Fishery Data Series No. 07-38

Assessment of Coho Salmon from the Kenai River, Alaska, 2003

by

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and

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June 2007

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

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-19, 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.

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This document should be cited as:
Massengill, R. and J. A. Carlon. 2007. Assessment of coho salmon from the Kenai River, Alaska, 2003. Alaska Department of Fish and Game, Fishery Data Series No. 07-38, Anchorage.

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ABSTRACT

Wild coho salmon *Oncorhynchus kisutch* smolt were captured within the Kenai River drainage in the spring of 2002, marked with an adipose finclip and coded wire tag (CWT), and recovered as adults in 2003. Marked adults were recovered from selected commercial fisheries of Upper Cook Inlet (UCI), Alaska, and from within the Kenai River drainage. Data collected during this smolt-to-adult (marking-recovery) cycle were used to estimate the UCI commercial harvest of Kenai River-bound coho salmon in selected fisheries in 2003 and smolt abundance in 2002. Estimates of commercial harvest in 2003 were based on the proportion of each fishery harvest examined, the number of tagged coho salmon recovered, and the tag-bearing proportion of the return passing through marine commercial fisheries. The estimate of smolt abundance in 2002 was based on the number of smolt marked with adipose finclips in 2002, the number of returning adults sampled inriver for finclips in 2003, and the number of finclipped adults detected. Commercial harvest and smolt abundance estimates represent the eleventh consecutive set of annual estimates available for the Kenai River population.

Of 101,677 coho salmon that were harvested among all UCI commercial fisheries, a total of 44,922 (44%) were examined. Most fishing periods were sampled. A total of 6,880 (15% of the sample) could not be positively assigned to fishery strata and were excluded from calculations of commercial harvest. Of the remaining 38,042, a total of 36,529 was examined as follows: 16,146 (67% of the harvest) were examined from Northern District harvests, 18,060 (34%) were examined from Central District drift gillnet harvests, and 2,323 (23%) were examined from Central District eastside set gillnet harvests. Among these fisheries, a total of 930 adipose-finclipped fish were observed, of which 912 were recovered, 795 bore a decodable CWT, and 146 were identified as being of Kenai River origin.

Significant and substantial temporal variation in the tag-bearing proportion measured at all inriver sampling locations precluded an accurate estimate of the tag-bearing proportion passing through marine commercial fisheries; accurate estimates of commercial harvest of Kenai River-bound coho salmon were therefore not possible. However, a point estimate of the overall tagged proportion of the return ($\hat{\theta}$=0.172; SE($\hat{\theta}$)=0.008; $\hat{\theta}^{-1}$=5.8; SE($\hat{\theta}^{-1}$)=0.259) was generated from a subset of inriver data, as were estimates of the potential minimum ($\hat{\theta}$=0.164; SE($\hat{\theta}$)=0.008; $\hat{\theta}^{-1}$=6.1; SE($\hat{\theta}^{-1}$)=0.290) and maximum ($\hat{\theta}$=0.246; SE($\hat{\theta}$)=0.0280; $\hat{\theta}^{-1}$=4.1; SE($\hat{\theta}^{-1}$)=0.486). Three resulting sets of harvest estimates were compared to evaluate the practical impact of the temporal variation on commercial harvest estimates. The evaluation indicated that harvest estimates based on the overall tagged proportion are practical for general research, assessment, and planning purposes, but must be qualified by the evaluation for addressing allocation issues.

A total of 2,475 coho salmon were captured within the Kenai River by fish wheels in 2003 and examined for adipose finclips and 428 were found with an adipose finclip. Of these, 422 were estimated as bearing a Kenai River coded wire tag and six with no tag, resulting in an overall estimated tagged proportion of 0.172. Based on this subset of inriver data, a qualified estimate of 2,122 (SE = 252) coho salmon of Kenai River origin were harvested by the Central District eastside set gillnet fishery, 330 (SE = 65) by the Central District drift gillnet fishery, and 126 (SE = 39) by all Northern District set gillnet fisheries for a total of 2,578 (SE = 263). Qualified harvest estimates represented 21% of the total eastside set gillnet harvest of coho salmon, 0.6% of the drift gillnet harvest, and 0.5% of the Northern District set gillnet harvest.

Based on the number of live smolt released with an adipose finclip at the Moose River in 2002 (108,520), the number of adult coho salmon examined for adipose fin status in the Kenai River fish wheel samples in 2003 (2,475), and the number of adults in the sample that had an adipose finclip (428), an estimated 626,335 (SE = 27,409) smolt emigrated from the Kenai River in 2002.

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

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, adults are harvested annually in mixed-

stock marine commercial and sport fisheries. Sport and personal use harvests also occur in fresh water. Cook Inlet ranks first in the 1990-2002 average sport harvest of coho salmon among all regions of the State, sixth in commercial harvest, and sixth in overall 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, 2006; Mills 1979-1980, 1981a-b, 1982-1994; Walker et al. 2003) and account for an average of about one of every six coho salmon sport-harvested from Alaskan waters. The population also contributes to marine commercial 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.

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 (CWT) release and recovery program (Carlon 2000, 2003; Carlon and Hasbrouck 1994; 1996-1998; Massengill *In prep;* Massengill and Carlon 2004a, b, 2007). 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, 2006; King 1993; Mills 1979-1980, 1981a-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 (Carlon and Evans *In prep*).

Because adult exploitation rates and total production have only recently been estimated, any relationship between the two quantities remains unknown; adults produced from the 1999 escapement - the first for which exploitation rate will be estimated - only recently returned in 2003. A series of escapement and subsequent production estimates is therefore not yet available for study. This approach to assessment of population status is therefore considered a long-term endeavor.

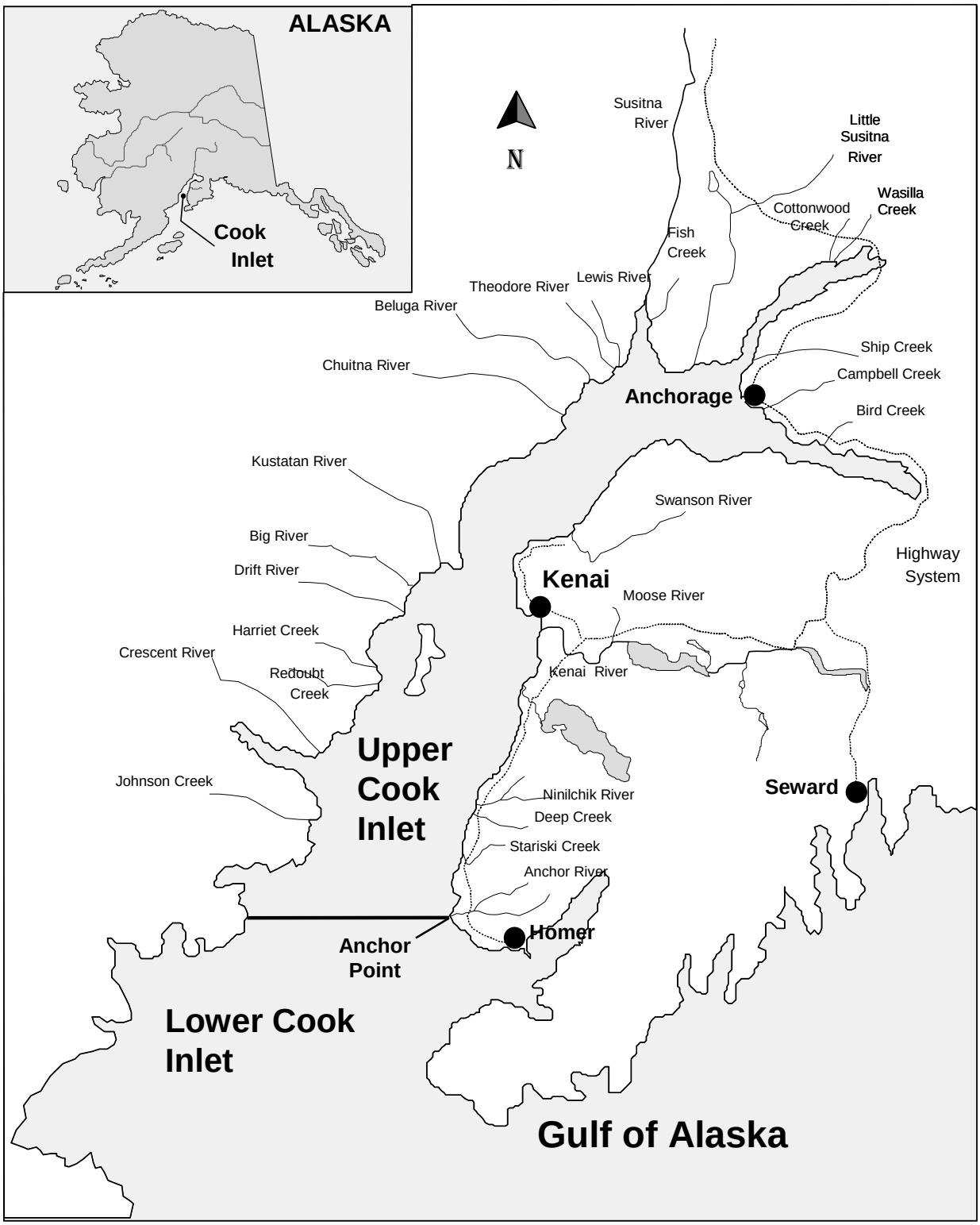

Figure 1.-Cook Inlet Basin with selected tributaries known to support coho salmon.

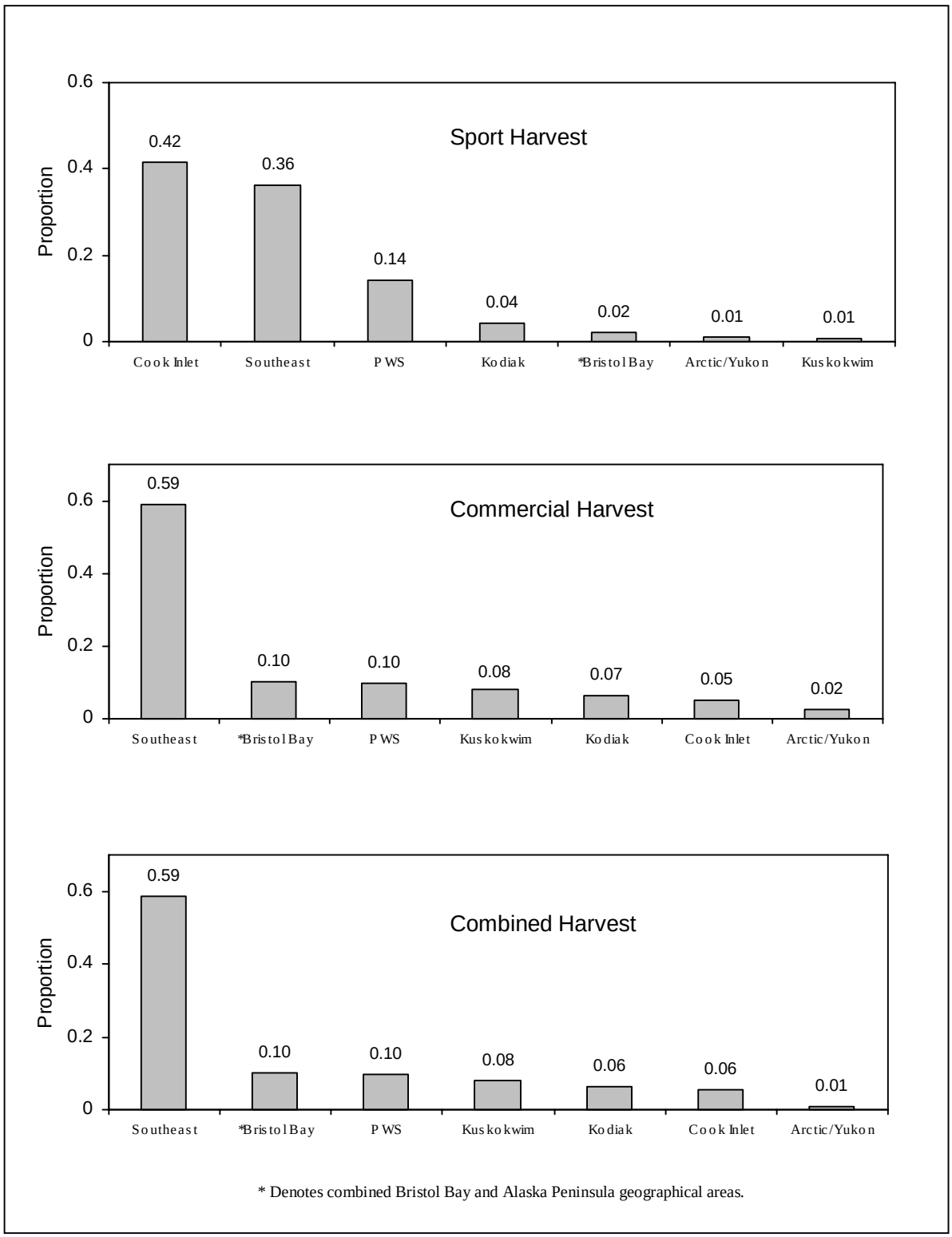

Figure 2.-Average proportions by region of the statewide commercial and sport harvests of coho salmon, 1990-2002.

In the interim, two indicators of sustainability are being monitored. The first, annual exploitation rate, is considered a more immediate indicator of sustainability. The second, annual smolt abundance, was initially considered ancillary information, but 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 Clark *Unpublished*). Although the cause of the decline remains unknown, it heightened the level of concern for the sustainability of historical harvest levels. The response to this concern was the development and adoption of the first management plan for Kenai River coho salmon. The Kenai River Coho Salmon Management Plan (Alaska Fish and Game Laws and Regulations Annotated, 1997-1998; 5 AAC 21.357) was adopted by the Alaska Board of Fisheries in the spring of 1997 and was 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 a basis for refining the management plan and configuring fisheries in the future.

Adult exploitation rate and production are estimated as objectives of a companion component of the assessment program and are reported elsewhere (Carlon and Evans *In prep*) while this report documents the 2003 population-specific commercial harvest and the 2002 smolt abundance estimates. This report is the eleventh in a series documenting commercial harvest since 1993 and smolt abundance since 1992 of coho salmon from the Kenai River (Carlon 2000, 2003; Carlon and Hasbrouck 1994; 1996-1998; Massengill *In prep;* Massengill and Carlon 2004a, b, 2007)

STUDY AREA

Smolt were captured for marking in 2002 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 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 this companion study provided data essential to achieving objectives documented in this report. 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 2003. The statistical area from which examined fish were harvested was recorded when possible (Figure 4).

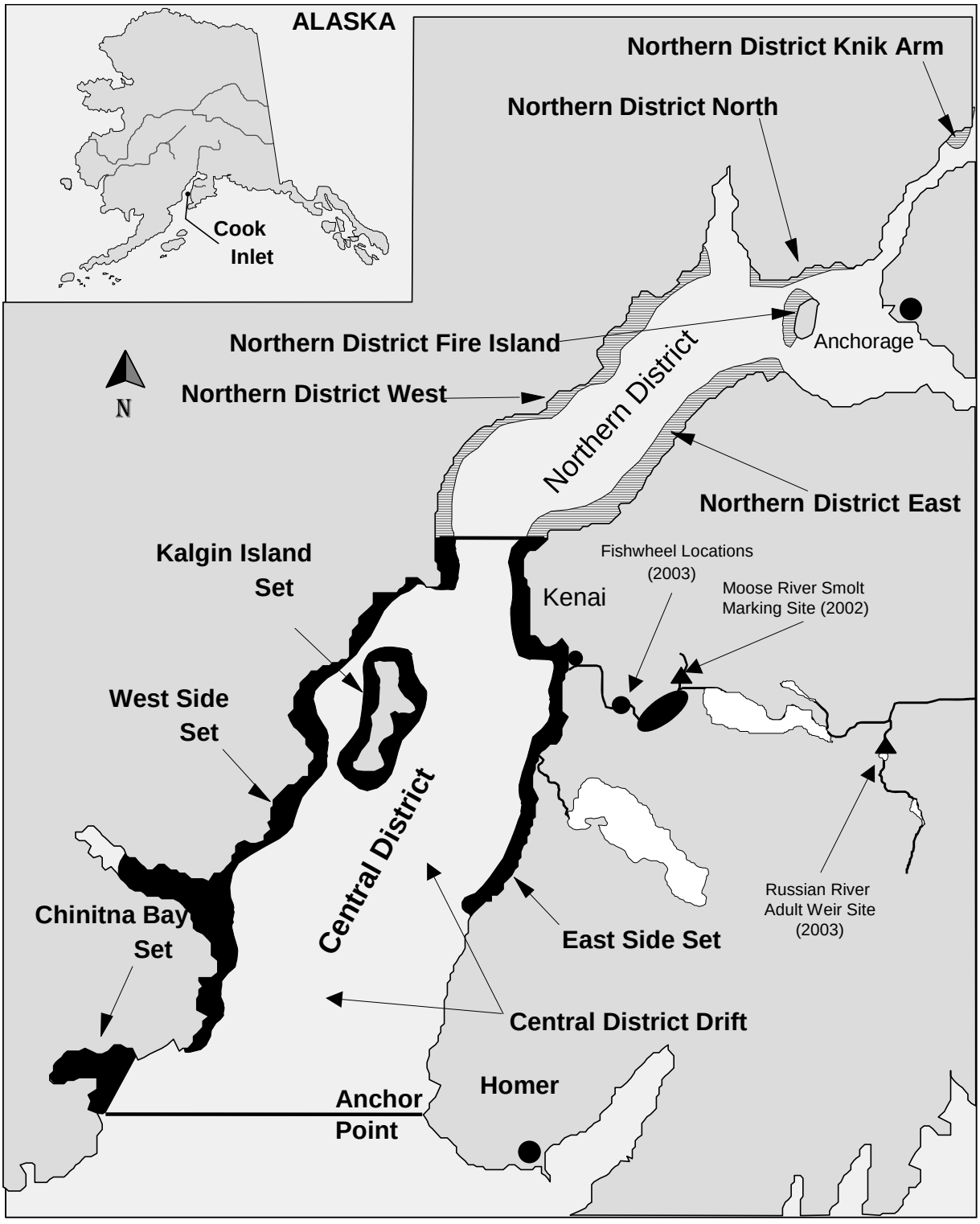

Figure 3.-Upper Cook Inlet showing 10 commercial set gillnet and drift gillnet fishery areas, location at which marked coho salmon smolt were released in the Kenai River drainage in 2002, Kenai River fish wheel and weir sampling locations in 2003.

