Fishery Data Series No. 98-4

Assessment of Coho Salmon from the Kenai River, Alaska, 1996

by

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and

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April 1998

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

Symbols and Abbreviations

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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, χ^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

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April 1998

This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-12, Job No. S-2-14.

The Fishery Data Series was established in 1987 for the publication of technically-oriented results for a single project or group of closely related projects. Fishery Data Series reports are intended for fishery and other technical professionals. Distribution is to state and local publication distribution centers, libraries and individuals and, on request, to other libraries, agencies, and individuals. This publication has undergone editorial and peer review.

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This document should be cited as:
Carlon, Jamie A. and James J. Hasbrouck. 1998. Assessment of coho salmon from the Kenai River, Alaska, 1996. Alaska Department of Fish and Game, Fishery Data Series No. 98-4, Anchorage.

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ABSTRACT

The 1996 commercial harvest of coho salmon *Oncorhynchus kisutch* of Kenai River origin in selected Upper Cook Inlet (UCI) fisheries was estimated based on the recovery of harvested adults marked with coded wire tags and adipose finclips. An estimated 2,671 (SE=235) coho salmon of Kenai River origin were harvested by the Central District drift gillnet fishery and an estimated 11,876 (SE=871) 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 171,361 coho salmon and 29% of the total eastside set gillnet harvest of 40,548 coho salmon. Commercial harvest estimates are the fourth available for this population of coho salmon.

The estimated harvest by the 1996 drift gillnet fishery was lower than the 1993 through 1995 average due to a lower overall harvest of coho salmon and a shortened fishing season. As in prior years, the majority (96%) of the population-specific harvest occurred during a 3-week period, but that period began about 1 week earlier (mid-July). Geographic trends in the drift gillnet fishery could not be discerned because harvests delivered to processing locations were usually a mix of fish from multiple statistical areas.

Estimated harvest in the 1996 eastside set gillnet fishery was similar to those observed in 1993 through 1995. The 3-week duration of the harvest was similar to that of 1993 through 1995, but began about 1 week earlier (mid-July). As in prior years, most (92%) of the harvest occurred during a 3-week period, but that period began about 1 week earlier (third week of July). There was a general decreasing trend in the portion of the total harvest comprising coho salmon of Kenai River origin from the southernmost statistical area to the northernmost; however, the harvest estimates were similar.

Coded wire tags recovered from the drift gillnet fishery were also examined to determine the effect of fishery restrictions on the harvest of coho salmon from the Kenai River. The harvest of coho salmon of Kenai River origin during restricted fishing periods did not increase even though the restriction concentrated fishing effort closer to the mouth of the Kenai River.

Based on the number of smolt marked at the Moose River in 1995 (94,535 smolt), the number of sport harvested adults examined for marks (3,687), and the estimated number of marked adults recovered in the sport harvest sample (749), an estimated 465,075 (SE = 15,091) coho salmon smolt emigrated from the Kenai River in 1995. This is the lowest of the four annual estimates available. The Alaska Board of Fisheries adopted a Kenai River Coho Salmon Management Plan in March of 1997 because of this relative decline in smolt abundance and the harvest potential among commercial and sport fisheries.

Precise placement of coded wire tags through proper selection of tag injector headmolds likely resulted in the low tag loss rate of 2% during the experiment.

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

INTRODUCTION

BACKGROUND

Coho salmon *Oncorhynchus kisutch* spawn and rear in freshwater drainages of Upper Cook Inlet (UCI, Figure 1). Adults returning to spawn 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. 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

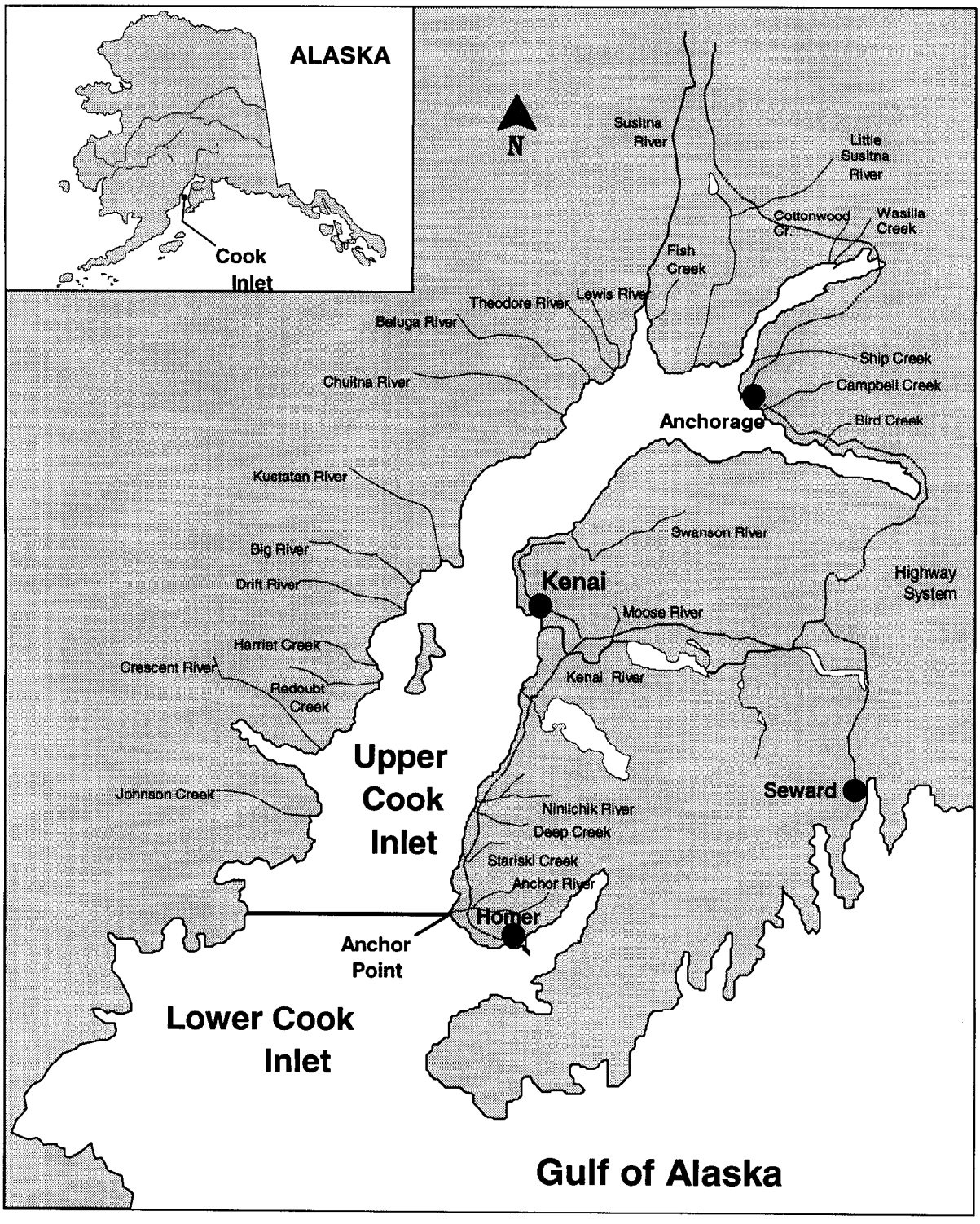
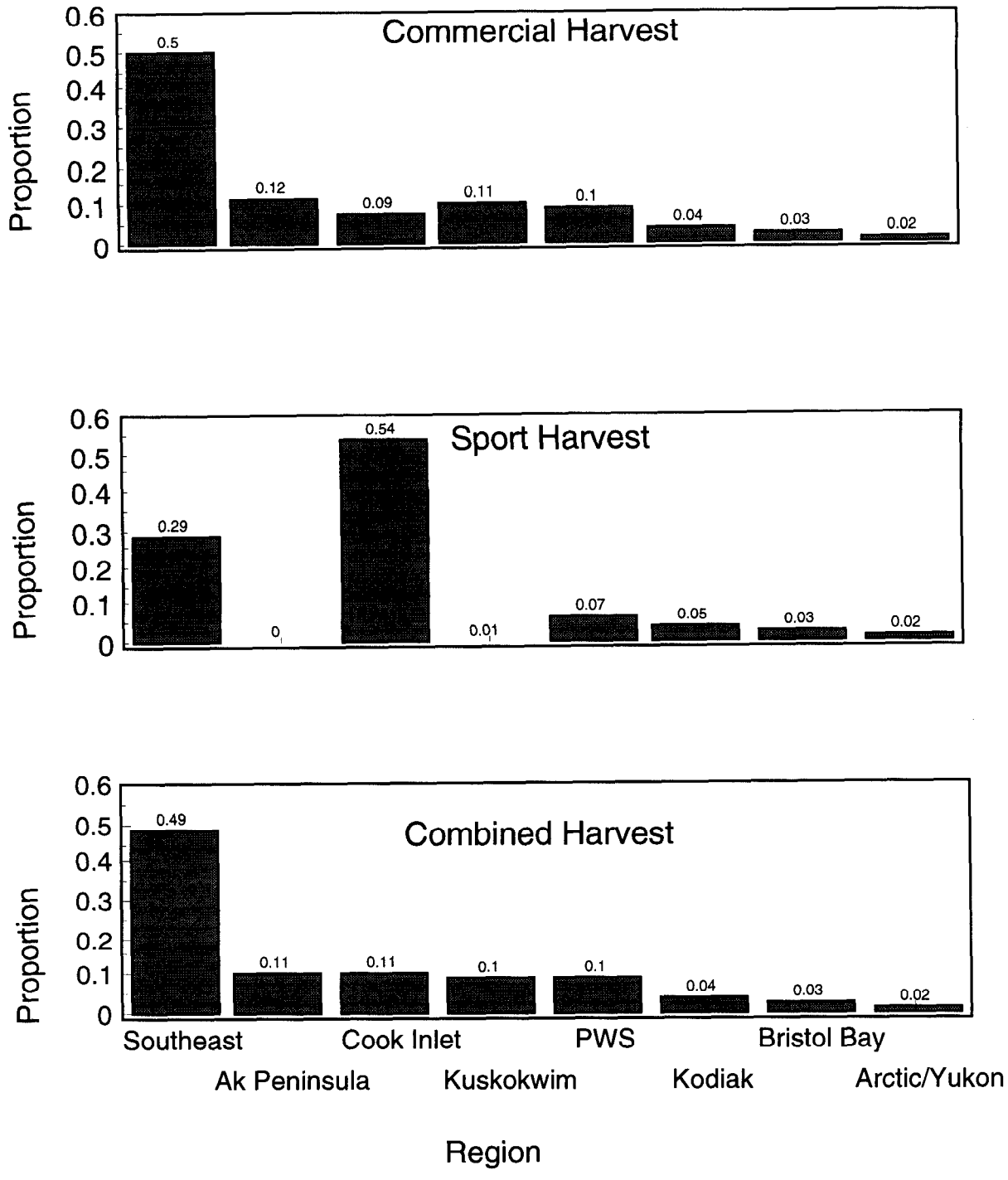


Figure l.-Schematic map of the Cook Inlet Basin with selected tributaries known to support coho salmon.



Data from: Rigby et al. (1991); Howe et al. (1995); ADF&G Fish Ticket Database.

Figure 2.-Average proportions of the statewide commercial and sport harvests of coho salmon by region, 1985-1994.

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 and 1996) and contribute to commercial marine harvests of UCI. Marine sport and inriver personal use fisheries also occur along migratory approach routes to Kenai River spawning areas, but the harvest of coho salmon from the Kenai River by these fisheries is currently considered inconsequential.

The initial goal of the Kenai River population assessment program was to estimate annual exploitation and production rates to determine if exploitation is threatening sustained production. The planned approach was to annually estimate: (1) the stock-specific harvest in marine commercial fisheries, (2) the inriver sport and personal use harvests, and (3) the spawning escapement. This assessment approach relies entirely on annual estimates of adult harvest and escapement. Commercial harvest has been estimated annually since 1993 by a coded wire tag (CWT) release and recovery program (Carlon and Hasbrouck 1994, 1996, 1997). 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 and 1996). Because spawning escapements have not been estimated, total adult production and exploitation remain unknown.

Smolt production estimates are available since 1992 as ancillary information from the tag release and recovery procedures used to estimate commercial harvest. Smolt production is therefore being considered as an alternative to adult production for assessing stock status. Monitoring of smolt production may obviate costly and complex procedures to estimate adult escapements. However, consideration of adult studies has not been abandoned. Monitoring smolt is considered a long-term approach which may not provide for a timely conservation response; the Kenai River population will continue to contribute to commercial harvests and there has been an increasing trend in the inriver sport harvest since 1977 to a record high of 87,000 fish in 1994 (Mills 1979-1994, Howe et al. 1995-1996).

This report is the fourth in a series of published estimates of the commercial harvest and smolt abundance of coho salmon from the Kenai River. This report documents commercial harvests in 1996 and smolt abundance in 1995. Estimates of the 1996 inriver recreational and personal use harvests will become available late in 1997. These estimates, when combined with the commercial harvest estimates presented in this report, will represent the fourth consecutive annual estimate of total harvest for this population.

Because the annual harvest was first estimated for1993 (Carlon and Hasbrouck 1994), the first paired estimates of harvest and subsequent smolt production will become available when the 1997 smolt production is estimated. Due to expected variability in the harvest-smolt relationship, the number of annual paired estimates needed to identify a sustainable yield with this method is not known. This illustrates the long-term nature of this endeavor.

STUDY AREA

Smolt were captured for marking in 1995 as they emigrated from the Moose River (Figure 3), a tributary to the Kenai River at Kenai River kilometer (rkm) 60.5. Samples of adults sport harvested from the lower 34 km of the Kenai River were examined in 1996 to estimate the portion of the return bearing tags. 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 in 1996. 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 1996, and
2. to estimate the number of coho salmon smolt that emigrated from the Kenai River in 1995.

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, 1996; and, if constant,
2. to estimate the marked proportion of the adult population returning to the Kenai River from August 1 through September 30, 1996.

METHODS

EXPERIMENTAL DESIGN AND ASSUMPTIONS

Harvest from a population of salmon in a mixed-population fishery can be estimated by marking juveniles in fresh water at a similar life stage 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 1995, marked with coded wire tags, and released. Total harvest of coho salmon in 1996 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 the inriver sport harvest in 1996.

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. This assumption was evaluated by examining coho salmon harvested in the Kenai River sport fishery for marks 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 so that the marked fraction could be estimated by pooling samples from the sport fishery over time. Such mixing implies that the inriver marked fraction equaled the marked fraction of the population as it passed through commercial harvest areas prior to entering the river (the marked fraction passing through commercial fishery areas must be known or estimated to estimate commercial harvest). Rejecting the hypothesis would indicate that marked fish were

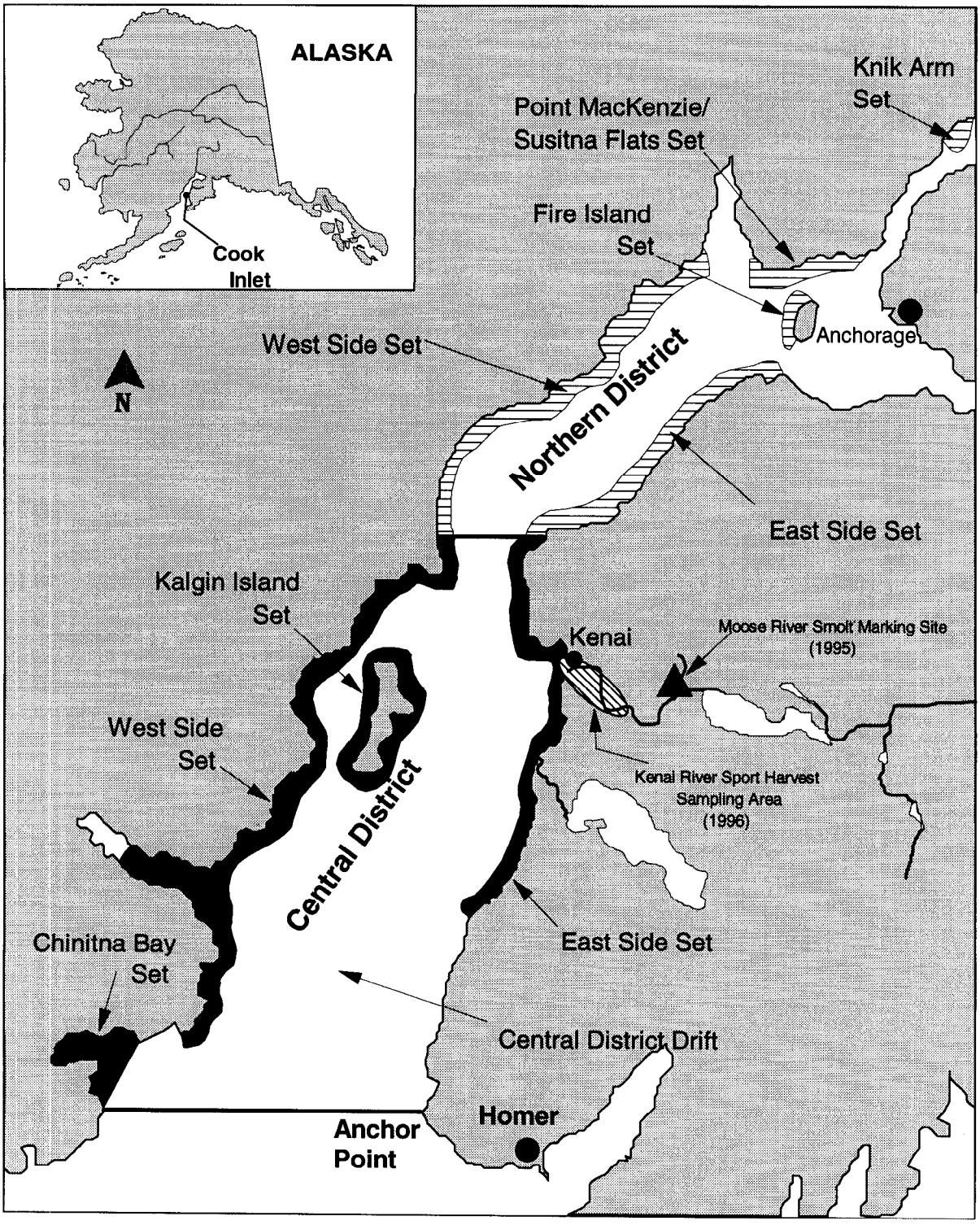


Figure 3.-Schematic map of Upper Cook Inlet showing 10 commercial set gillnet and drift gillnet fishery areas, location at which marked coho salmon smolt were released in the Kenai River drainage in 1995, and Kenai River section in which the sport harvest was examined in 1996.

