Fishery Data Series No. 04-24

Assessment of Coho Salmon from the Kenai River, Alaska, 2001

by

Rob Massengill

and

Jamie A. Carlon

November 2004

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

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

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

FISHERY DATA SERIES NO. 04-24

ASSESSMENT OF COHO SALMON FROM THE KENAI RIVER, ALASKA, 2001

by

Rob Massengill
and
Jamie A. Carlon
Division of Sport Fish, Soldotna

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska 99518-1599

November 2004

This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-17, Job No. S-2-14.

The Division of Sport Fish Fishery Data Series was established in 1987 for the publication of technically oriented results for a single project or group of closely related projects. Since 2004, the Division of Commercial Fisheries has also used the Fishery Data Series. Fishery Data Series reports are intended for fishery and other technical professionals. Fishery Data Series reports are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm This publication has undergone editorial and peer review.

Rob Massengill and Jamie A. Carlon
Alaska Department of Fish and Game, Division of Sport Fish
43961 Kalifornsky Beach Road, Suite B, Soldotna, AK 99669-8367, USA

This document should be cited as:
Massengill, R. and J. A. Carlon. 2004. Assessment of coho salmon from the Kenai River, Alaska, 2001. Alaska Department of Fish and Game, Fishery Data Series No. 04-24, Anchorage.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

Table **Page**

LIST OF FIGURES

LIST OF APPENDICES

Appendix **Page**

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. 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 2000. An estimated 103,319 coho sa1mon were marked with adipose finclips, and of those, 102,300 were released alive with coded wire tags, and 213,789 were enumerated emigrating from the Moose River.

In 2001, coho salmon smolt tagged in 2000 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. The pooled fish wheel catch appeared most representative for use in estimating the commercial harvest of coho of Kenai River origin. The 2000 drainage-wide smolt abundance was an estimated 601,236 coho salmon (SE = 25,454), based on the pooled number of fish examined at the fish wheel (2,670), the number observed to be missing an adipose fin (458), and the number of smolt marked and released with an adipose finclip in 2000 (103,319).

Based on the recovery of harvested adults marked with coded wire tags and adipose finclips in selected Upper Cook Inlet commercial fisheries, an estimated 282 (SE = 56) coho salmon of Kenai River origin were harvested in the Central District drift gillnet fishery and an estimated 349 (SE = 110) were harvested in the Central District eastside set gillnet fishery, and 1,303 (SE = 125) by all Northern District set gillnet fisheries for a total of 1,934 (SE = 176). Coho salmon of Kenai River origin comprised 0.7% of the total drift gillnet harvest, 8.2% of the total eastside set gillnet harvest, and 2.8% of the total Northern District set gillnet harvest in 2001.

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

INTRODUCTION

BACKGROUND

Wild 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, fifth in commercial harvest, and second in the combined sport and 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 unknown exploitation rates. These coho salmon support the largest freshwater sport harvest in the state (Howe et al. 1995-1996, 2001 a-d; Jennings et al. 2004; Mills 1979, 1980, 1981 a, b, 1982-1994; Walker et al. 2003) and account for an average of about 1 of every 6 of the roughly half million annual coho salmon sport-harvested from Alaskan waters. 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.

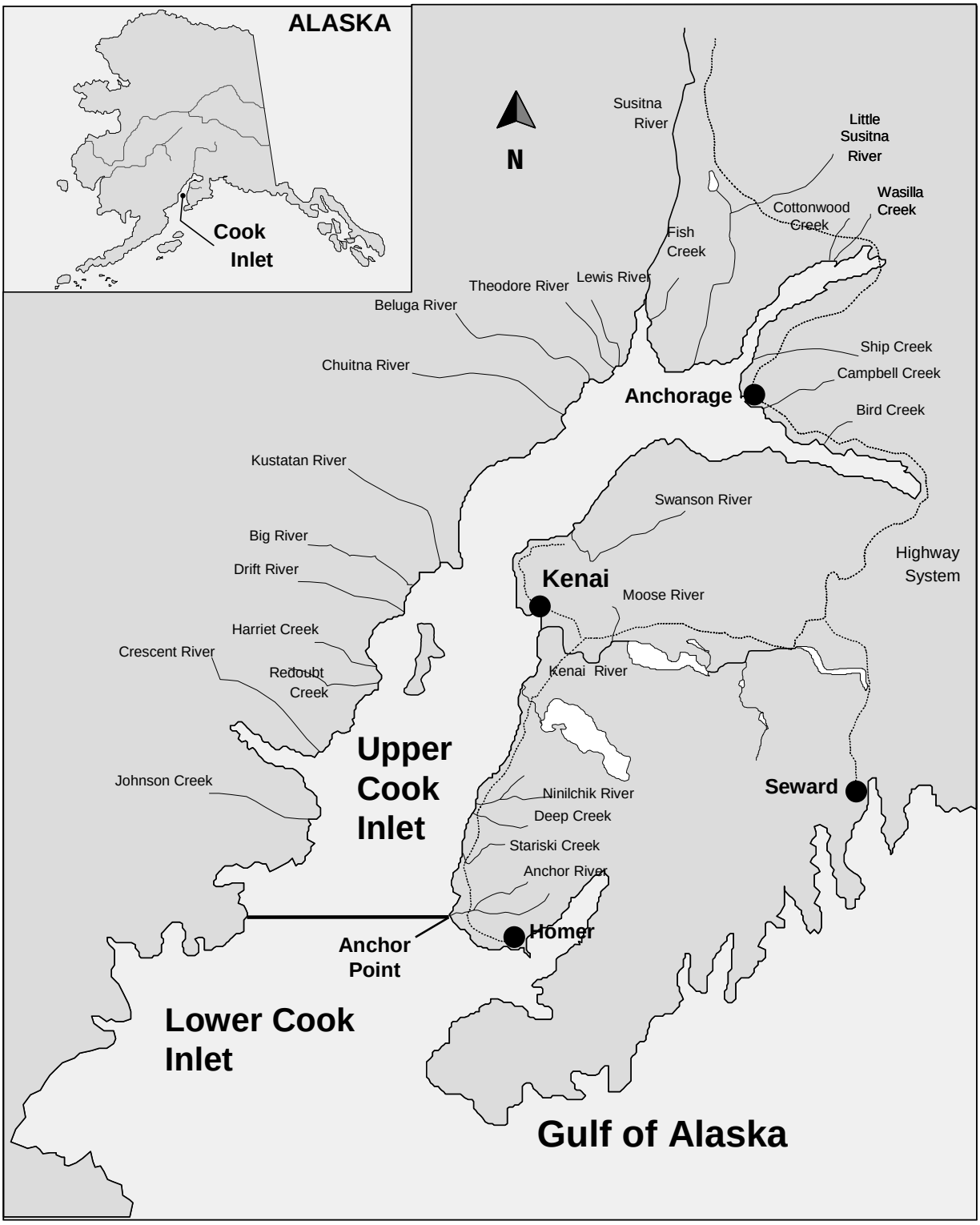

Figure 1.-Cook Inlet Basin with selected tributaries known to support coho salmon.

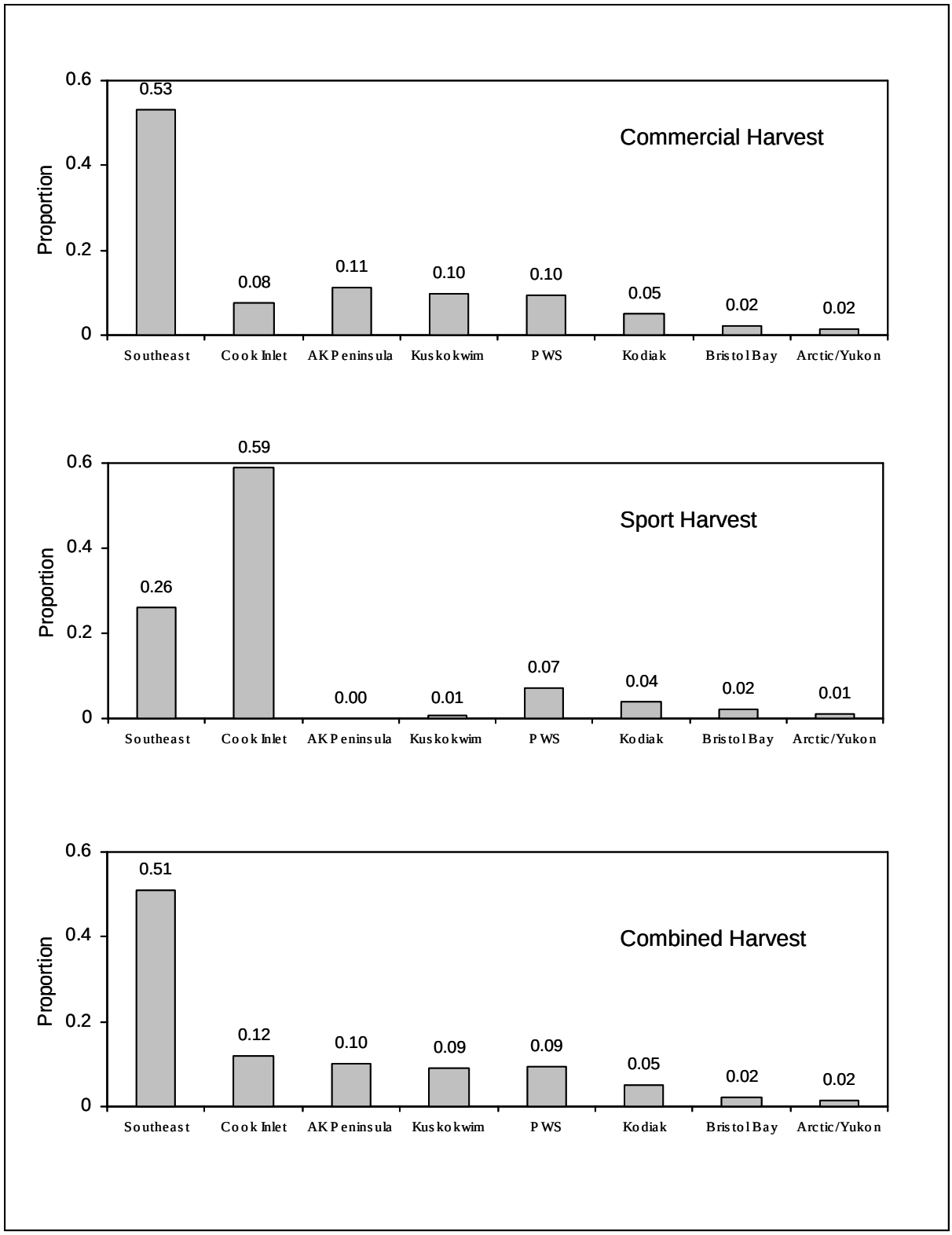

Figure 2.-Average proportions by region of the statewide commercial and sport harvests of coho salmon, 1985-2000.

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, annual records of exploitation rate and adult production were needed. A decline in production associated with increasing exploitation would signal the need for immediate conservation actions while 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.

Commercial harvest estimates (A) have been made annually since 1993 through a coded wire tag release and recovery program (Carlon 2000; Carlon and Hasbrouck 1994, 1996-1998; Carlon and Massengill *In prep*; Massengill and Carlon 2004). 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; Jennings et al. 2004; King 1993; Mills 1979, 1980, 1981 a, b, 1982-1994; Walker et al. 2003). Prior to 1999, the estimation of spawning escapement (C) was prevented due to technical limitations of sonar enumeration equipment (Bendock and Vaught 1994) and indications that coho salmon may be excessively sensitive to handling-induced stress associated with mark-recapture experiments in intertidal zones (Vincent-Lang et al. 1993). Therefore, total adult production and exploitation remained unknown until 1999 when a mark-recapture experiment was developed that addressed handling concerns (J. Carlon, Alaska Department of Fish and Game, Division of Sport Fish, Soldotna, personal communication).

Because adult exploitation rates and total production have only been estimated since 1999, any relationship between the two quantities remains unknown; adults produced from the 1999 escapement (the first with an estimated exploitation rate) will return in 2003. This approach to assessment of population status is therefore considered a long-term endeavor.

In the interim, two indicators of sustainability are being monitored. The first, annual exploitation rate (alone), is considered a more immediate indicator of sustainability. The second, annual smolt abundance, initially considered ancillary information, is now viewed as an interim 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 recent 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 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. Whether harvest opportunity was unnecessarily restricted is unknown. 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) while this report documents the 2001 population-specific commercial harvest and the 2000 smolt abundance estimates. This report is the ninth in a series documenting commercial harvest since 1993 and smolt abundance since 1992 of coho salmon from the Kenai River (Carlon 2000; Carlon and Hasbrouck 1994, 1996-1998; Carlon and Massengill *In prep*; Massengill and Carlon 2004).

STUDY AREA

Smolt were captured for marking in 2000 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 majority 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 2001. 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 2001, and
2. to estimate the number of coho salmon smolt that emigrated from the Kenai River in 2000.

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, 2001; and, if constant,

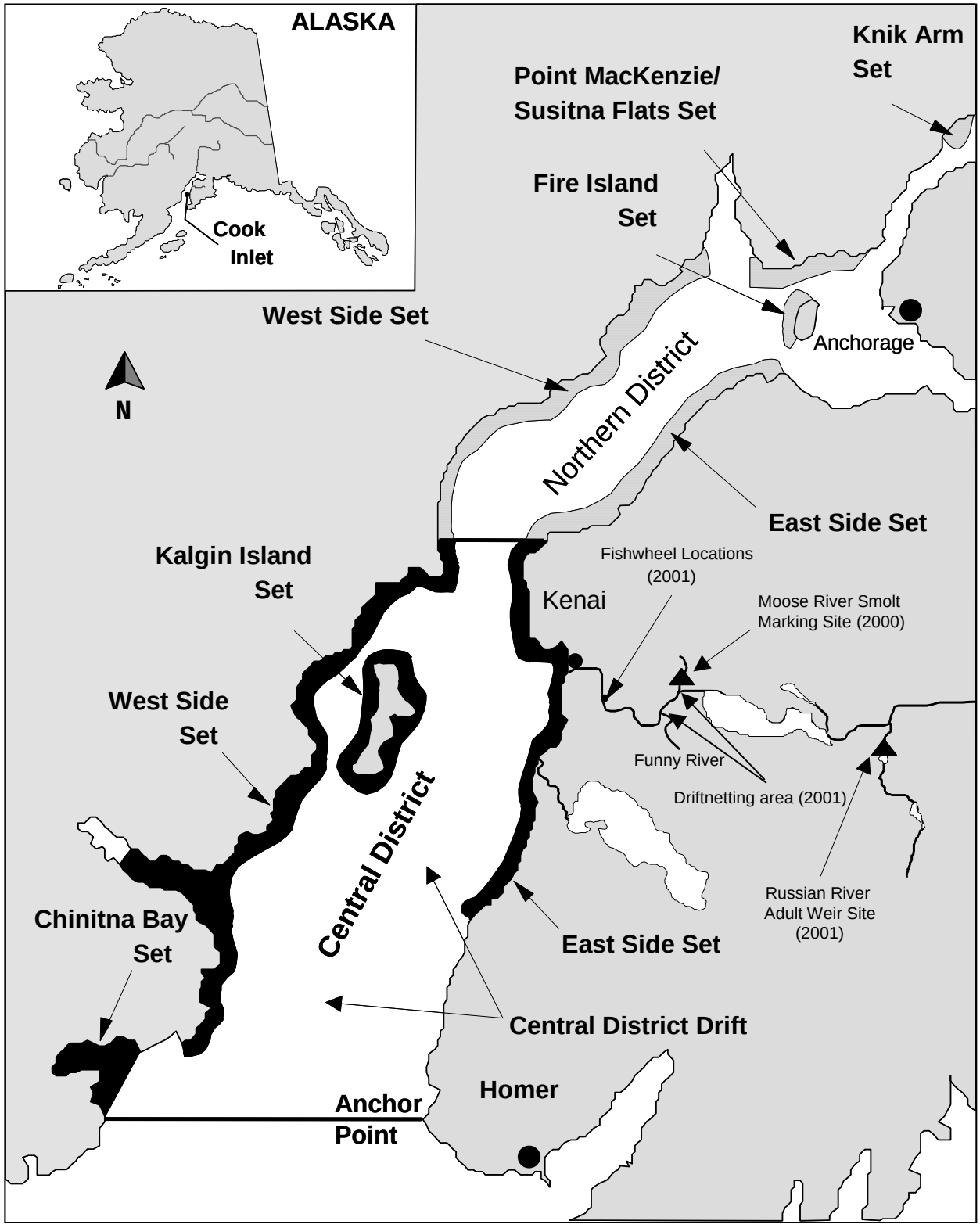

Figure 3.-Upper Cook Inlet showing ten commercial set gillnet and drift gillnet fishery areas, location at which marked coho salmon smolt were released in the Kenai River drainage in 2000, and Kenai River fish wheel and weir sampling locations at which adults were examined in 2001.