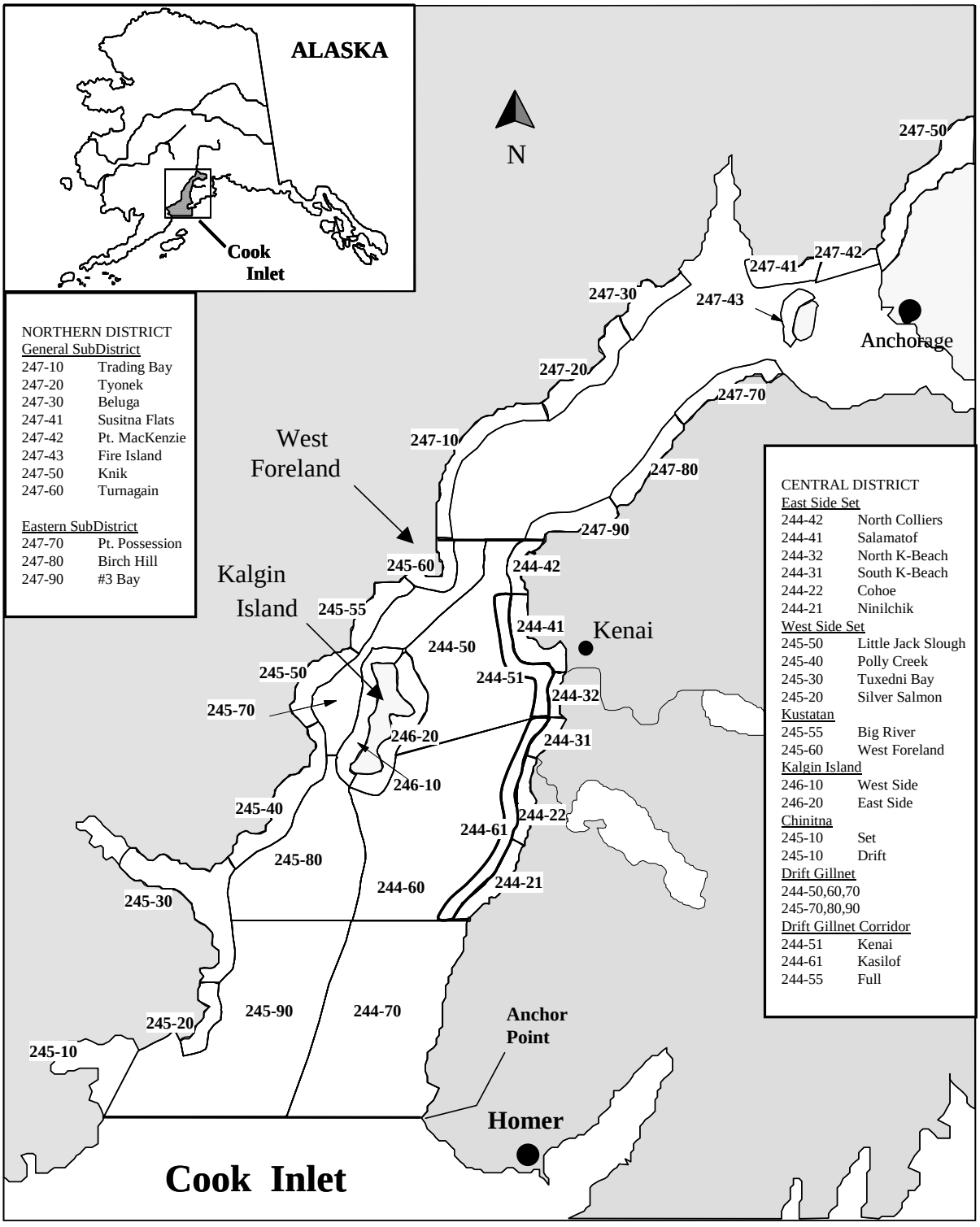

Figure 4.-Upper Cook Inlet statistical areas.

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 2003, and
2. To estimate the number of coho salmon smolt that emigrated from the Kenai River in 2002.

Prerequisite objectives to primary objective 1 (above) were:

1. 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, 2003; and, if constant,
2. To estimate the proportion of the population bearing coded wire tags from August 1 through September 30, 2003.

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

To estimate commercial harvest of coho salmon bound for the Kenai River, a sample of juvenile coho salmon was captured from within the Kenai River drainage in 2002, marked with coded wire tags, and released. Total harvest of coho salmon in 2003 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 (CF) Division. The tagged fraction of the adult return to the Kenai River was estimated by examining inriver samples in 2003.

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 have an adipose finclip must be checked to estimate the tag loss rate. In 2003, the majority of coho salmon with an adipose finclip that was caught in the fish wheels was 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 for estimation of commercial harvest is that fish marked in the Moose River are a representative sample of the drainage-wide smolt emigration or that marked fish mix completely with unmarked fish, and remain mixed through to the adult sampling stage of the study. A constant marked fraction measured from inriver samples of adults implies one or both of these conditions and 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.

The hypothesis that the tagged fraction in returning adults did not change over time was tested by sampling adult coho salmon from the river through the return. Failure to reject this hypothesis indicates that a representative sample of the smolt from the Kenai drainage was marked. Further, 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 not representative of the drainage wide smolt outmigration and/or that complete mixing did not occur between marking and adult sampling.

To conduct a meaningful test of the consistency of the marked fraction of the return over time, it must be assumed that each inriver sample was representative of the return during each time stratum. This is likely a valid assumption for both sampling methods (fish wheels and drift gillnetting). Within each method sampling effort was distributed both spatially and temporally. The two fish wheels were operated (one adjacent to each riverbank) continuously during most daylight periods, as was drift gillnetting over a 9.5 km stretch of river.

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 is possible.

The estimate of smolt abundance was considered accurate if it could be shown that there was no temporal variation in the fraction of adults marked with finclips in inriver samples. However, if smolt-to-adult tag loss is a rare event, tests of the tagged fraction for temporal variation (as described for the estimation of commercial harvest) can serve as a surrogate for testing of 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 were marked in proportion to their abundance, i.e. the smolt that were marked were representative of the drainage-wide smolt population.

In contrast to the commercial harvest model, temporal variation in the marked fraction does not necessarily result in estimation problems. 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. While bias in selection of individuals for marking is unknown, bias during adult sampling is considered minimal. Additional assumptions of the smolt abundance model are described in the data analysis section.

DATA COLLECTION

Data collection occurred during 2 calendar years. Mark-release data were collected when smolt were captured and marked in 2002 and mark-recovery data were collected in 2003 from commercial harvests and from inriver sources (rkm 44.5 fish wheels and drift gillnetting in a 9.5 kilometer stretch of the Kenai River).

Smolt Marking in 2002

Juveniles were captured for marking in 2002 at a single location within the Kenai River drainage. Prior to 1994, juveniles were captured for tagging 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 representatives 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 a total barrier to fish migration during the period May 18 through June 20, 2002. Marking smolt with both coded wire tags and adipose finclips began on May 20 and ended when the last of the coded wire tags was implanted on June 4, 2002.

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 2001 had been implanted in juveniles emigrating from the Moose River the prior year (Carlon 2000, 2003; Carlon and Hasbrouck 1994; 1996-1998; Massengill *In prep*; Massengill and Carlon 2004a, b, 2007). 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 smolt after 2 years in fresh water (Hammarstrom 1988-1992).

Additional evaluation of smolt marking at the Moose River from 1992 through 1994 indicated that the date of arrival at the weir was independent of the eventual adult return timing (Carlon and Hasbrouck 1994, 1996, 1997). Therefore, as a cost-saving measure, an attempt was made to

achieve the marking goal of 95,000 (Carlon *Unpublished*) as quickly as possible. After the marking goal was achieved, tagging was discontinued, personnel (and costs) were reduced, but the weir remained in place until June 23 to census the smolt emigration.

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. 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. 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). 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.

Tag codes released in 2002 were verified on site (through visual inspection with a binoculor 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 11,677 to 12,522 depending on the number of tags per tag spool. This resulted in 10 tag code groups being released during the emigration.

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 2003 Return

Data were collected from four inriver sample sources in 2003 to estimate the tagged and adipose-clipped proportion of the return. These sources were the fish wheel catch at rkm 44.5 (two banks) and drift gillnetting catches between rkm 48.9 and 58.4 (two banks).

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 adipose finclip.

Coho salmon were captured and examined for an adipose finclip from August 1 through September 30 (the last day on which coho salmon were caught). The majority of fish found to have an adipose finclip were checked with an electronic tag detection wand for the presence of

an embedded coded wire tag. A sample of marked fish in which no tag was detected was sacrificed to determine the rate of false-negative wand results. This was required to adjust the estimate of the tagged fraction to account for false-negative wand results. The false-positive rate was assumed to be zero.

Drift Gillnetting

Drift gillnets were the primary gear used in the recapture event of the companion capture-recapture experiment to estimate adult abundance in 2003. Minor catches made by hook-and-line sport fishing gear were also examined. These minor catches were combined with the drift gillnet gear in evaluating the recapture event as a sample source for estimating the tagged proportion of the 2003 return. This combination constituted the recapture event and provided a second source of adult coho salmon to examine for the adipose finclip.

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, such that, at least two and at most four crews deployed nets each day. Crews operated from riverboats, allowing them to move 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.

Commercial Harvest in 2003

Commercial fisheries operated in Upper Cook Inlet typically harvest coho salmon between late June and early September. The fisheries are managed primarily for sockeye salmon *O. nerka* through various combinations of time and area restrictions. Fishery management guidelines for all species are described in the Upper Cook Inlet Salmon Management Plan (Alaska Fish and Game Laws and Regulations Annotated, 2003-2004; 5 AAC 21.363 and associated plans); 2003 management actions are documented by Fox and Shields (2004).

Fisheries selected for sampling during 2003 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; Massengill *In prep;* Massengill and Carlon 2004a, b), but were sampled to estimate the harvest of hatchery-produced coho salmon stocked in Northern District streams (Bosch and Evans 2006, Dan Bosch, ADF&G Anchorage, personal communication). Harvests in other UCI commercial fisheries have been sampled incidental to this effort in prior years (Carlon 2000, 2003; Carlon and Hasbrouck 1994; 1996-1998; Massengill *In prep;* Massengill and Carlon 2004a, b, 2007).

In 2003, both the Central District drift gillnet and eastside set gillnet fishing seasons opened on June 26 (Fox and Shields 2004). The harvests in both fisheries were examined during most open periods 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 moved among commercial

processing locations (main plants and buying stations) and recorded daily totals of the number of coho salmon examined and the number with an adipose finclip. Heads were collected from adipose-clipped fish, frozen, and later shipped to the Mark Tag and Age Lab (Tag Lab) in Juneau 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.

Ancillary Information from the Russian River

A weir operated on the Russian River (Kenai River tributary at rkm 118) for a separate study of sockeye salmon provided supplemental information about coho salmon in the Kenai River drainage. The weir was operational from June 7 through September 4, 2003. Coho salmon were counted and visually examined for adipose fin status as they passed through the weir. They were not sacrificed for CWT retrieval nor checked with a tag detection wand. Although CWTs were not decoded, we assume that adult coho salmon that passed through the weir and were missing the adipose fin were marked as they smolted from the Moose River as that is the only location where coho salmon are marked in the Kenai drainage. Tag recovery efforts in previous years indicate that this assumption is true.

DATA ANALYSIS

Several steps were required before the objectives of estimating smolt production in 2002 and commercial harvest of coho salmon of Kenai River origin in 2003 could be achieved. For the estimate of smolt production, the essential steps were: (1) estimate the number of smolt marked in 2002 that survived the marking process, and (2) detect adipose finclipped fish in the 2003 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 2003 did not change over time, (2) estimate the proportion of the adult return in 2003 bearing coded wire tags, and (3) recover coded wire tags from known sample sizes from the commercial fishery.

Smolt Marking in 2002

Short-term mortality and tag loss were estimated to determine the total number of viable, adipose-clipped and tagged smolt released in 2002. 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 2002 was estimated by summing $\hat{m}_k$ over all marking shifts. This number was required to determine when the tagging goal (95,000 live fish retaining tags) was achieved. The quantities $\hat{s}_k$ and $\hat{b}_k$ also served as real-time quality control measures. 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 2003 Return

Estimating the commercial harvest of coho salmon of Kenai River origin in 2003 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 2002, but was estimated when adults returned in 2003 by examining fish captured in two fish wheels near rkm 44.5 (one adjacent to each riverbank) and the drift gillnetting catch along each riverbank between rkm 48.9 and 58.4.

Estimation of the tagged proportion (θ) from data collected from a specific bank at the fish wheel site was a three-step process. The first step involved estimating the adipose finclip rate (y_i) in the returning population sampled at the fish wheel during weekly interval *i*. The rate was estimated as the proportion of the sample of fish examined that were characterized by an adipose finclip. The second step involved estimating the smolt-to-adult tag retention rate (c_i) in the returning population of adipose-clipped fish sampled at the fish wheel during weekly interval *i*. Corrections for false negative wand results were made, if needed:

$$\hat{c}_i = v'_i / h_i , \tag{2}$$

where:

h_i = the number of adipose-finclipped fish that were wand-tested in the fish wheel sample in week *i*,

$$v'_i = v_i + (h_i - v_i)(\sum_i f_i / \sum_i s_i) , \tag{3}$$

where:

v_i = the number of positive wand results (tag detected) from sample h_i,

s_i = the number of fish with negative wand results (no tag detected) in h_i that were sacrificed to verify the negative result, and

f_i = the number, if any, of false negatives out of s_i (number of adipose-finclipped fish that tested negatively with the wand, were sacrificed, and were found to carry a tag).

Note that in equation 3, an overall false-negative correction factor $(\sum_i f_i / \sum_i s_i)$ is estimated by summing false-negative data (s_i and f_i) over all *i* weekly intervals. In doing this, it is assumed

that the probability of a false negative reading remains constant through weeks. The pooling was required because only a small sample of fish with negative wand results were sacrificed in 2003. Combining all data was necessary to obtain a reasonably precise estimate of the false-negative rate.

The third step involved estimating the tagged proportion (θ_i) of the population sampled at the fish wheel during weekly interval *i* that carried a tag implanted at the Moose River in 2002:

$$\hat{\theta}_i = \hat{y}_i \hat{c}_i . \quad (4)$$

Estimation of the tagged proportion (θ) from data collected from each driftnetting bank was calculated similarly, with the exception that no estimate of tag retention was made; an overall tag retention estimate calculated from the fish wheel data was used in place of c_i to adjust the adipose clip rate. Fish were not wanded to avoid physically detaining the spawning migration more than necessary; it was assumed that the tag retention rate was similar among all sample sources within the Kenai River.

For each sample source, a chi-square statistic was 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) for the sample source by combining data over weekly intervals. A chi-square statistic ($\alpha = 0.05$) was also used to compare pooled data among sampling sources. These calculations were used to determine if sample data could be combined among weeks and sources to provide a more precise estimate of the overall tagged proportion in the 2003 return.