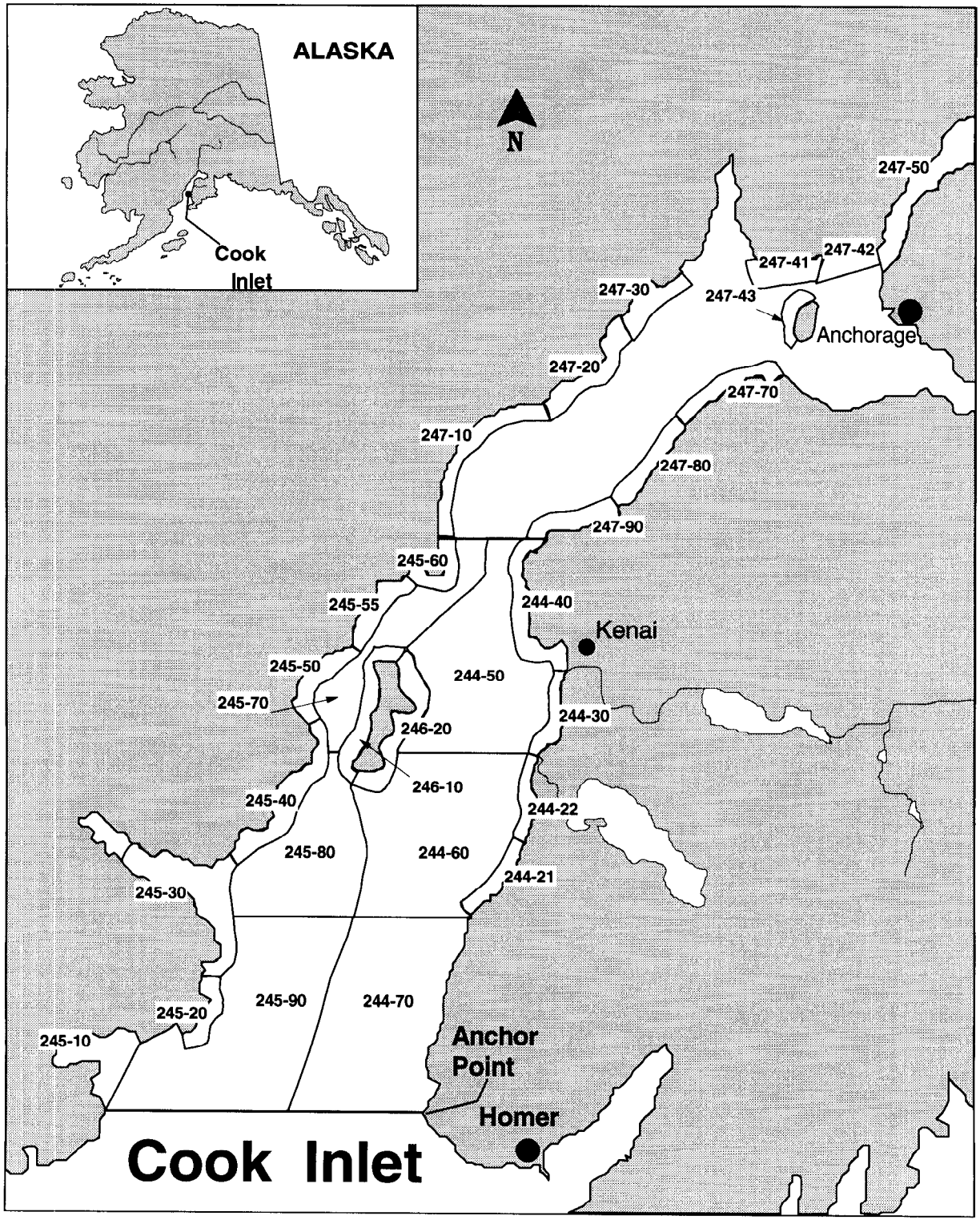


Figure 4.-Schematic map of Upper Cook Inlet statistical areas.

a biased sample of the population and estimating the commercial harvest of the population may not be possible unless bias is minimal.

DATA COLLECTION

Data collection occurred during 2 calendar years. Mark-release data were collected when smolt were captured and marked in 1995 and mark recovery data were collected in 1996 from commercial and sport harvests.

Juvenile Marking in 1995

Juveniles were captured for marking in 1995 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. Tags 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, 1996, 1997). The recovery of adults tagged 2 years prior to recovery has never occurred. Tags implanted during all segments of the 1992 through 1994 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* b) as quickly as possible. When the marking goal was achieved on June 9, the weir was dismantled. The emigration was therefore not censused in 1995. Observations indicate that most smolt arriving at the weir were tagged through June 9, but the number passing after June 9 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 20 through June 9, 1995. 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 1995 than in prior years and most fish were marked within 1 day of arrival at the weir. This permitted the marking of all smolt captured during 1995 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 coded wire tagging 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 10,440 to 12,480 depending on the number of tags per tag spool. This resulted in eight 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.

Sport Fishery in 1996

The sport harvest in the Kenai River was examined during 1996 to recover tags and determine if a representative sample of smolt was marked in 1995. Sport fishing for coho salmon occurs throughout the Kenai River mainstem from its mouth upstream to the outlet of Kenai Lake. The majority of the harvest occurs in the lower 34 km of the river downstream from the Sterling Highway bridge in Soldotna. The fishery occurs primarily during August and September, after which harvest and effort decline to low levels. Only limited spawning occurs in tributaries to this section of the mainstem.

During August and September 1996, coho salmon sport harvested from the lower 34 km of the Kenai River were examined for a missing adipose fin. Daily counts of fish examined and of those missing an adipose fin were recorded. Heads were collected from most adipose-clipped fish and shipped to the ADF&G Tag Lab in Juneau. Some anglers desired trophy mounts or entered fish in a salmon derby contest; heads were not recovered in these cases. Examined fish were marked by punching a hole in the caudal fin to avoid examining fish twice.

Examining fish harvested in the lower 34 km of the mainstem Kenai River provided the best opportunity to examine a representative sample of the adult return. Because a creel survey was

not conducted in 1996, it is not known if the sport harvest samples were temporally proportional to the sport harvest. Therefore, to estimate the marked fraction of the return, it must be assumed that the sport harvest from this river 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 non-selective. The validity of this assumption, however, has not been directly tested.

Commercial Fishery in 1996

Upper Cook Inlet commercial fisheries typically harvest coho salmon between late June and early September. The fisheries are managed primarily for sockeye salmon *O. nerka* through various combinations of time and area restrictions. Fishery management guidelines for all species are described in the Upper Cook Inlet Salmon Management Plan; 1996 management actions are documented by Ruesch and Fox (1997).

Fisheries selected for sampling during 1996 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 a few hundred 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. *In prep*). In 1996, both the drift gillnet and eastside set gillnet fishing seasons opened on June 28. The drift gillnet harvest was examined until the fishery closed on August 9 and the eastside set gillnet harvest was examined until the fishery closed on August 12. Northern District harvests were examined until harvests declined to low levels in early September. Harvests in other UCI commercial fisheries were sampled incidentally throughout the season.

Coho salmon harvested in commercial fisheries were examined at processing plants, buying stations, and aboard tenders throughout UCI to recover coded wire tags from marked 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 were missing an adipose fin. Heads were collected from adipose-clipped fish, frozen, and later shipped to the Tag Lab for retrieval of the embedded coded wire tag. The following information was also recorded: date sold (date harvested), statistical area of harvest when available, and processor. In general, the statistical area was known for set gillnet harvests. Drift gillnet harvests were typically a mixture of fish from multiple statistical areas.

DATA ANALYSIS

Several steps were required to estimate smolt production and commercial harvest of coho salmon of Kenai River origin. These were: (1) estimate the number of smolt marked in 1995 that survived and retained a coded wire tag, (2) test the hypothesis that the proportion of marked adults observed inriver in 1996 did not change over time, (3) estimate the marked proportion of the adult return in 1996, and (4) estimate smolt production in 1995 and commercial harvest for the two Central District commercial fisheries of interest in 1996.

Juvenile Marking in 1995

Short-term mortality and tag loss were estimated to determine the total number of viable, tagged smolt released in 1995. Short-term survival and tag retention for smolt marked during each shift

were estimated from a random sample of about 200 marked 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 tag retention rate (b_k) for smolt marked during a shift that survived was estimated as the fraction of surviving smolt that had retained their tags.

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

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

The total number of smolt marked with a tag at the Moose River in 1995 was estimated by summing the individual estimates for each marking shift over the entire smolt emigration. Because nearly all fish were estimated to have survived and retained the tag, the number of marked smolt in the population is considered fixed ($m \rightarrow m$).

Estimating the Proportion of the Cohort Bearing Marks in 1996

Estimating the commercial harvest of coho salmon of Kenai River origin in 1996 required estimating the proportion of the return marked with coded wire tags. This proportion was unknown at the time of smolt marking in 1995, but was estimated when adults returned in 1996 by examining the inriver sport harvest. The proportion y_g of the inriver sport harvest missing an adipose fin during each weekly interval g was estimated as the fraction of a sample missing that fin.

The proportion c_g of the heads collected during each interval that contained a tag implanted at the Moose River in 1995 was estimated as the fraction of heads that reached the CWT tag lab that contained a tag.

A chi-square statistic was used to test the hypothesis that the proportion missing an adipose fin did not change over time and to test the hypothesis that the proportion of fish of Moose River origin did not change over time (α = 0.05). Failure to reject these hypotheses confirm that marked adults were representative of the return and combining the inriver recovery data over all intervals to estimate the overall proportions $\hat{y}$ and $\hat{c}$ for the cohort would be appropriate. The overall marked proportion (θ) could then be estimated as the product of $\hat{y}$ and $\hat{c}$.

Estimation and hypothesis testing was therefore a two-step process. The first step involved examining the inriver sport harvest to estimate the proportion of the return that was missing an adipose fin. The second step involved decoding tags from heads collected from the sport fishery. The estimated marked proportion ($\hat{\theta}$) therefore accounts for heads that were not collected from coho salmon missing their adipose fin.

Marking smolt in 1995 and inriver sampling of marked adults in 1996 also provided data to estimate the number of smolt that emigrated from the Kenai River in 1995 with the Chapman modified Lincoln-Petersen model (Seber 1982):

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

where:

M = the number of marked smolt emigrating with a coded wire tag in 1995,

C = the number of adult coho salmon examined for a missing adipose fin in the 1996 sport harvest, and

R = the number of adult coho salmon recovered from the 1996 sport harvest that were marked at the Moose River in 1995.

The variance was estimated by:

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

This model produces unbiased estimates of abundance if:

1. adult coho salmon examined for marks were a random sample of the inriver return or the marked sample of smolt were a representative sample of the drainage-wide smolt emigration in 1995,
2. all juveniles marked at the Moose River in 1995 were actually smolt,
3. survival and catchability were the same for marked and unmarked individuals,
4. tag code and release location were correctly determined for all fish observed with a missing adipose fin in the sport harvest, and
5. no tags were lost between the mark and recovery events.

The relationship between the return timing of marked adults and the time of smolt marking was investigated as an additional indicator of mixing between the release and recovery events. Dependence between adult return timing and time of tagging as smolt would indicate that little or no mixing occurred after tagging. A chi-square statistic was used to test for independence between adult return timing in 1996 and time of smolt marking in 1995. The hypothesis was tested at $\alpha = 0.05$ with recoveries divided into tag code groups representing the first 50% of the smolt marked (May 20-June 3, 1995) and the second 50% of the smolt marked (June 5-June 10, 1995). The distributions of recoveries of these two groups were compared among 2-week intervals during the adult return in August and September 1996.

The remaining four assumptions likely hold. Previous experience and observations indicate most juveniles marked at the Moose River each year are smolt and, although some long-term tag loss occurs each year, it has been less than 3% (Carlon and Hasbrouck 1996, 1997). There are no indications that survival and catchability differ between marked and unmarked fish or that problems exist in correctly recording release or recovery data.

Commercial Harvest Estimates

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 strata variances.

Daily estimates also provided useful temporal trend information. The Commercial Fish Ticketing System managed by the ADF&G, Commercial Fisheries Management and Development (CFMD) Division 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 coded wire tags (CWTs) recovered were considered known. The proportion of the return bearing marks was estimated by sampling the inriver sport harvest of returning adults. The harvest of coho salmon from the Kenai River 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,

θ = proportion of the 1996 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 a missing adipose fin,

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

a_i = number of heads collected in stratum i from fish with a missing adipose fin,

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):

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

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 1996 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 insignificant because of the similarity of the marked proportion among intensively sampled processors (Figure 5). The proportion bearing 1995 Moose River tags ranged from 0.002 to 0.006 for intensively sampled processors of the drift harvest. Among intensively sampled processors of the eastside set gillnet harvest, the proportion ranged from 0.014 to 0.086. Only at eastside set gillnet harvest processor "H" was the marked proportion outside this range. This was probably because of the small number of fish examined there. Therefore, pooling data among processors in 1996 should improve precision of harvest estimates without introducing significant bias.

The harvest occurring on unsampled days was incorporated 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.

RESULTS

JUVENILE MARKING IN 1995

Smolt were marked with coded wire tags and adipose finclips as they emigrated from the Moose River during May 20 through June 9, 1995 (Appendix A1). An estimated 94,535 of the 94,995 marked smolt survived and retained tags based on estimates of short-term survival (99.8%) and tag retention (99.7%).

SPORT FISHERY IN 1996

Sampling and Mark Recovery

From August 1 through September 29, 1996, 3,687 sport-harvested coho salmon were examined (Table 1 and Appendix A2). Heads were recovered from 515 (67%) of the 765 adipose-clipped adults observed. Of the 515 heads processed at the Tag Lab, 504 (98%) were marked as smolt at the Moose River in 1995. Tags were missing from nine (2%) of the recovered heads. The remaining 2 recoveries from the sport harvest included 1 fish tagged at the Moose River during 1996 and 1 fish from which the recovered tag was lost before it could be decoded. An additional 12 coho salmon heads were voluntarily delivered by anglers to department personnel. All 12 fish were tagged at the Moose River in 1995.

Proportion of the Cohort Bearing Marks

Due to declining harvest and fishing effort after mid-September, only 107 fish were examined after September 15 and only two were examined after September 24. From August 1 through September 24, the proportion of adipose-clipped fish in the sport harvest differed significantly ($\chi^2 = 45.6$, df = 7, $P < 0.001$) among weekly intervals. The detection of a significant difference in the marked proportion among weeks was due mostly to large sample sizes and the resultant

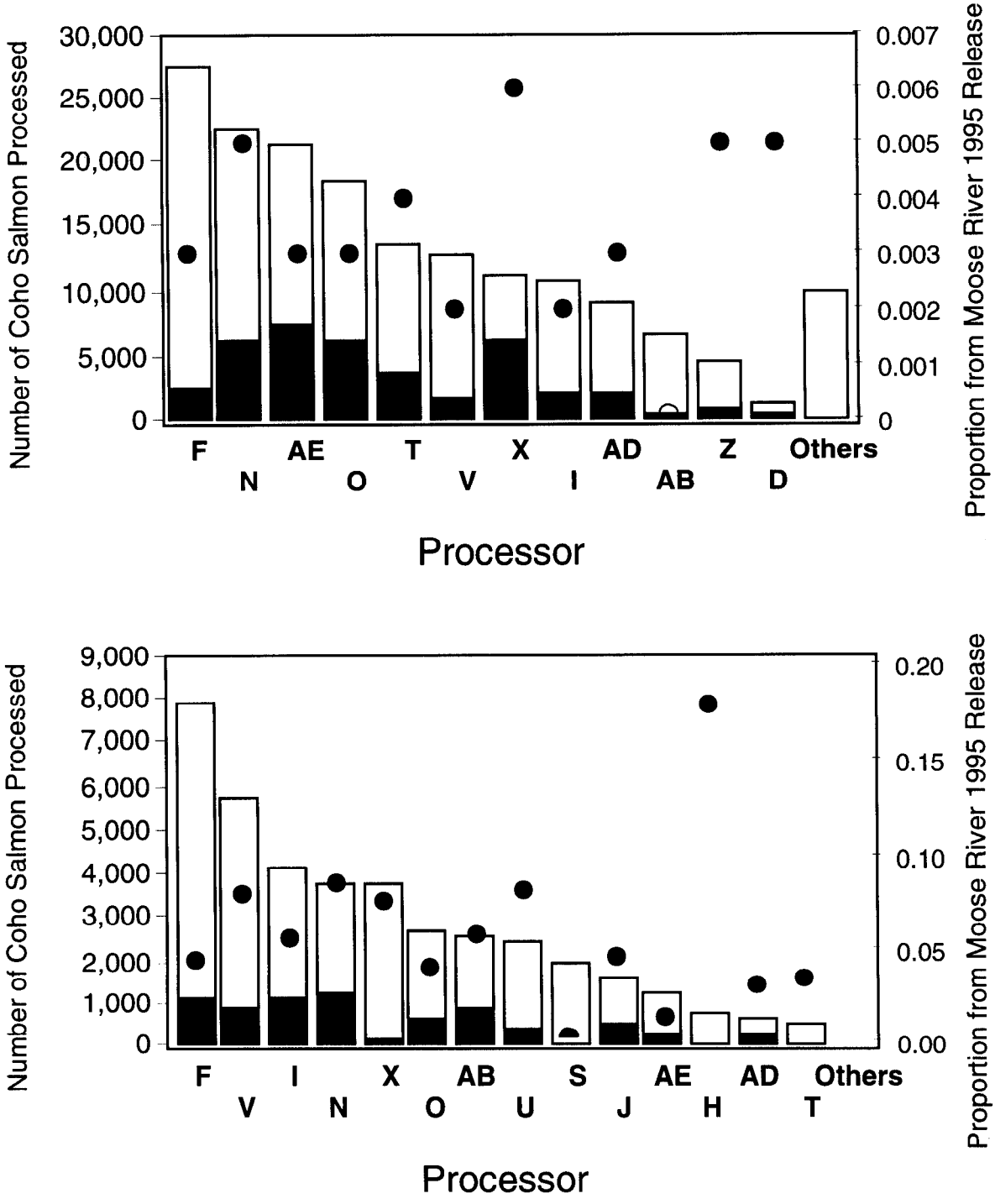


Figure 5.-Number of coho salmon harvested and processed in 1996 in the Central District drift gillnet fishery (top) and the Central District eastside set gillnet fishery (bottom) of Upper Cook Inlet by commercial processor, number examined, and proportion of examined fish that were originally marked at the Moose River in 1995.

