Fishery Data Series No. 04-23

Assessment of Coho Salmon from the Kenai River, Alaska, 2000

by

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and

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November 2004

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

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
milliliter	mL
millimeter	mm

Weights and measures (English)

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

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

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

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
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
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
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	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
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.
minute (angular)	'
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
variance	
population	Var
sample	var

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ABSTRACT

Since 1991, the Alaska Department of Fish and Game has assessed coho salmon *Oncorhynchus kisutch* of the Kenai River with an annual research program designed to estimate both the commercial harvest from Upper Cook Inlet and the Kenai River drainage-wide smolt production. As part of this ongoing study, coho salmon smolt were captured and marked with coded wire tags and adipose finclips at a weir on the Moose River, a tributary to the Kenai River. In 1999, 114,885 coho sa1mon were marked with adipose finclips, an estimated 113,824 were released alive with tags, and 163,484 were enumerated emigrating from the Moose River.

In 2000, coho salmon smolt tagged in 1999 at the Moose River returned to the Kenai River as adults. Fish wheels and drift gillnets on the Kenai River, and a weir at the Russian River (tributary to the Kenai River), were used to capture returning adult coho salmon to estimate the proportion bearing coded wire tags, which in turn was used to estimate commercial harvest of Kenai River origin. Captured coho from these efforts were examined for the presence of an adipose finclip. Additionally, a tag detector wand was used to confirm tag presence in adipose finclipped coho at the fish wheels. Although the marked proportion varied significantly ($P<0.006$) over weekly periods in all inriver capture efforts, the pooled fish wheel catch appeared most representative for use in estimating the commercial harvest of coho of Kenai River origin. The marked coho proportion from drift gillnets and the weir had either higher temporal or spatial bias. The 1999 drainage-wide smolt abundance was an estimated 578,335 coho salmon (SE = 19,884), based on the pooled number of fish examined at the fish wheel (3,413), the number observed to be missing an adipose fin (672), and the number of smolt marked and released with an adipose finclip in 1999 (114,885).

Based on the recovery of harvested adults marked with coded wire tags and adipose finclips in selected Upper Cook Inlet commercial fisheries, an estimated 531 (SE = 122) coho salmon of Kenai River origin were harvested in the Central District drift gillnet fishery, an estimated 2,351 (SE = 223) were harvested in the Central District eastside set gillnet fishery, and 83 (SE = 21) by all Northern District set gillnet fisheries for a total of 2,965 (SE = 255). Sampling within other areas of Upper Cook Inlet indicated that commercial harvest of Kenai River coho was very low. The estimated harvests represented 22% of the eastside set gillnet fishery and 0.4% of the total drift gillnet fishery.

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

INTRODUCTION

BACKGROUND

Coho salmon *Oncorhynchus kisutch* spawn and rear in freshwater drainages of Upper Cook Inlet, Alaska (UCI, Figure 1). As they return to spawn annually, adults are harvested in mixed-stock commercial and sport marine fisheries. Sport and personal use harvests also occur in fresh water. Cook Inlet ranks first in the 1985-2000 average combined marine and freshwater sport harvest of coho salmon among all regions of the state and fifth in commercial harvest (Figure 2).

In 1991, the Alaska Department of Fish and Game (ADF&G) initiated a program to assess the status of UCI coho salmon stocks (Meyer et al. *Unpublished*). Despite the importance of UCI coho salmon fisheries, no such program existed before 1991. A primary component of the program involves the wild population of coho salmon from the Kenai River. This population was selected for assessment because of a history 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, 1980, 1981 a, b, 1982-1994; Howe et al. 1995, 1996, 2001 a-d; Walker et al. 2003) and account for an average of about one of every six coho salmon of the roughly half million annually sport-harvested from all waters of Alaska. The population also contributes to commercial marine fisheries in UCI and, to a lesser degree, to marine sport and inriver personal use fisheries that occur along migratory approach routes to the Kenai River.

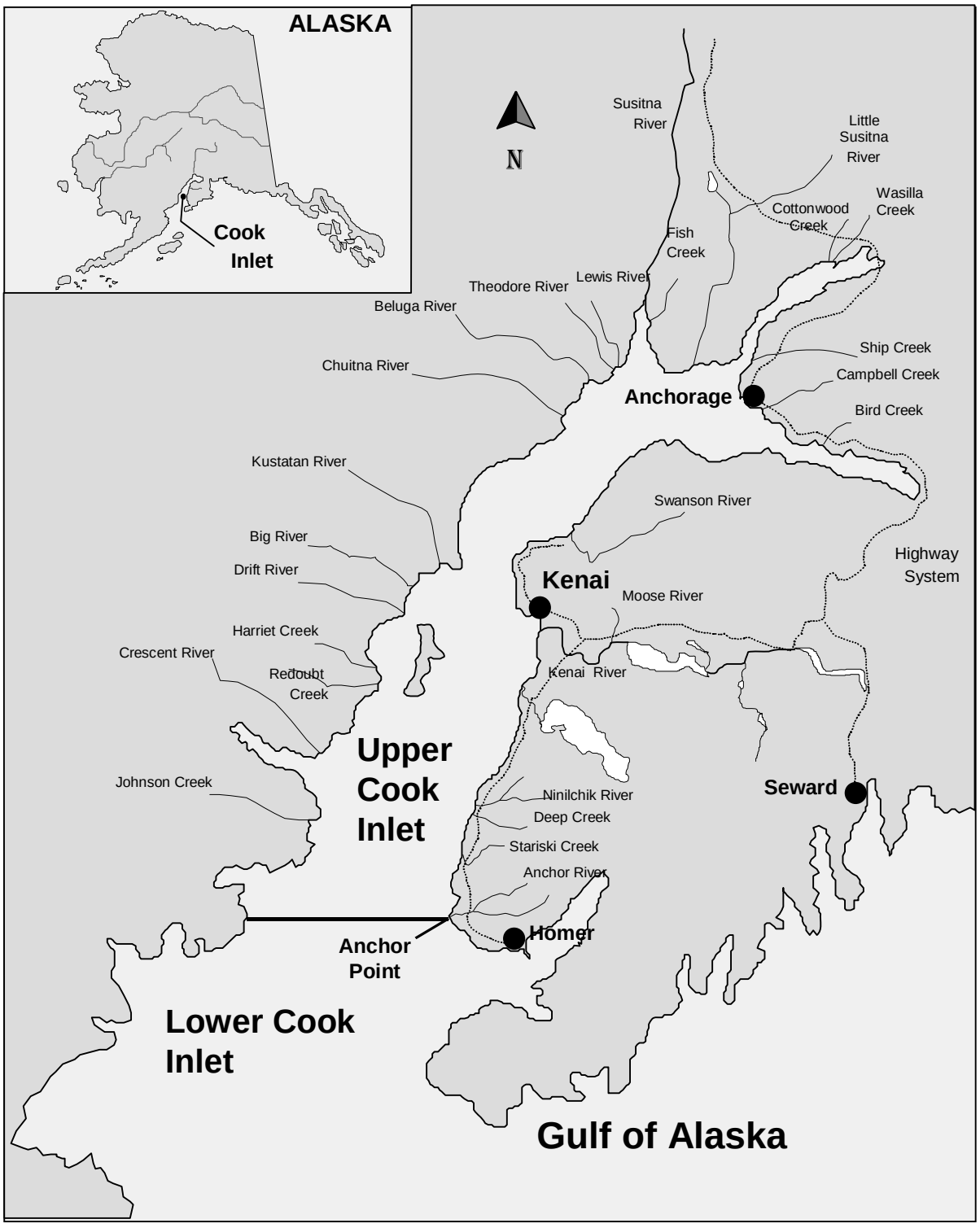

Figure 1.-The Cook Inlet Basin with selected tributaries known to support coho salmon.

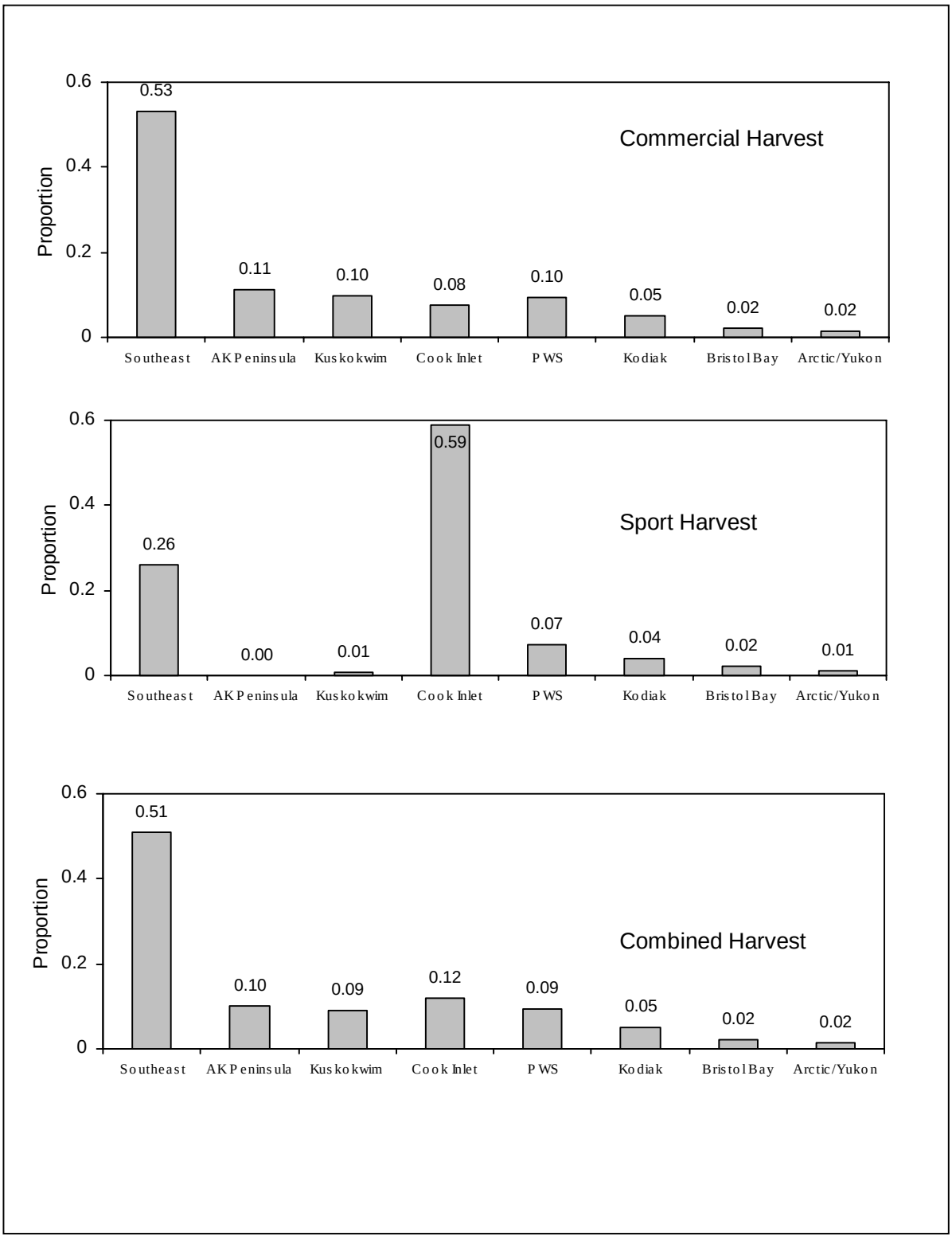

Figure 2.-Average proportions by region of the statewide commercial and sport harvests of coho salmon, 1985-2000.

The initial goals of the Kenai River population assessment program were to determine if exploitation by existing fisheries was threatening sustained yield and to develop a sustained-yield management objective (Meyer et al. *Unpublished*). To achieve these goals, a series of annual exploitation rates and annual adult production levels was needed. A decline in production that could be associated with increasing exploitation would signal the need for conservation actions. A long-term record would provide a quantitative way to develop a sustained-yield objective.

The initial research approach was to annually estimate: (A) the population specific harvest in marine commercial fisheries, (B) the inriver sport and personal use harvest, and (C) the spawning escapement. The sum of these three components (A + B + C) would provide the desired estimate of annual adult production. The sum of the two harvest components (A + B) divided by the estimated production would provide an estimate of exploitation rate.

Estimates of commercial harvest (A) have been made annually since 1993 through a coded wire tag release and recovery program (Carlon 2000;Carlon and Hasbrouck 1994, 1996-1998). Inriver sport and personal use harvests (B) are estimated annually by angler surveys (Hammarstrom 1977, 1978, 1988-1992; Howe et al. 1995-1996, 2001 a-d; King 1993; Mills 1979, 1980, 1981a; 1981b, 1982-1994; Walker et al. 2003). Prior to 1999, technical problems (Bendock and Vaught 1994) prevented the estimation of spawning escapements (C), and therefore, total adult production and exploitation remained unknown until then.

Because adult exploitation rates and total production have only recently been estimated, any relationship between the two quantities remains unknown; adults produced from the estimated 1999 spawning escapement will not return until 2003. This approach is therefore considered a long-term endeavor.

In the interim, two indicators of sustainability are being monitored. The first, annual exploitation rate, is considered a more immediate indicator of sustainability. The second, annual smolt abundance, initially considered ancillary information, is now viewed as an intermediate indicator of population size and sustainability.

Early results from the Kenai River assessment program revealed an overall decline in smolt abundance between 1992 and 1995 (Carlon and Hasbrouck 1996, 1997). Although the cause of the decline remains unknown, it heightened the level of concern for the sustainability of historical harvest levels. The response to this concern was the development and adoption of the first management plan for Kenai River coho salmon. The Kenai River Coho Salmon Management Plan (Alaska Fish and Game Laws and Regulations Annotated, 1997-1998; 5 AAC 21.357) was adopted by the Alaska Board of Fisheries in the spring of 1997 and was first in effect during the 1997 fishing season.

A subsequent review in 2000 suggested that adult abundance was in decline and that additional precautionary restrictions were necessary if the decline continued (Clark et al. *Unpublished*). Concurrently, other UCI coho salmon stocks were documented as declining and, in 2000, the Alaska Board of Fisheries responded by adopting the Kenai River Coho Salmon Conservation Management Plan (Alaska Fish and Game Laws and Regulations Annotated, 2000-2001; 5 AAC 21.357). This plan was a modification of the 1997 version and included additional precautionary restrictions to both commercial and sport fisheries.

Precautionary fishery restrictions implemented under the management plan are considered somewhat arbitrary because they were developed in the absence of a sustained-yield management objective. The degree of unnecessary loss of harvest opportunity is not quantifiable. Therefore, the assessment program will continue annually until a sustained-yield objective can be quantified; this will provide an objective basis for refining the management plan and configuring fisheries in the future.

Adult exploitation rate and production are estimated as objectives of a companion project (J. Carlon, Alaska Department of Fish and Game, Division of Sport Fish, Soldotna, personal communication) which uses a mark-recapture experiment, providing a source of samples for this project. This report documents the 2000 population-specific commercial harvest and the 1999 smolt abundance estimates. This report is the eighth in a series documenting commercial harvest since 1993 and smolt abundance since 1992 of coho salmon from the Kenai River (Carlon 2000, 2003; Carlon and Hasbrouck 1994, 1996-1998; Carlon and Massengill *In prep*).

STUDY AREA

Smolt were captured for marking in 1999 as they emigrated from the Moose River (Figure 3), a tributary to the Kenai River at Kenai River kilometer (rkm) 58.4. As part of a companion study to estimate the adult coho salmon population size, two fish wheels were operated near rkm 44.5 and a drift netting effort was conducted in the mainstem Kenai River between its confluences with the Moose and Funny rivers. The Funny River joins the Kenai River at rkm 48.9. The catches of adult coho salmon made during the companion study provided data essential to achieving objectives documented in this report. A weir was operated on the Russian River (Kenai River tributary at rkm 118) throughout the duration of the coho salmon return as another source for examining adults within the drainage. Samples of adults commercially harvested in the drift and eastside set gillnet fisheries of the Central District and the set gillnet fisheries of the Northern District were examined at processing plants and buying stations located along the UCI coast line in 2000. The statistical area from which examined fish were harvested 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 and in the set gillnet fisheries of the Northern District of UCI in 2000, and
2. to estimate the number of coho salmon smolt that emigrated from the Kenai River in 1999.

Prerequisite objectives to primary objective 1 (above) were:

3. to test the null hypothesis that the proportion of the Kenai River adult population bearing coded wire tags remained constant over the duration of the return from August 1 through September 30, 2000; and, if constant,
4. to estimate the proportion of the population bearing coded wire tags from August 1 through September 30, 2000.

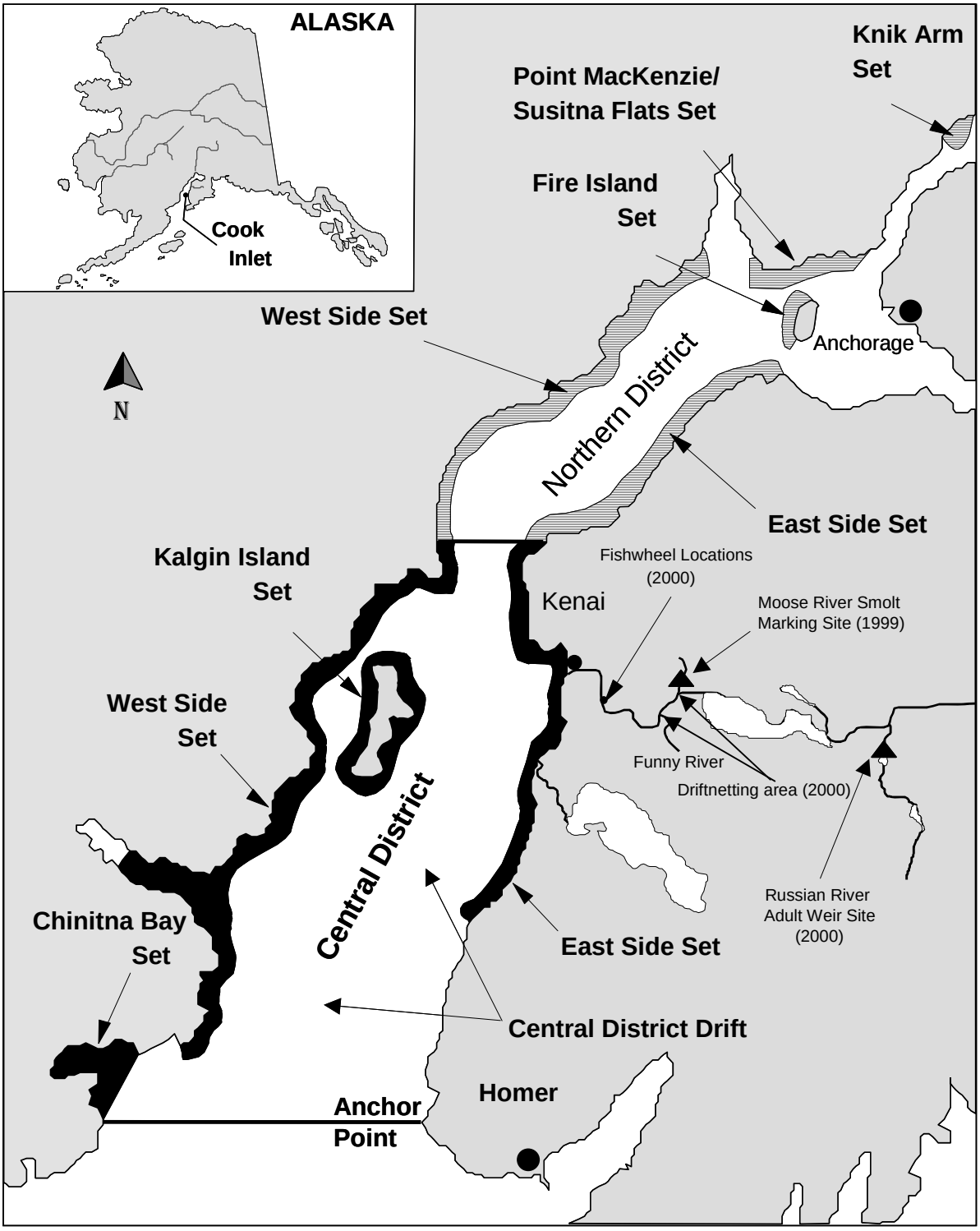

Figure 3.-Upper Cook Inlet showing ten commercial set gillnet and drift gillnet fishery areas, location at which marked coho salmon smolt were released in the Kenai River drainage in 1999, and Kenai River fish wheel and weir sampling locations at which adults were examined in 2000.