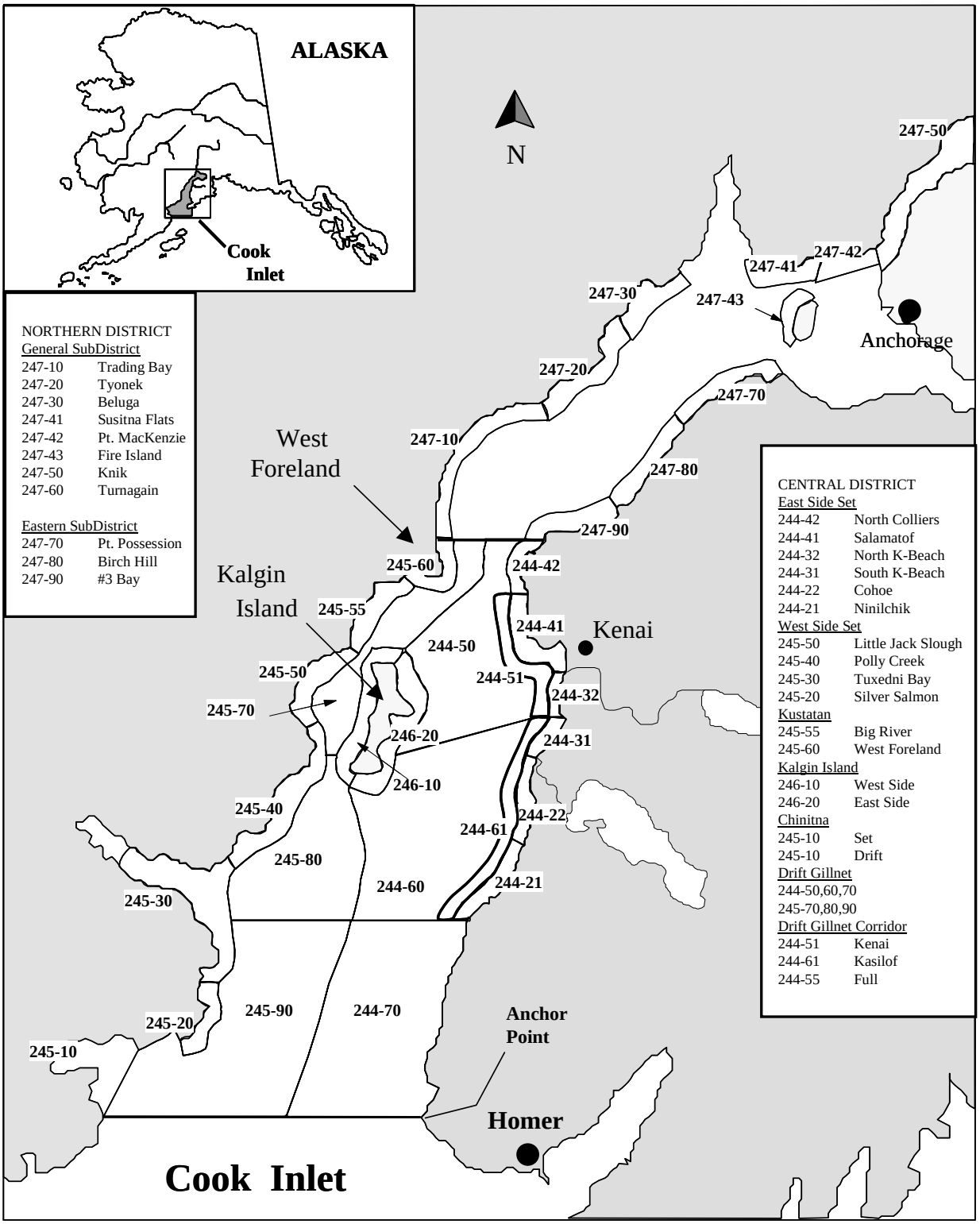

Figure 4.-Upper Cook Inlet statistical areas.

4. to estimate the proportion of the population bearing coded wire tags from August 1 through September 30, 2001.

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 2000, marked with coded wire tags, and released. Total harvest of coho salmon in 2001 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 2001.

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 is 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 must be checked to estimate the tag loss rate. In 2001, 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 detection results (a secondary correction for erroneous 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 prohibits the estimation of commercial harvest because the marked fraction passing through commercial harvest areas is 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 2001 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 (one adjacent to each riverbank) 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 (to examine 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 smolt marking year 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 tested by examining the inriver adult samples for temporal variations in the fraction marked with finclips. However, if smolt-to-adult tag loss is a rare event, tests of the tagged fraction for temporal variation (as necessary for estimating commercial harvest) can serve as a surrogate for the finclipped fraction. If tag loss is substantial, the finclipped fraction should be directly tested. A constant marked fraction is considered an indication that smolt of all return timings were marked in proportion to their abundance, i.e. the smolt that were marked were representative of the smolt population.

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 assumptions of the smolt abundance model are described in the data analysis section.

DATA COLLECTION

Data collection occurred during two calendar years. Mark-release data were collected when smolt were captured and marked in 2000, and mark-recovery data were collected in 2001 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 2000

Juveniles were captured for marking in 2000 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 to capture smolt for marking as they emigrated downstream from overwintering habitats 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 is attached to the riverbank with Vexar® netting and secured with sandbags. The downstream end is 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 18 through June 28, 2000. Virtually all smolt arriving at the weir between May 23 and June 17 were marked and released.

Smolt were the primary life stage captured for tagging at the Moose River. Historical data and observations indicate that smolt comprise nearly 100% of the annual springtime coho salmon emigration from the Moose River. Tags recovered from marked adults returning to spawn in 1993 through 2000 had been implanted in juveniles emigrating from the Moose River the prior year (Carlon 2000, 2003; Carlon and Hasbrouck 1994, 1996-1998, Massengill and Carlon 2004). 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 emigration because census data may eventually provide some predictive ability for estimating the adult return population and drainage-wide smolt abundance.

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 2001 Return

Data were collected among three inriver sample sources in 2001 to estimate the tagged proportion of the return. These were the fish wheel catch at rkm 44.5, drift gillnetting catches

between rkm 58.4 and 48.9, and the return of fish to the Russian River weir (Figure 5). Data from these sources were also collected 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.

Coho salmon were captured and examined for a missing adipose fin from August 1 through September 30, 2001 (the last day on which coho salmon were caught). The majority of fish found to be missing an adipose fin was 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 avoid 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. Drift gillnetting was supplemented by a limited amount of set gillnetting and by the use of hook-and-line 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 2001 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 5, 2001, 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 at the Russian River, a tributary to the Kenai River at approximately rkm 118. Sockeye *Oncorhynchus 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

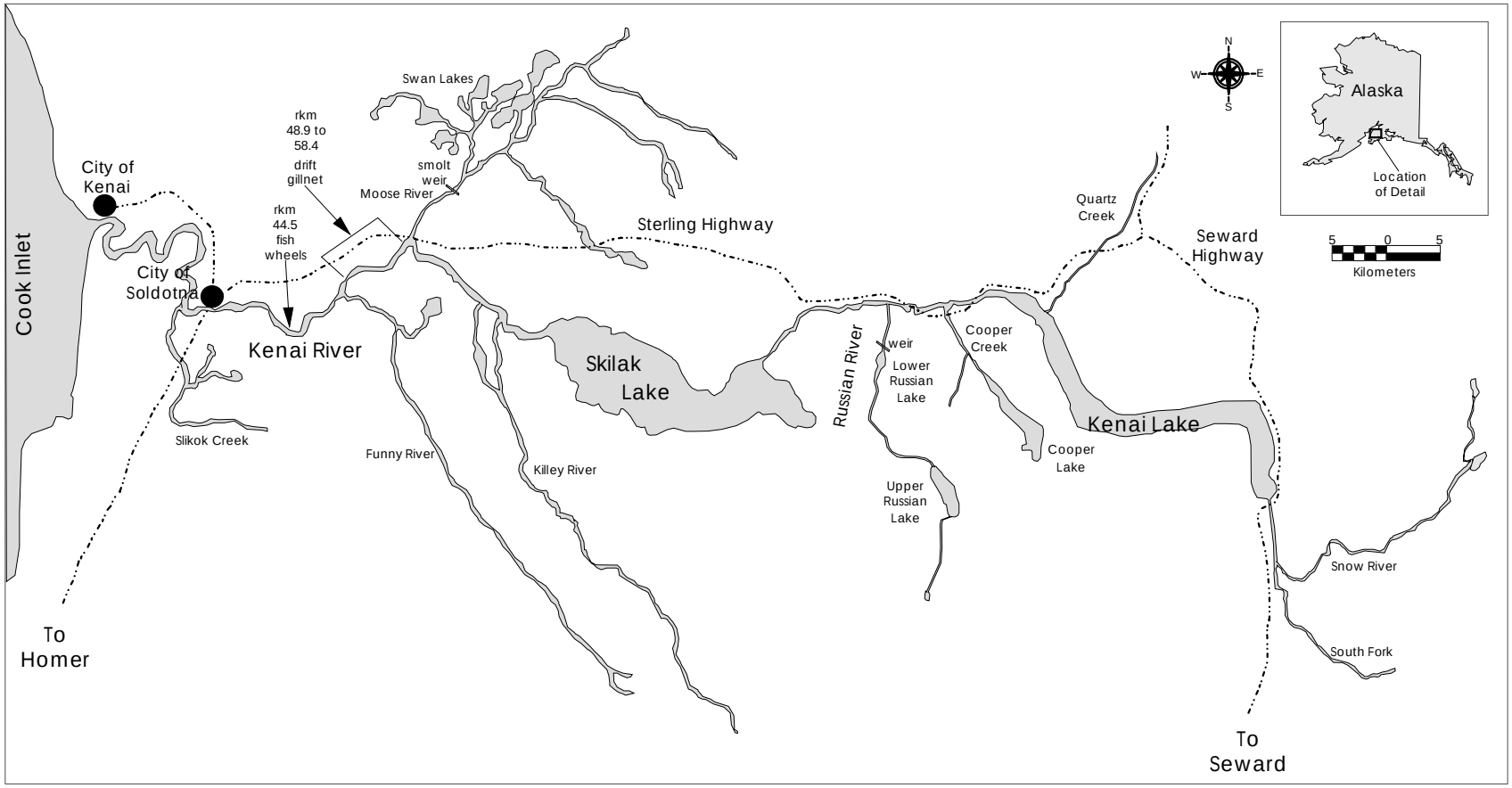

Figure 5.-Locations of coho salmon smolt marking in 2000 and adult coho salmon recovery in 2001.

of the sockeye salmon return. Since 1998, weir operation has been 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 six times before 2001 (Carlon 2000, 2003; Carlon and Massengill *In prep*; Marsh 1995; Massengill and Carlon 2004; 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 and to provide another 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 2001

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 (Alaska Fish and Game Laws and Regulations Annotated, 2000-2001; 5 AAC 21.363 and associated plans); 2001 management actions are documented by Fox and Shields (2001).

Fisheries selected for sampling during 2001 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, 2003; Carlon and Hasbrouck 1994, 1996-1998; Carlon and Massengill *In prep*; Massengill and Carlon 2004), 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; Massengill and Carlon 2004), and the west side set gillnet fishery was incidentally sampled in 2001.

In 2001, both the Central District drift gillnet and eastside set gillnet fishing seasons opened on June 25 (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 2000 and commercial harvest of coho salmon of Kenai River origin in 2001 could be achieved. For the estimate of smolt production, the essential steps were: (1) estimate the number of smolt marked in 2000 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 2001 did not change over time, (2) estimate the proportion of the adult return in 2001 bearing coded wire tags, and (3) recover coded wire tags from known sample sizes from the commercial fishery.

Smolt Marking in 2000

Short-term mortality and tag loss were estimated to determine the total number of viable, adipose-clipped and tagged smolt released in 2000. 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 :

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

The total number of smolt that were marked, survived, and retained a tag at the Moose River in 2000 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 2001 Return

Estimating the commercial harvest of coho salmon of Kenai River origin in 2001 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 2000, but was estimated when adults returned in 2001 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 were 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 were 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 in 2000. 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. Samples were combined over weekly intervals and among sources for which inter-source differences were not detected (or were inconsequential) to provide a single estimate of the tagged proportion (θ) of the 2001 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, corrections for false negative wand results were made and the c_{gi} was estimated as:

$$c_{gi} = v'_{gi} / h_{gi}, \quad (3)$$

where:

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

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

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, and

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 2001. Combining all data was appropriate to obtain a reasonably precise estimate of the false-negative rate.

For the Russian River weir and Kenai River recapture event samples, no wand was used and the single, overall tag retention rate estimated from fish wheel samples was used to correct the adipose clip rate. Fish were not wanded to avoid physically detaining the spawning migration at the Russian River weir and to simplify handling for safety reasons in the mainstem recapture event. It is assumed that the tag retention rate is similar among all stocks within the Kenai River. Correcting the adipose-clip count in the Russian River weir and fish wheel samples allowed direct comparison of weekly and overall tagged proportions (θ) with 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 2001 return.

Smolt Abundance in 2000

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 2000,

C = the number of adult coho salmon examined for an adipose finclip in the 2001 return sample, and

R = the number of adult coho salmon in the 2001 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 were a representative sample of the drainage-wide smolt emigration in 2000 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 2000 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.

There is a high likelihood that all three conditions of assumption 1 (above) are fulfilled. Independence between the timing of tagging as smolt and adult return timing has been noted in all prior study years (Carlon 2000, 2003; Carlon and Hasbrouck 1994, 1996-1998; Carlon and Massengill *In prep*; Massengill and Carlon 2004). The independence is considered indicative of mixing of marked and unmarked fish after tagging. Additional analyses in prior years indicate that smolt emigrating 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.

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, 2003; Carlon and Hasbrouck 1994, 1996-1998; Carlon and Massengill *In prep*; Massengill and Carlon 2004) 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, 2003; Carlon and Hasbrouck 1994, 1996-1998; Carlon and Massengill *In prep*; Massengill and Carlon 2004) supporting the supposition that naturally missing adipose fins are rare.

Commercial Harvest in 2001

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 additionally stratified by statistical area or

a combination thereof representing a discrete fishery. The drift gillnet harvest was not stratified geographically 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):

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

where:

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

θ = the proportion of the 2001 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 2000 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 2000 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):

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

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 simulation.

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 2001 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, 2003; Carlon and Hasbrouck 1997, 1998; Carlon and Massengill *In prep*, Massengill and Carlon 2004). Pooling data among processors in 2001 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 2000

Smolt were marked with coded wire tags and adipose finclips as they emigrated from the Moose River during May 22 through June 8, 2000 (Appendix A1). During this period, 103,415 smolt were coded wire tagged. Of these, an estimated 103,319 survived the tagging process based on the estimated short-term survival rate (~ 99.9%). Of the surviving marked smolt, more than 99% retained tags resulting in an estimated 102,300 smolt that were released alive with tags. Although marked fish were released as late as June 8 (from the overnight retention and survival sample), marking was discontinued after the marking goal was achieved on June 7, 2000. The weir remained in place until June 29 allowing for a smolt emigration census. The total number of smolt arriving at the weir between May 22 and June 29, 2000 was 213,789.

TAGGED PROPORTION OF THE 2001 RETURN

Adults marked as smolt (with adipose finclips and coded wire tags) at the Moose River in 2000 returned to the Kenai River drainage in 2001. 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 0.171 [$\hat{V}(\hat{\theta}^{-1}) = 0.083$], 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 Wheel Sampling

Fish wheels were used exclusively to capture coho salmon in the capture event of the companion mark-recapture experiment to estimate adult abundance in 2001. Each fish wheel was generally operated during the daylight hours of each day from August 1 through September 30, 2001. Daily hours of operation varied based on personnel scheduling and fish wheel maintenance requirements, but averaged 14.2 hrs per day (J. Carlon, Alaska Department of Fish and Game, Division of Sport Fish, Soldotna, personal communication).

From August 1 through September 30, a total of 2,670 unique coho salmon were captured in the fish wheels and examined (Table 1 and Appendix A2). Of these, 458 (17.2%) were missing an adipose fin. The tag detection wand was used to check 363 of the adipose-clipped fish and a tag was detected in 361 (99.4%). The two adipose-clipped fish in which a tag was not detected by the wand were sacrificed to verify the negative wand results and no tag was found in either. Therefore, no correction factor was required to account for false negative wanding results in the calculation of the tag-bearing proportion from any of the five sample sources in 2001.

Of the 2,670 unique coho salmon captured in fish wheels, 1,822 were captured in the south bank fish wheel. Based on wand results, the weekly tagged proportion in the south bank fish wheel catch ranged from 0.110 to 0.267 and varied significantly over all weeks during which fish were examined ($P = 0.03$). The overall tagged proportion estimated by pooling the full season of south bank fish wheel data was 0.163.

An additional 848 coho salmon were captured in the north bank fish wheel. Based on wand results, the weekly tagged proportion ranged from 0.092 to 0.329 and varied significantly over all weeks when fish were examined ($P < 0.001$). The overall tagged proportion estimated by pooling the full season of north bank fish wheel data was 0.187. This tagged proportion was not significantly different from that estimated for the south bank fish wheel ($P = 0.12$). The data to estimate the tagged proportion were therefore pooled across both fish wheel sample sources to generate a single, season-wide estimate of the tagged proportion detected in the fish wheels (0.171, SE = 0.007).

Drift Gillnet Sampling

Drift gillnets were fished each day from August 1 through October 5, 2001. Of the 4,535 coho salmon captured in drift gillnets, 2,041 were captured and examined along the south bank (Table 1, Appendix A3). Because adipose-finclipped fish caught in gillnets were not checked with a tag detection wand, the weekly tagged fractions were estimated by correcting the weekly marked (adipose finclipped) fractions by the overall tag retention rate detected among the pooled fish.