The data collected to estimate the tagged proportion in the 2003 return also provided an important component of the estimator of the number of smolt that emigrated from the Kenai River in 2002. The mark used to estimate smolt abundance was the adipose clip as opposed to the presence of a coded wire tag. The number of adipose-finclipped fish recovered in the 2003 inriver sampling program was recorded as a partial requirement of estimating smolt abundance in 2002.

Smolt Abundance in 2002

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

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

where:

M = the number of smolt marked with an adipose finclip and surviving to emigrate in 2002,

C = the number of adult coho salmon examined for an adipose finclip in the 2003 return sample, and

R = the number of adult coho salmon in the 2003 sample that had an adipose finclip.

The variance of the smolt abundance estimate was estimated by:

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

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

1. Adult coho salmon examined for marks were a random sample of the inriver return or the marked sample of smolt was a representative sample of the drainage-wide smolt emigration in 2002 or there is complete mixing of marked and unmarked individuals between the marking and recapture events,
2. All juveniles marked at the Moose River in 2002 were actually smolt,
3. Survival and catchability were the same for marked and unmarked individuals,
4. Adipose fins were not regenerated between the mark and recovery events,
5. There was no natural loss of adipose fins at any time during the life of the population, and
6. Fish were correctly categorized for the presence or absence of an adipose fin when examined at each inriver sampling source.

Independence between the timing of tagging as smolt and adult return timing has been noted in all prior study years from either inriver recoveries, commercial recoveries, or both (Carlon 2000; Carlon and Hasbrouck 1994; 1996-1998). The independence observed from inriver samples is consistent with the notion that fish marked in the Moose River, at least, mix before being sampled inriver as adults. Observations in prior years also indicate that smolt emigrating from the Moose River contain representatives of the entire Kenai River population. While the independence of release and return timing and the cosmopolitan nature of the Moose River smolt migration do not guarantee representative tagging of the entire Kenai River smolt population, or complete mixing of marked and unmarked fish between tagging and recapture, they are at least consistent with the latter two conditions of assumption 1. With respect to the first condition of assumption 1, 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, although depensatory sampling cannot be strictly ruled out (probability of capture declining with fish passage). It is believed that there is a good chance that at least one of the three conditions of assumption 1 is fulfilled.

The remaining five assumptions are also likely valid. Previous experience and observations indicate that most juveniles marked at the Moose River each year are smolt (assumption 2). Short-term survival of marked smolt has been nearly 100% during all smolt-marking events at the Moose River (assumption 3) (Carlon 2000, 2003, Carlon and Evans *In prep*; Carlon and Hasbrouck 1994; 1996-1998; Massengill *In prep*; Massengill and Carlon 2004a, b, 2007) although long-term survival and catchability assumptions remain untested for this wild population. Vincent-Lang (1993) has, however, found that hatchery-produced coho salmon marked with adipose clips and coded wire tags and released in a western Kenai Peninsula drainage system experienced similar smolt-to-adult survival as that of unmarked coho salmon. 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 1,200,000 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 Evans *In prep*; Carlon and Hasbrouck 1994; 1996-1998; Massengill *In prep*; Massengill and Carlon 2004a, b, 2007), this supports the notion that naturally missing adipose fins are rare.

Commercial Harvest in 2003

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 CF Division provided the commercial harvest by fishery, date, and statistical area. The Central District commercial harvest data used in this report were provided during March of 2003 and may differ slightly (>80) from the total Central District harvest data reported elsewhere due to a very small number of previously unreported fish tickets being reported after the deadline.

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 fish wheel catch and the inriver drift netting catch. 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):

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

where:

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

θ = the proportion of the 2003 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 2002 tagging event,

n_i = the number of fish harvested during stratum *i* and examined for an adipose finclip, 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 an adipose finclip,

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 2002 event).

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

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

where:

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

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

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

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

Although the number of fish harvested is estimated by commercial processors as a product of pounds purchased and average weight per fish, the overall variance of the number harvested is considered small because the entire harvest is weighed. Therefore, the number of coho salmon harvested by fishery was considered a known constant, not an estimate. The variance component associated with estimated average weight is not known and is not included in the variance associated with 2003 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 1994; 1996-1998; Massengill *In prep*; Massengill and Carlon 2004a, b, 2007). Pooling data among processors in 2003 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 2002

From May 21 through June 4, 2002, 108,558 smolt were marked with coded wire tags and adipose finclips as they emigrated from the Moose River Smolt (Appendix A1). The last release of marked smolt occurred on June 5, 2002. Of these, an estimated 108,520 survived the tagging process based on the estimated short-term survival rate (~ 99.9%). Of the surviving marked smolt, more than 98% retained tags resulting in an estimated 107,069 smolt that were released alive with tags. Although marked fish were released as late as June 5 (from the overnight retention and survival sample), marking was discontinued after the marking goal was achieved on June 4, 2002. The weir remained in place until June 21 allowing for a census of smolt emigration. The total number of smolt arriving at the weir between May 21 and June 20, 2002 was 228,059.

TAGGED PROPORTION OF THE 2003 RETURN

Adults marked as smolt (with adipose finclips and coded wire tags) at the Moose River in 2002 returned to the Kenai River drainage in 2003. Marked and unmarked adults from four adult sample sources were examined over weekly periods to produce a qualified estimate of the proportion ($\hat{\theta}$) of the adult return bearing tags.

Fish Wheel Sampling

Two fish wheels were used exclusively in the capture event of the companion mark-recapture experiment to estimate adult abundance in 2003. Each fish wheel (one operated adjacent to each riverbank) was scheduled to operate a consistent number of hours per day from August 1 through September 30 to minimize seasonal sampling bias. Daily hours of operation varied based on fish wheel maintenance requirements, but averaged 12.2 hrs per day for the fish wheel adjacent to the north bank and 11.5 hrs per day for the fish wheel adjacent to the south bank (Carlon *In prep*). From August 1 through September 30, a combined total of 2,475 unique coho salmon were captured and examined (Table 1 and Appendix A2). The tag detection wand was used to check the adipose-clipped fish for tags.

Of the 2,475 coho salmon captured in fish wheels, 2,184 were captured in the south bank fish wheel. The weekly tagged proportion in the south bank fish wheel catch ranged from 0.038 to 0.400 and varied significantly over all weeks (P = 0.023), but did not vary significantly over the first 7 weeks (P = 0.057). The overall tagged proportion estimated by pooling the full season of south bank fish wheel data was 0.167.

An additional 291 coho salmon were captured in the north bank fish wheel. The weekly tagged proportion ranged from zero to 0.429 but did not vary significantly over weeks (weeks 1-3, and 7-9 collapsed to avoid small cell counts; P = 0.245). The tagged proportion estimated by pooling the full season of north bank fish wheel data was 0.210. This tagged proportion was not significantly different from that estimated for the south bank fish wheel (P = 0.068).

The relative consistency of the tagged proportion over the majority of the season for both wheels, and the lack of a significant difference in the tagged proportion between fish wheels suggest that pooling all fish wheel data to estimate the tagged proportion of the return may be valuable; its utility will be detailed later in this report. Of the total 2,475 coho salmon captured in the fish wheels, 428 (0.230) had an adipose finclip. The overall tag retention rate for fish sampled at the fish wheel (c) was (422/425 = 0.993); of the three fish for which a tag was not detected by the

Table 1.-Recoveries of coho salmon from multiple sources within the Kenai River drainage from August 1 through October 5, 2003 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	4	0	0.000	0	0	1.000	0.000	0
08/08 - 08/14	33	4	0.121	4	4	1.000	0.121	0
08/15 - 08/21	7	3	0.429	3	3	1.000	0.429	0
08/22 - 08/28	122	21	0.172	21	21	1.000	0.172	0
08/29 - 09/04	33	7	0.212	7	7	1.000	0.212	0
09/05 - 09/11	40	13	0.325	12	12	1.000	0.325	0
09/12 - 09/18	36	8	0.222	8	8	1.000	0.222	0
09/19 - 09/25	3	1	0.333	1	1	1.000	0.333	0
09/26 - 09/30	13	4	0.308	4	4	1.000	0.308	0
Total	291	61	0.21	60	60	1.000	0.210	0
			South Bank Fish Wheel					
08/01 - 08/07	26	1	0.038	1	1	1.000	0.038	0
08/08 - 08/14	453	71	0.157	71	69	0.972	0.152	2
08/15 - 08/21	774	121	0.156	121	120	0.992	0.155	1
08/22 - 08/28	500	85	0.170	84	84	1.000	0.170	0
08/29 - 09/04	287	57	0.199	57	57	1.000	0.199	0
09/05 - 09/11	82	18	0.220	18	18	1.000	0.220	0
09/12 - 09/18	10	4	0.400	3	3	1.000	0.400	0
09/19 - 09/25	21	1	0.048	1	1	1.000	0.048	0
09/26 - 09/30	31	9	0.290	9	9	1.000	0.290	0
Total	2,184	367	0.168	365	362	0.992	0.167	3
			North Bank Recapture Effort					
08/01 - 08/07	4	0	0.000			0.993	0.000	0
08/08 - 08/14	98	20	0.204			0.993	0.203	0
08/15 - 08/21	340	82	0.241			0.993	0.239	1
08/22 - 08/28	518	125	0.241			0.993	0.240	1
08/29 - 09/04	336	89	0.265			0.993	0.263	1
09/05 - 09/11	179	48	0.268			0.993	0.266	0
09/12 - 09/18	169	37	0.219			0.993	0.217	0
09/19 - 09/25	170	45	0.265			0.993	0.263	0
09/26 - 10/02	115	32	0.278			0.993	0.276	0
10/03 - 10/05	18	1	0.056			0.993	0.055	0
Total	1,947	479	0.246			0.993	0.244	3

-continued-

Table 1.-Page 2 of 2.

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 Recapture Effort								
08/01 - 08/07	9	1	0.111			0.993	0.110	0
08/08 - 08/14	88	10	0.114			0.993	0.113	0
08/15 - 08/21	248	34	0.137			0.993	0.136	0
08/22 - 08/28	263	49	0.186			0.993	0.185	0
08/29 - 09/04	234	54	0.231			0.993	0.229	0
09/05 - 09/11	141	33	0.234			0.993	0.232	0
09/12 - 09/18	153	34	0.222			0.993	0.221	0
09/19 - 09/25	211	51	0.242			0.993	0.240	0
09/26 - 10/02	181	50	0.276			0.993	0.274	0
10/03 - 10/05	13	4	0.308			0.993	0.306	0
Total	1,541	320	0.208			0.993	0.206	2
Combined North and South Banks Fish Wheels								
08/01 - 08/07	30	1	0.033	1	1	1.000	0.033	0
08/08 - 08/14	486	75	0.154	75	73	0.973	0.150	2
08/15 - 08/21	781	124	0.159	124	123	0.992	0.157	1
08/22 - 08/28	622	106	0.170	105	105	1.000	0.170	0
08/29 - 09/04	320	64	0.200	64	64	1.000	0.200	0
09/05 - 09/11	122	31	0.254	30	30	1.000	0.254	0
09/12 - 09/18	46	12	0.261	11	11	1.000	0.261	0
09/19 - 09/25	24	2	0.083	2	2	1.000	0.083	0
09/26 - 09/30	44	13	0.295	13	13	1.000	0.295	0
Total	2,475	428	0.173	425	422	0.993	0.172	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 river banks in the recapture efforts 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 2002 based on tag detection results.

[d] Estimated proportion of the number examined bearing a coded wire tag originally implanted at the Moose River in 2002.

[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.

wand, all were sacrificed to verify the negative wand results and no tags were found. No false-negative adjustment was therefore needed. Adjusting the overall adipose finclip rate (y) based on pooled fish wheel samples (0.173) by this tag retention rate produced an estimate of the overall tagged proportion ($\hat{\theta}$) of 0.172. The weekly tagged proportion ranged from 0.033 to 0.295 and varied significantly over weekly intervals (P = 0.003) although there was no significant difference among the first 5 weekly intervals from August 1 through September 4 (P = 0.09). Likewise, there was no significant difference among the last 4 weekly intervals from September 5 through September 30 (P = 0.25).

Drift Gillnets and Hook and Line Sampling

Drift gillnets were the primary gear used in the recapture event of the companion capture-recapture experiment to estimate adult abundance in 2003. Minor catches made by hook-and-line sport fishing gear and set gillnetting were also examined. These minor catches were combined with the primary gear in evaluating the recapture event as a sample source for estimating the tagged proportion of the 2003 return. Recapture effort was scheduled each day between August 1 and October 5, 2003 inclusive in an effort to expend a similar amount of effort each week to minimize seasonal sampling bias. However, because the driftnetting technique requires adequate daylight for boat operation, effort declined substantially over the season due to decreasing daylight.

From August 1 through October 5, a combined total of 3,488 unique coho salmon were captured, examined, and assigned to a bank of capture (Table 1 and Appendix A3). A tag detection wand was not used to check for tag retention in the drift gillnetting catches and the tagged proportion ($\hat{\theta}$) for each drift gillnetting sample was estimated by multiplying the gillnet adipose finclip rate (y_i) by the overall tag retention rate (c) measured in the capture event.

Of the 3,488 coho salmon captured in the diftnetting sample, 1,541were captured along the south bank. After adjusting for tag retention (based on the tag retention rate detected in the fish wheel catch), the weekly tagged proportion in the south bank catch ranged from 0.110 to 0.306 and varied significantly over all weeks during which fish were examined (P = 0.007). The seasonal tagged proportion estimated by pooling all south bank drift gillnetting data was 0.206. This proportion differed significantly from the pooled fish wheel sample (P = 0.006).

The remaining 1,947 sampled coho salmon were captured along the north bank in the drift gillnetting effort. The weekly tagged proportion ranged from zero to 0.276 but did not vary significantly over the second through eighth weeks (99% of the sample) (P = 0.80). The seasonal tagged proportion estimated by pooling all north bank drift gillnetting data was 0.244. This proportion differed significantly from that estimated from south drift gillnetting samples (P = 0.008) and from the pooled fish wheel sample (P<0.001).

Of the total 3,488 coho salmon sampled, 799 (0.229) had an adipose finclip. The overall tagged proportion ($\hat{\theta}$) for the drift gillnetting catch was estimated by multiplying the overall gillnet adipose finclip rate (y) of 0.229 by the overall tag retention rate (c) measured in the capture event (0.993) for an estimate of 0.227. This proportion differed significantly from the overall fish wheel proportion of 0.172 (P < 0.001). The weekly tagged proportion ranged from 0.076 to 0.275 and varied significantly over weekly intervals (P < 0.036) although there was no difference among the first four weekly intervals from August 1 through August 28 (P = 0.163).

Qualified Estimate of the Tagged Proportion

Because statistically significant temporal variations in the tagged proportion were detected, estimates of commercial harvest could be biased, depending on the actual tagged proportion present in marine commercial fisheries of Upper Cook Inlet. However, a point estimate of the overall tagged proportion of the return was made from a subset of the data and sensitivity tests conducted to examine the effect of using putative minimum and maximum tagged proportions on the estimates of harvest in commercial fisheries. The overall tagged proportion from the fish wheel effort was therefore used to generate qualified point estimates (and variances) of harvest in commercial fisheries while the two extremes (minimum and maximum) in the tagged proportion in the fish wheel data were used to calculate extreme bounds for point estimates of commercial harvest.

The overall estimated tagged proportion ($\hat{\theta}$) of the 2003 return was 0.172 (SE($\hat{\theta}$)=0.008; $\hat{\theta}^{-1}$=5.8; SE($\hat{\theta}^{-1}$)=0.259). Because of the significant temporal trend in the pooled fish wheel data, this estimate is considered a "qualified" estimate of the tagged proportion passing through commercial fishing areas as described above. The minimum tagged proportion of 0.164 (SE($\hat{\theta}$)=0.008; $\hat{\theta}^{-1}$=6.1; SE($\hat{\theta}^{-1}$)=0.29) was estimated from samples collected during the first 5 weeks of sampling (8/1–9/4) because no difference was detected in the tagged proportion among those weeks. The maximum tagged proportion was estimated from samples taken during the last 4 weekly periods (9/5-9/30) and was estimated as 0.246 (SE($\hat{\theta}$)=0.0280; $\hat{\theta}^{-1}$=4.1; SE($\hat{\theta}^{-1}$)=0.486).

SMOLT ESTIMATE IN 2002

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, for reasons outlined above.

Based on the number of live smolt released with an adipose finclip at the Moose River in 2002 (108,520), the number of adult coho salmon examined for adipose fin status in the Kenai River fish wheel samples in 2003 (2,475), and the number of adults in the sample that had an adipose finclip (428), an estimated 626,335 (SE = 27,409) smolt emigrated from the Kenai River in 2002.