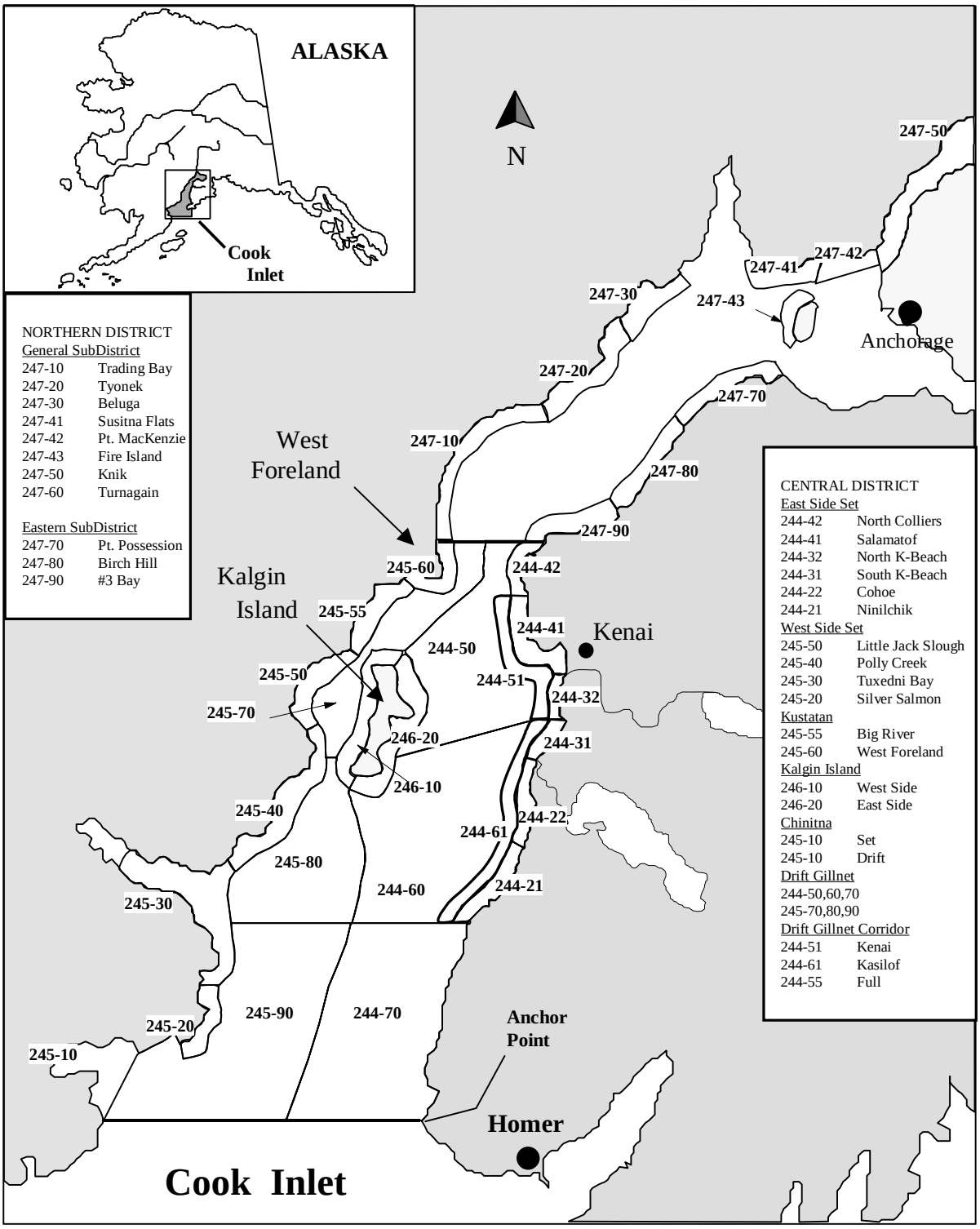

Figure 4.-Upper Cook Inlet statistical areas.

METHODS

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

EXPERIMENTAL DESIGN AND ASSUMPTIONS

Commercial Harvest Objective

Harvest from a population of salmon in a mixed-stock fishery can be estimated by marking juveniles in fresh water and recovering marked adults in the fishery. Total harvest in the fishery and the fraction of fish in the population of interest bearing marks must be known or estimated. The number of marks recovered from the fishery can then be expanded into a population-specific harvest estimate by accounting for unmarked fish in the population and for the portion of the total harvest not examined (Clark and Bernard 1987).

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 1999, marked with coded wire tags, and released. Total harvest of coho salmon in 2000 commercial fisheries was available from the ADF&G commercial fishery fish ticket database system. Sampling of the commercial harvest for marked fish was accomplished by personnel of the ADF&G Commercial Fisheries (CFD) Division. The tagged fraction of the adult return to the Kenai River was estimated by examining inriver samples in 2000.

For the purpose of estimating commercial harvest, the tagged fraction refers to the fraction of the return to the Kenai River physically bearing a coded wire tag that was implanted during the smolt stage. The number of tags of Kenai River origin recovered from a sample from the commercial fishery is then expanded by multiplying by the inverse of the tagged fraction (determined from inriver sampling) to estimate and account for untagged fish in the commercial sample. The result is an estimate of the number of Kenai River fish in the sample. Because the sample is most often smaller than the harvest, the estimate of fish of Kenai River origin in the sample was further expanded to account for the portion of the harvest that was not examined. Knowledge of the number of fish harvested is therefore required.

Every fish recovered in the inriver sampling component of the study is checked for an adipose finclip, but not necessarily for a coded wire tag. Because of the potential for smolt-to-adult tag loss, a sample of the inriver fish found to be missing an adipose fin were checked to estimate the tag loss rate. In 2000, the majority of coho salmon with an adipose finclip that were caught in fish wheels were checked for the presence of a tag using an electronic tag detector (Northwest Marine Technologies Tag Detection Wand). The fraction of the returning adults possessing a coded wire tag was then estimated by correcting the adipose finclipped fraction by the tag loss rate and also adjusting for false negative results (a secondary correction for faulty tag wand results).

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

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

Rejecting the hypothesis would indicate that marked fish were a biased sample of the population. Substantial bias would prohibit the estimation of commercial harvest because the marked fraction passing through commercial harvest areas would be unknown. However, if bias is minimal, commercial harvest estimates may still be practical and valid for current research and management applications.

To make a meaningful test of the consistency of the marked fraction of the return over time, it must be assumed that the inriver sample was representative of the return during each time stratum. This is likely a valid assumption because two, diverse sampling methods were used (fish wheels and drift gillnetting) in 2000 resulting in a wide distribution, both spatially and temporally, of sampling effort between rkm 58.4 and 44.5 of the Kenai River. Both the fish wheel and drift gillnetting locations are downstream of tributaries where significant coho salmon spawning has been documented and little mainstem spawning is suspected to occur below these locations. The two fish wheels were operated on both banks continuously during most daylight periods as were drift gillnetting efforts. These drift gillnetting efforts were distributed throughout a 9.5 kilometer river reach. A comparison of marked fractions among sample sources provides a method to evaluate whether they provide representative samples.

Smolt Abundance Objective

All marking and recovery efforts associated with the objective of estimating commercial harvest also provided the data with which to estimate smolt abundance. The experimental design is a two-event mark-recapture experiment, with marking of smolt with finclips constituting the first event and the sampling of adults from the inriver return for finclips constituting the second event. If all assumptions of the mark-recapture model are valid, an accurate estimate of the drainage-wide smolt abundance during the year in which adults were marked as smolt (the year prior to inriver sampling of adults) is possible.

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

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

DATA COLLECTION

Data collection occurred during 2 calendar years. Mark- release data were collected when smolt were captured and marked in 1999, and mark-recovery data were collected in 2000 from commercial harvests and from inriver sources (rkm 44.5 fish wheels, drift gillnetting in a 9.5 kilometer stretch of the Kenai River, and the Russian River weir.)

Smolt Marking in 1999

Juveniles were captured for marking in 1999 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.

A weir with a trap was installed in the mainstem of the Moose River at rkm 7.5 (Figure 5) to capture smolt for marking as they emigrated downstream from overwintering lakes in the drainage. The weir was constructed of aluminum framed panels faced with Vexar® forming a continuous "fence" between stream banks. The upstream end of the weir was attached to the riverbank with Vexar® netting and secured with sandbags. The downstream end was attached to a trap box made of aluminum angle and perforated plate. The weir was believed to be a total barrier to fish migration during the period May 23 through June 28, 1999. Virtually all smolt arriving at the weir between May 23 and June 8 were marked and released.

Smolt were the primary lifestage captured for tagging at the Moose River. Historical data and observations 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 1997 had been implanted in juveniles emigrating from the Moose River the prior year (Carlon 2000; Carlon and Hasbrouck 1994, 1996-1998). The recovery of adults tagged 2 years prior to recovery has never occurred. 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 supplemental indications that most of the juvenile coho salmon emigrating from the Moose River and tagged 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, 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 as quickly as possible. After the marking goal was achieved, tagging was discontinued, personnel (and costs) were reduced, but the weir remained in place until June 28 to census the smolt immigration because census data may eventually provide some predictive ability for estimating the adult return population and drainage-wide smolt abundance.

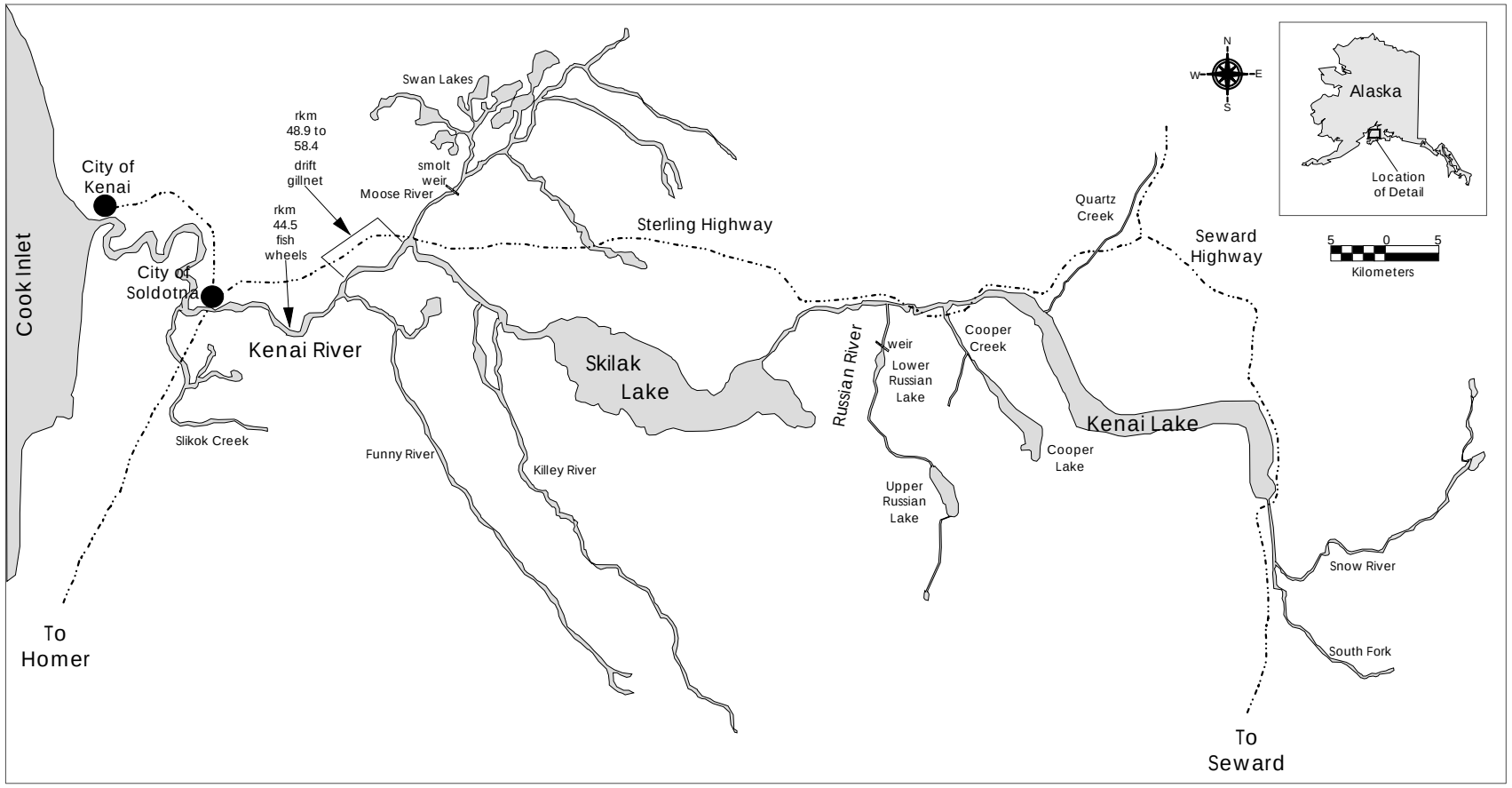

Figure 5.-Locations of coho salmon smolt marking in 1999 and adult coho salmon recovery in 2000.

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 two length groups, and transferred to instream holding pens. An inriver tag facility allowed fish to be netted directly into a holding tank for tagging. Fish were handled and marked following standard coded wire tagging procedures (Moberly et al. 1977). Fish were re-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. 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). 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. Rarely, smolt > 150 mm were captured. These were released untagged because of the excessive time required to sedate and tag them. Because this was a rare occurrence, it is likely that this had no impact on the marked proportion in the subsequent year's return of adults. Tag codes released in 1999 were verified on site (through visual inspection with a binocular microscope) and the number of smolt marked each day was recorded. 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 11,245 to 11,659 depending on the number of tags per tag spool. This resulted in 10 tag code groups being released during the emigration.

With the exception of a small sample detained each day, all marked fish were released to continue their downstream migration after recovering from anesthesia in an instream holding pen.

Short-term survival and tag retention rates were estimated for smolt 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 rates were also used to estimate the total number of marked smolt that survived the marking procedure. The number of marked fish that survived and were released is a partial requirement of the model used to estimate smolt abundance.

Recovery of Marked Adults in the 2000 Return

Three inriver sample sources were examined in 2000 to estimate the tagged proportion of the return: fish wheel catches at rkm 44.5 and drift gillnetting catches between rkm 58.4 and 48.9 from the companion adult mark-recapture experiment, and the return of fish to the Russian River weir. Data from these sources were examined to determine if the recovery of adipose-clipped fish could be used to estimate smolt abundance.

Fish wheels

As part of the independent and concurrent mark-recapture experiment to estimate the inriver abundance of adults, two fish wheels were operated in the mainstem of the Kenai River to capture adults for marking. This also provided a sample source for the examination of fish for the missing adipose fin mark for this study.

Coho salmon were captured and examined for a missing adipose fin from August 1 through October 6 (the last day on which coho salmon were caught). Almost all of the fish found to be missing an adipose fin were checked with an electronic tag detection wand for the presence of an

embedded coded wire tag. A sample of marked fish in which no tag was detected was sacrificed to determine the rate of false-negative wand results. This was required to adjust the estimate of the tagged fraction to account for false-negative wand results. The false-positive rate was assumed to be zero to limit sacrificing live fish as a large number of fish would be needed to accurately detect this rate of occurrence.

Drift Gillnetting

Also as part of the mark-recapture experiment to estimate the abundance of adults, drift gillnetting was conducted. This constituted the recapture event and provided a second source of adult coho salmon to examine for the missing adipose fin mark for this study. Drift gillnetting was supplemented by a limited amount of set gillnetting and by the use of sport fishing gear. However, the primary, and by far the most effective recapture method, was drift gillnetting. Minor catches from set gillnetting and hook-and-line were combined with the drift gillnet samples in evaluating the recapture event as a sample source for estimating the tagged proportion of the 2000 return.

Four, two-person crews were scheduled to deploy drift gillnets in the mainstem Kenai River during all daylight hours from August 1 through October 6, such that, at least two and at most four crews deployed nets each day. Crews operated from riverboats allowing them to rove between riverbanks and over the recapture reach (rkm 48.9 to rkm 58.4) so that effort was widely distributed over the entire reach and throughout the day.

Upon capture, all coho salmon were marked with a dorsal fin punch (to avoid duplicate examination), examined for external tags (as a requirement of the adult mark-recapture experiment), and examined for the presence or absence of the adipose fin. The number with and without an adipose fin were thereby recorded each day.

Russian River

Supplemental information was also collected for this study during a concurrent project at the Russian River, a tributary to the Kenai River at approximately rkm 118. Sockeye *O. nerka*, coho, and Chinook *O. tshawytscha* salmon spawn in the drainage annually. The Russian River supports an intense, directed sport fishery for sockeye salmon and this return is managed for an escapement goal. A weir is used to census that escapement and is usually operated until about mid-September, the approximate end of the sockeye salmon return. Since 1998, weir operation was extended through early October to enumerate later-returning coho salmon and to examine the Russian River segment of the population for adipose finclipped fish. Fish were not sacrificed for coded wire tag retrieval nor were they detained to check for the presence of a tag with a tag detection wand. Fish were simply counted and visually examined for adipose fin status as they passed through the weir. The Russian River weir is the only facility operated annually within the Kenai River drainage that permits a census of a coho salmon tributary escapement, but escapements were fully enumerated there only five times before 2000 (Carlon 2000, 2003; Carlon and Massengill *In prep*; Marsh 1995; Nelson 1983). A census at the Russian River weir was deemed valuable during the 1997 return because of the conservation concern that developed in that year (Carlon 2000). The census has been repeated annually since 1997 by extending the weir as an enhancement to the overall assessment program. Weir operation provides another inriver source of adults to examine for estimating the marked fraction and can also serve to show the rate of Moose River utilization for rearing by fish natal to more distant tributaries.