Table 1.-Recoveries of coho salmon from multiple sources within the Kenai River drainage from August 1 through October 5, 2001 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]
			North Bank Fish Wheel					
08/01 - 08/07	46	5	0.109			0.993	0.108	0
08/08 - 08/14	130	12	0.092	9	9	1.000	0.092	0
08/15 - 08/21	247	41	0.166	41	40	0.976	0.162	1
08/22 - 08/28	77	11	0.143	11	11	1.000	0.143	0
08/29 - 09/04	117	22	0.188	12	12	1.000	0.188	0
09/05 - 09/11	46	13	0.283	7	7	1.000	0.283	0
09/12 - 09/18	76	24	0.316	24	24	1.000	0.316	0
09/19 - 09/25	82	27	0.329	27	27	1.000	0.329	0
09/26 - 09/30	27	5	0.185	5	5	1.000	0.185	0
Total	848	160	0.189	136	135	0.993	0.187	1
			South Bank Fish Wheel					
08/01 - 08/07	45	5	0.111			0.996	0.111	0
08/08 - 08/14	118	13	0.110	13	13	1.000	0.110	0
08/15 - 08/21	439	61	0.139	61	61	1.000	0.139	0
08/22 - 08/28	325	47	0.145	47	47	1.000	0.145	0
08/29 - 09/04	499	83	0.166	50	50	1.000	0.166	0
09/05 - 09/11	177	40	0.226	7	7	1.000	0.226	0
09/12 - 09/18	45	12	0.267	12	12	1.000	0.267	0
09/19 - 09/25	113	23	0.204	23	23	1.000	0.204	0
09/26 - 09/30	61	14	0.230	14	13	0.929	0.213	1
Total	1,822	298	0.164	227	226	0.996	0.163	1
			North Bank Gillnets					
08/01 - 08/07	9	2	0.222			0.994	0.221	0
08/08 - 08/14	319	67	0.210			0.994	0.209	0
08/15 - 08/21	491	133	0.271			0.994	0.269	1
08/22 - 08/28	451	155	0.344			0.994	0.342	1
08/29 - 09/04	363	121	0.333			0.994	0.331	1
09/05 - 09/11	196	62	0.316			0.994	0.315	0
09/12 - 09/18	230	73	0.317			0.994	0.316	0
09/19 - 09/25	284	88	0.310			0.994	0.308	0
09/26 - 10/02	101	15	0.149			0.994	0.148	0
10/03 - 10/05	50	14	0.280			0.994	0.278	0
Total	2,494	730	0.293			0.994	0.291	4

-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]
South Bank Gillnets								
08/01 - 08/07	11	2	0.182			0.994	0.181	0
08/08 - 08/14	310	33	0.106			0.994	0.106	0
08/15 - 08/21	340	65	0.191			0.994	0.190	0
08/22 - 08/28	361	62	0.172			0.994	0.171	0
08/29 - 09/04	230	33	0.143			0.994	0.143	0
09/05 - 09/11	195	52	0.267			0.994	0.265	0
09/12 - 09/18	138	31	0.225			0.994	0.223	0
09/19 - 09/25	182	49	0.269			0.994	0.268	0
09/26 - 10/02	199	33	0.166			0.994	0.165	0
10/03 - 10/05	75	21	0.280			0.994	0.278	0
Total	2,041	381	0.187			0.994	0.186	2
Russian River Weir								
07/12 - 07/17	0	0	0.000			0.994	0.000	0
07/18 - 07/24	0	0	0.000			0.994	0.000	0
07/25 - 07/31	0	0	0.000			0.994	0.000	0
08/01 - 08/07	4	1	0.250			0.994	0.249	0
08/08 - 08/14	69	6	0.087			0.994	0.086	0
08/15 - 08/21	387	29	0.075			0.994	0.075	0
08/22 - 08/28	651	138	0.212			0.994	0.211	1
08/29 - 09/04	1,727	160	0.093			0.994	0.092	1
09/05 - 09/11	838	87	0.104			0.994	0.103	0
09/12 - 09/18	2,494	272	0.109			0.994	0.108	1
09/19 - 09/25	2,457	270	0.110			0.994	0.109	1
09/26 - 10/02	953	105	0.110			0.994	0.110	1
10/03 - 10/05	111	7	0.063			0.994	0.063	0
Total	9,691	1,075	0.111			0.994	0.110	6
Combined North and South Banks Fish Wheels								
08/01 - 08/07	91	10	0.110	0	0	1.000	0.110	0
08/08 - 08/14	248	25	0.101	22	22	1.000	0.101	0
08/15 - 08/21	686	102	0.149	102	101	0.990	0.147	1
08/22 - 08/28	402	58	0.144	58	58	1.000	0.144	0
08/29 - 09/04	616	105	0.170	62	62	1.000	0.170	0
09/05 - 09/11	223	53	0.238	14	14	1.000	0.238	0
09/12 - 09/18	121	36	0.298	36	36	1.000	0.298	0
09/19 - 09/25	195	50	0.256	50	50	1.000	0.256	0
09/26 - 09/30	88	19	0.216	19	18	0.947	0.205	1
Total	2,670	458	0.172	363	361	0.994	0.171	3

-continued-

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 in samples from both riverbanks in the gillnets and 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 2000 based on tag detection results.

[d] Estimated proportion of the number examined bearing a coded wire tag originally implanted at the Moose River in 2000.

[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.

wheel samples. The resulting estimates of the weekly tagged proportion in the south bank catch ranged from 0.106 to 0.278 and varied significantly over all weeks during which fish were examined ($P = 0.0001$). The seasonal tagged proportion estimated by pooling all south bank gillnet data was 0.186. This pooled proportion did not differ significantly from that estimated from the fish wheel samples ($P = 0.17$).

An additional 2,494 coho salmon were captured along the north bank in gillnets. Estimated weekly tagged proportions ranged from 0.148 to 0.342 and varied significantly over all weeks during which fish were examined ($P = 0.0002$). The seasonal tagged proportion estimated by pooling all north bank gillnet samples was 0.291. This proportion differed significantly from that estimated from south bank gillnet samples ($P < 0.0001$) and from pooled fish wheel samples ($P < 0.0001$). 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 gillnet samples were excluded from calculating an overall estimate of the tagged proportion of the 2001 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, 2001, but the first coho salmon did not arrive at the weir until July 30 (Table 1, Appendix A4). Between July 30 and October 5, a total of 9,915 coho salmon were passed through the weir and 9,691 were examined for adipose fin status. Of these, 1,075 (11%) were missing an adipose fin. The weekly tagged fractions passing through the weir were estimated by correcting the weekly marked (adipose finclipped) fractions by the overall tag retention rate detected among the pooled fish wheel samples. The estimated weekly proportions of fish bearing a coded wire tag ranged from 0.063 to 0.249 and varied significantly among weekly periods ($P < 0.0001$). The tagged proportion estimated by pooling all Russian River weir data was 0.110. This proportion was significantly and substantially lower than that estimated from the pooled fish wheel samples ($P < 0.0001$), from the south bank gillnet samples ($P < 0.0001$), and from the north bank gillnet samples

($P < 0.0001$). The Russian River weir data were therefore excluded from the formulation of an overall estimate of the tagged proportion of the 2001 adult return and the final estimate of 0.171 was based solely on samples collected at the fish wheels.

SMOLT ESTIMATE IN 2000

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 gillnets 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 gillnets.

Based on the number of live smolt released with an adipose clip at the Moose River in 2000 (103,319), the number of adult coho salmon examined for adipose fin status in the Kenai River fish wheel samples in 2001 (2,670), and the number of adults in the sample that were missing an adipose fin (458), an estimated 601,236 (SE = 25,454) smolt emigrated from the Kenai River in 2000.

COMMERCIAL HARVEST IN 2001

General inlet-wide sampling is summarized to add perspective and to document the incidental 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 2001 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 2001 fishing season, 113,311 coho salmon were harvested in commercial fisheries of UCI (Table 2). This was the lowest harvest since 1973 and, excluding the anomalous 1997 fishing season, represents 35% of the 1991-2000 average (Fox and Shields 2001). About 59% of the 2001 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 (35%); other fisheries ranged from 4% to 13% (Figure 6).

Of the inlet-wide harvest, 70,579 fish (62%) were examined for adipose clips (Table 2). Adipose-clipped fish were found in all sampled fisheries. Exact fishery stratum of harvest (temporal/statistical area) could not be identified for 17,563 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, 385 were found with an adipose finclip (2%), heads were recovered from 383 fish, and a decodable tag was found in 333 of the recovered heads. Of the 333 decodable tags recovered, 54 had been implanted in smolt at the Moose River in 2000.

The remaining 53,016 examined fish were positively assigned to fishery strata (Appendix A6) and were used to calculate harvest estimates. Of these, 2,198 (4%) were missing the adipose fin and heads were collected from 2,191 of them. Of the 2,191 heads recovered, 190 (8.8%)

Table 2.-Sampling performance and recovery of coded wire tags (CWT) from coho salmon harvested in Upper Cook Inlet commercial fisheries in 2001.

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 2000
CENTRAL DISTRICT										
Central District Drift	39,418	16,808	43%	319	2%	319	34	11%	285	24
East Side Set (by Statistical Area)										
244-21	781	215	28%	7	3%	7	0	0%	7	7
244-22	973	281	29%	9	3%	9	2	22%	7	3
244-31/32	577	141	24%	3	2%	3	0	0%	3	1
244-41/42	1,915	611	32%	10	2%	10	0	0%	10	2
East Side Set Total	4,246	1,248	29%	29	2%	29	2	7%	27	13
Kalgin Is. Set	13,205									
West Side Set	10,514	2,506	24%	4	0%	4	1	25%	3	1
Mixed Drift/East Side Set[c]		756		14	2%	14	2	14%	12	1
Mixed Drift/West Side Set/Kalgin Island Set[c]		236		2	1%	2	0	0%	2	0
Mixed East Side Set[c]		46		2	4%	2	0	0%	2	1
Mixed West Side Set/Kalgin Island Set[c]		13,471		288	2%	286	41	14%	245	47
Central District Total	67,383	35,071	52%	658	2%	656	80	12%	576	87
NORTHERN DISTRICT										
West Side Set	14,763	8,687	59%	126	1%	126	18	14%	108	20
Pt. MacKenzie/Susitna Flats Set	14,382	12,453	87%	1,045	8%	1,038	94	9%	944	13
East Side Set	11,472	6,420	56%	168	3%	168	6	4%	162	110
Fire Island Set	5,311	4,894	92%	507	10%	507	38	7%	469	18
Mixed East Side Set/West Side Set[c]		558		43		43	1	2%	42	3
Northern District Total	45,928	33,012	72%	1,889	6%	1,882	157	8%	1,725	164
MIXED DISTRICTS										
Mixed Central District Drift/East Side Set/Northern District West Side Set [c]		2,163		26	1%	26	5	19%	21	0
Mixed Central District West Side Set/Northern District East Side Set[c]		314		9	3%	9	1	11%	8	2
Mixed District Total		2,477		35	1%	35	6	17%	29	2

-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 2000
AMBIGUOUS SAMPLES										
Northern District, Fire Island, 7/21/03 [d]		19		1	5%	1	0	0%	1	0
Unmixed and Unambiguous Fishery Total[e]	113,311	53,016	47%	2,198	4%	2,191	193	9%	1,998	199
Grand Total	113,311	70,579	62%	2,583	4%	2,574	243	9%	2,331	253

[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 were examined, but fishery was closed on this date and zero harvest was reported. Erroneous identification of the fishery is assumed to have occurred when the fish were examined.

[e] Sampling result totals for samples positively assigned to known fisheries throughout Upper Cook Inlet.

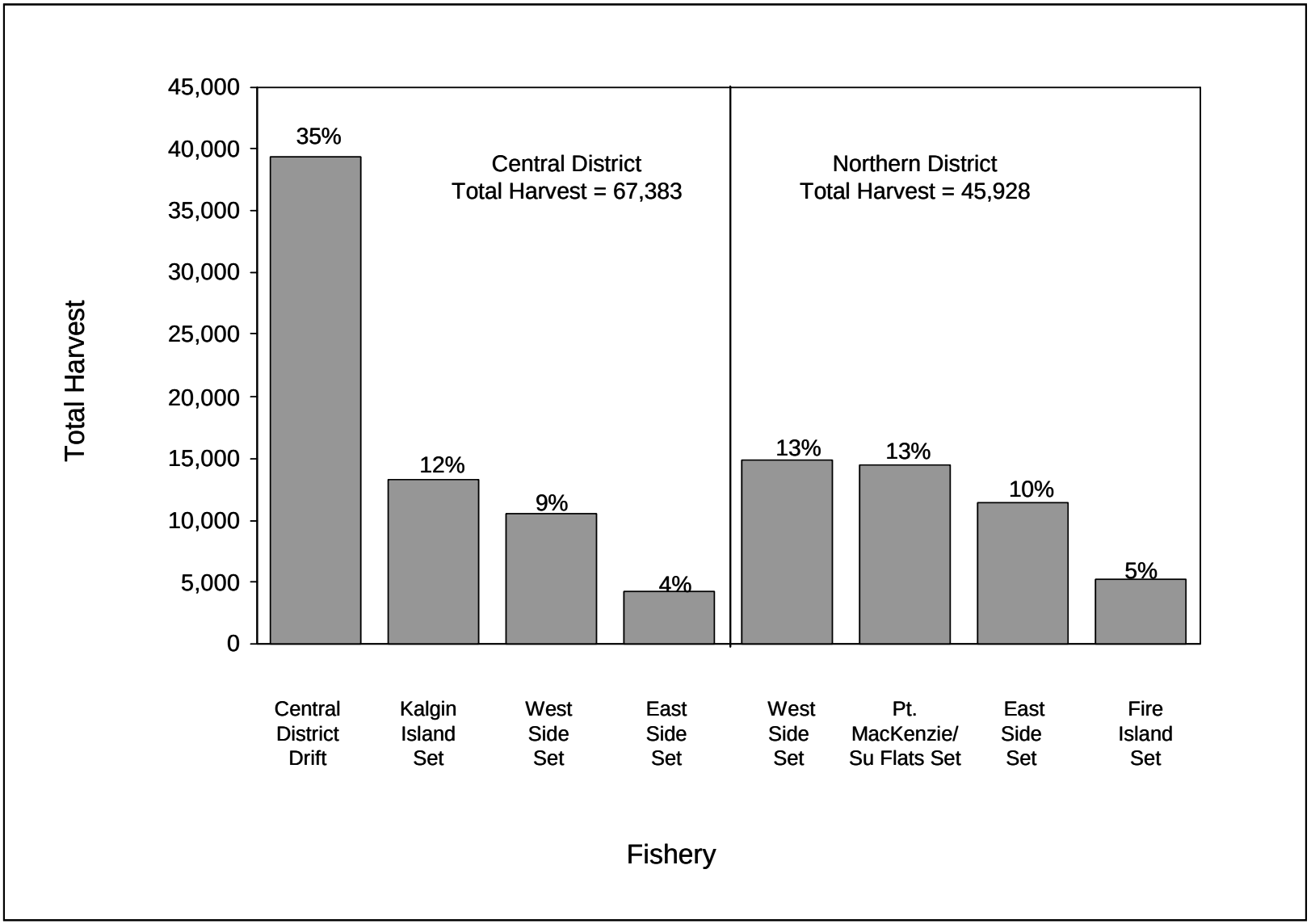

Figure 6.-Coho salmon harvest in eight Upper Cook Inlet commercial fishery areas in 2001.

contained no tag and an additional three were lost during the head dissection resulting in a total of 1,998 decodable tags. All but four of these tags had originated from UCI release locations in 2000, 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. The remaining four fish were also from UCI release locations, but were released in 1999 (Bosch et al. *In prep*).

Of the 1,998 decodable tags recovered from adults commercially harvested in known fishery strata, a total of 199 (10%) were originally released as smolt emigrating from the Kenai River drainage. All 199 were originally implanted in smolt emigrating from the Moose River in 2000. An unprecedented majority of the recoveries (81%) of Kenai River origin were obtained from Northern District fisheries while 19% were recovered from known Central District fisheries.

Among commercial processors receiving coho salmon harvested in the Central District eastside set gillnet fisheries, the proportion of examined coho that carried coded wire tags originating from the release of wild Moose River smolt tagged in 2000 did not exceed 0.05 (Figure 7). Among plants processing coho salmon harvested in the Central District drift gillnet fishery, the proportion did not exceed 0.02. The proportions did not differ radically among processors, therefore sampling summaries (and harvest estimates) that follow are based on samples pooled among processors.

Central District Drift Gillnet Fishery

During the 2001 fishing season, 39,418 coho salmon were harvested in the Central District drift gillnet fishery (Table 3). Excluding the anomalous fishery in 1997 (Ruesch and Fox 1998), the 2001 harvest was 23% of the 1991-2000 average.

The Central District drift gillnet fishery harvest was sampled on 13 of 15 fishing periods between the first open period on June 25 and the last on August 9. Adipose-finclipped fish were found on 10 of 13 dates sampled. Overall, 43% of the harvest was examined. The harvest occurring on days not sampled accounted for 0.1% of the total harvest.

A total of 16,808 fish were examined and positively assigned to drift fishery temporal strata (Table 2); all were therefore used to calculate harvest estimates. Of fish examined, 319 (2%) were missing the adipose fin and heads were collected from all. Of the 319 heads recovered, 285 contained decodable tags, 2 were lost during dissection, and the remaining 32 (10%) did not contain a tag. Of the decodable tags, 213 originated from the 2000 annual release of hatchery-produced smolt among multiple Northern District streams, 48 originated from a 2000 wild smolt tagging study in Cottonwood Creek (Northern District), and the remaining 24 were originally implanted in wild smolt emigrating from the Moose River (Kenai River drainage) in 2000. Therefore, of the 16,808 fish examined in this fishery, tags implanted at the Moose River in 2000 were physically recovered from 0.14%.

The first recoveries of fish bearing Moose River coded wire tags occurred on July 19, some 25 days after the first fishing period. Coho salmon marked at the Moose River were recovered on 3 of 13 sampled days between June 25 and the close of the fishing season on August 9.