COMMERCIAL HARVEST IN 2003

General inlet-wide sampling is summarized to add perspective and to document the recovery of marked coho salmon of Kenai River origin in other areas of Cook Inlet. Commercial fishery sampling is summarized in detail for the target fisheries of the Central District (drift and eastside set) and all Northern District fisheries. Additional details of 2003 Northern District sampling efforts and recoveries of hatchery-produced coho salmon are documented in a companion report (Dan Bosch, ADF&G, Division of Sport Fish, Anchorage, personal communication).

Inlet-Wide Fisheries

During the 2003 fishing season, 101,677 coho salmon were harvested in commercial fisheries of UCI (Table 2). This harvest was 38% of the 1993-2002 average harvest (Fox and Shields 2003). About 76% of the 2003 UCI commercial harvest was taken in Central District fisheries. Among Central District fisheries, the greatest harvest occurred in the drift gillnet fishery (67.5% of the Central District harvest); other fisheries represented from 7.6% to 13% of the Central District harvest (Figure 5). The Northern District set gillnet fisheries comprised 24% of the total UCI commercial harvest.

Of the inlet-wide commercial harvest, 44,922 fish (44%) were examined for adipose clips. Adipose-clipped fish were found in all sampled fisheries. Exact fishery stratum of harvest (statistical area) could not be identified for 6,880 examined fish (Appendix A5); these fish were sampled from processor deliveries consisting of harvests from multiple statistical areas. They were not used to calculate harvest estimates due to the ambiguity of their origin. Of these samples from mixed areas, a total of 104 were found with an adipose finclip (1.5%), heads were recovered from all of them, and a decodable tag was found in 84 of the recovered heads. Of the 84 decodable tags recovered, 12 had been implanted in smolt at the Moose River in 2002.

The remaining 38,042 examined fish were positively assigned to fishery strata (Appendix A6). Of these, 930 (2.4%) had an adipose finclip and heads were collected from 912 of them. Of the 912 heads recovered, 795 had decodable tags (87%). All tagged fish had originated from UCI release locations in 2002, either as hatchery-produced coho salmon smolt released into Northern District streams or as wild coho salmon smolt captured and tagged as they emigrated from Cottonwood Creek (Northern District) or from the Kenai River drainage.

Of the 795 decodable tags recovered from adults commercially harvested in known fishery strata, 146 (18.4%) were originally released as smolt emigrating from the Kenai River drainage. All 146 were originally implanted in smolt emigrating from the Moose River tributary in 2002. Most (92%) were recovered from Central District fisheries while 12 were recovered from known Northern District fisheries.

Among the commercial processors receiving at least 500 coho salmon harvested in the Central District eastside set gillnet fisheries in 2003, the proportion of the number examined at each processor that carried coded wire tags implanted in smolt at the Moose River in 2002 did not exceed 0.071 (Figure 6). Among all plants processing coho salmon harvested in the Central District drift gillnet fishery, the proportion did not exceed 0.004. The proportions did not differ radically among processors and sampling summaries (and harvest estimates) that follow are therefore based on samples pooled among processors.

Central District Drift Gillnet Fishery

During the 2003 fishing season, 52,421 coho salmon were harvested in the Central District drift gillnet fishery. The 2003 harvest was 38% of the1993-2002 average harvest (Fox and Shields 2004).

The Central District drift gillnet fishery harvest was sampled during most fishing periods between the first open period on June 26 and the last on August 7. Overall, 34% of the harvest was examined. The harvest occurring on days not sampled accounted for 6% of the total harvest.

A total of 18,060 fish was examined and positively assigned to drift fishery temporal strata and used to calculate harvest estimates. Of fish examined, 310 (1.7%) had an adipose finclip and heads were collected from all but one. Of the 309 heads recovered, 265 had decodable tags. Of these decodable tags, 207 originated from the 2002 annual release of hatchery-produced smolt among multiple Northern District streams, 29 originated as Northern District wild smolt emigrating from Cottonwood Creek in 2002, 1 each originating from the Homer Spit release of hatchery-produced smolt and from Deep Creek wild smolt, and the remaining 27 were originally implanted in wild smolt emigrating from the Moose River (Kenai River drainage) in 2002.

Table 2.-Sampling performance and recovery of coded wire tags (CWT) from coho salmon harvested in Upper Cook Inlet commercial fisheries in 2003.

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 2002
CENTRAL DISTRICT										
Central District Drift	52,421	18,060	0.34	310	0.02	309	44	0.14	265	27
East Side Set (by Statistical Area)										
244-21	1,511	339	0.22	28	0.08	28	1	0.04	27	24
244-22	2,617	248	0.09	13	0.05	13	1	0.08	12	11
244-31/32	1,171	271	0.23	15	0.06	15	0	0.00	15	14
244-41/42	4,872	1,465	0.30	77	0.05	77	6	0.08	71	49
East Side Set Total	10,171	2,323	0.23	133	0.06	133	8	0.06	125	98
Kalgin Is. Set	9,192	449	0.05	14	0.03	14	1	0.07	13	9
West Side Set	5,878	1,064	0.18	3	0.00	3	2	0.67	1	0
Mixed East Side Set[c]		229		7	0.03	7	0	0.00	7	6
Mixed West Side Set/Kalgin Island Set[c]		6,304		14	0.00	71	16	0.23	55	6
Mixed East Side and Central District Drift		59		1	0.02	1	1	1.00	0	0
Central District Total	77,662	21,896	0.28	460	0.02	459	55	0.12	404	134
NORTHERN DISTRICT										
West Side Set	4,671	4,347	0.93	7	0.00	2	0	0.00	2	0
Pt. MacKenzie/Susitna Flats Set	8,226	5,243	0.64	289	0.06	280	31	0.11	249	1
East Side Set	9,372	5,343	0.57	90	0.02	88	23	0.26	65	8
Fire Island Set	1,746	1,213	0.69	84	0.07	83	8	0.10	75	3
Northern District Set Total	24,015	16,146	0.67	470	0.03	453	62	0.14	391	12
Mixed Fire Island and Pt. MacKenzie/Susitna Flats Set		288		25	0.09	25	3	0.12	22	0
Northern District Total	24,015	16,434	0.68	495	0.03	478	65	0.14	413	12
Mixed Fishery Total		6,880		47	0.01	104	20	0.19	84	12
Unmixed Fishery Total[d]	101,677	38,042	0.37	930	0.02	912	117	0.13	795	146
Grand Total[e]	101,677	44,922	0.44	977	0.02	1,016	137	0.13	879	158

-continued-

Table 2.-Page 2 of 2.

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

[e] Sampling result total for all samples positively assigned to known fisheries and also samples not assigned to known fisheries throughout Upper Cook Inlet.

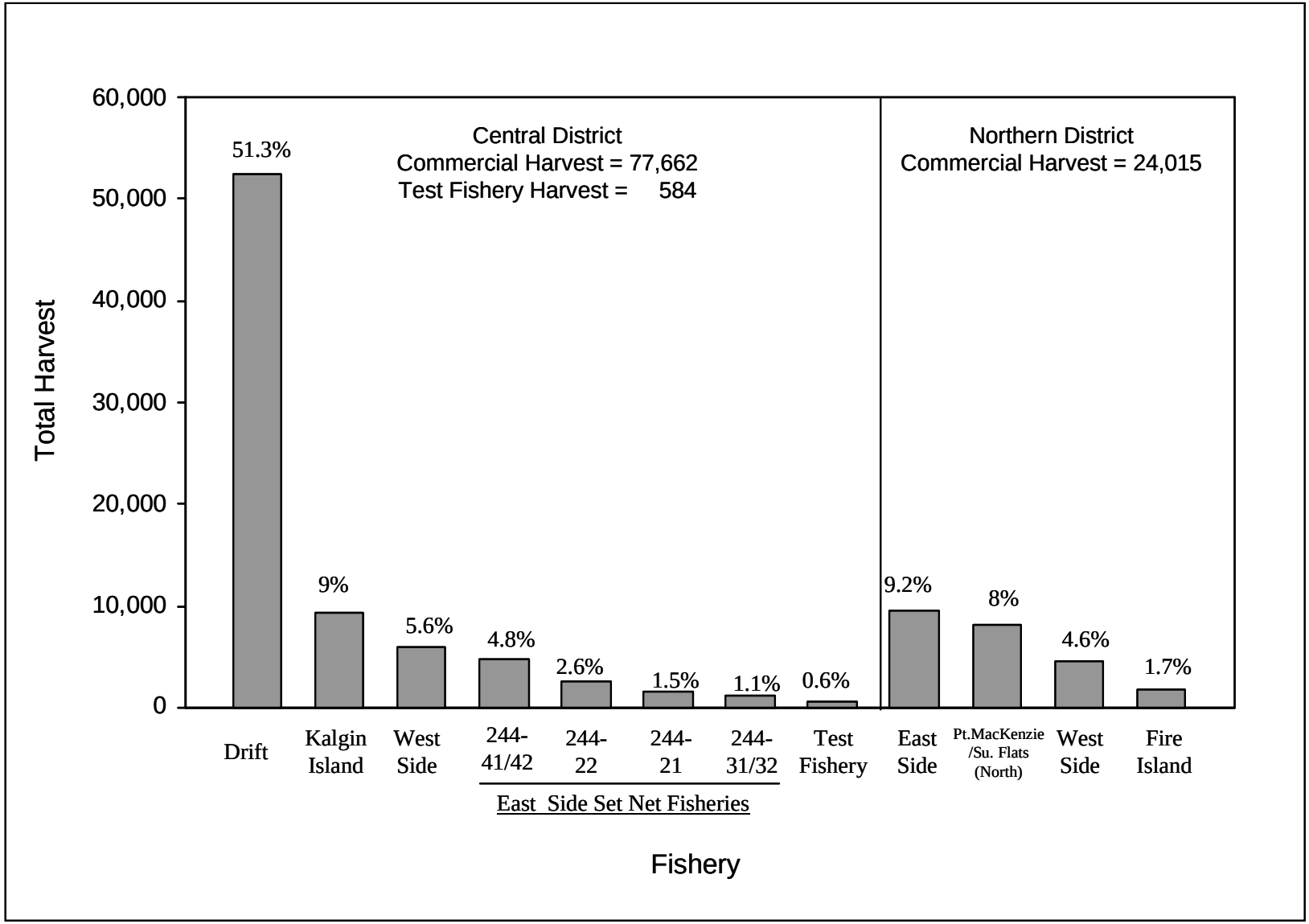

Figure 5.-Coho salmon harvest in 11 Upper Cook Inlet (UCI) commercial fishery areas including Alaska Department of Fish and Game UCI test fisheries in 2003.

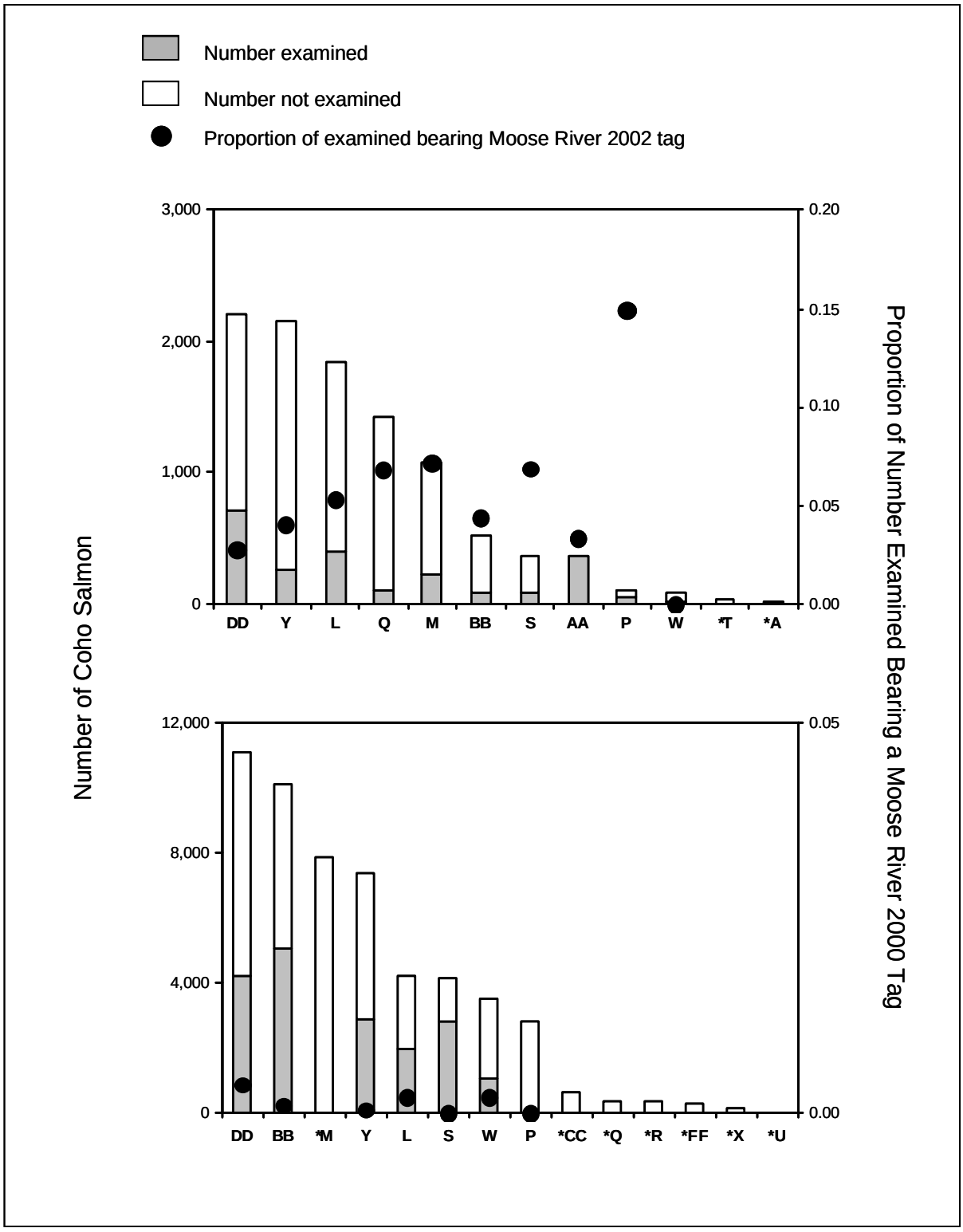

Figure 6.-Number of coho salmon harvested and processed in 2003 in the Eastside setnet fishery (top) and Central District drift fishery including Alaska Department of Fish and Game Offshore Test Fishery (bottom) of Upper Cook Inlet by commercial processor (alias name) and proportion of examined fish that were originally marked at the Moose River in 2002.

Therefore, of the 18,060 fish examined in this fishery, tags implanted at the Moose River in 2002 were physically recovered from 0.15%.

The first recoveries of fish bearing Moose River coded wire tags occurred on July 21, some 26 days after the first fishing period. Coho salmon marked at the Moose River were recovered on 7 of the 12 sampled days between July 3 and the last open fishing period on August 7.

Central District Eastside Set Gillnet Fishery

During the 2003 fishing season, 10,171 coho salmon were harvested in the Central District eastside set gillnet fishery. The 2003 harvest was 34% of the 1992-2002 average harvest (Fox and Shields 2004).

Between the first open period on June 30 and the last on August 7, the Central District eastside set gillnet fishery harvest was sampled on 14 of the 26 days on which fishing occurred. Overall, 23% of the harvest (2,323 fish) was examined and positively assigned to spatial-temporal strata. The combined eastside harvest occurring on days not sampled accounted for 23% of the total harvest. Adipose-finclipped fish were found on all but 4 of the days sampled.

Of the 2,323 fish examined and assigned to fishery strata, 133 (5.7%) had an adipose finclip and heads were collected from all. Of the 133 heads recovered, 8 (6%) had no tag; the remaining 125 heads all had decodable tags. Of these decodable tags, 25 originated from the 2002 annual release of hatchery-produced smolt among multiple Northern District streams, 1 originated from the 2002 wild smolt tagging study in Cottonwood Creek, 1 originated from the release of 2002 hatchery-produced smolt into the Homer Spit Lagoon, and the remaining 98 were originally implanted in wild smolt emigrating from the Moose River in 2002. Therefore, of the 2,323 fish examined in this fishery, tags implanted at the Moose River in 2002 were physically recovered from 4.2%.

Among statistical areas, portions of the harvest were not examined early in the season. The portion of the harvest occurring on days not sampled ranged from 22% to 50% among statistical areas. Coho salmon marked at the Moose River in 2002 were recovered from all statistical areas in 2003. The first recovery of Moose River tags occurred on July 21 in statistical area 24441/42, on July 23 in statistical area 24422, on July 28 in statistical areas 24421, and 24431/32. The portions of fish examined in 2003 that had been marked as smolt at the Moose River in 2002 were 7.1%, 4.4%, 5.2, and 3.3% for statistical areas 24421, 24422, 24431/32, and 24441/42, respectively.