Commercial Harvest in 2000

Upper Cook Inlet commercial fisheries typically harvest coho salmon between late June and early September. The fisheries are managed primarily for sockeye salmon through various combinations of time and area restrictions. Fishery management guidelines for all species are described in the Upper Cook Inlet Salmon Management Plan; 2000 management actions are documented by Fox and Shields (2001).

Fisheries selected for sampling during 2000 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 coho salmon harvest (Ruesch and Fox 1995). Northern District fisheries typically harvest less than a few hundred coho salmon of Kenai River origin (Carlon 2000; Carlon and Hasbrouck 1994, 1996-1998), but were sampled to estimate the harvest of hatchery-produced coho salmon stocked in Northern District streams (Bosch et al. *In prep*). Harvests in other UCI commercial fisheries have been sampled incidental to this effort in prior years (Carlon 2000; Carlon and Hasbrouck 1994, 1996-1998), but none were sampled in 2000.

In 2000, the Central District drift gillnet and eastside set gillnet fishing seasons opened on June 26 and July 3, respectively (Fox and Shields 2001). With the exception of several fishing periods, the harvests in both fisheries were examined during each open period through the end of the fishing season. Northern District set gillnet harvests were likewise examined through the last period during which fishing effort occurred.

Harvested coho salmon were examined at shorebased processing locations 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 of each sampled set gillnet harvest was known. Drift gillnet harvests were typically a mixture of fish from multiple statistical areas. All tag recovery data were keypunched and archived by the Tag Lab. The raw data are accessible via the World Wide Web at URL http://tagotoweb.adfg.state.ak.us.

DATA ANALYSIS

Several steps were required before the objectives of estimating smolt production in 1999 and commercial harvest of coho salmon of Kenai River origin in 2000 could be achieved. For the estimate of smolt production, the essential steps were: (1) estimate the number of smolt marked in 1999 that survived the marking process, and (2) detect adipose finclipped fish in the adult inriver return from known sample sizes. For the estimate of the commercial harvest of the Kenai River population, the essential steps involved were: (1) test the hypothesis that the proportion of coded wire tagged adults observed inriver in 2000 did not change over time, (2) estimate the proportion of the adult return in 2000 bearing coded wire tags, and (3) recover coded wire tags from known sample sizes from the commercial fishery.

Smolt Marking in 1999

Short-term mortality and tag loss were estimated to determine the total number of viable, adipose-clipped and tagged smolt released in 1999. Short-term survival and tag retention for smolt marked during each shift were estimated from a representative 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 the detainment period.

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 to yield an estimate of the total number of tagged smolt that survived and retained a tag in shift k, m_k :

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

The total number of smolt that were marked, survived, and retained a tag at the Moose River in 1999 was estimated by summing $\hat{m}_k$ over all marking shifts. This number was required to determine when the goal of releasing 95,000 tagged live fish was achieved and as a real-time quality control measure. The total number of smolt marked with an adipose finclip was estimated by summing the individual estimates of the number of marked fish that survived the marking process. This number represented the number of marked fish released in the marking event of the mark-recapture experiment to estimate smolt abundance.

Recovery of Marked Adults in the 2000 Return

Estimating the commercial harvest of coho salmon of Kenai River origin in 2000 required estimating the tagged proportion (θ) of the return, i.e., the proportion physically bearing coded wire tags. The tagged proportion was unknown at the time of smolt marking in 1999, but was estimated when adults returned in 2000 by examining fish from five different sampling sources. These sources were the catch of coho salmon in two fish wheels near rkm 44.5 (one adjacent to each riverbank), the drift gillnetting catch along each riverbank between rkm 48.9 and 58.4, and the return of fish to the weir on the Russian River.

Estimation of the tagged proportion (θ) was a four-step process. The first step involved estimating the adipose finclip rate (y_{g_i}) in the returning population sampled at source g during weekly interval i. The rate was estimated as the proportion of the sample of fish examined that was characterized by a missing adipose fin. The second step involved estimating the smolt-to-adult tag retention rate (c_{g_i}) in the returning population of adipose-clipped fish sampled at source g during weekly interval i. This rate was estimated as the proportion of adipose-clipped fish examined for a coded wire tag that was found to possess one. The third step involved estimating the tagged proportion (θ_{gi}) of the population sampled at source g during weekly interval i that carried a tag implanted at the Moose River 1999. This proportion was estimated as:

$$\hat{\theta}_{gi} = \hat{y}_{gi} \hat{c}_{gi} . \quad (2)$$

The fourth step involved a battery of hypothesis tests to determine if the tagged proportion varied significantly over weekly intervals within a sample source or among sample sources. If no differences were detected or if differences were inconsequential, samples were combined over weekly intervals and among sample sources to provide a single estimate of the tagged proportion (θ) of the 2000 return.

Although the adipose finclip rate (y_{gi}) was estimated similarly for all sample sources, the smolt-to-adult tag retention rate (c_{gi}) was estimated differently depending on the sample source. For samples from the fish wheel or drift netting sources, corrections for false negative wand results were made and the c_{gi} was estimated as:

$$c_{gi} = v'_{gi} / h_{gi}, \tag{3}$$

where:

h_{gi} = the number of adipose-finclipped fish that were wand-tested in the sample from source g in week i,

$$v'_{gi} = v_{gi} + (h_{gi} - v_{gi})(\sum_{gi} f_{gi} / \sum_{gi} s_{gi}), \tag{4}$$

where:

v_{gi} = the number of positive wand results (tag detected) from sample h_{gi},

s_{gi} = the number of fish with negative wand results (no tag detected) in h_{gi} that were sacrificed to verify the negative result,

f_{gi} = the number of false negatives out of s_{gi} (number of adipose-finclipped fish that tested negatively with the wand, were sacrificed, and were found to carry a tag.

Note that in equation 4, an overall false-negative correction factor $(\sum_{gi} f_{gi} / \sum_{gi} s_{gi})$ is estimated by summing false-negative data (s_{gi} and f_{gi}) over all i weekly intervals and over all g sample sources. In doing this, it is assumed that the probability of a false negative reading remains constant through weeks and over samples. The pooling was required because only a small sample of fish with negative wand results was sacrificed in 2000. Combining all data was necessary to obtain a reasonably precise estimate of the false-negative rate.

For the Russian River weir sample, no wand was used and the single, overall tag retention rate estimated above was used to correct the adipose clip rate. Fish were not wanded to avoid physically detaining the spawning migration and it is assumed that the tag retention rate is similar among all stocks within the Kenai River. Correcting the adipose-clip count at the Russian River weir allowed direct comparison of weekly and overall tagged proportions (θ) to other sample sources.

For each sample source g, a chi-square statistic was then used to test the hypothesis that the proportion of fish carrying a Moose River tag did not change among weekly intervals

$(\alpha = 0.05)$. Failure to reject the hypothesis would indicate that the proportion of adults bearing a tag was constant over weeks, allowing calculation of an overall estimate of the tagged proportion (θ_g) for sample source g by combining data over weekly intervals. A chi-square statistic $(\alpha = 0.05)$ was then used to compare the resultant overall estimates among sampling sources to determine if sample data could be combined among sources to provide a more precise estimate of the overall tagged proportion in the 2000 return.

The data collected to estimate the tagged proportion in the 2000 return also provided an important component of the estimator of the number of smolt that emigrated from the Kenai River in 1999. The mark used to estimate smolt abundance was the adipose clip as opposed to the presence of a coded wire tag. The number of adipose-finclipped fish recovered in the inriver sampling program was recorded and used in the smolt abundance estimate.

Smolt Abundance in 1999

The model used to estimate smolt abundance was the Chapman modified Lincoln-Petersen model (Seber 1982):

$$\hat{N} = \frac{(M+1)(C+1)}{(R+1)} - 1, \tag{5}$$

where:

M = the number of smolt marked with an adipose finclip and surviving to emigrate in 1999,

C = the number of adult coho salmon examined for an adipose finclip in the 2000 return sample, and

R = the number of adult coho salmon in the 2000 sample that had an adipose finclip.

The variance of the smolt abundance estimate was estimated by:

$$\hat{V}(\hat{N}) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}. \tag{6}$$

This model produces unbiased estimates of abundance if all of the following apply:

1. adult coho salmon examined for marks were a random sample of the inriver return or the marked sample of smolt was a representative sample of the drainage-wide smolt emigration in 1999 or if complete mixing of marked and unmarked individuals occurred between the marking and recapture events,
2. all juveniles marked at the Moose River in 1999 were actually smolt,
3. survival and catchability were the same for marked and unmarked individuals,
4. adipose fins were not regenerated between the mark and recovery events,
5. there was no natural loss of adipose fins at any time during the life of the population, and
6. fish were correctly categorized for the presence or absence of an adipose fin when examined at each inriver sampling source.

Independence between the timing of tagging as smolt and adult return timing has been noted in all prior study years (Carlon 2000; Carlon and Hasbrouck 1994, 1996-1998). The independence is indicative of mixing of marked and unmarked fish after tagging. Additional analyses in prior years indicate that smolt that emigrate from the Moose River are representative of the entire Kenai River population with respect to return timing. Also, the sample of inriver fish wheel and drift gillnet-caught fish is assumed to mimic a random sample because of the wide spatial and temporal distribution of the fishing effort. There is a high likelihood that all three conditions of assumption 1 (above) are fulfilled.

The remaining five assumptions are also likely valid. Previous experience and observations indicate that most juveniles marked at the Moose River each year are smolt (assumption 2). Short-term survival of marked smolt has been nearly 100% during all smolt-marking events at the Moose River (assumption 3) (Carlon 2000; Carlon and Hasbrouck 1994, 1996-1998) although long-term survival and catchability assumptions remain untested for this wild population. For hatchery-produced coho salmon marked with adipose clips and coded wire tags and released in a western Kenai Peninsula drainage system the smolt-to-adult survival was no different than that of unmarked coho salmon (Vincent-Lang 1993). Thompson and Blankenship (1997) found no regeneration of adipose fins of coho salmon after their excision if the fin was completely removed at the outset (assumption 4). No quantitative study has been carried out to estimate the occurrence of naturally missing adipose fins in the Kenai River drainage (assumption 5). However, of more than 1,000,000 coho salmon juveniles handled for tagging since 1991, only a rare few have been found to be naturally missing the adipose fin. Naturally missing adipose fins appear to be a rare occurrence in coho salmon in the Kenai River drainage. Also, the short-term and long-term tag retention rates have been nearly identical (Carlon 2000; Carlon and Hasbrouck 1994, 1996-1998); this supports the supposition that naturally missing adipose fins are rare.

Commercial Harvest in 2000

All 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. Likewise, the Northern District set gillnet harvest was stratified by statistical area or a combination thereof representing a discrete fishery. 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 for each stratum. Because sampling among strata was considered independent, the variance of total harvest was calculated by summing strata variances. The Commercial Fish Ticketing System managed by the ADF&G CFD 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 examining the inriver capture event (fish wheel) catch, the inriver recapture event (drift netting) catch, and the return of adults to the Russian River weir. Based on these data sources, the harvest of coho salmon of Kenai River origin in each commercial fishery stratum i was estimated by (Bernard and Clark 1996):

$$\hat{r}_i = N_i \hat{\theta}^{-1} \left(\frac{m_i}{\lambda_i n_i} \right) = N_i \hat{\theta}^{-1} \hat{p}_i , \quad (7)$$

where:

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

θ = the proportion of the 2000 Kenai River return marked with coded wire tags,

m_i = the number of coded wire tags recovered from commercial fishery stratum i and subsequently decoded as the tag of interest, i.e., Moose River 1999 tagging event,

n_i = the number of fish harvested during stratum i and examined for a missing adipose fin, and

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

where:

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

a_i' = the number of heads collected in stratum i that arrived at the Tag Lab,

t_i = the number of heads collected in stratum i with coded wire tags detected, and

t_i' = the number of coded wire tags found that were readable as a code released in any coho salmon marking event (not necessarily just the Moose River 1999 event).

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

$$\hat{V}(\hat{r}_i) = \hat{r}_i^2 \left[G(\hat{p}_i) + G(\hat{\theta}^{-1}) - G(\hat{p}_i) G(\hat{\theta}^{-1}) \right], \quad (8)$$

where:

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

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

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

where $\hat{V}(\hat{\theta}^{-1})$ is estimated by bootstrapping.

Although the number of fish harvested is estimated as a product of pounds purchased by commercial processors 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 2000 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 receiving fish from harvests occurring within the estimation stratum (area and/or time). Bias associated with this pooling is assumed insignificant because of the similarity of the marked proportion among intensively sampled processors in prior years (Carlon 2000; Carlon and Hasbrouck 1997, 1998). Pooling data among processors in 2000 should improve precision of harvest estimates without introducing significant bias.

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

RESULTS

SMOLT MARKING IN 1999

Smolt were marked with coded wire tags and adipose finclips as they emigrated from the Moose River during May 22 through June 16, 1999 (Appendix A1). During this period, 115,074 smolt were coded wire tagged. Of these, an estimated 114,885 survived the tagging process based on the estimated short-term survival rate (~ 99.8%). Of the surviving marked smolt, more than 99% retained tags resulting in an estimated 113,824 smolt that were released alive with tags. Although marked fish were released as late as June 17 (from the overnight retention and survival sample), marking was discontinued after the marking goal was achieved on June 16, 1999. The weir remained in place through June 28 allowing for a smolt emigration census. The total number of smolt arriving at the weir between May 22 and June 28, 1999 was 163,484.

TAGGED PROPORTION OF THE 2000 RETURN

Adults marked as smolt (with adipose finclips and coded wire tags) at the Moose River in 1999 returned to the Kenai River drainage in 2000. Marked and unmarked adults from all adult sample sources were examined over weekly periods to estimate the proportion of the adult return bearing tags (Table 1). The estimated proportion ($\hat{\theta}$) was 0.191 $[\hat{V}(\hat{\theta}^{-1}) = 0.0340]$. This estimate was based on pooling data from the two fish wheel sample sources. All other sources of data were excluded to minimize bias associated with significant and substantial temporal and spatial differences in the marked proportion within and between the excluded sources and the fish wheel sources.

Fish Wheels

Fish wheels were used exclusively to capture coho salmon in the capture event of the companion capture-recapture experiment to estimate adult abundance in 2000. Each fish wheel was generally operated during the daylight hours of each day from August 1 through October 6, 2000. Daily hours of operation varied based on personnel scheduling and fish wheel maintenance requirements, but averaged about 14.5 hrs per day.

Table 1.-Recoveries of coho salmon from multiple sources within the Kenai River drainage from August 1 through October 13, 2000 with estimates of weekly and seasonal marked and tagged proportions by source and overall estimates based on combining representative sources.

Weekly Period	Number Examined	Marked Fish Observed	y_i [a]	Marked Fish Checked for a CWT[b]	Number of CWTs Detected	c_i [c]	$Theta_i$ [d]	Estimated CWTs Missing [e]
South Bank Fish Wheel								
08/01-08/07	33	3	0.091	3	3	1.000	0.091	0
08/08-08/14	16	2	0.125	2	2	1.000	0.125	0
08/15-08/21	32	7	0.219	7	6	0.870	0.190	1
08/22-08/28	23	3	0.130	3	3	1.000	0.130	0
08/29-09/04	133	30	0.226	30	28	0.939	0.212	2
09/05-09/11	176	36	0.205	36	36	1.000	0.205	0
09/12-09/18	162	24	0.148	22	21	0.959	0.142	1
09/19-09/25	211	43	0.204	43	43	1.000	0.204	0
09/26-10/02	46	10	0.217	10	10	1.000	0.217	0
10/03-10/06	3		0.000			0.977	0.000	0
Total	835	158	0.189	156	152	0.977	0.185	4
North Bank Fish Wheel								
08/01-08/07	169	16	0.095	16	14	0.886	0.084	2
08/08-08/14	148	15	0.101	15	14	0.939	0.095	1
08/15-08/21	253	50	0.198	50	49	0.982	0.194	1
08/22-08/28	204	40	0.196	40	36	0.909	0.178	4
08/29-09/04	402	86	0.214	86	78	0.915	0.196	7
09/05-09/11	192	31	0.161	31	29	0.941	0.152	2
09/12-09/18	321	91	0.283	90	90	1.000	0.283	0
09/19-09/25	657	135	0.205	135	130	0.966	0.199	5
09/26-10/02	189	47	0.249	47	46	0.981	0.244	1
10/03-10/06	17	3	0.176	3	3	1.000	0.176	0
Total	2,552	514	0.201	513	489	0.957	0.193	22
South Bank Gillnets								
08/01-08/07	45	7	0.156			0.974	0.151	0
08/08-08/14	362	38	0.105			0.974	0.102	1
08/15-08/21	166	24	0.145	9	9	1.000	0.145	0
08/22-08/28	73	17	0.233	11	10	0.917	0.214	1
08/29-09/04	16	3	0.188	3	2	0.697	0.131	1
09/05-09/11	108	30	0.278	14	13	0.935	0.260	2
09/12-09/18	283	65	0.230	30	29	0.970	0.223	2
09/19-09/25	297	73	0.246	39	39	1.000	0.246	0
09/26-10/02	171	30	0.175	22	22	1.000	0.175	0
10/03-10/09	39	9	0.231	9	9	1.000	0.231	0
10/10-10/13	15	2	0.133	2	2	1.000	0.133	0
Total	1,575	298	0.189	139	135	0.974	0.184	7

-continued-

Table 1.-Page 2 of 3.