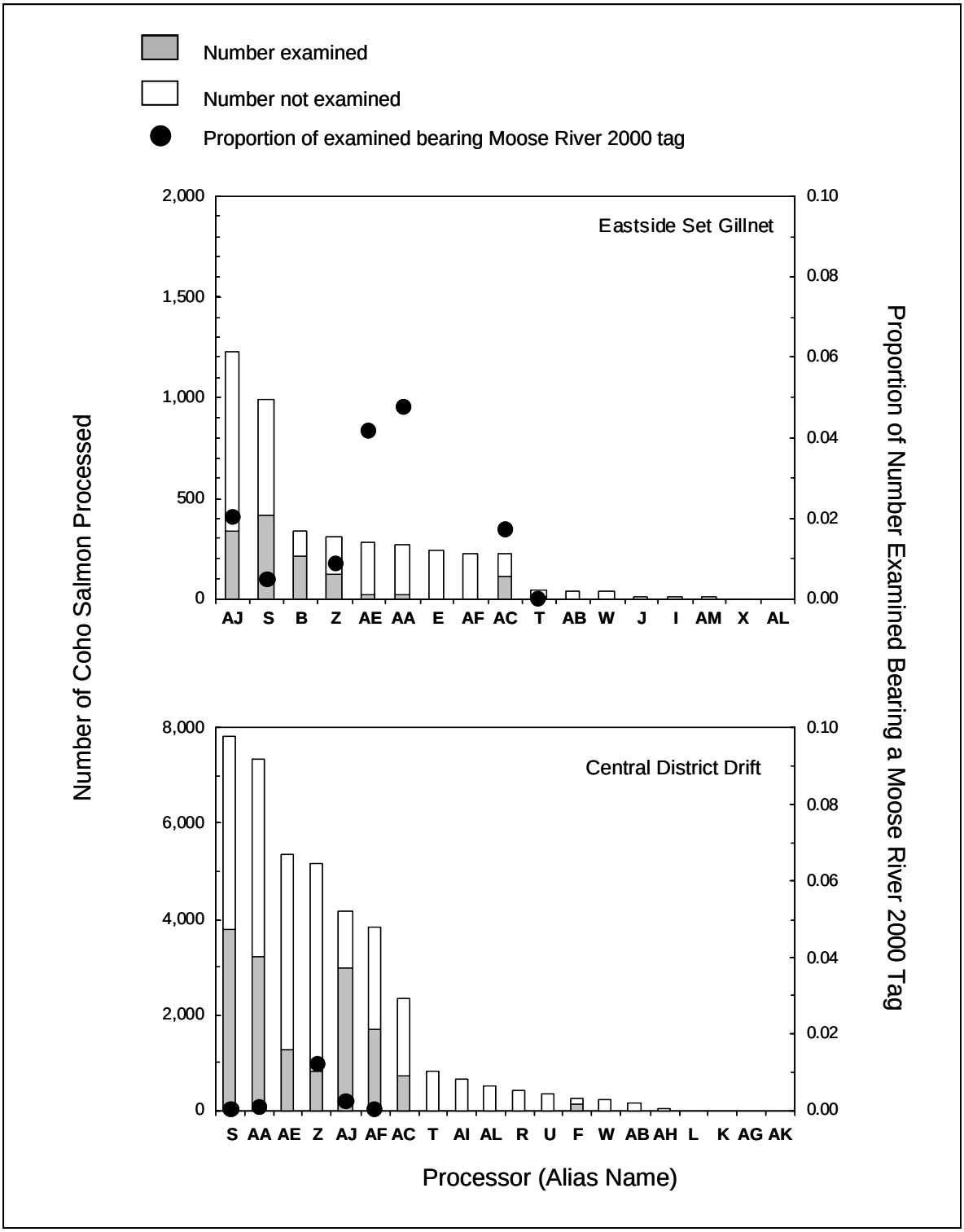

Figure 7.-Number of coho salmon harvested and processed in 2001 in the East Side set net fishery (top) and Central District drift fishery (bottom) of Upper Cook Inlet by commercial processor (alias name) and proportion of examined fish that were originally marked at the Moose River in 2000.

Table 3.-Estimated harvest, and associated standard errors, 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, 2001.

Interval	Total Harvest	Estimated Harvest of Coho Salmon of Kenai River Origin	Standard Error	Percent of Total Harvest
6/25 - 7/5	851	0	0	0.0%
7/6 - 7/17	11,697	0	0	0.0%
7/18 - 7/26	13,443	15	14	0.1%
7/27 - 8/5	6,073	61	26	1.0%
8/6 - 8/9	7,354	206	47	2.8%
Total	39,418	282	56	0.7%

Central District Eastside Set Gillnet Fishery

During the 2001 fishing season, a total of 4,246 coho salmon were harvested in the Central District eastside set gillnet fishery. Excluding the anomalous fishery in 1997 (Ruesch and Fox 1998), the 2000 harvest was 12% of the 1991-2000 average.

Between the first open period on July 2 and the last on July 28, the Central District eastside set gillnet fishery harvest was sampled on 13 of 19 total fishing periods. Adipose-finclipped fish were found on 8 of 13 dates sampled. Overall, 29% of the harvest (1,248) was examined and positively assigned to spatial-temporal strata. The harvest occurring on days not sampled accounted for 4.4% of the total harvest.

Of the 1,248 fish sampled and assigned to fishery strata, 29 were missing the adipose fin and heads were collected from all (Table 2). Of the 29 heads recovered, 2 (7%) had no tag, resulting in a total of 27 decodable tags. Of these decodable tags, 11 originated from the 2000 annual release of hatchery-produced smolt among multiple Northern District streams, 3 originated from the 2000 wild smolt tagging study in Cottonwood Creek, and the remaining 13 were originally implanted in wild smolt emigrating from the Moose River in 2000. Therefore, of the 1,248 fish examined in this fishery, tags implanted at the Moose River in 2000 were physically recovered from 1%.

Coho salmon marked at the Moose River in 2000 were recovered from all statistical areas in 2001 (Appendix A5). The first recovery of Moose River tags occurred on July 25 in statistical areas 24421 and 24431/32 and on July 26 in statistical areas 24422 and 24441/42. Coho salmon marked at the Moose River were recovered on 3 of 13 sampled days between June 25 and the close of the fishing season on August 9. The portions of fish examined in 2001 that had been marked as smolt at the Moose River in 2000 were 3.3%, 1.1%, 0.7%, and 0.3% for statistical areas 24421, 24422, 24431/32, and 24441/42, respectively.

Northern District Gillnet Fisheries

During the 2001 fishing season, a total of 45,928 coho salmon were harvested among all Northern District set net fisheries. Excluding the anomalous fishery in 1997 (Ruesch and Fox 1998), the 2001 harvest was 53% of the 1991-2000 average.

Between the first open fishing period on July 2 and the last on September 24, Northern District fisheries were sampled on 16 of 23 total fishing periods. Adipose-finclipped fish were found on all sampled days. Collectively, the harvest among all Northern District fisheries was sampled the most intensively of all UCI fisheries with 33,012 fish examined (72% of the harvest). Of all fish examined, 32,454 could be positively assigned to a fishery stratum and were used to calculate harvest estimates. The harvest occurring on days not sampled accounted for 0.9% of the total harvest.

Of the 32,454 fish examined and assigned to fishery strata, 1,846 (5.6%) were missing the adipose fin and heads were collected from all but 7. Of the 1,839 heads recovered, 155 (8%) had no tag, and 1 tag was lost during dissection resulting in a total of 1,683 decodable tags. Of these decodable tags, 1,124 originated from the 2000 annual release of hatchery-produced smolt among multiple Northern District streams, 394 originated from the 2000 wild smolt tagging study in Cottonwood Creek, 2 originated from the 1999 annual release of hatchery-produced smolt in Northern District streams, 2 originated from the 1999 wild smolt tagging study at Cottonwood creek, and the remaining 161 were originally implanted in wild smolt emigrating from the Moose River tributary to the Kenai River in 2000. Therefore, of the 32,454 fish examined among Northern District fisheries, tags implanted at the Moose River in 2000 were physically recovered from 0.5%. Of the 161 tags recovered, 110 were recovered from the eastside set gillnet fishery, 18 from the Fire Island fishery, 13 from the Pt. Mackenzie/Susitna Flats fishery, and 20 from the westside fishery.

Commercial Harvest Estimates

Based on commercial catch sampling data and the point estimate of the tagged proportion of the 2001 adult return to the Kenai River, a set of commercial harvest estimates was generated for UCI commercial fisheries in 2001. An estimated 282 (SE = 56) coho salmon of Kenai River origin were harvested by the Central District drift gillnet fishery (Table 3), 349 (SE = 110) by the Central District eastside set gillnet fishery (Table 4), and 1,303 (SE = 125) by all Northern District set gillnet fisheries (Appendix A6) for a combined total of 1,934 (SE = 176) fish harvested during 2001. Coho salmon of Kenai River origin comprised 0.7% of the total drift gillnet harvest, 8.2% of the total eastside set gillnet harvest, and 2.8% of the total Northern District set gillnet harvest in 2001.

Between the first Central District drift gillnet fishing period on June 25 and the detection of the first Kenai River-bound coho salmon on July 19, the harvest of 12,548 coho salmon represented 32% of the total coho salmon harvest in this fishery in 2001. All of the harvest of coho salmon of Kenai River origin occurred during five fishery openings distributed over a 19-day period between July 19 and August 6. The minimal harvest (relative to prior fishing seasons) precluded the detection of meaningful trends. However, the greatest proportional contribution (2.8%) and the greatest absolute harvest (206) occurred during the last four days of the fishery (Figure 8).

Table 4.-Total harvest and estimated contribution of coho salmon of Kenai River origin to the eastside set gillnet fishery of Upper Cook Inlet by statistical area and selected time intervals, 2001.

Interval	Total Harvest	Estimated Contribution	Standard Error	Portion of Total Harvest
		Statistical Area 244-21		
7/2 - 7/6	10	0		
7/7 - 7/12	18	0		
7/13 - 7/18	147	0		
7/19 - 7/24	234	0		
7/25 - 7/28	372	175	75	47.0%
Total	781	175	75	22.4%
		Statistical Area 244-22		
7/2 - 7/6	10	0		
7/7 - 7/12	14	0		
7/13 - 7/18	130	0		
7/19 - 7/24	347	0		
7/25 - 7/28	472	93	54	19.7%
Total	973	93	54	9.6%
		Statistical Area 244-31/32		
7/2 - 7/6	3	0		
7/7 - 7/12	26	0		
7/13 - 7/18	122	0		
7/19 - 7/24	210	0		
7/25 - 7/28	216	59	58	27.3%
Total	577	59	58	10.2%
		Statistical Area 244-41/42		
7/2 - 7/6 [a]				
7/7 - 7/12	36	0		
7/13 - 7/18	765	0		
7/19 - 7/24	915	0		
7/25 - 7/26	199	22	15	11.1%
Total	1,915	22	15	1.1%
		Combined Statistical Areas		
7/2 - 7/6	23	0		
7/7 - 7/12	94	0		
7/13 - 7/18	1,164	0		
7/19 - 7/24	1,706	0		
7/25 - 7/28	1,259	349	110	27.7%
Total	4,246	349	110	8.2%

[a] No fishing periods occurred during this time period in Statistical Area 244-41/42.

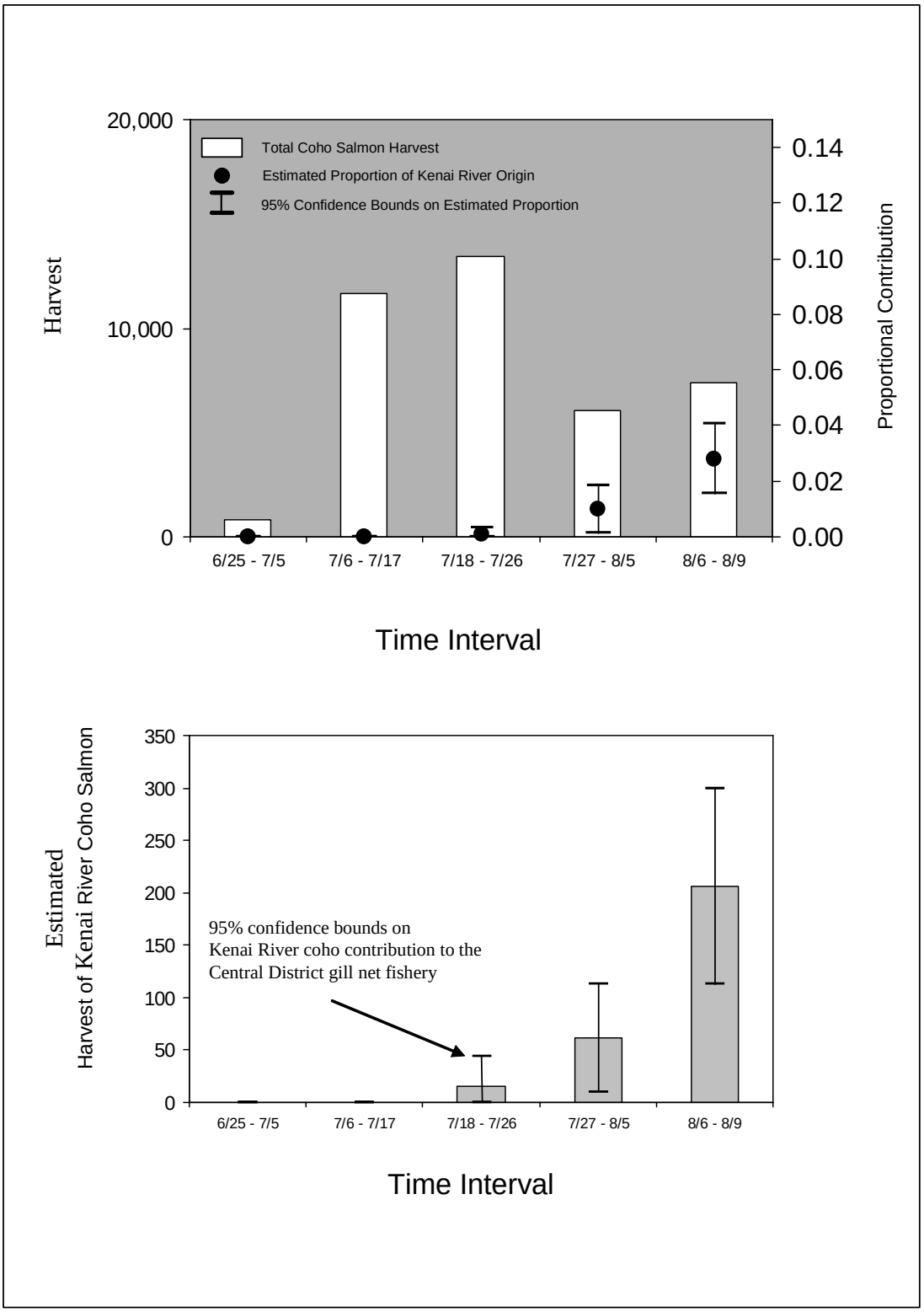

Figure 8.–Temporal trend in proportional contribution of Kenai River coho salmon to the total harvest (top) and trend in absolute contribution (bottom) occurring in the drift gillnet fishery of the Central District of Upper Cook Inlet, 2001.

Between the first Central District eastside set gillnet fishing period on July 2 and the detection of the first Kenai River-bound coho salmon on July 25, the harvest of 2,987 coho salmon represented 70% of the total coho salmon harvest in this fishery in 2001. The minimal harvest (relative to prior fishing seasons) precluded the detection of meaningful trends. However, 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 absolute harvest of Kenai River-bound fish occurred during the last week of July.

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 four areas (Figure 10). The end result was a similar absolute harvest within all statistical areas for Kenai River-bound coho salmon.

The first coho salmon of Kenai River origin were detected in the Northern District set gillnet harvest on July 30th. The harvest of 9,795 coho salmon before July 30 represents 21% 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 11) and the greatest total harvest occurred after the first week in August.

Among statistical areas of the Northern District set gillnet fishery, the estimated harvest of 961 coho salmon of Kenai River origin in the eastside setnet area was substantially higher than the remaining three areas (Figure 12).

Effect of Variations of the Tagged Proportion on Commercial Harvest Estimates

Although the sample of fish examined in the pooled fish wheel catch likely provided an accurate estimate of the overall tagged proportion in the 2001 adult population, it is uncertain if the sample provided an accurate estimate of the tagged proportion of the population as it passed through marine commercial fisheries of UCI. The general increasing trend in the proportion over the first 7 weeks of inriver sampling (8/1 through 9/18) followed by a decline over the last 2 sampling weeks did not fulfill the study design requirement of a constant tagged proportion necessary for accurate harvest contribution estimates ($\chi^2 = 47.21$, df = 8, $P < 0.001$).

A test was therefore 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 targeted UCI fisheries and examined for practical differences (Table 5). Estimates were calculated using the estimated tagged proportion based on pooled samples (0.191), the minimum weekly proportion (0.101) and the maximum (0.298). The resulting minimum and maximum harvest estimates therefore represent what we believe to be plausible, but unlikely, for commercial harvest estimates. The minimum and maximum harvest estimates (summed among all fisheries) differed from the pooled estimate by 69% and 43%, respectively. The maximum difference from the pooled estimates represented 0.5% of the total drift gillnet harvest, 2% of the total Northern District harvest, and 6% of the total eastside set gillnet harvest, and 1% of the harvest occurring in these combined fisheries.

