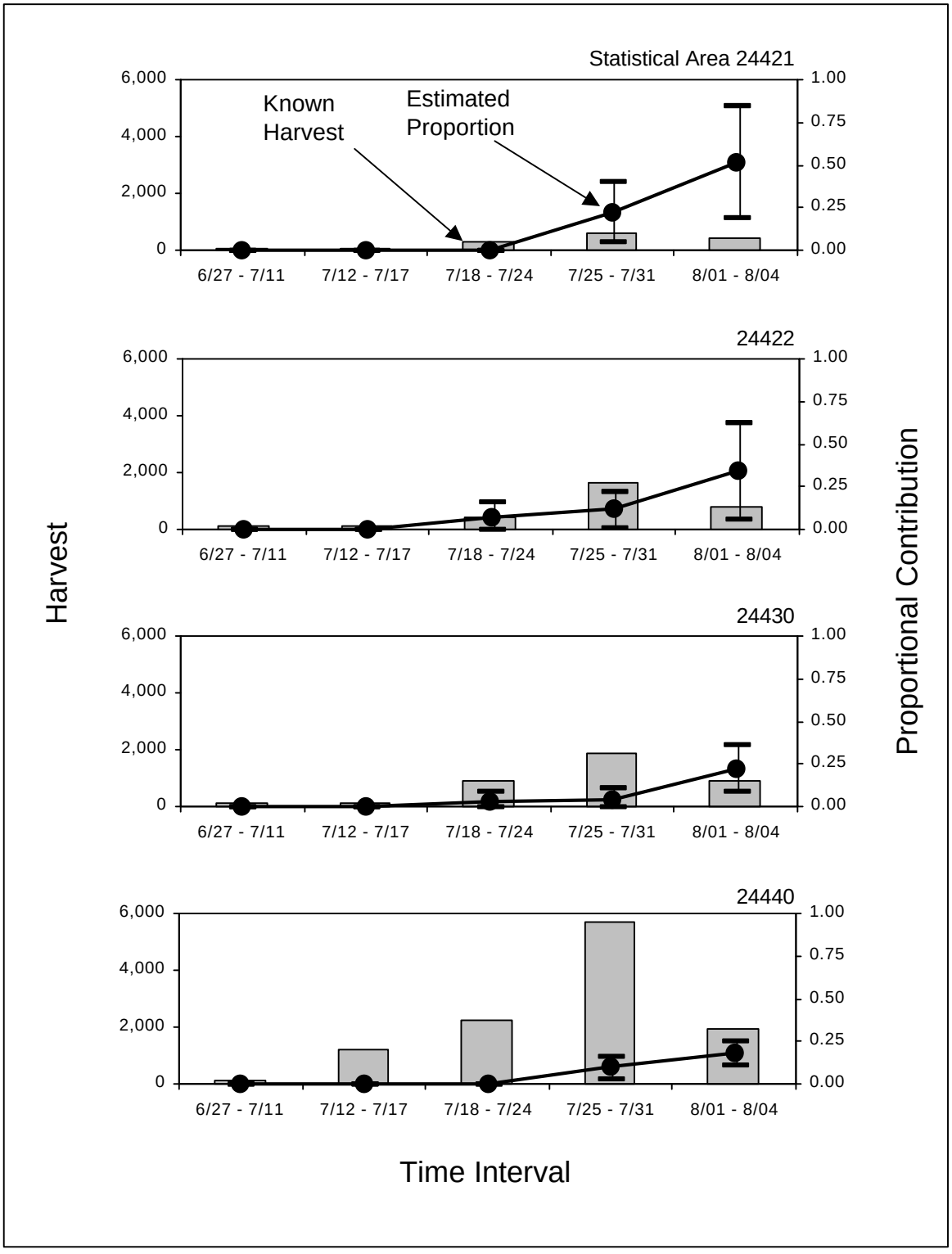



**Figure 12.-Temporal trends in total harvest and proportional contribution of coho salmon from the Kenai River to the total harvest of coho salmon occurring in four statistical areas of the Upper Cook Inlet Central District eastside set gillnet fishery during five selected time periods in 1997.**

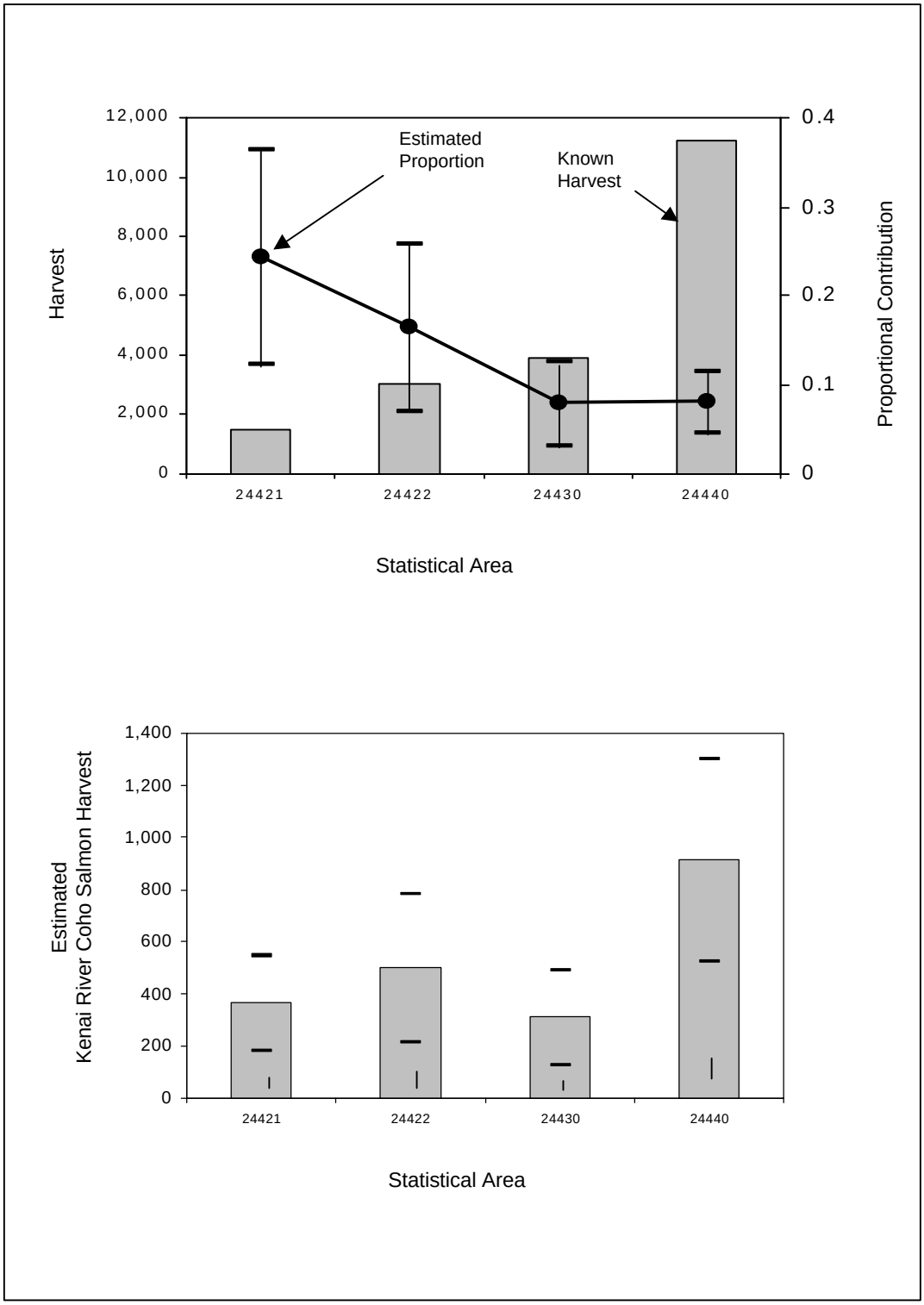



**Figure 13.-Geographic trends in total coho salmon (top) and in estimated number of coho salmon of Kenai River origin (bottom) harvested among statistical areas in the eastside set gillnet fishery of the Central District of Upper Cook Inlet, 1997.**

**Table 6.-Estimated effort, catch, and harvest of coho salmon by angler-type during each stratum of the fishery for coho salmon in the downstream section of the Kenai River, 1997.**

| Angler Day | | | Number of | Effort | | Catch | | Harvest | |
|---|---|---|---|---|---|---|---|---|---|
| Type | n[a] | N[b] | Interviews[c] | Estimate | SE | Estimate | SE | Estimate | SE |
| Guided Boat | | | | | | | | | |
| Mondays | 3 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Weekdays | 7 | 21 | 19 | 6,039 | 2,577 | 534 | 206 | 455 | 201 |
| Weekends | 6 | 10 | 50 | 1,837 | 355 | 153 | 72 | 137 | 63 |
| Unguided Boat | | | | | | | | | |
| Mondays | 3 | 6 | 34 | 956 | 225 | 91 | 69 | 91 | 69 |
| Weekdays | 7 | 21 | 39 | 7,200 | 2,161 | 417 | 190 | 358 | 181 |
| Weekends | 6 | 10 | 83 | 3,730 | 512 | 417 | 130 | 417 | 130 |
| Unguided Shore | | | | | | | | | |
| Mondays | 3 | 6 | 20 | 716 | 167 | 130 | 36 | 130 | 38 |
| Weekdays | 7 | 21 | 14 | 4,377 | 1,425 | 708 | 493 | 708 | 495 |
| Weekends | 6 | 10 | 29 | 2,002 | 531 | 640 | 373 | 487 | 217 |
| Subtotals: | | | | | | | | | |
| Guided Boat | 3 | 6 | 69 | 7,876 | 2,602 | 687 | 218 | 592 | 210 |
| Unguided Boat | 7 | 21 | 156 | 11,886 | 2,232 | 925 | 240 | 866 | 233 |
| Unguided Shore | 6 | 10 | 63 | 7,095 | 1,529 | 1,477 | 619 | 1,324 | 541 |
| Total | 16 | 37 | 288 | 26,857 | 3,754 | 3,089 | 699 | 2,782 | 626 |

[a] Number of days during which interviews were collected.

[b] Number of days possible for interviewing.

[c] Complete trip interviews only.

estimating adult abundance and the potentially high cost of implementing a project to do so successfully. However, the weak 1997 return and the resultant inseason fishery restrictions have rekindled the need to estimate adult abundance and exploitation rates as a more immediate stock assessment measure.

## Smolt Abundance in 1996

Until a long-term harvest-smolt record or adult assessment information becomes available, the annual accrual of smolt abundance estimates will be monitored for population assessment clues. The most recent estimate of 534,000 smolt emigrating from the Kenai River in 1996 was 28% less than the average emigration of 738,000 smolt from 1992 through 1995 (Carlon and Hasbrouck 1994, 1996, 1997). Factors influencing the decline in abundance remain unknown.

However, the point estimate of 1996 smolt abundance is greater than the estimated 1995 smolt abundance of 465,000 (Figure 14). The estimates are not distinguishable from one another because of overlap of 95% confidence bounds, but seem to indicate that the annual decline between 1993 and 1995 did not continue in 1996.

## COMMERCIAL HARVEST

Both the 1997 total harvest of coho salmon and the harvest of coho salmon bound for the Kenai River were the lowest on recent record (Ruesch and Fox 1998). The atypical return of all coho salmon to UCI in 1997 and the truncation of inlet-wide commercial fishing after August 4 were the primary causes of these low harvests.

As in prior years, the Kenai River population comprised a minimal portion of the total coho salmon harvest in both the drift and eastside setnet fisheries of the Central District (Figure 15). Most of the harvest in these fisheries originated from other drainages. The relative contribution of the Kenai River population to the drift fishery harvest was typical (about 2%), while the contribution to the eastside setnet fishery harvest was the lowest among the study years (11%).