Weekly Period	Number Examined	Marked Fish Observed	y_i [a]	Marked Fish Checked for a CWT[b]	Number of CWTs Detected	c_i [c]	$Theta_i$ [d]	Estimated CWTs Missing [e]
North Bank Gillnets								
08/01-08/07	58	5	0.086			0.982	0.085	0
08/08-08/14	302	55	0.182			0.982	0.179	1
08/15-08/21	308	73	0.237	40	39	0.977	0.232	2
08/22-08/28	329	88	0.267	54	52	0.966	0.258	3
08/29-09/04	193	53	0.275	46	45	0.980	0.269	1
09/05-09/11	94	26	0.277	12	12	1.000	0.277	0
09/12-09/18	35	11	0.314	10	10	1.000	0.314	0
09/19-09/25	165	38	0.230	27	27	1.000	0.230	0
09/26-10/02	68	16	0.235	14	14	1.000	0.235	0
10/03-10/09	23	4	0.174	3	3	1.000	0.174	0
10/10-10/13	10	1	0.100	1	1	1.000	0.100	0
Total	1,585	370	0.233	207	203	0.982	0.229	7
Russian River Weir								
07/25-07/31	2	0	0.000			0.962	0.000	0
08/01-08/07	14	0	0.000			0.962	0.000	0
08/08-08/14	248	8	0.032			0.962	0.031	0
08/15-08/21	435	15	0.034			0.962	0.033	1
08/22-08/28	601	26	0.043			0.962	0.042	1
08/29-09/04	842	44	0.052			0.962	0.050	2
09/05-09/11	718	42	0.058			0.962	0.056	2
09/12-09/18	1124	53	0.047			0.962	0.045	2
09/19-09/25	752	45	0.060			0.962	0.058	2
09/26-10/02	55	4	0.073			0.962	0.070	0
10/03-10/06	1	0	0.000			0.962	0.000	0
Total	4,792	237	0.049			0.962	0.048	9
Combined North and South Banks Fish Wheels								
08/01-08/07	202	19	0.094	19	17	0.904	0.085	2
08/08-08/14	164	17	0.104	17	16	0.947	0.098	1
08/15-08/21	285	57	0.200	57	55	0.968	0.194	2
08/22-08/28	227	43	0.189	43	39	0.915	0.173	4
08/29-09/04	535	116	0.217	116	106	0.922	0.200	9
09/05-09/11	368	67	0.182	67	65	0.973	0.177	2
09/12-09/18	483	115	0.238	112	111	0.991	0.236	1
09/19-09/25	868	178	0.205	178	173	0.974	0.200	5
09/26-10/02	235	57	0.243	57	56	0.984	0.239	1
10/02-10/06	20	3	0.150	3	3	1.000	0.150	0
Total	3,387	672	0.198	669	641	0.962	0.191	26

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Table 1.-Page 3 of 3.

[a] Proportion of fish examined that were found to be missing the adipose fin.

[b] Number of marked fish checked for the presence of an embedded coded wire tag using an electronic tag detection wand. Marked fish observed at the Russian River weir were not checked; the proportion bearing a coded wire tag was assumed to be the same as that verified in the sample of fish wheel-caught fish.

[c] Estimated proportion of adipose clipped fish bearing a coded wire tag implanted at the Moose River in 1999 based on tag detection results.

[d] Estimated proportion of the number examined bearing a coded wire tag originally implanted at the Moose River in 1999.

[e] Estimated number of coded wire tags that are missing from the marked fish observed ((Marked Fish Observed)-[(Thetai) x (Number Examined)]). This field is required to develop contingency tables for comparing marked proportions over weekly period and among sample sources. Weekly estimates are rounded to the nearest whole fish; weekly estimates may not sum to total due to rounding.

From August 1 through October 6, a total of 3,387 coho salmon were captured and examined (Table 1 and Appendix A2) in the fish wheel sample. Of these, 672 (19.8%) were missing an adipose fin. The tag detection wand was used to check 669 of the adipose-clipped fish and a tag was detected in 641 (95.8%) of those checked. Of the 28 fish in which a tag was not detected by the wand, seven were sacrificed to verify the negative results and a tag was found in one. Four fish with negative wand results in the gillnets were also sacrificed and all were missing a tag. Because so few were sacrificed in the gillnets, these additional four fish were pooled with the fish wheel-caught fish to better estimate the overall false-negative rate. Therefore, the overall false-negative rate applied to wanding results at the fish wheel was based on 11 sacrificed fish, only one of which carried a tag, for an overall false-negative rate of 0.091.

Of the 3,387 coho salmon captured in fish wheels, 835 were captured in the south bank fish wheel. Based on wand results corrected for the overall false-negative rate, the weekly tagged proportion ($Theta_i$) in the south bank fish wheel catch ranged from 0.091 to 0.217 but did not vary significantly over all weeks when fish were examined ($\chi^2 = 7.30$, df = 9, P = 0.61). The overall tagged proportion estimated by pooling the full season of south bank fish wheel data was 0.185.

An additional 2,552 coho salmon were captured in the north bank fish wheel. The weekly tagged proportion ranged from 0.084 to 0.283 and did vary significantly over all weeks during which fish were checked for a tag ($\chi^2 = 45.12$, df = 9, $P < 0.001$). However, after excluding data from the 2 weeks that accounted for the extremes, only a marginal difference was detected among the remaining 8 weeks ($\chi^2 = 14.87$, df = 7, P =0.04). The tagged proportion estimated by pooling the full season of north bank fish wheel data (including the extreme weeks) was 0.193. This tagged proportion was not significantly different from that estimated for the south bank fish wheel ($\chi^2 = 0.28$, df = 1, P = 0.59) for which there was no significant variation over weeks. The two weekly extremes in the tagged proportion detected at the north bank fish wheel were therefore considered inconsequential for the purpose of estimating an overall tagged proportion based on fish wheel catches. The data to estimate the tagged proportion were therefore pooled across fish wheels to generate a single, season-wide estimate of the tagged proportion detected in the fish wheels (0.191).

Drift Gillnet Samples

Drift gillnets were fished each day between August 1 and October 13, 2000, inclusive. Of the 3,160 coho salmon captured in gillnets, 1,575 were captured along the south bank (Appendix A3, Table 1). Based on wand results corrected for the overall false-negative rate, the weekly tagged proportion ($Theta_i$) in the south bank catch ranged from 0.102 to 0.260 and varied significantly over all weeks during which fish were examined ($\chi^2 = 34.29$, df = 10, P = 0.0002). The seasonal tagged proportion estimated by pooling all south bank gillnet data was 0.184. This pooled proportion did not differ significantly from that estimated from the fish wheel samples ($\chi^2 = 0.25$, df = 1, P = 0.62).

An additional 1,585 coho salmon were captured along the north bank in gillnets. The weekly tagged proportion ranged from 0.085 to 0.314 and varied significantly over all weeks during which fish were examined ($\chi^2 = 18.41$, df = 10, P = 0.05) although the significance was marginal. The seasonal tagged proportion estimated by pooling all north bank gillnet samples was 0.229. This proportion differed significantly from that estimated from south bank gillnet samples ($\chi^2 = 9.43$, df = 1, P = 0.002) and from pooled fish wheel samples ($\chi^2 = 9.79$, df = 1, P = 0.002). Because of the substantial and significant difference from the tagged proportion estimated from south bank samples, gillnet data were not pooled to estimate an overall tagged proportion for gillnets. Additionally, all gillnets samples were excluded from calculating an overall estimate of the tagged proportion of the 2000 adult return because of significant temporal (weekly), spatial (riverbank), and inter-gear differences.

Russian River Sampling

The Russian River weir was operational from June 9 through October 5, 2000, but the first coho salmon did not arrive at the weir until July 31 (Table 1, Appendix A4). Between July 31 and October 5, a total of 4,819 coho salmon were passed through the weir and 4,792 were examined for adipose fin status. Of these, 237 (4.9%) were missing an adipose fin. The estimated weekly proportion of fish bearing a coded wire tag ranged from zero to 0.07, but did not vary significantly among weekly periods ($\chi^2 = 8.48$, df = 10, P = 0.58). The tagged proportion estimated by pooling all Russian River weir data was 0.048. This proportion was significantly and substantially lower than that estimated from the pooled fish wheel samples ($\chi^2 = 426$, df = 1, P < 0.001) and from that estimated from the south bank recapture ($\chi^2 = 298$, df = 1, P < 0.001) and north bank recapture ($\chi^2 = 466$, df = 1, P < 0.001) samples. The Russian River weir data were therefore also excluded from the formulation of an overall estimate of the tagged proportion of the 2000 adult return.

SMOLT ESTIMATE IN 1999

Sources of data used to estimate smolt abundance were the same as those used to estimate the tagged proportion, i.e., the combined north and south bank fish wheels. Data collected at the Russian River weir and in the recapture event of the adult capture-recapture experiment were likewise excluded because of a significantly and substantially lower marked fraction detected at the weir and significant temporal (weekly), spatial (riverbank), and inter-event differences associated with the recapture event.

Based on the number of live smolt released with an adipose clip at the Moose River in 1999 (114,885), the number of adult coho salmon examined for adipose fin status in the Kenai River fish wheel samples in 2000 (3,387), and the number of adults in the sample that were missing an adipose fin (672), an estimated 578,355 (SE = 19,884) smolt emigrated from the Kenai River in 1999.

COMMERCIAL HARVEST IN 2000

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) and all Northern District fisheries. Additional details of 2000 Northern District sampling efforts and recoveries of hatchery-produced coho salmon are documented in a companion report (Bosch et al. *In prep*).

Inlet-Wide Fisheries

During the 2000 fishing season, 236,128 coho salmon were harvested in commercial fisheries of UCI (Table 2). This harvest was 67% of the average from 1990-1999 (Fox and Shields 2001; Ruesch and Fox 1999). About 70% of the 2000 UCI commercial harvest was taken in Central District fisheries (Figure 6). Among all UCI fisheries, the greatest harvest occurred in the drift gillnet fishery of the Central District (55%); other fisheries ranged from 3% to 14% (Figure 6).

Of the inlet-wide harvest, 100,587 fish (43%) were examined for adipose clips. Adipose-clipped fish were found in all sampled fisheries. Exact fishery stratum of harvest (temporal/statistical area) could not be identified for 9,930 examined fish (Appendix A5); these fish were sampled from processor deliveries consisting of harvests from multiple statistical areas or were assigned to fisheries on days when zero harvest was reported. They were not used to calculate harvest estimates due to the ambiguity of their origin. Of these samples from mixed areas, a total of 128 were found with an adipose finclip (1%), heads were recovered from 127 fish, and a decodable tag was found in 104 of the recovered heads. Of the 104 decodable tags recovered, 9 had been implanted in smolt at the Moose River in 1999.

The remaining 90,657 examined fish were positively assigned to fishery strata (Appendix A6) and were used to calculate harvest estimates. Of these, 2,729 (3%) were missing the adipose fin and heads were collected from 2,723 of them. Of the 2,723 heads recovered, 266 (9.6%) had no tag and one was lost during the decoding process at the Tab Lab, resulting in a total of 2,456 decodable tags. All 2,456 tagged fish had originated from UCI release locations in 1999, either as hatchery-produced coho salmon smolt released into Northern District streams or as wild coho salmon smolt captured and tagged as they emigrated from Cottonwood Creek (Northern District) or from the Kenai River drainage.

Of the 2,456 decodable tags recovered from adults commercially harvested in known fishery strata, a total of 172 (7%) were originally released in smolt emigrating from the Kenai River drainage. All 172 were originally implanted in smolt emigrating from the Moose River in 1999. Most (91%) were recovered from Central District fisheries while 15 were recovered from known Northern District fisheries.

Among individual commercial processors receiving coho salmon harvested in the Central District eastside set gillnet fisheries, the proportion of the number examined for each processor that carried coded wire tags implanted in smolt at the Moose River in 1999 did not exceed 0.15 (Figure 7). Among plants processing coho salmon harvested in the Central District drift gillnet fishery, the proportion did not exceed 0.34. The proportions did not differ radically among processors and sampling summaries (and harvest estimates) that follow are based on samples pooled among processors.

Table 2.-Sampling performance and recovery of coded wire tags (CWT) from coho salmon harvested in Upper Cook Inlet commercial fisheries in 2000.

Gillnet Fishery	Harvest	Number Examined	Percent of Harvest Examined	Marked Fish Found[a]	Percent Marked	Heads Recovered	Missing, Lost, or Unreadable	Percent Missing Tag	Heads with Decodable CWT[b]	Number from Cohort Marked at Moose R. in 1999
CENTRAL DISTRICT										
Drift	131,200	32,459	25%	669	2%	667	65	10%	602	20
East Side Set (by Statistical Area)										
244-21	2,211	488	22%	22	5%	22	0	0%	22	22
244-22	3,313	1,284	39%	82	6%	82	2	2%	80	73
244-31/32	2,928	801	27%	54	7%	54	3	6%	51	42
244-41/42	2,388	923	39%	17	2%	17	4	24%	13	0
East Side Set Total	10,840	3,496	32%	175	5%	175	9	5%	166	137
Kalgin Is. Set	11,160		0%							
West Side Set	11,680		0%							
Mixed Drift/CD East Side Set[c]		78		1	1%	1	0	0%	1	0
Mixed CD East Side Set[c]		189		7	4%	7	1	14%	6	5
Mixed CD West Side/Kalgin Is. Set[c]		8,197		83	1%	82	17	21%	65	4
Central District Total	164,880	44,419	27%	935	2%	932	92	10%	840	166
NORTHERN DISTRICT										
West Side Set	33,652	25,484	76%	156	1%	155	44	28%	111	10
East Side Set	18,409	10,597	58%	91	1%	90	10	11%	80	4
Fire Is. Set	7,238	7,681	106%	783	10%	783	66	8%	717	1
Pt. MacKenzie/Su Flats Set	11,949	10,940	92%	855	8%	853	73	9%	780	0
Northern District Total	71,248	54,702	77%	1,885	3%	1,881	193	10%	1,688	15

-continued-

Table 2.-Page 2 of 2.

Gillnet Fishery	Harvest	Number Examined	Percent of Harvest Examined	Marked Fish Found[a]	Percent Marked	Heads Recovered	Missing, Lost, or Unreadable	Percent Missing Tag	Heads with Decodable CWT[b]	Number from Cohort Marked at Moose R. in 1999
MIXED DISTRICTS										
Mixed Drift/ND East Side Set[c]		575		16	3%	16	3	19%	13	0
Mixed CD West Side/ND West Side Set[c]		567		11	2%	11	1	9%	10	0
Mixed District Total		1,142		27	2%	27	4	15%	23	0
AMBIGUOUS SAMPLES[d]										
Northern District, Fire Island Set		324		10	3%	10	1	10%	9	0
Grand Total	236,128	100,587	43%	2,857	3%	2,850	290	10%	2,560	181

[a] Marked fish are those missing an adipose fin.

[b] Includes marked wild fish released in the Kenai River and hatchery-produced, marked fish released at other Cook Inlet locations.

[c] Examined fish were from an unknown mixture harvested from among multiple Upper Cook Inlet commercial fisheries.

[d] Coho salmon examined, but zero harvest reported for this fishery on tabulated dates. Erroneous identification of the fishery is assumed to have occurred when fish were examined.

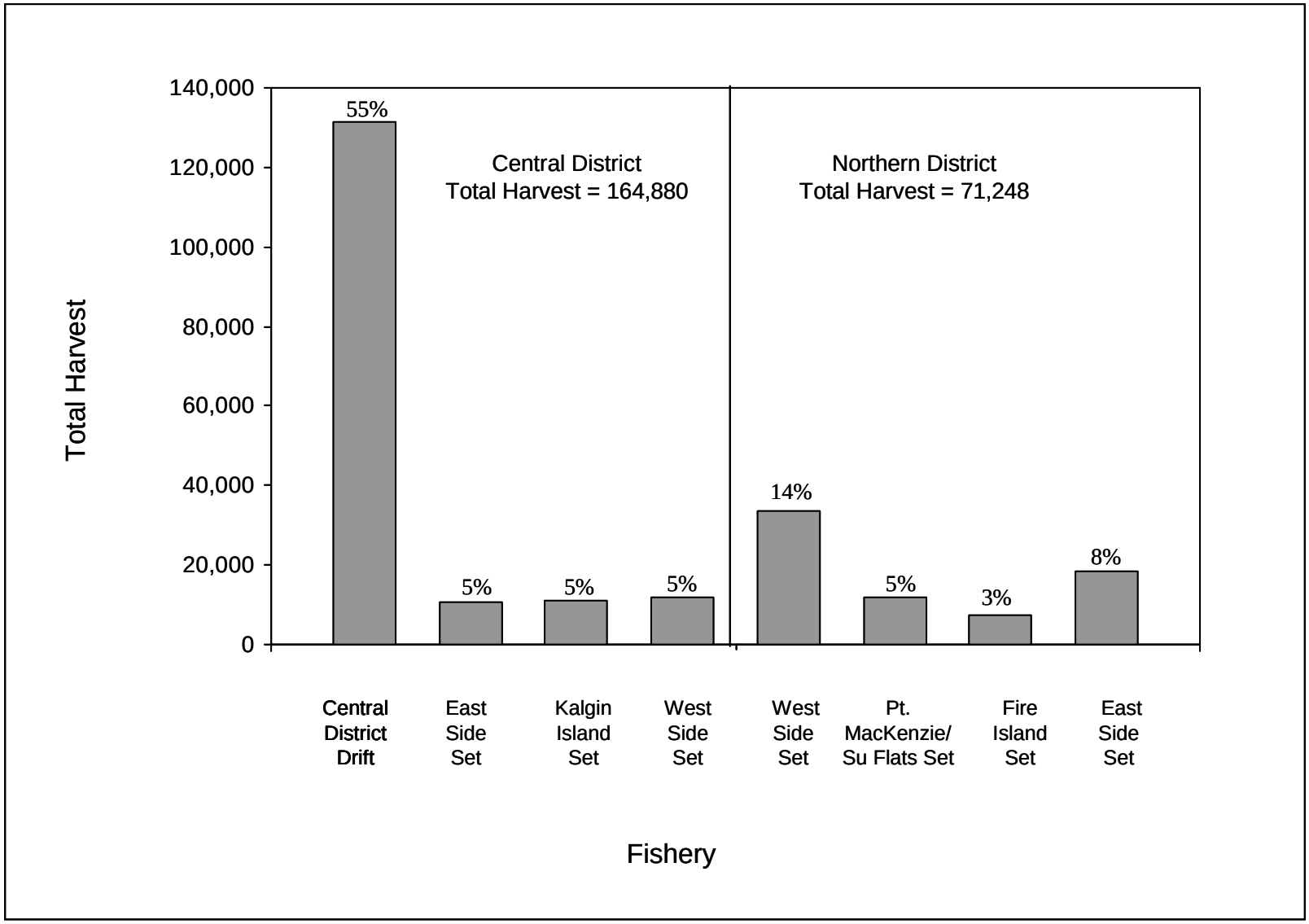

Figure 6.-Coho salmon harvest in eight Upper Cook Inlet commercial fishery areas in 2000.