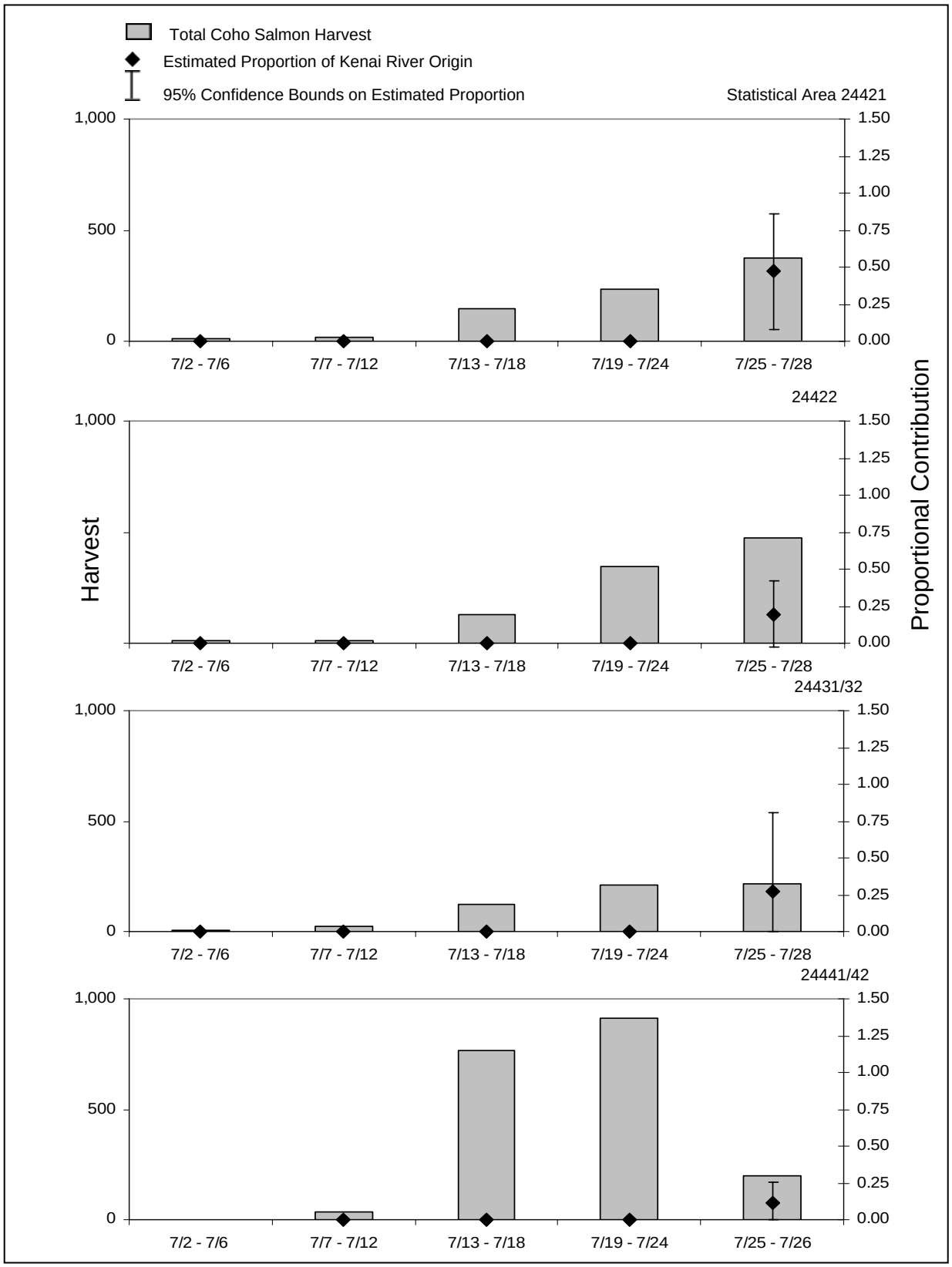

Figure 9.-Temporal trends in total harvest of coho salmon and proportional contribution of coho salmon from the Kenai River to the total harvest occurring in four statistical areas of the Upper Cook Inlet Central District eastside set gillnet fishery during five selected time periods in 2001.

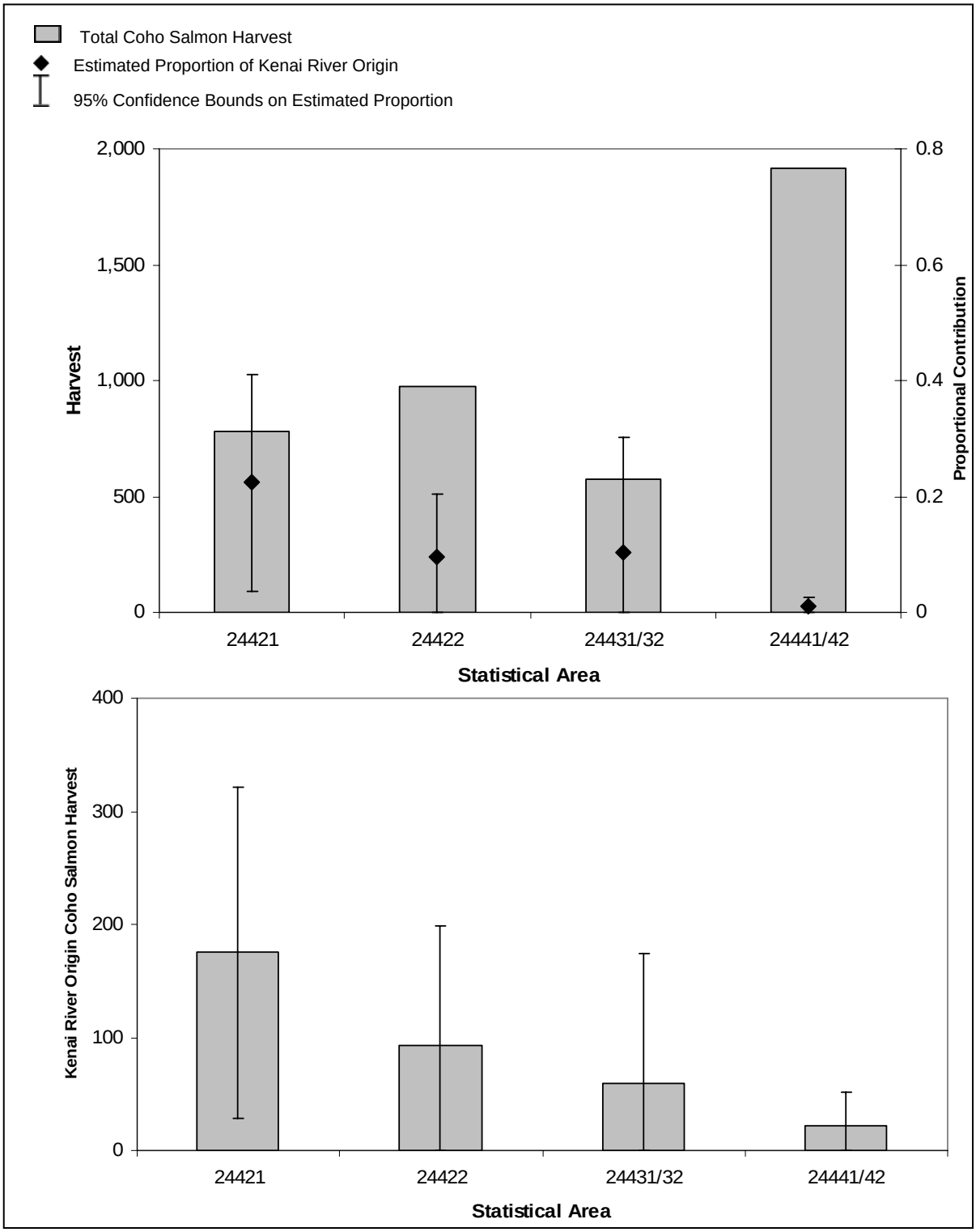

Figure 10.-Geographic trends in total coho salmon harvest and proportional contribution of coho salmon of Kenai River origin (top) and in estimated number of coho salmon of Kenai River origin (bottom) harvested amongstatistical areas in the eastside set gillnet fishery of the Central District of Upper Cook Inlet, 2001.

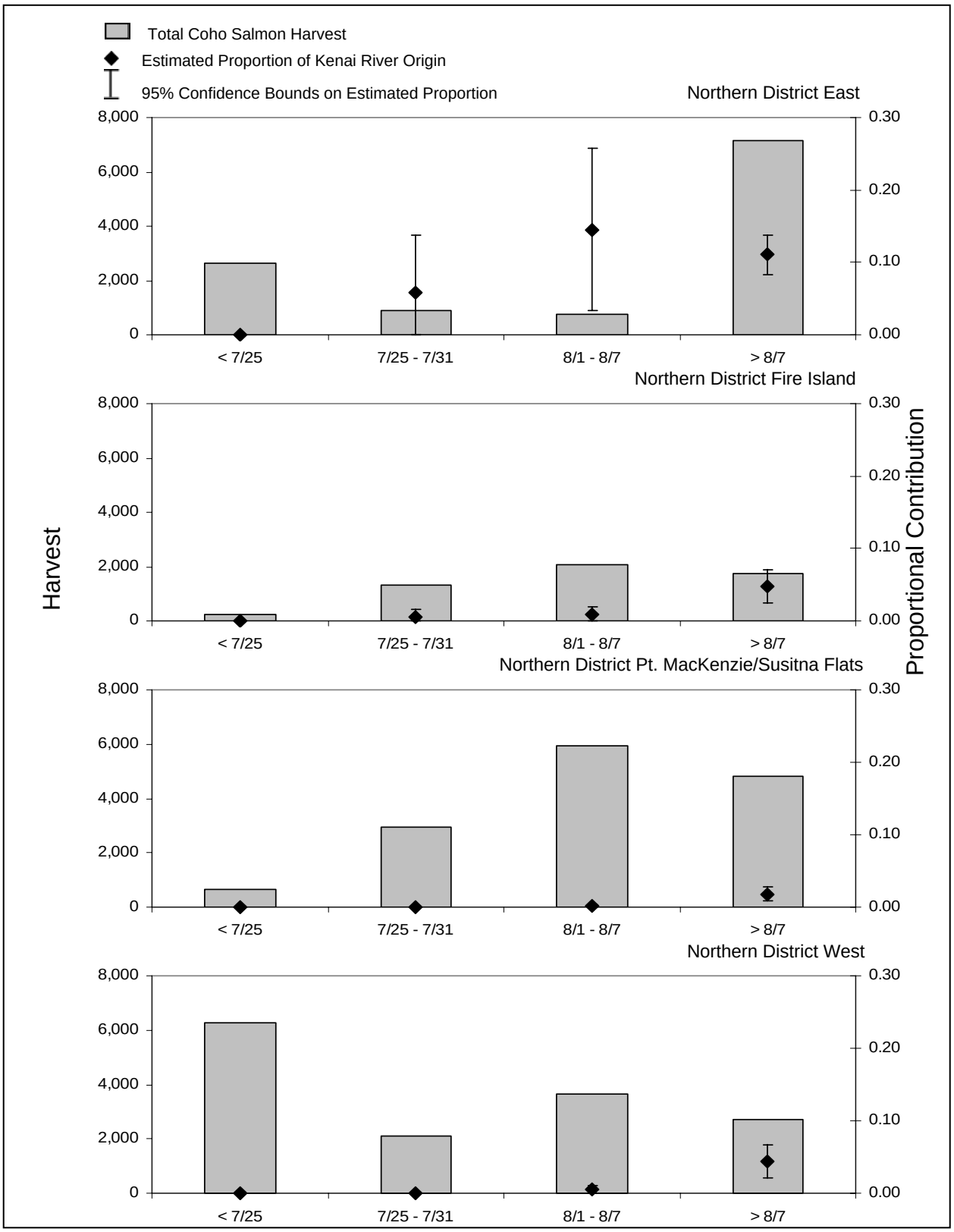

Figure 11.-Temporal trends in total harvest of coho salmon and proportional contribution of coho salmon from the Kenai River to the total harvest occurring in four set gillnet fisheries of the Upper Cook Inlet Northern District during four selected time periods in 2001.

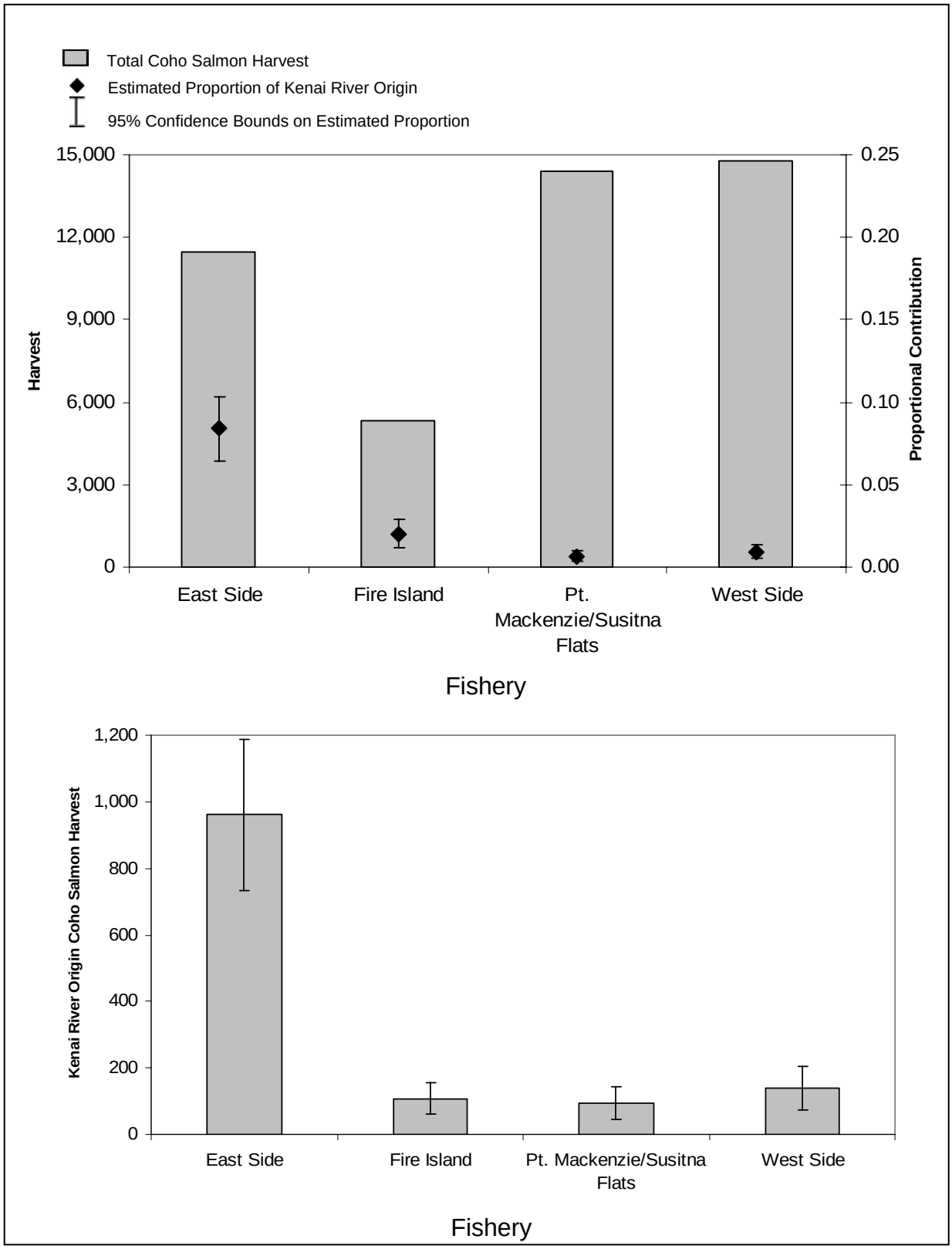

Figure 12.-Geographic trends in total coho salmon harvest and proportional contribution of coho salmon of Kenai River origin (top) and in estimated number of coho salmon of Kenai River origin (bottom) harvested among set gillnet fisheries of the Northern District of Upper Cook Inlet, 2001.

Table 5.-Sensitivity of commercial harvest estimates to maximum temporal variations in the tagged proportion estimated from pooled samples of coho salmon captured by fish wheels from the Kenai River, 2001.

		Pooled Marked Proportion (0.191)	Marked Proportion: Minimum (0.101)				Marked Proportion: Maximim (0.298)			
Fishery	Total Harvest	Estimated Contribution[a]	Estimated Contribution[a]	Difference from Pooled	% Difference from Pooled	Difference from Pooled as % of Total Harvest	Estimated Contribution[a]	Difference from Pooled	% Difference from Pooled	Difference from Pooled as % of Total Harvest
Central District Drift Gillnet	39,418	282	477	195	69%	0.5%	162	-120	-43%	0.3%
Central District East Side Set Gillnet[b]										
244-21	781	175	297	122	70%	16%	101	-74	-42%	9.5%
244-22	973	93	158	65	70%	7%	53	-40	-43%	4.1%
244-31/32	577	59	99	40	68%	7%	34	-25	-42%	4.3%
244-41/42	1,915	22	38	16	73%	1%	13	-9	-41%	0.5%
Combined	4,246	349	592	243	70%	6%	201	-148	-42%	3.5%
Northern District Set Gillnet	45,928	1,303	2,204	901	69%	2%	745	-558	-43%	1.2%
Total[c]	89,592	1,934	3,273	1,339	69%	1%	1,108	-826	-43%	0.9%

[a] Kenai River population-specific harvest estimate.

[b] By statistical area and combined.

[c] Sum of estimates for Central District drift gillnet, Central District eastside set gillnet, and Northern District set gillnet fisheries.

DISCUSSION

COMMERCIAL HARVEST

Bias in the point estimates of commercial harvest is almost certain because commercial harvest estimates were based on a pooled estimate of the tagged proportion when it is known that there was significant temporal variability of the proportion in the Kenai River samples. However, it was considered unreasonable to abandon the commercial harvest contribution estimates without evaluating the potential magnitude and meaning of the bias; minimally biased estimates are of value for assessment and planning purposes. The sensitivity analysis indicates that the point estimates of harvest are of some value. The extreme estimate of the Kenai River coho salmon contribution (3,273) represents 3.7% of the total UCI commercial harvest versus 2.2% for the estimate based on the pooled marked proportion. When focusing on the effect on the harvest of Kenai River-bound coho salmon, the extreme estimate represents 5.8%, versus 3.4% (for the estimate based on the pooled marked proportion) of the combined sport and personal use harvest of coho salmon from the Kenai River. However, we do acknowledge that while the difference among these percentages is small, the choice of estimate of marked proportion (pooled or otherwise) does have an appreciable effect on the estimate of commercial harvest of Kenai River-bound coho salmon. The above observations reflect the fact that the commercial harvest of Kenai River-bound coho salmon is small, relative to the sport and personal use fisheries. The qualified estimates are presented for discussion and are considered meaningful for current research and management purposes.