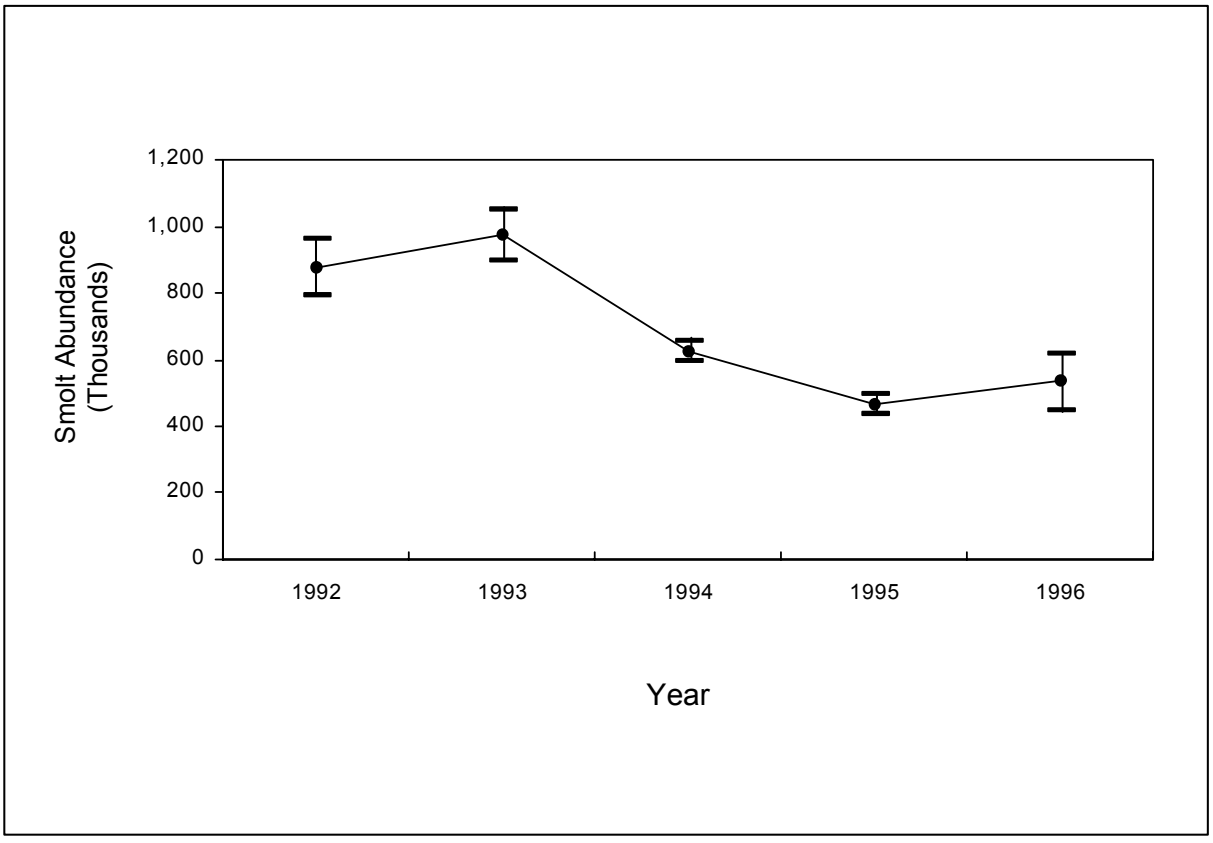



**Figure 14.-Estimates of coho salmon smolt abundance in the Kenai River, 1992-1996.**

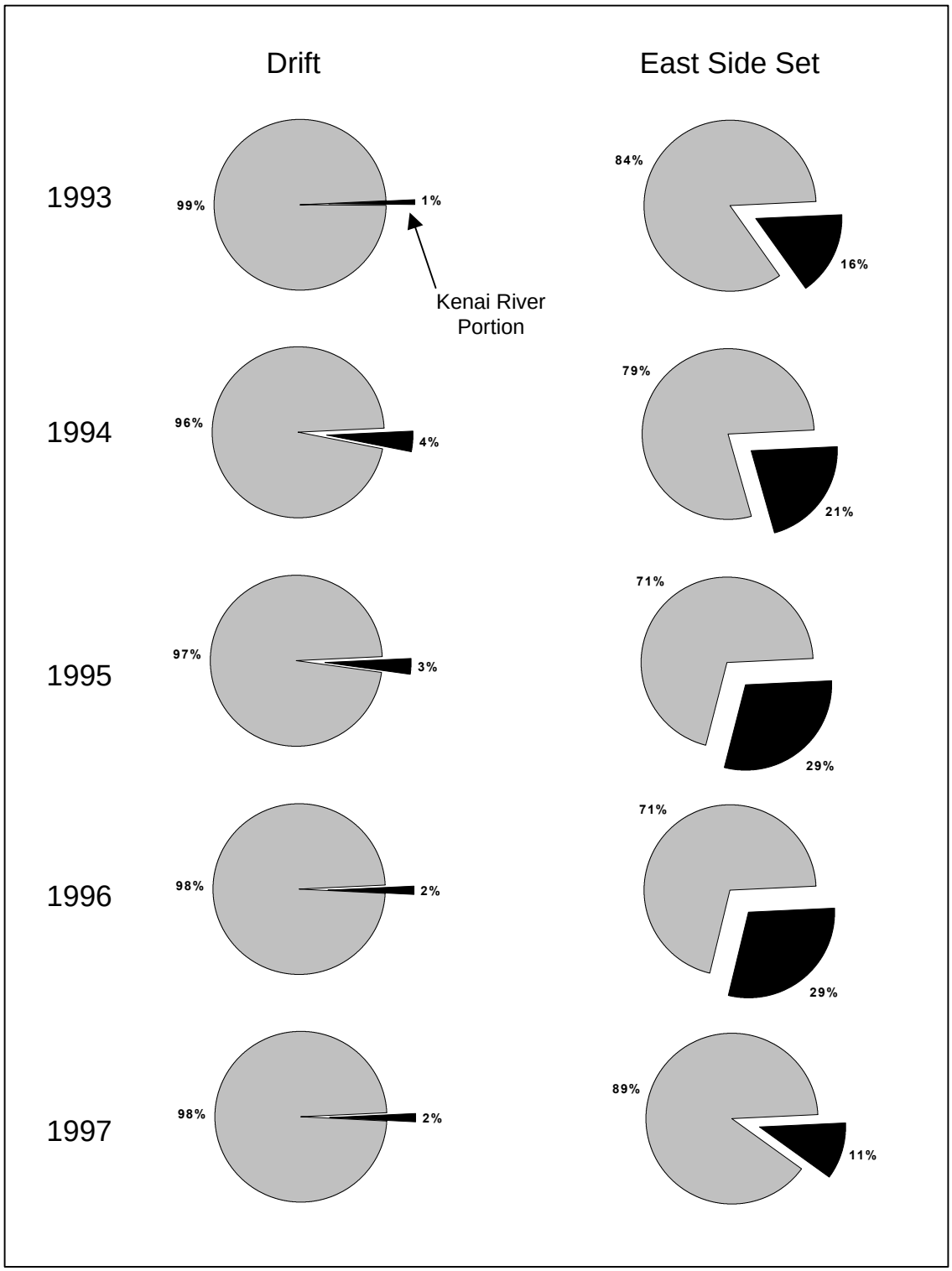



**Figure 15.-Contribution of coho salmon from the Kenai River to the drift and eastside set gillnet commercial fisheries of the Central District of Upper Cook Inlet, 1993-1997.**

This lower relative contribution was likely due in part to the early closure of the fishery. In all study years, the portion of the eastside setnet harvest composed of Kenai River-bound coho salmon has tended to increase later in the fishing season, reaching its highest during approximately the first 10 days of August (Carlon and Hasbrouck 1994 and 1996-1998). In 1997, the proportional contribution had increased to its highest level just prior to the closure of the fishery, but had not reached levels documented in prior years. The timing of the fishery closure likely had the intended effect of reducing the harvest of the Kenai River population, among others.

## INRIVER SPORT HARVEST

Harvest, catch, and effort in 1997 were the lowest on record (Hammarstrom 1977, 1978, and 1988-1992; Schwager-King 1993; Mills 1979-1994; Howe et al. 1995-1996). This phenomenon can be associated with: (1) a weak return, (2) inriver fishery restrictions, and (3) low angler participation. The intended inseason management effect (to minimize harvest) was achieved in 1997 through a combination of low success rates and fishery restrictions, both of which likely curtailed angler participation.

The 1997 creel survey was implemented in response to a general management concern identified before the 1997 fishing season. It was intended to provide an index of the river-wide harvest and to provide fishery dynamics information. Inseason and postseason information was determined to be of more immediate value than waiting an extra year for harvest estimates from the Statewide Harvest Survey. In addition, species-specific effort and harvest rate are rarely provided by that survey. Because the return and fishing season were anomalous, 1997 estimates of harvest, harvest and catch rates, and effort may be of little value in the long-term assessment program goal of defining sustained yield. However, the survey was a valuable tool in detecting atypical harvest rates early in the season and aiding in the management decision to implement inseason conservation measures. It also measured the angler response to the 1997 fishery scenario.

The creel survey was also implemented to monitor the response of anglers to the new management plan by providing quantitative harvest, catch, and effort information by month and angler type. Once again, because of the anomalous season, the survey results do not document a meaningful response to the plan. However, a survey will also be implemented during the 1998 fishing season to provide as much fishery dynamics information as possible prior to the February 1999 Alaska Board of Fisheries review of Upper Cook Inlet salmon issues.

## POPULATION-SPECIFIC HARVEST: 1993 THROUGH 1996

Total harvest of coho salmon of Kenai River origin becomes available when the results of the Statewide Sport Fishing Harvest Survey are released. Survey results for the fishing season of the prior calendar year are reported each fall. The survey estimates, among other things, the total sport and personal use harvests of coho salmon within the Kenai River drainage. These harvest estimates are added to estimates of commercial harvest to accrue total harvest information. The onsite creel survey results are not used for this purpose because that survey does not estimate total harvest for the entire drainage. The sum of UCI commercial and inriver harvest estimates constitutes virtually all of the known harvest of coho salmon of Kenai River origin.

In November of 1997, the inriver harvests of coho salmon were reported for the 1996 fishing season (Howe et al. 1997). Total harvest information for the Kenai River population is now available for the 4-year period from 1993 through 1996 by summing commercial and inriver harvest estimates (Table 7). The total harvest from all sources has ranged from about 63,000 to 123,000, averaging nearly 81,000.

## HARVEST TO SMOLT ASSESSMENT APPROACH

The 1996 smolt abundance estimate documented in this report represents an information milestone in the Kenai River coho salmon assessment program. The 1996 smolt emigration was comprised primarily of the progeny of the 1993 brood (most coho salmon emigrate from the Kenai River as age-2 smolt). The first ever estimates of total harvest of this population were calculated for the 1993 brood. The first pair of harvest and subsequent smolt production estimates are therefore now available.

**Table 7.-Estimated harvests of Kenai River coho salmon, 1993–1996.**

| | Harvest (thousands of fish)[a] | | | |
|---|---|---|---|---|
| Fishery | 1993 | 1994 | 1995 | 1996 |
| **Inriver Harvest** | | | | |
| Inriver Mainstem Sport | 51 | 87 | 46 | 42 |
| Russian River Sport | 2 | 5 | 4 | 4 |
| Inriver Personal Use | 1 | 2 | 1 | 4 |
| Inriver Subsistence [b] | No fishery | 3 | 1 | No fishery |
| Inriver Subtotal | 54 | 96 | 53 | 50 |
| **Marine Harvest** | | | | |
| UCI Commercial [c] | 8 | 27 | 21 | 15 |
| SE/PWS Commercial [d] | 0.55 | 0.15 | 0.08 | N/A |
| Marine Subtotal | 8 | 27 | 21 | 15 |
| Total Harvest | 63 | 123 | 74 | 64 |

[a] Harvests are rounded to the nearest thousand fish.

[b] 1994 and 1995 harvest is based on returned permits only; harvest is therefore a minimum.

[c] Combined Central District drift, east side set, and Northern District set harvests.

[d] 1995 harvest includes troll harvest only. Gill and seine net harvest were not estimated due to time constraints.

That a single pair of estimates is available from among five annual smolt abundance estimates and four total harvest estimates illustrates the long-term nature of this endeavor. The long-term approach and the resulting uncertain status of the population have been acknowledged by the department and the BOF with the development of the precautionary management plan aimed at reducing harvest potential until population-specific management objectives are defined.

Although the intent of this approach is to develop a sustainable harvest management objective by establishing a link between total harvest and subsequent smolt production, variability in freshwater survival may obscure any link. Factors influencing freshwater survival are unknown and unmeasured. The duration of the commitment necessary to define management objectives using this assessment approach is therefore unknown. Likewise, it is not known if this approach will provide sufficient information with which to define management objectives.

Until this approach provides enough data to be evaluated, additional conservation actions may be necessary as fishing pressure increases and population status remains uncertain. More aggressive and immediate research activities are therefore recommended to avoid unnecessary reductions in fishing opportunity and to better quantify appropriate conservation measures. A single estimate of exploitation rate imposed on the population would provide immediately useful assessment information. An extremely high exploitation rate would suggest that a more conservative harvest is appropriate. Conversely, a low exploitation rate may suggest that the fishery is somewhat self-regulating and that additional restrictions are unnecessary. Initially, an experiment to estimate exploitation rate should be considered as a supplement to the long-term assessment program. Eventually, estimates of exploitation rate (and ancillary escapement estimates) would provide perspective with which to interpret a long-term smolt abundance record.