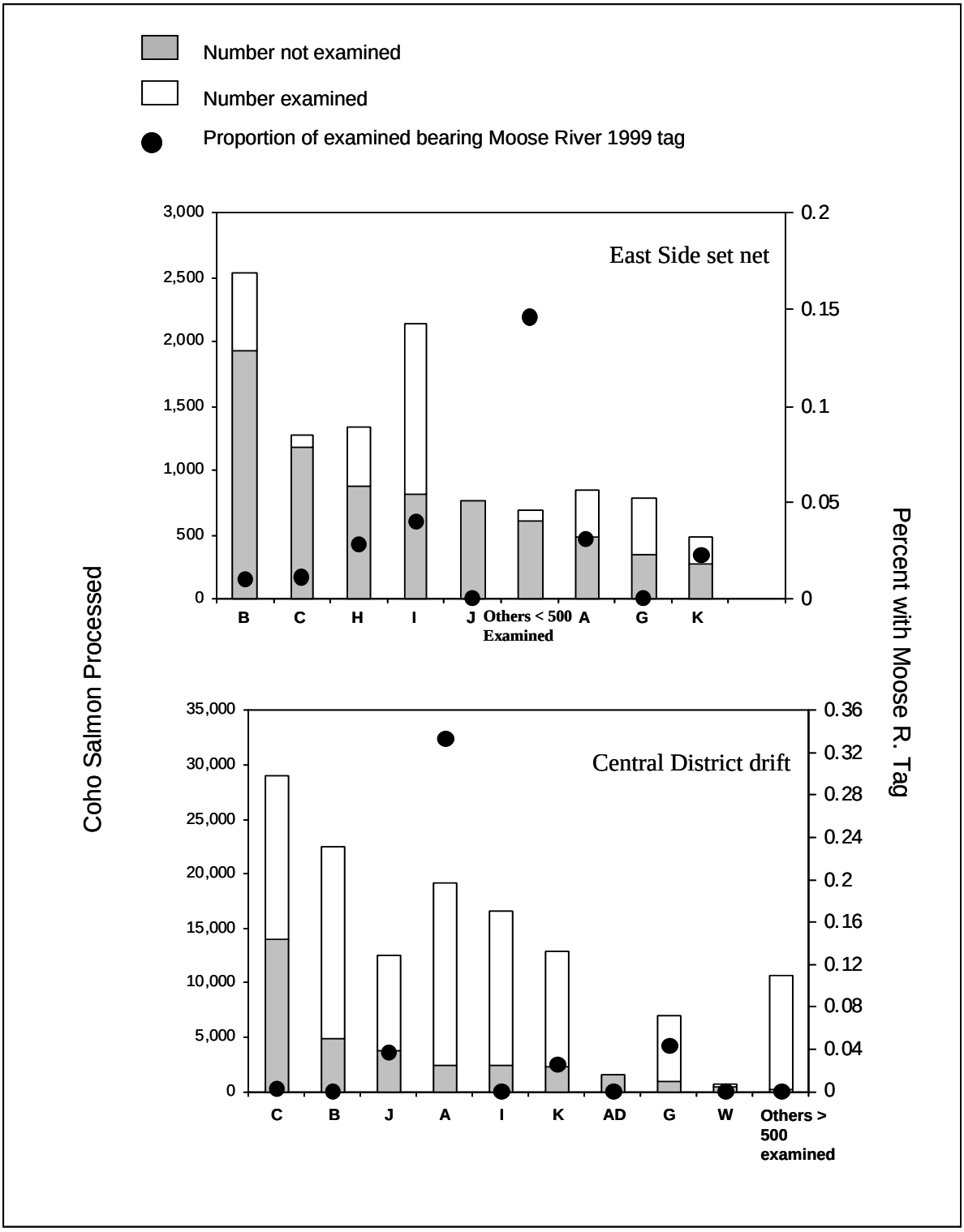

Figure 7.-Number of coho salmon harvested and processed in 2000 in the East Side set net fishery (top) and Central District drift fishery (bottom) of Upper Cook Inlet by commercial processor (alias name), number examined, and proportion of examined fish that were originally marked at the Moose River in 1999.

Central District Drift Gillnet Fishery

During the 2000 fishing season, 131,200 coho salmon were harvested in the Central District drift gillnet fishery. Excluding the anomalous fishery in 1997 (Ruesch and Fox 1998), the 2000 harvest was 70% of the average of 1990-1999.

The Central District drift gillnet fishery harvest was sampled during most fishing periods between the first open period on June 26 and the last on August 7. Overall, 25% of the harvest was examined. The harvest occurring on days not sampled accounted for 8% of the total harvest.

A total of 32,459 fish was examined and positively assigned to drift fishery temporal strata; all were therefore used to calculate harvest estimates. Of fish examined, 669 (2%) were missing the adipose fin and heads were collected from all but two. Of the 667 heads recovered, 64 (10%) had no tag and 1 was lost during the decoding process at the Tab Lab, resulting in a total of 602 decodable tags. Of these decodable tags, 468 originated from the 1999 annual release of hatchery-produced smolt among multiple Northern District streams, 101 originated from a 1999 wild smolt tagging study in Cottonwood Creek (Northern District), 13 originated from the 1998 annual release of hatchery-produced smolt in Northern District stream, and the remaining 20 were originally implanted in wild smolt emigrating from the Moose River (Kenai River drainage) in 1999. Therefore, of the 32,459 fish examined in this fishery, tags implanted at the Moose River in 1999 were physically recovered from 0.06%.

The first recoveries of fish bearing Moose River coded wire tags occurred on July 10, some 15 days after the first fishing period. Coho salmon marked at the Moose River were recovered on all but 4 sampled days between June 26 and the close of the fishing season after August 7.

Central District Eastside Set Gillnet Fishery

During the 2000 fishing season, a total of 10,840 coho salmon were harvested in the Central District East Side set gillnet fishery. Excluding the anomalous fishery in 1997 (Ruesch and Fox 1998), the 2000 harvest was 27% of the average of 1990-1999.

Between the first open period on June 26 and the last on August 7, the Central District eastside set gillnet fishery harvest was sampled during two-thirds of the fishing periods. Overall, 32% of the harvest (3,496 fish) was examined and positively assigned to spatial-temporal strata. The harvest occurring on days not sampled accounted for 7% of the total harvest. Adipose-finclipped fish were found on all but one sampled day (July 12).

Of the 3,496 fish examined and assigned to fishery strata, 175 (5%) were missing the adipose fin and heads were collected from all. Of the 175 heads recovered, 9 (5%) had no tag, resulting in a total of 166 decodable tags. Of these decodable tags, 18 originated from the 1999 annual release of hatchery-produced smolt among multiple Northern District streams, 10 originated from the 1999 wild smolt tagging study in Cottonwood Creek, 1 originated from the 1998 annual release of hatchery-produced smolt in Northern District streams, and the remaining 137 were originally implanted in wild smolt emigrating from the Moose River in 1999. Therefore, of the 3,496 fish examined in this fishery, tags implanted at the Moose River in 1999 were physically recovered from 4%.

Among statistical areas, small portions of the harvest were not examined early in the season. The portion of the harvest occurring on days not sampled ranged from 0% to 11.8% among statistical areas. Coho salmon marked at the Moose River in 1999 were recovered from all but one statistical area (24441/42) in 2000. The first recovery of Moose River tags occurred on July 24 in statistical

area 24421, on July 10 in statistical area 24422, and on July 18 in statistical area 24431/32. The portions of fish examined in 2000 that had been marked as smolt at the Moose River in 1999 were 4.5%, 5.7%, and 5.2% for statistical areas 24421, 24422, and 24431/32, respectively.

Northern District Gillnet Fisheries

During the 2000 fishing season, a total of 71,248 coho salmon were harvested among all Northern District set net fisheries. Excluding the anomalous fishery in 1997 (Ruesch and Fox 1998), the 2000 harvest was 76% of the average from 1990-1999.

Sampling of the harvest in the Northern District occurred during most fishery openings after July 10. Although specific Northern District fisheries were not sampled on several days near the end of the fishing season, collectively, the harvest among all Northern District fisheries was sampled the most intensively of all UCI fisheries with 55,026 fish examined (77% of the harvest). Of the 55,026 fish examined, almost all (54,702) could be positively assigned to a fishery stratum and were used to calculate harvest estimates. The harvest occurring on days not sampled accounted for 1.2% of the total harvest. Adipose-clipped fish were found on all sampled days with the exception of 5 days irregularly spaced throughout the duration of the Northern District eastside set gillnet fishery.

Of the 54,702 fish examined and assigned to fishery strata, 1,885 (3%) were missing the adipose fin and heads were collected from all but 4. Of the 1,881 heads recovered, 193 (10%) had no tag, resulting in a total of 1,688 decodable tags. Of these decodable tags, 1,177 originated from the 1999 annual release of hatchery-produced smolt among multiple Northern District streams, 473 originated from the 1999 wild smolt tagging study in Cottonwood Creek, 23 originated from the 1998 annual release of hatchery-produced smolt in Northern District streams, and the remaining 15 were originally implanted in wild smolt emigrating from the Moose River tributary to the Kenai River in 1999. Therefore, of the 54,702 fish examined among Northern District fisheries, tags implanted at the Moose River in 1999 were physically recovered from 0.03%.

Commercial Harvest Estimates

Based on commercial catch sampling data and the point estimate of the tagged proportion of the 2000 adult return to the Kenai River, a set of commercial harvest estimates was generated for UCI commercial fisheries in 2000. An estimated 531 (SE = 122) coho salmon of Kenai River origin were harvested by the Central District drift gillnet fishery (Table 3), 2,351 (SE = 223) by the Central District eastside set gillnet fishery (Table 4), and 83 (SE = 21) by all Northern District set gillnet fisheries (Appendix A6) for a total of 2,965 (SE = 255) harvested during 2000. Coho salmon of Kenai River origin comprised 0.4% of the total drift gillnet harvest, 22% of the total eastside set gillnet harvest, and 0.1% of the total Northern District set gillnet harvest in 2000.

The first coho salmon of Kenai River origin were detected in the Central District drift gillnet harvest on July 13. The harvest of 3,940 coho salmon before July 13 represents 3% of the total harvest of coho salmon in this fishery. All of the harvest of coho salmon of Kenai River origin occurred during a 26-day period between July 13 and the last fishing period on August 7. Although there was no trend in the portion of the harvest comprised of Kenai River fish, the greatest proportional contribution (>5%) and the greatest absolute harvest occurred during the first week of August (the last week of the fishery) (Figure 8).

Table 3.-Estimated harvest, and associated variance, of coho salmon of Kenai River origin in the commercial drift gillnet fishery of the Central District of Upper Cook Inlet during selected time intervals, 2000.

Interval	Total Harvest	Estimated Harvest of Coho Salmon of Kenai River Origin	Standard Error	Portion of Total Harvest
6/22 - 7/10	3,923	0	-	0.0%
7/11 - 7/18	81,689	92	41	0.1%
7/19 - 7/25	32,353	123	54	0.4%
7/26 - 7/31	7,706	26	25	0.3%
8/01 - 9/11	5,529	290	98	5.2%
Total	131,200	531	122	0.4%

The first coho salmon of Kenai River origin were detected in the Central District eastside set gillnet harvest on July 10. The harvest of 63 coho salmon before July 10 represents 0.6% of the total harvest in this fishery. The portion of the harvest comprised of coho salmon of Kenai River origin was greater at the end of the season than at the beginning (Figure 9) and the greatest total harvest occurred during the first week of August.

Among statistical areas of the Central District eastside set gillnet fishery, the portion of the harvest comprised of coho salmon of Kenai River origin was similar among the three southernmost areas while the population did not contribute to the northernmost (Figure 10). The end result was a similar absolute harvest within the three southernmost statistical areas for Kenai River-bound coho salmon.

Meaningful temporal or geographic trends occurring in Northern District commercial fisheries were not detectable because of the inconsequential harvest of 83 coho salmon of Kenai River origin. Only 10, 4, 1, and zero fish bearing a coded wire tag from the Kenai River drainage were detected in the Northern District west side, east side, Fire Island, and Point MacKenzie/Susitna Flats set gillnet fisheries, respectively. The first recovery of a coded wire tag from an adult tagged as a smolt in 1999 at the Moose River occurred on July 27, 2000.

Effect of Variations of the Marked Proportion on Commercial Harvest Estimates

Although the tagged proportion measured in the fish wheel catch did vary significantly over all weekly periods, harvest estimates as presented in this report (based on the pooled fish wheel estimate of tagged proportion) are considered practical for current management and research needs. After pooling the fish wheel samples across locations (riverbank), the tagged proportion was still found to vary significantly over week ($\chi^2 = 33.5$, df = 9, $P < 0.001$), but it did not vary over the last 8 weeks ($\chi^2 = 6.9$, df = 7, $P = 0.44$); the tagged proportion during this pooled later period (August 15 through October 6) was estimated as 0.211 while the minimum weekly tagged proportion observed in the earlier pooled samples (August 1-August 14) was 0.094.

Table 4.-Total harvest and estimated harvest (with relative precision) of coho salmon of Kenai River origin in the eastside set gillnet fishery of Upper Cook Inlet by statistical area and selected time intervals, 2000.

Interval	Total Harvest	Estimated Harvest	Standard Error	Portion of Total Harvest
		Statistical Area 244-21		
7/03-7/10	60	0	0	0%
7/11-7/18	489	10	9	2%
7/19-7/25	348	56	24	16%
7/26-7/31	475	207	103	44%
8/1-8/07	839	385	110	46%
Total	2,211	658	246	11%
		Statistical Area 244-22		
7/03-7/10	14	8	7	57%
7/11-7/18	962	49	28	5%
7/19-7/25	507	36	15	7%
7/26-7/31	630	281	57	45%
8/1-8/07	1,200	818	128	68%
Total	3,313	1,192	144	36%
		Statistical Area 244-31/32		
7/03-7/10	62	0	0	0%
7/11-7/18	1,519	25	24	2%
7/19-7/25	493	9	8	2%
7/26-7/31	209	88	30	42%
8/1-8/07	645	379	65	59%
Total	2,928	501	76	17%
		Statistical Area 244-41/42		
7/03-7/10	61	0	0	0%
7/11-7/18	1,663	0	0	0%
7/19-7/25	664	0	0	0%
7/26-7/31	0			
8/1-8/07	0			
Total	2,388	0	0	0%
		Combined Statistical Areas		
7/03-7/10	197	8	7	4%
7/11-7/18	4,633	84	38	2%
7/19-7/25	2,012	101	29	5%
7/26-7/31	1,314	576	121	44%
8/1-8/07	2,684	1,582	181	59%
Total	10,840	2,351	223	22%

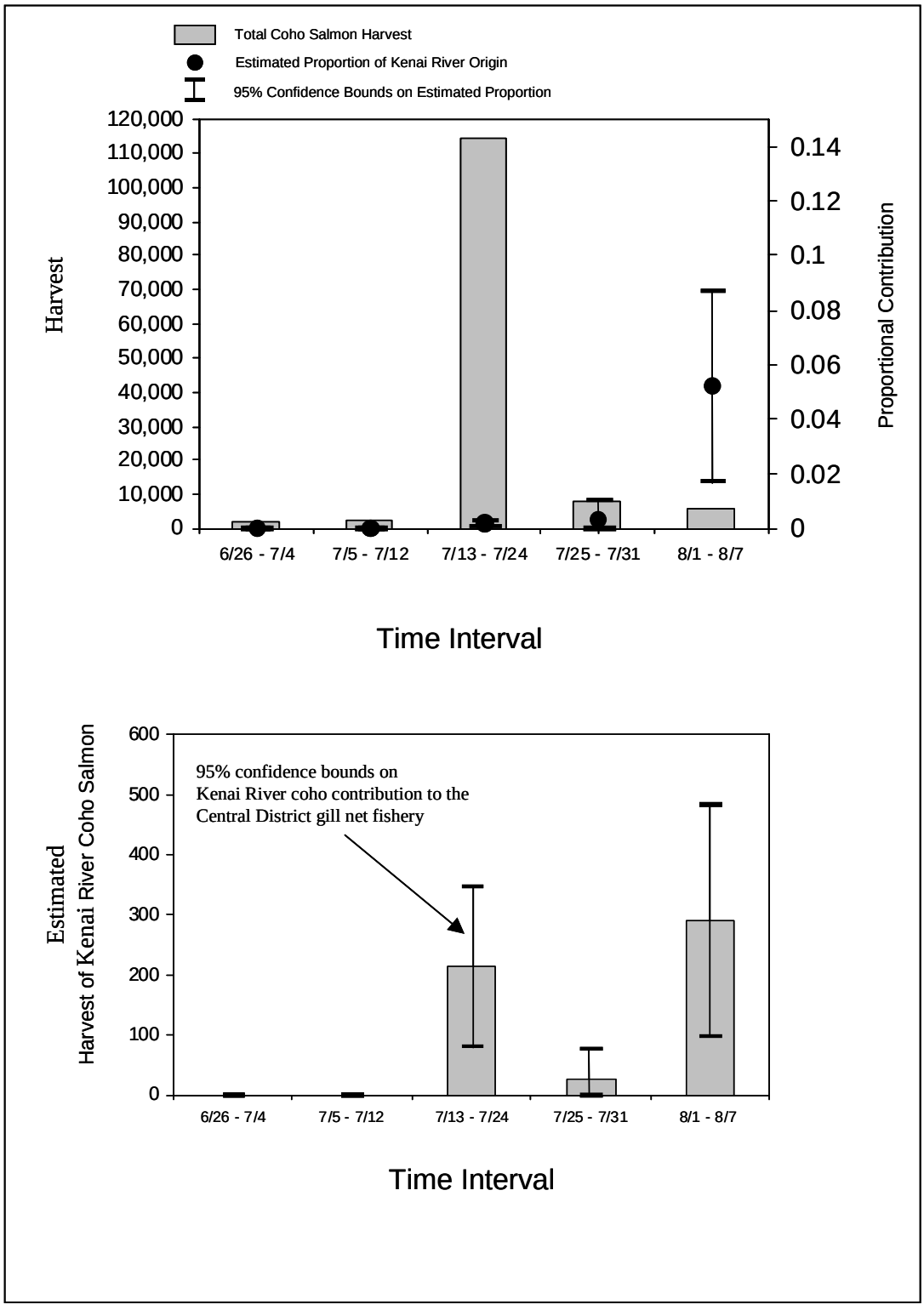

Figure 8.-Temporal trend in proportional contribution of Kenai River coho salmon to the total harvest (top) and trend in absolute contribution (bottom) occurring in the drift gillnet fishery of the Central District of Upper Cook Inlet, 2000.