Table 1.-Sources of marked coho salmon adults recovered at random from the Kenai River sport harvest by week, August through September, 1996.

Period (g)	Number Examined	Marked Fish Observed	y_g [a]	Marked Fish Recovered	Source = Moose R. 1995	c_g [b]	θ_g	Other Sources CWT Missing	Other Sources Moose R. 1996
8/01-8/07	472	63	0.133	45	44	0.978	0.131	1	0
8/08-8/14	613	104	0.170	82	80	0.976	0.166	2	0
8/15-8/21	538	100	0.186	65	63	0.969	0.180	1	1
8/22-8/28	557	138	0.248	84	83	0.988	0.245	1	0
8/29-9/04	580	150	0.259	99	97	0.980	0.253	2	0
9/05-9/11 [c]	600	146	0.243	100	98	0.980	0.238	1	0
9/12-9/18	254	55	0.217	34	34	1.000	0.217	0	0
9/19-9/29 [d]	73	9	0.123	6	5	0.833	0.103	1	0
Grand	3,687	765	0.207	515	504	0.979	0.203	9	1

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

[b] Proportion of marked fish recovered that were originally marked at the Moose River in 1995 based on recovery of the coded wire tag.

[c] One of the coded wire tags recovered on 9/06/96 was unreadable.

[d] Sport fishing effort and harvest was minimal presumably due to low angler harvest rates. Among the few anglers present only 73 fish were examined during this period.

statistical power to detect small changes. The actual variation in the marked proportion observed among weeks appeared relatively small (Figure 6). Therefore, pooling the inriver sample data to estimate the marked proportion should not result in considerable bias in commercial harvest estimates.

The estimated marked proportion ($\hat{\theta}$) of the 1996 adult return to the Kenai River was 0.203 [$V(\hat{\theta}^{-1}) = 0.0427$]. The minimum weekly marked proportion measured was 0.131 (Table 1). This represented the maximum difference (35%) among weeks from the pooled estimate. Additional analysis, described in the Discussion section of this report, was conducted to explore potential bias in estimates of commercial harvest associated with this range in the weekly marked proportion.

Smolt Estimate in 1995

The return timing of adults in 1996 was independent of time of marking as smolt at the Moose River in 1995 ($\chi^2 = 5.25$, df = 2, P = 0.07) (Appendix A3) and all tag codes released at the Moose River were observed in the adult return. This indicates that mixing of marked and

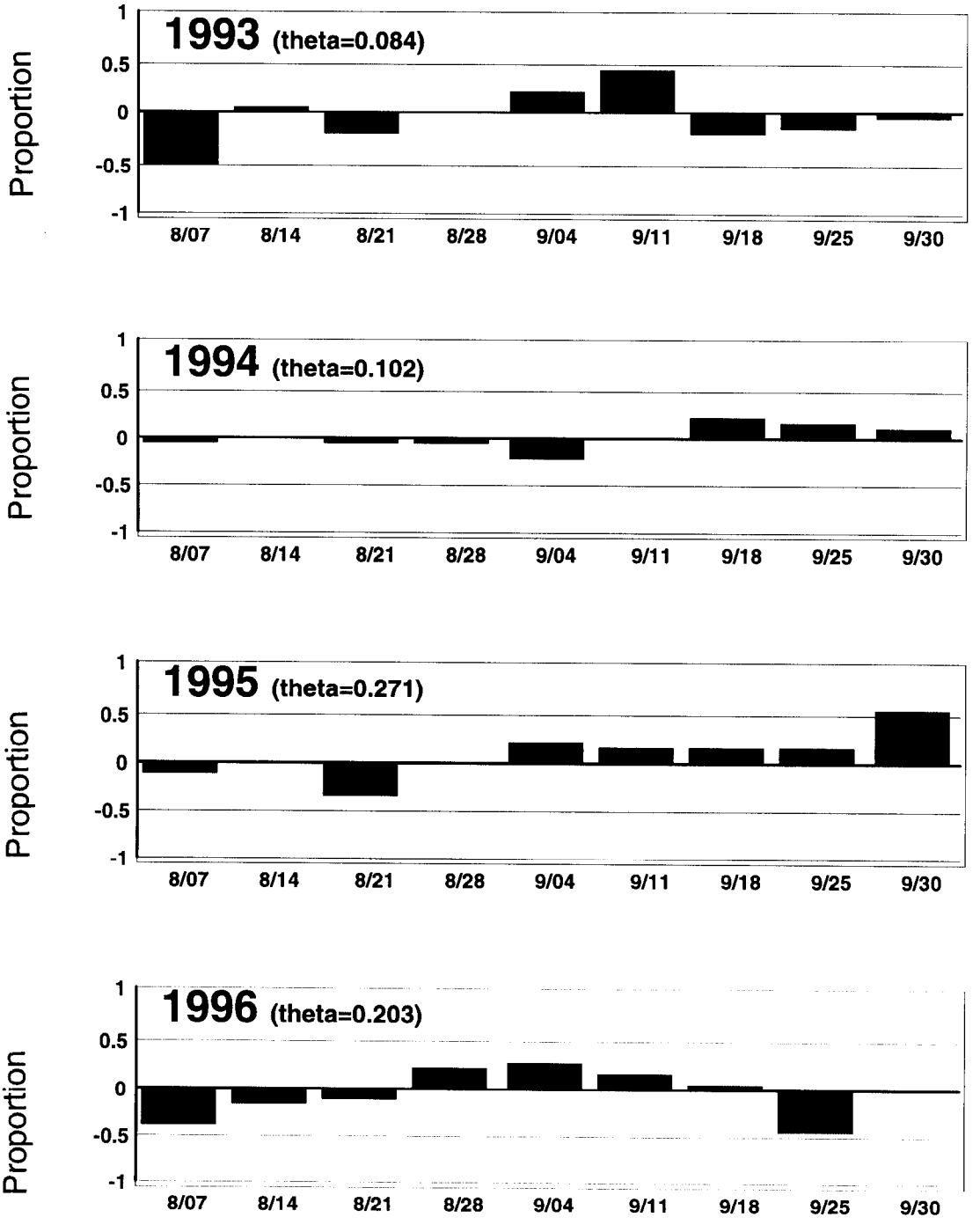


Figure 6.-Difference between weekly estimates of the marked proportion of the Kenai River coho salmon return and the pooled, seasonal estimate, 1993-1996 (difference is expressed as a proportion of the seasonal estimate).

unmarked fish occurred between the release and recovery events and smolt abundance could be estimated. Based on the number of marked smolt released at the Moose River in 1995 (94,535), the number of adult coho salmon examined for marks in the Kenai River sport harvest in 1996 (3,687), and the estimated number of tagged adults in the sample of adipose-clipped fish found in 1996 (749), an estimated 465,075 (SE = 15,091) smolt emigrated from the Kenai River in 1995.

COMMERCIAL FISHERIES IN 1996

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 1996 Northern District sampling efforts and recoveries of hatchery produced coho salmon are documented in a companion report (Cyr et al. *In prep*).

Inlet-Wide Fisheries

In 1996, 321,411 coho salmon were harvested in commercial fisheries of UCI (Table 2). This harvest was 36% less than the average of the last 10 years (Ruesch and Fox 1997). About 75% of the 1996 UCI commercial harvest was taken in Central District fisheries (Figure 7). The greatest harvest occurred in the drift gillnet fishery of the Central District (53%), followed by the set gillnet fishery on the west side of the Northern District (14%) and the Central District eastside set gillnet fishery (13%). The other seven fisheries accounted for 20% of the total harvest.

Of the inlet-wide harvest, 110,190 fish (34%) were examined for adipose clips. Adipose-clipped fish were found in all sampled fisheries. Exact fishery or statistical area of harvest could not be identified for 10,287 examined fish (Appendix A4); these fish were not used to calculate harvest estimates. The other 99,903 examined fish were positively assigned to fishery strata (Appendix A5). Of these, 3,741 (4%) were missing the adipose fin and heads were collected from 3,709 of the fish. Of the 3,709 heads recovered, 230 (6%) had no tag and 4 tags were not decodable. All but one of the 3,475 decodable tags were from hatchery-produced fish released as juveniles in Cook Inlet or from juveniles marked within the Kenai River drainage. The one exception was a coho salmon raised at the Medvejie Hatchery in Southeast, Alaska (near Sitka) and released in Deep Inlet (Statistical Area 113-41, also near Sitka).

Of the 3,475 decodable tags recovered from adults commercially harvested from known fishery strata, a total of 574 (16%) were tags used at the Kenai River. All 574 were originally implanted in smolt marked at the Moose River in 1995. Most (99%) of the Moose River tags were recovered from Central District fisheries with only three Moose River tags recovered in Northern District fisheries.

Central District Drift Gillnet Fishery

The Central District drift gillnet fishery harvest was sampled during most openings between July 1 and August 9 (Figure 8, Appendix A5). Overall, 24% of the harvest was examined (Table 2). The harvest occurring on days not sampled accounted for 2% of the total harvest.

The first recoveries of fish tagged at Moose River occurred on July 12, 12 days after sampling began. Coho salmon marked at the Moose River were recovered on all but one sampled day (July 21) between July 12 and August 9. Of all fish examined, 0.4% had been marked as smolt at the Moose River in 1995.

Table 2.-Summary of sampling effort and recovery of coded wire tags (CWT) from adipose-clipped coho salmon harvested in Upper Cook Inlet commercial fisheries in 1996.

Gillnet Fishery	Harvest	Number Examined	Percent of Harvest Examined	Ad-clips Found	Heads Recovered	Missing CWT or Unreadable	Heads with Decodable CWT [a]	Number from cohort marked at Moose R. in 1995
CENTRAL DISTRICT								
Drift	171,361	41,478	24	1,326	1,321	85	1,236	154
East Side Set (by Statistical Area)								
244-21	8,404	1,058	13	110	102	1	101	94
244-22	7,644	1,450	19	111	111	6	105	90
244-30	7,595	1,074	14	80	73	5	68	50
244-40	16,905	3,352	20	227	225	10	215	176
East Side Set Total	40,548	6,934	17	528	511	22	489	410
Kalgin Is. Set	15,559	4,053	26	51	50	3	47	7
West Side Set	15,616	0	0					
Chinitna Bay Drift	230	0	0					
Mixed East Side Set Stat. Areas [b]		826		75	74	3	71	61
Mixed Drift/East Side Set [c]		401		27	26	2	24	13
Mixed West Side/Kalgin Is. Set [d]		6,079		30	30	3	27	10
Central District Total	243,314	59,771	25	2,037	2,012	118	1,894	655
NORTHERN DISTRICT								
West Side Set	45,013	28,888	64	277	272	36	236	0
East Side Set	16,444	6,411	39	62	62	7	55	3
Fire Is. Set	8,375	7,387	88	1,003	1,001	51	950	0
Pt. MacKenzie/Su Flats Set	6,463	4,752	74	494	492	30	462	0
Knik Arm Set	1,802	0	0					
Mixed West/East Side Set [e]		2,476		153	113	3	110	1
Mixed Pt. MacKenzie/Fire Is. Set [f]		505		40	40	2	38	0
Northern District Total	78,097	50,419	65	2,029	1,980	129	1,851	4
Grand Total	321,411	110,190	34	4,066	3,992	247	3,745	659

[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 Pt. MacKenzie statistical area and the Fire Island setnet fisheries.

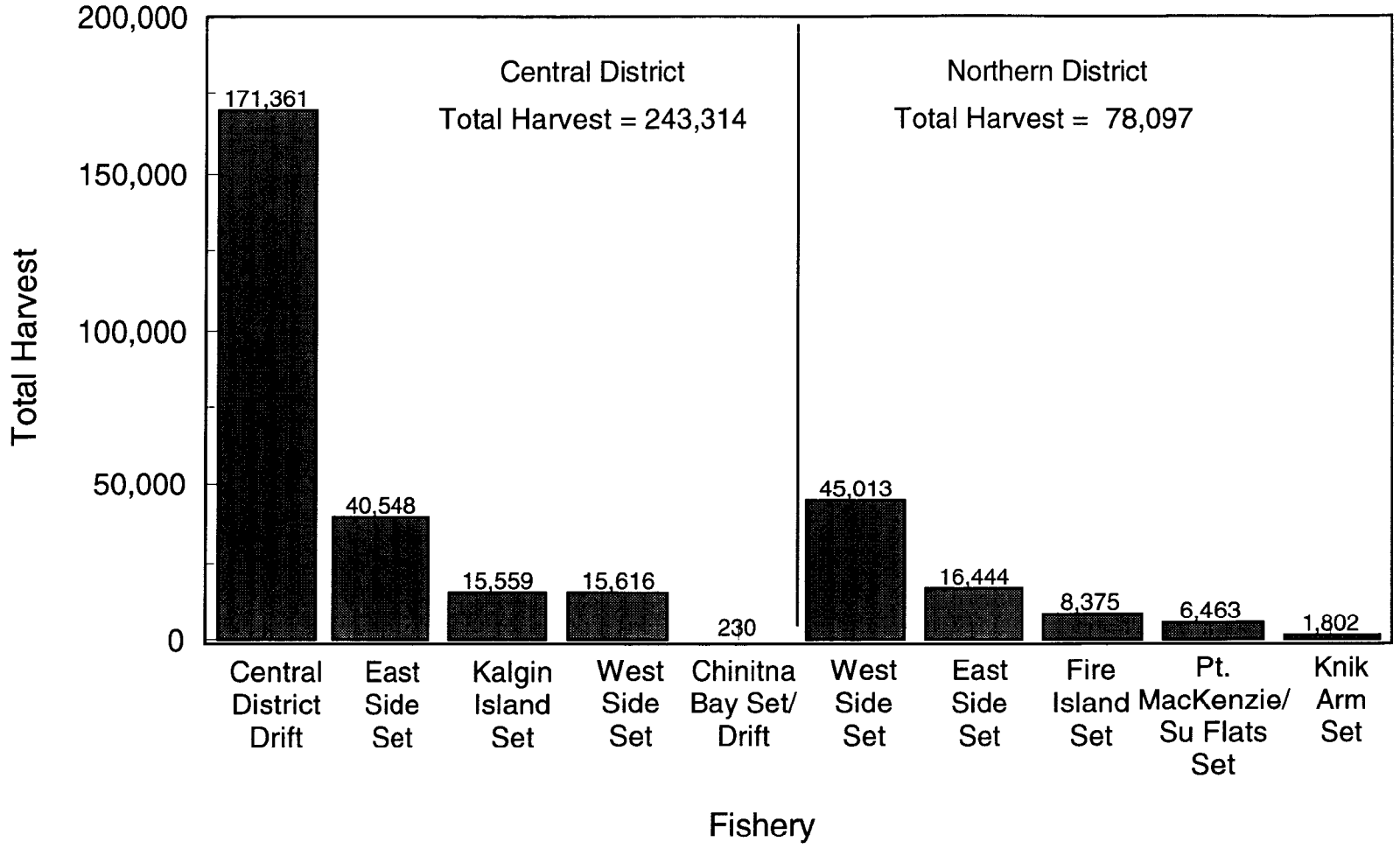


Figure 7.-Coho salmon harvest in 10 Upper Cook Inlet commercial fishery areas in 1996.