Northern District Gillnet Fisheries

During the 2003 fishing season, a total of 24,015 coho salmon were harvested among all Northern District set net fisheries. The 2003 harvest was 35% of the 1993-2002 average harvest (Fox and Shields 2004).

Sampling of the harvest in the Northern District occurred during most fishery openings after the first open period on July 3. Although specific Northern District fisheries were not sampled on several days near the beginning and end of the fishing season, collectively, the harvest among all Northern District fisheries was sampled the most intensively of all UCI fisheries with 16,146 fish examined (67% of the harvest). Of the 16,146 fish examined from unmixed district samples, all could be positively assigned to a fishery stratum and were used to calculate harvest estimates. The harvest occurring on days not sampled accounted for 5.0% of the total harvest. Adipose-clipped fish were found on all but 2 sampled days.

Of the 16,146 fish examined and assigned to fishery strata, 470 (2.9%) had an adipose finclip and heads were collected from all but 17. Of the 453 heads recovered, 61 (13%) had no tag, resulting in a total of 392 heads with tags, of which 391 were decodable. Of these decodable tags, 315 originated from the 2002 annual release of hatchery-produced smolt among multiple Northern District streams, 64 originated from the 2002 wild smolt tagging study in Cottonwood Creek, and the remaining 12 were originally implanted in wild smolt emigrating from the Moose River tributary to the Kenai River in 2002. Therefore, of the 16,146 fish examined among Northern District fisheries, tags implanted at the Moose River in 2002 were physically recovered from 0.07%.

Commercial Harvest Estimates

Based on commercial catch sampling data and the point estimate of the tagged proportion of the 2003 adult return to the Kenai River, a set of qualified commercial harvest estimates was generated for UCI commercial fisheries in 2003. The point estimates of commercial harvest are considered qualified because the point estimate of the tagged proportion on which they are based is considered germane to the population as a whole and not necessarily to the population at the time it passed through commercial fishing areas. The approximations are further qualified as described in the section to follow.

A qualified estimate of 330 (SE = 65) coho salmon of Kenai River origin were harvested by the Central District drift gillnet fishery (Table 3), 2,122 (SE = 252) by the Central District eastside set gillnet fishery (Table 4), and 126 (SE = 39) by all Northern District set gillnet fisheries (Appendix A6) for a total of 2,578 (SE = 263) during 2003. These qualified estimates comprised 0.6% of the total drift gillnet harvest, 20.8% of the total eastside set gillnet harvest, and 0.5% of the total Northern District set gillnet harvest in 2003.

The first coho salmon of Kenai River origin was detected in the Central District drift gillnet harvest on July 21. The contribution of Kenai River origin fish to the harvest remained minimal throughout the commercial drift gillnet season with the greatest proportional contribution (2.5%) occurring during the last 2 days of July and the first 7 days in August. Although the greatest harvest of all coho salmon did not occur during that period, the greatest absolute harvest of Kenai River-bound coho salmon did (Figure 7).

The first coho salmon of Kenai River origin was detected in the Central District eastside set gillnet harvest on July 21. The harvest of 2,920 coho salmon before July 21 represents 29% of the total harvest in this fishery. In general, both the proportion of the harvest comprised of coho salmon of Kenai River origin, and the total overall harvest, was greater during the latter half of the fishing season (Figure 8).

The total coho salmon harvest occurring in the Central District eastside set gillnet fishery ranged from a low of 1,171 in statistical area 244-31/32 to a high of 4,872 in statistical area 244-41/42 (Figure 9). The portion of the seasonal harvest comprised of coho salmon of Kenai River origin ranged from 7.7% to 47.6%.

Meaningful temporal or geographic trends occurring in Northern District commercial fisheries were not detectable because of the inconsequential harvest estimate of 126 coho salmon of Kenai River origin. Only 12 fish bearing a coded wire tag from the Kenai River drainage were detected in the combined Northern District set gillnet fishery, eight of which came from the eastside set area. The first recovery of a coded wire tag from an adult tagged as a smolt in 2002 at the Moose River occurred on August 7, 2003.

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, 2003.

Interval	Total Harvest	Estimated Harvest of Coho Salmon of Kenai River Origin	Standard Error	Portion of Total Harvest
06/26 - 07/07	2,636	0		
07/08 - 07/19	16,669	0		
07/20 - 07/29	24,802	119	44	0.005
07/30 - 08/07	8,314	211	47	0.025
Total	52,421	330	65	0.006

Effect of Variations of the Tagged Proportion on Commercial Harvest Estimates

Although the tagged proportion measured in the fish wheel catch did vary significantly over all weekly periods, harvest estimates as presented in this report (based on the pooled fish wheel estimate of the tagged proportion) are considered practical for current management and research needs.

An analysis was conducted to determine the sensitivity of commercial harvest estimates to the observed temporal variation in the estimated tagged proportion. Three sets of commercial harvest estimates were calculated for the sampled fisheries and examined for practical differences (Table 5). Estimates were calculated using the pooled tagged proportion (0.172), the minimum proportion detected from data pooled over the first 5 weeks (0.165), and the maximum weekly proportion detected from data pooled from the last 4 weeks (0.246). Minimum and maximum harvest estimates based on the extremes in the tagged proportion therefore represent the most-extreme plausible scenarios. The lower and upper bound harvest estimates differed from the pooled estimate by +5% and -30%, respectively.

DISCUSSION

COMMERCIAL HARVEST

There is potential for bias in the point estimates of the Kenai River's contribution to the commercial harvest of coho salmon due to the temporal variability of the tagged proportion in the inriver samples. However, it was considered unreasonable to abandon the estimates without evaluating the potential magnitude of the bias; minimally biased estimates are still of value for assessment, management, and research planning purposes. The sensitivity analysis demonstrated that useful harvest estimates are available from this study.

The contrast between the largest point estimate of commercial harvest (2,700) and the commercial harvest estimated under the pooled scenario (2,578) - relative to harvest magnitudes and total return - illustrates the intrinsic value of the estimates regardless of bias. The largest estimate represents 3.1% of the total UCI commercial harvest (excluding the Central District areas of Kalgin Island set and the westside set where interception of Kenai River bound coho

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, 2003.

Interval	Total Harvest	Estimated Contribution	Portion of Total Harvest
	Statistical Area 244-21		
06/30 - 07/10	18	0	
07/11 - 07/21	117	0	
07/22 - 07/30	731	88	0.120
07/31 - 08/07	645	631	0.978
Total	1,511	719	0.476
	Statistical Area 244-22		
06/30 - 07/10	27	0	
07/11 - 07/21	1,634	0	
07/22 - 07/31	523	78	0.149
08/01 - 08/07	433	123	0.284
Total	2,617	201	0.077
	Statistical Area 244-31/32		
06/30 - 07/10	42	0	
07/11 - 07/21	324	0	
07/22 - 07/31	466	178	0.382
08/01 - 08/07	339	92	0.271
Total	1,171	270	0.231
	Statistical Area 244-41/42		
06/30 - 07/10	44	0	
07/11 - 07/21	1,075	14	0.013
07/22 - 07/31	2,603	549	0.211
08/01 - 08/07	1,150	369	0.321
Total	4,872	932	0.191
	Combined Statistical Areas		
06/30 - 07/10	131	0	
07/11 - 07/21	3,150	14	0.004
07/22 - 07/31	4,323	893	0.207
08/01 - 08/07	2,567	1,215	0.473
Total	10,171	2,122	0.209

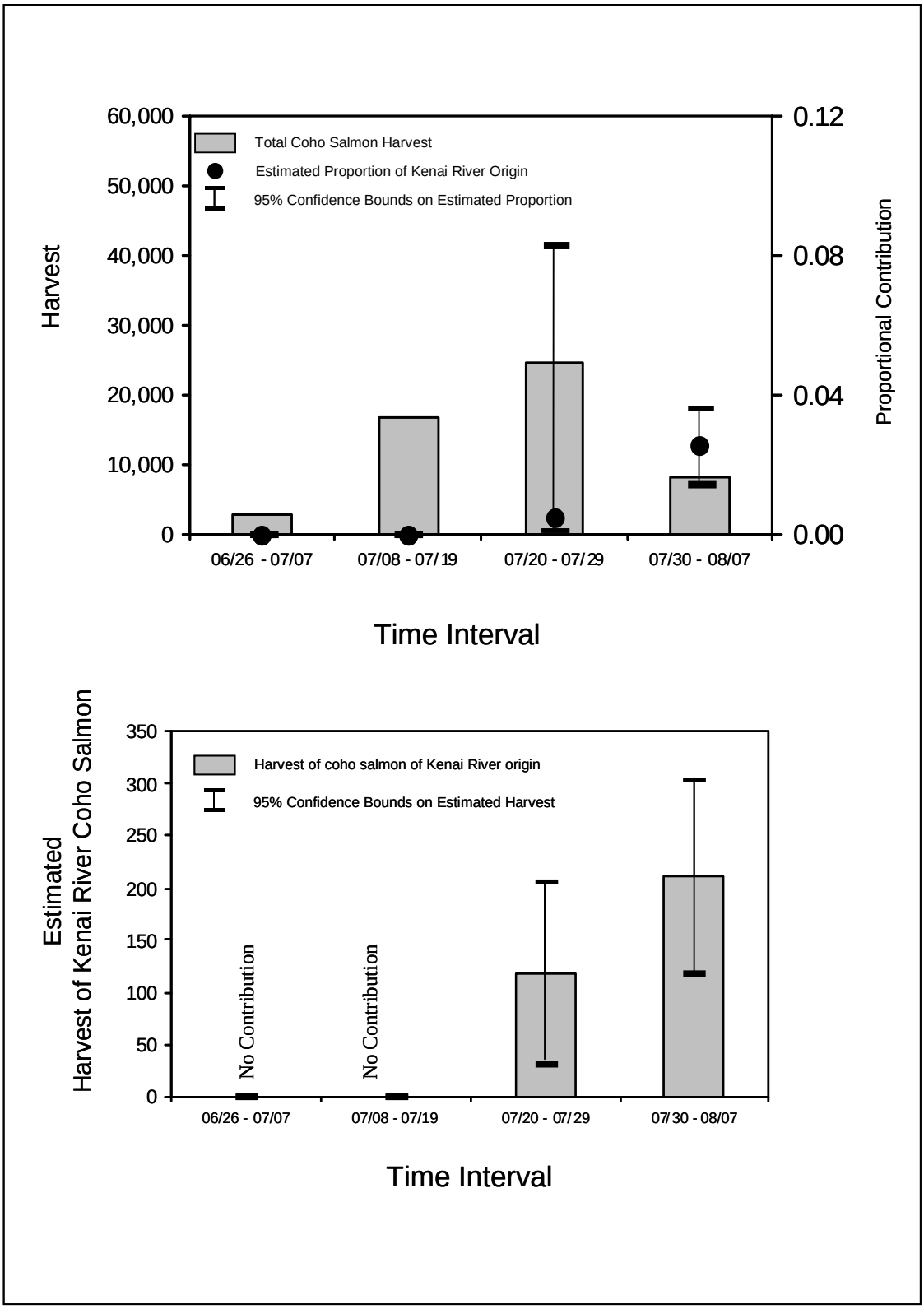

Figure 7.-Temporal trend in proportional contribution of Kenai River coho salmon to the total harvest (top) and trend in absolute contribution (bottom) occurring in the drift gillnet fishery of the Central District of Upper Cook Inlet, 2003.

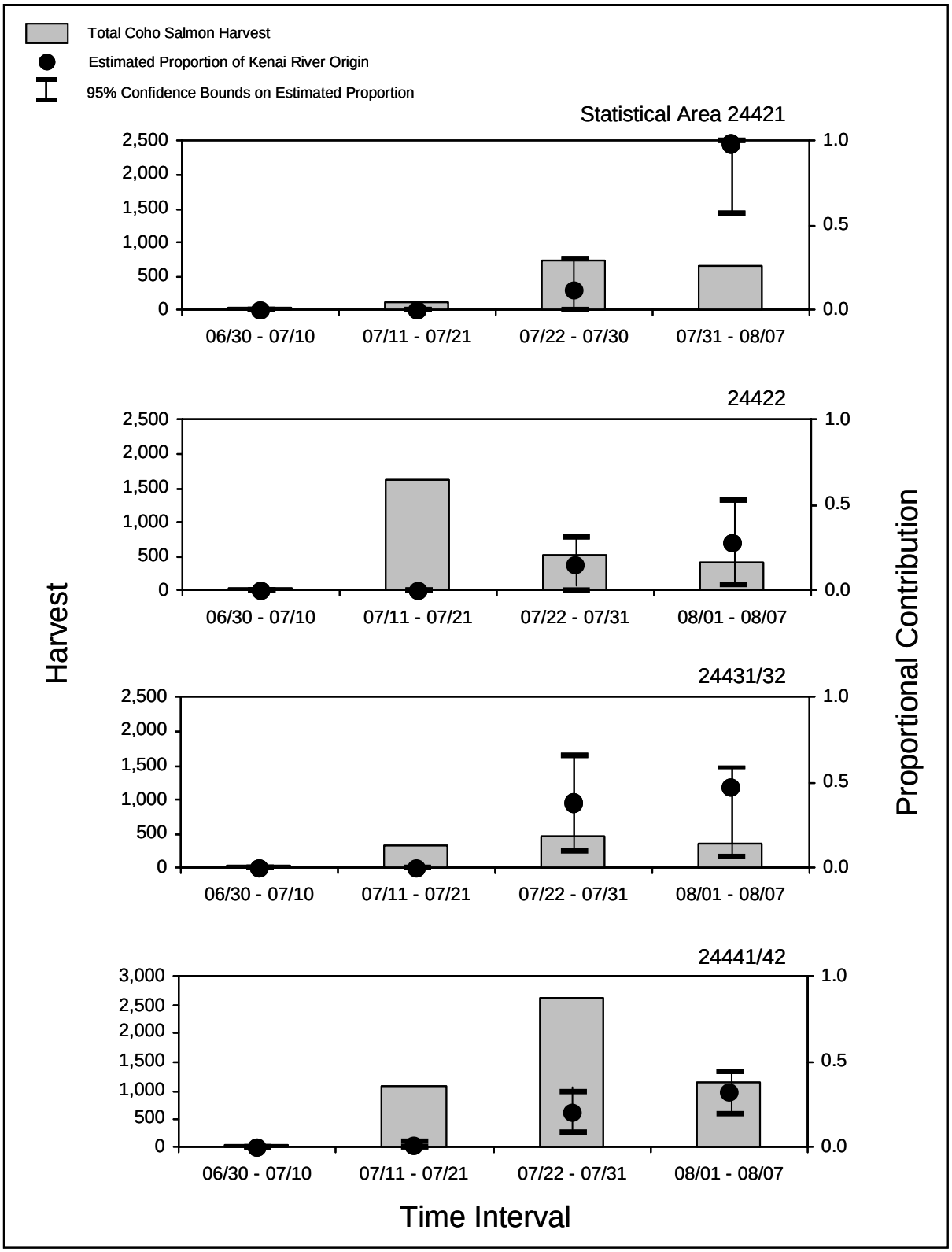

Figure 8.-Temporal trends in total harvest of coho salmon and proportional contribution of coho salmon from the Kenai River to the total harvest occurring in four statistical areas of the Upper Cook Inlet Central District Eastside set gillnet fishery during four selected time periods in 2003.