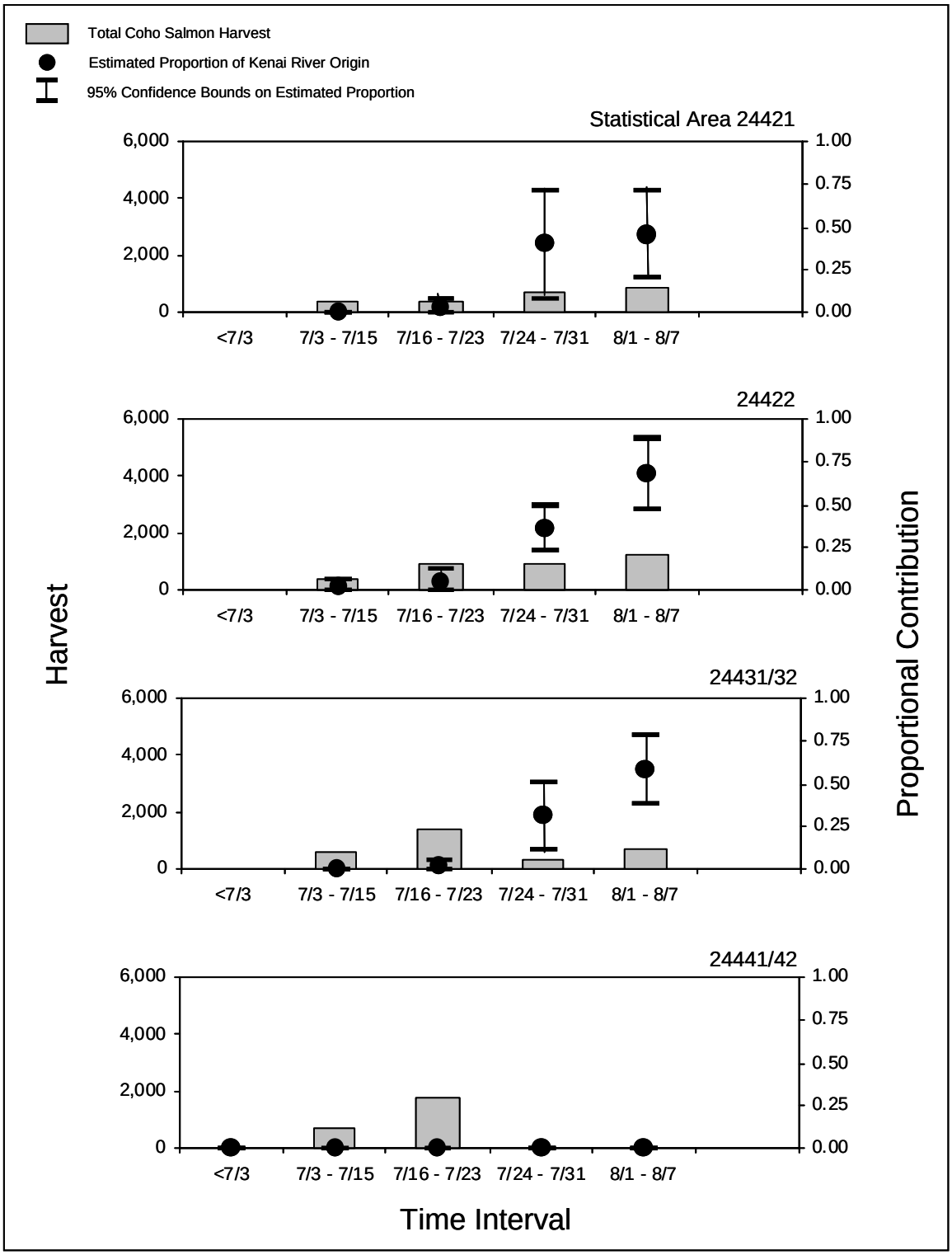

Figure 9.-Temporal trends in total harvest of coho salmon and proportional contribution of coho salmon from the Kenai River to the total harvest occurring in four statistical areas of the Upper Cook Inlet Central District eastside set gillnet fishery during five selected time periods in 2001.

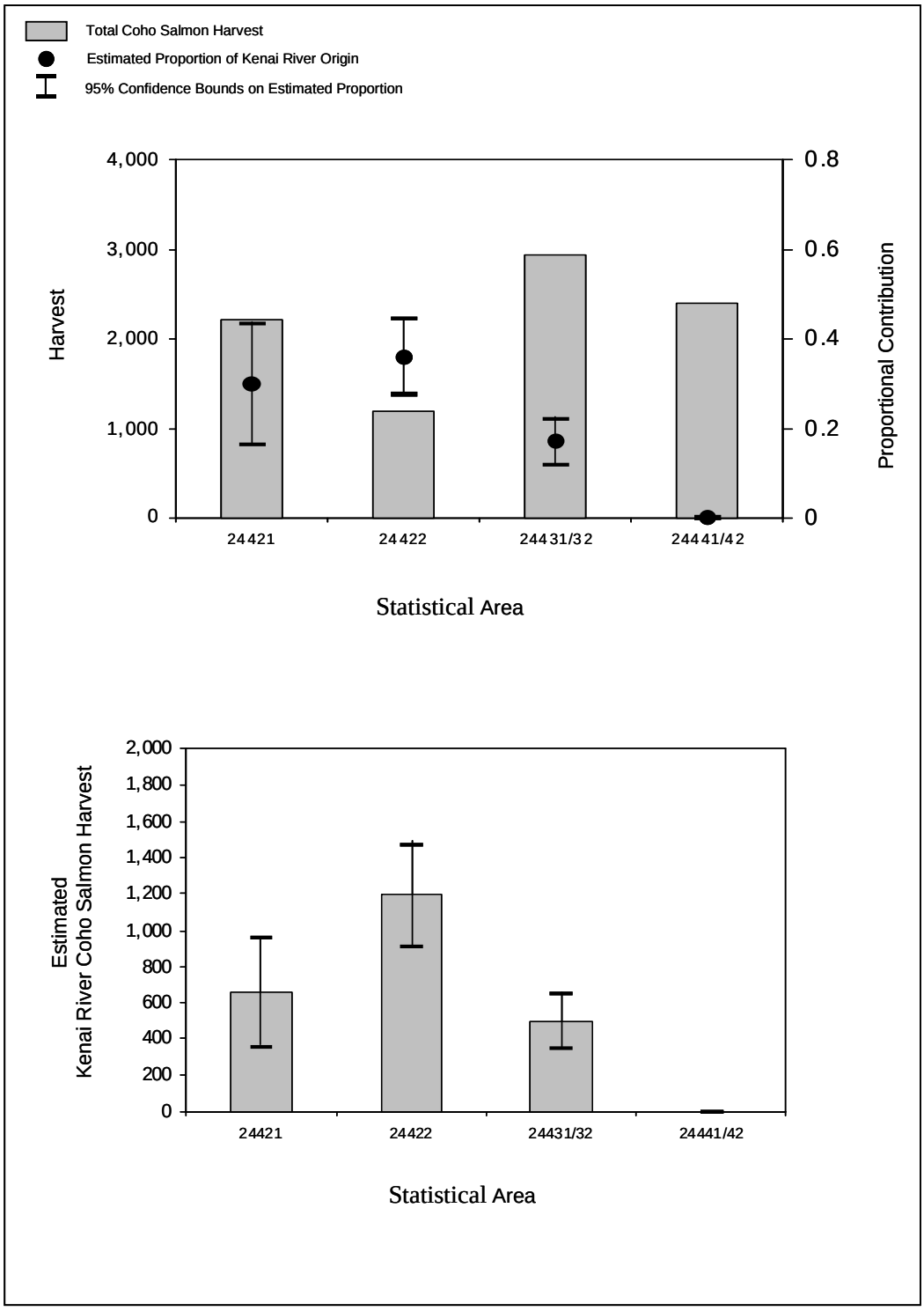

Figure 10.-Geographic trends in total coho salmon harvest and proportional contribution of coho salmon of Kenai River origin (top) and in estimated number of coho salmon of Kenai River origin (bottom) harvested among statistical areas in the eastside set gillnet fishery of the Central District of Upper Cook Inlet, 2000.

A test was conducted to determine the sensitivity of commercial harvest estimates to the observed temporal variation in the estimated marked proportion. Three sets of commercial harvest estimates were calculated for the sampled Central District fisheries and examined for practical differences (Table 5). Estimates were calculated using the pooled tagged proportion (0.191), the minimum from the first week (0.094), and the maximum observed (0.241). The resulting minimum and maximum harvest estimates are therefore considered lower and upper bounds for bias and represent extreme-case scenarios. The minimum and maximum harvest estimates differed from the pooled estimate by 21% and 103%, respectively. The maximum difference from the pooled estimates represented 0.4% of the total drift gillnet harvest and 22.4% of the total eastside set gillnet harvest.

DISCUSSION

COMMERCIAL HARVEST

At present, there has been no evaluation of migration rates of Kenai River-bound coho salmon in the marine waters of UCI. A thorough evaluation would be useful to determine if migration rate could be used as an objective criterion for selecting a subset of the inriver samples on which to base an accurate estimate of the tagged proportion passing through commercial fishery areas. Using migration rates to "lag" or synchronize inriver samples with samples collected from marine commercial harvests may provide a means to select a more representative sample of fish for this purpose. Under the current approach, accurate harvest estimates rely on detecting a constant tagged proportion within the inriver samples over a 2-month sampling period. If significant variation is detected, the only objective alternative developed to date has been to qualify the estimates with a sensitivity analysis. An evaluation of marine migratory rates should be considered because significant, temporal variation was detected in the tagged proportion in 2000 (current study), 1998, and 1999 (Carlon 2003, Carlon and Massengill *In prep*).

The sensitivity analysis and extreme-case scenarios for bias were necessary to determine if point estimates of commercial harvest were of value under the circumstance of a variable marked proportion in 2000. Bias in the point estimates of commercial harvest is almost certain because commercial harvest estimates were based on a point estimate of the tagged proportion in which temporal variability was detected within the Kenai River samples. However, it is unreasonable to abandon the commercial harvest contribution estimates without evaluating the potential magnitude of the bias; minimally biased estimates are of value for assessment and planning purposes. The most extreme-case scenarios indicate that the point estimates of harvest are of value, because these extremes were not substantially different enough from point estimates relative to total harvests. The qualified estimates are therefore presented as such for discussion and are considered useful.

The point estimate of commercial harvest of Kenai River-bound coho salmon in the two Central District fisheries was the lowest since 1993 and was 76% less than the 1993-1999 average (Table 6). Reasons contributing to this decline likely include new restrictions imposed on commercial fisheries in 2000. Significant restrictions included a closure of these fishing seasons after the first regularly scheduled period following August 7 and the elimination of all but one non-regular fishing period between August 1 and August 7, 2000. These restrictions (among others affecting all user groups) were adopted by the Alaska Board of Fisheries in February of 2000 as part of the Kenai River Coho Salmon Conservation

Table 5.-Sensitivity of commercial harvest estimates to maximum temporal variations in the marked proportion of coho salmon measured in pooled samples from the fish wheels used to capture coho salmon from the Kenai River, 2000.

Cental District Fishery	Total Harvest	Pooled Marked Proportion (0.191) Estimated Harvest [a]	Marked Proportion: Minimum (0.094) Estimated Harvest [a]	Difference from Pooled	% Difference from Pooled	Difference from Pooled as % of Total Harvest	Marked Proportion: Maximum (0.241) Estimated Harvest [a]	Difference from Pooled	% Difference from Pooled	Difference from Pooled as % of Total Harvest
Drift	131,200	531	1,086	555	105%	0.4%	421	-110	20%	-0.1%
244-21	2,211	658	1,336	678	103%	31%	521	-137	20%	-6%
244-22	3,313	1,192	2,422	1,230	103%	37%	944	-248	20%	-7%
244-30	2,928	501	1,017	516	103%	18%	397	-104	20%	-4%
244-40	2,388	0	0	0	0%	0%	0	0	0%	0%
East Side Total	10,840	2,351	4,775	2,424	103%	22%	1,862	-489	1	0
Drift + East Side	142,040	2,882	5,861	2,979	103%	2%	2,283	-599	21%	-0.4%

[a] Kenai River population-specific harvest estimate.

Table 6.-Estimated total harvest of coho salmon of Kenai River origin in UCI marine commercial fisheries, 1993-2000.

	Central District			Northern District	
Year	Eastside Set Gillnet	Drift Gillnet	Total	Set Gillnet	Total
1993	6,806	930	7,736	148	7,884
1994	14,673	11,732	26,405	477	26,882
1995	13,152	6,956	20,108	582	20,690
1996	11,856	2,671	14,527	29	14,556
1997	2,093	1,236	3,329	36	3,365
1998	8,096	1,974	10,070	175	10,245
1999	2,905	818	3,723	171	3,894
Average	8,512	3,760	12,271	231	12,502
2000	2,351	531	2,882	83	2,965

Sources: Carlon 2000, 2003; Carlon and Hasbrouck 1996; 1997; 1998; Carlon and Massengill *In prep*.

Management Plan. The 2000 plan imposed additional restrictions to those imposed in 1997 when the Kenai River Coho Salmon Management Plan was first adopted (Carlon 2000).

Typically, a substantial portion of the harvest of Kenai River-bound coho salmon occurs during the last week of July and the first week of August in the Central District drift gillnet fishery and the first week of August in the Central District eastside set gillnet fishery (Carlon 2000; Carlon and Hasbrouck 1996-1998). The additional restrictions imposed by the management plan during the 2000 commercial fishing season likely had their intended conservation effect of reducing the Kenai River population-specific harvest in commercial fisheries. The Kenai River population comprised a minority of the total harvest in Central District commercial fisheries for the eighth year in a row (Carlon and Hasbrouck 1996, 1997 and Figure 11). The inconsequential harvest of the Kenai River population in Northern District fisheries was typical of prior years (Carlon 2000, 2003; Carlon and Hasbrouck 1996, 1997).

SMOLT ABUNDANCE

History

The record of estimated smolt abundance has become an important element of the population assessment program. The complete record (since 1992) has been cited by the Department as a basis for recommending conservation actions. Recommendations were based on a relative decline in smolt abundance and were presented to the Alaska Board of Fisheries (BOF) in the spring of 1997. At that time, the first Kenai River-specific management plan was developed, adopted into regulation, and was first implemented during the 1997 fishing season. It was later revised in 2000.

Although the smolt abundance record was the impetus for developing the plan, it was not originally intended to be applied in this manner. The original intent was to monitor smolt abundance relative to parent year harvest to determine the degree of linkage between fishing mortality and smolt production. Therefore, the management plan (which is still in effect) is considered precautionary in nature because it is not known if the decline is harvest-induced, natural, or a combination of both.

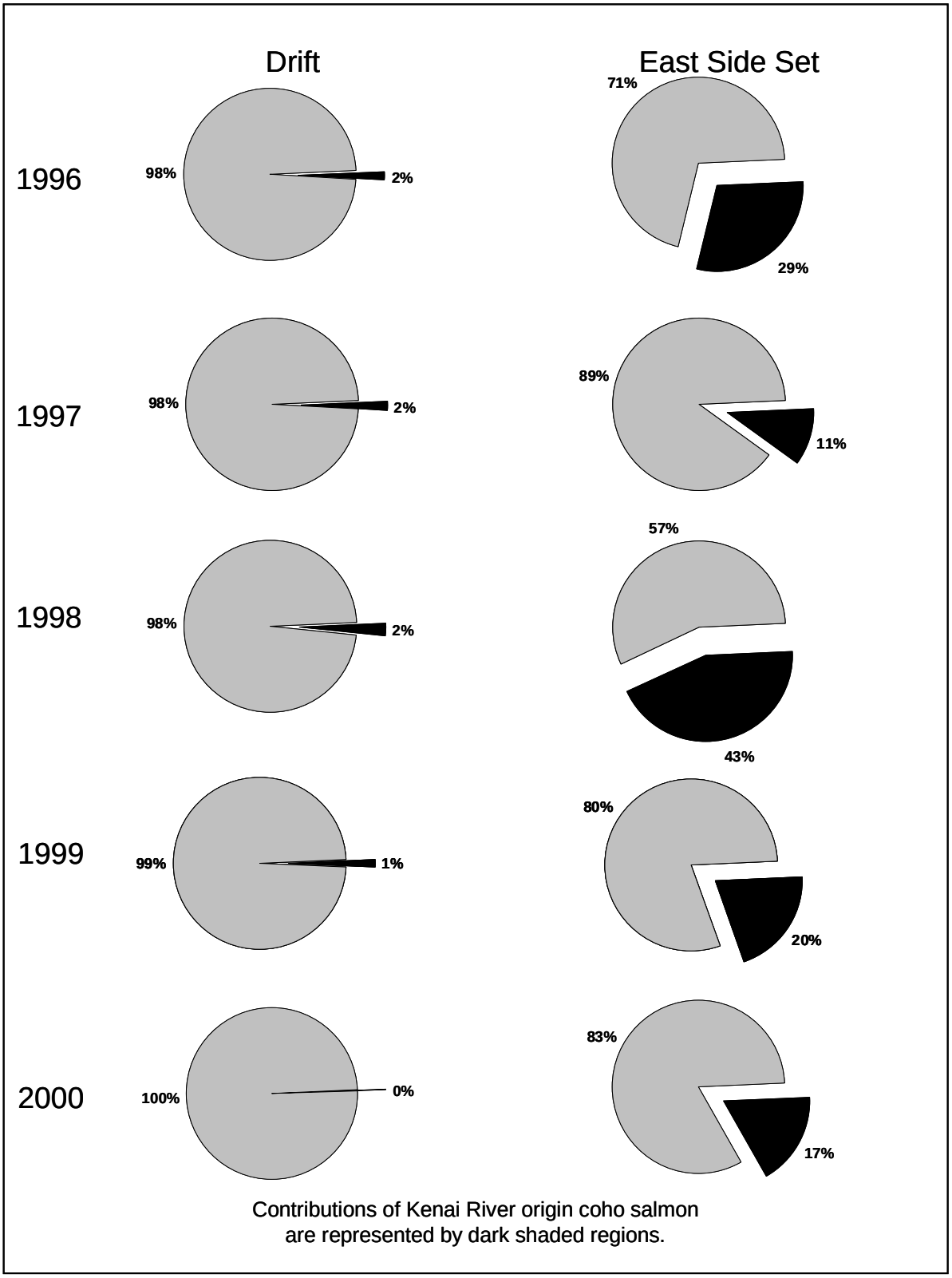

Figure 11.-Contribution of coho salmon from the Kenai River to the drift and eastside set gillnet commercial fisheries of Upper Cook Inlet, 1996-2000.

Smolt abundance estimates had been the sole population assessment "barometer" from 1995-1998, when smolt abundance had been identified as an alternative to an adult-based population assessment. Developing a time series of harvest estimates and resulting smolt abundance estimates was acknowledged as a long-term endeavor, but was favored because of the lack of success in estimating adult abundance and the potentially high cost of implementing a project to do so. However, the weak 1997 return and the resultant inseason fishery restrictions renewed interest in estimates of adult inriver abundance. A study was conducted in 1998 to test the feasibility of estimating adult abundance. Beginning in 1999, a full-scale mark-recapture experiment to estimate the adult population size was conducted and has since been repeated in 2000. The combination of smolt abundance, total harvest, and baseline adult return and escapement estimates will enhance the Department's ability to assess the status of this population and the sustainability of the fisheries it supports. The first available smolt production estimate from the first known escapement (1999) will become available in 2003 when the 2002 smolt production will be estimated. Until then, the long-term approach of relating smolt production to parent year harvest will be monitored.