### RUSSIAN RIVER

The extended operation of the Russian River weir provided valuable assessment information in 1997. More fish escaped to spawn in 1997 (4,104) than in the 2 prior years in which weir operation was extended through the coho salmon return (2,202 fish in 1982; 2,966 fish in 1994). The 1997 weir count indicates that this component of the Kenai River population likely spawned in numbers exceeding recent historical levels. Although speculative, this suggests that commercial fishery and inriver sport fishery restrictions may have reduced the harvest of this population component.

Until sustainable management objectives are developed for the Kenai River population, the Russian River weir should be operated through the first week of October to provide an escapement index. Currently, it is the only location in the drainage at which a count of adults is possible. In addition, the weir and support facilities are installed with other funding sources; extension of its operation requires minimal additional funding for personnel only. Coho salmon escapement information can be collected there as a cost-effective enhancement to the assessment program. The long-term value of annual weir counts can be evaluated if and when estimates of drainage-wide escapement become available with which to evaluate the accuracy of the Russian River return as an index of total return

## PROJECT DESIGN CONSIDERATIONS

### Assessment Program Supplements

Although this assessment program has provided a new resource perspective through previously unavailable estimates of total harvest and smolt abundance, the program has not provided immediate and quantifiable information with which to develop management objectives. The long-term approach was consciously selected by staff biologists over developing more immediately applicable information (such as escapement or exploitation rate estimates) as a cost-saving measure. Funds were applied to other issues.

With the fishery restrictions implemented in 1997, inseason information has become more valuable. Until the long-term approach provides management objectives, the only response to atypically weak returns under uncertain conditions is to manage the resource conservatively. Should weak returns continue, the department would like to take appropriate actions that ensure resource conservation while avoiding undue restrictions to sport fishing opportunity.

A more comprehensive research program is therefore recommended to supplement the long-term approach. The recommended program includes continuing projects to estimate commercial harvest, sport and personal use harvests, and smolt production. In addition feasibility studies should be initiated immediately to test the ability to determine the following:

1. population exploitation rate,
2. spawning escapements through ground survey counts,
3. genetic composition, and
4. juvenile freshwater life histories.

These supplements are considered complimentary to one another and to existing program components. Parallel development of new project components is an attempt to develop a more robust program that can provide useful information if one or more program components fail and to provide a comprehensive package of information if all succeed. Information from all program components should result in a synergy of information and, therefore, a better perspective with which to interpret all results.

Estimates of exploitation would provide some perspective for interpreting the harvest-smolt relationship. For example, extremely low exploitation rates corresponding to declining smolt production would indicate that factors other than harvest are responsible for the decline. In addition, exploitation rate estimates could be used to expand harvest estimates into total return and drainage-wide escapement estimates. Total return estimates would yield smolt-to-adult survival rates. In short, estimates of exploitation can be leveraged into an extensive perspective of population dynamics.

Spawning ground surveys would provide minimum estimates of escapement. Because escapement is unknown at present, minimum estimates would provide maximum estimates of exploitation. Maximum estimates of exploitation that were within acceptable levels would indicate that immediate and extreme management actions may not be necessary, and precautionary measures are appropriate.

Spawning groups identified in such ground surveys should be examined for genetic composition. The conservative regulatory response recently adopted by the BOF treated the drainage-wide smolt population as a single unit because the response was based on a decline in total smolt abundance. Observations and studies (Booth 1990) indicate that the population is composed of isolated groups rather than a globally adapted, single group. Coho salmon exhibit a protracted spawning period in the Kenai River and spawning groups have been observed in disparate areas within the drainage. The degree of genetic isolation among groups would provide population structure information and, therefore, a more informed definition of the appropriate management scale for the population. Because genetic assay techniques have not been applied to coho salmon in the Kenai River, a feasibility approach should be initiated immediately to ensure that genetic information is available to provide perspective for the results of other assessment program components.

Also of particular interest is the ability to identify the return timing trait in smolt. This would provide a means to apportion the annual smolt estimate by return timing. Differential exploitation (and escapement) of early- and late-returning components of the Kenai River return is likely. The early-returning fish (August) experience exploitation from marine commercial fisheries and from intense, inriver sport and personal use fisheries; while late-returning fish (September and later) experience exploitation only from a less intense sport fishery (typically, two-thirds of the sport harvest occurs in August with one-third occurring after August [Howe et al. 1996, 1997]).

The desire here is to improve the resolution of the harvest-smolt approach by providing estimates of the differential production of early- and late-returning smolt. Without this ability, a decline in the production of smolt with early return timing may be masked by an increase in the production of smolt with a later return timing. This would appear as stable overall smolt production, and the more intense fisheries supported by early-returning smolt could be affected with no forewarning or explanation.

Finally, life history studies should be initiated as a secondary priority to identify rearing areas from which smolt emigrate. Up to 80% of the smolt population emigrates from areas other than the Moose River. It is important to determine the distribution of this majority of the population and the stability of the habitats that they utilize.

# RECOMMENDATIONS

1. **Continue estimating total harvest and smolt abundance of coho salmon of Kenai River origin.**
   The long-term relationship between total annual fishing mortality and smolt abundance should be monitored to determine if harvest levels are influencing smolt production. This is the current approach to assessing the status of the population.

2. **A comprehensive research program should be considered.**
   Parallel development of new project elements would provide more comprehensive resource information and a more informed perspective with which to develop management objectives. In addition, a more diverse and robust program would provide useful information if one or more approaches fail. New project elements that should be considered are:

a. estimating population exploitation rate,
b. continue to enumerate coho salmon at the Russian River,
c. ground surveys to identify and count spawning groups,
d. genetic assay to determine if isolation exists within the population, and
e. juvenile freshwater life histories.

## ACKNOWLEDGMENTS

The following people comprised the team that marked smolt at the Moose River in 1996. Troy Tydingco was the field project leader and participated in all phases of field operation. Terry Evans, Wendy Langston, Sandee Simons, and Kurt Strausbaugh also participated in all phases of field operations. Jerry Strait assisted on several days during the season. All team members provided valuable insights into enhancing the capture and handling of coho salmon smolt.

The commercial harvest was examined in 1997 by technicians of the Commercial Fisheries Division. Dave Waltemyer, Kim Rudge, and Sandee Simons supervised commercial harvest sampling, provided logistical support, and collated commercial sampling data. Ed Borden, Phyllis McCutchan, and Gary Titus sampled the sport harvest. Sandee Simons also assisted with sport harvest sampling. Mary Schwager-King provided logistical support. Terry Bendock and Steve Hammarstrom provided guidance, insight, and logistical support throughout the project. Scott Meyer, Doug Vincent-Lang, and Doug McBride provided the vision to initiate the project in 1990.

Larry Marsh implemented the creel survey, provided inseason information, and postseason estimates. He also provided a summary of field procedures to guide the authors in documenting the survey. Allen Bingham provided the support necessary to design the survey. Steve Fleischman provided final estimates and the technical documentation of the creel survey data analysis.

Saree Timmons and Margaret Leonard provided the final reviews of the report and prepared the final manuscript.

"Cotton" and Lorraine Moore granted convenient access to the Moose River as did Jim and Jane Fellman. Dr. Bill West granted access to a convenient boat launch on the Moose River. All graciously contributed to an efficient field project.

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# APPENDIX A

## Appendix A1.-Kenai River Coho Salmon Management Plan adopted in March 1997.

05 AAC 021.0357 – KENAI RIVER COHO SALMON MANAGEMENT PLAN.

(a) The purpose of this management plan is to ensure an adequate escapement of coho salmon into the Kenai River drainage and to provide management guidelines to the department.

(b) Notwithstanding 5 AAC 21.310 and 5 AAC 31.320, in the set gillnet fishery in the Upper Subdistrict of the Central District the season shall close following the first regularly scheduled fishing period on or after August 10.

(c) Notwithstanding any provisions of 5 AAC 56, in the Kenai River drainage

(1) coho salmon fishing is prohibited from October 1 through June 30; any coho salmon caught must be released immediately without further harm;

(2) only unbaited artificial lures may be used in the flowing waters of the Kenai River drainage from October 1 through June 30 unless otherwise provided by emergency order under 5 AAC 56.070;

(3) from July 31 or the end of the king salmon season, whichever is later, through September 30, sport fishing from a vessel that is registered with the Department of Natural Resources, Division of Parks, as a guide vessel is restricted as follows:

(A) a person who is a guide as defined in 5 AAC 75.995, may not sport fish while a client is present or is within the guide's control or responsibility, except when guiding a client with a disability as defined in 5 AAC 61.036;

(B) the maximum number of fishing rods that may be operated may not exceed the number of clients on board the vessel;

(C) downstream from the confluence of the Moose and Kenai Rivers, sport fishing on Mondays is prohibited;

(D) upstream from the confluence of the Moose and Kenai Rivers, sport fishing for coho salmon on Mondays is prohibited; any coho salmon caught must be released immediately without further harm.

(d) Notwithstanding 5 AAC 77.540, the Kenai River personal use dip net fishery is closed after July 31.

(e) If the commissioner determines that additional conservation measures are necessary for the inriver sport or personal use fisheries, the commissioner may close, by emergency order, the season and immediately reopen a season during which any or a combination of the following restrictions may be applied:

(1) the daily bag and possession limits are two coho salmon;

(2) the daily bag and possession limits are one coho salmon;

(3) only unbaited artificial lures may be used;

(4) fishing time may be reduced;

(5) fishing areas may be reduced.

(f) The provisions of this section do not apply after December 31, 2002.

History –
Eff. 6/21/97, Register 142
Authority –
AS 16.05.060
AS 16.05.251

**Appendix A2.-Alaska Department of Fish and Game emergency order closing commercial fishing in all areas of Upper Cook Inlet after August 6, 1997.**

# COMMERCIAL FISHING

## Alaska Department of Fish & Game

## *emergency order*

**under authority of AS 16.05.060**

Emergency Order Number 2S-26-97 Issued at Soldotna, August 7, 1997

Effective Date: August 7, 1997 Expiration Date: December 31, 1997 unless superseded by subsequent emergency order

**EXPLANATION:** This emergency order closes all commercial salmon fishing in all areas of Upper Cook Inlet for the remainder of the 1997 fishing season effective August 7.

**REGULATION:** 5AAC 21.310 FISHING SEASONS is superseded by the following language:

Salmon may not be taken after August 6 in any area of Upper Cook Inlet.

**JUSTIFICATION:** The status of Upper Cook Inlet coho salmon stocks, in general, appears to be indicative of very poor overall run strength. Although the Department lacks specific information on large numbers of individual stocks, commercial fishery performance data on mixed stocks and escapement data on the limited number of stocks for which this information is available portray similar impressions throughout Upper Cook Inlet that most, if not all, coho salmon returns are far below average. Although no management objectives in the form of finite escapement goals exist for coho salmon, run strength is so far below the historical norm that continued fisheries exploitation would raise doubts about the sufficiency of surviving spawning fish to ensure sustained yield. All segments of the commercial fishery are currently or will soon be harvesting predominantly coho salmon and will continue to do so for the remainder of the 1997 fishing season . To ensure the sustained yield of Upper Cook Inlet coho salmon stocks, closure of all commercial fishing in Upper Cook Inlet for the remainder of the year is warranted.

Frank Rue
Commissioner

By Delegation To: _____
Paul H. Ruesch
Area Management Biologist

**DISTRIBUTION:** Lt. Governor; Attorney General; Director, Division of Commercial Fisheries; Director, Fish and Wildlife Protection; Detachment Commander, Fish and Wildlife Protection; Fish and Wildlife Protection, Homer and Seward; Members of the Board of Fisheries; U.S. Coast Guard, Juneau; commercial processors, advisory committees, post offices in Cook Inlet, magistrates in Cook Inlet.

**Appendix A3.-Alaska Department of Fish and Game emergency order restricting sport fishing bag limits and methods in all waters of Upper Cook Inlet after August 8, 1997.**

# SPORT FISHING

## Emergency Order

**ALASKA DEPARTMENT OF FISH AND GAME**

Under Authority of AS 16.05.060

***Emergency Order No.***: 2-SS-02-31-97 ***Issued at***: Anchorage, August 7, 1997

***Effective Date***: 12:01 am, Saturday, August 9, 1997 ***Expiration Date***: October 15, 1997

EXPLANATION:

This emergency order reduces the daily bag and possession limit for coho salmon to one in all waters of Cook Inlet. This includes fresh and salt waters north and west of a line from Homer Spit to Point Pogibshi and all waters north of a line from Point Pogibshi to Sea Otter Point. In addition, only unbaited artificial lures may be used in flowing fresh waters north of these lines. Bait may continue to be used in the lakes and ponds of these drainages unless previously restricted by regulation, and bait may continue to be used in marine waters. Hatchery enhanced coho salmon runs to Bird, Ship, and Campbell creeks and the Eklutna Tailrace are not included in these fishery restrictions. Marine and fresh water sport fisheries in Kachemak Bay east of the line from Homer Spit to Point Pogibshi are also excluded from these restrictions.