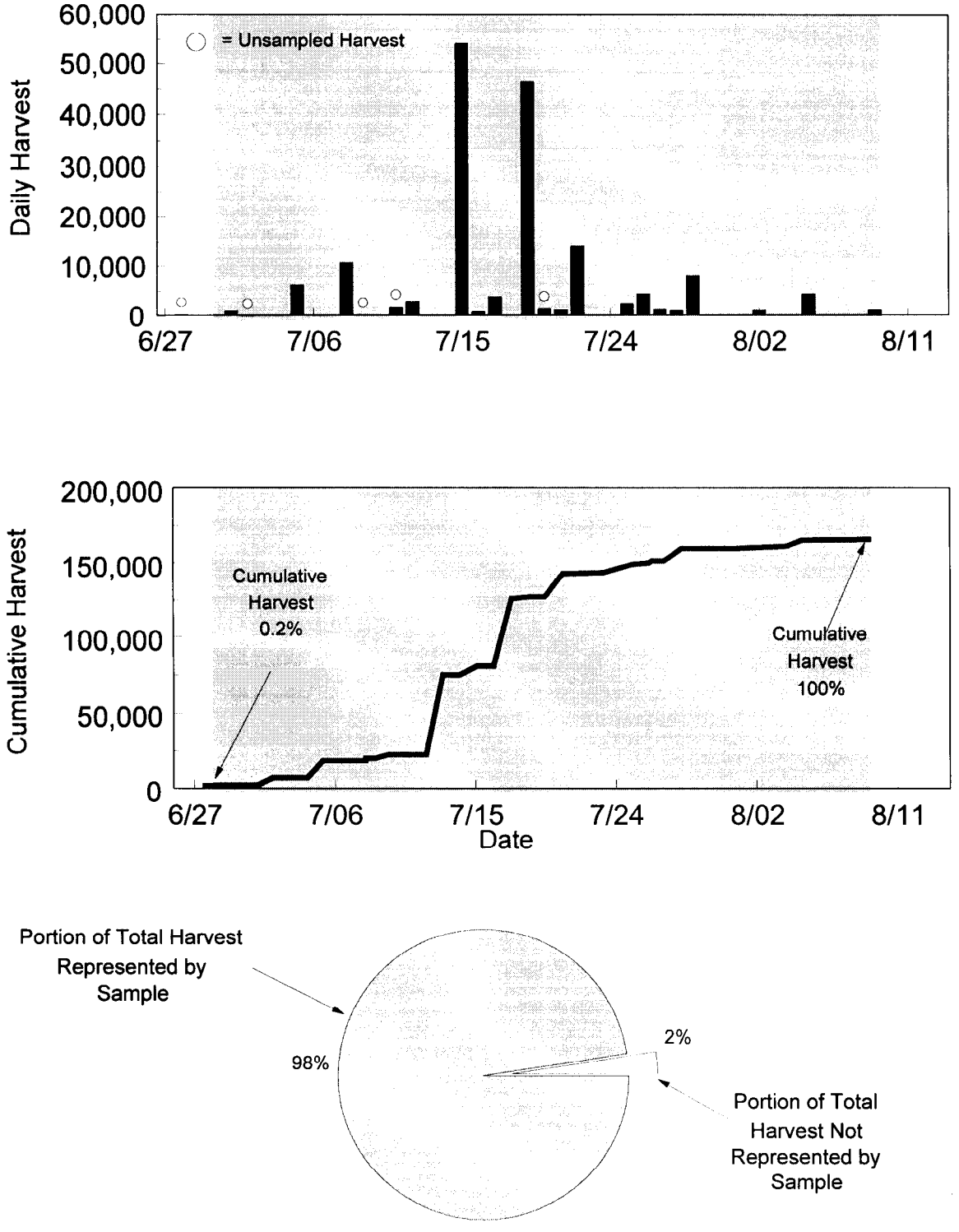


Figure 8.-Coho salmon harvest and sampling performance occurring in the Upper Cook Inlet Central District drift gillnet fishery in 1996. Shaded region represents the time period during which the harvest was examined.

Central District Eastside Set Gillnet Fishery

The Central District eastside set gillnet fishery harvest was sampled during most fishing periods from July 12 through the last day of the fishery on August 12 (Figure 9, Appendix A5). Overall, 17% of the harvest was examined (Table 2). About 20% of the harvest was examined in areas 244-22 and 244-40 while about 14% was examined in both 244-21 and 244-30. The harvest occurring on days not sampled accounted for 9% of the total harvest. Among statistical areas, small portions of the harvest (1.0% to 4.4%) were not examined early in the season (Figure 10). The portion of the harvest occurring on days not sampled ranged from 14% to 22% among statistical areas.

Coho salmon marked at the Moose River in 1995 were recovered from all four statistical areas in 1996. The first recovery of Moose River marks occurred on July 15 in statistical areas 244-22 and 244-40, on July 17 in statistical area 244-21, and on July 25 in statistical area 244-30. The portions of fish examined in 1996 that had been marked as smolt at the Moose River in 1995 were 9%, 6%, 5%, and 5% for statistical areas 244-21, 244-22, 244-30, and 244-40, respectively.

Commercial Harvest Estimates

An estimated 2,671 (SE = 235) coho salmon of Kenai River origin were harvested by the drift gillnet fishery and 11,856 (SE = 871) by the eastside set gillnet fishery, for a total of 14,527 (SE = 902) during 1996 (Tables 3 and 4). Coho salmon of Kenai River origin comprised 2% of the total drift gillnet harvest and 29% of the total eastside set gillnet harvest in 1996.

The harvest occurring in the drift gillnet fishery before the first coho salmon from the Kenai River were detected on July 12 was 12% (20,925 coho salmon) of the total harvest. Over 96% of the harvest of coho salmon of Kenai River origin occurred during the 3-week period between July 16 and the last open fishing period on August 9. There was a temporal increase in the portion of the harvest comprising Kenai River fish (Figure 11). Although the greatest proportional contribution (nearly 8%) occurred during the last week of July through the end of the fishery on August 9, the greatest absolute harvest occurred during the last week of July.

The harvest occurring in the eastside set gillnet fishery before the first coho salmon from the Kenai River were detected on July 15 was 6% (2,262 coho salmon) of the total harvest. Coho salmon from the Kenai River made up a greater portion of the harvest later in the season than earlier although there was no consistent temporal trend among all statistical areas (Figure 12).

The greatest absolute harvest of coho salmon of Kenai River origin occurred during the last week of July in the southernmost two statistical areas and during the first week of August in the northernmost two statistical areas.

The total harvest of coho salmon was similar among the three southernmost statistical areas while the harvest in the northernmost statistical area was nearly double that occurring in the others (Figure 13). However, from the southernmost statistical area to the northernmost, there was a general decreasing trend in the portion of the harvest composed of coho salmon from the Kenai River (Figure 13) resulting in a similar absolute harvest of this population among all four statistical areas.

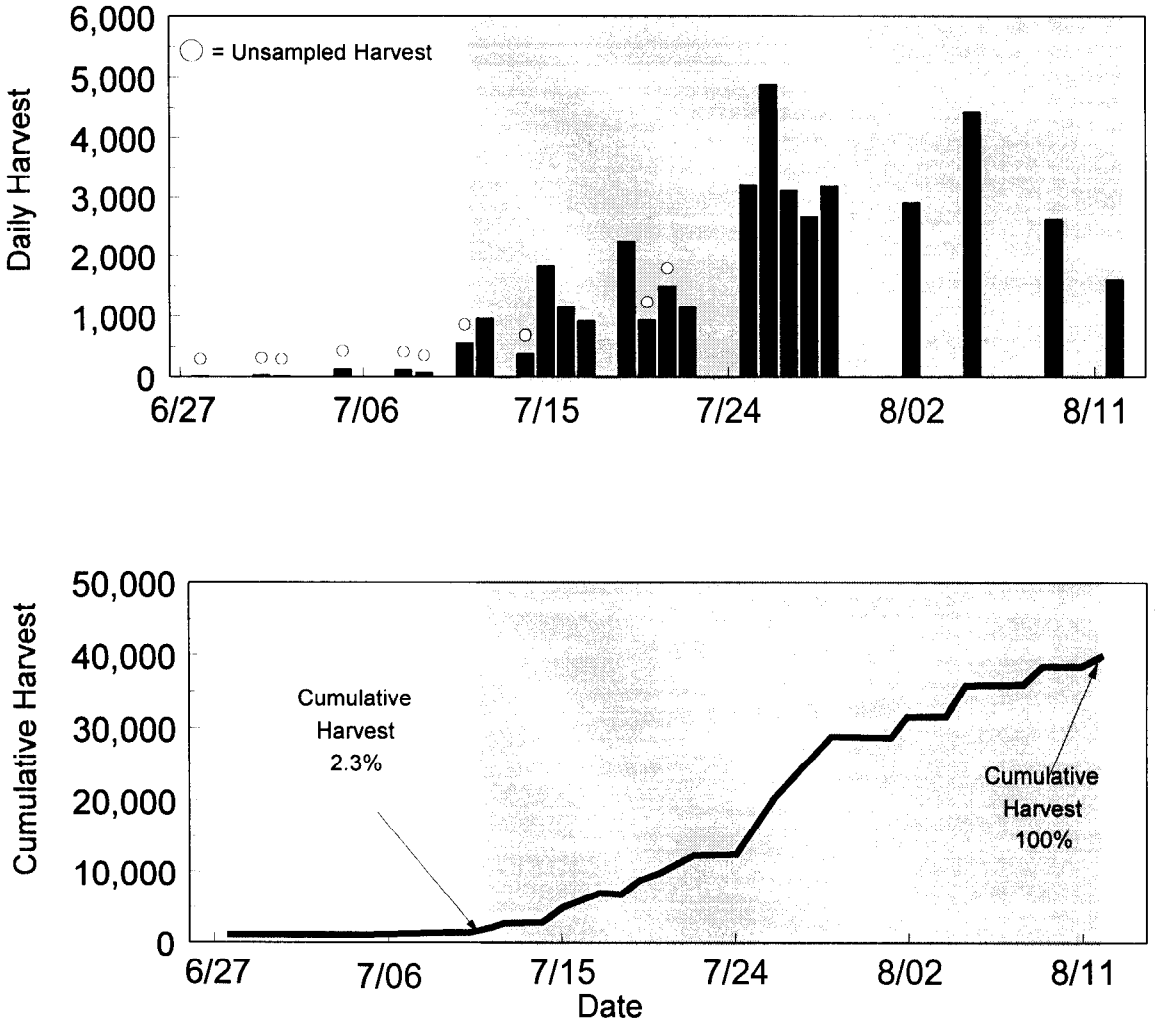


Figure 9.-Coho salmon harvest and sampling performance occurring in the Upper Cook Inlet Central District eastside set gillnet fishery in 1996. Shaded region represents the time period during which the harvest was examined.

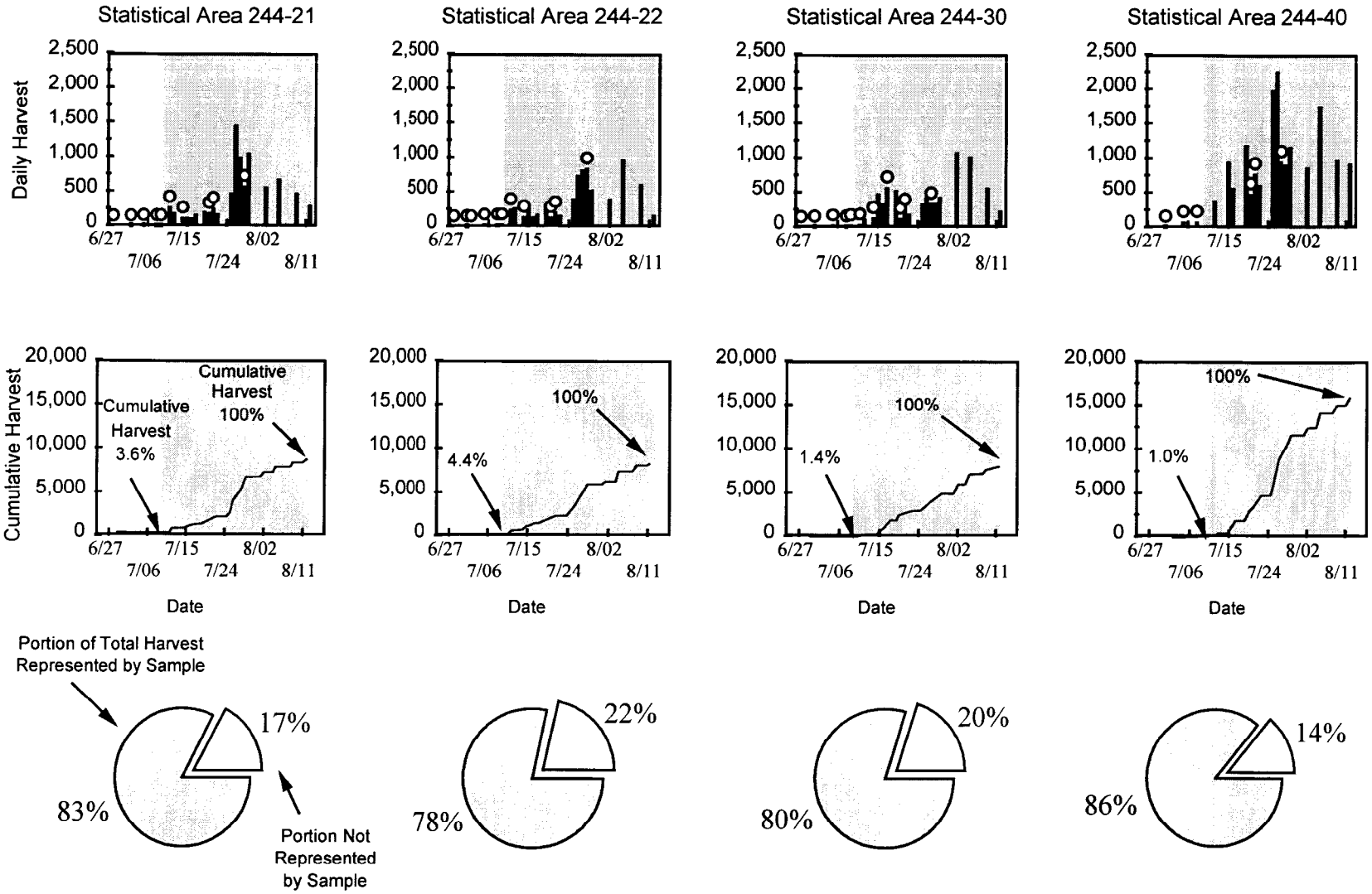


Figure 10.-Coho salmon harvest and sampling performance occurring in the Upper Cook Inlet Central District eastside set gillnet fishery by statistical area in 1996. Shaded region represents the time period during which the harvest was examined.

Table 3.-Estimated harvest $(\hat{r})$ and associated variance $\left[\hat{V}(\hat{r})\right]$ of coho salmon of Kenai River origin in the commercial drift gillnet fishery of the Central District of Upper Cook Inlet during selected time periods, 1996.

Period	Total Harvest	Estimated Harvest of Coho Salmon of Kenai River Origin	Percent of Total Harvest	Variance of Harvest Estimate	Relative Precision
6/26 - 7/08	18,706	0	0.0%	0	
7/09 - 7/15	59,336	100	0.2%	2,482	97.9%
7/16 - 7/22	68,488	663	1.0%	12,573	33.2%
7/23 - 7/29	18,054	1,391	7.7%	20,910	20.4%
7/30 - 8/09	6,777	518	7.6%	19,400	52.8%
Total	171,361	2,672	1.6%	55,365	17.3%

DISCUSSION

COMMERCIAL HARVEST ESTIMATES

The estimated commercial harvest of coho salmon of Kenai River origin remains low, especially given the proximity of fishing effort to the mouth of the river and given that the range in total harvest in these fisheries was over 200,000 fish among years. The 1996 combined drift and eastside set gillnet harvest of 14,527 coho salmon of Kenai River origin was actually below the 1993-1995 average of about 18,000 fish. The lower harvest was likely due in part to the shortened drift gillnetting season; a new regulation ended the fishery on August 9 as compared to August 15 during previous years.

For both fisheries, the portion of the total harvest comprised of Kenai River fish changed little among years (Figure 14). In all 4 years, Kenai River fish were a minority of the total harvest. The similarity among years is noteworthy because these are mixed-population, mixed-species fisheries with management actions differing substantially among years. Despite these similarities, it is too early to conclude that the Kenai River contribution to the harvest is consistently low. Additional estimates of the population-specific commercial harvest are necessary to provide insight into the variability of the commercial harvest of coho salmon bound for the Kenai River.

Accurate estimates of the commercial harvest of coho salmon bound for the Kenai River depend on an accurate estimate of the marked proportion of adults as they migrate through commercial harvest areas. That marked proportion was estimated by pooling all inriver observations of marked and unmarked fish even though a statistical difference in the marked proportion was detected among weeks. Pooling all inriver sampling data may produce a biased estimate of the

Table 4.-Total harvest (N_i) and estimated harvest $(\hat{r}_i)$ with associated variance $[\hat{V}(\hat{r}_i)]$, of coho salmon of Kenai River origin in the eastside set gillnet fishery of Upper Cook Inlet by statistical area and selected time periods, 1996.

	244-21				244-22				244-30				244-40				Total			
Period	Total Harv.	Est. Harv.	v	R.P.[a]	Total Harv.	Est. Harv.	v	R.P.[a]	Total Harv.	Est. Harv.	v	R.P.[a]	Total Harv.	Est. Harv.	v	R.P.[a]	Total Harv.	Est. Harv.	v	R.P.[a]
6/28-7/15	728	0	0		1,031	40	1,581	193.6%	835	0	0		1,494	33	1,030	193.0%	4,088	73	2,611	137.5%
/16 - 7/22	1,114	578	61,022	83.8%	1,142	140	4,812	97.1%	1,994	0	0		3,632	136	6,933	119.6%	7,882	854	72,767	61.9%
/23 - 7/29	4,557	2,626	107,997	24.5%	3,333	1,182	48,202	36.4%	1,871	886	166,158	90.2%	7,270	948	82,822	59.5%	17,031	5,642	405,179	22.1%
7/30-8/05	1,236	276	76,009	195.6%	1,366	626	25,160	49.7%	2,097	1,144	84,443	49.8%	2,612	1,573	25,082	19.7%	7,311	3,619	210,694	24.9%
8/06-8/12	769	509	51,972	87.8%	772	342	4,200	37.1%	798	353	6,612	45.1%	1,897	463	3,886	26.4%	4,236	1,668	66,670	30.3%
Total[b]	8,404	3,989	297,000	26.8%	7,644	2,330	83,954	24.4%	7,595	2,384	257,214	41.7%	16,905	3,153	119,753	21.5%	40,548	11,856	757,921	14.4%

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

[b] Totals are rounded to nearest whole number.