At present, there has been no evaluation of migration rates of Kenai River-bound coho salmon in the marine waters of UCI or the lower 44 km of the Kenai River. 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 2001 and has been detected annually since 1998 (Carlon 2003, Carlon and Massengill *In prep*, Massengill and Carlon 2004).

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 94% less than the 1993-2000 average (Table 6). Reasons contributing to this decline likely include restrictions imposed on commercial fisheries beginning in 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 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). In addition, emergency closures in 2001 prevented fishing within the Central District eastside set areas after July 28, 2001. In previous recent years, the eastside set gillnet

Table 6.-Estimated total harvest of coho salmon of Kenai River origin in UCI marine commercial fisheries, 1993-2001.

	Central District		Northern	
	Drift	Eastside	District	
Year	Gillnet	Set Gillnet	Set GillNet	Total
1993	930	6,806	148	7,884
1994	11,732	14,673	477	26,882
1995	6,956	13,152	582	20,690
1996	2,671	11,856	29	14,556
1997	1,236	2,093	36	3,365
1998	1,974	8,096	175	10,245
1999	818	2,905	171	3,894
2000	531	2,351	83	2,965
Average	3,356	7,742	213	11,310
2001	282	349	1,303	1,934

Sources: Carlon 2000, 2003; Carlon & Hasbrouck 1996-1998; Carlon and Massengill *In prep*; Massengill and Carlon 2004.

fishery was open on scheduled fishing periods through approximately August 10, a time when the greatest proportion of Kenai River coho salmon are usually harvested.

Typically, a substantial portion of the Kenai River-bound coho salmon harvest 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, 2003; Carlon and Hasbrouck 1996-1998; Carlon and Massengill *In prep*, Massengill and Carlon 2004). The additional restrictions imposed by the management plan during the 2001 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 ninth year in a row (Carlon 2000, 2003; Carlon and Hasbrouck 1996-1998; Carlon and Massengill *In prep*, Massengill and Carlon 2004 and Figure 13).

An estimated 1,303 Kenai River origin coho salmon were harvested from the combined Northern District set gillnet fisheries in 2001. Of the four fishery areas comprising the Northern District, the greatest harvest (961) occurred in the eastside set gillnet fishery. Previously, the highest combined Northern District harvest of Kenai River origin coho salmon (582) occurred in 1995. The total 2001 Northern District harvest of 1,303 Kenai River-bound coho salmon was 123% greater than that reported for 1995.

The cause of this geographic anomaly in harvest is unclear. Because sampling efficiency in both the Northern and Central District target fisheries is high (71% and 41% respectively), an

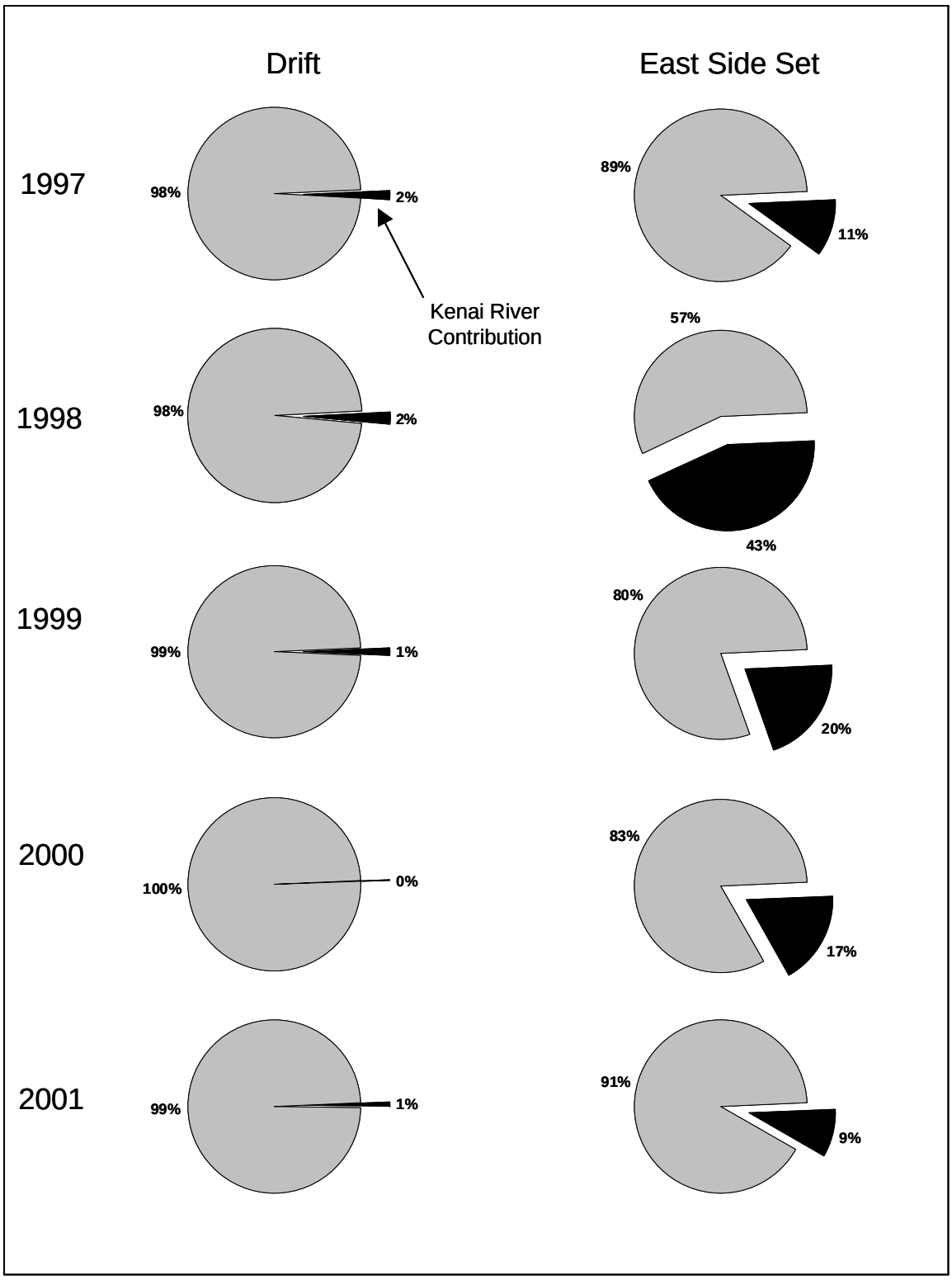

Figure 13.-Recent contribution of coho salmon from the Kenai River to the drift and eastside set gillnet commercial fisheries of Upper Cook Inlet, 1997-2001 (1993-1996 contribution proportions are similar).

abnormally large Northern District harvest of Kenai River origin coho salmon does not appear to be a result of sampling bias. If this geographic shift in harvest distribution persists or intensifies, it could become a potential management concern, especially during years when Kenai River coho salmon returns are perceived to be weak.

SMOLT ABUNDANCE

History

The record of estimated smolt abundance has become an important element of the population assessment program. The complete record since 1992 (Figure 14) has been cited by the Department as a basis for recommending conservation actions. Recommendations were based on a relative decline in smolt abundance between 1993 and 1995 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.

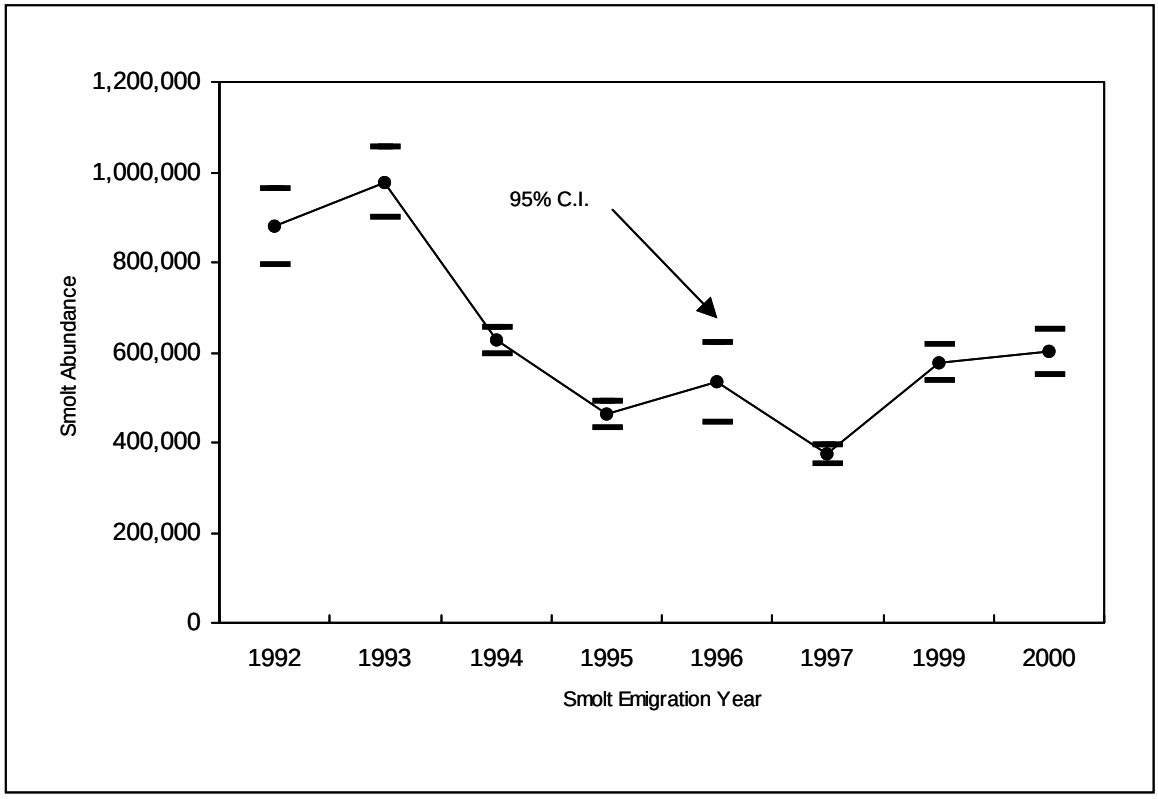

Figure 14.-Estimates of coho salmon smolt abundance in the Kenai River, 1992-2000.

Although the smolt abundance record was the impetus for developing the plan, the record was not originally intended for this purpose. 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 yet known if the decline in smolt abundance was

harvest-induced, natural, or a combination of both. In fact, since recommendations were made, there has been no declining trend in smolt abundance.

Smolt abundance estimates had been the sole population assessment "barometer" from 1995-1998, when smolt abundance was 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 annually. 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 estimate of smolt production from a known escapement (1999) will become available in 2003 when the 2002 smolt production will be estimated. Until a series of 'smolt-per-spawner' (or 'return-per-spawner') estimates becomes available, the long-term approach of relating smolt production to parent year harvest will be monitored.

Relationship Between Total Harvest and Smolt Abundance

The 2000 smolt abundance represents the ninth such annual estimate since 1992. From 1993 through 2000, eight annual estimates of total adult harvest have also been made (Table 7 and Figure 15). The pairing of these two records produces five pairs of harvest and subsequent smolt abundance estimates (Figure 16). The newly available 2000 smolt abundance estimate, when paired with the 1997 total harvest estimate, represents the fifth such pair available to date. While the relationship does not clearly identify a threshold harvest beyond which smolt abundance is significantly, negatively, and consistently influenced (there is no significant correlation between harvest and smolt abundance to date), it does suggest 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 sufficient assessment 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, five 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 guidelines if continued.

Table 7.-Total harvest of coho salmon of Kenai River origin in UCI inriver and marine commercial fisheries, 1993-2001.

	Inriver							UCI Marine Commercial[b]				
	Sport[a]					Personal						
	Mainstem			Russian		Use/	Inriver	Eastside	Drift	Northern	Commercial	Grand
Year	Unguided	Guided	Total	River	Total	Subsisten	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
1999	23,550	8,087	31,637	3,910	35,547	1,009 [g]	36,556	2,905	818	171	3,894	40,450
2000	39,170	9,349	48,519	3,938	52,457	1,449 [g]	53,906	2,351	531	83	2,965	56,871
Averag	27,674	15,998	43,671	4,077	47,749	1,419	49,168	7,742	3,356	213	11,310	60,478
2001	36,264	13,563	49,827	5,222	55,049	1,555 [g]	56,604	349	282	1,303	1,934	58,563

[a] Sources: Statewide Harvest Survey (Howe et al 1995, 1996, 2001a-d; Jennings et al. 2004; Mills 1994; Walker et al. 2003). 1996-1999 are revised estimates. Mainstem unguided includes Skilak Lake.

[b] Carlon 2000, 2003; Carlon & Hasbrouck 1996-1998; Carlon and Massengill *In prep*, J. Carlon, Alaska Department of Fish and Game, Division of Sport Fish, personal communication.

[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 estimates of harvest from permits not returned (S. Sonnichsen, ADF&G, Anchorage, personal communication, 3/5/02).

[g] Reimer and Sigurdsson *In prep.*

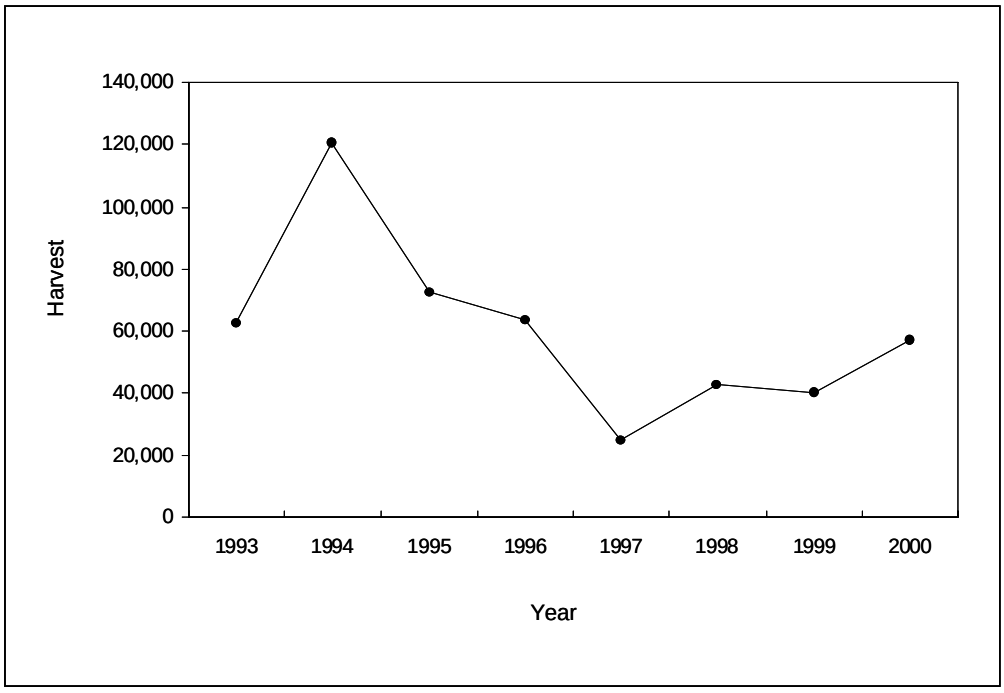

Figure 15.-Estimates of total harvest of coho salmon of Kenai River origin by combining estimates of commercial marine harvest with inriver estimates of personal use, mainstem sport, and Russian River sport harvest, 1993-2000.

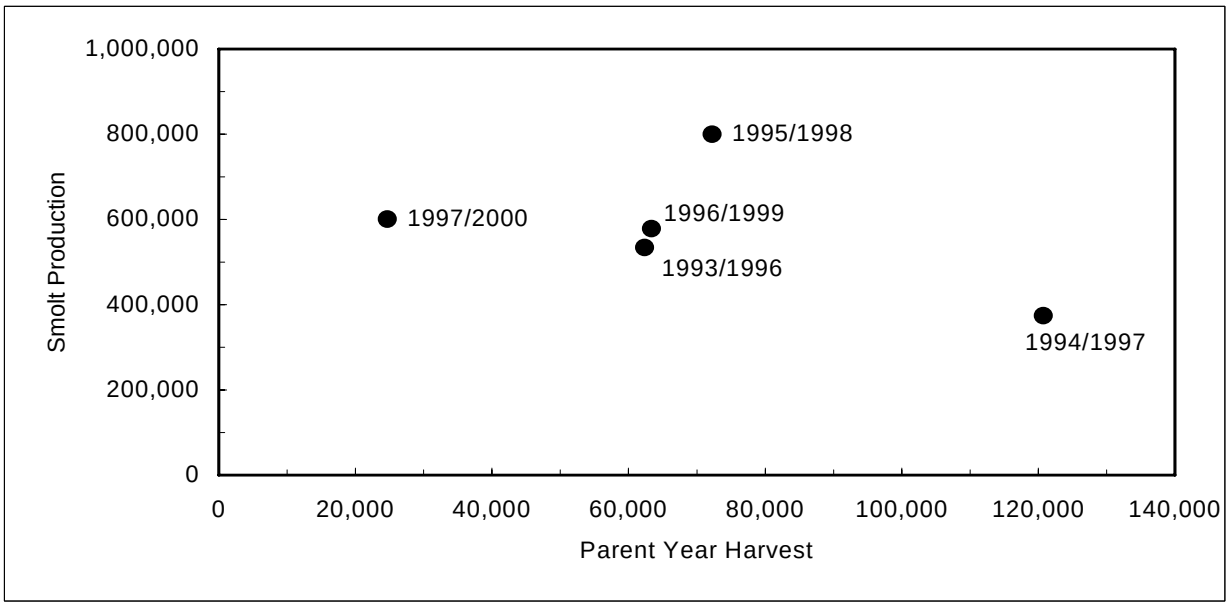

Figure 16.-Available points in the long-term assessment approach of relating smolt production to parent year harvest for coho salmon from the Kenai River, Alaska.