REGULATIONS:

5 AAC 58.020. BAG LIMITS, POSSESSION LIMITS, AND SIZE LIMITS is amended to read:

**5 AAC 58.020. BAG LIMITS, POSSESSION LIMITS, AND SIZE LIMITS.** (c) (7) in all salt waters north of a line extending from Sea Otter Point to Point Pogibshi and west of a line extending from the southern tip of Homer Spit to Point Pogibshi, the daily bag and possession limits for salmon other than king salmon 16 inches or more in length are six (6) fish of which not more than one (1) can be a coho salmon.

5 AAC 61.020. BAG LIMITS, POSSESSION LIMITS, AND SIZE LIMITS is amended to read:

**5 AAC 61.020. BAG LIMITS, POSSESSION LIMITS, AND SIZE LIMITS.** (b) (20) in flowing waters of Cook Inlet from the west bank of Ingram Creek to Sea Otter Point, except Bird, Campbell, and Ship creeks, and the Eklutna Tailrace, the daily bag and possession limits for salmon other than king salmon 16 inches or more in length are three (3) fish of which not more than one (1) can be a coho salmon.

5 AAC 61.035. METHODS AND MEANS is amended to read:

**5 AAC 61.035. METHODS AND MEANS.** (m) in flowing waters of Cook Inlet from the west bank of Ingram Creek to Sea Otter Point, except Bird, Campbell, and Ship creeks, and the Eklutna Tailrace, only unbaited artificial lures may be used.

11-113(8/88)

-continued-

5 AAC 56.020. BAG LIMITS, POSSESSION LIMITS, AND SIZE LIMITS is amended to read:

**5 AAC 56.020. BAG LIMITS, POSSESSION LIMITS, AND SIZE LIMITS.** (b)(15) in flowing waters of Cook Inlet from the west bank of the mouth of Ingram Creek to the southern tip of Homer Spit, daily bag and possession limits for salmon other than king salmon 16 inches or more in length are three (3) fish of which not more than one (1) can be a coho salmon

5 AAC 56.035. METHODS AND MEANS is amended to read:

**5 AAC 56.035. METHODS AND MEANS.** (p) in flowing waters of Cook Inlet from the west bank of the mouth of Ingram Creek to the southern tip of Homer Spit, only unbaited artificial lures may be used.

Frank Rue
Commissioner

by delegation to: _____ for
Doug McBride
Regional Supervisor

JUSTIFICATION:

Poor marine survival rates appear to have depressed upper Cook Inlet coho salmon stocks to such a low level that these restrictive regulations are necessary to provide for sustained yield of Cook Inlet coho salmon. While few programs have been established in Cook Inlet to evaluate coho salmon run strength in-season, those that are established indicate coho runs are extremely weak. Yentna River sonar and fishwheel passage information indicate coho salmon runs are less than half the average return level. Weirs are currently being operated on Deshka River, Fish Creek in the Big Lake drainage, the Little Susitna River, and Cottonwood and Wasilla creeks in Knik Arm. A weir is also being operated for the first time on Deep Creek to evaluate the returns to that drainage. Only a few fish have passed the weirs to date. Sport fishermen have had very limited success harvesting coho salmon on the Kenai River. The daily harvest in the Cook Inlet commercial east side set net fishery is the lowest since the early 1970's. In addition to these sport fishery restrictions, the Upper Cook Inlet commercial fishery has been closed for the remainder of the 1997 season.

DISTRIBUTION:

Office of the Governor; Lt. Governor; Commissioner, Department of Fish and Game; Director, Division of Sport Fish; Regional Supervisors, Divisions of Sport Fish and Commercial Fisheries Management and Development; Members of Alaska Board of Fisheries; Director, Fish and Wildlife Protection; Detachment Commander and Area Offices, Fish and Wildlife Protection; Local Fish and Game Advisory Committee Chairs; Cook Inlet Area Biologists, Division of Sport Fish; Division of Sport Fish Regional Offices; and selected area newspapers, radio and television stations.

**Appendix A4.-Number of wild coho salmon smolt captured from the Moose River, marked with an adipose finclip and coded wire tags, and released in 1996, and number identified in the sample of 34 marked fish recovered from the Kenai River sport harvest in 1997.**

| Tag Code | First Day Released | Last Day Released | Number Marked[a] | Short-Term Survival Rate | Number Marked at Release[b] | Short-Term Tag Retention Rate | Number Tagged at Release[c] | Number Identified in Sport Harvest Sample in 1997[d] |
|---|---|---|---|---|---|---|---|---|
| 31-25-35 | 5/21 | 5/29 | 5,973 | 100.0% | 5,973 | 99.8% | 5,961 | 3 |
| 31-25-36 | 5/28 | 5/30 | 6,044 | 100.0% | 6,044 | 98.4% | 5,947 | 6 |
| 31-25-37 | 5/29 | 5/31 | 6,116 | 99.9% | 6,110 | 99.8% | 6,098 | 2 |
| 31-25-38 | 5/30 | 6/01 | 6,115 | 100.0% | 6,115 | 99.5% | 6,084 | 4 |
| 31-25-39 | 5/31 | 6/02 | 6,179 | 100.0% | 6,179 | 99.4% | 6,142 | 2 |
| 31-25-40 | 6/01 | 6/03 | 6,094 | 100.0% | 6,094 | 99.9% | 6,088 | 3 |
| 31-22-52 | 6/02 | 6/05 | 11,305 | 99.9% | 11,294 | 100.0% | 11,294 | 0 |
| 31-22-53 | 6/04 | 6/07 | 11,535 | 99.9% | 11,525 | 99.7% | 11,490 | 4 |
| 31-22-54 | 6/06 | 6/08 | 11,946 | 99.7% | 11,914 | 99.9% | 11,902 | 6 |
| 31-22-55 | 6/07 | 6/11 | 11,492 | 99.7% | 11,462 | 99.9% | 11,451 | 2 |
| 31-24-21 | 6/10 | 6/14 | 11,525 | 100.0% | 11,525 | 99.7% | 11,490 | 1 |
| 31-25-41 | 6/13 | 6/15 | 3,814 | 99.6% | 3,797 | 100.0% | 3,797 | 1 |
| Total | | | 98,138 | 99.9% | 98,032 | 99.7% | 97,744 | 34 |

[a] Total number of smolt adipose-clipped and injected with a coded wire tag.

[b] Estimated number of marked smolt that survived to release.

[c] Estimated number of marked smolt that survived and retained a tag to release.

[d] The Kenai River sport fishery for coho salmon was restricted inseason by emergency order in 1997. See Appendix A3.

**Appendix A5.-Sources of marked coho salmon adults recovered at random from the Kenai River sport harvest between August 2 and September 7, 1997, as determined from recovery of coded wire tags.**

| Date | Number Examined | Marked Fish Observed | Marked Fish Recovered | Coded Wire Tag Missing | Release Location and Year of Release: Moose River 1996 |
|---|---|---|---|---|---|
| 08/02/97 | 1 | 1 | 0 | | |
| 08/06/97 | 21 | 5 | 0 | | |
| 08/07/97 | 21 | 3 | 2 | 0 | 2 |
| 08/08/97 | 53 | 6 | 0 | | |
| 08/09/97 | 5 | 2 | 0 | | |
| 08/10/97 | 3 | 2 | 1 | 0 | 1 |
| 08/11/97 | 4 | 1 | 0 | | |
| 08/14/97 | 12 | 3 | 0 | | |
| 08/15/97 | 10 | 3 | 2 | 0 | 2 |
| 08/16/97 | 10 | 0 | 0 | | |
| 08/17/97 | 12 | 3 | 3 | 0 | 3 |
| 08/18/97 | 7 | 0 | 0 | | |
| 08/21/97 | 18 | 2 | 2 | 0 | 2 |
| 08/22/97 | 12 | 0 | 0 | | |
| 08/23/97 | 22 | 2 | 2 | 0 | 2 |
| 08/24/97 | 26 | 4 | 3 | 0 | 3 |
| 08/25/97 | 15 | 6 | 6 | 0 | 6 |
| 08/28/97 | 14 | 3 | 3 | 0 | 3 |
| 08/29/97 | 8 | 2 | 1 | 0 | 1 |
| 08/30/97 | 16 | 5 | 5 | 0 | 5 |
| 08/31/97 | 5 | 0 | 0 | | |
| 09/01/97 | 5 | 0 | 0 | | |
| 09/04/97 | 3 | 1 | 1 | 0 | 1 |
| 09/05/97 | 5 | 1 | 1 | 0 | 1 |
| 09/06/97 | 4 | 0 | 0 | | |
| 09/07/97 [a] | 5 | 2 | 2 | 0 | 2 |
| Total | 317 | 57 | 34 | 0 | 34 |

[a] Sport harvest creel survey was continuous through September 10, 1997, but no fish were examined after September 7. Survey was discontinued after September 10 due to extremely low angler effort and harvest at that time.

**Appendix A6.-Daily summary of coho salmon adults captured by fish wheel at river kilometer 31 of the Kenai River between August 15 and September 16, 1997.**

| Date | Number Examined | Marked Fish Observed | Marked Fish Checked with Tag Detector [a] | Tag Detector Results: Tag Detected | Tag Detector Results: Tag Not Detected |
|---|---|---|---|---|---|
| 08/15/97 | 31 | 3 | 3 | 3 | 0 |
| 08/16/97 | 16 | 2 | 2 | 2 | 0 |
| 08/17/97 | 22 | 11 | 11 | 11 | 0 |
| 08/18/97 | 16 | 1 | 1 | 1 | 0 |
| 08/19/97 | 17 | 1 | 1 | 1 | 0 |
| 08/20/97 | 5 | 3 | 3 | 3 | 0 |
| 08/21/97 | 15 | 4 | 4 | 3 | 1 |
| 08/22/97 | 26 | 6 | 5 | 5 | 0 |
| 08/23/97 | 18 | 2 | 2 | 2 | 0 |
| 08/24/97 | 6 | 0 | | | |
| 08/25/97 | 20 | 5 | 3 | 3 | 0 |
| 08/26/97 | 12 | 3 | 0 | 0 | 0 |
| 08/27/97 | 12 | 1 | 0 | 0 | 0 |
| 08/28/97 | 10 | 1 | 0 | 0 | 0 |
| 08/29/97 | 5 | 1 | 0 | 0 | 0 |
| 08/30/97 | 2 | 0 | | | |
| 09/02/97 | 5 | 0 | | | |
| 09/03/97 | 5 | 1 | 1 | 1 | 0 |
| 09/04/97 | 1 | 0 | | | |
| 09/05/97 | 1 | 1 | 0 | | |
| 09/08/97 | 6 | 1 | 1 | 1 | 0 |
| 09/09/97 | 15 | 3 | 3 | 3 | 0 |
| 09/10/97 | 6 | 1 | 1 | 1 | 0 |
| 09/11/97 | 10 | 1 | 0 | 0 | 0 |
| 09/12/97 | 3 | 0 | | | |
| 09/16/97 [b] | 2 | 1 | 1 | 1 | 0 |
| Total | 287 | 53 | 42 | 41 | 1 |

[a] Captured coho salmon that were missing an adipose fin were checked for the presence of a coded wire tag by using a Northwest Marine Technologies tag detection wand. A subsample of 42 of the 53 adipose-clipped fish were checked because the tag detector was not available at all times.

[b] Fish wheel operation was discontinued after September 16 due to declining catch.