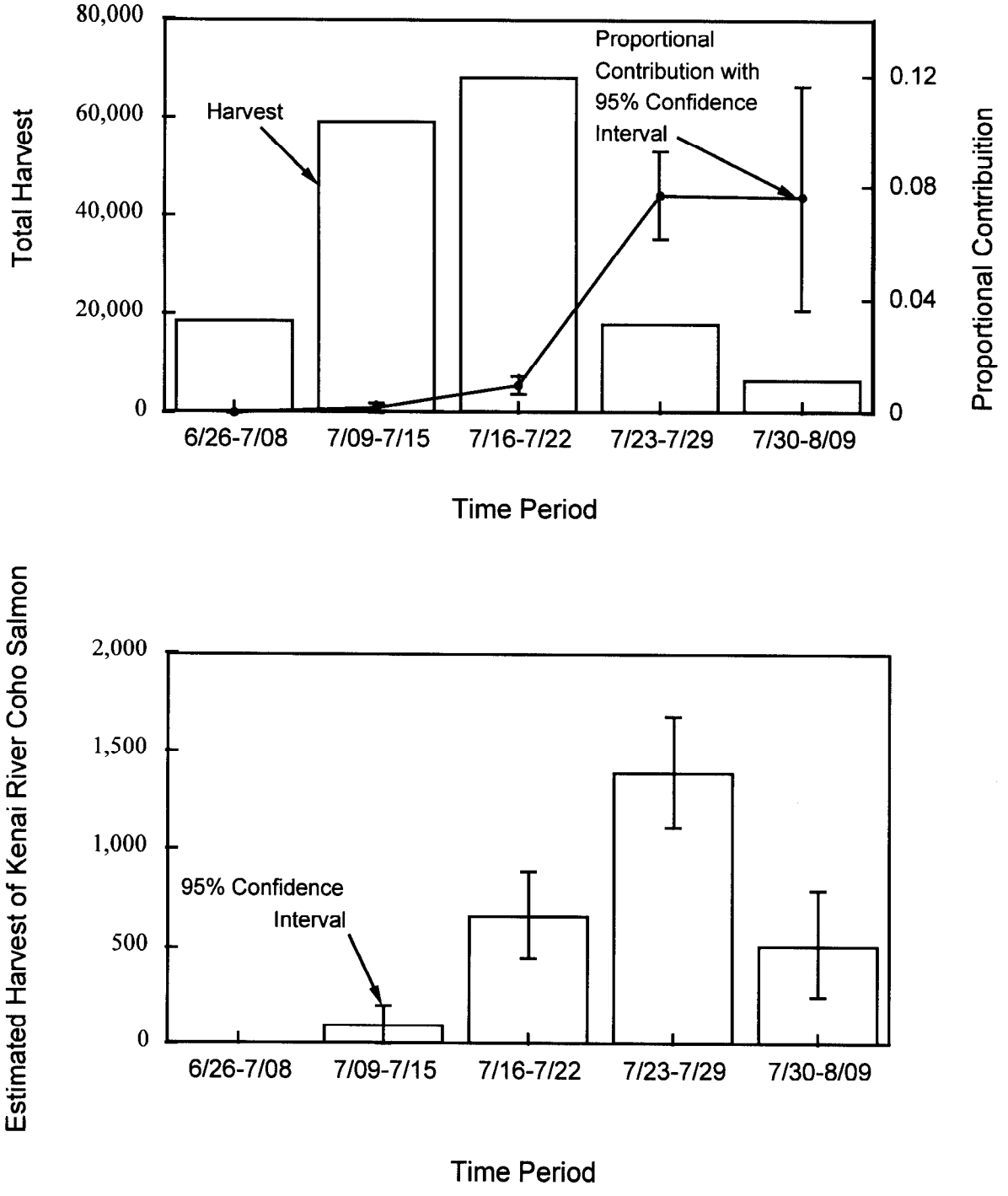


Figure 11.-Trend in proportional contribution of Kenai River coho salmon to the total harvest (top) and trend in absolute contribution (bottom) occurring in the drift gillnet fishery of the Central District of Upper Cook Inlet, 1996.

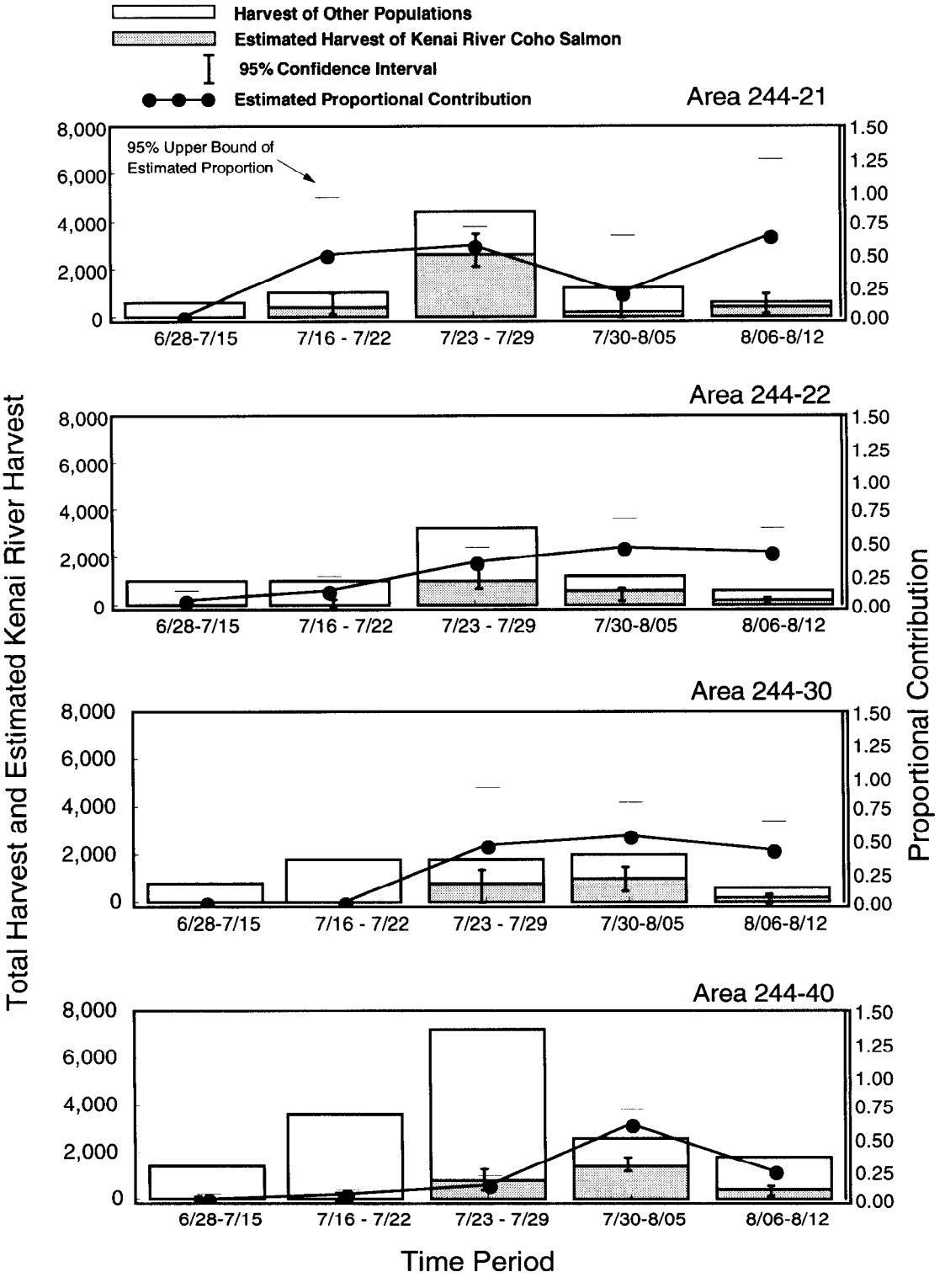


Figure 12.-Trends in proportional and absolute contribution of coho salmon from the Kenai River to the total harvest of coho salmon occurring in four statistical areas of the Upper Cook Inlet Central District eastside set gillnet fishery during five time periods in 1996.

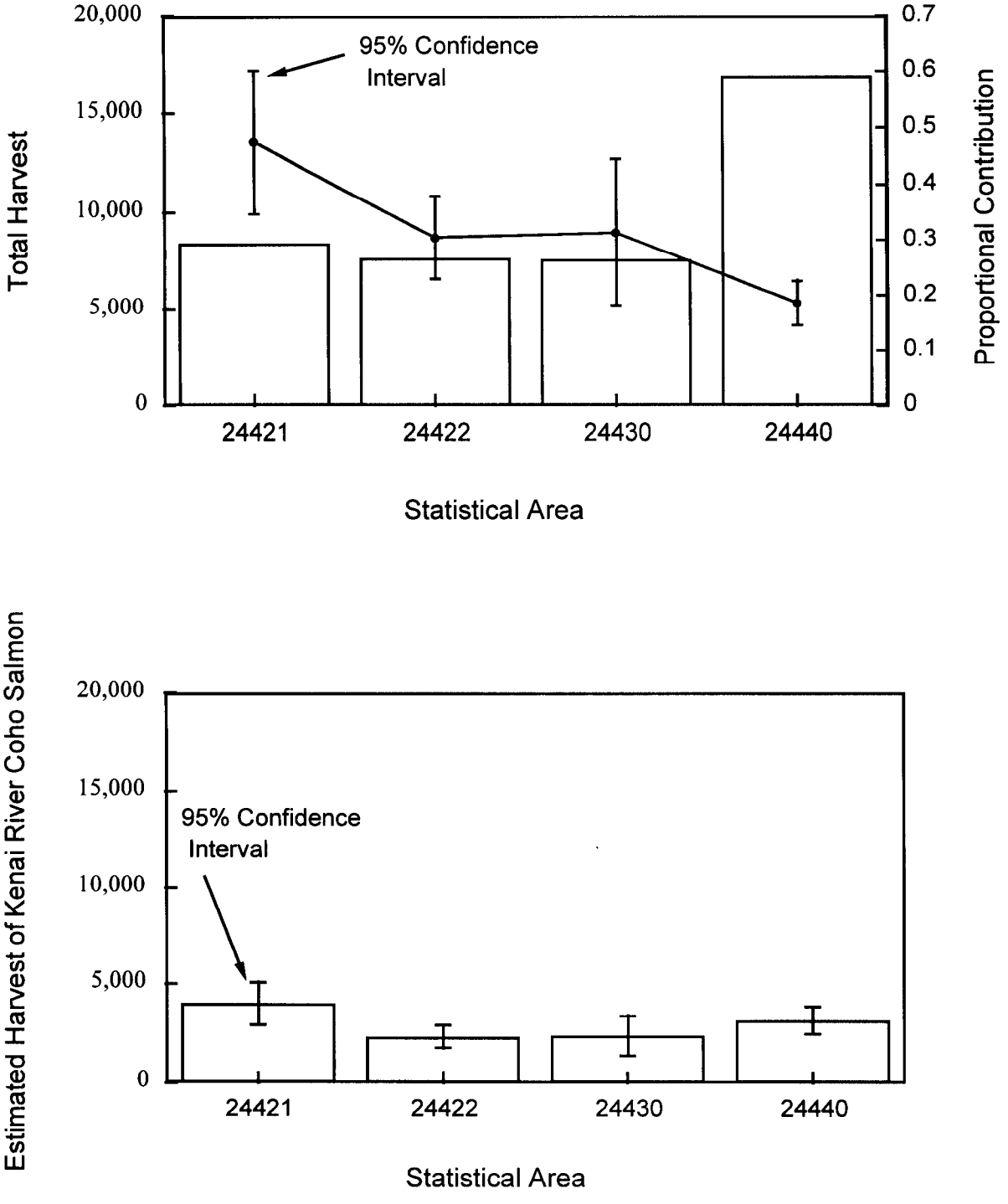


Figure 13.-Geographic trends in total coho salmon (top) and in estimated number of coho salmon of Kenai River origin (bottom) harvested among statistical areas in the eastside set gillnet fishery of the Central District of Upper Cook Inlet, 1996.

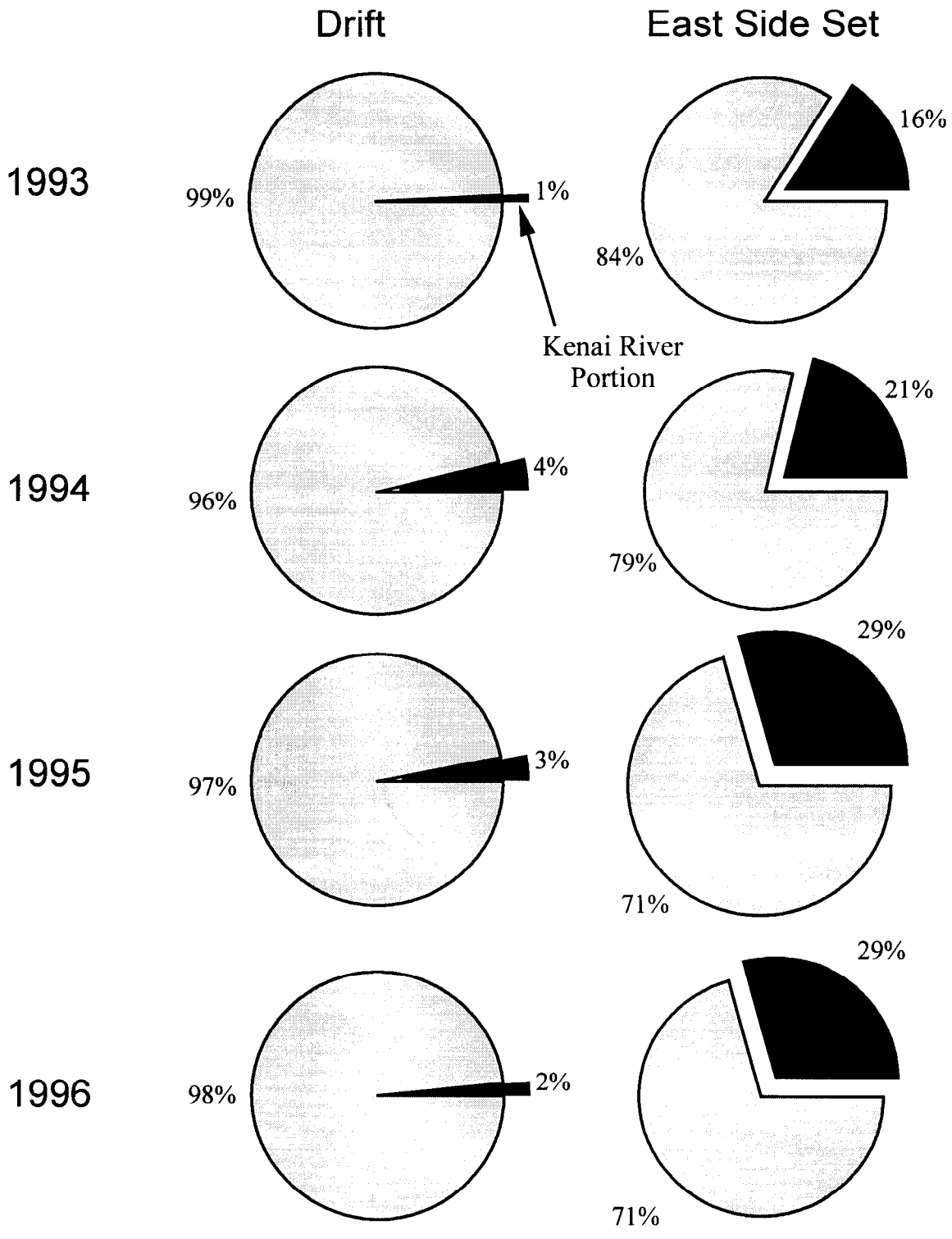


Figure 14.-Contribution of coho salmon from the Kenai River to the drift and eastside set gillnet commercial fisheries of the Central District of Upper Cook Inlet, 1993-1996.

marked proportion passing through the commercial fisheries and, therefore, biased estimates of commercial harvest.

It is currently not possible to apply temporally variable inriver marked proportions to specific commercial fishing periods by adjusting for migration rates. Migratory behaviors of coho salmon bound for the Kenai River, such as rates or routes through Cook Inlet, are unknown. It is also likely that rates and approach routes vary annually. Therefore, in the absence of radical trends or major fluctuations in the marked proportion measured inriver in 1996, commercial harvests were estimated based on the inriver pooled marked proportion.

To determine the potential bias in commercial harvest estimates associated with pooling inriver observations, we performed a sensitivity analysis (Table 5). Three sets of commercial harvest estimates were calculated and examined for practical differences. Estimates were generated using the pooled (0.203), the minimum (0.131), and the maximum (0.253) marked proportions observed in the sport harvest during weekly intervals. The resulting minimum and maximum harvest estimates can therefore be considered lower and upper bounds for bias, respectively, and represent a worst-case scenario. The resulting minimum and maximum harvest estimates differed from the pooled estimate by 20% and 56%, respectively. The maximum difference from the pooled estimates represented 1% of the total drift gillnet harvest and 16% of the total eastside set gillnet harvest. Also, minimum harvest estimates were often within, or only a few hundred fish different than, the lower bound of the 95% confidence interval associated with estimates based on pooled inriver data. Based on this analysis, point estimates as presented in this report are considered practical for current management and research needs; biases in estimates of commercial harvest associated with pooling are assumed minor.