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 annually, should be continued to enhance the assessment of the population of coho salmon from the Kenai River.

ACKNOWLEDGMENTS

The following people comprised the team that marked smolt at the Moose River in 2000. Kurt Strausbaugh was the field project leader and participated in all phases of field investigation. Sandee Simons, Jake Glotfelty, Myke Bon, Stan Walker, and James Cannava assisted with all phases of the field investigation including logistical support, weir operation and maintenance, and smolt tagging and enumeration. "Cotton" and Lorraine Moore granted convenient access to the Moose River as did Jim and Jane Fellman. Dr. Bill West granted access to a convenient boat launch on the Moose River.

The commercial harvest was examined in 2001 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 2000 and 2001. All CFD personnel contributed to the successful achievement of study objectives.

Jim Hasbrouck and David Evans provided in-depth, biometric and editorial reviews of the operational plan and this report. Saree Timmons and Margaret Leonard provided the final technical and formatting reviews and prepared the final manuscript.

REFERENCES CITED

Bendock, T. N., and K. Vaught. 1994. Feasibility of using sonar to estimate adult coho salmon returns to the Kenai River. Alaska Department of Fish and Game, Fishery Data Series No. 94-50, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds94-50.pdf

Bernard, D. R., and J. E. Clark. 1996. Estimating salmon harvest based on return of coded-wire tags. Canadian Journal of Fisheries and Aquatic Sciences 53:2323-2332.

Bosch, D. E., D. G. Evans, P. Cyr, and J. J. Hasbrouck. *In prep*. Estimates of commercial and sport harvest and escapement in 1999-2001 of coho salmon stocks into Northern Cook Inlet streams in 1998-2000. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Brannian, L., and J. Fox. 1996. Upper Cook Inlet subsistence and personal use fisheries, report to the Alaska Board of Fisheries, 1996. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development. Regional Information Report N0. 2A96-03. Anchorage.

Carlon, J. A. 1992. Feasibility of capturing and marking juvenile coho salmon for stock assessment in the Kenai River. Alaska Department of Fish and Game, Fishery Data Series No. 92-57, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds92-57.pdf

Carlon, J. A. 2000. Assessment of coho salmon from the Kenai River, Alaska, 1997. Alaska Department of Fish and Game, Fishery Data Series No. 00-15, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds00-15.pdf

Carlon, J. A. 2003. Assessment of coho salmon from the Kenai River, Alaska, 1998. Alaska Department of Fish and Game, Fishery Data Series No. 03-06, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds03-06.pdf

Carlon, J. A., and J. J. Hasbrouck. 1993. Marking juvenile coho salmon in the Kenai River with coded microwire tags. Alaska Department of Fish and Game, Fishery Data Series No. 93-52, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds93-52.pdf

Carlon, J. A., and J. J. Hasbrouck. 1994. The contribution of Kenai River coho salmon to commercial fisheries of upper Cook Inlet, Alaska in 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-52, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds94-52.pdf

Carlon, J. A., and J. J. Hasbrouck. 1996. Estimated harvest of coho salmon of Kenai River origin in commercial fisheries of Upper Cook Inlet, Alaska, 1993-1994. Alaska Department of Fish and Game, Fishery Data Series No. 96-7, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds96-07.pdf

Carlon, J. A., and J. J. Hasbrouck. 1997. Assessment of coho salmon from the Kenai River, Alaska, 1995. Alaska Department of Fish and Game, Fishery Data Series No. 97-7, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds97-07.pdf

Carlon, J. A., and J. J. Hasbrouck. 1998. Assessment of coho salmon from the Kenai River, Alaska, 1996. Alaska Department of Fish and Game, Fishery Data Series No. 98-4, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds98-04.pdf

Carlon, J. A., and R. Massengill. *In prep*. Assessment of coho salmon from the Kenai River, Alaska, 1999. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Clark, B., R. Lafferty, G. Sandone, J. Fox, P. Cyr, J. Carlon, and J. Hasbrouck. *Unpublished*. Stock status of coho salmon in Upper Cook Inlet A report to the Alaska Board of Fisheries, February 2000. Located at: Alaska Department of Fish and Game, Division of Sport Fish, 333 Raspberry Road, Anchorage, Alaska.

Clark, J. E., and D. R. Bernard. 1987. A compound multivariate binomial-hypergeometric distribution describing coded microwire tag recovery from commercial salmon catches in Southeastern Alaska. Alaska Department of Fish and Game, Informational Leaflet No. 261, Juneau.

Fox, J. R., and P. A. Shields. 2001. Upper Cook Inlet fisheries annual management report 2001. Alaska Department of Fish and Game, Regional Information Report No. 2A01-25, Anchorage.

REFERENCES CITED (Continued)

Hammarstrom, S. L. 1977. Inventory and cataloging of Kenai Peninsula, and Cook Inlet drainages and fish stocks. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1976-1977, Project F-9-9, 18 (G-I-C), Juneau.

Hammarstrom, S. L. 1978. Inventory and cataloging of Kenai Peninsula, Cook Inlet and fish stocks. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1977-1978, Project F-9-10, 19 (G-I-C), Juneau.

Hammarstrom, S. L. 1988. Angler effort and harvest of chinook salmon *Oncorhynchus tshawytscha* and coho salmon *O. kisutch* by the recreational fisheries in the lower Kenai River, 1987. Alaska Department of Fish and Game, Fishery Data Series No. 50, Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds-050.pdf

Hammarstrom, S. L. 1989. Angler-effort and harvest of chinook salmon and coho salmon by the recreational fisheries in the lower Kenai River, 1988. Alaska Department of Fish and Game, Fishery Data Series No. 100, Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds-100.pdf

Hammarstrom, S. L. 1990. Angler-effort and harvest of chinook salmon and coho salmon by the recreational fisheries in the lower Kenai River, 1989. Alaska Department of Fish and Game, Fishery Data Series No. 90-22, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds90-22.pdf

Hammarstrom, S. L. 1991. Angler effort and harvest of chinook salmon and coho salmon by the recreational fisheries in the lower Kenai River, 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-44, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds91-44.pdf

Hammarstrom, S. L. 1992. Angler effort and harvest of chinook salmon by the recreational fisheries in the Lower Kenai River, 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-25, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds92-25.pdf

Howe, A. L., G. Fidler, A. E. Bingham, and M. J. Mills. 1996. Harvest, catch, and participation in Alaska sport fisheries during 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-32, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds96-32.pdf

Howe, A. L., G. Fidler, and M. J. Mills. 1995. Harvest, catch, and participation in Alaska sport fisheries during 1994. Alaska Department of Fish and Game, Fishery Data Series No. 95-24, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds95-24.pdf

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001a. Harvest, catch, and participation in Alaska sport fisheries during 1996. Alaska Department of Fish and Game, Fishery Data Series No. 97-29 (revised), Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds97-29(revised).pdf

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001b. Harvest, catch, and participation in Alaska sport fisheries during 1997. Alaska Department of Fish and Game, Fishery Data Series No. 98-25 (revised), Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds98-25(revised).pdf

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001c. Participation, catch, and harvest in Alaska sport fisheries during 1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-41 (revised), Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds99-41(revised).pdf

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001d. Participation, catch, and harvest in Alaska sport fisheries during 1999. Alaska Department of Fish and Game, Fishery Data Series No. 01-8, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds01-08.pdf

Jennings, G. B., K. Sundet, A. E. Bingham, and D. Sigurdsson. 2004. Participation, catch, and harvest in Alaska sport fisheries during 2001. Alaska Department of Fish and Game, Fishery Data Series No. 04-11, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds04-11.pdf

King, M. A. 1993. Angler effort and harvest of coho salmon during the recreational fisheries in the lower Kenai River, 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-31, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds93-31.pdf

REFERENCES CITED (Continued)

Marsh, L. E. 1995. Catch and effort statistics for the sockeye salmon sport fishery during the late run to the Russian River with estimates of escapement, 1994. Alaska Department of Fish and Game, Fishery Data Series No. 95-10, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds95-10.pdf

Massengill, R., and J. A. Carlon. 2004. Assessment of coho salmon from the Kenai River, Alaska, 2000. Alaska Department of Fish and Game, Fishery Data Series No. 04-23, Anchorage.

Meyer, S. C., D. Vincent-Lang, and D. McBride. *Unpublished*. Goal statement and study plan for the development of a stock assessment program for upper Cook Inlet coho salmon stocks. November 1991. Located at: Alaska Department of Fish and Game, Division of Sport Fish, 333 Raspberry Road, Anchorage.

Mills, M. J. 1979. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Performance Report 1978-1979, Project F-9-11, 20 (SW-I-A), Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/f-9-11(20)SW-I-A.pdf

Mills, M. J. 1980. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1979-1980, Project F-9-12, 21 (SW-I-A), Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/f-9-12(21)SW-I-A.pdf

Mills, M. J. 1981a. Alaska statewide sport fish harvest studies - 1979 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1980-1981, Project F-9-13, 22 (SW-I-A), Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/f-9-13(22a)SW-I-A.pdf

Mills, M. J. 1981b. Alaska statewide sport fish harvest studies - 1980 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1980-1981, Project F-9-13, 22 (SW-I-A), Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/f-9-13(22b)SW-I-A.pdf

Mills, M. J. 1982. Alaska statewide sport fish harvest studies - 1981 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1981-1982, Project F-9-14, 23 (SW-I-A), Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/f-9-14(23)SW-I-A.pdf

Mills, M. J. 1983. Alaska statewide sport fish harvest studies - 1982 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1982-1983, Project F-9-15, 24 (SW-I-A), Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/f-9-15(24)SW-I-A.pdf

Mills, M. J. 1984. Alaska statewide sport fish harvest studies - 1983 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1983-1984, Project F-9-16, 25 (SW-I-A), Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/f-9-16(25)SW-I-A.pdf

Mills, M. J. 1985. Alaska statewide sport fish harvest studies - 1984 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1984-1985, Project F-9-17, 26 (SW-I-A), Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/f-9-17(26)SW-I-A.pdf

Mills, M. J. 1986. Alaska statewide sport fish harvest studies - 1985 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1985-1986, Project F-10-1, 27 (RT-2), Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/f-10-1(27)RT-2.pdf

Mills, M. J. 1987. Alaska statewide sport fisheries harvest report, 1986. Alaska Department of Fish and Game, Fishery Data Series No. 2, Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds-002.pdf

Mills, M. J. 1988. Alaska statewide sport fisheries harvest report, 1987. Alaska Department of Fish and Game, Fishery Data Series No. 52, Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds-052.pdf

Mills, M. J. 1989. Alaska statewide sport fisheries harvest report, 1988. Alaska Department of Fish and Game, Fishery Data Series No. 122, Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds-122.pdf

Mills, M. J. 1990. Harvest and participation in Alaska sport fisheries during 1989. Alaska Department of Fish and Game, Fishery Data Series No. 90-44, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds90-44.pdf

Mills, M. J. 1991. Harvest, catch, and participation in Alaska sport fisheries during 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-58, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds91-58.pdf

REFERENCES CITED (Continued)

Mills, M. J. 1992. Harvest, catch, and participation in Alaska sport fisheries during 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-40, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds92-40.pdf

Mills, M. J. 1993. Harvest, catch, and participation in Alaska sport fisheries during 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-42, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds93-42.pdf

Mills, M. J. 1994. Harvest, catch, and participation in Alaska sport fisheries during 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-28, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds94-28.pdf

Moberly, S. A., R. Miller, K. Crandall, and S. Bates. 1977. Marking tag manual for salmon. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development, Juneau.

Nelson, D. C. 1983. Russian River sockeye salmon study. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1982-1983, Project AFS-44, 24 (AFS-44-9), Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/f-9-15(24)AFS-44-9.pdf

Northwest Marine Technologies Inc. 1990. Operations manual: Mark IV tag injector and Mark IV quality control device. Northwest Marine Technologies, Inc., Shaw Island, Washington.

Peltz, L., and P. A. Hansen. 1994. Marking, enumeration, and size estimation for coho and chinook salmon smolt releases into upper Cook Inlet, Alaska in 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-21, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds94-21.pdf

Reimer, A. M., and D. Sigurdsson. 2004. Upper Cook Inlet personal use salmon fisheries report, 1996-2003. Alaska Department of Fish and Game, Fishery Data Series No. 04-31, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds04-31.pdf

Ruesch, P. H., and J. Fox. 1995. Upper Cook Inlet commercial fisheries annual management report, 1994. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 2A95-26, Anchorage.

Ruesch, P. H., and J. Fox. 1996. Upper Cook Inlet commercial fisheries annual management report, 1995. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report No. 2A96-27, Anchorage.

Ruesch, P. H., and J. Fox. 1998. Upper Cook Inlet Commercial Fisheries Annual Management Report, 1997. Alaska Department of Fish and Game Commercial Fisheries Division, Regional Information Report No. 2A98-21.

Seber, G. A. F. 1982. On the estimation of animal abundance and related parameters, second edition. Griffin and Company, Ltd. London.

Thompson, D. A., and H. L. Blankenship. 1997. Regeneration of adipose fins given complete and incomplete clips. North American Journal of Fisheries Management 17: 467-469.

Vincent-Lang, D. 1993. Relative survival of unmarked and fin-clipped coho salmon from Bear Lake, Alaska. The Progressive Fish-Culturist 55(3):141-148.

Vincent-Lang, D., M. Alexandersdottir, and D. McBride. 1993. Mortality of coho salmon caught and released using sport tackle in the Little Susitna River, Alaska. Fisheries Research 15:339-356

Walker, R. J., C. Olnes, K. Sundet, A. L. Howe, and A. E. Bingham. 2003. Participation, catch, and harvest in Alaska sport fisheries during 2000. Alaska Department of Fish and Game, Fishery Data Series No. 03-05, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds03-05.pdf

Yoshikawa, H., Y. Ishida, S. Ueno, and H. Mitsuda. 1988. Changes in depth of anesthesia of the carp anesthetized with a constant level of carbon dioxide. Bulletin of the Japanese Society of Scientific Fisheries 54:457-462.

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 2000, and tag codes identified in the sample of 199 Moose River tagged fish recovered from known UCI commercial fishery strata in 2001.

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 2001 [d]
31-02-20	5/22	5/28	11,402	99.9%	11,388	99.2%	11,297	22
31-02-21	5/28	5/30	11,860	100.0%	11,860	99.9%	11,848	29
31-02-22	5/29	5/31	10,592	100.0%	10,592	99.7%	10,560	18
31-02-23	5/30	6/01	11,887	99.8%	11,865	99.6%	11,818	28
31-02-24	5/31	6/02	11,622	99.9%	11,616	99.8%	11,593	14
31-02-25	6/01	6/03	11,641	100.0%	11,641	99.7%	11,606	23
31-02-26	6/02	6/04	11,520	99.6%	11,475	96.3%	11,050	16
31-02-27	6/03	6/05	11,464	99.9%	11,455	98.4%	11,272	23
31-02-28	6/04	6/08	11,427	100.0%	11,427	98.5%	11,256	26
Total			103,415	99.9%	103,319	99.0%	102,300	199

[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 the north and south banks of the Kenai River near river kilometer 44.5 between August 1 and September 30, 2001.

	August					September			
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					09/01	4	1		
08/02	3				09/02	5	1		
08/03	12				09/03	5	2		
08/04	17	3			09/04	6			
08/05	11	2			09/05	11	4	1	1
08/06	1				09/06	15	2		
08/07	2				09/07	5	1		
08/08	9	2			09/08	3			
08/09	15				09/09				
08/10	21				09/10	3	1	1	1
08/11	14	2	2	2	09/11	9	5	5	5
08/12	10	2	2	2	09/12	6	2	2	2
08/13	15	1	1	1	09/13	14	5	5	5
08/14	46	5	4	4	09/14	15	6	6	6
08/15	40	7	7	7	09/15	8	3	3	3
08/16	33	7	7	7	09/16	8	2	2	2
08/17	43	6	6	6	09/17	10	1	1	1
08/18	42	5	5	5	09/18	15	5	5	5
08/19	31	3	3	3	09/19	14	4	4	4
08/20	27	5	5	4	09/20	15	4	4	4
08/21	31	8	8	8	09/21	16	3	3	3
08/22	12	4	4	4	09/22	11	5	5	5
08/23	13	1	1	1	09/23	12	6	6	6
08/24	9	1	1	1	09/24	12	3	3	3
08/25	13				09/25	2	2	2	2
08/26	9	2	2	2	09/26	7			
08/27	5				09/27	3			
08/28	16	3	3	3	09/28	6	2	2	2
08/29	58	11	11	11	09/29	2			
08/30	19	1	1	1	09/30	9	3	3	3
08/31	20	6							
Subtotal	597	87	73	72		251	73	63	63
North Bank Subtotal						848	160	136	135

-continued-

Appendix A2.-Page 2 of 2.