**Appendix A7.-Daily summary of coho salmon adults examined at the Russian River weir, August 13 through October 6, 1997.**

| Date | Weir Count | Number Examined | Marked Fish Observed |
|---|---|---|---|
| 08/13/97 [a] | 7 | 7 | 0 |
| 08/14/97 | 0 | 0 | 0 |
| 08/15/97 | 24 | 24 | 2 |
| 08/16/97 | 17 | 17 | 3 |
| 08/17/97 | 7 | 7 | 1 |
| 08/18/97 | 25 | 25 | 2 |
| 08/19/97 | 22 | 22 | 2 |
| 08/20/97 | 19 | 19 | 1 |
| 08/21/97 | 3 | 3 | 0 |
| 08/22/97 | 45 | 45 | 5 |
| 08/23/97 | 6 | 6 | 0 |
| 08/24/97 | 67 | 67 | 6 |
| 08/25/97 | 36 | 36 | 3 |
| 08/26/97 | 81 | 81 | 8 |
| 08/27/97 | 90 | 90 | 11 |
| 08/28/97 | 26 | 26 | 3 |
| 08/29/97 | 55 | 55 | 10 |
| 08/30/97 | 94 | 94 | 11 |
| 08/31/97 | 49 | 49 | 9 |
| 09/01/97 | 183 | 183 | 22 |
| 09/02/97 | 222 | 222 | 25 |
| 09/03/97 | 225 | 225 | 30 |
| 09/04/97 | 205 | 205 | 19 |
| 09/05/97 | 161 | 161 | 28 |
| 09/06/97 | 78 | 78 | 14 |
| 09/07/97 | 206 | 206 | 25 |
| 09/08/97 | 192 | 192 | 39 |
| 09/09/97 | 335 | 335 | 64 |
| 09/10/97 | 420 | 420 | 67 |
| 09/11/97 | 348 | 348 | 59 |
| 09/12/97 | 283 | 283 | 65 |
| 09/13/97 | 127 | 127 | 33 |
| 09/14/97 | 24 | 24 | 4 |
| 09/15/97 | 115 | 115 | 28 |
| 09/16/97 | 29 | 29 | 8 |
| 09/17/97 | 73 | 73 | 21 |
| 09/18/97 | 36 | 36 | 8 |
| 09/19/97 | 21 | 21 | 6 |
| 09/20/97 | 36 | 36 | 6 |
| 09/21/97 | 17 | 17 | 3 |
| 09/22/97 | 27 | 27 | 9 |
| 09/23/97 | 21 | 21 | 3 |
| 09/24/97 | 8 | 8 | 2 |
| 09/25/97 | 6 | 6 | 1 |
| 09/26/97 | 7 | 7 | 2 |
| 09/27/97 | 0 | 0 | 0 |
| 09/28/97 | 2 | 2 | 1 |
| 09/29/97 | 1 | 1 | 0 |
| 09/30/97 | 2 | 2 | 1 |
| 10/01/97 | 12 | 12 | 3 |
| 10/02/97 | 0 | 0 | 0 |
| 10/03/97 | 4 | 4 | 0 |
| 10/04/97 | 0 | 0 | 0 |
| 10/05/97 | 3 | 3 | 1 |
| 10/06/97 | 2 | 2 | 1 |
| Total | 4,104 | 4,104 | 675 |

[a] The weir was operational from early June through October 6, but the first coho salmon did not arrive at the weir until August 13.

**Appendix A8.-Coho salmon harvest sampling, coded wire tag recoveries, and recovery of marked coho salmon of Kenai River origin in commercial harvest samples from mixed Cook Inlet statistical areas in 1997.**

| District | Fishery | Statistical Area | Date | ($n_i$) Number Examined | ($a_i$) Adclips Observed | ($a'_i$) Heads Recovered | ($t_i$) Heads with Tags | ($t'_i$) Decodable Tags | ($m_i$) Source= Moose R 1996 |
|---|---|---|---|---|---|---|---|---|---|
| Central | East Side Set | 24422/30 | 8/04/97 | 6 | 1 | 1 | 0 | 0 | |
| | | **East Side Set 24422/30 Total** | | 6 | 1 | 1 | 0 | 0 | 0 |
| Central | East Side Set | Unknown Mix | 7/11/97 | 22 | 0 | 0 | 0 | 0 | |
| Central | East Side Set | Unknown Mix | 7/13/97 | 8 | 0 | 0 | 0 | 0 | |
| Central | East Side Set | Unknown Mix | 7/17/97 | 3 | 0 | 0 | 0 | 0 | |
| Central | East Side Set | Unknown Mix | 7/23/97 | 4 | 0 | 0 | 0 | 0 | |
| Central | East Side Set | Unknown Mix | 7/25/97 | 15 | 1 | 1 | 1 | 1 | 0 |
| Central | East Side Set | Unknown Mix | 7/27/97 | 52 | 1 | 1 | 1 | 1 | 0 |
| Central | East Side Set | Unknown Mix | 7/28/97 | 60 | 3 | 3 | 3 | 3 | 1 |
| Central | East Side Set | Unknown Mix | 7/29/97 | 20 | 3 | 3 | 2 | 2 | 0 |
| Central | East Side Set | Unknown Mix | 7/31/97 | 15 | 0 | 0 | 0 | 0 | |
| Central | East Side Set | Unknown Mix | 8/01/97 | 19 | 1 | 1 | 1 | 1 | 0 |
| | | **East Side Set Unknown Mix Total** | | 218 | 9 | 9 | 8 | 8 | 1 |
| Central | Drift/East Side Set | Unknown Mix | 7/13/97 | 124 | 2 | 2 | 1 | 1 | 0 |
| Central | Drift/East Side Set | Unknown Mix | 7/14/97 | 6 | 1 | 1 | 1 | 1 | 0 |
| Central | Drift/East Side Set | Unknown Mix | 7/17/97 | 121 | 2 | 2 | 2 | 2 | 0 |
| Central | Drift/East Side Set | Unknown Mix | 7/21/97 | 3 | 0 | 0 | 0 | 0 | |
| Central | Drift/East Side Set | Unknown Mix | 7/23/97 | 215 | 11 | 11 | 11 | 11 | 0 |
| Central | Drift/East Side Set | Unknown Mix | 7/24/97 | 45 | 2 | 2 | 2 | 2 | 0 |
| Central | Drift/East Side Set | Unknown Mix | 7/26/97 | 41 | 3 | 3 | 3 | 3 | 0 |
| Central | Drift/East Side Set | Unknown Mix | 7/30/97 | 51 | 2 | 2 | 2 | 2 | 1 |
| Central | Drift/East Side Set | Unknown Mix | 7/31/97 | 136 | 4 | 4 | 4 | 4 | 0 |
| Central | Drift/East Side Set | Unknown Mix | Mixed 7/10-7/11 | 29 | 0 | 0 | 0 | 0 | |
| | | **Drift/East Side Set Unknown Mix Total** | | 771 | 27 | 27 | 26 | 26 | 1 |
| Central | West Side/Kalgin Isalnd Set | 24530-24610/20 | 7/21/97 | 491 | 7 | 7 | 7 | 7 | 1 |
| Central | West Side/Kalgin Isalnd Set | 24530-24610/20 | 8/04/97 | 1,601 | 20 | 20 | 18 | 18 | 1 |
| | | **West Side/Kalgin I. Set 24530-24610/20 Total** | | 2,092 | 27 | 27 | 25 | 25 | 2 |
| Northern | West Side/East Side Set | 24720/70 | 8/01/97 | 1,517 | 72 | 72 | 66 | 66 | 3 |
| Northern | West Side/East Side Set | 24720/70 | 8/04/97 | 1,012 | 40 | 40 | 37 | 37 | 1 |
| | | **West Side/East Side Set 24720/70 Total** | | 2,529 | 112 | 112 | 103 | 103 | 4 |
| Northern | SuFlats/Fire I. Set | 24741/43 | 7/25/97 | 73 | 5 | 5 | 4 | 4 | 0 |
| | | **SuFlats/Fire I. Set 24741/43 Total** | | 73 | 5 | 5 | 4 | 4 | 0 |
| Northern | PtMcKenzie/Fire I. Set | 24742/43 | 7/28/97 | 1,133 | 123 | 122 | 117 | 117 | 0 |
| | | **Pt. MacKenzie/Fire I. Set 24742/43 Total** | | 1,133 | 123 | 122 | 117 | 117 | 0 |
| | | **Grand Total** | | 6,822 | 304 | 303 | 283 | 283 | 8 |

Note: These data were excluded from analyses and estimates of contribution due to the ambiguity of the sample source.

**Appendix A9.-Upper Cook Inlet commercial coho salmon harvest in 1997, coded wire tag recoveries, and population-specific harvest estimates of coho salmon of Kenai River origin based on recoveries of fish marked at the Moose River in 1996.**

| Date | (H) Total Harvest | ($n_i$) Number Examined | ($a_i$) Adclips Observed | ($a'_i$) Heads Recovered | ($t_i$) Heads with Tags | ($t'_i$) Decodable Tags | ($m_i$) Source= Moose R 1996 | ($r_i$) Harvest Estimate | $V(r_i)$ Variance |
|---|---|---|---|---|---|---|---|---|---|
| **Central Drift (24450/60/70-24570/80/90)** | | | | | | | | | |
| 6/27/97 | 13 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/30/97 | 47 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/2-7/4-7/5/97 | 267 | 60 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 7/7-7/8/97 | 863 | 346 | 8 | 8 | 6 | 6 | 0 | 0 | 0 |
| 7/9-7/10/97 | 290 | 149 | 4 | 4 | 3 | 3 | 0 | 0 | 0 |
| 7/11/97 | 493 | 285 | 6 | 5 | 3 | 3 | 0 | 0 | 0 |
| 7/13/97 | 1,763 | 880 | 23 | 23 | 19 | 19 | 0 | 0 | 0 |
| 7/14/97 | 5,901 | 3,104 | 65 | 63 | 57 | 57 | 0 | 0 | 0 |
| 7/17/97 | 816 | 470 | 18 | 18 | 15 | 15 | 0 | 0 | 0 |
| 7/18/97 | 1,330 | 819 | 25 | 25 | 23 | 23 | 0 | 0 | 0 |
| 7/19/97 | 1,586 | 11 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 7/20/97 | 1,130 | 488 | 20 | 20 | 15 | 15 | 1 | 13 | 156 |
| 7/21/97 | 1,196 | 806 | 22 | 22 | 20 | 20 | 0 | 0 | 0 |
| 7/23/97 | 2,874 | 1,089 | 48 | 48 | 44 | 44 | 0 | 0 | 0 |
| 7/24/97 | 2,255 | 698 | 36 | 35 | 32 | 32 | 0 | 0 | 0 |
| 7/25/97 | 26,950 | 11,501 | 431 | 428 | 401 | 401 | 8 | 105 | 1,385 |
| 7/26/97 | 1,190 | 197 | 6 | 6 | 6 | 6 | 0 | 0 | 0 |
| 7/27/97 | 3,497 | 1,573 | 68 | 68 | 67 | 67 | 7 | 86 | 1,045 |
| 7/28/97 | 2,780 | 1,291 | 48 | 48 | 46 | 46 | 4 | 48 | 548 |
| 7/29/97 | 1,024 | 126 | 2 | 2 | 2 | 2 | 0 | 0 | 0 |
| 7/30/97 | 865 | 290 | 23 | 23 | 22 | 21 | 5 | 87 | 1,497 |
| 7/31/97 | 642 | 226 | 12 | 12 | 10 | 10 | 1 | 16 | 240 |
| 8/1-8/2/97 | 12,928 | 3,339 | 222 | 222 | 204 | 203 | 20 | 431 | 10,889 |
| 8/3-8/4/97 | 8,394 | 2,067 | 104 | 104 | 100 | 100 | 20 | 450 | 11,890 |
| **Total** | 79,094 | 29,830 | 1,193 | 1,186 | 1,097 | 1,095 | 66 | 1,236 | 27,649 |
| **Central Chinitna Bay Drift (24510)** | | | | | | | | | |
| 7/18/97 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| **Total** | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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## Appendix A9.-Page 2 of 5.

| Date | (H) Total Harvest | ($n_i$) Number Examined | ($a_i$) Adclips Observed | ($a'_i$) Heads Recovered | ($t_i$) Heads with Tags | ($t'_i$) Decodable Tags | ($m_i$) Source= Moose R 1996 | ($r_i$) Harvest Estimate | $V(r_i)$ Variance |
|---|---|---|---|---|---|---|---|---|---|
| **Central East Side Set** | | | | | | | | | |
| **24421** | | | | | | | | | |
| 6/27-7/11/97 | 56 | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/13/97 | 29 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/14/97 | 15 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/17/97 | 26 | 6 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 7/18/97 | 8 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/19, 7/20/97 | 34 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/21/97 | 28 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/23/97 | 185 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/24/97 | 64 | 24 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 7/25, 7/26/97 | 105 | 27 | 2 | 2 | 2 | 2 | 2 | 43 | 893 |
| 7/27, 7/28/97 | 202 | 37 | 2 | 2 | 2 | 2 | 1 | 30 | 871 |
| 7/29/97 | 130 | 37 | 1 | 1 | 1 | 1 | 1 | 19 | 343 |
| 7/30-7/31/97 | 177 | 44 | 4 | 4 | 4 | 4 | 2 | 45 | 979 |
| 8/1, 8/2/97 | 176 | 34 | 4 | 4 | 4 | 4 | 3 | 86 | 2,437 |
| 8/3, 8/4/97 | 269 | 90 | 10 | 8 | 8 | 8 | 7 | 145 | 3,067 |
| **Total** | 1,504 | 371 | 25 | 23 | 23 | 23 | 16 | 368 | 8,589 |
| **24422** | | | | | | | | | |
| 6/27-7/11/97 | 103 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/13/97 | 32 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/14/97 | 33 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/17/97 | 33 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/18/97 | 26 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/19, 7/20/97 | 69 | 15 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 7/21/97 | 79 | 26 | 1 | 1 | 1 | 1 | 1 | 17 | 272 |
| 7/23/97 | 157 | 65 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/24/97 | 94 | 41 | 3 | 3 | 2 | 2 | 1 | 13 | 156 |
| 7/25, 7/26/97 | 309 | 49 | 3 | 3 | 3 | 3 | 1 | 35 | 1,190 |
| 7/27, 7/28/97 | 504 | 96 | 5 | 5 | 5 | 5 | 1 | 29 | 812 |
| 7/29/97 | 326 | 44 | 4 | 4 | 4 | 4 | 2 | 82 | 3,320 |
| 7/30-7/31/97 | 470 | 58 | 3 | 3 | 3 | 3 | 1 | 45 | 1,980 |
| 8/1, 8/2/97 | 315 | 19 | 2 | 2 | 2 | 2 | 1 | 92 | 8,373 |
| 8/3, 8/4/97 | 487 | 108 | 16 | 15 | 14 | 14 | 7 | 187 | 5,155 |
| **Total** | 3,037 | 607 | 38 | 37 | 35 | 35 | 15 | 500 | 21,258 |

