Fishery Data Series No. 07-35

Assessment of Coho Salmon from the Kenai River, Alaska, 2002

by

Rob Massengill

and

Jamie A. Carlon

June 2007

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Measures (fisheries)

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

Mathematics, statistics

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

FISHERY DATA SERIES NO. 07-35

ASSESSMENT OF COHO SALMON FROM THE KENAI RIVER, ALASKA, 2002

by

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

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

June 2007

This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-18, Job No. S-2-14.

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

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

This document should be cited as:
Massengill, R. and J. A. Carlon. 2007. Assessment of coho salmon from the Kenai River, Alaska, 2002. Alaska Department of Fish and Game, Fishery Data Series No. 07-35, Anchorage.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

Table **Page**

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Wild coho salmon *Oncorhynchus kisutch* smolt were captured within the Kenai River drainage in the spring of 2001, marked with an adipose finclip and coded wire tag (CWT), and recovered as adults in 2002. 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 2002 and smolt abundance in 2001. Estimates of commercial harvest in 2002 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 2001 was based on the number of smolt marked with adipose finclips in 2001, the number of returning adults sampled inriver for finclips in 2002, and the number of finclipped adults detected. Commercial harvest and smolt abundance estimates represent the tenth consecutive set of annual estimates available for the Kenai River population.

Of 246,281 coho salmon that were harvested among all UCI commercial fisheries, a total of 94,730 (38%) were examined. Most fishing periods were sampled. A total of 18,268 (19% of the sample) could not be positively assigned to fishery strata and were excluded from calculations of commercial harvest. Of the remaining 76,462, a total of 72,337 were examined as follows: 34,463 (69% of the harvest) were examined from Northern District harvests, 32,019 (25%) were examined from Central District drift gillnet harvests, and 5,855 (17%) were examined from Central District eastside set gillnet harvests. Among these fisheries, a total of 2,074 adipose-finclipped fish were observed, of which 2,063 were recovered, 1,879 bore a decodable CWT, and 253 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 ($\hat{\theta}$=0.229; SE($\hat{\theta}$)=0.005; $\hat{\theta}^{-1}$=4.4; SE($\hat{\theta}^{-1}$)=0.12) was generated from a subset of inriver data, as were estimates of the potential minimum ($\hat{\theta}$=0.112 SE($\hat{\theta}$)=0.007; $\hat{\theta}^{-1}$=8.9; SE($\hat{\theta}^{-1}$)=0.56) and maximum ($\hat{\theta}$=0.381 SE($\hat{\theta}$)=0.014; $\hat{\theta}^{-1}$=2.6; SE($\hat{\theta}^{-1}$)=0.095). 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 6,523 coho salmon were captured within the Kenai River by fish wheels in 2002 and examined for adipose finclips, and 1,503 were found to missing an adipose fin. Of these, 1,496 were estimated as bearing a Kenai River coded wire tag and seven with no tag, resulting in an overall estimated tagged proportion of 0.229. Based on this subset of inriver data, a qualified estimate of 4,688 (SE = 469) coho salmon of Kenai River origin were harvested by the Central District eastside set gillnet fishery, 1,370 (SE = 166) by the Central District drift gillnet fishery, and 57 (SE = 25) by all Northern District set gillnet fisheries for a total of 6,115 (SE = 499). Qualified harvest estimates represented 13.3% of the total eastside set gillnet harvest of coho salmon, 1.1% of the drift gillnet harvest, and 0.1% of the Northern District set gillnet harvest.

Based on the number of live smolt released with an adipose finclip at the Moose River in 2001 (147,931), the number of adult coho salmon examined for adipose fin status in the Kenai River fish wheel samples in 2002 (6,523), and the number of adults in the sample that were missing an adipose fin (1,503), an estimated 641,693 (SE = 14,436) smolt emigrated from the Kenai River in 2001.

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 (UCI), Alaska (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 1990-2001 average sport harvest of coho salmon among all regions of the State, fourth in commercial harvest, and third overall (Figure 2).

In 1991, the Alaska Department of Fish and Game (ADF&G) initiated a program to assess the status of UCI coho salmon stocks (Meyer et al. *Unpublished*). Despite the importance of UCI coho salmon fisheries, no such program existed before 1991. A primary component of the program involves the wild population of coho salmon from the Kenai River. This population was selected for assessment because of a history of large inriver harvests and because the level of exploitation was unknown. These coho salmon support the largest freshwater sport harvest in the state (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 all waters of Alaska. 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, a series of annual exploitation rates and annual adult production levels was needed. A decline in production that could be associated with increasing exploitation would signal the need for conservation actions. A long-term record would provide a quantitative way to develop a sustained-yield objective.

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

Estimates of commercial harvest (A) have been made annually since 1993 through a coded wire tag (CWT) release and recovery program (Carlon 2000, 2003; Carlon and Hasbrouck 1994; 1996-1998; Massengill *In prep*; Massengill and Carlon 2004a, b). Inriver sport and personal use harvests (B) are estimated annually by angler surveys (Hammarstrom 1977, 1978, Hammarstrom 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 and McBride 1989). 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*).

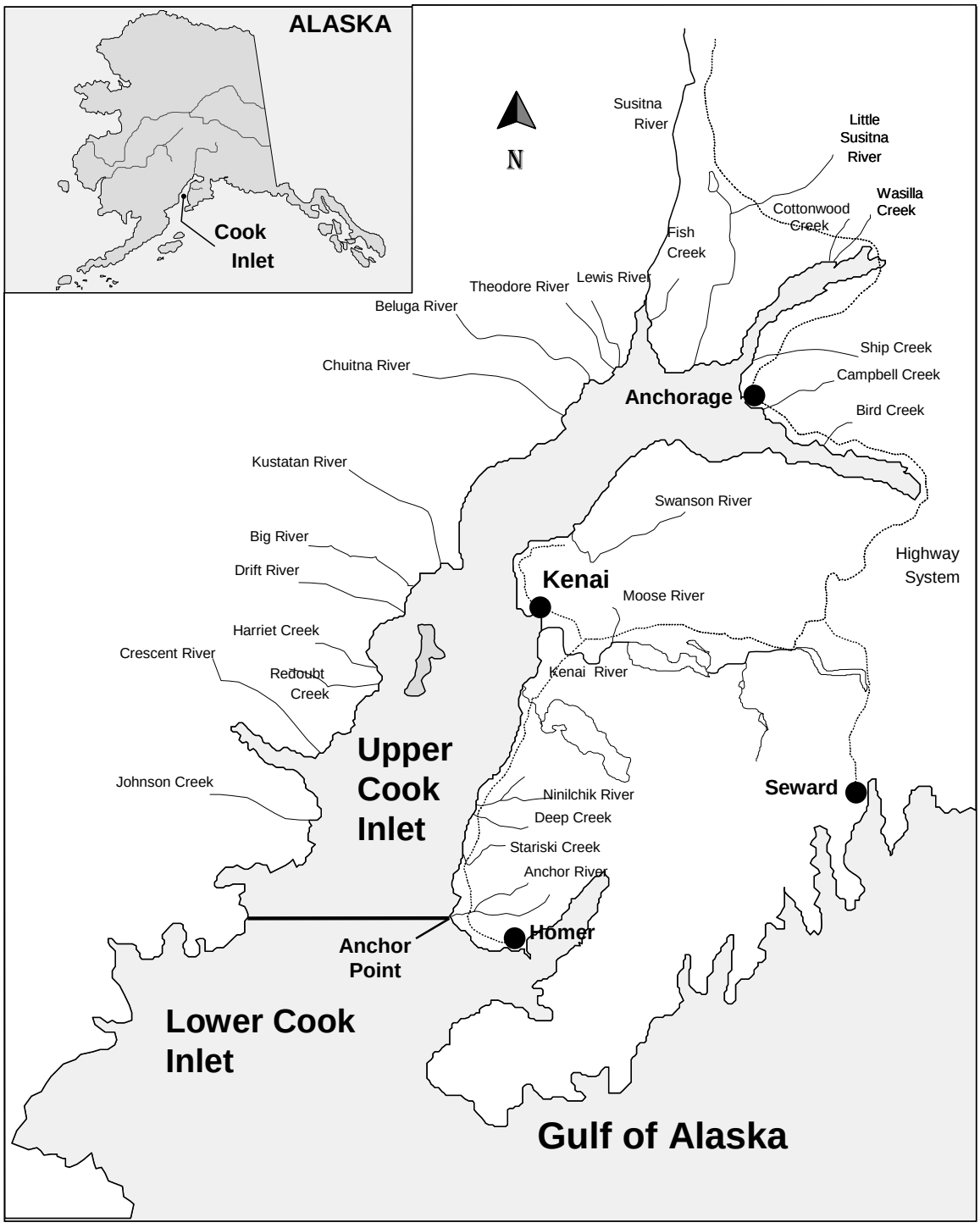

Figure 1.-The Cook Inlet Basin with selected tributaries known to support coho salmon.