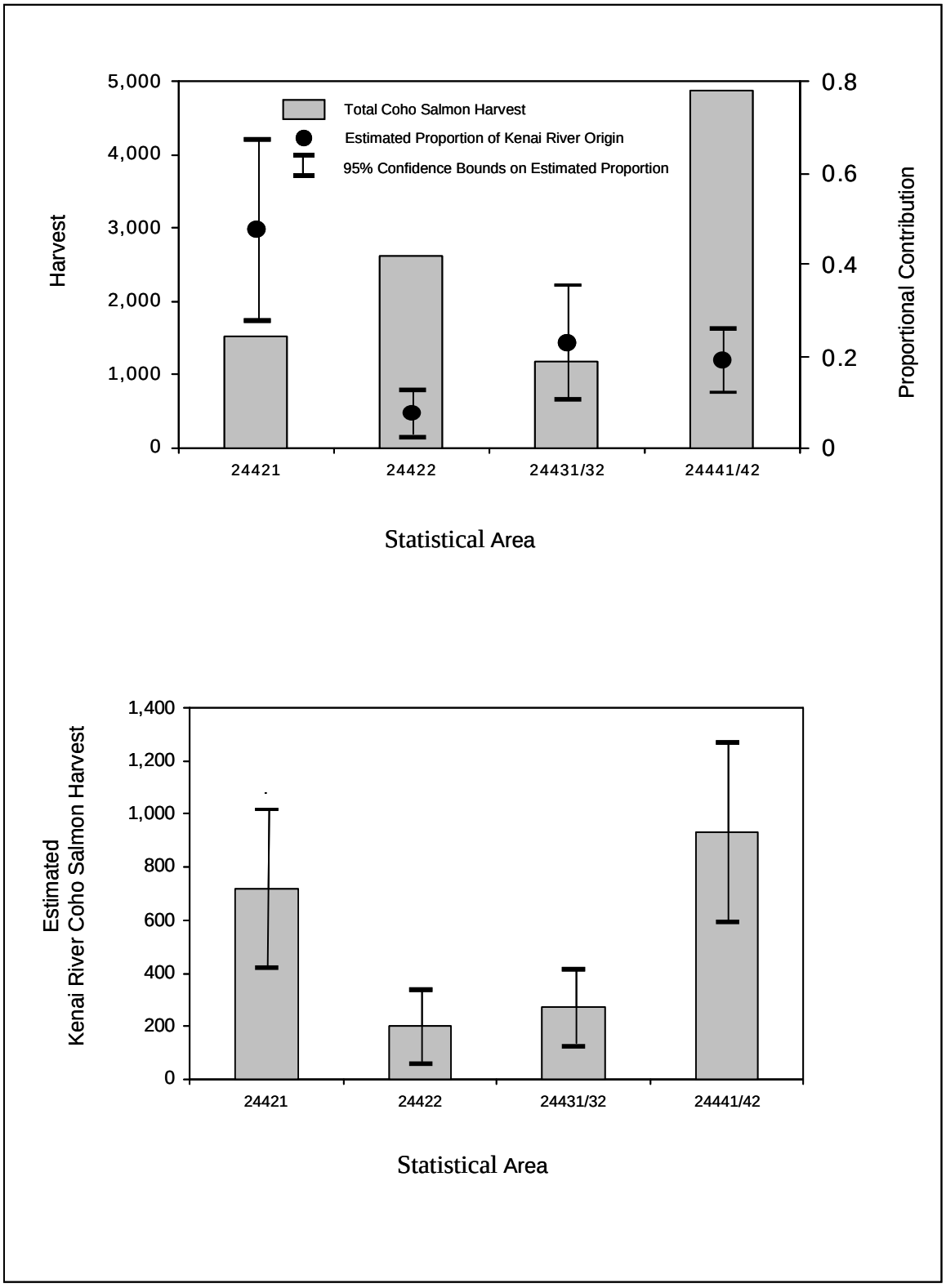

Figure 9.-Geographic trends in total coho salmon harvest and proportional contribution of coho salmon of Kenai River origin (top) and in estimated number of coho salmon of Kenai River origin (bottom) harvested among statistical areas in the Eastside set gillnet fishery of the Central District of Upper Cook Inlet, 2003.

Table 5.-Sensitivity of 2003 commercial harvest estimates to variations in tagged proportions.

Fishery	Total Harvest	Pooled Marked Proportion (0.172) Estimated Contribution [c]	Marked Proportion: Minimum [a] (0.164) Estimated Contribution [c]	Difference from Pooled	% Difference from Pooled	Difference from Pooled as % of Total Harvest	Marked Proportion: Maximim [b] (0.246) Estimated Contribution [c]	Difference from Pooled	% Difference from Pooled	Difference from Pooled as % of Total Harvest
Central District Drift Gillnet	52,421	330	347	17	5%	0.0%	231	-99	-30%	0.2%
Central District East Side Set Gillnet [d]										
244-21	1,511	719	753	34	5%	2.3%	502	-217	-30%	14.4%
244-22	2,617	201	210	9	4%	0.3%	140	-61	-30%	2.3%
244-31/32	1,171	270	283	13	5%	1.1%	188	-82	-30%	7.0%
244-41/42	4,872	932	975	43	5%	0.9%	651	-281	-30%	5.8%
Combined	10,171	2,122	2,221	99	5%	1.0%	1,481	-641	-30%	6.3%
Northern District Set Gillnet	24,015	126	132	6	5%	0.0%	88	-38	-30%	0.2%
Total [e]	86,607	2,578	2,700	122	5%	0.1%	1,800	-778	-30%	0.9%

[a] The minimum marked proportion determined from the pooled fish wheel data collected from August 1 through September 4.

[b] The maximum marked proportion determined from the pooled fish wheel data collected from September 5 through September 30.

[c] Kenai River population-specific harvest estimate.

[d] By statistical area and combined.

[e] Sum of estimates for Central District drift gillnet, Central District eastside set gillnet, and Northern District set gillnet fisheries. Does not include Central District westside set or Kalgin Island set (areas that were incidentally sampled because of a history of insignificant harvest of Kenai River origin coho salmon).

salmon is negligible) as opposed to 3.0% under the pooled scenario. The contrast reveals the small part that the Kenai River population plays in the overall UCI coho salmon commercial harvest. The commercial harvest estimation component of this study is useful; managers can reliably state that less than about 3.9% (upper bound of 95% confidence interval associated with lowest tagged proportion) of the UCI commercial harvest is of Kenai River origin. The largest estimate also represents only 5.2% of the 10-year average (1993-2002) combined sport and personal use harvest of coho salmon from the Kenai River as opposed to 5.0% under the pooled scenario, showing that within Kenai River specific harvests, the commercial harvest is also relatively small.

These contrasts are an objective way to evaluate the impact of potential bias when using the pooled point estimates during decision-making processes. The point estimates are of value because they demonstrate that the potential range in contribution to the commercial harvest remains relatively small, and under the current management plan, commercial fishing intercepts a relatively small percentage of the total Kenai River coho salmon return.

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 kilometers of the Kenai River. A thorough evaluation may allow selection of a subset of the inriver samples on which to base the tagged proportion appropriate for UCI commercial fisheries. Selecting a subset of the inriver samples for estimating commercial harvest would be beneficial during years when the inriver marked proportion varies significantly over temporal strata. Currently, accurate harvest estimates rely on detection of 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 lower Kenai River and UCI marine migratory rates should be considered because significant temporal variation has been detected in the tagged proportion annually since 1998 (Carlon 2003; Massengill *In prep*; Massengill and Carlon 2004a, b, 2007).

The point estimate of commercial harvest of Kenai River-bound coho salmon in the two primary Central District fisheries in 2003 was 2,452 and represents 25.7% of the 1993-2002 average (Table 6). Reasons contributing to this below-average harvest likely include the restrictions imposed on commercial fisheries starting in 2000. Significant restrictions included a closure of these fishing seasons after the first regularly scheduled period following August 7 and the elimination of all but one non-regular fishing period between August 1 and August 7. 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).

Typically, a substantial portion of the harvest of Kenai River-bound coho salmon occurs during the last week of July and the first week of August in the Central District drift gillnet fishery and the first week of August in the Central District eastside set gillnet fishery (Carlon 2000, 2003; Carlon and Hasbrouck 1996-1998; Massengill *In prep*; Massengill and Carlon 2004a, b, 2007). The additional restrictions imposed by the management plan during the 2003 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 eleventh year in a row (Figure 10), and since the restrictions were imposed in 2000, the commercial harvest of Kenai

Table 6.-Harvest of all coho salmon and coho salmon of Kenai River origin in selected UCI marine commercial fisheries, 1993-2003.

	Central District				Northern District			
	Drift		Eastside Set		Set		Total	
Year	All	Kenai River	All	Kenai River	All	Kenai River	All	Kenai River
1993	121,829	930	43,098	6,806	106,294	148	271,221	7,884
1994	310,114	11,732	68,449	14,673	144,064	477	522,627	26,882
1995	241,473	6,956	44,750	13,152	89,300	582	375,523	20,690
1996	171,434	2,671	40,724	11,856	78,105	29	290,263	14,556
1997	78,662	1,236	19,668	2,093	37,369	36	135,699	3,365
1998	83,338	1,974	18,677	8,096	34,359	175	136,374	10,245
1999	64,814	818	11,923	2,905	31,446	171	108,183	3,894
2000	131,478	531	11,078	2,351	71,475	83	214,031	2,965
2001	39,418	282	4,246	349	45,928	1,303	89,592	1,934
2002	125,831	1,370	35,153	4,688	50,292	57	211,276	6,115
Average	136,839	2,850	29,777	6,697	68,863	306	235,479	9,853
2003	52,421	330	10,171	2,122	24,015	126	86,607	2,578

Note: Sources of harvest of Kenai River-specific coho salmon are: Carlon 2000, 2003; Carlon and Hasbrouck 1996-1998; Massengill *In prep*; Massengill and Carlon 2004a, b, 2007. Source of harvest of all coho salmon is the ADF&G CF Division Fish Ticket Database.

River-bound coho salmon has been lower than average. The inconsequential harvest of the Kenai River population (126 coho salmon) in Northern District fisheries was typical of most years with the exception of the 2001 Northern District commercial harvest (Carlon 2000, 2003; Carlon and Hasbrouck 1996 ,1997; Massengill *In prep*; Massengill and Carlon 2004a, b, 2007).

SMOLT ABUNDANCE

History

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

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

Smolt abundance estimates had been the sole population assessment "barometer" from 1995-1998, after smolt abundance had been identified as an alternative to an adult-based population assessment. Developing a time series of harvest estimates and resulting smolt abundance was

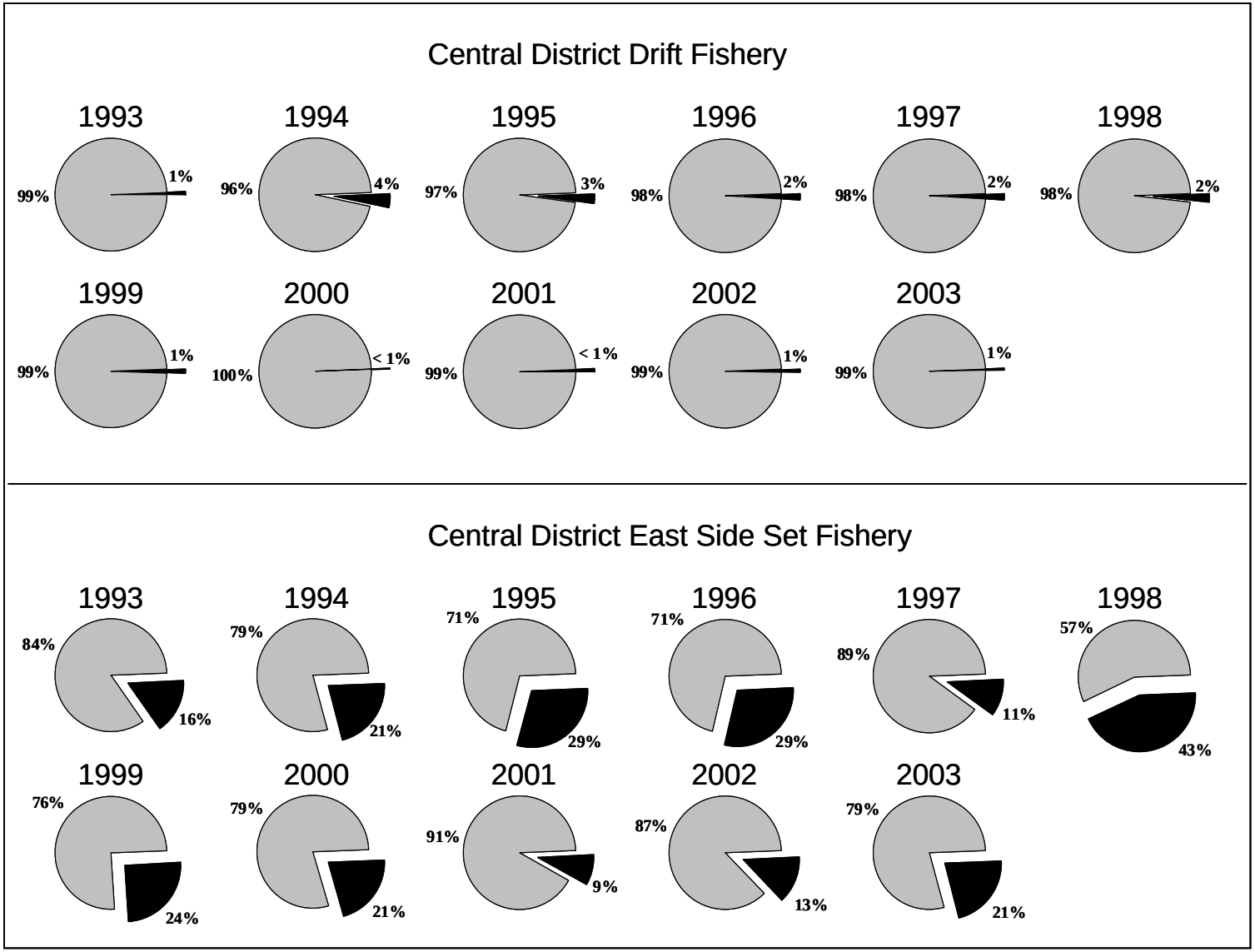

Figure 10.-Contribution of coho salmon (shaded black) from the Kenai River to the drift and eastside set gillnet commercial fisheries of Upper Cook Inlet during the last 11 years (1993-2003).

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 inriver adult 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 newly available estimate of 2002 smolt abundance represents the eleventh such annual estimate since 1992 (Figure 11). It also represents the first estimate of smolt production that can be associated with an estimate of parent-year escapement for the Kenai River coho salmon population. Because most coho salmon smolt from the Kenai River as age-2 smolt, the primary parent year for the 2002 smolt emigration is 1999. The escapement estimate for that year is preliminary (Carlon *In prep*), but will approximate about 24,000 adults. This escapement is associated with an average smolt production of about 626,000 smolt. It is too early to determine if a relationship between escapement and smolt production has any value in developing management objectives for this population, e.g., an escapement goal, however, the relationship will be monitored as additional estimates become available annually. These products of the overall assessment program provide a unique opportunity to simultaneously monitor the biological relationship between escapement, smolt production, and associated adult returns.

Relationship Between Total Harvest and Smolt Abundance

In addition to the record of 11 smolt abundance estimates, 10 annual estimates of total adult harvest have also been made between 1993 and 2002 (Table 7 and Figure 12). The pairing of these two records produces pairs of harvest and smolt abundance estimates (Figure 13). The newly available 2002 smolt abundance estimate, when paired with the 1999 total harvest estimate, represents the seventh such pair available to date. While the relationship does not clearly identify a threshold harvest beyond which smolt abundance is significantly, negatively, and consistently impacted, it suggests that the record adult harvest in 1994 may have been excessive. At the very least, it is associated with the 1997 smolt production (Carlon 2003) which remains the lowest on record. This also suggests that at least some of the precautionary measures adopted under the Kenai River Coho Salmon Conservation Management Plan should be retained until additional information demonstrates that surplus yield is available. Monitoring the harvest-smolt relationship as additional pairs of estimates accrue annually is necessary to determine whether it will be practical for identifying a harvest guideline management objective. This relationship, and others developing from the accrual of information from the ongoing assessment program, will eventually provide indications with which to modify the management plan or formulate quantitative management objectives.

ANCILLARY INFORMATION FROM THE RUSSIAN RIVER

The first coho salmon arrived at the Russian River weir on August 6. A total of 545 coho salmon were passed through the weir, with 530 examined for adipose fin status, of which 39 (7.4%) had an adipose finclip (Appendix A4). This indicates that some coho salmon that were spawned in the Russian River drainage migrate as fry to the Moose River, smolt from the Moose River, then return to spawn in the Russian River. This is ancillary information that marking outmigrating smolt at the Moose River provided a representative sample of the entire drainage.