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## Appendix A9.-Page 3 of 5.

| Date | (H) Total Harvest | ($n_i$) Number Examined | ($a_i$) Adclips Observed | ($a'_i$) Heads Recovered | ($t_i$) Heads with Tags | ($t'_i$) Decodable Tags | ($m_i$) Source= Moose R 1996 | ($r_i$) Harvest Estimate | $V(r_i)$ Variance |
|---|---|---|---|---|---|---|---|---|---|
| **Central East Side Set (continued)** | | | | | | | | | |
| **24430** | | | | | | | | | |
| 6/27-7/5/97 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/7,8,9,10/97 | 66 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/11/97 | 39 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/13/97 | 48 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/14/97 | 27 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/17/97 | 47 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/18/97 | 17 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/19, 7/20/97 | 147 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/21/97 | 228 | 82 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 7/23/97 | 291 | 57 | 1 | 1 | 1 | 1 | 1 | 28 | 757 |
| 7/24/97 | 205 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/25/97 | 203 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/26/97 | 275 | 25 | 1 | 1 | 1 | 1 | 1 | 61 | 3,661 |
| 7/27/97 | 234 | 71 | 1 | 1 | 1 | 1 | 1 | 18 | 306 |
| 7/28/97 | 361 | 118 | 2 | 2 | 2 | 2 | 0 | 0 | 0 |
| 7/29/97 | 414 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/30/97 | 211 | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/31/97 | 173 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8/1/97 | 108 | 32 | 1 | 1 | 1 | 1 | 1 | 19 | 342 |
| 8/2/97 | 232 | 45 | 3 | 3 | 3 | 3 | 2 | 57 | 1,587 |
| 8/3/97 | 357 | 109 | 10 | 10 | 10 | 10 | 5 | 91 | 1,642 |
| 8/4/97 | 193 | 89 | 5 | 5 | 5 | 5 | 3 | 36 | 406 |
| **Total** | 3,883 | 842 | 25 | 25 | 25 | 25 | 14 | 310 | 8,701 |
| **24440** | | | | | | | | | |
| 7/11/97 | 133 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/13/97 | 409 | 39 | 2 | 2 | 2 | 2 | 0 | 0 | 0 |
| 7/14/97 | 342 | 39 | 2 | 2 | 2 | 2 | 0 | 0 | 0 |
| 7/17,7/18/97 | 490 | 49 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 7/19, 7/20/97 | 445 | 32 | 2 | 1 | 1 | 1 | 0 | 0 | 0 |
| 7/21/97 | 517 | 132 | 5 | 5 | 3 | 3 | 0 | 0 | 0 |
| 7/23/97 | 591 | 35 | 2 | 2 | 2 | 2 | 0 | 0 | 0 |
| 7/24/97 | 691 | 53 | 3 | 3 | 3 | 3 | 0 | 0 | 0 |
| 7/25/97 | 680 | 69 | 4 | 4 | 4 | 4 | 1 | 55 | 2,970 |
| 7/26/97 | 962 | 86 | 5 | 5 | 5 | 5 | 1 | 62 | 3,783 |
| 7/27/97 | 513 | 177 | 7 | 7 | 7 | 7 | 0 | 0 | 0 |
| 7/28/97 | 1,117 | 287 | 9 | 9 | 8 | 8 | 1 | 22 | 462 |
| 7/29-7/30/97 | 1,714 | 120 | 8 | 8 | 7 | 7 | 4 | 317 | 25,674 |
| 7/31/97 | 687 | 321 | 27 | 27 | 25 | 25 | 8 | 95 | 1,125 |
| 8/1/97 | 394 | 196 | 16 | 16 | 15 | 15 | 5 | 56 | 600 |
| 8/2/97 | 361 | 192 | 17 | 17 | 17 | 17 | 9 | 94 | 979 |
| 8/3/97 | 692 | 288 | 22 | 22 | 22 | 22 | 12 | 160 | 2,244 |
| 8/4/97 | 506 | 104 | 10 | 10 | 10 | 10 | 2 | 54 | 1,421 |
| **Total** | 11,244 | 2,237 | 142 | 141 | 134 | 134 | 43 | 915 | 39,259 |

-continued-

## Appendix A9.-Page 4 of 5.

| Date | (H) Total Harvest | ($n_i$) Number Examined | ($a_i$) Adclips Observed | ($a'_i$) Heads Recovered | ($t_i$) Heads with Tags | ($t'_i$) Decodable Tags | ($m_i$) Source= Moose R 1996 | ($r_i$) Harvest Estimate | $V(r_i)$ Variance |
|---|---|---|---|---|---|---|---|---|---|
| **Central Kalgin Island Set (24610/20)** | | | | | | | | | |
| 6/27/97 | 0 | | | | | | | NH[a] | NA |
| 6/30/97 | 5 | | | | | | | HNEx[b] | NA |
| 7/4/97 | 3 | | | | | | | HNEx | NA |
| 7/7/97 | 3 | | | | | | | HNEx | NA |
| 7/11/97 | 117 | 98 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/14/97 | 273 | | | | | | | HNEx | NA |
| 7/18/97 | 451 | | | | | | | HNEx | NA |
| 7/21/97 | 344 | | | | | | | HNEx | NA |
| 7/25/97 | 2,705 | | | | | | | HNEx | NA |
| 7/28/97 | 2,599 | | | | | | | HNEx | NA |
| 8/1/97 | 1,132 | | | | | | | HNEx | NA |
| 8/4/97 | 1,273 | | | | | | | HNEx | NA |
| **Total** | 8,905 | 98 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Central West Side Set (24520/30/40/50/55/60)** | | | | | | | | | |
| 06/02/1997 | 0 | | | | | | | NH | NA |
| 06/04/1997 | 0 | | | | | | | NH | NA |
| 06/06/1997 | 0 | | | | | | | NH | NA |
| 06/09/1997 | 0 | | | | | | | NH | NA |
| 06/11/1997 | 0 | | | | | | | NH | NA |
| 06/13/1997 | 0 | | | | | | | NH | NA |
| 06/18/1997 | 0 | | | | | | | NH | NA |
| 06/23/1997 | 15 | | | | | | | HNEx | NA |
| 06/27/1997 | 0 | | | | | | | NH | NA |
| 06/30/1997 | 1 | | | | | | | | |
| 07/04/1997 | 1 | | | | | | | HNEx | NA |
| 07/07/1997 | 1 | | | | | | | HNEx | NA |
| 07/11/1997 | 17 | | | | | | | HNEx | NA |
| 07/14/1997 | 125 | | | | | | | HNEx | NA |
| 07/18/1997 | 413 | | | | | | | HNEx | NA |
| 07/21/1997 | 339 | | | | | | | HNEx | NA |
| 07/25/1997 | 1,221 | | | | | | | HNEx | NA |
| 07/28/1997 | 1,865 | | | | | | | HNEx | NA |
| 08/01/1997 | 2,192 | 505 | 5 | 5 | 5 | 5 | 0 | 0 | 0 |
| 08/04/1997 | 1,599 | | | | | | | HNEx | NA |
| **Total** | 7,789 | 505 | 5 | 5 | 5 | 5 | 0 | 0 | 0 |
| **CENTRAL TOTAL** | | | | | | | | | |
| | 115,467 | 34,490 | 1,428 | 1,417 | 1,319 | 1,317 | 6,142 | 3,329 | 105,456 |

-continued-

## Appendix A9.-Page 5 of 5.

| Date | (H) Total Harvest | ($n_i$) Number Examined | ($a_i$) Adclips Observed | ($a'_i$) Heads Recovered | ($t_i$) Heads with Tags | ($t'_i$) Decodable Tags | ($m_i$) Source= Moose R 1996 | ($r_i$) Harvest Estimate | $V(r_i)$ Variance |
|---|---|---|---|---|---|---|---|---|---|
| **Northern East Side Set (24770/80/90)** | | | | | | | | | |
| 6/2-7/14/97 | 269 | 112 | 2 | 2 | 2 | 2 | 0 | 0 | 0 |
| 07/25/1997 | 429 | 468 | 35 | 35 | 30 | 30 | 0 | 0 | 0 |
| 07/28/1997 | 281 | 330 | 13 | 13 | 12 | 12 | 1 | 6 | 30 |
| 08/01/1997 | 772 | 371 | 26 | 26 | 25 | 25 | 0 | 0 | 0 |
| 08/04/1997 | 468 | 380 | 31 | 31 | 28 | 28 | 1 | 7 | 42 |
| **Total** | 2,219 | 1,661 | 107 | 107 | 97 | 97 | 2 | 13 | 71 |
| **Northern Fire Island Set (24743)** | | | | | | | | | |
| 6/2-7/14/97 | 54 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/25-7/28/97 | 1,718 | 707 | 90 | 90 | 87 | 87 | 0 | 0 | 0 |
| 08/01/1997 | 897 | 427 | 62 | 62 | 59 | 59 | 0 | 0 | 0 |
| 08/04/1997 | 1,079 | 1,110 | 214 | 214 | 200 | 200 | 0 | 0 | 0 |
| **Total** | 3,748 | 2,274 | 366 | 366 | 346 | 346 | 0 | 0 | 0 |
| **Northern Knik Arm Set (24750)** | | | | | | | | | |
| 07/15/1997 | 5 | | | | | | | HNEx | NA |
| 07/20/1997 | 112 | | | | | | | HNEx | NA |
| **Total** | 117 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Northern Pt. MacKenzie/Su Flats Set (24741/42)** | | | | | | | | | |
| 6/2-7/14/97 | 248 | 28 | 3 | 3 | 3 | 3 | 0 | 0 | 0 |
| 07/25/1997 | 651 | 726 | 61 | 61 | 58 | 58 | 0 | 0 | 0 |
| 07/28/1997 | 828 | 804 | 78 | 78 | 74 | 74 | 0 | 0 | 0 |
| 08/01/1997 | 1,678 | 2,237 | 310 | 310 | 294 | 294 | 0 | 0 | 0 |
| 08/04/1997 | 1,578 | 1,254 | 132 | 132 | 124 | 124 | 1 | 7 | 42 |
| **Total** | 4,983 | 5,049 | 584 | 584 | 553 | 553 | 1 | 7 | 42 |
| **Northern West Side Set (24710/20/30)** | | | | | | | | | |
| 6/2-7/14/97 | 2,316 | 1,293 | 8 | 8 | 5 | 5 | 0 | 0 | 0 |
| 07/25/1997 | 7,231 | 4,494 | 23 | 23 | 17 | 17 | 0 | 0 | 0 |
| 07/28/1997 | 7,335 | 3,841 | 29 | 28 | 24 | 24 | 0 | 0 | 0 |
| 08/01/1997 | 5,671 | 3,865 | 61 | 61 | 55 | 55 | 2 | 16 | 114 |
| 08/04/1997 | 3,749 | 1,671 | 11 | 11 | 8 | 8 | 0 | 0 | 0 |
| **Total** | 26,302 | 15,164 | 132 | 131 | 109 | 109 | 2 | 16 | 114 |
| **NORTHERN TOTAL** | 37,369 | 24,148 | 1,189 | 1,188 | 1,105 | 1,105 | 5 | 36 | 227 |
| **GRAND TOTAL** | 152,836 | 58,638 | 2,617 | 2,605 | 2,424 | 2,422 | 8,143 | 3,365 | 105,684 |