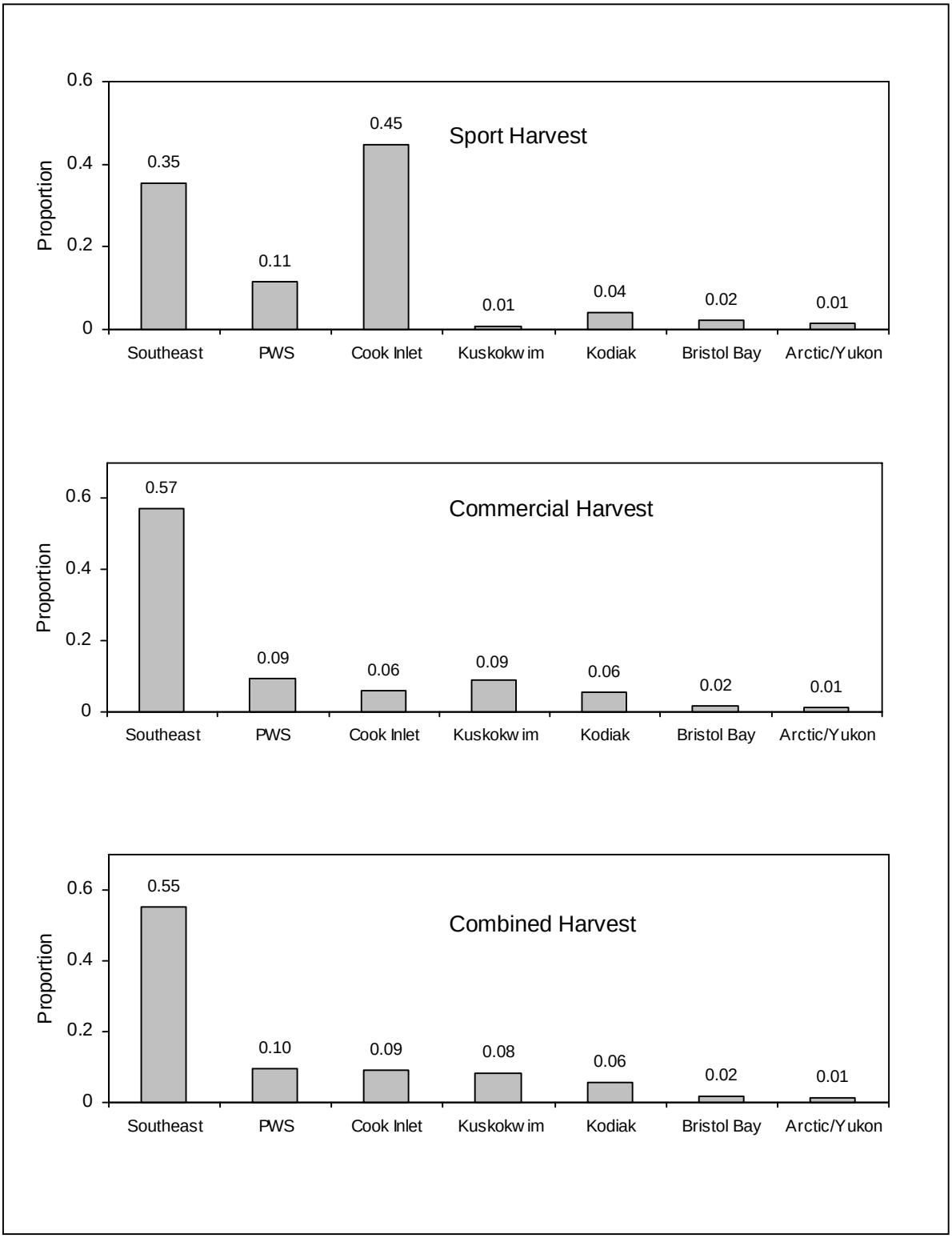

Figure 2.-Average proportions by region of the statewide commercial and sport harvests of coho salmon, 1990-2001.

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

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

Early results from the Kenai River assessment program revealed an overall decline in smolt abundance between 1992 and 1995 (Carlon and 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 first in effect during the 1997 fishing season.

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

Precautionary fishery restrictions implemented under the management plan are considered somewhat arbitrary because they were developed in the absence of a sustained-yield management objective. The degree of unnecessary loss of harvest opportunity is not quantifiable. Therefore, the assessment program will continue annually until a sustained-yield objective can be quantified; this will provide 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 project and are reported elsewhere (Carlon and Evans *In prep*) while this report documents the 2002 population-specific commercial harvest and the 2001 smolt abundance estimate. This report is the tenth 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).

STUDY AREA

Smolt were captured for marking in 2001 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 were examined to provide 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

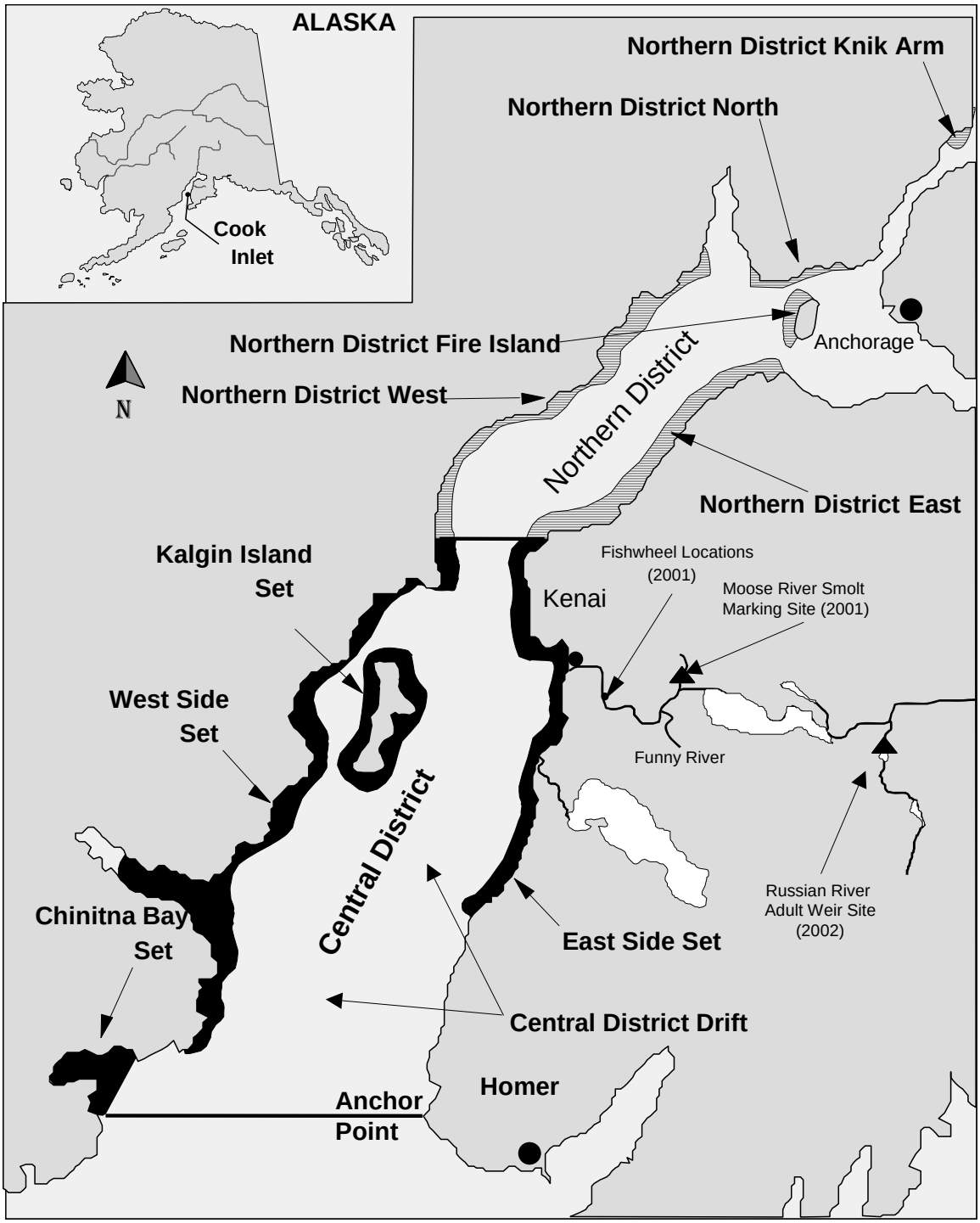

Figure 3.-Upper Cook Inlet showing 10 commercial set gillnet and drift gillnet fishery areas, location at which marked coho salmon smolt were released in the Kenai River drainage in 2001, and Kenai River fish wheel and weir sampling locations at which adults were examined in 2002.