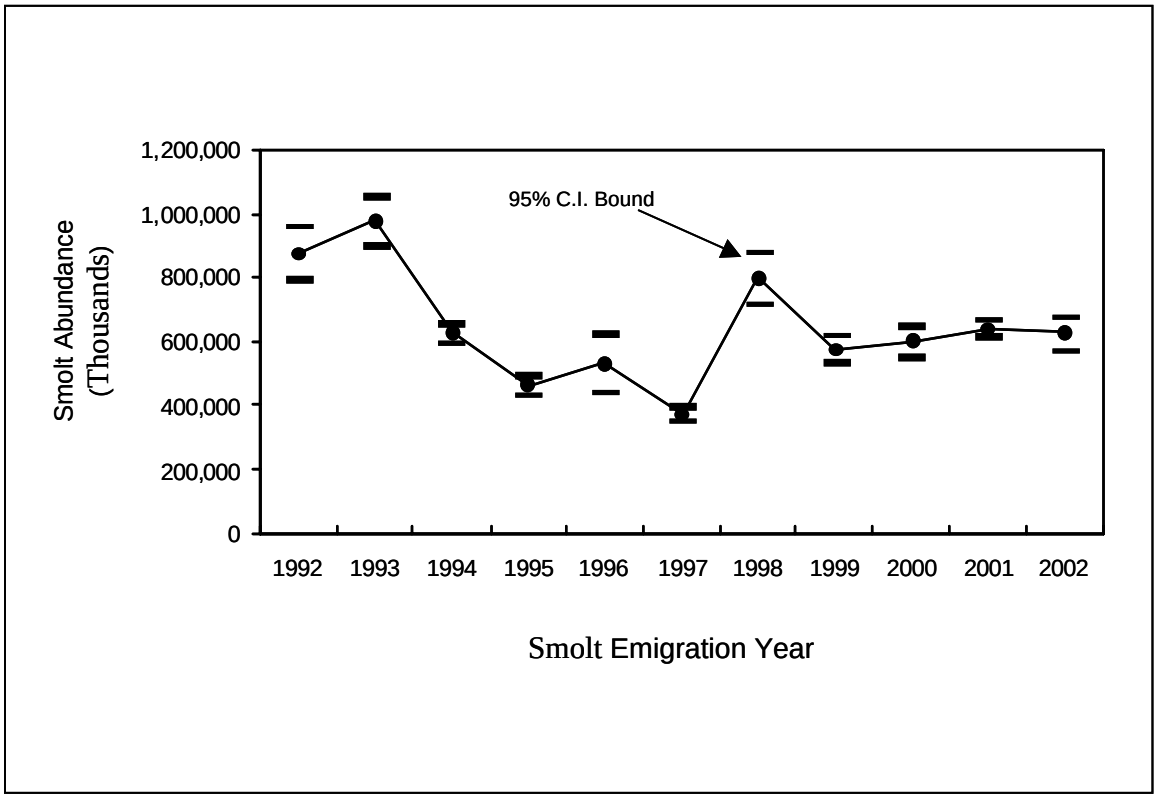

Figure 11.-Estimates of coho salmon smolt abundance in the Kenai River, 1992-2002.

RECOMMENDATIONS

Continue estimating total harvest and smolt abundance of coho salmon of Kenai River origin.

The long-term relationship between total annual fishing mortality and smolt abundance should be monitored to determine if harvest levels are influencing smolt production. Currently, only seven pairs of estimates are available and it is not yet possible to establish a link between harvest and smolt production. The record harvest of 1994 is now associated with the lowest smolt abundance on record (1997); this suggests that this approach may be sensitive enough to provide management implications if continued.

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 of relating smolt production to harvest. The record harvest in 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 since) should be continued to enhance the assessment of the population of coho salmon from the Kenai River.

Table 7.-Total harvest of coho salmon of Kenai River origin in UCI inriver and marine commercial fisheries, 1993-2002.

	Inriver											
	Sport[a]					Personal		UCI Marine Commercial[b]				
	Mainstem			Russian		Use/	Inriver	Eastside	Drift	Northern	Commercial	Grand
Year	Unguided[a]	Guided	Total	River	Total	Subsistence	Total	Set Gillnet	Gillnet	District	Total	Total
1993	26,805	23,743	50,548	2,290	52,838	1,597 [c]	54,435	6,806	930	148	7,884	62,319
1994	45,623	41,170	86,793	4,607	91,400	2,535 [d]	93,935	14,673	11,732	477	26,882	120,817
1995	22,663	23,587	46,250	4,077	50,327	1,261 [e]	51,588	13,152	6,956	582	20,690	72,278
1996	28,764	13,728	42,492	4,599	47,091	1,932 [f]	49,023	11,856	2,671	29	14,556	63,579
1997	13,063	3,101	16,164	4,586	20,750	559 [f]	21,309	2,093	1,236	36	3,365	24,674
1998	21,750	5,217	26,967	4,612	31,579	1,011 [f]	32,590	8,096	1,974	175	10,245	42,835
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
2001	36,264	13,563	49,827	5,222	55,049	1,555 [g]	56,604	349	282	1,303	1,934	58,538
2002	45,243	14,444	59,687	6,093	65,780	1,721 [f,g]	67,501	4,688	1,370	57	6,115	73,616
Average	30,290	15,599	45,888	4,393	50,282	1,463	51,745	6,697	2,850	306	9,853	61,598

Source is Statewide Harvest Survey (Howe et al. 1995, 1996, 2001 a-d; Jennings et al. 2004, 2006; Mills 1994; Walker et al. 2003). 1996-2000 are revised estimates. Mainstem unguided includes Skilak Lake and Hidden Lake harvests.

[b] Carlon 2000, 2003; Carlon and Hasbrouck 1996-1998; Massengill *In prep;* Massengill and Carlon 2004a, b, 2007.

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

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

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

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

[g] Reimer and Sigurdsson 2004.

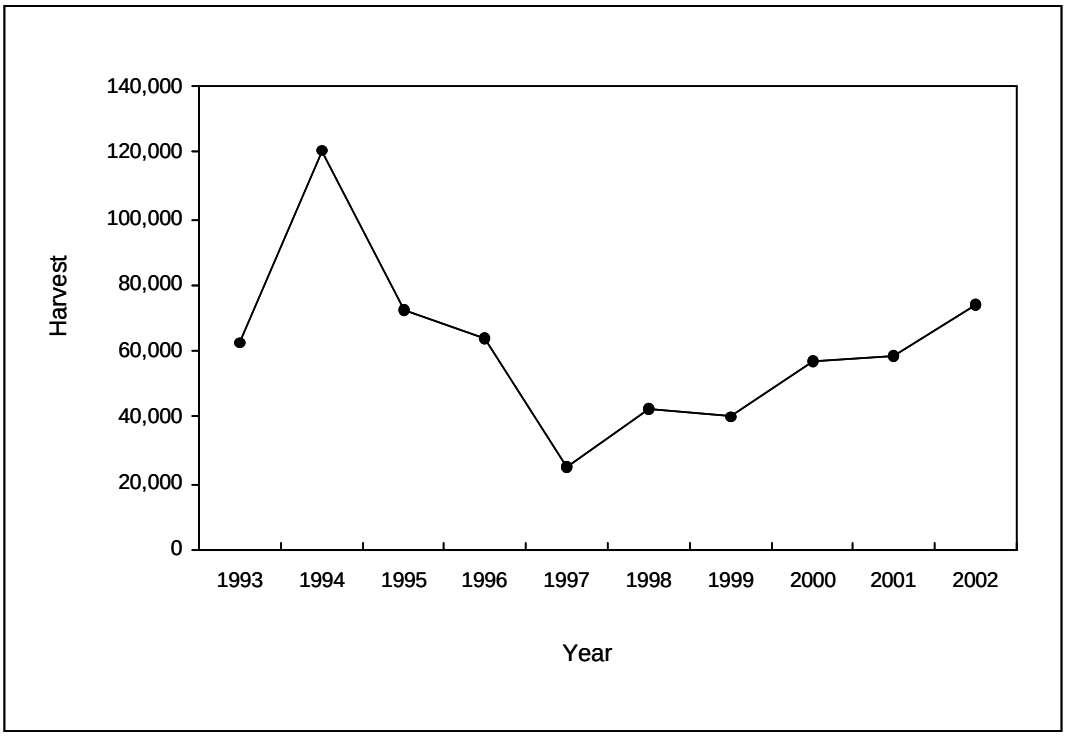

Figure 12.-Estimates of total harvest of coho salmon of Kenai River origin by combining estimates of commercial marine harvest with inriver estimates of personal use, mainstem sport, and Russian River sport harvest, 1993-2002.

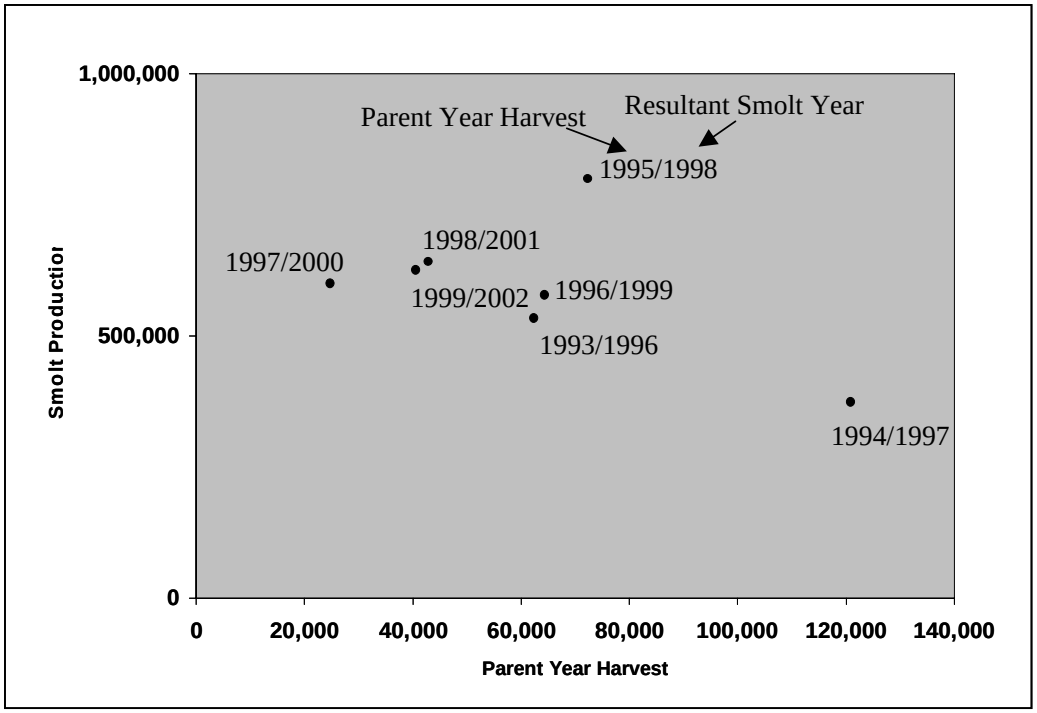

Figure 13.-Available points in the long-term assessment approach of relating smolt production to parent year harvest for coho salmon from the Kenai River, Alaska.

Distribute coded wire tags more evenly throughout the smolt emigration.

Significant inriver variations in the adult marked proportion have been detected since 2000 and it is recommended that the current methodology of tagging the first 95,000 smolt emigrating from the Moose River be modified in a way that distributes the tags more evenly throughout the emigration.

ACKNOWLEDGMENTS

The following people comprised the team that marked smolt at the Moose River in 2002. Kurt Strausbaugh was the field project leader and participated in all phases of field investigation. Sandee Simons, Jake Glotfelty, Jerry Strait, Stan Walker, T.D. Hacklin and Heidi Biggs (American Fisheries Society: E.F. Hutton Student) 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.

The commercial harvest was examined in 2003 by technicians of the Commercial Fisheries (CF) Division. Kim Rudge-Karic supervised commercial harvest sampling, provided logistical support, and collated commercial sampling data. Personnel of the CF Mark, Tag, and Aging Laboratory in Juneau processed all coded wire tag data collected in 2002 and 2003. All CF personnel contributed to the successful achievement of study objectives.

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.

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APPENDIX A

Appendix A1.-Number of wild coho salmon smolt captured from the Moose River, marked with an adipose finclip and coded wire tags, and released in 2002, and tag codes identified in the sample of 146 Moose River tagged fish recovered from known, unmixed UCI commercial fishery strata in 2003.

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 2003 [d]
310284	05/21	05/26	11,677	99.87%	11,662	96.70%	11,277	8
310285	05/25	05/28	12,043	100.00%	12,043	97.4%	11,730	11
310286	05/27	05/29	12,003	100.00%	12,003	99.0%	11,883	23
310287	05/28	05/29	11,994	99.81%	11,971	98.9%	11,839	20
310288	05/29	05/31	12,522	100.00%	12,522	98.3%	12,309	22
310289	05/30	06/01	12,284	100.00%	12,284	99.4%	12,210	13
310290	05/31	06/03	11,926	100.00%	11,926	99.3%	11,843	19
310291	06/02	06/04	12,155	100.00%	12,155	100.0%	12,155	16
310292	06/03	06/05	11,954	100.00%	11,954	98.9%	11,823	14
Total			108,558	99.96%	108,520	98.7%	107,069	146

[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 by commercial fishing in 2003 and positively decoded as Moose River coho salmon released in 2002.

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, 2003.

	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	1	1
08/02					09/02	2			
08/03					09/03	6	1	1	1
08/04	2				09/04	17	4	4	4
08/05					09/05	6	3	3	3
08/06	1				09/06	6	4	4	4
08/07	1				09/07	2	1		
08/08	10				09/08	5	1	1	1
08/09	2	1	1	1	09/09	6	2	2	2
08/10					09/10	7	1	1	1
08/11	10	1	1	1	09/11	8	1	1	1
08/12	2				09/12	10	3	3	3
08/13	3	1	1	1	09/13	3	1	1	1
08/14	6	1	1	1	09/14	8	2	2	2
08/15	2				09/15	4			
08/16					09/16	5	1	1	1
08/17					09/17	6	1	1	1
08/18	2	1	1	1	09/18				
08/19					09/19				
08/20	2	1	1	1	09/20				
08/21	1	1	1	1	09/21	1	1	1	1
08/22	4	1	1	1	09/22				
08/23	10	2	2	2	09/23	1			
08/24	12				09/24				
08/25	45	6	6	6	09/25	1			
08/26	30	8	8	8	09/26	5	1	1	1
08/27	11	3	3	3	09/27	2	1	1	1
08/28	10	1	1	1	09/28	1			
08/29	1	1	1	1	09/29	2	1	1	1
08/30	3				09/30	3	1	1	1
08/31									
Subtotal	170	29	29	29		121	32	31	31
North Bank Subtotal						291	61	60	60

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Date	August Number Captured and Examined	August Marked Fish Observed[a]	August Marked Fish Checked with Tag Detector[b]	August Coded Wire Tag Detected	Date	September Number Captured and Examined	September Marked Fish Observed[a]	September Marked Fish Checked with Tag Detector[b]	September Coded Wire Tag Detected
				South Bank					
08/01					09/01	30	6	6	6
08/02					09/02	60	13	13	13
08/03					09/03	45	7	7	7
08/04	2				09/04	38	3	3	3
08/05	2	1	1	1	09/05	28	6	6	6
08/06	6				09/06	12	3	3	3
08/07	16				09/07	17	3	3	3
08/08	36	5	5	5	09/08	4	1	1	1
08/09	25	5	5	5	09/09	18	3	3	3
08/10	22	5	5	5	09/10	3	2	2	2
08/11	40	6	6	6	09/11				
08/12	98	10	10	9	09/12	3	2	1	1
08/13	73	10	10	10	09/13	3			
08/14	159	30	30	29	09/14	4	2	2	2
08/15	176	19	19	19	09/15				
08/16	119	15	15	15	09/16				
08/17	120	21	21	21	09/17				
08/18	108	23	23	23	09/18				
08/19	101	20	20	20	09/19				
08/20	74	11	11	11	09/20				
08/21	76	12	12	11	09/21				
08/22	83	15	15	15	09/22	2			
08/23	80	15	15	15	09/23	7			
08/24	78	8	8	8	09/24	8			
08/25	100	10	10	10	09/25	4	1	1	1
08/26	78	19	18	18	09/26	11	1	1	1
08/27	43	12	12	12	09/27	2			
08/28	38	6	6	6	09/28	3	1	1	1
08/29	51	12	12	12	09/29	7	4	4	4
08/30	38	8	8	8	09/30	8	3	3	3
08/31	25	8	8	8					
Subtotal	1,867	306	305	302		317	61	60	60
South Bank Subtotal						2,184	367	365	362
Grand Total (both banks)						2,475	428	425	422

[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) and examined for a missing adipose fin on the Kenai River between river kilometer 48.9 and 58.4 from August 1 through October 5, 2003.

	August					September-October			
Date[a]	Number Captured and Examined	Marked Fish Observed[b]	Number Captured and Examined	Marked Fish Observed[b]	Date[a]	Number Captured and Examined	Marked Fish Observed[b]	Number Captured and Examined	Marked Fish Observed[b]
	North Bank		**South Bank**			**North Bank**		**South Bank**	
08/01	0	0	0	0	09/01	43	12	17	5
08/02	0	0	0	0	09/02	58	20	26	7
08/03	0	0	0	0	09/03	60	13	41	11
08/04	2	0	0	0	09/04	64	18	49	13
08/05	1	0	4	0	09/05	47	11	26	8
08/06	1	0	1	1	09/06	28	5	17	2
08/07	0	0	4	0	09/07	14	6	7	1
08/08	5	0	12	2	09/08	19	4	7	0
08/09	10	1	10	0	09/09	30	12	34	8
08/10	5	1	12	1	09/10	25	7	31	8
08/11	24	4	13	1	09/11	16	3	19	6
08/12	11	1	21	2	09/12	21	5	30	9
08/13	14	3	4	0	09/13	24	3	18	2
08/14	29	10	16	4	09/14	18	5	13	1
08/15	41	11	44	6	09/15	21	5	20	5
08/16	21	2	20	3	09/16	28	7	22	9
08/17	19	6	25	4	09/17	23	6	23	4
08/18	26	5	22	3	09/18	34	6	27	4
08/19	70	19	36	6	09/19	18	5	41	7
08/20	80	19	50	8	09/20	24	3	50	15
08/21	83	20	51	4	09/21	32	9	22	4
08/22	71	8	42	6	09/22	21	7	13	6
08/23	58	9	53	6	09/23	32	9	29	9
08/24	37	9	24	11	09/24	21	7	34	5
08/25	62	21	17	5	09/25	22	5	22	5
08/26	113	33	83	14	09/26	39	11	46	19
08/27	103	25	28	6	09/27	18	2	23	7
08/28	74	20	16	1	09/28	10	4	24	5
08/29	45	6	34	4	09/29	10	1	21	2
08/30	36	8	44	9	09/30	14	7	28	7
08/31	30	12	23	5	10/01	9	1	18	5
					10/02	15	6	21	5
					10/03	17	1	9	3
					10/04	0		4	1
					10/05	1			
Subtotal	1,071	253	709	112		876	226	832	208

	North Bank Total		South Bank Total	
	1,947	479	1,541	320
Grand total	3,488	799		

[a] Recapture event operational from August 1 through October 5, 2003.