[a] NH = No Harvest

[b] HNEx = Harvest, but none examined

**Appendix A10.-Daily angler count data, statistics, and estimates of effort for the coho salmon sport fishery in the lower 34 km of the Kenai River in 1997.**

| Post Stratification | Stratum | Date | Hours in Sampled Day | Number of Counts | Mean Angler Count | Variance of Angler Count | Estimated Hours | Variance of Est. Hours |
|---|---|---|---|---|---|---|---|---|
| Guided, Boat | Mondays | 11-Aug | 16 | 4 | 0 | 0 | 0 | 0 |
| | | 25-Aug | 16 | 4 | 0 | 0 | 0 | 0 |
| | | 01-Sep | 12 | 4 | 0 | 0 | 0 | 0 |
| | Weekdays | 06-Aug | 16 | 4 | 65 | 664 | 1,036 | 170,080 |
| | | 08-Aug | 16 | 4 | 35 | 156 | 556 | 39,957 |
| | | 14-Aug | 16 | 4 | 9 | 14 | 144 | 3,456 |
| | | 22-Aug | 16 | 4 | 9 | 7 | 144 | 1,899 |
| | | 29-Aug | 16 | 2 | 3 | 6 | 40 | 1,600 |
| | | 05-Sep | 12 | 4 | 8 | 9 | 93 | 1,356 |
| | | 09-Sep | 12 | 4 | 0 | 0 | 0 | 0 |
| | Weekends | 09-Aug | 16 | 4 | 23 | 23 | 360 | 5,813 |
| | | 17-Aug | 16 | 4 | 9 | 13 | 140 | 3,264 |
| | | 23-Aug | 16 | 4 | 16 | 17 | 256 | 4,405 |
| | | 24-Aug | 16 | 4 | 10 | 51 | 164 | 13,163 |
| | | 31-Aug | 16 | 4 | 8 | 7 | 128 | 1,771 |
| | | 06-Sep | 12 | 4 | 5 | 3 | 54 | 390 |
| Unguided, Boat | Mondays | 11-Aug | 16 | 4 | 5 | 1 | 72 | 213 |
| | | 25-Aug | 16 | 4 | 11 | 18 | 172 | 4,672 |
| | | 01-Sep | 12 | 4 | 20 | 3 | 234 | 486 |
| | Weekdays | 06-Aug | 16 | 4 | 54 | 42 | 860 | 10,816 |
| | | 08-Aug | 16 | 4 | 48 | 41 | 760 | 10,496 |
| | | 14-Aug | 16 | 4 | 9 | 4 | 144 | 1,056 |
| | | 22-Aug | 16 | 4 | 19 | 12 | 296 | 3,019 |
| | | 29-Aug | 16 | 2 | 12 | 20 | 184 | 5,184 |
| | | 05-Sep | 12 | 4 | 11 | 9 | 126 | 1,314 |
| | | 09-Sep | 12 | 4 | 3 | 1 | 30 | 150 |
| | Weekends | 09-Aug | 16 | 4 | 12 | 11 | 192 | 2,837 |
| | | 17-Aug | 16 | 4 | 25 | 21 | 396 | 5,429 |
| | | 23-Aug | 16 | 4 | 30 | 55 | 472 | 14,101 |
| | | 24-Aug | 16 | 4 | 27 | 28 | 424 | 7,189 |
| | | 31-Aug | 16 | 4 | 36 | 120 | 568 | 30,837 |
| | | 06-Sep | 12 | 4 | 16 | 15 | 186 | 2,100 |
| Unguided, Shore | Mondays | 11-Aug | 16 | 4 | 11 | 6 | 180 | 1,429 |
| | | 25-Aug | 16 | 4 | 7 | 10 | 112 | 2,581 |
| | | 01-Sep | 12 | 4 | 6 | 1 | 66 | 84 |
| | Weekdays | 06-Aug | 16 | 4 | 21 | 9 | 336 | 2,219 |
| | | 08-Aug | 16 | 4 | 27 | 68 | 424 | 17,429 |
| | | 14-Aug | 16 | 4 | 33 | 28 | 520 | 7,264 |
| | | 22-Aug | 16 | 4 | 8 | 3 | 128 | 789 |
| | | 29-Aug | 16 | 2 | 0 | 0 | 0 | 0 |
| | | 05-Sep | 12 | 4 | 4 | 2 | 51 | 222 |
| | | 09-Sep | 12 | 4 | 0 | 0 | 0 | 0 |
| | Weekends | 09-Aug | 16 | 4 | 24 | 243 | 388 | 62,229 |
| | | 17-Aug | 16 | 4 | 22 | 45 | 352 | 11,637 |
| | | 23-Aug | 16 | 4 | 13 | 21 | 204 | 5,429 |
| | | 24-Aug | 16 | 4 | 9 | 26 | 144 | 6,709 |
| | | 31-Aug | 16 | 4 | 4 | 2 | 68 | 405 |
| | | 06-Sep | 12 | 4 | 4 | 0 | 45 | 30 |

**Appendix A11.-Daily angler interview data, statistics, and estimates of catch and harvest for the coho salmon sport fishery in the lower 34 km of the Kenai River in 1997.**

| | Interview Data | | | | | SE | Estimated | SE | | SE | Estimated | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Interviews | Effort | Catch | Harvest | CPUE [a] | CPUE | Catch | Catch | HPUE [a] | HPUE | Harvest | Harvest |
| **Guided, Boat** | | | | | | | | | | | | |
| **Mondays** | | | | | | | | | | | | |
| 11-Aug | 0 | | | | | | 0.0 | 0.0 | | | 0.0 | 0.0 |
| 25-Aug | 0 | | | | | | 0.0 | 0.0 | | | 0.0 | 0.0 |
| 01-Sep | 0 | | | | | | 0.0 | 0.0 | | | 0.0 | 0.0 |
| **Weekdays** | | | | | | | | | | | | |
| 06-Aug | 3 | 18 | 1 | 1 | 0.056 | 0.055 | 57.6 | 57.6 | 0.056 | 0.056 | 57.6 | 57.6 |
| 08-Aug | 6 | 28 | 2 | 2 | 0.072 | 0.045 | 40.0 | 27.1 | 0.072 | 0.045 | 40.0 | 27.1 |
| 14-Aug | 4 | 16 | 0 | 0 | 0.000 | 0.000 | 0.0 | 0.0 | 0.000 | 0.000 | 0.0 | 0.0 |
| 22-Aug | 6 | 36 | 7 | 4 | 0.185 | 0.114 | 26.6 | 17.7 | 0.105 | 0.049 | 15.2 | 8.1 |
| 29-Aug | 0 | | | | 0.938 | 0.352 | 37.5 | 37.5 | 0.678 | 0.471 | 27.1 | 27.1 |
| 05-Sep | 0 | | | | 0.176 | 0.110 | 16.4 | 11.3 | 0.127 | 0.145 | 11.8 | 13.2 |
| 09-Sep | 0 | | | | 0.080 | 0.032 | 0.0 | 0.0 | 0.058 | 0.022 | 0.0 | 0.0 |
| **Weekends** | | | | | | | | | | | | |
| 09-Aug | 16 | 57 | 3 | 3 | 0.051 | 0.032 | 18.3 | 11.5 | 0.051 | 0.030 | 18.3 | 11.5 |
| 17-Aug | 8 | 22 | 1 | 1 | 0.046 | 0.045 | 6.5 | 6.4 | 0.047 | 0.046 | 6.5 | 6.4 |
| 23-Aug | 0 | | | | 0.162 | 0.084 | 41.5 | 23.5 | 0.142 | 0.049 | 36.3 | 15.3 |
| 24-Aug | 22 | 127 | 9 | 7 | 0.070 | 0.032 | 11.5 | 8.6 | 0.055 | 0.017 | 9.0 | 6.6 |
| 31-Aug | 4 | 24 | 0 | 0 | 0.000 | 0.000 | 0.0 | 0.0 | 0.000 | 0.000 | 0.0 | 0.0 |
| 06-Sep | 0 | | | | 0.259 | 0.184 | 14.0 | 10.6 | 0.226 | 0.107 | 12.2 | 7.0 |

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**Appendix A11.-Page 2 of 3.**

| Date | Interview Data: Interviews | Effort | Catch | Harvest | CPUE [a] | SE CPUE | Estimated Catch | SE Catch | HPUE [a] | SE HPUE | Estimated Harvest | SE Harvest |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unguided, Boat** | | | | | | | | | | | | |
| **Mondays** | | | | | | | | | | | | |
| 11-Aug | 15 | 38 | 2 | 2 | 0.053 | 0.032 | 3.8 | 2.7 | 0.053 | 0.036 | 3.8 | 2.7 |
| 25-Aug | 7 | 15 | 4 | 4 | 0.242 | 0.141 | 41.6 | 27.9 | 0.242 | 0.143 | 41.6 | 27.9 |
| 01-Sep | 12 | 23 | 0 | 0 | 0.000 | 0.000 | 0.0 | 0.0 | 0.000 | 0.000 | 0.0 | 0.0 |
| **Weekdays** | | | | | | | | | | | | |
| 06-Aug | 10 | 52 | 1 | 1 | 0.018 | 0.000 | 15.5 | 16.8 | 0.018 | 0.020 | 15.5 | 16.8 |
| 08-Aug | 4 | 12 | 0 | 0 | 0.000 | 0.000 | 0.0 | 0.0 | 0.000 | 0.000 | 0.0 | 0.0 |
| 14-Aug | 7 | 25 | 1 | 1 | 0.042 | 0.045 | 6.1 | 5.8 | 0.042 | 0.040 | 6.1 | 5.8 |
| 22-Aug | 7 | 16 | 2 | 1 | 0.129 | 0.084 | 38.1 | 25.3 | 0.063 | 0.065 | 18.7 | 19.2 |
| 29-Aug | 3 | 5 | 2 | 2 | 0.367 | 0.255 | 67.5 | 50.5 | 0.367 | 0.255 | 67.5 | 50.5 |
| 05-Sep | 8 | 13 | 1 | 1 | 0.069 | 0.077 | 8.7 | 9.8 | 0.069 | 0.078 | 8.7 | 9.8 |
| 09-Sep | 0 | | | | 0.103 | 0.045 | 3.1 | 1.8 | 0.093 | 0.046 | 2.8 | 1.7 |
| **Weekends** | | | | | | | | | | | | |
| 09-Aug | 7 | 30 | 0 | 0 | 0.000 | 0.000 | 0.0 | 0.0 | 0.000 | 0.000 | 0.0 | 0.0 |
| 17-Aug | 11 | 43 | 2 | 2 | 0.047 | 0.032 | 18.7 | 12.6 | 0.047 | 0.032 | 18.7 | 12.6 |
| 23-Aug | 18 | 41 | 9 | 9 | 0.215 | 0.071 | 101.4 | 42.4 | 0.215 | 0.074 | 101.4 | 42.4 |
| 24-Aug | 8 | 22 | 3 | 3 | 0.134 | 0.071 | 56.9 | 31.2 | 0.134 | 0.070 | 56.9 | 31.2 |
| 31-Aug | 36 | 173 | 3 | 3 | 0.017 | 0.000 | 9.6 | 6.3 | 0.017 | 0.010 | 9.6 | 6.3 |
| 06-Sep | 3 | 6 | 2 | 2 | 0.343 | 0.161 | 63.8 | 33.2 | 0.343 | 0.162 | 63.8 | 33.2 |

-continued-

**Appendix A11.-Page 3 of 3.**

| Date | Interview Data: Interviews | Effort | Catch | Harvest | CPUE [a] | SE CPUE | Estimated Catch | SE Catch | HPUE [a] | SE HPUE | Estimated Harvest | SE Harvest |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unguided, Shore** | | | | | | | | | | | | |
| **Mondays** | | | | | | | | | | | | |
| 11-Aug | 0 | | | | 0.092 | 0.032 | 16.6 | 7.3 | 0.092 | 0.062 | 16.6 | 11.6 |
| 25-Aug | 18 | 50 | 10 | 10 | 0.186 | 0.084 | 20.8 | 12.6 | 0.185 | 0.084 | 20.8 | 12.6 |
| 01-Sep | 2 | 3 | 1 | 1 | 0.417 | 0.251 | 27.5 | 16.8 | 0.417 | 0.250 | 27.5 | 16.8 |
| 06-Aug | 1 | 2 | 0 | 0 | 0.000 | 0.000 | 0.0 | 0.0 | 0.000 | 0.000 | 0.0 | 0.0 |
| 08-Aug | 3 | 6 | 3 | 3 | 0.456 | 0.155 | 193.2 | 86.9 | 0.456 | 0.156 | 193.2 | 86.9 |
| 14-Aug | 0 | | | | 0.061 | 0.045 | 31.8 | 21.1 | 0.061 | 0.057 | 31.8 | 30.0 |
| 22-Aug | 4 | 13 | 1 | 1 | 0.046 | 0.100 | 5.9 | 12.8 | 0.046 | 0.102 | 5.9 | 12.8 |
| 29-Aug | 6 | 12 | 3 | 3 | 0.261 | 0.105 | 0.0 | 0.0 | 0.263 | 0.106 | 0.0 | 0.0 |
| 05-Sep | 0 | | | | 0.100 | 0.077 | 5.1 | 4.1 | 0.100 | 0.113 | 5.1 | 5.7 |
| 09-Sep | 0 | | | | 0.190 | 0.063 | 0.0 | 0.0 | 0.191 | 0.062 | 0.0 | 0.0 |
| 09-Aug | 0 | | | | 0.000 | 0.000 | 0.0 | 0.0 | 0.000 | 0.000 | 0.0 | 0.0 |
| 17-Aug | 4 | 8 | 4 | 2 | 0.220 | 0.562 | 77.3 | 190.0 | 0.198 | 0.161 | 69.7 | 57.9 |
| 23-Aug | 6 | 6 | 7 | 5 | 1.171 | 0.445 | 238.8 | 120.9 | 0.835 | 0.330 | 170.4 | 87.9 |
| 24-Aug | 14 | 34 | 8 | 7 | 0.216 | 0.095 | 31.1 | 21.1 | 0.186 | 0.097 | 26.7 | 19.1 |
| 31-Aug | 3 | 6 | 1 | 0 | 0.166 | 0.167 | 11.3 | 11.3 | 0.000 | 0.000 | 0.0 | 0.0 |
| 06-Sep | 2 | 4 | 2 | 2 | 0.560 | 0.084 | 25.2 | 4.8 | 0.560 | 0.083 | 25.2 | 4.8 |

[a] Bias-corrected catch per unit-hour of effort (CPUE) and harvest per unit-hour of effort (HPUE).