District were examined at processing plants and buying stations located along the UCI coast line in 2002. The statistical area from which examined fish were harvested was recorded when possible (Figure 4).

OBJECTIVES

The primary objectives of this study were:

1. To estimate the harvest of coho salmon of Kenai River origin in the eastside set gillnet and drift gillnet fisheries of the Central District and in the set gillnet fisheries of the Northern District of UCI in 2002, and
2. To estimate the number of coho salmon smolt that emigrated from the Kenai River in 2001.

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, 2002; and, if constant,
2. To estimate the proportion of the population bearing coded wire tags from August 1 through September 30, 2002.

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 2001, marked with coded wire tags, and released. Total harvest of coho salmon in 2002 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 2002.

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

Cook Inlet Commercial Salmon Statistical Areas

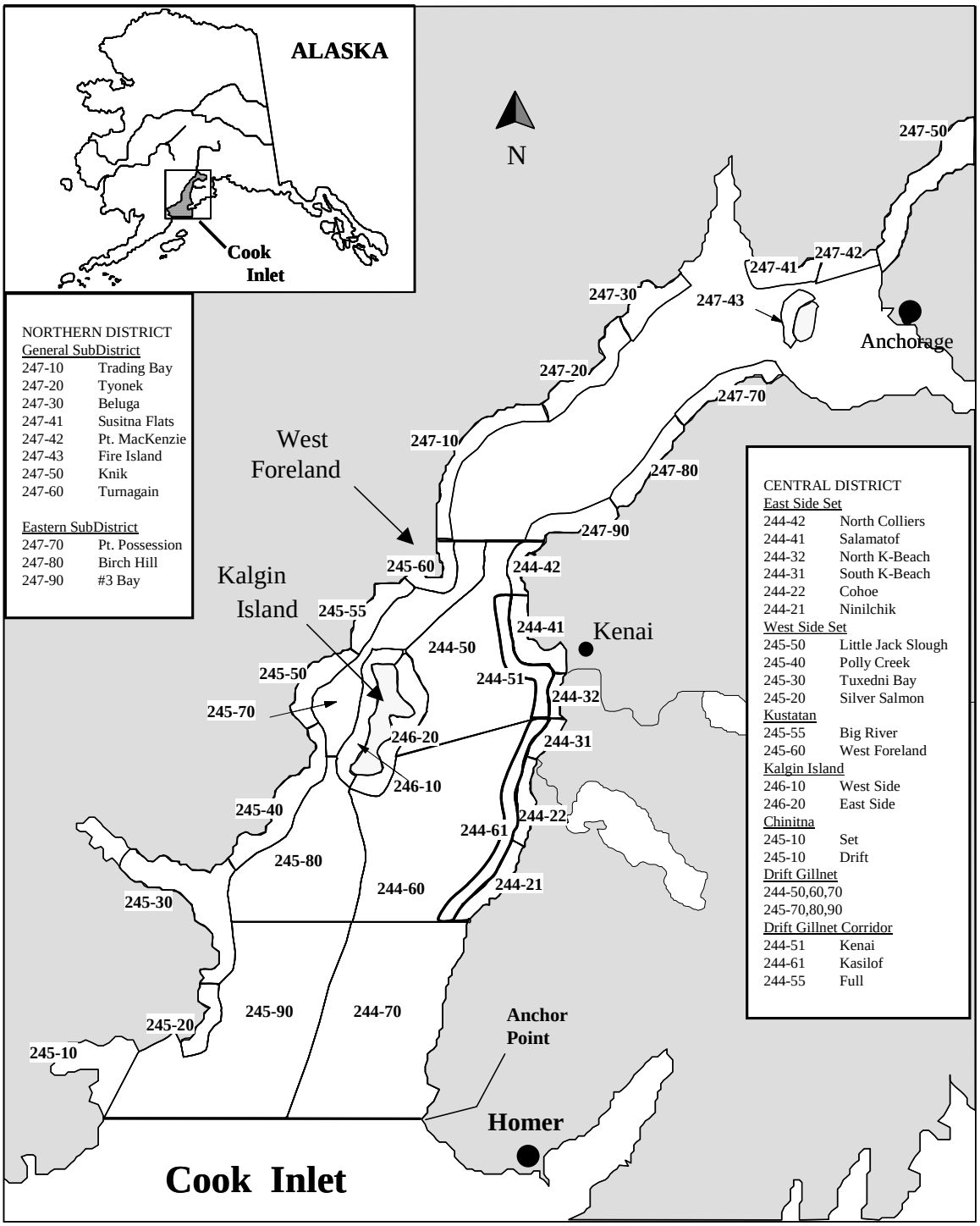

Figure 4.-Upper Cook Inlet statistical areas.

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.

To determine the tagged fraction of the return to the Kenai River, every fish recovered in the inriver sampling component of the study is checked for an adipose finclip, but not necessarily for a coded wire tag. Because of the potential for smolt-to-adult tag loss, a sample of the inriver fish found to be missing an adipose fin must be checked to estimate the tag loss rate. In 2002, most fish wheel-caught adipose finclipped coho salmon were checked for the presence of a tag using an electronic tag detector (Northwest Marine Technologies Tag Detection Wand). The fraction of the returning adults possessing a coded wire tag was then estimated by correcting the adipose finclipped fraction by the tag loss rate and also by adjusting for false negative results (a secondary correction for faulty 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; the marking of smolt with finclips constitutes the first event and the sampling of adults from the inriver return for finclips constitutes 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. A constant marked fraction is an indication that smolt of all return timings were marked in proportion to

their abundance, i.e. the smolt that were marked were representative of the 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 the adult sampling is considered minimal. Additional details of smolt model assumptions are described in the data analysis section.

DATA COLLECTION

Data collection occurred during 2 calendar years. Mark-release data were collected when smolt were captured and marked in 2001 and mark-recovery data were collected in 2002 from commercial harvests and from inriver sources (rkm 44.5 fish wheels and drift gillnetting in a 9.5 km stretch of the Kenai River).

Smolt Marking in 2001

Juveniles were captured for marking in 2001 at a single location within the Kenai River drainage. Prior to 1994, juveniles were captured at a variety of locations (Carlon 1992; Carlon and Hasbrouck 1993). However, subsequent recoveries of adults marked as juveniles indicated that the Moose River was the only location that provided a suitable sample of smolt for marking (Carlon and Hasbrouck 1994); in addition to providing access to a sufficient number of smolt, the Moose River provided smolt that were 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 26, 2001. Most of the smolt arriving at the weir between May 21 and June 10 were marked and released.

Smolt were the primary life stage captured for tagging at the Moose River. Historical data and observations indicate that smolt comprise nearly 100% of the annual springtime 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). 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 FL were present during each emigration, these were not marked because they were substantially different in appearance (parr marks highly visible and substantially less silver skin pigmentation), there were very few of them, and scale samples from fish shorter than 100 mm all exhibited only one annulus. Most coho salmon of Kenai River origin undergo smoltification after 2 years in fresh water (Hammarstrom 1988-1992).