	August					September			
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	72	14		
08/02	1				09/02	27	2		
08/03	6				09/03	30	8	1	1
08/04	6				09/04	22	4	1	1
08/05	13	2			09/05	34	7		
08/06	7				09/06	45	11	3	3
08/07	12	3			09/07	30	8	1	1
08/08	15	2	2	2	09/08	25	4		
08/09	19	2	2	2	09/09	26	6		
08/10	15	2	2	2	09/10	14	3	2	2
08/11	7	2	2	2	09/11	3	1	1	1
08/12	11				09/12	13	3	3	3
08/13	18	4	4	4	09/13				
08/14	33	1	1	1	09/14	4	1	1	1
08/15	45	8	8	8	09/15	8			
08/16	50	3	3	3	09/16	5	2	2	2
08/17	55	5	5	5	09/17	4	1	1	1
08/18	62	7	7	7	09/18	11	5	5	5
08/19	41	4	4	4	09/19	6			
08/20	65	8	8	8	09/20	4	1	1	1
08/21	121	26	26	26	09/21	16	4	4	4
08/22	59	11	11	11	09/22	20	4	4	4
08/23	81	7	7	7	09/23	30	8	8	8
08/24	38	5	5	5	09/24	19	3	3	3
08/25	28	5	5	5	09/25	18	3	3	3
08/26	30	8	8	8	09/26	14	5	5	5
08/27	54	7	7	7	09/27	14	2	2	1
08/28	35	4	4	4	09/28	14	2	2	2
08/29	175	26	26	26	09/29	17	5	5	5
08/30	119	22	22	22	09/30	2			
08/31	54	7							
Subtotal	1,275	181	169	169		547	117	58	57
South Bank Subtotal						1,822	298	227	226
Grand Total (both banks)						2,670	458	363	361

[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 5, 2001.

	August					September-October				
Date[a]	Number Captured and Examined[b]	Marked Fish Observed[c]	Number Captured and Examined[b]	Marked Fish Observed[c]		Date[a]	Number Captured and Examined[b]	Marked Fish Observed[c]	Number Captured and Examined[b]	Marked Fish Observed[c]
	North Bank		**South Bank**				**North Bank**		**South Bank**	
08/01						09/01	46	11	48	2
08/02						09/02	34	7	18	3
08/03	2	1	1			09/03	22	11	14	2
08/04						09/04	39	15	22	10
08/05						09/05	21	7	31	6
08/06	1		1	1		09/06	39	11	48	11
08/07	6	1	9	1		09/07	20	7	28	10
08/08	18	2	25	3		09/08	16	4	33	7
08/09	53	6	43	3		09/09	34	9	13	7
08/10	49	9	38	2		09/10	39	15	24	6
08/11	56	13	62	4		09/11	27	9	18	5
08/12	28	7	21	3		09/12	46	15	22	1
08/13	51	11	39	6		09/13	39	14	14	3
08/14	64	19	82	12		09/14	41	8	30	7
08/15	55	16	41	7		09/15	29	10	37	13
08/16	77	15	55	8		09/16	12	7	5	1
08/17	75	22	57	13		09/17	28	10	4	
08/18	90	20	69	11		09/18	35	9	26	6
08/19	65	15	34	8		09/19	85	26	48	11
08/20	39	18	17	3		09/20	52	13	33	8
08/21	90	27	67	15		09/21	27	8	16	4
08/22	27	7	29	8		09/22	59	19	40	14
08/23	69	22	71	14		09/23	36	16		
08/24	79	25	76	9		09/24	8	3	12	6
08/25	71	29	69	12		09/25	17	3	33	6
08/26	70	27	42	9		09/26	16	2	38	8
08/27	57	17	38	7		09/27	23	5	46	7
08/28	78	28	36	3		09/28	21	2	33	5
08/29	82	28	39	8		09/29	2		23	2
08/30	70	27	57	5		09/30	7		6	1
08/31	70	22	32	3		10/01	15	2	33	6
						10/02	17	4	20	4
						10/03	27	6	26	9
						10/04	21	7	27	8
						10/05	2	1	22	4
Subtotal	1,492	434	1,150	178			1,002	296	891	203
					Grand Total		2,494	730	2,041	381

[a] Gillnets operational from August 1 through October 5, 2001.

[b] Includes only coho salmon that were assigned a bank location; an additional 96 coho salmon were captured at offshore locations, but these are excluded from comparisons with bank-oriented fish wheels.

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

Appendix A4.-Daily summary of coho salmon adults examined at the Russian River weir, July 30 through October 5, 2001.

Date	Weir Count	Examined	Marked Fish Observed [a]	Date	Weir Count	Examined	Marked Fish Observed [a]
7/30	5	0	0	9/1	257	255	23
7/31	0	0	0	9/2	194	193	23
8/1	0	0	0	9/3	204	202	25
8/2	0	0	0	9/4	244	244	26
8/3	0	0	0	9/5	63	62	5
8/4	0	0	0	9/6	48	48	2
8/5	0	0	0	9/7	46	46	7
8/6	1	1	0	9/8	238	238	27
8/7	3	3	1	9/9	31	31	8
8/8	1	1	0	9/10	124	119	11
8/9	4	4	0	9/11	399	294	27
8/10	15	15	1	9/12	39	39	3
8/11	4	4	0	9/13	298	296	36
8/12	5	5	2	9/14	172	171	15
8/13	15	15	0	9/15	556	550	64
8/14	26	25	3	9/16	189	188	18
8/15	26	26	2	9/17	147	145	18
8/16	20	20	1	9/18	1,145	1,105	118
8/17	26	25	3	9/19	482	479	58
8/18	80	79	7	9/20	909	887	90
8/19	105	105	6	9/21	223	219	30
8/20	1	1	0	9/22	60	60	9
8/21	131	131	10	9/23	66	65	6
8/22	9	9	3	9/24	566	566	61
8/23	30	30	3	9/25	181	181	16
8/24	115	115	12	9/26	449	449	55
8/25	115	109	14	9/27	124	124	11
8/26	17	15	3	9/28	155	155	16
8/27	4	4	0	9/29	86	86	12
8/28	369	369	103	9/30	33	33	3
8/29	324	323	21	10/1	77	77	6
8/30	277	274	25	10/2	29	29	2
8/31	241	236	17	10/3	85	84	6
				10/4	22	22	1
				10/5	5	5	0
Subtotal	1,969	1,944	237	Subtotal	7,946	7,747	838
				Grand Total	9,915	9,691	1,075

[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 2001.

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 2000
Mixed Central District Statistical Areas							
Drift and East Side Set							
7/19	244CDD,24441	756	14	14	12	12	1
East Side Set							
7/18	24421/22	16	0	0	0	0	
7/19	24421/22	14	0	0	0	0	
7/25	24421/22	11	1	1	1	1	
7/17	24421/31	1	0	0	0	0	
7/16	24422/31	1	0	0	0	0	
7/26	24422/31	3	1	1	1	1	1
Total		46	2	2	2	2	1
West Side and Kalgin Island Set							
7/23	24530,24610/20	2,698	43	42	36	36	
7/26	24530,24610/20	1,643	22	22	19	19	
7/30	24530,24610/20	711	7	7	6	6	1
8/2	24530,24610/20	714	23	23	17	17	2
8/6	24530,24610/20	2,922	90	90	80	80	18
8/9	24530,24610/20	3,036	82	81	73	73	22
8/13	24530,24610/20	1,747	21	21	14	14	4
Total		13,471	288	286	245	245	47
Drift, West Side, and Kalgin Island Set							
7/16	244CDD,24530,24610/20	236	2	2	2	2	
Mixed Central District Total		14,509	306	304	261	261	49
Mixed Northern District Areas							
Northern District East Side Set and West Side Set							
8/9	24770,30	558	43	43	42	42	3
Mixed Central and Northern District Statistical Areas							
Central District Drift, Central District East Side Set, and Northern District West Side Set							
7/16	244CDD,24422/31,24730	2,163	26	26	21	21	
Central District West Side Set and Northern District East Side Set							
8/2	24550,24770/80	314	9	9	8	8	2
Mixed Districts Total		2,477	35	35	29	29	2
Ambiguous Samples							
Northern District, Fire Island[a]							
7/21	24743	19	1	1	1	1	0
Grand Total		17,563	385	383	333	333	54

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 were examined, but fishery was closed on this date and zero harvest was reported. Erroneous identification of the fishery is assumed to have occurred when the fish were examined.

Appendix A6.-Upper Cook Inlet commercial coho salmon harvest in 2001, 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 2000.

Date (2001)[b]	(H) Total Harvest	(ni) Number Examined[c]	(ai) Adclips Observed	(a'i) Heads Recovered	(ti) Heads with Tags	(t'i) Decodable Tags	(mi) Source = Moose R 2000	(ri) Harvest Estimate [d]	V(ri) Variance [d]
Central District									
Drift Gillnet									
6/25	8	3	0	0	0	0	0	0	0
6/28	41	14	1	1	1	1	0	0	0
7/2	202	40	0	0	0	0	0	0	0
7/4, 5	600	278	5	5	5	5	0	0	0
7/8, 9	42	15	0	0	0	0	0	0	0
7/12	4,158	1,808	20	20	19	19	0	0	0
7/16, 17	7,497	3,095	44	44	38	38	0	0	0
7/19	12,881	5,026	116	116	104	104	1	15	210
7/26	562	224	5	5	5	5	0	0	0
7/30	1,893	127	2	2	2	2	0	0	0
8/2	4,180	2,010	31	31	30	30	5	61	691
8/6	5,238	2,751	91	91	81	79	18	206	2,249
8/9	2,116	1,417	4	4	2	2	0	0	0
Total	39,418	16,808	319	319	287	285	24	282	3,150
East Side Set									
Statistical Area 24421									
7/2, 4, 5, 8, 9, 10	13	1	0	0	0	0	0	0	0
7/11	7	2	0	0	0	0	0	0	0
7/12, 14	15	5	0	0	0	0	0	0	0
7/16	28	11	0	0	0	0	0	0	0
7/17	15	1	0	0	0	0	0	0	0
7/18	97	34	0	0	0	0	0	0	0
7/19	56	12	0	0	0	0	0	0	0
7/21, 23	178	62	0	0	0	0	0	0	0
7/25	67	18	3	3	3	3	3	65	1,351
7/26	179	23	2	2	2	2	2	91	4,060
7/27	47	29	2	2	2	2	2	19	162
7/28	79	17	0	0	0	0	0	0	0
Total	781	215	7	7	7	7	7	175	5,573
Statistical Area 24422									
7/2, 4, 5, 8, 9, 10	16	1	0	0	0	0	0	0	0
7/11	1	1	0	0	0	0	0	0	0
7/12, 14	10	2	0	0	0	0	0	0	0
7/16	68	11	1	1	0	0	0	0	0
7/17	14	6	0	0	0	0	0	0	0
7/18	45	12	0	0	0	0	0	0	0
7/19	79	11	1	1	1	1	0	0	0
7/21, 23	268	111	3	3	2	2	0	0	0
7/25	108	52	0	0	0	0	0	0	0
7/26	148	38	1	1	1	1	1	23	506
7/27, 28	216	36	3	3	3	3	2	70	2,386
Total	973	281	9	9	7	7	3	93	2,892
Statistical Area 24431/32									
7/2, 4, 5, 8, 9, 10, 11, 12, 14, 16,	140	34	1	1	1	1	0	0	0
7/18, 19	75	24	0	0	0	0	0	0	0
7/21, 23	146	67	0	0	0	0	0	0	0
7/25, 26	110	11	1	1	1	1	1	59	3,422
7/27, 28	106	5	1	1	1	1	0	0	0
Total	577	141	3	3	3	3	1	59	3,422
Statistical Area 24441/42									
7/9	15	11	1	1	1	1	0	0	0
7/12	21	10	0	0	0	0	0	0	0
7/16	765	254	1	1	1	1	0	0	0
7/19	915	232	4	4	4	4	0	0	0
7/26	199	104	4	4	4	4	2	22	221
Total	1,915	611	10	10	10	10	2	22	221
Eastside Set Gillnet Total	4,246	1,248	29	29	27	27	13	349	12,108

-continued-

Appendix A6.–Page 2 of 3.

Date (2001)[b]	(H) Total Harvest	(ni) Number Examined[c]	(ai) Adclips Observed	(a'i) Heads Recovered	(ti) Heads with Tags	(t'i) Decodable Tags	Source (mi) = Moose R 2000	(ri) Harvest Estimate [d]	V(ri) Variance [d]
Kalgin Island Set Area 24610/20									
7/2	1								
7/5	29								
7/9	76								
7/12	93								
7/16	289								
7/19	1,495								
7/23	2,261								
7/26	1,301								
7/30	183								
8/2	999								
8/6	2,267								
8/9	2,451								
8/13	1,123								
8/16	43								
8/27	306								
9/13	288								
Total	13,205								
West Side Set Areas 24520/30/40/50/55/60									
7/2	3								
7/5	10								
7/6	4								
7/7	3								
7/8	7								
7/9	18								
7/10	42								
7/11	41								
7/12	41								
7/13	72								
7/14	62								
7/15	35								
7/16	57	22	0	0	0	0	0	0	0
7/17	180								
7/18	85								
7/19	122								
7/21	131								
7/22	37								
7/23	669	82	0	0	0	0	0	0	0
7/24	164								
7/25	142								
7/26	802								
7/28	1,121								
7/30	792	45	0	0	0	0	0	0	0
8/2	978								
8/6	1,125	737	0	0	0	0	0	0	0
8/9	1,238	590	1	1	1	1	0	0	0
8/13	1,104	503	2	2	1	1	0	0	0
8/16	895	527	1	1	1	1	1	10	90
8/23	172								
8/27	180								
8/30	92								
9/3	90								
Total	10,514	2,506	4	4	3	3	1	10	90
Central District Total	67,383	20,562	352	352	317	315	38	641	15,348

-continued-

Appendix A6.-Page 3 of 4.

Date (2001)[b]	(H) Total Harvest	(ni) Number Examined[c]	(ai) Adclips Observed	(a'i) Heads Recovered	(ti) Heads with Tags	(t'i) Decodable Tags	(mi) Source = Moose R 2000	(ri) Harvest Estimate [d]	V(ri) Variance [d]
				Northern District					
East Side Set Areas 24770/80/90									
7/2, 5, 9	31	3	0	0	0	0	0	0	0
7/12	170	11	0	0	0	0	0	0	0
7/16	1,018	111	2	2	2	2	0	0	0
7/19	1,404	685	8	8	6	6	0	0	0
7/30	914	202	6	6	6	6	2	53	1,355
8/2	347	51	1	1	1	1	1	40	1,560
8/6	424	413	25	25	25	25	12	72	372
8/9	1,070	265	8	8	6	6	4	95	2,178
8/13	992	1,021	26	26	26	26	12	68	330
8/16	2,635	825	23	23	22	22	17	318	5,862
8/20	74	138	1	1	1	1	1	3	7
8/23	700	1,332	30	30	29	29	24	74	202
8/27	439	489	15	15	15	15	14	74	337
8/30	192	184	13	13	13	13	13	80	426
9/3	593	469	8	8	8	8	8	59	384
9/6, 10, 13, 27	469	221	2	2	2	2	2	25	288
Total	11,472	6,420	168	168	162	162	110	961	13,301
Fire Island Set Area 24743									
7/2, 5, 9	21	16	3	3	3	3	0	0	0
7/12	10	10	0	0	0	0	0	0	0
7/16	150	148	9	9	7	7	0	0	0
7/19	38	19	0	0	0	0	0	0	0
7/30	1,296	1,080	121	121	115	115	1	7	42
8/2	1,173	973	95	95	85	85	1	7	42
8/6	896	895	88	88	84	84	2	12	60
8/9	899	892	118	118	107	107	2	12	60
8/13	402	451	28	28	26	26	4	21	92
8/16	371	355	40	40	37	37	6	37	194
8/27	55	55	5	5	5	5	2	12	60
Total	5,311	4,894	507	507	469	469	18	108	550
Pt. MacKenzie/Su Flats Set Area 24741/42[c]									
7/9	4	10	1	1	1	1	0	0	0
7/12	17	20	1	1	1	1	0	0	0
7/16	230	168	14	14	14	14	0	0	0
7/19	416	338	15	15	13	13	0	0	0
7/30	2,958	2,359	203	197	186	185	0	0	0
8/2	3,038	2,473	202	202	181	181	1	7	42
8/6	2,883	2,864	225	225	204	204	0	0	0
8/9	2,172	1,798	173	173	158	158	2	14	84
8/13	975	846	86	85	73	73	1	7	42
8/16	1,081	1,074	96	96	85	85	2	12	60
8/20	218	186	11	11	11	11	0	0	0
8/23	150	143	5	5	5	5	1	6	30
8/27	132	92	7	7	7	7	3	25	185
8/30	36	36	3	3	3	3	1	6	30
9/3,13, 20, 24	72	46	3	3	3	3	2	18	145
Total	14,382	12,453	1,045	1,038	945	944	13	95	618
West Side Set Area 24710/20/30									
6/18, 7/2, 5, 9	328	81	0	0	0	0	0	0	0
7/12	471	662	1	1	1	1	0	0	0
7/16, 19	5,487	1,768	22	22	20	20	0	0	0
7/30	2,106	1,859	26	26	21	21	0	0	0
8/2	2,321	2,074	27	27	20	20	3	20	114
8/6	1,341	347	5	5	5	5	0	0	0
8/9	1,257	783	18	18	16	16	3	28	235
8/13, 16	1,452	933	23	23	21	21	10	91	756
8/23[c]	0	180	4	4	4	4	4	0	0
Total	14,763	8,687	126	126	108	108	20	139	1,104
Northern District Total	45,928	32,454	1,846	1,839	1,684	1,683	161	1,303	15,573
Grand Total	113,311	53,016	2,198	2,191	2,001	1,998	199	1,944	30,921

-continued-

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] The number examined may exceed the reported harvest on some dates. This occasionally occurs when harvest estimates are biased high due to the method used by processors to estimate number delivered (delivered weight/mean weight of a coho salmon). On these dates (as all other dates), the reported harvest is the basis for estimating contribution. For rare instances when fish were examined on dates when no harvest was reported, contribution estimates of zero are therefore generated.

[c] 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.