# APPENDIX B. ESTIMATION OF ANGLER EFFORT, HARVEST, AND CATCH

## Appendix B1.-Estimation of angler effort, harvest, and catch.

### Angler Effort

For each angler type g and stratum h, total angler effort (in hours) during day i and its variance were estimated as:

$$\hat{E}_{ghi} = \bar{x}_{ghi} T_{hi}, \text{ and} \tag{B1}$$

$$\hat{V}\left[\hat{E}_{ghi}\right] = \hat{V}\left[\bar{x}_{ghi}\right] T_{hi}^2, \tag{B2}$$

where $\bar{x}_{ghi}$ is the average number of anglers of type g counted fishing, $T_{hi}$ is the number of hours in each fishing day (16 in August, 12 in September), and $\hat{V}\left[\bar{x}_{ghi}\right]$ is obtained approximately by using the successive difference formula appropriate for systematic samples (Wolter 1985:251):

$$\hat{V}\left[\bar{x}_{ghi}\right] \approx \frac{\sum_{j=2}^{r_{hi}} \left(x_{ghij} - x_{ghi(j-1)}\right)^2}{2 r_{hi} (r_{hi} - 1)}, \tag{B3}$$

where $x_{ghij}$ is number of type g anglers during angler count j and $r_{hi}$ is the number of angler counts per day (4).

Total effort by anglers of type g during stratum h was estimated by expanding over days:

$$\hat{E}_{gh} = D_h \bar{E}_{gh}, \tag{B4}$$

where:

$$\bar{E}_{gh} = \frac{\sum_{i=1}^{d_h} \hat{E}_{ghi}}{d_h}, \tag{B5}$$

and $D_h$ and $d_h$ are the number of days and sampled days, respectively, of type h in the survey.

The variance of angler effort by stratum was estimated as:

$$\hat{V}\left[\hat{E}_{gh}\right] = (1 - f_{1h}) \frac{D_h^2}{d_h} \frac{\sum_{i=1}^{d_h} \left(\hat{E}_{ghi} - \bar{E}_{gh}\right)^2}{d_h - 1} + f_{1h} \frac{D_h^2}{d_h^2} \sum_{i=1}^{d_h} \hat{V}\left[\hat{E}_{ghi}\right], \tag{B6}$$

where $f_{ih}$ is the first-stage sampling fraction $(d_h / D_h)$.

Total effort for angler-type g (across all time strata h) was estimated as:

$$\hat{E}_g = \sum_{h=1}^{3} \hat{E}_{gh}, \text{ and} \tag{B7}$$

$$\hat{V}\left[\hat{E}_g\right] = \sum_{h=1}^{3} \hat{V}\left[\hat{E}_{gh}\right]. \quad \text{(B8)}$$

Finally, total effort across all angler types was estimated as:

$$\hat{E} = \sum_{g=1}^{3} \hat{E}_g \text{ , and} \quad \text{(B9)}$$

$$\hat{V}\left[\hat{E}\right] = \sum_{g=1}^{3} \hat{V}\left[\hat{E}_g\right]. \quad \text{(B10)}$$

**Angler Harvest and Catch**

Harvest and catch, their associated variances, and standard errors were estimated using the following procedures.

Within day i of stratum h, estimates of mean harvest per unit effort for anglers of type g were calculated using a jackknife procedure (Efron 1982) to reduce bias. Data from completed-trip interviews only were used. First, the mean harvest of angler-trips was divided by the mean length of trip to estimate the sample ratio of HPUE:

$$\overline{\text{HPUE}}_{ghi} = \frac{\overline{H}_{ghi}}{\overline{e}_{ghi}} = \frac{\sum_{k=1}^{m_{ghi}} H_{ghik} \Big/ m_{ghi}}{\sum_{k=1}^{m_{ghi}} e_{ghik} \Big/ m_{ghi}} = \frac{\sum_{k=1}^{m_{ghi}} H_{ghik}}{\sum_{k=1}^{m_{ghi}} e_{ghik}}, \quad \text{(B11)}$$

where $H_{ghik}$ was the harvest, by species, during an angler trip k, $e_{ghik}$ was the effort expended (in hours) during angler-trip k, and $m_{ghi}$ was the number of completed-trip interviews from anglers of type g. Since the above estimate of mean HPUE has an inherent bias of order $1/m_{ghi}$ (Cochran 1977), the jackknifed estimate of mean HPUE was calculated (Efron 1982):

$$\overline{\text{HPUE}}^{*}_{ghi} = \frac{\sum_{k=1}^{m_{ghi}} \text{HPUE}^{*}_{ghik}}{m_{ghi}}, \quad \text{(B12)}$$

where:

$$\text{HPUE}^{*}_{ghik} = \frac{\sum_{\substack{m=1 \\ m \neq k}}^{m_{ghi}} H_{ghim}}{\sum_{\substack{m=1 \\ m \neq k}}^{m_{ghi}} e_{ghim}}. \quad \text{(B13)}$$

The jackknifed estimate was used to reduce the inherent bias to order $1/m_{ghi}^2$ through the adjustment:

$$\overline{\overline{HPUE}}_{ghi}^{**} = m_{ghi}\left[\overline{\overline{HPUE}}_{ghi} - \overline{\overline{HPUE}}_{ghi}^{*}\right] + \overline{\overline{HPUE}}_{ghi}^{*}. \quad \text{(B14)}$$

The variance of $\overline{\overline{HPUE}}_{ghi}^{**}$ is the variance of $\overline{\overline{HPUE}}_{ghi}^{*}$:

$$\hat{V}\left[\overline{\overline{HPUE}}_{ghi}^{**}\right] = \hat{V}\left[\overline{\overline{HPUE}}_{ghi}^{*}\right] = \frac{m_{ghi}-1}{m_{ghi}} \sum_{k=1}^{m_{ghi}} \left[HPUE_{ghik}^{*} - \overline{\overline{HPUE}}_{ghik}^{*}\right]^2. \quad \text{(B15)}$$

Mean catch per unit effort (CPUE) was estimated using equations B11-B15, after first substituting catch $C_{ghik}$ for harvest $H_{ghik}$.

Total harvest by anglers of type g during day i of stratum h was estimated as the product of estimated effort and bias-corrected HPUE:

$$\hat{H}_{ghi} = \hat{E}_{ghi}\,\overline{\overline{HPUE}}_{ghi}^{**}, \quad \text{(B16)}$$

and its variance followed Goodman (1960):

$$\hat{V}\left[\hat{H}_{ghi}\right] = \hat{V}\left(\overline{\overline{HPUE}}_{ghi}^{**}\right)\hat{E}_{ghi}^{2} + \hat{V}\left(\hat{E}_{ghi}\right)\overline{\overline{HPUE}}_{ghi}^{**2} - \hat{V}\left(\overline{\overline{HPUE}}_{ghi}^{**}\right)\hat{V}\left(\hat{E}_{ghi}\right). \quad \text{(B17)}$$

Occasionally, there were no guided boat anglers or unguided shore anglers interviewed on a given day, so $\overline{\overline{HPUE}}_{ghi}^{**}$ was missing. When this occurred, an imputed value was substituted as follows:

$$\overline{\overline{HPUE}}_{ghi}^{**} = a_{gg'h}\,\overline{\overline{HPUE}}_{g'hi}^{**}, \text{ and} \quad \text{(B18)}$$

$$\hat{V}\left[\overline{\overline{HPUE}}_{ghi}^{**}\right] = a_{gg'h}^{2}\,\hat{V}\left[\overline{\overline{HPUE}}_{g'hi}^{**}\right], \quad \text{(B19)}$$

where $\overline{\overline{HPUE}}_{g'hi}^{**}$ is the bias-corrected mean harvest rate for unguided boat anglers for that day, and $a_{gg'h}$ is the weighted ratio of harvest rates between angler types g (guided boat or unguided shore) and g' (unguided boat):

$$a_{gg'h} = \frac{\sum_{i=1}^{d_h}\left(m_{ghi} + m_{g'hi}\right)\overline{\overline{HPUE}}_{ghi}^{**}}{\sum_{i=1}^{d_h}\left(m_{ghi} + m_{g'hi}\right)\overline{\overline{HPUE}}_{g'hi}^{**}}, \quad \text{(B20)}$$

where the summation is over all days in stratum h with at least one interview from angler type g, and the weights $\left(m_{ghi} + m_{g'hi}\right)$ are the total number of interviews of type g and g'.

Total harvest by anglers of type g during stratum h was estimated by expanding over days:

$$\hat{H}_{gh} = D_h \overline{H}_{gh}, \tag{B21}$$

where:

$$\overline{H}_{gh} = \frac{\sum_{i=1}^{d_h} \hat{H}_{ghi}}{d_h}, \tag{B22}$$

and $D_h$ and $d_h$ are the number of days and sampled days, respectively, of type h in the survey.

The variance of $\hat{H}_{gh}$ by stratum was estimated as:

$$\begin{aligned} \hat{V}\left[\hat{H}_{gh}\right] = (1 - f_{1h}) \frac{D_h^2}{d_h} \frac{\sum_{i=1}^{d_h} \left(\hat{H}_{ghi} - \overline{H}_{gh}\right)^2}{d_h - 1} + f_{1h} \frac{D_h^2}{d_h^2} \sum_{i=1}^{d_h} \hat{V}\left[\hat{H}_{ghi}\right] \\ + 2 f_{1h} \frac{D_h^2}{d_h^2} \sum_{i=1}^{d_h} a_{gg'h} b_{ghi} \hat{V}\left[\overline{\text{HPUE}}^{**}_{ghi}\right] \hat{E}_{ghi} \hat{E}_{g'hi}, \end{aligned} \tag{B23}$$

where $f_{ih}$ is the first-stage sampling fraction $(d_h / D_h)$, the last term is the variance penalty for imputation (Bernard et al. 1998), and $b_{ghi}$ = 1 if day i has a substituted value for mean harvest rate or 0 if not.

Total harvest by anglers of type g (across all time strata h) was estimated as:

$$\hat{H}_g = \sum_{h=1}^{3} \hat{H}_{gh}, \text{ and} \tag{B24}$$

$$\hat{V}\left[\hat{H}_g\right] = \sum_{h=1}^{3} \hat{V}\left[\hat{H}_{gh}\right]. \tag{B25}$$

Finally, total harvest across all angler types was estimated as:

$$\hat{H} = \sum_{g=1}^{3} \hat{H}_g, \text{ and} \tag{B26}$$

$$\hat{V}\left[\hat{H}\right] = \sum_{g=1}^{3} \hat{V}\left[\hat{H}_g\right]. \tag{B27}$$

Catch statistics were estimated similarly, after substituting $\overline{\text{CPUE}}^{**}_{hij}$ for $\overline{\text{HPUE}}^{**}_{hij}$ in equations B16-B27. However a different imputation procedure was used when $\overline{\text{CPUE}}^{**}_{hij}$ was missing:

$$\overline{\text{CPUE}}^{**}_{ghi} = c_{gh}\,\overline{\text{HPUE}}^{**}_{ghi}, \text{ and} \tag{B28}$$

$$\hat{V}\left[\overline{\text{CPUE}}^{**}_{ghi}\right] = c_{gh}^2\,\hat{V}\left[\overline{\text{HPUE}}^{**}_{ghi}\right], \tag{B29}$$

where $\overline{\text{HPUE}}^{**}_{ghi}$ is the bias-corrected mean harvest rate for angler-type g, stratum h, and day i, and $c_{gh}$ is the weighted ratio of catch rate to harvest rate for angler-type g, stratum h:

$$c_{gh} = \frac{\sum_{i=1}^{d_h} m_{ghi}\,\overline{\text{CPUE}}^{**}_{ghi}}{\sum_{i=1}^{d_h} m_{ghi}\,\overline{\text{HPUE}}^{**}_{ghi}}. \tag{B30}$$