Additional evaluation of smolt marking at the Moose River from 1992 through 1994 indicated that the date of arrival at the weir was independent of the eventual adult return timing (Carlon and Hasbrouck 1994; 1996-1997). Therefore, as a cost-saving measure, an attempt was made to achieve the marking goal of 95,000 (Carlon *Unpublished*) as quickly as possible. However, due to an unprecedented large smolt emigration, an inseason decision was made to increase the marking goal about 30%. After the new marking goal was achieved, tagging was discontinued, personnel (and costs) were reduced, but the weir remained in place until June 26 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 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 2001 were verified on site through visual inspection with a binocular microscope, and the number of smolt marked each day was recorded. Groups of smolt were batch marked; a single tag code was applied to all individuals in the group. The number marked per group ranged from 11,266 to 13,991 depending on the number of tags per tag spool. This resulted in 12 tag code groups being released during the emigration.

Short-term survival and tag retention rates were estimated for smolt marked during each tagging shift by detaining samples of about 200 marked fish in holding pens overnight. Fish that survived overnight were passed through a tag detector to determine if the tag was retained. 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 2002 Return

Data were collected from four inriver sample sources in 2002 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 an 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 provided an opportunity to examine fish for an 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). Almost all of the 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

As part of the mark-recapture experiment to estimate the abundance of adults, drift gillnetting was conducted. This constituted the recapture event and provided a second source of adult coho salmon to examine for adipose finclips. Drift gillnetting was supplemented by a limited amount of set gillnetting and by the use of sport fishing gear. However, the primary and most effective recapture method was drift gillnetting.

Four, two-person crews were scheduled to deploy drift gillnets in the mainstem Kenai River during all daylight hours from August 1 through October 4, 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 recorded each day.

Commercial Harvest in 2002

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; 2002 management actions are documented by Fox and Shields (2003).

Fisheries selected for sampling during 2002 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). With the exception of 2001, Northern District fisheries typically harvest less than a few hundred coho salmon of Kenai River origin (Carlon and Hasbrouck 1994; 1996-1998; Carlon 2000, 2003; 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, Division of Sport Fish, personal communication). Harvests in other UCI commercial fisheries have been sampled incidental to this effort in prior years (Carlon and Hasbrouck 1994-1998, 2000, 2003; Massengill *In prep*; Massengill and Carlon 2004a, b). In

2002, incidental samples were examined in both the Central District westside set gillnet fishery and the ADF&G offshore test fishery.

In 2002, both the Central District drift gillnet and eastside set gillnet fishing seasons opened on June 27 (Fox and Shields 2003). 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) located 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 10, 2002. 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 2001 and commercial harvest of coho salmon of Kenai River origin in 2002 could be achieved. For the estimate of smolt production, the essential steps were: (1) estimate the number of smolt marked in 2001 that survived the marking process, and (2) detect adipose finclipped fish in the 2002 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 2002 did not change over time, (2) estimate the proportion of the adult return in 2002 bearing coded wire tags, and (3) recover coded wire tags from known sample sizes from the commercial fishery.

Smolt Marking in 2001

Short-term mortality and tag loss were estimated to determine the total number of viable, adipose-clipped and tagged smolt released in 2001. 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 that were marked and survived during a shift was estimated as the fraction of surviving smolt that had retained their tags.

The total number of smolt marked with a tag during each shift k (m'_k) was adjusted to account for short-term survival and tag retention to yield an estimate of the total number of tagged smolt that survived and retained a tag in shift k, m_k:

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

The total number of smolt that were marked, survived, and retained a tag at the Moose River in 2001 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 2002 Return

Estimating the commercial harvest of coho salmon of Kenai River origin in 2002 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 2001, but was estimated when adults returned in 2002 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_g) 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 a missing adipose fin. The second step involved estimating the smolt-to-adult tag retention rate (c) 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:

$$\hat{c}_i = v'_i / h_i , \quad (2)$$

where:

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

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

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 was sacrificed in 2002. 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 2001:

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

Estimation of the tagged proportion (θ) from data collected from each drift gillnetting 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 finclip rate. Fish were not wanded to avoid physically detaining the spawning migration more than necessary; it was assumed that the tag retention rate is 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 2002 return.

The data collected to estimate the tagged proportion in the 2002 return also provided an important component of the estimator of the number of smolt that emigrated from the Kenai River in 2001. The mark used to estimate smolt abundance was the adipose finclip as opposed to the presence of a coded wire tag. The number of adipose-finclipped fish recovered in the 2002 inriver sampling program was recorded as a partial requirement of estimating smolt abundance in 2001.

Smolt Abundance in 2001

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

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

where:

M = the number of smolt marked with an adipose finclip and surviving to emigrate in 2001,

C = the number of adult coho salmon examined for an adipose finclip in the 2002 return sample, and

R = the number of adult coho salmon in the 2002 sample that had an adipose finclip.

The variance of the smolt abundance estimate was estimated by:

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

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

1. Adult coho salmon examined for marks were a random sample of the inriver return or the marked sample of smolt was a representative sample of the drainage-wide smolt emigration in 2001 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 2001 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 marking and inriver 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 Hasbrouck 1994; 1996-1998; Massengill *In prep*; Massengill and Carlon 2004a, b) 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 Hasbrouck 1994; 1996-1998; Massengill *In prep*; Massengill and Carlon 2004a, b); this supports the notion that naturally missing adipose fins are rare.

Commercial Harvest in 2002

All estimates of commercial harvest of coho salmon of Kenai River origin were stratified by date (fishing period). The eastside set gillnet harvest was additionally stratified by statistical area. Likewise, the Northern District set gillnet harvest was stratified by statistical area or a combination thereof representing a discrete fishery. The drift gillnet harvest was not stratified by area because sampled fish were often a mixture of the harvest from more than one statistical area. The total harvest of Kenai River coho salmon in each fishery was estimated by summing estimates for each stratum. Because sampling among strata was considered independent, the variance of total harvest was calculated by summing strata variances. The Commercial Fish Ticketing System managed by the ADF&G CF Division provided the commercial harvest by fishery, date, and statistical area.

Commercial harvest of coho salmon of Kenai River origin was estimated; total harvest, number examined for marks, and number of CWTs recovered were considered known. The proportion of the return bearing tags was estimated by examining the inriver capture event (fish wheel) catch and the inriver recapture event (drift netting) catch. The proportions were compared among inriver sampling sources and a subset of data was selected that was best suited for estimating the tagged proportion of the population as it passed through commercial fishing areas. Based on these data sources, the harvest of coho salmon of Kenai River origin in each commercial fishery stratum i was estimated by (Bernard and Clark 1996):

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

where:

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

θ = the estimated proportion of the 2002 Kenai River return bearing 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 2001 tagging event,

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

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

where:

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

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

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

t_i' = the number of coded wire tags found that were readable as a code released in any coho salmon marking event (not necessarily just the Moose River 2001 event).

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

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

where:

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

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

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

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

Although the number of fish harvested is estimated 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 2002 harvest estimates. The extent of this variance component could be measured in the future based on data collected by ADF&G harvest sampling personnel.

Harvest estimates were based on sample data pooled among processors receiving fish from harvests occurring within the estimation stratum (area and/or time). Bias associated with this pooling is assumed insignificant because of the similarity of the marked proportion among intensively sampled processors in prior years (Carlon 2000, 2003; Carlon and Hasbrouck 1997; 1998; Massengill *In prep*; Massengill and Carlon 2004a, b). Pooling data among processors in 2002 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 2001

From May 21 through June 10, 2001, 148,054 smolt were marked with coded wire tags and adipose finclips as they emigrated from the Moose River (Appendix A1). Of these, an estimated 147,931 survived the tagging process based on the estimated short-term survival rate (~ 99.9%). Of the surviving marked smolt, more than 99% retained tags resulting in an estimated 146,776 smolt that were released alive with tags. Although marked fish were released as late as June 11 (from the overnight retention and survival sample), marking was discontinued after the marking goal was achieved on June 10, 2001. The weir remained in place through June 26 allowing for a census of the smolt emigration. The total number of smolt arriving at the weir between May 22 and June 26, 2001 was 289,731.

TAGGED PROPORTION OF THE 2002 RETURN

Adults marked as smolt (with adipose finclips and coded wire tags) at the Moose River in 2001 returned to the Kenai River drainage in 2002. 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.