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

Appendix A4.-Daily summary of coho salmon adults examined at the Russian River weir, June 7 through September 4, 2003.

Date	Weir Count	Examined	Marked Fish Observed [a]	Date	Weir Count	Examined	Marked Fish Observed [a]
8/6	3	2	0	8/21	22	20	3
8/7	2	1	0	8/22	22	22	4
8/8	2	2	0	8/23	15	15	2
8/9	2	2	0	8/24	5	5	1
8/10	7	7	0	8/25	11	11	2
8/11	17	17	0	8/26	42	42	3
8/12	14	14	0	8/27	12	12	1
8/13	18	18	0	8/28	26	26	2
8/14	25	24	3	8/29	14	13	1
8/15	11	10	0	8/30	25	25	1
8/16	23	21	1	8/31	15	15	2
8/17	41	36	1	9/1	36	36	2
8/18	14	14	2	9/2	42	42	4
8/19	16	16	4	9/3	21	21	0
8/20	16	16	0	9/4	26	25	0
Subtotal	211	200	11	Subtotal	334	330	28
				Grand Total	545	530	39

Note: Weir was operated between June 7 and September 4, 2003, but the first coho salmon did not arrive at the weir until August 6, 2003.

[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 in 2003.

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 2001
		Mixed Central District Statistical Areas					
East Side Set							
7/14/2003	24421/22	1	0	0	0	0	0
7/21/2003	24421/22	5	0	0	0	0	0
7/24/2003	24421/22	88	2	2	2	2	1
7/25/2003	24421/22	41	0	0	0	0	0
7/27/2003	24421/22	12	1	1	1	1	1
7/28/2003	24421/22	38	2	2	2	2	2
8/7/2003	24421/22	44	2	2	2	2	2
Total		229	7	7	7	7	6
West Side and Kalgin Island Set							
8/11/2003	24530/50, 24610	489	1	1	1	1	1
8/14/2003	24530/50, 24610	220	2	2	2	2	1
7/21/2003	24530, 24610/20	567	8	8	8	8	0
7/24/2003	24530, 24610/20	479	5	5	2	2	0
7/28/2003	24530, 24610/20	345	2	2	1	1	0
7/31/2003	24530, 24610/20	1,818	25	25	18	18	0
8/4/2003	24530, 24610/20	1,090	14	14	11	11	2
8/7/2003	24530, 24610/20	1,296	14	14	12	12	2
Total		6,304	71	71	55	55	6
Central District Drift and East Side Set							
7/31/2003	244CDD, 24422	59	1	1	0	0	
Mixed Central District Total		6,592	79	79	62	62	12
		Mixed Northern District Statistical Areas					
Northern District East Side and Fire Island Set							
7/21/2003	24741/43	288	25	25	22	22	0
Grand Total		6,880	104	104	84	84	12

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

Appendix A6.-Upper Cook Inlet commercial and test fishery coho salmon harvest in 2003, 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 2002.

Date (2003)[a]	(H) Total Harvest	(n_i) Number Examined [b]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[c]	(t'_i) Decodable Tags[d]	(m_i) Source= Moose R 2002	(r_i) Harvest Estimate	$V(r_i)$ Variance
Commercial Harvest									
Central District									
Drift Gillnet									
Central									
06/26 - 07/04	618	134	0	0	0	0	0	0	0
07/07	2,018	804	4	4	2	2	0	0	0
07/10	322	161	5	5	3	3	0	0	0
07/14	5,724	1,824	32	32	29	28	0	0	0
07/17 - 07/19	10,623	3,166	62	62	52	52	0	0	0
07/20 - 07/21	7,490	2,630	51	51	49	49	2	33	513
07/23 - 07/24	9,180	2,686	59	59	51	51	0	0	0
07/25 - 07/26	4,758	1,318	23	23	18	18	2	42	842
07/27 - 07/29	3,374	1,347	32	32	28	28	3	44	604
07/30 - 08/01	3,456	1,908	18	17	13	13	5	56	576
08/03 - 08/04	3,526	1,176	10	10	8	8	3	52	853
08/07	1,332	906	14	14	13	13	12	103	800
Total	52,421	18,060	310	309	266	265	27	330	4,188
East Side Set									
Statistical Area 24421									
06/30 - 07/10	18	2	0	0	0	0	0	0	0
07/12 - 07/14	19	1	0	0	0	0	0	0	0
07/16 - 07/18	30	3	0	0	0	0	0	0	0
07/19 - 07/21	68	25	2	2	2	2	0	0	0
07/23	50	10	0	0	0	0	0	0	0
07/24	231	54	1	1	0	0	0	0	0
07/25	151	55	0	0	0	0	0	0	0
07/27 - 07/28	174	47	1	1	1	1	1	22	462
07/29 - 07/30	125	11	1	1	1	1	1	66	4,290
07/31,8/3,8/4,8/7	645	131	23	23	23	23	22	631	18,212
Total	1,511	339	28	28	27	27	24	719	22,964

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Date (2003)[a]	(H) Total Harvest	(n_i) Number Examined [b]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[c]	(t'_i) Decodable Tags[d]	(m_i) Source= Moose R 2002	(r_i) Harvest Estimate	$V(r_i)$ Variance
East Side Set				**Commercial Harvest**					
Statistical Area 24422				**Central District**					
07/03 - 07/07	16	3	0	0	0	0	0	0	0
07/09 - 07/10	11	5	0	0	0	0	0	0	0
07/12 - 07/14	39	14	1	1	0	0	0	0	0
07/16 - 07/18	1,533	11	0	0	0	0	0	0	0
07/19 - 07/21	62	14	0	0	0	0	0	0	0
07/23	55	8	2	2	2	2	1	40	1,560
07/24	220	38	0	0	0	0	0	0	0
07/25	116	27	0	0	0	0	0	0	0
07/27	37	4	0	0	0	0	0	0	0
07/28 - 07/29	46	13	1	1	1	1	1	21	420
07/30	20	7	0	0	0	0	0	0	0
07/31	29	40	4	4	4	4	4	17	60
08/03 - 08/04	223	53	5	5	5	5	5	123	2,926
08/07	210	11	0	0	0	0	0	0	0
Total	2,617	248	13	13	12	12	11	201	4,966
Statistical Area 24431/32									
07/03 - 07/07	13	2	0	0	0	0	0	0	0
07/10	29	11	0	0	0	0	0	0	0
07/12 - 07/14	63	7	0	0	0	0	0	0	0
07/16 - 07/19	205	34	0	0	0	0	0	0	0
07/20 - 07/21	56	14	0	0	0	0	0	0	0
07/23	33	9	0	0	0	0	0	0	0
07/24 - 07/25	98	10	0	0	0	0	0	0	0
07/27 - 07/28	137	26	2	2	2	2	1	31	930
07/29 - 07/31	198	47	6	6	6	6	6	147	3,490
08/03 - 08/04	236	59	1	1	1	1	1	23	506
08/07	103	52	6	6	6	6	6	69	733
Total	1,171	271	15	15	15	15	14	270	5,659

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Date (2003)[a]	(H) Total Harvest	(n_i) Number Examined [b]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[c]	(t'_i) Decodable Tags[d]	(m_i) Source= Moose R 2002	(r_i) Harvest Estimate	$V(r_i)$ Variance
East Side Set				**Commercial Harvest**					
Statistical Area 24441/42				**Central District**					
07/10	44	31	0	0	0	0	0	0	0
07/14	72	24	0	0	0	0	0	0	0
07/17 - 07/19	542	144	7	7	7	7	0	0	0
07/20 - 07/21	461	186	4	4	4	4	1	14	182
07/23	122	11	0	0	0	0	0	0	0
07/24 - 07/25	581	221	11	11	10	10	2	31	450
07/27 - 07/28	1,371	147	8	8	8	8	8	435	23,543
07/29 - 07/30	290	52	3	3	2	2	0	0	0
07/31	239	185	14	14	12	12	11	83	555
08/03 - 08/04	693	231	12	12	11	11	10	175	2,942
08/07	457	233	18	18	17	17	17	194	2,090
Total	4,872	1,465	77	77	71	71	49	932	29,762
Eastside Set Gillnet Total	10,171	2,323	133	133	125	125	98	2,122	63,351
Kalgin Island Set Area 24610/20									
06/26	1								
06/30	4								
07/03	19								
07/07	73								
07/10	94								
07/14	113								
07/17	141								
07/21	228								
07/24	270								
07/28	377								
07/31	529								
08/03	540								
08/04	580								
08/07	705	449	14	14	13	13	9	82	677
08/11	984								
08/14	1,064								
08/18	1,586								
08/21	1,884								
Total	9,192	449	14	14	13	13	9	82	677

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Date (2003)[a]	(H) Total Harvest	(n_i) Number Examined [b]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[c]	(t'_i) Decodable Tags[d]	(m_i) Source= Moose R 2002	(r_i) Harvest Estimate	$V(r_i)$ Variance
West Side Set Areas 24520/30/40/50/55/60				**Commercial Harvest**					
				Central District					
06/26	1								
06/30	1								
07/02	2								
07/03	2								
07/04	6								
07/05	4								
07/06	12								
07/07	19								
07/08	5								
07/09	6								
07/10	21								
07/11	19								
07/12	26								
07/13	34								
07/14	38								
07/15	11								
07/16	82								
07/17	190								
07/18	100								
07/19	105								
07/20	135								
07/21	146	59	1	1	1	1		0	0
07/22	153								
07/23	264								
07/24	243	87	0	0	0	0		0	0
07/25	183								
07/26	120								
07/27	37								
07/28	358	66	0	0	0	0		0	0
07/29	10								
07/30	186								
07/31	301	278	1	1	0	0		0	0
08/01	332								
08/04	1,055	353	1	1	0	0		0	0
08/07	527	221	0	0	0	0		0	0
08/11	333								
08/14	129								
08/18	397								
08/21	285								
Total	5,878	1,064	3	3	1	1	0	0	0
Central District East Side Set Net and Drift Gill Net Fishery Total	62,592	20,383	443	442	391	390	125	2,452	67,539
Entire Central District Total	77,662	21,896	460	459	405	404	134	2,534	68,216

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Date (2003)[a]	(H) Total Harvest	(n_i) Number Examined [b]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[c]	(t'_i) Decodable Tags[d]	(m_i) Source= Moose R 2002	(r_i) Harvest Estimate	$V(r_i)$ Variance
Commercial Harvest									
Northern District									
East Side Set Areas 24770/80/90									
07/03 - 07/07	27	18	0	0	0	0	0	0	0
07/10	51	41	0	0	0	0	0	0	0
07/14	41	30	0	0	0	0	0	0	0
07/17	238	118	6	5	4	4	0	0	0
07/21	368	101	3	3	3	3	0	0	0
07/24	525	497	21	21	17	17	0	0	0
07/28	606	529	14	14	8	8	0	0	0
07/31	354	135	5	5	3	3	0	0	0
08/04	304	73	1	1	0	0	0	0	0
08/07	683	643	7	6	5	5	1	7	42
08/11	979	839	14	14	12	12	1	7	42
08/14	383	239	3	3	3	3	0	0	0
08/18	1,799	1,147	8	8	3	3	2	18	145
08/21	1,118	438	4	4	4	4	3	45	632
08/25 - 09/11	1,896	495	4	4	3	3	1	22	462
Total	9,372	5,343	90	88	65	65	8	99	1,323
Fire Island Set Area 247/43									
07/10	17	17	1	1	1	1	0	0	0
07/14	79	52	1	1	1	1	0	0	0
07/21	243	1	0	0	0	0	0	0	0
07/28	75	101	12	12	12	12	0	0	0
07/31	495	394	26	25	22	21	0	0	0
08/04	245	158	15	15	13	13	0	0	0
08/07	241	239	21	21	20	20	1	6	30
08/18	277	177	3	3	3	3	1	9	72
08/21	74	74	5	5	4	4	1	6	30
Total	1,746	1,213	84	83	76	75	3	21	132

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Date (2003)[a]	(H) Total Harvest	(n_i) Number Examined[b]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[c]	(t'_i) Decodable Tags[d]	(m_i) Source= Moose R 2002	(r_i) Harvest Estimate	$V(r_i)$ Variance
Commercial Harvest									
Northern District									
Pt. MacKenzie/Su Flats Set Area 24741/42									
07/07	15	4	0	0	0	0	0	0	0
07/10	71	25	0	0	0	0	0	0	0
07/14	146	86	3	3	3	3	0	0	0
07/17	536	192	7	7	7	7	0	0	0
07/21	799	355	23	23	23	23	0	0	0
07/24	894	400	48	48	42	42	0	0	0
07/28	1,272	559	42	42	39	39	0	0	0
07/31	719	867	22	22	19	19	0	0	0
08/04	942	563	33	33	28	28	0	0	0
08/07	1,419	1,229	69	62	52	52	0	0	0
08/11	198	234	13	11	11	11	1	6	31
08/14	473	383	20	20	17	17	0	0	0
08/18	262	203	6	6	5	5	0	0	0
08/21	208	52	2	2	2	2	0	0	0
08/25	92	61	1	1	1	1	0	0	0
08/28 - 09/04	180	30	0	0	0	0	0	0	0
Total	8,226	5,243	289	280	249	249	1	6	31
West Side Set Area 24710/20/30									
07/07	15	12	0	0	0	0	0	0	0
07/10 - 07/11	53	54	0	0	0	0	0	0	0
07/14	188	38	1	1	1	1	0	0	0
07/17	0	111	0	0	0	0	0	0	0
07/21	896	51	0	0	0	0	0	0	0
07/24	3,172	3,202	5	0	0	0	0	0	0
07/28	256	377	0	0	0	0	0	0	0
07/31	0	122	0	0	0	0	0	0	0
08/04	0	163	0	0	0	0	0	0	0
08/07	91	182	1	1	1	1	0	0	0
08/14	0	35	0	0	0	0	0	0	0
Total	4,671	4,347	7	2	2	2	0	0	0
Northern District Total	24,015	16,146	470	453	392	391	12	126	1,486
Northern District Total and Central District Drift/East Side Set Total	86,607	36,529	913	895	783	781	137	2,578	69,025
Commercial Harvest Grand Total	101,677	38,042	930	912	797	795	146	2,660	69,702

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Date (2003)[a]	(H) Total Harvest	(n_i) Number Examined [b]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[c]	(t'_i) Decodable Tags[d]	(m_i) Source= Moose R 2002	(r_i) Harvest Estimate	$V(r_i)$ Variance
Test Fishery									
Central District									
Set Gill Net Test Fishery[e]									
07/11	4								
Total	4								
Drift Gill Net Test Fishery[f]									
07/01	3								
07/04	17								
07/06	12								
07/08	9								
07/09	43								
07/10	10								
07/11	54								
07/12	19								
07/14	58								
07/16	61	40	1	1	1	1		0	0
07/18	63	50	1	1	1	1		0	0
07/20	53								
07/22	58	42	2	2	2	2		0	0
07/24	29	10	1	1	1	1		0	0
07/26	28								
07/28	45								
07/30	18								
Total	580	142	5	5	5	5	0	0	0
Test Fishery Total	584	142	5	5	5	5	0	0	0
Commercial and Test Fishery Total	102,261	38,184	935	917	802	800	146	2,660	69,702

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

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

[b] Estimates with blank entries indicate that although a harvest was reported the fishery was not sampled.

[c] Denotes heads with tags magnetically detected.

[d] Denotes the number of heads with tags that were decoded and assigned to a known release event.

[e] Denotes an Alaska Department of Fish and Game set gillnet test fishery occurring in statistical area 24431.

[f] Denotes an Alaska Department of Fish and Game offshore drift gillnet test fishery (OTF) occurring in statistical areas 24590 and 24470.