Relationship Between Total Harvest and Smolt Abundance

The newly available estimate of 1999 smolt abundance represents the eighth such annual estimate since 1992 (Figure 12). From 1993 through 1999, seven annual estimates of total adult harvest have also been made (Table 7 and Figure 13). The pairing of these two records produces four pairs of harvest and smolt abundance estimates (Figure 14). The newly available 1999 smolt abundance estimate, when paired with the 1996 total harvest estimate, represents the fourth such pair available to date. While the relationship does not clearly identify a threshold harvest beyond which smolt abundance is significantly, negatively, and consistently impacted, it suggests that the record adult harvest in 1994 may have been excessive. At the very least, it is associated with the 1997 smolt production (Carlon 2003) which remains the lowest on record. This also suggests that precautionary measures adopted under the Kenai River Coho Salmon Conservation Management Plan should be retained until additional information demonstrates that surplus yield is available. Monitoring the harvest-smolt relationship as additional pairs of estimates accrue annually is necessary to determine whether it will be practical for identifying a harvest guideline management objective.

RECOMMENDATIONS

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. Currently, only four pairs of estimates are available and it is not yet possible to establish a link between harvest and smolt production. The record harvest of 1994 is now associated with the lowest smolt abundance on record (1997); this suggests that this approach may be sensitive enough to provide management implications if continued.

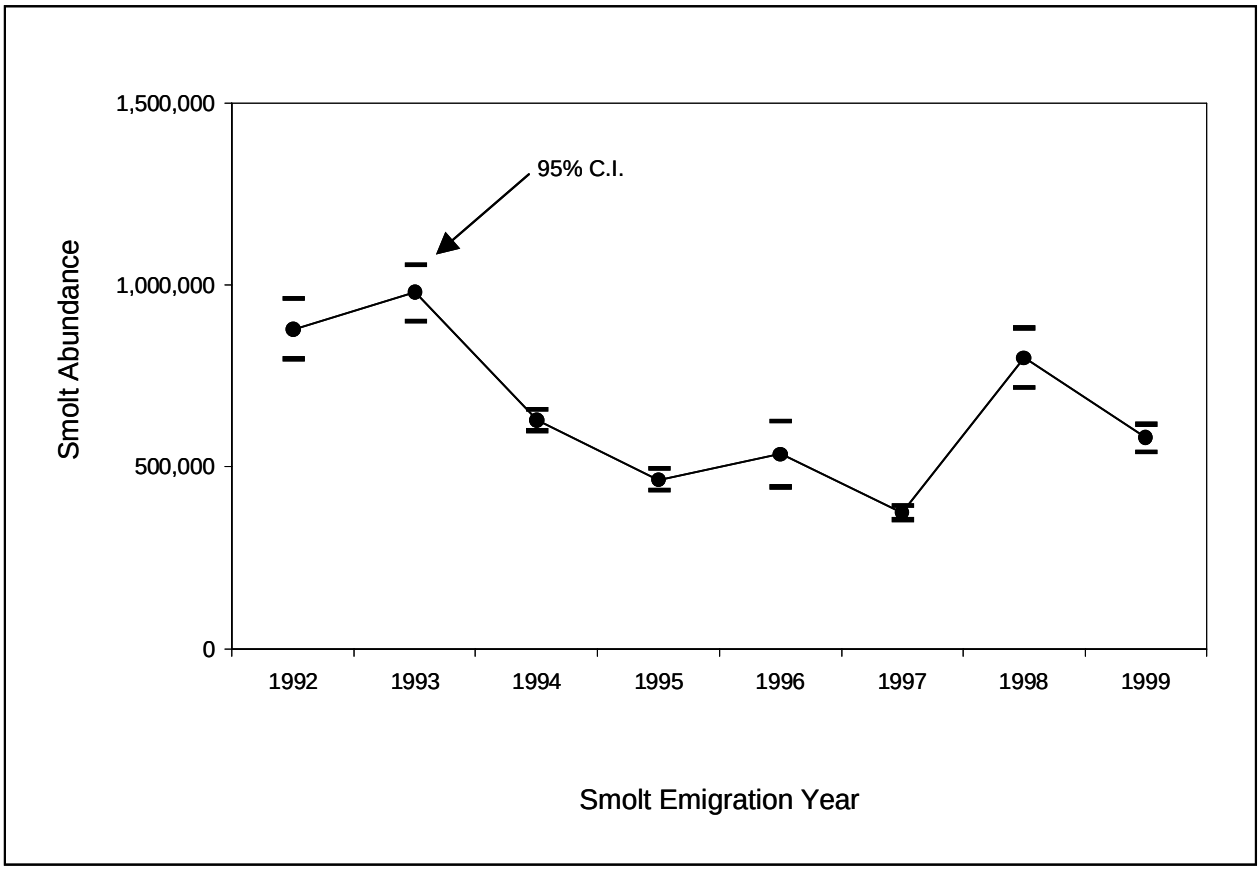

Figure 12.-Estimates of coho salmon smolt abundance in the Kenai River, 1992-1999.

Continue companion project to estimate the spawning escapement.

The concurrent experiment to estimate adult abundance, exploitation rate, and escapement will provide more immediate assessment information than can be provided by the long-term approach relating harvest to smolt production. The record harvest of 1994 demonstrates the substantial harvest potential of sport and commercial fisheries in UCI. More immediate assessment information is desired to supplement the long-term approach. The mark-recapture experiment initiated in 1998 (and repeated in 1999 and 2000) should be continued to enhance the assessment of population of coho salmon from the Kenai River.

Table 7.-Total harvest of coho salmon of Kenai River origin in UCI inriver and marine commercial fisheries, 1993-1999.

	Inriver											
	Sport[a]					Personal		UCI Marine Commercial[b]				
	Mainstem			Russian		Use/		Eastside	Drift	Northern		Grand
Year	Unguided[a]	Guided	Total	River	Total	Subsistence	Total	Set Gillnet	Gillnet	District	Total	Total
1993	26,805	23,743	50,548	2,290	52,838	1,597 [c]	54,435	6,806	930	148	7,884	62,319
1994	45,623	41,170	86,793	4,607	91,400	2,535 [d]	93,935	14,673	11,732	477	26,882	120,817
1995	22,663	23,587	46,250	4,077	50,327	1,261 [e]	51,588	13,152	6,956	582	20,690	72,278
1996	28,764	13,728	42,492	4,599	47,091	1,932 [f]	49,023	11,856	2,671	29	14,556	63,579
1997	13,063	3,101	16,164	4,586	20,750	559 [f]	21,309	2,093	1,236	36	3,365	24,674
1998	21,750	5,217	26,967	4,612	31,579	1,011 [f]	32,590	8,096	1,974	175	10,245	42,835
Average	26,445	18,424	44,869	4,129	48,998	1,483	50,480	9,446	4,250	241	13,937	64,417
1999	23,550	8,087	31,637	3,910	35,547	1,009 [f]	36,556	2,905	818	171	3,894	40,450

[a] Source is Statewide Harvest Survey (Howe et al. 1995-1996, Howe et al. 2001a-d; Mills 1994; 1996-1999 are revised estimates. Mainstem unguided includes Skilak Lake.

[b] Carlon 2000, 2003; Carlon and Hasbrouck, 1996-1998; Carlon and Massengill *In prep*.

[c] Kenai River personal use dip net fishery harvest (Mills 1994).

[d] Kenai River subsistence dip net fishery harvest (Brannian and Fox 1996).

[e] Kenai River personal use dip net fishery harvest (Ruesch and Fox 1996).

[f] Calculated from returned permits expanded to include estimated harvest from permits not returned (S. Sonnichsen, ADF&G, Anchorage, personal communication, 3/5/02).

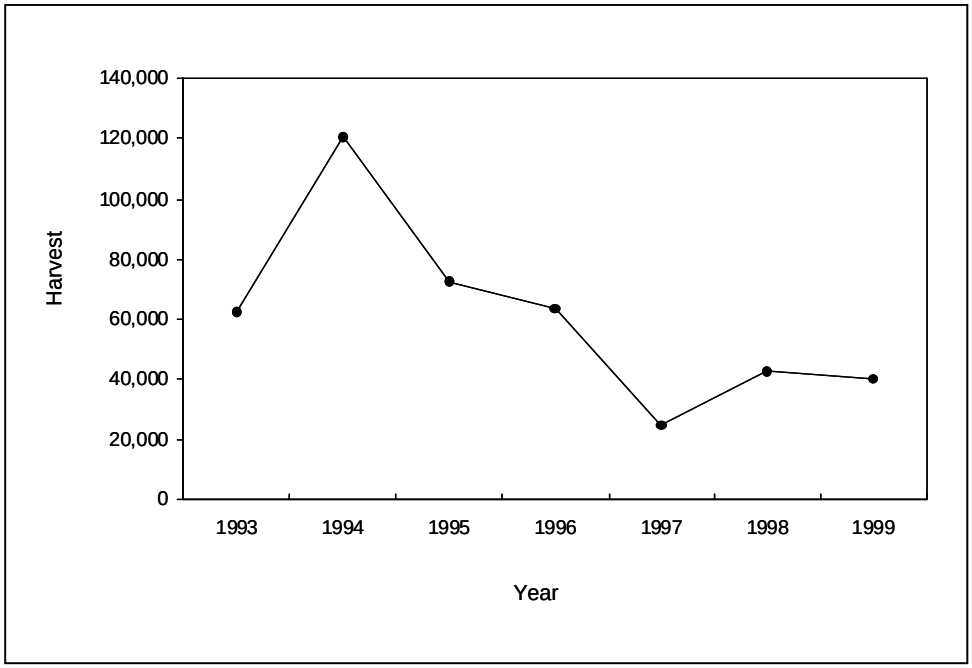

Figure 13.-Estimates of total harvest of coho salmon of Kenai River origin by combining estimates of commercial marine harvest with inriver estimates of personal use, mainstem sport, and Russian River sport harvest, 1993-1999.

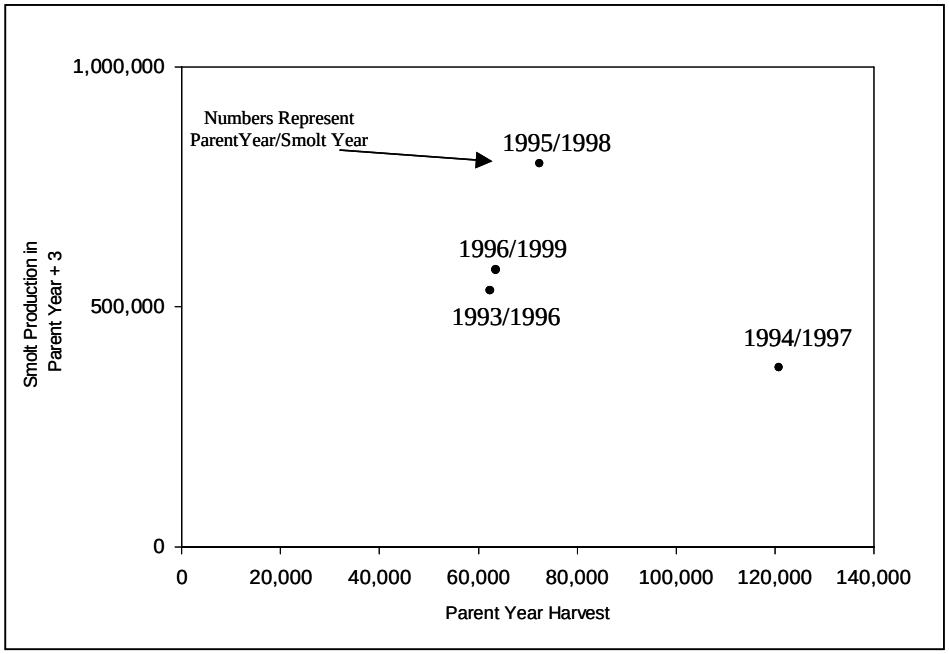

Figure 14.-Available points in the long-term assessment approach of relating smolt production to parent year harvest for coho salmon from the Kenai River, Alaska.

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The commercial harvest was examined in 2000 by technicians of the Commercial Fisheries Division (CFD). Kim Rudge-Karic supervised commercial harvest sampling, provided logistical support, and collated commercial sampling data. Personnel of the CFD Mark, Tag, and Aging Laboratory in Juneau processed all coded wire tag data collected in 1999 and 2000. All CFD personnel contributed to the successful achievement of study objectives.

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APPENDIX A

Appendix A1.-Number of wild coho salmon smolt captured from the Moose River, marked with an adipose finclip and coded wire tags, and released in 1999, and number identified in the sample of 2,718 marked fish recovered from UCI commercial fishing sampling in 2000.

Tag Code	First Day Released	Last Day Released	Number Marked [a]	Short-Term Survival rate	Number Marked at Release [b]	Short-Term Tag Retention	Number Tagged at Release [c]	Number Identified in UCI Commercial Harvest Sample in 2000 [d]
31-23-26	5/23	5/28	11,245	99.9%	11,233	96.4%	10,829	17
31-23-27	5/28	5/30	11,364	100.0%	11,364	99.2%	11,273	19
31-23-28	5/30	5/31	11,611	99.4%	11,538	99.9%	11,526	25
31-23-29	5/31	6/02	11,362	99.6%	11,322	99.5%	11,265	15
31-23-30	6/02	6/03	11,648	99.8%	11,629	99.7%	11,594	18
31-02-10	6/03	6/05	11,448	100.0%	11,448	99.7%	11,414	15
31-02-11	6/05	6/06	11,584	99.9%	11,568	98.3%	11,371	15
31-02-12	6/06	6/07	11,540	99.9%	11,526	99.4%	11,457	19
31-02-13	6/07	6/08	11,659	100.0%	11,659	99.5%	11,601	18
31-02-14	6/08	6/17	11,613	99.9%	11,598	99.1%	11,494	11
Total			115,074	99.8%	114,885	99.1%	113,824	172

[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.

[d] Number of tags physically recovered from known fishery areas of UCI and positively decoded.

Appendix A2.-Daily summary of coho salmon adults captured by two fish wheels located along north and south banks of the Kenai River near river kilometer 44.5 between August 1 and October 6, 2000.

	August					September-October				
Date	Number Captured and Examined	Marked Fish Observed[a]	Marked Fish Checked with Tag Detector[b]	Coded Wire Tag Detected		Date	Number Captured and Examined	Marked Fish Observed[a]	Marked Fish Checked with Tag Detector[b]	Coded Wire Tag Detected
					North Bank					
08/01	2					09/01	51	14	14	13
08/02	14	1	1	1		09/02	44	7	7	6
08/03	24	4	4	3		09/03	60	11	11	11
08/04	54	5	5	5		09/04	37	6	6	2
08/05	30	2	2	2		09/05	28	4	4	4
08/06	18					09/06	39	5	5	5
08/07	27	4	4	3		09/07	38	9	9	7
08/08	14					09/08	21		4	4
08/09	32	3	3	3		09/09	15	4	5	5
08/10	25	2	2	1		09/10	30	5	4	4
08/11	24	1	1	1		09/11	21	4	8	8
08/12	28	4	4	4		09/12	40	8	8	8
08/13	17	4	4	4		09/13	40	9	14	14
08/14	8	1	1	1		09/14	54	14	21	21
08/15	30	9	9	9		09/15	55	21	10	10
08/16	34	4	4	4		09/16	37	10	5	5
08/17	27	4	4	4		09/17	22	5	24	24
08/18	30	2	2	2		09/18	73	24	11	10
08/19	28	12	12	12		09/19	56	11	12	12
08/20	69	8	8	8		09/20	47	12	17	17
08/21	35	11	11	10		09/21	90	17	31	30
08/22	47	9	9	9		09/22	151	31	31	30
08/23	35	6	6	6		09/23	168	31	18	17
08/24	51	12	12	9		09/24	76	18	15	14
08/25	23	4	4	4		09/25	69	15	19	18
08/26	13	2	2	2		09/26	67	19	5	5
08/27	15	4	4	4		09/27	40	5	8	8
08/28	20	3	3	2		09/28	37	8	6	6
08/29	36	8	8	8		09/29	18	6	4	4
08/30	62	18	18	16		09/30	13	4	3	3
08/31	112	22	22	22		10/01	9	3	2	2
						10/02	5	2	1	1
						10/03	8	1	2	2
						10/04	5	2		
						10/05	2			
						10/06	2			
Subtotal	984	169	169	159			1,568	345	344	330
North Bank Subtotal							2,552	514	513	489

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	August					September-October				
Date	Number Captured and Examined	Marked Fish Observed[a]	Marked Fish Checked with Tag Detector[b]	Coded Wire Tag Detected		Date	Number Captured and Examined	Marked Fish Observed[a]	Marked Fish Checked with Tag Detector[b]	Coded Wire Tag Detected
				South Bank						
08/01						09/01	27	6	6	6
08/02	2					09/02	32	7	7	7
08/03	8	1	1	1		09/03	27	6	6	5
08/04	12	1	1	1		09/04	19	5	5	5
08/05						09/05	16	4	4	4
08/06	3					09/06	15	5	5	5
08/07	8	1	1	1		09/07	26	3	3	3
08/08	6					09/08	22	6	6	6
08/09	2					09/09	30	6	6	6
08/10						09/10	35	6	6	6
08/11	2					09/11	32	6	6	6
08/12	4	1	1	1		09/12	29	6	6	5
08/13	2	1	1	1		09/13	19	3	1	1
08/14						09/14	28	2	2	2
08/15	2	1	1	1		09/15	15	4	4	4
08/16	6	1	1	1		09/16	32	2	2	2
08/17	3					09/17	25	4	4	4
08/18	6	1	1			09/18	14	3	3	3
08/19	3	1	1	1		09/19	24	3	3	3
08/20	11	3	3	3		09/20	32	6	6	6
08/21	1					09/21	55	13	13	13
08/22	1					09/22	58	10	10	10
08/23	4	1	1	1		09/23	28	7	7	7
08/24	8	1	1	1		09/24	6	2	2	2
08/25	7	1	1	1		09/25	8	2	2	2
08/26	3					09/26	16	6	6	6
08/27						09/27	13	1	1	1
08/28						09/28	6	2	2	2
08/29	13	3	3	2		09/29	6			
08/30	8	1	1	1		09/30				
08/31	7	2	2	2		10/01	1	1	1	1
						10/02	4			
						10/03	1			
						10/04	1			
						10/05	1			
						10/06				
Subtotal	132	21	21	19			703	137	135	133
South Bank Subtotal							835	158	156	152
Grand Total (both banks)							3,387	672	669	641

[a] Number of coho salmon missing an adipose fin.

[b] Captured coho salmon that were missing an adipose fin were checked for the presence of a coded wire tag by using a Northwest Marine Technologies tag detection wand prior to releasing the fish.

Appendix A3.-Daily summary of coho salmon adults captured by all recapture gear (primarily drift gillnetting) located on the Kenai River between river kilometer 58.4 and 48.9 from August 1 through October 13, 2000.