Capture Event Sampling

Two fish wheels were used exclusively in the capture event of the companion mark-recapture experiment to estimate adult abundance in 2002. 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 9.3 hrs per day for the fish wheel adjacent to the north bank and 9.75 hrs per day for the fish wheel adjacent to the south bank (Carlon and Evans *In prep*).

From August 1 through September 30, a combined total of 6,523 unique coho salmon were captured and examined (Table 1 and Appendix A2). Of the total, 1,503 (proportion = 0.230) had an adipose finclip. The tag detection wand was used to check 1,162 of the adipose-clipped fish and a tag was detected in 1,143 (proportion = 0.984). Of the 19 fish for which a tag was not detected by the wand, 15 were sacrificed to verify the negative wand results and tags were found in 11. Therefore, an overall false-negative rate of 0.733 (11/15) was applied to the 19 negative

Table 1.-Recoveries of coho salmon from multiple sources within the Kenai River drainage from August 1 through October 4, 2002 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	12		0.000			0.998	0.000	0
08/08 - 08/14	29	4	0.138	4	4	1.000	0.138	0
08/15 - 08/21	235	32	0.136	32	31	0.992	0.135	0
08/22 - 08/28	571	79	0.138	69	64	0.981	0.136	2
08/29 - 09/04	570	118	0.207			0.998	0.207	0
09/05 - 09/11	652	196	0.301	102	101	0.997	0.300	1
09/12 - 09/18	966	391	0.405	390	390	1.000	0.405	0
09/19 - 09/25	692	207	0.299	206	206	1.000	0.299	0
09/26 - 09/30	179	54	0.302	54	54	1.000	0.302	0
Total	3,906	1,081	0.28	857	850	0.998	0.276	2
			South Bank Fish Wheel					
08/01 - 08/07	97	7	0.072	5	4	0.947	0.068	0
08/08 - 08/14	182	17	0.093	17	17	1.000	0.093	0
08/15 - 08/21	342	31	0.091	31	25	0.948	0.086	2
08/22 - 08/28	647	72	0.111	56	51	0.976	0.109	2
08/29 - 09/04	512	75	0.146			0.989	0.145	1
09/05 - 09/11	204	46	0.225	23	23	1.000	0.225	0
09/12 - 09/18	290	87	0.300	86	86	1.000	0.300	0
09/19 - 09/25	233	59	0.253	59	59	1.000	0.253	0
09/26 - 09/30	110	28	0.255	28	28	1.000	0.255	0
Total	2,617	422	0.161	305	293	0.989	0.160	4
			North Bank Recapture Effort					
08/01 - 08/07	21	4	0.190			0.996	0.190	0
08/08 - 08/14	172	37	0.215			0.996	0.214	0
08/15 - 08/21	223	39	0.175			0.996	0.174	0
08/22 - 08/28	191	46	0.241			0.996	0.240	0
08/29 - 09/04	87	22	0.253			0.996	0.252	0
09/05 - 09/11	145	38	0.262			0.996	0.261	0
09/12 - 09/18	285	104	0.365			0.996	0.363	0
09/19 - 09/25	230	77	0.335			0.996	0.333	0
09/26 - 10/02	202	69	0.342			0.996	0.340	0
10/03 - 10/04	11	3	0.273			0.996	0.272	0
Total	1,567	439	0.280			0.996	0.279	2

-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	28	3	0.107			0.996	0.107	0
08/08 - 08/14	203	21	0.103			0.996	0.103	0
08/15 - 08/21	438	63	0.144			0.996	0.143	0
08/22 - 08/28	303	41	0.135			0.996	0.135	0
08/29 - 09/04	230	50	0.217			0.996	0.216	0
09/05 - 09/11	380	96	0.253			0.996	0.252	0
09/12 - 09/18	528	175	0.331			0.996	0.330	1
09/19 - 09/25	879	290	0.330			0.996	0.328	1
09/26 - 10/02	430	112	0.260			0.996	0.259	0
10/03 - 10/04	79	11	0.139			0.996	0.139	0
Total	3,498	862	0.246			0.996	0.245	4
			Combined North and South Bank Fish Wheels					
08/01 - 08/07	109	7	0.064	5	4	0.947	0.061	0
08/08 - 08/14	211	21	0.100	21	21	1.000	0.100	0
08/15 - 08/21	577	63	0.109	63	56	0.970	0.106	2
08/22 - 08/28	1,218	151	0.124	125	115	0.979	0.121	3
08/29 - 09/04	1,082	193	0.178	0	0	0.996	0.178	1
09/05 - 09/11	856	242	0.283	125	124	0.998	0.282	1
09/12 - 09/18	1,256	478	0.381	476	476	1.000	0.381	0
09/19 - 09/25	925	266	0.288	265	265	1.000	0.288	0
09/26 - 09/30	289	82	0.284	82	82	1.000	0.284	0
Total	6,523	1,503	0.230	1,162	1,143	0.996	0.229	7

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

[b] Number of marked fish checked for the presence of an embedded coded wire tag using an electronic tag detection wand. Marked fish observed in samples from both riverbanks in the 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 2001 based on tag detection results.

[d] Estimated proportion of the number examined bearing a coded wire tag originally implanted at the Moose River in 2001.

[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.

wanding results to estimate that 14 of the 19 were carrying an undetected tag. This estimate was added to the number of positive wand results to more accurately estimate the overall tag retention rate (c) of 0.996. Adjusting the overall adipose finclip rate (y) based on pooled fish wheel samples (0.230) by this tag retention rate produced an estimate of the overall tagged proportion ($\hat{\theta}$) of 0.229. The weekly tagged proportion ranged from 0.061 to 0.381 and varied significantly over weekly intervals ($P < 0.001$) although there was no difference among the first 4 weekly intervals from August 1 through August 28 ($P = 0.26$).

Of the 6,523 coho salmon captured in fish wheels, 2,617 were captured in the south bank fish wheel. After correcting for the false-negative wanding rate, the weekly tagged proportion in the south bank fish wheel catch ranged from 0.068 to 0.300 and varied significantly over all weeks ($P < 0.001$), but did not vary over the first 4 weeks ($P = 0.53$). The overall tagged proportion estimated by pooling the full season of south bank fish wheel data was 0.160.

An additional 3,906 coho salmon were captured in the north bank fish wheel. The weekly tagged proportion ranged from zero to 0.405 and varied significantly over all weeks ($P < 0.001$), but did not vary over the first 4 weeks ($P = 0.60$). The tagged proportion estimated by pooling the full season of north bank fish wheel data was 0.276. This tagged proportion was significantly different from that estimated for the south bank fish wheel ($P < 0.001$).

Recapture Event Sampling

Drift gillnets were the primary gear used in the recapture event of the companion capture-recapture experiment to estimate adult abundance in 2002. Minor catches made by hook-and-line sport fishing gear (including snagging) 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 2002 return. Recapture effort was scheduled each day between August 1 and October 4, 2002 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 a decreasing seasonal trend in daylight.

From August 1 through October 4, a combined total of 5,065 unique coho salmon were captured, examined, and assigned to a bank of capture (Table 1 and Appendix A3). Of the total, 1,301 (0.257) had an adipose finclip. A tag detection wand was not used to check for tag retention in the recapture event. Therefore, the overall tagged proportion ($\hat{\theta}$) for the recapture event was estimated by multiplying the overall adipose finclip rate (y) from the recapture event of 0.257 by the overall tag retention rate (c) measured in the capture event (0.996) for an estimate of 0.256. The weekly tagged proportion ranged from 0.143 to 0.342 and varied significantly over weekly intervals ($P < 0.001$) although there was no difference among the first 4 weekly intervals from August 1 through August 28 ($P = 0.73$).

Of the 5,065 coho salmon captured in the recapture event that were examined for an adipose finclip, 3,498 were captured along the south bank. Based on wand results corrected for the overall false-negative rate, the weekly tagged proportion in the south bank catch ranged from 0.103 to 0.330 and varied significantly over all weeks during which fish were examined ($P < 0.001$). The seasonal tagged proportion estimated by pooling all south bank recapture event

data was 0.245. This proportion did not differ significantly from that estimated from the pooled fish wheel samples (P = 0.07).