TOTAL HARVEST OF KENAI RIVER COHO SALMON: 1993 THROUGH 1995

Available estimates of harvest of coho salmon of Kenai River origin and estimates of smolt abundance indicate a conservation concern for the coho salmon resource of the Kenai River. The estimate of about 465,000 smolt in 1995 is the lowest of the four estimates available (Figure 15). Total estimated harvest (sport, commercial, personal use, and subsistence) in 1993, 1994, and 1995 was about 60,000, 118,000, and 68,000 coho salmon, respectively. The 1994 estimate of 118,000 fish demonstrates the substantial harvest potential of existing fisheries. If an average total harvest of 81,000 occurs during a return produced from a smolt abundance of 465,000, an extremely high exploitation rate (0.87) would occur, given a marine survival rate for smolt of about 0.20, an average survival rate documented for wild coho salmon populations in Alaska's Taku River (McPherson et al. 1994; McPherson and Bernard 1995). Because of the great harvest potential among existing fisheries, the unknown relationship between harvest and smolt abundance, and the relative decline in production to 465,000 smolt, the department has recommended conservative actions.

In March 1997, the department presented a review of existing smolt and total harvest information to the Alaska Board of Fisheries (BOF) (Carlon *Unpublished* a). Based on that review, the BOF recognized the potential threat to sustainability of current harvest levels and adopted conservative regulations in the form of a new management plan for the Kenai River coho salmon resource (Appendix A6).

Table 5.-Sensitivity of commercial harvest estimates to maximum variations in the marked proportion of coho salmon observed in the Kenai River sport harvest in 1996.

		Pooled Marked Proportion (0.203)	Minimum Observed Marked Proportion (0.131) [b]				Maximum Observed Marked Proportion (0.253)			
Cental District Fishery	Total Harvest	Estimated Harvest [a]	Estimated Harvest [a]	Difference from Pooled	% Difference from Pooled	Difference from Pooled as % of Total Harvest	Estimated Harvest [a]	Difference from Pooled	% Difference from Pooled	Difference from Pooled as % of Total Harvest
Drift	171,361	2,671	4,165	1,494	56%	1%	2,145	526	20%	0.3%
244-21	8,404	3,989	6,220	2,230	56%	27%	3,203	786	20%	9%
244-22	7,644	2,330	3,633	1,303	56%	17%	1,871	459	20%	6%
244-30	7,595	2,384	3,716	1,333	56%	18%	1,914	470	20%	6%
244-40	16,905	3,153	4,916	1,763	56%	10%	2,532	621	20%	4%
East Side Total	40,548	11,856	18,485	6,629	56%	16%	9,520	2,336	20%	6%
Drift + East Side	211,909	14,527	22,650	8,122	56%	4%	11,665	2,862	20%	1%

[a] Kenai River population-specific harvest estimate.

[b] The minimum marked proportion of 0.106 occurring during the week of 9/19/96 was not used in this sensitivity test due to the small sample size.

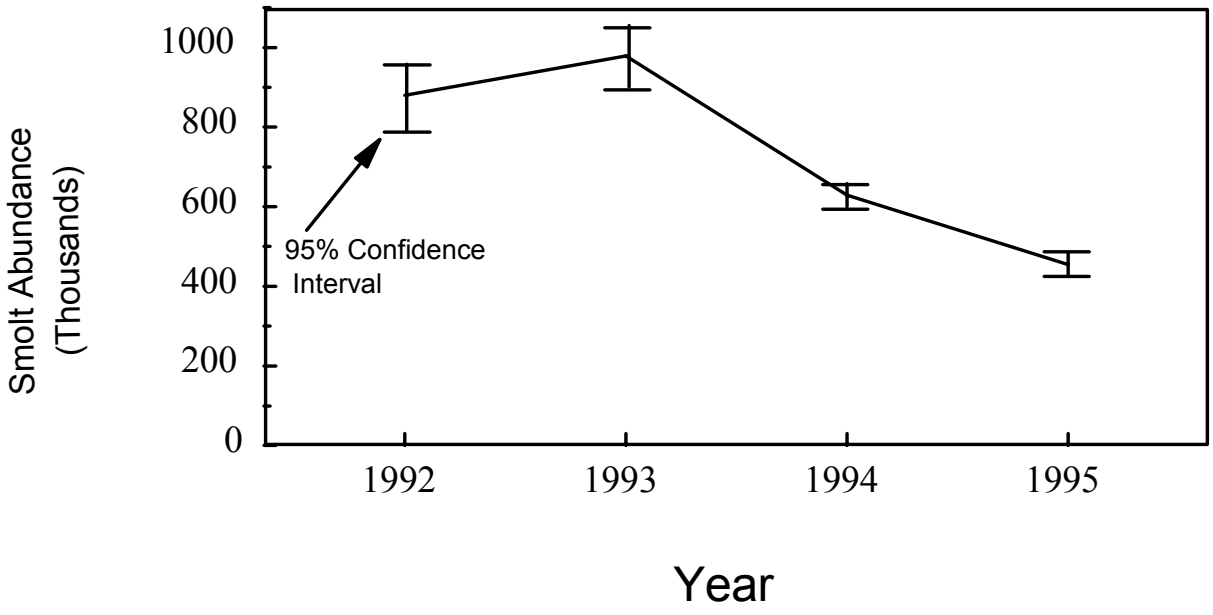


Figure 15.-Estimates of coho salmon smolt abundance in the Kenai River, 1992-1995.

SMOLT ESTIMATES

The estimated 465,000 smolt emigrating from the Kenai River in 1995 was 44% less than the average emigration of 829,000 smolt from 1992 through 1994 (Carlon and Hasbrouck 1994, 1996, 1997). Factors influencing the reduction are unknown. Because total inriver return of coho salmon is not assessed, estimating spawning escapement, exploitation rate of adults, juvenile production, or smolt-to-adult survival is not possible at present. The decline may be due to harvests alone or may reflect interactions among harvest, variable freshwater production, and variable smolt-to-adult survival. Although the relative decline in smolt abundance has already prompted short-term, conservative management actions, a commitment to estimating smolt abundance is necessary to develop specific, long-term management strategies.

COMMERCIAL FISHERY INFORMATION

The drift gillnet fishery appears to harvest few coho salmon of Kenai River origin prior to about mid-July. Most (96%) of the harvest of the Kenai River population occurred during the latter half of July and the first week of August. Over 45% of the total coho salmon harvest by the drift gillnet fishery occurred before this period. This harvest timing pattern was similar to that observed in 1993 through 1995 (Carlon and Hasbrouck 1994, 1996, 1997).

A harvest timing pattern was also detected in the eastside set gillnet fishery in 1996. Most of the total harvest and most (92%) of the harvest of Kenai River-bound fish occurred during the last week of July and the first 2 weeks of August. About 27% of the total harvest occurred prior to

the last week of July. In 1993, 1994, and 1995, the timing was somewhat later, with most of the harvest of Kenai River-bound fish occurring during the first 2 weeks of August (Carlon and Hasbrouck 1996, 1997).

The geographic distribution of the harvest of Kenai River-bound coho salmon among the four statistical areas of the eastside set gillnet fishery was similar to that observed in previous years (Carlon and Hasbrouck 1994, 1996, 1997). Although the proportion of the harvest composed of the Kenai River population generally decreased from south to north, the population-specific harvest was similar among the four areas. No one statistical area accounted for a majority of the harvest of the Kenai River population.

An inseason management action commonly used by CFMD Division staff (Paul Ruesch, Alaska Department of Fish and Game, Soldotna, personal communication) to achieve goals of the Upper Cook Inlet Salmon Management Plan is to restrict drift gillnet fishing to a zone within 3 miles of most of the eastern shore of the Central District (Figure 16). The drift gillnet fleet is restricted to various portions of this zone, commonly referred to as "the corridor," at selected times to minimize the harvest of salmon populations migrating off shore while providing fishing opportunity and harvest of populations migrating near shore.

In 1996 and previous study years (Carlon and Hasbrouck 1994, 1996, 1997), total harvest of coho salmon was substantially lower during fishing periods restricted to the corridor than during district-wide periods (Figure 17). In addition, corridor fishing has not accounted for a majority of the harvest of coho salmon of Kenai River origin in the drift gillnet fishery between 1993 and 1996. The estimated harvest of coho salmon from the Kenai River during corridor fishing periods has always been less than during district-wide periods occurring on nearby dates (Figure 18). Through 1995, a low percentage (range 10%-17%) of the harvest of coho salmon from the Kenai River occurred on days when drift gillnetting was restricted to the corridor. In 1996, nearly 40% occurred during corridor openings because of the greater frequency of corridor fishing relative to previous years.

PROJECT DESIGN CONSIDERATIONS

Harvest Sampling

Estimates of the 1996 commercial harvest of coho salmon from the Kenai River were within the desired relative precision of 20%. This level of precision was attained because of the number of smolt marked in 1995 (95,000) and the portion of the commercial harvests examined in 1996 (24% of the drift harvest and 17% of the eastside set harvest). Based on sample effort of returning adults since 1993, about 20%-25% of the drift gillnet harvest and 15%-20% of the eastside set gillnet harvest should be sampled annually to ensure that this level of precision is attained. Maintaining this level of sampling (when 95,000 smolt are marked) should maintain adequate precision in harvest estimates and minimize potential sources of bias. Trends in smolt abundance must be monitored because substantial changes in abundance will require changes in catch sampling or smolt marking intensity. The level of inriver sampling achieved annually since 1993 (about 3,500 to 5,500 fish) is also considered adequate. The accuracy and precision of commercial harvest and smolt abundance estimates were within the desired range (Carlon *Unpublished* b).

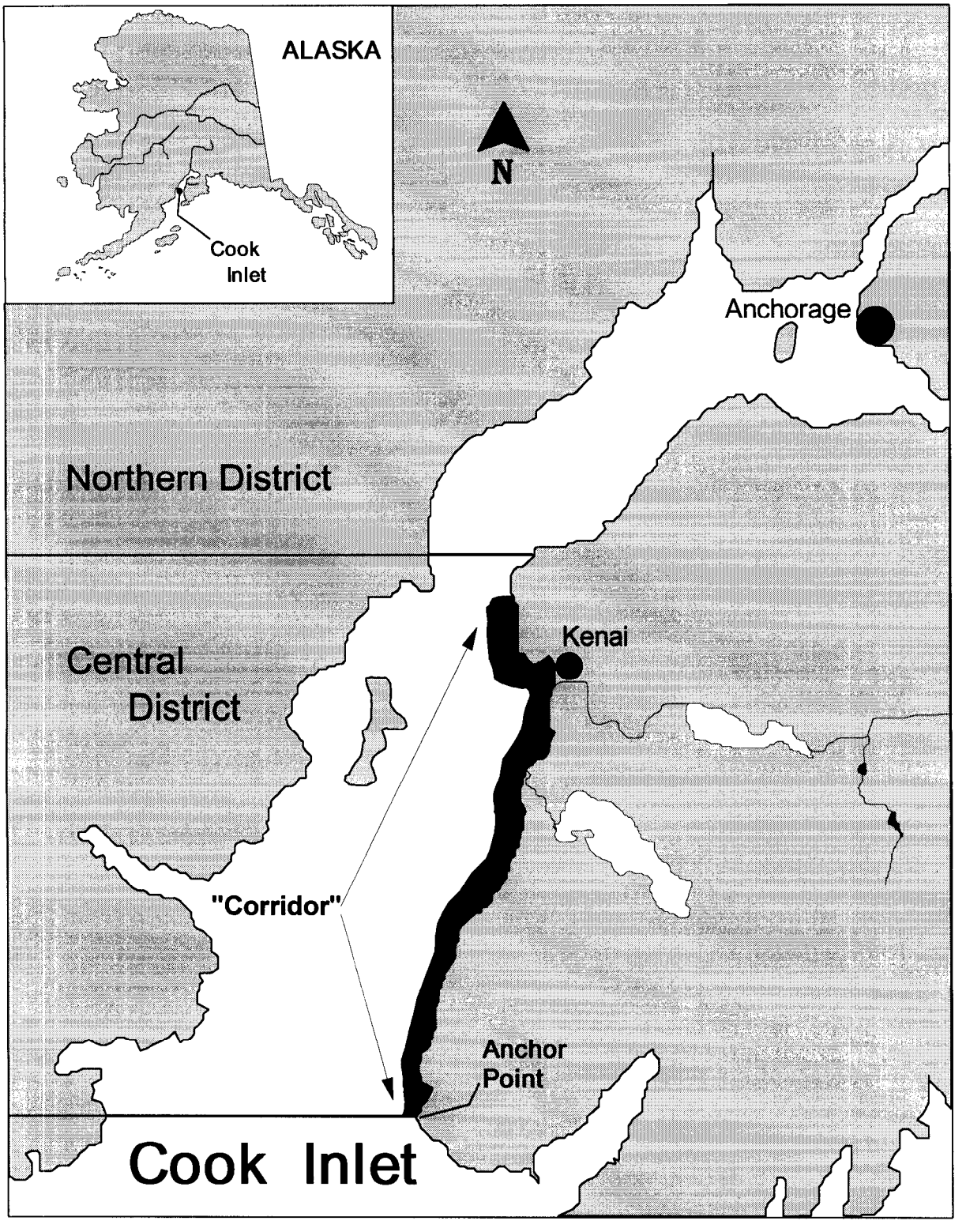


Figure 16.-Schematic map of the corridor fishing area used in the management of the commercial drift gillnet fishery in the Central District of Upper Cook Inlet.

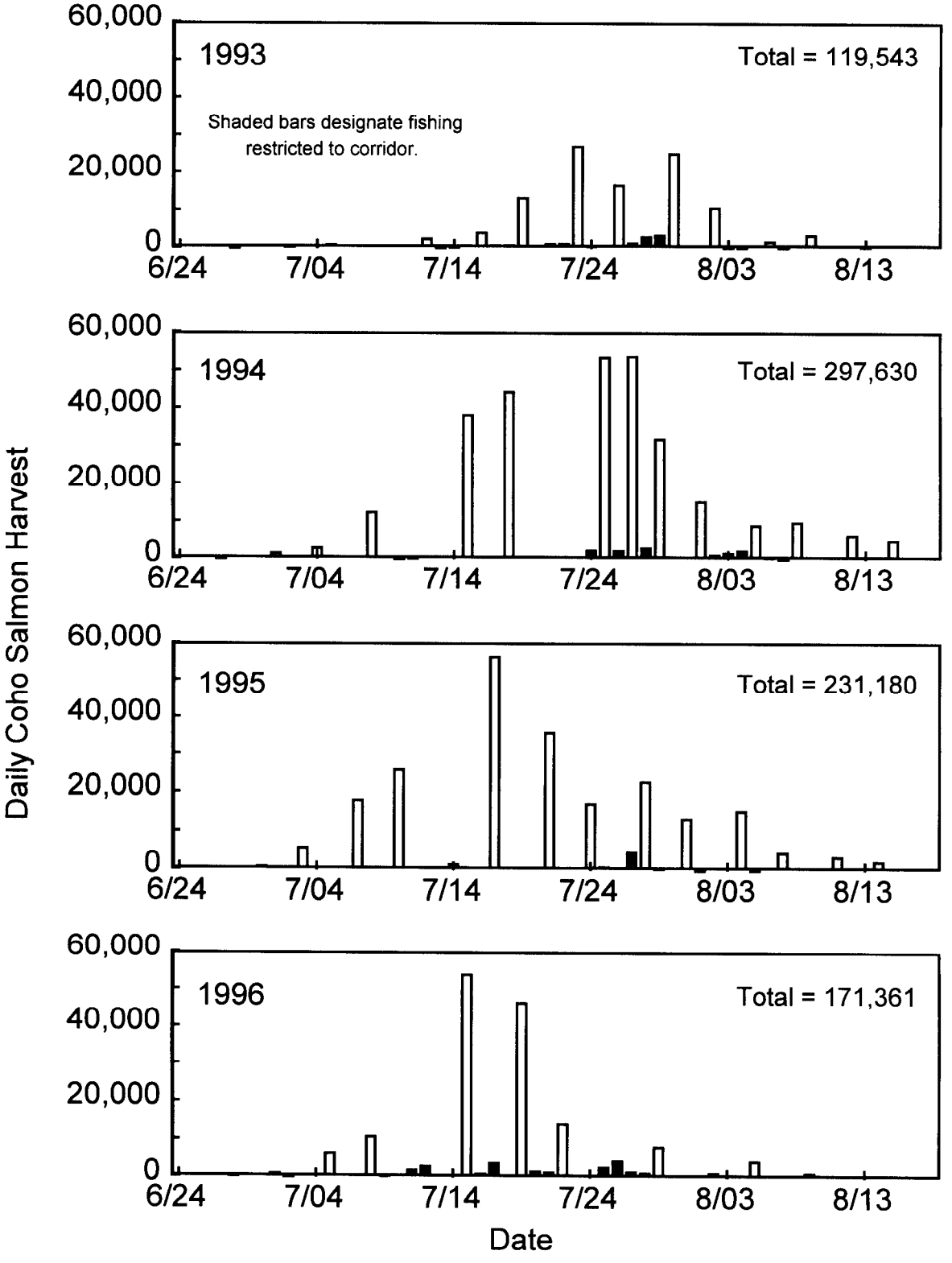


Figure 17.-Daily harvest of coho salmon in the Central District drift gillnet fishery, 1993-1996.