	August					September-October				
Date[a]	Number Captured and Examined	Marked Fish Observed[b]	Marked Fish Checked with Tag Detector[c]	Coded Wire Tag Detected		Date[a]	Number Captured and Examined	Marked Fish Observed[b]	Marked Fish Checked with Tag Detector[c]	Coded Wire Tag Detected
					North Bank					
08/01						09/01	39	9	8	8
08/02	7	1				09/02	30	8	7	7
08/03	9					09/03	29	10	9	9
08/04	18	2				09/04	36	17	15	15
08/05	10					09/05	20	3	3	3
08/06						09/06	11	1	1	1
08/07	14	2				09/07	18	7	1	1
08/08	28	4				09/08	19	6	3	3
08/09	23	4				09/09	7	5		
08/10	48	7				09/10	14	3	3	3
08/11	63	14				09/11	5	1	1	1
08/12	44	6				09/12	2			
08/13	48	7				09/13	8	3	3	3
08/14	48	13				09/14	5	2	2	2
08/15	23	3				09/15	9	2	1	1
08/16	32	10	1	1		09/16	4	1	1	1
08/17	46	9	4	4		09/17	7	3	3	3
08/18	66	11				09/18				
08/19	46	18	17	16		09/19				
08/20	54	12	9	9		09/20	7			
08/21	41	10	9	9		09/21				
08/22	56	19	17	17		09/22	1	1	1	1
08/23	51	15	9	8		09/23	32	8	2	2
08/24	54	13	7	6		09/24	95	22	17	17
08/25	55	11	5	5		09/25	30	7	7	7
08/26	45	11				09/26	24	5	4	4
08/27	28	4	1	1		09/27	18	6	6	6
08/28	40	15	15	15		09/28	2	2	2	2
08/29	20	5	5	5		09/29	5	1	1	1
08/30	24	3	1			09/30	6			
08/31	15	1	1	1		10/01	13	2	1	1
						10/02				
						10/03	1			
						10/04	12	2	2	2
						10/05	1			
						10/06	2	1		
						10/07	3			
						10/08	2			
						10/09	2	1	1	1
						10/10	2			
						10/11	5	1	1	1
						10/12	2			
						10/13	1			
Subtotal	1,056	230	101	97			529	140	106	106
North Bank Subtotal							1,585	370	207	203

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	August					September-October				
Date[a]	Number Captured and Examined	Marked Fish Observed[b]	Marked Fish Checked with Tag Detector[c]	Coded Wire Tag Detected		Date[a]	Number Captured and Examined	Marked Fish Observed[b]	Marked Fish Checked with Tag Detector[c]	Coded Wire Tag Detected
					South Bank					
08/01	14	2				09/01	1	1	1	1
08/02	5	1				09/02	1			
08/03	5					09/03	6	1	1	1
08/04	6	1				09/04				
08/05	1					09/05	2	1	1	1
08/06						09/06	16	4		
08/07	14	3				09/07	9	1		
08/08	44	4				09/08	12	3		
08/09	28	4				09/09	17	5	1	1
08/10	40	2				09/10	41	12	8	7
08/11	67	5				09/11	11	4	4	4
08/12	48	6				09/12	9	3		
08/13	83	9				09/13	33	8	5	5
08/14	52	8				09/14	121	21	13	12
08/15	43	6				09/15	78	24	5	5
08/16	12	1				09/16	8	2	1	1
08/17	12	3				09/17	27	7	6	6
08/18	24	1				09/18	7			
08/19	3					09/19	6	1		
08/20	58	11	8	8		09/20	15	5	3	3
08/21	14	2	1	1		09/21	7	3	2	2
08/22	11					09/22	84	25	11	11
08/23	20	5	3	2		09/23	76	17	12	12
08/24	15	4	4	4		09/24	61	12	1	1
08/25	18	6	3	3		09/25	48	10	10	10
08/26	4					09/26	17	2	2	2
08/27	4	2	1	1		09/27	44	10	6	6
08/28	1					09/28	30	8	7	7
08/29	2					09/29	20	3	3	3
08/30	5	1	1	1		09/30	21	1	1	1
08/31	1					10/01	34	5	2	2
						10/02	5	1	1	1
						10/03	11	1	1	1
						10/04	5	1	1	1
						10/05	9	1	1	1
						10/06	9	4	4	4
						10/07	5	2	2	2
						10/08				
						10/09				
						10/10	6	1	1	1
						10/11	1			
						10/12	3			
						10/13	5	1	1	1
Subtotal	654	87	21	20			921	211	118	116
South Bank Subtotal							1,575	298	139	136
Grand Total (both banks)							3,160	668	346	339

[a] Gillnets operational from August 1 through October 13, 2000.

[b] Number of coho salmon missing an adipose fin.

[c] Captured coho salmon that were missing an adipose fin were checked for the presence of a coded wire tag by using a Northwest Marine Technologies tag detection wand.

Appendix A4.-Daily summary of coho salmon adults examined at the Russian River weir, July 31 through October 5, 2000.

Date	Weir Count	Examined	Marked Fish Observed [a]	Date	Weir Count	Examined	Marked Fish Observed [a]
7/31	2	2	0	9/1	0	0	0
8/1	0	0	0	9/2	277	277	19
8/2	0	0	0	9/3	163	163	4
8/3	3	3	0	9/4	252	252	10
8/4	3	2	0	9/5	63	63	5
8/5	1	0	0	9/6	34	34	1
8/6	2	2	0	9/7	142	142	7
8/7	7	7	1	9/8	264	264	15
8/8	35	33	2	9/9	0	0	0
8/9	39	38	2	9/10	79	79	4
8/10	28	20	1	9/11	136	136	5
8/11	19	18	0	9/12	85	85	4
8/12	26	25	2	9/13	328	328	14
8/13	42	41	0	9/14	275	275	7
8/14	74	73	4	9/15	159	159	8
8/15	56	55	0	9/16	108	108	8
8/16	36	35	3	9/17	136	136	7
8/17	123	121	6	9/18	33	33	3
8/18	76	76	1	9/19	46	46	3
8/19	45	44	0	9/20	242	242	17
8/20	59	58	1	9/21	323	323	15
8/21	46	46	3	9/22	39	39	3
8/22	104	102	8	9/23	38	38	1
8/23	105	104	9	9/24	49	49	3
8/24	20	19	0	9/25	15	15	0
8/25	68	68	2	9/26	8	8	0
8/26	31	31	1	9/27	17	17	2
8/27	51	51	3	9/28	17	17	1
8/28	226	226	14	9/29	7	7	1
8/29	82	82	3	9/30	2	2	0
8/30	10	10	0	10/1	0	0	0
8/31	58	58	4	10/2	4	4	0
				10/3	1	1	0
				10/4	0	0	0
				10/5	0	0	0
Subtotal	1,477	1,450	70	Subtotal	3,342	3,342	167
Grand Total					4,819	4,792	237

[a] Number of coho salmon missing an adipose fin.

Appendix A5.-Coho salmon examined, coded wire tag recoveries, and recovery of marked coho salmon of Kenai River origin in commercial harvest samples from mixed Cook Inlet statistical areas or ambiguous dates in 2000.

Date	Statistical Areas	(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 1999
Mixed Central District Statistical Areas							
Drift and East Side Set (Unknown Statistical Areas)							
7/13		78	1	1	1	1	0
East Side Set							
7/10	24421/31	3	0	0	0	0	0
7/13	24421/22	14	0	0	0	0	0
7/13	24421/22/31	11	0	0	0	0	0
7/13	24422/31	4	0	0	0	0	0
7/17	24422/31	34	0	0	0	0	0
7/20	24421/22/31	18	0	0	0	0	0
7/20	24421/22/31/32/41/42	6	1	1	0	0	0
7/20	24422/31	3	0	0	0	0	0
7/31	24421/22/31	87	5	5	5	5	4
8/7	24422/31	9	1	1	1	1	1
Total		189	7	7	6	6	5
West Side and Kalgin Island Set							
7/11	24530,24610/20	504	4	4	4	4	0
7/17	24530,24610/20	475	9	9	6	6	0
7/24	24530,24610/20	1,721	14	14	13	13	0
7/27	24530,24610/20	931	12	11	9	9	1
7/31	24530,24610/20	1,935	27	27	20	20	2
8/3	24530,24610/20	524	6	6	4	4	0
8/7	24530,24610/20	1,267	6	6	6	6	1
8/10	24530,24610/20	840	5	5	3	3	0
Total		8,197	83	82	65	65	4
Central District Total		8,464	91	90	72	72	9
Mixed Central and Northern District Statistical Areas							
Central District Drift and Northern District East Side Set							
8/3	CD Drift, 24770/80/90	575	16	16	13	13	0
Central District West Side Set and Northern District West Side Set							
7/10	24560,24710/20	567	11	11	10	10	0
Ambiguous Samples							
Northern District, Fire Island Set[a]							
8/17	24743	224	6	6	5	5	0
8/21	24743	69	2	2	2	2	0
8/24	24743	31	2	2	2	2	0
Total		324	10	10	9	9	0
Grand Total		9,930	128	127	104	104	9

Note: These data were excluded from analyses and estimates of harvest contribution due to geographic or temporal ambiguity in the sample source.

[a] Coho salmon examined, but zero harvest reported for this fishery on tabulated dates. Erroneous identification of the fishery is assumed to have occurred when fish were examined.

Appendix A6.-Upper Cook Inlet commercial coho salmon harvest in 2000, coded wire tag sampling information, and population-specific harvest estimates of coho salmon of Kenai River origin based on recoveries of fish marked at the Moose River in 1999.

Date (2000)[a]	(H) Total Harvest	(ni) Number Examined	(ai) Adclips Observed	(a'i) Heads Recovered	(ti) Heads with Tags	(t'i) Decodable Tags	(mi) Source= Moose R 1999	(ri) Harvest Estimate [b]	V(ri) Variance [c]
Central District									
Drift Gillnet									
Statistical Area 24450/60/70-24570/80/90									
6/26, 6/29	864	37	1	1	0	0	0		
7/3	874	284	2	2	1	1	0	0	0
7/6	2,087	759	21	21	19	19	0	0	0
7/10	98	44	3	3	3	3	0	0	0
7/12	17	13	0	0	0	0	0	0	0
7/13, 7/15, 7/16	39,380	8,039	135	134	123	123	1	26	650
7/17, 7/18	42,292	13,412	292	291	261	261	4	66	1,028
7/20	32,353	6,928	195	195	178	177	5	123	2,919
7/31	7,706	1,552	10	10	8	8	1	26	650
8/3	3,877	1,154	3	3	3	3	2	35	579
8/7	1,652	237	7	7	7	7	7	255	9,107
Total	131,200	32,459	669	667	603	602	20	531	14,932
East Side Set									
Statistical Area 24421									
7/3,7/6, 7/10	60	2	0	0	0	0	0	0	0
7/12	10	2	0	0	0	0	0	0	0
7/13, 7/15	272	65	0	0	0	0	0	0	0
7/16, 7/17	171	50	0	0	0	0	0	0	0
7/18	36	19	1	1	1	1	1	10	90
7/20	166	80	0	0	0	0	0	0	0
7/24	182	85	5	5	5	5	5	56	575
7/31	475	48	4	4	4	4	4	207	10,547
8/7	839	137	12	12	12	12	12	385	12,143
Total	2,211	488	22	22	22	22	22	658	23,355
Statistical Area 24422									
7/3,7/6, 7/10	14	9	2	2	2	2	1	8	56
7/12	6	5	0	0	0	0	0	0	0
7/13, 7/15	327	98	0	0	0	0	0	0	0
7/16, 7/17	454	167	1	1	1	1	1	14	182
7/18	175	52	2	2	2	2	2	35	579
7/20	258	185	2	2	2	2	0	0	0
7/24	249	183	7	7	7	7	5	36	224
7/31	630	270	24	24	23	23	23	281	3,250
8/7	1,200	315	44	44	43	43	41	818	16,346
Total	3,313	1,284	82	82	80	80	73	1,192	20,638
Statistical Area 24431/32									
7/3, 7/10	62	7	2	2	1	1	0	0	0
7/12	26	9	0	0	0	0	0	0	0
7/13, 7/15	498	100	1	1	1	1	0	0	0
7/16, 7/17	632	48	0	0	0	0	0	0	0
7/18	363	77	5	5	4	4	1	25	600
7/20	388	116	2	2	2	2	0	0	0
7/24	105	59	2	2	2	2	1	9	72
7/31	209	100	9	9	9	9	8	88	888
8/7	645	285	33	33	32	32	32	379	4,290
Total	2,928	801	54	54	51	51	42	501	5,851
Statistical Area 24441/42									
7/10	61	17	0	0	0	0	0	0	0
7/13	576	344	4	4	3	3	0	0	0
7/17	688	349	9	9	8	8	0	0	0
7/18	399	60	0	0	0	0	0	0	0
7/20	664	153	4	4	2	2	0	0	0
Total	2,388	923	17	17	13	13	0	0	0
Eastside Set Gillnet Total	10,840	3,496	175	175	166	166	137	2,351	49,843

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Date (2000)[a]	(H) Total Harvest	(ni) Number Examined	(ai) Adclips Observed	(a'i) Heads Recovered	(ti) Heads with Tags	(t'i) Decodable Tags	(mi) Source= Moose R 1999	(ri) Harvest Estimate [b]	V(ri) Variance [c]
Kalgin Island Set Area 24610/20									
6/26	10								
6/29	36								
7/3	2								
7/6	17								
7/10	377								
7/13	687								
7/17	1,057								
7/20	1,481								
7/24	1,207								
7/27	979								
7/31	1,597								
8/3	547								
8/7	626								
8/10	475								
8/14	442								
8/17	336								
8/21	440								
8/24	256								
8/28	267								
9/4	309								
9/7	12								
Total	11,160								
West Side Set Areas 24520/30/40/50/55/60									
6/22	1								
6/29	5								
7/3	4								
7/5	3								
7/6	4								
7/7	15								
7/8	12								
7/9	52								
7/10	85								
7/11	44								
7/12	110								
7/13	176								
7/14	278								
7/15	355								
7/16	78								
7/17	287								
7/18	799								
7/19	237								
7/20	725								
7/21	1,194								
7/22	564								
7/23	542								
7/24	587								
7/25	928								
7/27	725								
7/31	1,537								
8/3	540								
8/7	916								
8/10	444								
8/14	317								
8/17	116								
Total	11,680								
Central District Total	164,880	35,955	844	842	769	768	157	2,882	64,774

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Date (2000)[a]	(H) Total Harvest	(ni) Number Examined	(ai) Adclips Observed	(a'i) Heads Recovered	(ti) Heads with Tags	(t'i) Decodable Tags	(mi) Source= Moose R 1999	(ri) Harvest Estimate [b]	V(ri) Variance [c]
Northern District									
East Side Set Areas 24770/80/90									
6/29,7/3,7/6, 7/10	44	16	0	0	0	0	0	0	0
7/13, 7/15	267	59	2	2	2	2	0	0	0
7/17	468	10	0	0	0	0	0	0	0
7/20	510	60	0	0	0	0	0	0	0
7/24	2,472	1,283	38	38	36	36	0	0	0
7/27	149	812	16	16	15	15	1	1	1
7/31	846	592	18	18	17	17	1	7	42
8/3	833	50	0	0	0	0	0	0	0
8/7	1,305	873	1	1	1	1	0	0	0
8/10	3,137	1,650	7	7	5	5	0	0	0
8/14	2,554	1,649	1	1	1	1	0	0	0
8/17	2,116	1,447	5	4	1	1	1	10	90
8/21	1,636	880	1	1	1	1	0	0	0
8/24	972	631	1	1	0	0	0		
8/28	460	280	0	0	0	0	0	0	0
36769	272	186	1	1	1	1	1	8	56
9/4,9/7, 9/11	368	119	0	0	0	0	0	0	0
Total	18,409	10,597	91	90	80	80	4	26	188
Fire Island Set Area 24743									
7/10	83	100	7	7	6	6	0	0	0
7/13	103	47	4	4	4	4	0	0	0
7/17	860	813	85	85	82	82	0	0	0
7/20	1,783	1,900	190	190	171	171	0	0	0
7/24	2,129	2,745	279	279	253	253	0	0	0
7/27	1,014	938	113	113	105	105	0	0	0
7/31	39	186	23	23	22	22	0	0	0
8/7	429	378	38	38	33	33	0	0	0
8/10	531	361	30	30	29	29	1	8	56
8/14,9/4, 9/7	267	213	14	14	12	12	0	0	0
Total	7,238	7,681	783	783	717	717	1	8	56
Pt. MacKenzie/Su Flats Set Area 24741/42									
6/29,7/3,7/6, 7/10	95	56	7	7	6	6	0	0	0
7/13	50	72	4	4	4	4	0	0	0
7/17	215	390	25	25	23	23	0	0	0
7/20	1,740	1,544	113	113	107	107	0	0	0
7/24	3,783	3,482	263	263	235	235	0	0	0
7/27	2,312	2,112	183	182	166	166	0	0	0
7/31	893	485	52	51	47	47	0	0	0
8/3	235	255	25	25	20	20	0	0	0
8/7	888	1,089	99	99	90	90	0	0	0
8/10	847	732	53	53	51	51	0	0	0
8/14	414	292	18	18	18	18	0	0	0
8/17	123	248	5	5	5	5	0	0	0
8/21	165	147	7	7	7	7	0	0	0
8/24,8/28,8/31,9/4,9/7, 9/11	189	36	1	1	1	1	0	0	0
Total	11,949	10,940	855	853	780	780	0	0	0
West Side Set Area 24710/20/30									
6/26,6/29,7/3,7/6, 7/10	1,889	601	2	2	1	1	0	0	0
7/13	4,093	4,395	8	8	3	3	0	0	0
7/17	1,521	943	1	1	1	1	0	0	0
7/20	9,860	7,395	39	39	23	23	0	0	0
7/24	7,175	4,725	16	16	9	9	0	0	0
7/27	4,599	3,356	30	29	23	23	1	7	42
7/31	1,496	1,691	39	39	34	34	8	37	140
8/3	455	515	8	8	6	6	1	5	20
8/7	1,418	965	7	7	6	6	0	0	0
8/10	494	636	3	3	2	2	0	0	0
8/14, 8/24	652	262	3	3	3	3	0	0	0
Total	33,652	25,484	156	155	111	111	10	49	203
Northern District Total	71,248	54,702	1,885	1,881	1,688	1,688	15	83	447
Grand Total	236,128	90,657	2,729	2,723	2,457	2,456	172	2,965	65,221

Note: The Central District set gillnet fisheries of Kalgin Island and the West Side were not sampled or were sampled incidentally, but are included here to add perspective to information from sampled fisheries.

[a] Multiple date entries represent strata when unsampled harvests were combined with a temporally adjacent sampled harvest as necessary to account for contributions to unsampled harvests.

b Estimates with blank entries indicate that although a harvest was reported, no readable tags were recovered from adipose-clipped fish or that the fishery was not sampled.