An additional 1,567 coho salmon were captured along the north bank in the recapture event and examined for an adipose finclip. The weekly tagged proportion ranged from 0.174 to 0.363 and varied significantly over all weeks during which fish were examined (P < 0.001). The seasonal tagged proportion estimated by pooling all north bank recapture event data was 0.279. This proportion differed significantly from that estimated from south bank recapture event samples (P = 0.01) and from pooled fish wheel samples (P < 0.001).

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 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 2002 return was 0.229 (SE($\hat{\theta}$)=0.005; $\hat{\theta}^{-1}$=4.4; SE($\hat{\theta}^{-1}$)=0.12). Because of its 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 0.112 (SE($\hat{\theta}$)=0.007; $\hat{\theta}^{-1}$=8.9; SE($\hat{\theta}^{-1}$)=0.56) was estimated from samples collected during the first 4 weeks of sampling (8/1 – 8/28) because no difference was detected in the tagged proportion among those weeks. The maximum tagged proportion was detected during the seventh weekly period (9/12-9/18) and was estimated as 0.381 (SE($\hat{\theta}$)=0.014; $\hat{\theta}^{-1}$=2.6; SE($\hat{\theta}^{-1}$)=0.095).

SMOLT ESTIMATE IN 2001

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 2001 (147,931), the number of adult coho salmon examined for adipose fin status in the Kenai River fish wheel samples in 2002 (6,523), and the number of adults in the sample that had an adipose finclip (1,503), an estimated 641,693 (SE = 14,436) smolt emigrated from the Kenai River in 2001.

COMMERCIAL HARVEST IN 2002

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 2002 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 2002 fishing season, 246,281 coho salmon were harvested in commercial fisheries of UCI (Table 2). This harvest was 91% of the average of the last 10 years (Fox and Shields 2003). About 80% of the 2002 UCI commercial harvest was taken in Central District fisheries (Figure 5). Among all UCI fisheries, the greatest harvest occurred in the drift gillnet fishery of the Central District (51.1%), followed by the eastside set gillnet fishery (14.3%), the Kalgin Island set gillnet fishery (8.9%), and the westside set gillnet fishery (5.3%). In the Northern District set gillnet fisheries, the greatest contribution to the total UCI commercial harvest occurred in the Pt. MacKenzie/Susitna Flats fishery (6.2%), followed by westside fishery (5.8%), the eastside fishery (5.6%), and the Fire Island fishery (2.8%).

Of the inlet-wide commercial harvest, 94,730 fish (38%) were examined for adipose clips. Adipose-clipped fish were found in all sampled fisheries. Exact fishery stratum of harvest (temporal/statistical area) could not be identified for 18,268 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 138 were found with an adipose finclip (0.7%), heads were recovered from 136 fish, and a decodable tag was found in 115 of the recovered heads. Of the 115 decodable tags recovered, 19 had been implanted in smolt at the Moose River in 2001.

The remaining 76,462 examined fish (Appendix A6) were positively assigned to fishery strata and were used to calculate harvest estimates. Of these, 2,080 (2.7%) were missing the adipose fin and heads were collected from 2,069 of them. Of the 2,069 heads recovered, 1,883 had decodable tags (91%). All 1,883 tagged fish had originated from UCI release locations in 2001, 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 1,883 decodable tags recovered from adults commercially harvested in known fishery strata, a total of 255 (13.5%) were originally released in smolt emigrating from the Kenai River drainage. All 255 were originally implanted in smolt emigrating from the Moose River tributary in 2001. Most (97%) were recovered from Central District fisheries while seven were recovered from known Northern District fisheries.

Among commercial processors receiving coho salmon harvested in the Central District eastside set gillnet fisheries, 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 0.043 (Figure 6). Among plants processing coho salmon harvested in the Central District drift gillnet fishery, the proportion did not exceed 0.005. 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 2002 fishing season, 125,831 coho salmon were harvested in the Central District drift gillnet fishery. The 2002 harvest was 92% of the average of the last 10 years (Fox and Shields 2003).

The Central District drift gillnet fishery harvest was sampled during most fishing periods between the first open period on June 27 and the last on August 12. Overall, 25% of the harvest

Table 2.-Sampling performance and recovery of coded wire tags (CWT) from coho salmon harvested in Upper Cook Inlet commercial fisheries in 2002.

Gillnet Fishery	Harvest	Number Examined	Percent of Harvest Examined	Marked Fish Found[a]	Percent Marked	Heads Recovered	Tag Missing, Lost, or Unreadable	Percent Missing Tag	Heads with Decodable Tag[b]	Number from Cohort Marked at Moose R. in 2001
CENTRAL DISTRICT										
Central District Drift	125,831	32,019	25%	613	1.9%	606	55	9%	551	67
East Side Set (by Statistical Area)										
244-21	4,317	960	22%	69	7.2%	69	4	6%	65	62
244-22	4,846	999	21%	59	5.9%	59	2	3%	57	40
244-31/32	6,710	952	14%	46	4.8%	46	5	11%	41	24
244-41/42	19,280	2,944	15%	81	2.8%	81	3	4%	78	53
East Side Set Total	35,153	5,855	17%	255	4.4%	255	14	5%	241	179
Kalgin Is. Set	21,969									
West Side Set	13,036	4,125	32%	6	0.1%	6	2	33%	4	2
Mixed West Side Set/Kalgin Island Set, and East Side Set[c]		5,295		58	1.1%	57	9	16%	48	8
Mixed East Side Set[c]		298		9	3.0%	9	0	0%	9	8
Mixed West Side Set/Kalgin Island Set[c]		11,554		60	0.5%	59	9	15%	50	2
Central District Total	195,989	59,146	30%	1,001	1.7%	992	89	9%	903	266
NORTHERN DISTRICT										
West Side Set	14,229	11,482	81%	22	0.2%	20	12	60%	8	0
Pt. MacKenzie/Susitna Flats Set	15,279	11,012	72%	590	5.4%	588	59	10%	529	0
East Side Set	13,798	5,482	40%	31	0.6%	31	5	16%	26	4
Fire Island Set	6,986	6,487	93%	563	8.7%	563	39	7%	524	3
Northern District Total	50,292	34,463	69%	1,206	3.5%	1,202	115	10%	1,087	7
MIXED DISTRICTS										
Central District East Side Set, and Northern District East Side Set		329		8	2.4%	8	1	13%	7	0
Central District West Side Set, Kalgin Island Set, and Northern District East Side Set		792		3	0.4%	3	2	67%	1	1
Mixed District Total		1,121		11	1.0%	11	3	79%	8	1
Mixed Fishery Total		18,268		138	0.8%	136	21	15%	115	19
Unmixed Fishery Total[d]	246,281	76,462	31%	2,080	2.7%	2,069	186	9%	1,883	255
Grand Total[e]	246,281	94,730	38%	2,218	2.3%	2,205	207	9%	1,998	274

-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.