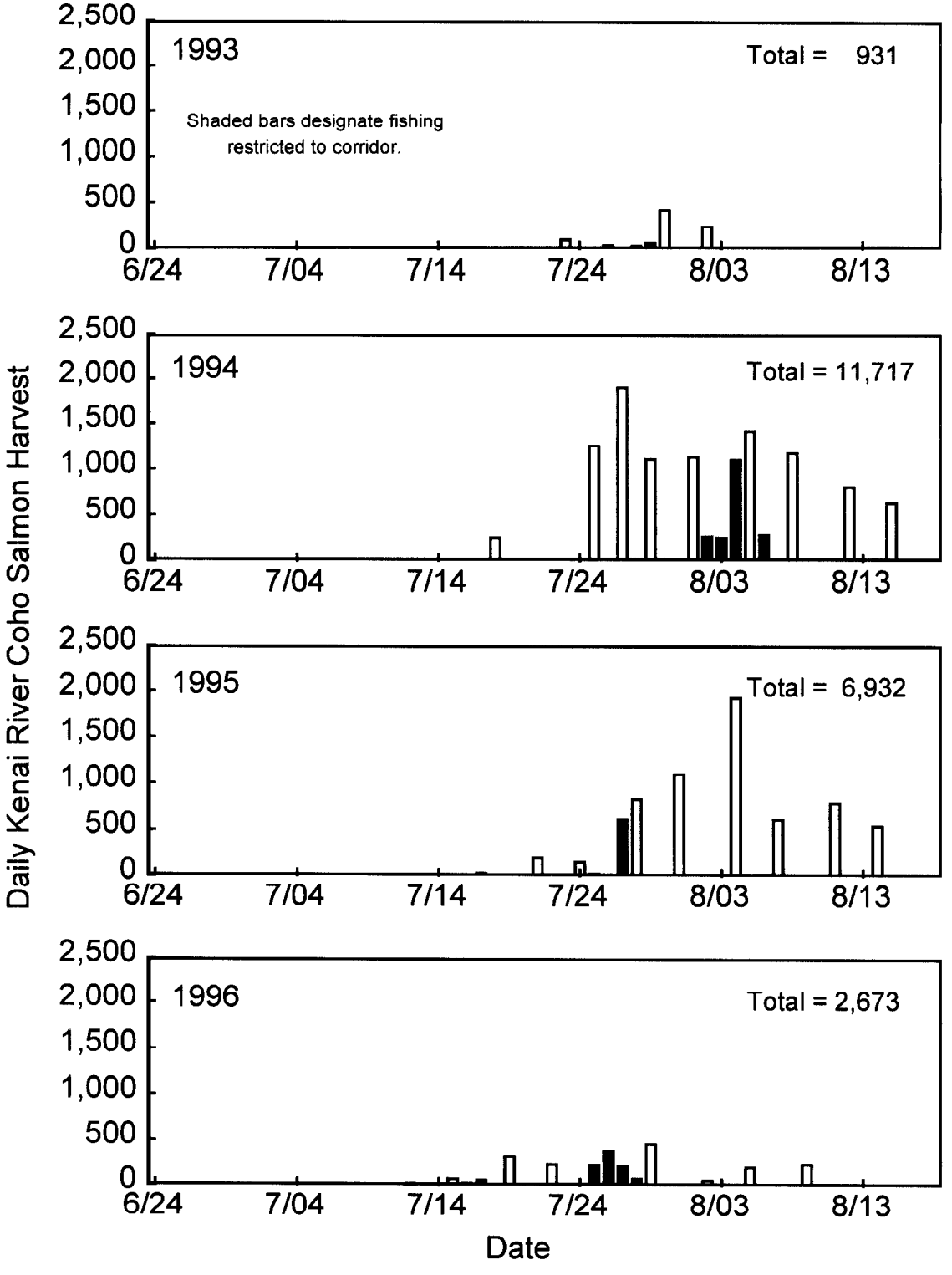


Figure 18.-Daily harvest of coho salmon of Kenai River origin in the Central District drift gillnet fishery, 1993-1996.

Assessment Program Supplements

It is not currently known whether the relative decline in smolt abundance is harvest-induced or of an environmental nature. Monitoring the harvest-smolt relationship to help define a sustainable harvest for this population remains a goal of the program, but is considered a long-term approach because of the expected variable nature in harvest and smolt production. The first paired estimates of harvest and subsequent smolt production provided by this project will not become available until 1997; only four pairs of estimates will be available by the year 2000. It is unlikely that four pairs of estimates will provide enough information to define sustainable yield.

A more comprehensive research program is therefore recommended to supplement this 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 our ability to determine the following:

1. population exploitation rate,
2. spawning escapements through ground survey counts, and
3. genetic composition.

These supplements are considered complimentary to each other 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 (1) 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.

Spawning ground surveys (2) 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.

Spawning groups identified in such ground surveys should be examined for genetic composition (3). 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 unit for this 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 when other program supplements begin to yield information.

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 is an attempt to provide more comprehensive resource information on which to base management objectives and to develop a robust program that can provide useful information if one or more approaches fail. New project elements that should be considered are:

   1. estimating population exploitation rate,
   2. ground surveys to identify and count spawning groups, and
   3. genetic assay to determine if isolation exists within the population.

3. **Determine if a relationship exists between harvest of coho salmon and timing of fishery area closures in the eastside set gillnet fishery.**

   Information provided by this assessment program illustrated the relationship between the harvest of coho salmon from the Kenai River and the drift fishery "corridor" management strategy. Tag recovery data collected since 1993 should be examined for its utility in illustrating the effect of other management actions on the drift gillnet and eastside set gillnet harvests of coho salmon of Kenai River origin.

ACKNOWLEDGMENTS

The following people assisted with the smolt marking in 1995. Jerry Strait provided training for project staff in the use of coded wire tagging equipment and also provided field supervision at the Moose River weir. Earl Chauvin, Wendy Langston, Kurt Strausbaugh, and Troy Tydingco marked smolt and provided logistical support. Soldotna Sport Fish staff provided additional logistical support.

The commercial harvest was examined by technicians of the Commercial Fisheries Management and Development 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.

Jim and Jane Fellman and family granted convenient access to the Moose River through their property. Dr. Bill West granted access to a convenient boat launch on the Moose River.

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APPENDIX A

Appendix A1.-Number of wild coho salmon smolt captured from the Moose River, marked with coded wire tags, and released in 1995.

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]
31-24-08	5/23	5/29	11,781	99.5%	11,725	99.2%	11,631
31-24-10	5/28	5/31	12,116	99.5%	12,057	99.8%	12,033
31-24-11	5/31	6/02	11,583	99.7%	11,551	99.9%	11,539
31-24-12	6/01	6/03	12,333	99.8%	12,310	100.0%	12,310
31-24-17	6/02	6/05	12,298	99.9%	12,281	99.9%	12,269
31-24-18	6/04	6/07	12,480	99.9%	12,462	99.5%	12,400
31-24-19	6/06	6/09	11,964	100.0%	11,964	99.8%	11,940
31-24-20	6/08	6/10	10,440	99.8%	10,423	99.9%	10,413
Total			94,995	99.8%	94,773	99.7%	94,535

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

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

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

Appendix A2.-Sources of marked coho salmon adults recovered from the Kenai River sport harvest during August and September, 1996, as determined from recovery of coded wire tags.

Date	Number Examined	Marked Fish Observed	Marked Fish Recovered	CWT Missing	Release Location and Year of Release: Moose River 1995	Release Location and Year of Release: Moose River 1996
Random Samples						
08/01/96	42	8	3	0	3	0
08/02/96	135	18	14	1	13	0
08/03/96	85	13	9	0	9	0
08/04/96	61	9	8	0	8	0
08/05/96	78	10	6	0	6	0
08/06/96	68	3	3	0	3	0
08/07/96	3	2	2	0	2	0
08/08/96	105	11	8	0	8	0
08/09/96	110	21	18	0	18	0
08/10/96	146	25	22	1	21	0
08/11/96	109	21	18	1	17	0
08/12/96	108	18	13	0	13	0
08/13/96	33	6	2	0	2	0
08/14/96	2	2	1	0	1	0
08/15/96	76	7	5	0	5	0
08/16/96	119	27	18	0	17	1
08/17/96	113	28	18	0	18	0
08/18/96	85	10	6	1	5	0
08/19/96	51	12	8	0	8	0
08/20/96	31	5	3	0	3	0
08/21/96	63	11	7	0	7	0
08/22/96	70	24	10	0	10	0
08/23/96	130	36	22	0	22	0
08/24/96	80	15	12	0	12	0
08/25/96	111	23	12	0	12	0
08/26/96	77	17	16	1	15	0
08/27/96	49	16	8	0	8	0
08/28/96	40	7	4	0	4	0
08/29/96	59	12	5	0	5	0
08/30/96	87	24	19	2	17	0
08/31/96	114	30	19	0	19	0
August Total	2,440	471	319	7	311	1

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Date		Number Examined	Marked Fish Observed	Marked Fish Recovered	CWT Missing	Release Location and Year of Release: Moose River 1995	Release Location and Year of Release: Moose River 1996
09/03/96		85	21	14	0	14	0
09/04/96		13	3	2	0	2	0
09/05/96		99	31	25	0	25	0
09/06/96	[a]	112	30	14	0	13	0
09/07/96		139	37	20	0	20	0
09/08/96		80	16	14	1	13	0
09/09/96		66	13	10	0	10	0
09/10/96		76	12	12	0	12	0
09/11/96		28	7	5	0	5	0
09/12/96		64	14	8	0	8	0
09/13/96		57	12	6	0	6	0
09/14/96		54	11	9	0	9	0
09/15/96		45	9	6	0	6	0
09/16/96		16	2	1	0	1	0
09/17/96		11	3	3	0	3	0
09/18/96		7	4	1	0	1	0
09/19/96		13	2	1	1	0	0
09/20/96		13	1	1	0	1	0
09/21/96		28	4	2	0	2	0
09/22/96		11	2	2	0	2	0
09/23/96		5	0	0	0	0	0
09/24/96		1	0	0	0	0	0
09/25/96	[b]	0					
09/26/96	[b]	0					
09/27/96	[b]	0					
09/28/96		2	0	0	0	0	0
09/29/96	[b]	0					
09/30/96	[c]						
September Total		1,025	234	156	2	2,148	1,996
Random Total		3,465	705	475	9	2,459	1,997
Non-Random Samples	[d]						
08/04/96				1	0	1	0
09/19/96				10	0	10	0
09/25/96				1	0	1	0
Non Random Total				12	0	12	0

[a] One of the 14 coded wire tags recovered was unreadable.

[b] Sport fishing effort was minimal; among the few anglers present, no fish were examined.

[c] Sampling effort was discontinued after 9/29 due to minimal angler effort and harvest observed between 9/25 and 9/29.

[d] Non-random recoveries are voluntary angler returns to ADF&G personnel and are not used in quantitative calculations.

Appendix A3.-Kenai River sport harvest recoveries in 1996 of coho salmon adults marked with coded wire tags as smolt early and late in the 1995 emigration from the Moose River.

	Tag Code, Last Date of Release, and Number Released for Each Code										
	Early Smolt [a]					Late Smolt [a]					
Date of	312408	312410	312411	312412		312417	312418	312419	312420		
Adult	05/29	05/31	06/02	06/03	Total	06/05	06/07	06/09	06/10	Total	Total
Recovery	11,631	12,033	11,539	12,310	47,513	12,269	12,400	11,940	10,413	47,022	94,535
08/01	1				1	1	1			2	3
08/02	1	4	1	1	7	1	1	2	2	6	13
08/03			1	1	2	2	4		1	7	9
08/04				1	1	4	1	2		7	8
08/05		1	1		2	1	1		2	4	6
08/06		2			2			1		1	3
08/07		1			1				1	1	2
08/08		1	1	1	3	2	2	1		5	8
08/09	2	1	2	2	7	3	2	1	5	11	18
08/10	2	6	1		9	2	3	4	3	12	21
08/11		4	2	1	7	4	2	2	2	10	17
08/12	2	3		4	9	1	1	2		4	13
08/13							1		1	2	2
08/14									1	1	1
08/15	1			1	2	2			1	3	5
Period Total	9	23	9	12	53	23	19	15	19	76	129
08/16	2	2	2	1	7	4	2	1	3	10	17
08/17	3	1		4	8	3	3	1	3	10	18
08/18	1		1		2	1	1		1	3	5
08/19	1	1	1		3		4	1		5	8
08/20			1		1	1	1			2	3
08/21	3		1		4		1	1	1	3	7
08/22	1	1	1	2	5	2	2	1		5	10
08/23	4	3	5	1	13	1	5	3		9	22
08/24		3	2		5	1	2	4		7	12
08/25	4	1	1	2	8	2		1	1	4	12
08/26		3	1	1	5	4	3	1	2	10	15
08/27		1	1	2	4	1			3	4	8
08/28	2				2	1	1			2	4
08/29	1	2			3				2	2	5
08/30		5	3	5	13	1	2		1	4	17
08/31	3	6	2	3	14	1	1	2	1	5	19
Period Total	25	29	22	21	97	23	28	16	18	85	182

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	Tag Code, Last Date of Release, and Number Released for Each Code										
	Early Smolt [a]					Late Smolt [a]					
Date of	312408	312410	312411	312412		312417	312418	312419	312420		
Adult	05/29	05/31	06/02	06/03	Total	06/05	06/07	06/09	06/10	Total	Total
Recovery	11,631	12,033	11,539	12,310	47,513	12,269	12,400	11,940	10,413	47,022	94,535
09/01	3	3	2	2	10	2	2	2	1	7	17
09/02	2	2	2	5	11	2	2	3	5	12	23
09/03	1			2	3	4	1	3	3	11	14
09/04		1			1		1			1	2
09/05		1	6	4	11	2	1	4	7	14	25
09/06			3	3	6	1	3	1	2	7	13
09/07		3	3	1	7	4	2	3	4	13	20
09/08	2	2	3	2	9	1	1	1	1	4	13
09/09	2	1	1	1	5	1		1	3	5	10
09/10	2	1	1	1	5	2	2	1	2	7	12
09/11	1				1	1	1	2		4	5
09/12	2	1	2		5	1	2			3	8
09/13			2		2	1	3			4	6
09/14	1	1			2	1	1	1	4	7	9
09/15	1			2	3		1		2	3	6
Period Total	17	16	25	23	81	23	23	22	34	102	183
09/16						1				1	1
09/17		1		2	3						3
09/18		1			1						1
09/19											
09/20								1		1	1
09/21							1		1	2	2
09/22						1			1	2	2
09/23											
09/24											
09/25											
09/26											
09/27											
09/28											
09/29											
09/30											
Period Total		2		2	4	2	1	1	2	6	10
Season Total	51	70	56	58	235	71	71	54	73	269	504

[a] "Early Smolt" refers to the first 50% of the smolt tagged in 1995 and "Late Smolt" refers to the second 50% tagged in 1995.

Appendix A4.-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 fishery statistical areas in 1996.

District	Fishery	Statistical Area	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 1995
Central	East Side Set	Unknown Mix	07/15		3	0	0	0	0	0
Central	East Side Set	Unknown Mix	07/16		51	0	0	0	0	0
Central	East Side Set	Unknown Mix	07/17		57	4	4	4	4	3
Central	East Side Set	Unknown Mix	07/19		61	5	5	5	5	3
Central	East Side Set	Unknown Mix	07/22		43	2	2	2	2	2
Central	East Side Set	Unknown Mix	07/25		9	0	0	0	0	0
Central	East Side Set	Unknown Mix	07/26		101	12	11	11	11	8
Central	East Side Set	Unknown Mix	07/27		24	0	0	0	0	0
Central	East Side Set	Unknown Mix	07/29		93	15	15	13	13	10
Central	East Side Set	Unknown Mix	08/02		102	11	11	11	11	10
Central	East Side Set	Unknown Mix	08/05		115	8	8	8	8	8
Central	East Side Set	Unknown Mix	08/09		110	16	16	15	15	15
Central	East Side Set	Unknown Mix	08/12		7	2	2	2	2	2
		Unknown Mix Total			776	75	74	71	71	61
Central	East Side Set	24422/30	07/12		50	0	0	0	0	0
		24422/30 Total			50	0	0	0	0	0
Central	Drift/East Side Set	Unknown Mix	07/05		15	1	1	1	1	0
Central	Drift/East Side Set	Unknown Mix	07/12		25	0	0	0	0	0
Central	Drift/East Side Set	Unknown Mix	07/25		288	16	15	14	14	4
Central	Drift/East Side Set	Unknown Mix	07/27		73	10	10	9	9	9
		Unknown Mix Total			401	27	26	24	24	13
Central	West Side/Kalgin Island Set	24530-24610/20	08/02		765	5	5	5	5	0
Central	West Side/Kalgin Island Set	24530-24610/20	08/05		1,306	12	12	11	11	3
Central	West Side/Kalgin Island Set	24530-24610/20	08/09		1,029	3	3	2	2	1
Central	West Side/Kalgin Island Set	24530-24610/20	08/12		878	4	4	3	3	2
Central	West Side/Kalgin Island Set	24530-24610/20	08/14		463	1	1	1	1	0
Central	West Side/Kalgin Island Set	24530-24610/20	08/16		650	3	3	3	3	2
Central	West Side/Kalgin Island Set	24530-24610/20	08/21		755	1	1	1	1	1
Central	West Side/Kalgin Island Set	24530-24610/20	08/23		233	1	1	1	1	1
		24530-24610/20 Total			6,079	30	30	27	27	10
Central Total					7,306	132	130	122	122	84
Northern	Pt. MacKenzie/Fire I. Set	24742/43	07/19		505	40	40	38	38	0
		24742/43 Total			505	40	40	38	38	0
Northern	West Side/East Side Set	Unknown Mix	07/29		964	42	42	42	42	0
Northern	West Side/East Side Set	Unknown Mix	08/02		157	3	3	3	3	0
Northern	West Side/East Side Set	Unknown Mix	08/05		571	40	40	37	37	0
Northern	West Side/East Side Set	Unknown Mix	08/09		784	28	28	28	28	1
		Unknown Mix Total			2,476	113	113	110	110	1
Northern Total					2,981	153	153	148	148	1
		Grand Total			10,287	285	283	270	270	85

Note: An additional 204 fish were examined as a harvest mixture from both Upper and Lower Cook Inlet. Two heads were recovered from two adipose-clipped fish found. Neither of the two decodable tags were from the Kenai River.

Appendix A5.-Upper Cook Inlet commercial coho salmon harvest in 1996, 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 1995.