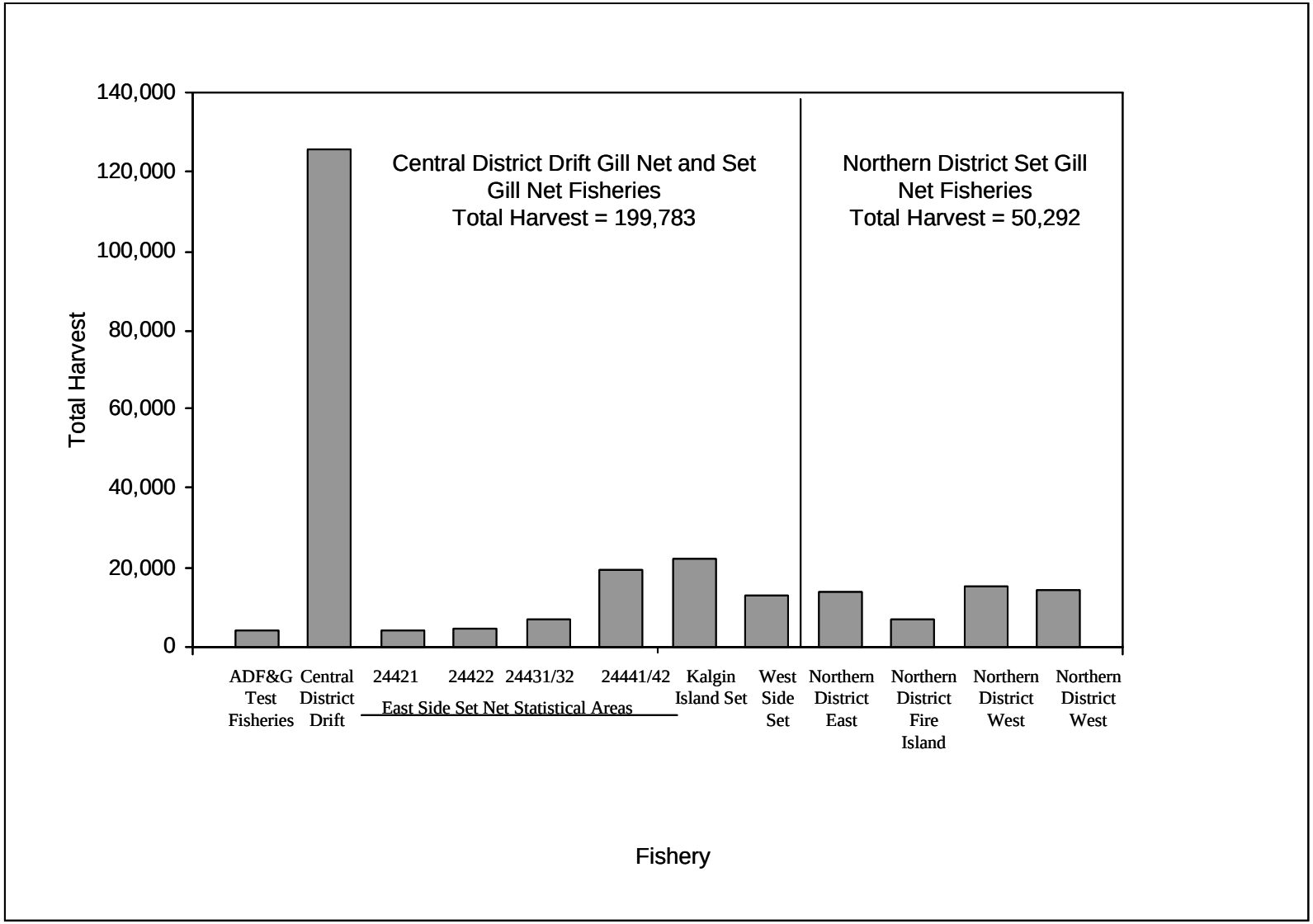

Figure 5.-Coho salmon harvest in 11 Upper Cook Inlet commercial fishery areas and Alaska Department of Fish and Game UCI test fisheries in 2002.

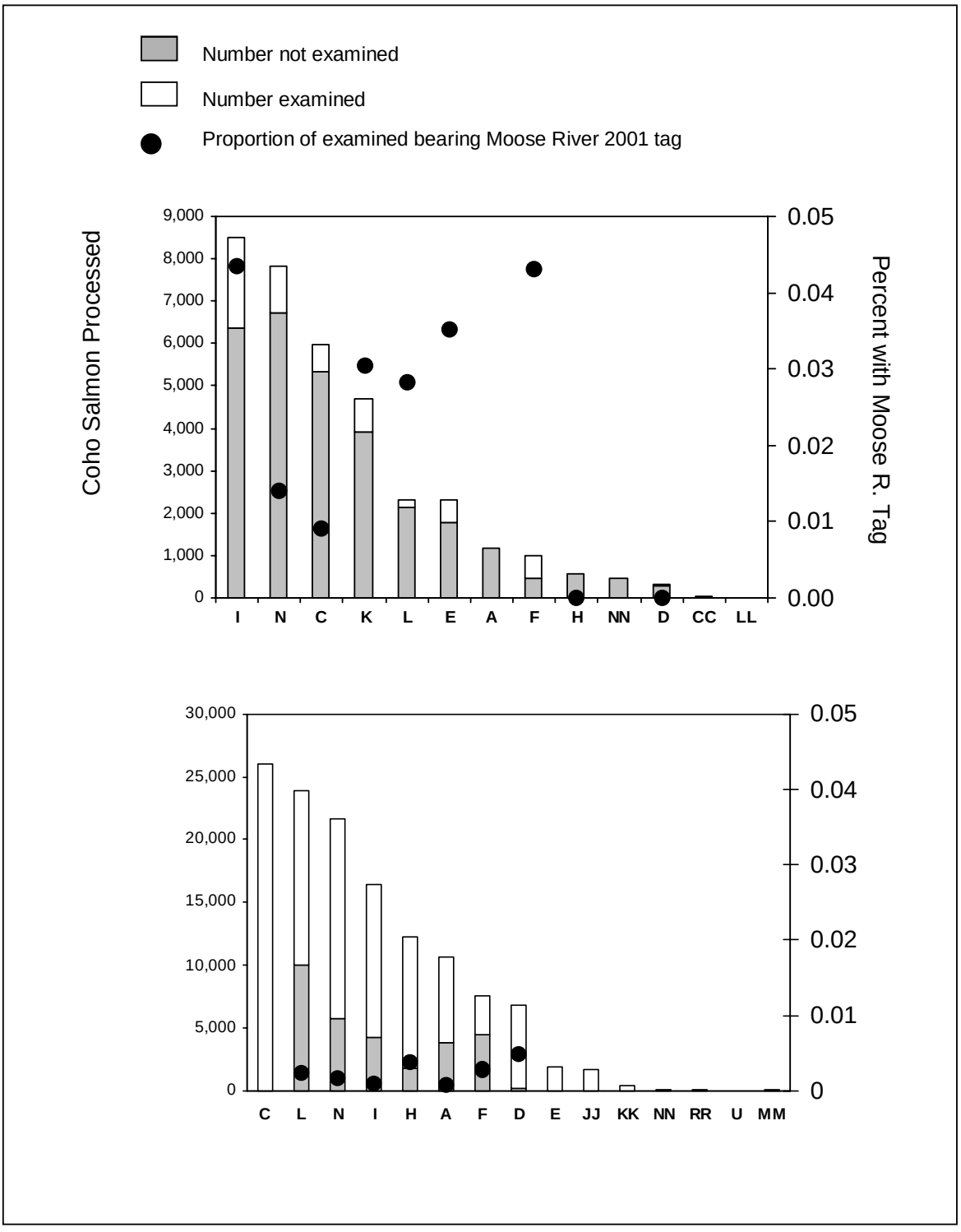

Figure 6.-Number of coho salmon harvested, examined, and processed in 2002 in the Eastside setnet fishery (top) and Central District drift gillnet fishery, including the Alaska Department of Fish and Game offshore test fishery (bottom) of Upper Cook Inlet by commercial processor (alias name) and proportion of examined fish that were originally marked at the Moose River in 2001.

was examined. The harvest occurring on days not sampled accounted for 4% of the total harvest (not including the unsampled experimental pink salmon fishery that opened during three different days after August 9; only 10 coho salmon were harvested in that experimental fishery).

A total of 32,019 fish were examined and positively assigned to drift fishery temporal strata and used to calculate harvest estimates. Of fish examined, 613 (2%) were missing the adipose fin and heads were collected from all but seven. Of the 606 heads recovered, 551 had decodable tags. Of these decodable tags, 403 originated from the 2001 annual release of hatchery-produced smolt among multiple Northern District streams, 2 originated from hatchery-produced smolt released in Northern District streams in 2000, 79 originated as Northern District wild smolt emigrating from Cottonwood Creek in 2001, and the remaining 67 were originally implanted in wild smolt emigrating from the Moose River (Kenai River drainage) in 2001. Therefore, of the 32,019 fish examined in this fishery, tags implanted at the Moose River in 2001 were physically recovered from 0.2%.

The first recoveries of fish bearing Moose River coded wire tags occurred on July 18, some 22 days after the first fishing period. Coho salmon marked at the Moose River were recovered on 7 of the 14 sampled days between July 18 and the last open fishing period on August 12.

Central District Eastside Set Gillnet Fishery

During the 2002 fishing season, a total of 35,153 coho salmon were harvested in the Central District Eastside set gillnet fishery. The 2002 harvest was 118% of the average of the last 10 years (Fox and Shields 2003).

Between the first open period on July 1 and the last on August 5, the Central District eastside set gillnet fishery harvest was sampled on 13 of the 23 days fishing occurred. Overall, 17% of the harvest (5,855 fish) was examined and positively assigned to spatial-temporal strata. The combined eastside harvest occurring on days not sampled accounted for 26% of the total harvest. Adipose finclipped fish were found on 7 of the 13 days sampled.