District	Fishery [a]	Statistical Area	Date [b]	(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 1995	(r_i) Harvest Estimate [c]	$V(r_i)$ Variance [c]
Central	Drift	24450/60/70-24570/80/90	6/28-7/02	1,480	19	0	0	0	0	0	0	0
Central	Drift	24450/60/70-24570/80/90	07/05	6,420	1,348	18	18	15	15	0	0	0
Central	Drift	24450/60/70-24570/80/90	07/08	10,806	3,349	47	47	41	41	0	0	0
Central	Drift	24450/60/70-24570/80/90	7/09-7/12	5,279	1,529	23	23	23	23	1	17	271
Central	Drift	24450/60/70-24570/80/90	07/15	54,057	9,671	206	205	185	185	3	83	2,211
Central	Drift	24450/60/70-24570/80/90	07/16	901	144	5	5	5	5	1	31	915
Central	Drift	24450/60/70-24570/80/90	07/17	3,978	548	14	14	13	13	2	71	2,479
Central	Drift	24450/60/70-24570/80/90	07/19	46,531	12,065	354	353	331	330	17	324	6,030
Central	Drift	24450/60/70-24570/80/90	7/20-7/21	2,925	505	18	18	17	17	0	0	0
Central	Drift	24450/60/70-24570/80/90	07/22	14,153	5,069	217	215	202	201	17	237	3,150
Central	Drift	24450/60/70-24570/80/90	07/25	2,694	630	48	48	48	48	11	231	4,713
Central	Drift	24450/60/70-24570/80/90	07/26	4,541	2,194	129	129	122	122	38	387	3,802
Central	Drift	24450/60/70-24570/80/90	07/27	1,491	332	26	26	25	25	10	221	4,728
Central	Drift	24450/60/70-24570/80/90	07/28	1,120	393	18	18	18	18	6	84	1,103
Central	Drift	24450/60/70-24570/80/90	07/29	8,208	2,858	164	163	156	156	33	469	6,563
Central	Drift	24450/60/70-24570/80/90	08/02	1,113	81	7	7	7	7	1	68	4,493
Central	Drift	24450/60/70-24570/80/90	08/05	4,484	526	23	23	21	21	5	209	8,629
Central	Drift	24450/60/70-24570/80/90	08/09	1,180	217	9	9	9	9	9	241	6,278
		24450/60/70-24570/80/90 Total		171,361	41,478	1,326	1,321	1,238	1,236	154	2,671	55,365
Central	East Side Set	24421	6/28-7/12	490	62	0	0	0	0	0	0	0
Central	East Side Set	24421	7/14-7/15	238	34	0	0	0	0	0	0	0
Central	East Side Set	24421	07/16	110	48	1	1	1	1	0	0	0
Central	East Side Set	24421	07/17	168	29	2	2	2	2	1	28	782
Central	East Side Set	24421	07/19	210	6	0	0	0	0	0	0	0
Central	East Side Set	24421	7/20-7/22	626	28	6	6	6	6	5	549	60,240
Central	East Side Set	24421	07/25	474	128	6	6	6	6	6	109	1,896
Central	East Side Set	24421	07/26	1,454	170	28	27	27	27	26	1,133	50,450
Central	East Side Set	24421	7/27-7/28	1,575	135	14	14	14	14	14	803	46,278
Central	East Side Set	24421	07/29	1,054	321	40	40	39	39	36	581	9,373
Central	East Side Set	24421	08/02	562	20	2	1	1	1	1	276	76,009
Central	East Side Set	24421	08/05	674	29	5	0	0	0	0	Unknown	NA
Central	East Side Set	24421	08/09	474	24	4	4	4	4	4	388	37,496
Central	East Side Set	24421	08/12	295	24	2	1	1	1	1	121	14,476
		24421 Total		8,404	1,058	110	102	101	101	94	3,989	297,000

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District	Fishery [a]	Statistical Area	Date [b]	(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 1995	(r_i) Harvest Estimate [c]	$V(r_i)$ Variance [c]
Central	East Side Set	24422	6/28-7/12	605	112	2	2	2	2	0	0	0
Central	East Side Set	24422	7/14-7/15	426	52	2	2	2	2	1	40	1,581
Central	East Side Set	24422	07/16	135	27	0	0	0	0	0	0	0
Central	East Side Set	24422	07/17	181	20	2	2	1	1	1	44	1,934
Central	East Side Set	24422	07/19	322	146	6	6	5	5	2	22	214
Central	East Side Set	24422	7/20-7/22	504	67	7	7	7	7	2	74	2,664
Central	East Side Set	24422	07/25	403	133	16	16	16	16	15	223	3,185
Central	East Side Set	24422	07/26	739	88	6	6	5	5	5	206	8,371
Central	East Side Set	24422	7/27-7/28	1,659	150	13	13	12	12	12	652	35,490
Central	East Side Set	24422	07/29	532	210	11	11	10	10	8	100	1,156
Central	East Side Set	24422	08/02	397	86	7	7	7	7	7	159	3,482
Central	East Side Set	24422	08/05	969	102	12	12	11	11	10	467	21,678
Central	East Side Set	24422	08/09	609	236	27	27	27	27	27	342	4,200
Central	East Side Set	24422	08/12	163	21	0	0	0	0	0	0	0
		24422 Total		7,644	1,450	111	111	105	105	90	2,330	83,954
Central	East Side Set	24430	6/28-7/12	225	33	1	1	1	1	0	0	0
Central	East Side Set	24430	7/14-7/15	610	194	5	4	3	3	0	0	0
Central	East Side Set	24430	7/16-7/17	903	30	1	1	0	0	0	Unknown	NA
Central	East Side Set	24430	07/19	529	133	3	3	3	3	0	0	0
Central	East Side Set	24430	7/20-7/22	562	58	1	1	0	0	0	Unknown	NA
Central	East Side Set	24430	07/25	332	59	8	7	7	7	7	221	6,845
Central	East Side Set	24430	07/26	424	70	6	6	6	6	1	30	856
Central	East Side Set	24430	7/27-7/28	684	24	4	2	2	2	2	560	156,662
Central	East Side Set	24430	07/29	431	85	8	8	8	8	3	75	1,795
Central	East Side Set	24430	08/02	1,081	117	13	13	12	12	12	545	24,677
Central	East Side Set	24430	08/05	1,016	75	9	7	7	6	6	599	59,766
Central	East Side Set	24430	08/09	565	117	7	7	7	7	7	166	3,819
Central	East Side Set	24430	08/12	233	79	14	13	13	13	12	187	2,794
		24430 Total		7,595	1,074	80	73	69	68	50	2,384	257,214

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District	Fishery [a]	Statistical Area	Date [b]	(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 1995	(r_i) Harvest Estimate [c]	$V(r_i)$ Variance [c]
Central	East Side Set	24440	7/01-7/12	552	53	0	0	0	0	0	0	0
Central	East Side Set	24440	07/15	942	142	2	2	1	1	1	33	1,030
Central	East Side Set	24440	07/16	569	245	4	4	4	4	1	11	119
Central	East Side Set	24440	07/19	1,186	236	13	13	13	13	2	49	1,173
Central	East Side Set	24440	7/20-7/22	1,877	122	4	4	4	4	1	76	5,642
Central	East Side Set	24440	07/25	1,989	203	9	9	8	8	4	193	9,132
Central	East Side Set	24440	07/26	2,259	233	13	12	12	12	7	361	18,488
Central	East Side Set	24440	7/27-7/28	1,860	41	2	2	2	2	1	223	49,485
Central	East Side Set	24440	07/29	1,162	167	11	11	10	10	5	171	5,717
Central	East Side Set	24440	08/02	866	275	36	36	35	35	34	526	8,092
Central	East Side Set	24440	08/05	1,746	565	72	71	70	70	68	1,047	16,989
Central	East Side Set	24440	08/09	981	501	35	35	32	32	30	289	2,632
Central	East Side Set	24440	08/12	916	569	26	26	24	24	22	174	1,254
		24440 Total		16,905	3,352	227	225	215	215	176	3,153	119,753
Central	Chinitna Bay Drift	24510	06/28	0							NA	NA
Central	Chinitna Bay Drift	24510	07/05	1							Unknown	NA
Central	Chinitna Bay Drift	24510	07/08	6							Unknown	NA
Central	Chinitna Bay Drift	24510	07/15	67							Unknown	NA
Central	Chinitna Bay Drift	24510	08/23	156							Unknown	NA
		24510 Total		230	0	0	0	0	0	0	0	0

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District	Fishery [a]	Statistical Area	Date [b]	(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 1995	(r_i) Harvest Estimate [c]	$V(r_i)$ Variance [c]
Central	Kalgin Island Set	24610/20	06/28	180							Unknown	NA
Central	Kalgin Island Set	24610/20	07/01	27							Unknown	NA
Central	Kalgin Island Set	24610/20	07/05	248							Unknown	NA
Central	Kalgin Island Set	24610/20	07/08	171							Unknown	NA
Central	Kalgin Island Set	24610/20	07/12	873							Unknown	NA
Central	Kalgin Island Set	24610/20	07/15	2,150							Unknown	NA
Central	Kalgin Island Set	24610/20	07/19	2,957							Unknown	NA
Central	Kalgin Island Set	24610/20	07/22	1,320							Unknown	NA
Central	Kalgin Island Set	24610/20	07/26	612							Unknown	NA
Central	Kalgin Island Set	24610/20	07/29	2,771	2,859	30	30	27	27	2	10	36
Central	Kalgin Island Set	24610/20	07/31	511	492	8	8	8	8	1	5	21
Central	Kalgin Island Set	24610/20	08/02	258							Unknown	NA
Central	Kalgin Island Set	24610/20	08/05	1,070							Unknown	NA
Central	Kalgin Island Set	24610/20	08/07	796	702	13	12	12	12	4	24	122
Central	Kalgin Island Set	24610/20	08/09	434							Unknown	NA
Central	Kalgin Island Set	24610/20	08/12	319							Unknown	NA
Central	Kalgin Island Set	24610/20	08/14	93							Unknown	NA
Central	Kalgin Island Set	24610/20	08/16	174							Unknown	NA
Central	Kalgin Island Set	24610/20	08/19	376							Unknown	NA
Central	Kalgin Island Set	24610/20	08/21	114							Unknown	NA
Central	Kalgin Island Set	24610/20	08/23	54							Unknown	NA
Central	Kalgin Island Set	24610/20	08/26	14							Unknown	NA
Central	Kalgin Island Set	24610/20	08/28	37							Unknown	NA
		24610/20 Total		15,559	4,053	51	50	47	47	7	39	180

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District	Fishery [a]	Statistical Area	Date [b]	(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 1995	(r_i) Harvest Estimate [c]	$V(r_i)$ Variance [c]
Central	West Side Set	24520/30/40/50/55/60	06/03	0							NA	NA
Central	West Side Set	24520/30/40/50/55/60	06/05	0							NA	NA
Central	West Side Set	24520/30/40/50/55/60	06/07	0							NA	NA
Central	West Side Set	24520/30/40/50/55/60	06/10	0							NA	NA
Central	West Side Set	24520/30/40/50/55/60	06/12	0							NA	NA
Central	West Side Set	24520/30/40/50/55/60	06/14	0							NA	NA
Central	West Side Set	24520/30/40/50/55/60	06/17	0							NA	NA
Central	West Side Set	24520/30/40/50/55/60	06/19	0							NA	NA
Central	West Side Set	24520/30/40/50/55/60	06/21	0							NA	NA
Central	West Side Set	24520/30/40/50/55/60	06/24	1							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	06/28	3							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	07/01	4							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	07/05	65							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	07/08	255							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	07/12	58							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	07/15	418							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	07/19	922							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	07/22	1,214							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	07/26	336							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	07/29	1,329							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	08/02	1,142							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	08/05	1,195							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	08/09	1,784							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	08/12	1,564							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	08/14	671							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	08/16	1,080							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	08/19	914							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	08/21	706							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	08/23	591							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	08/26	392							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	08/28	208							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	09/02	351							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	09/04	301							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	09/06	32							Unknown	NA
Central	West Side Set	24520/30/40/50/55/60	09/09	80							Unknown	NA
		24520/30/40/50/55/60 Total		15,616	0	0	0	0	0	0	0	0
Central Total				243,314	52,465	1,905	1,882	1,775	1,772	8,551	14,566	813,466

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District	Fishery [a]	Statistical Area	Date [b]	(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 1995	(r_i) Harvest Estimate [c]	$V(r_i)$ Variance [c]
Northern	East Side Set	24770/80/90	6/28-7/19	2,550	11	0	0	0	0	0	0	0
Northern	East Side Set	24770/80/90	07/26	588	40	3	3	3	3	0	0	0
Northern	East Side Set	24770/80/90	07/29	962	290	8	8	8	8	0	0	0
Northern	East Side Set	24770/80/90	08/02	523	121	2	2	1	1	0	0	0
Northern	East Side Set	24770/80/90	08/05	1,428	598	8	8	8	8	0	0	0
Northern	East Side Set	24770/80/90	08/09	2,184	838	6	6	5	5	1	13	151
Northern	East Side Set	24770/80/90	08/12	2,027	835	20	20	19	19	0	0	0
Northern	East Side Set	24770/80/90	08/16	1,823	1,222	8	8	5	5	0	0	0
Northern	East Side Set	24770/80/90	08/19	1,595	1,147	3	3	3	3	0	0	0
Northern	East Side Set	24770/80/90	08/23	677	151	0	0	0	0	0	0	0
Northern	East Side Set	24770/80/90	08/26	1,722	1,034	4	4	3	3	2	16	118
Northern	East Side Set	24770/80/90	8/30-9/02	270	39	0	0	0	0	0	0	0
Northern	East Side Set	24770/80/90	09/06	95	85	0	0	0	0	0	0	0
		24770/80/90 Total		16,444	6,411	62	62	55	55	3	29	269
Northern	Fire Island Set	24743	7/05-7/15	1,298	1,191	103	103	98	98	0	0	0
Northern	Fire Island Set	24743	07/19	1,019	1,127	133	133	126	126	0	0	0
Northern	Fire Island Set	24743	07/26	1,405	781	138	138	133	133	0	0	0
Northern	Fire Island Set	24743	07/29	2,641	2,180	377	377	356	356	0	0	0
Northern	Fire Island Set	24743	08/02	459	342	42	42	40	40	0	0	0
Northern	Fire Island Set	24743	08/05	280	815	119	118	111	110	0	0	0
Northern	Fire Island Set	24743	08/09	679	609	72	71	68	68	0	0	0
Northern	Fire Island Set	24743	08/12	455	190	5	5	5	5	0	0	0
Northern	Fire Island Set	24743	08/16	106	110	11	11	11	11	0	0	0
Northern	Fire Island Set	24743	08/19	33	42	3	3	3	3	0	0	0
		24743 Total		8,375	7,387	1,003	1,001	951	950	0	0	0
Northern	Knik Arm Set	24750	07/16	358							Unknown	NA
Northern	Knik Arm Set	24750	07/21	775							Unknown	NA
Northern	Knik Arm Set	24750	07/23	669							Unknown	NA
		24750 Total		1,802	0	0	0	0	0	0	0	0

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District	Fishery [a]	Statistical Area	Date [b]	(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 1995	(r_i) Harvest Estimate [c]	$V(r_i)$ Variance [c]
Northern	Pt. MacKenzie/Su Flats Set	24741/42	6/28-7/15	1,334	1,104	54	54	51	51	0	0	0
Northern	Pt. MacKenzie/Su Flats Set	24741/42	07/19	1,406	736	61	60	56	56	0	0	0
Northern	Pt. MacKenzie/Su Flats Set	24741/42	07/26	1,407	1,085	159	159	151	151	0	0	0
Northern	Pt. MacKenzie/Su Flats Set	24741/42	07/29	1,454	980	134	134	124	124	0	0	0
Northern	Pt. MacKenzie/Su Flats Set	24741/42	08/05	283	123	7	6	6	6	0	0	0
Northern	Pt. MacKenzie/Su Flats Set	24741/42	08/09	365	471	60	60	57	57	0	0	0
Northern	Pt. MacKenzie/Su Flats Set	24741/42	8/12-8/26	214	253	19	19	17	17	0	0	0
		24741/42 Total		6,463	4,752	494	492	462	462	0	0	0
Northern	West Side Set	24710/20/30	6/28-7/15	18,867	11,047	34	33	24	24	0	0	0
Northern	West Side Set	24710/20/30	07/19	7,517	5,975	42	41	35	35	0	0	0
Northern	West Side Set	24710/20/30	07/26	7,125	2,523	49	49	40	40	0	0	0
Northern	West Side Set	24710/20/30	07/29	7,698	7,011	135	132	122	122	0	0	0
Northern	West Side Set	24710/20/30	8/02-8/05	1,579	897	9	9	9	9	0	0	0
Northern	West Side Set	24710/20/30	08/09	1,361	925	7	7	6	6	0	0	0
Northern	West Side Set	24710/20/30	8/12-8/23	866	510	1	1	0	0	0	Unknown	NA
		24710/20/30 Total		45,013	28,888	277	272	236	236	0	0	0
Northern Total				78,097	47,438	1,836	1,827	1,704	1,703	1,998	29	269
		Grand Total		321,411	99,903	3,741	3,709	3,479	3,475	12,544	14,595	813,735

[a] Chinitna Bay, Kalgin Island, and Central District West Side set gillnet fisheries were not sampled or were sampled only incidentally, but are included here to add perspective to information from sampled fisheries.

[b] Dates for which harvest is zero indicates that the fishery was operating, but no coho salmon were harvested.

[c] Harvest estimates listed as "Unknown" and variance estimates listed as "NA" indicate that no readable tags were recovered from adipose-clipped fish or that the fishery was not sampled.

Appendix A6.-Kenai River Coho Salmon Management Plan.

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 AC 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