Of the 5,855 fish examined and assigned to fishery strata, 255 (4.4%) had an adipose finclip and heads were collected from all. Of the 255 heads recovered, 11 (4%) had no tag, 2 tags were retrieved from heads but were lost before being decoded, and 1 tag was unreadable, resulting in a total of 241 decodable tags. Of these decodable tags, 50 originated from the 2001 annual release of hatchery-produced smolt among multiple Northern District streams, 11 originated from the 2001 wild smolt tagging study in Cottonwood Creek, 1 originated from the 2001 wild smolt tagging study in Deep Creek in the Central District, and the remaining 179 were originally implanted in wild smolt emigrating from the Moose River in 2001. Therefore, of the 5,855 fish examined in this fishery, tags implanted at the Moose River in 2001 were physically recovered from 3%.

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 29% to 44% among statistical areas. Coho salmon marked at the Moose River in 2001 were recovered from all statistical areas in 2002. The first recovery of Moose River tags occurred on July 22 in statistical areas 24421 and 24431/32, and on July 25 in statistical areas 24422 and 24441/42. The portions of fish examined in 2002 that had been marked as smolt at the Moose River in 2001 were 6.5%, 4.0%, 2.5%, and 1.8 % for statistical areas 24421, 24422, 24431/32, and 24441/42, respectively.

Northern District Gillnet Fisheries

During the 2002 fishing season, a total of 50,292 coho salmon were harvested among all Northern District set gillnet fisheries. The 2002 harvest was 73% of the average of the last 10 years (Fox and Shields 2003).

Sampling of the harvest in the Northern District occurred during most fishery openings after the first open period on July 4. 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 34,463 fish examined (69% of the harvest). Of the 34,463 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 4% of the total harvest. Adipose clipped fish were found on all sampled days with the exception of 5 days irregularly spaced throughout the duration of the Northern District eastside set gillnet fishery.

Of the 34,463 fish examined and assigned to fishery strata, 1,206 (3.5%) were missing the adipose fin and heads were collected from all but 4. Of the 1,202 heads recovered, 115 (10%) had no tag, resulting in a total of 1,087 heads with tags, all of which were decodable. Of these decodable tags, 887 originated from the 2001 annual release of hatchery-produced smolt among multiple Northern District streams, 1 originated from the 2000 annual release of hatchery-produced smolt in the Northern District, 190 originated from the 2001 wild smolt tagging study in Cottonwood Creek, 2 from the 2000 wild smolt tagging study in Cottonwood Creek, and the remaining 7 were originally implanted in wild smolt emigrating from the Moose River tributary to the Kenai River in 2001. Therefore, of the 34,463 fish examined among Northern District fisheries, tags implanted at the Moose River in 2001 were physically recovered from 0.02%.

Commercial Harvest Estimates

Based on commercial catch sampling data and the point estimate of the tagged proportion of the 2002 adult return to the Kenai River, a set of qualified commercial harvest estimates were generated for UCI commercial fisheries in 2002. 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 1,370 (SE = 166) coho salmon of Kenai River origin were harvested by the Central District drift gillnet fishery (Table 3), 4,688 (SE = 469) by the Central District eastside set gillnet fishery (Table 4), and 57 (SE = 25) by all Northern District set gillnet fisheries (Appendix A6) for a total of 6,115 (SE = 499) during 2002. These qualified estimates comprised 1.1% of the total drift gillnet harvest, 13.3% of the total eastside set gillnet harvest, and 0.1% of the total Northern District set gillnet harvest in 2002.

The first coho salmon of Kenai River origin were detected in the Central District drift gillnet harvest on July 18. The contribution of Kenai River origin fish to the harvest remained minimal throughout the commercial drift gillnet season with the greatest proportional contribution (2.2%) occurring during the last few days of July and the first 5 days in August. The greatest overall commercial drift gillnet harvest occurred from July 21 through August 5 (Figure 7).

Table 3.-Total coho salmon harvest and qualified estimates of harvest 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, 2002.

Interval	Total Harvest	Estimated Harvest of Coho Salmon of Kenai River Origin	Standard Error	Percent of Total Harvest
6/25 - 7/5	446	0		
7/6 - 7/17	15,622	0		
7/18 - 7/26	53,755	95	35	0.2%
7/27 - 8/5	49,737	1,191	158	2.4%
8/6 - 8/9	6,271	84	36	1.3%
Total	125,831	1,370	166	1.1%

The first coho salmon of Kenai River origin were detected in the Central District eastside set gillnet harvest on July 8. The harvest of 26 coho salmon before July 8 represents 0.07% of the total harvest in this fishery. In general, the proportion of the harvest comprised of coho salmon of Kenai River origin, and the total overall harvest, peaked during the last week of July (Figure 8) and was at its lowest during the first 2 weeks of July.

The total coho salmon harvest occurring in the Central District eastside set gillnet fishery was similar among the three southern-most statistical areas while the harvest occurring in the northernmost statistical area was substantially greater (Figure 9). The portion of the harvest comprised of coho salmon of Kenai River origin was similar among all four areas. The end result was a similar absolute harvest of Kenai River-bound coho salmon among the three southern-most areas with a greater harvest occurring in the northern-most area.

Meaningful temporal or geographic trends occurring in Northern District commercial fisheries were not detectable because of the inconsequential harvest estimate of 57 coho salmon of Kenai River origin. Only four fish bearing a coded wire tag from the Kenai River drainage were detected in the Northern District westside set gillnet fishery while only three were detected in the eastside set gillnet fishery. None were detected in the remaining two sampled fisheries. The first recovery of a coded wire tag from an adult tagged as a smolt in 2001 at the Moose River occurred on July 22, 2002.

Effect of Variations of the Tagged Proportion on Commercial Harvest Estimates

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

Table 4.-Total coho salmon harvest and qualified estimates of harvest of coho salmon of Kenai River origin in the eastside set gillnet fishery of Upper Cook Inlet by statistical area and selected time intervals, 2002.

Interval	Total Harvest	Estimated Harvest of Coho Salmon of Kenai River Origin	Standard Error	Portion of Total Harvest
		Statistical Area 244-21		
7/1 - 7/15	141	0		
7/16 - 7/22	503	10	9	2.0%
7/23 - 8/1	2,120	693	93	32.7%
8/2 - 8/5	1,553	372	165	24.0%
Total	4,317	1,075	190	24.9%
		Statistical Area 244-22		
7/1 - 7/15	166	0		
7/16 - 7/22	452	0		
7/23 - 8/1	2,755	499	88	18.1%
8/2 - 8/5	1,473	338	150	22.9%
Total	4,846	837	174	17.3%
		Statistical Area 244-31/32		
7/1 - 7/15	207	0		
7/16 - 7/22	445	26	26	5.8%
7/23 - 8/1	4,556	489	118	10.7%
8/2 - 8/5	1,502	0		
Total	6,710	515	120	7.7%

-continued-

Table 4.-Page 2 of 2.

Interval	Total Harvest	Estimated Harvest of Coho Salmon of Kenai River Origin	Standard Error	Portion of Total Harvest
		Statistical Area 244-41/42		
7/1 - 7/15	835	0		
7/16 - 7/22	3,481	0		
7/23 - 8/1	10,974	1,507	331	13.7%
8/2 - 8/5	3,990	754	172	18.9%
Total	19,280	2,261	373	11.7%
		Combined Statistical Areas		
7/1 - 7/15	1,349	0		
7/16 - 7/22	4,881	36	27	0.7%
7/23 - 8/1	20,405	3,188	374	15.6%
8/2 - 8/5	8,518	1,464	282	17.2%
Total	35,153	4,688	469	13.3%

Note: See text for description of qualifications on estimated harvest.

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 (0.229), the minimum proportion detected from data pooled over the first 4 weeks (0.112), and the maximum weekly proportion detected (0.381). 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 -40% and 105%, respectively.

DISCUSSION

COMMERCIAL HARVEST

Potential bias in the point estimates of commercial harvest exists because commercial harvest estimates were based on a pooled estimate of the tagged proportion, in the face of significant temporal variability in inriver samples. However, it was considered unreasonable to abandon the estimates without evaluating the potential magnitude of the bias; minimally biased estimates are 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

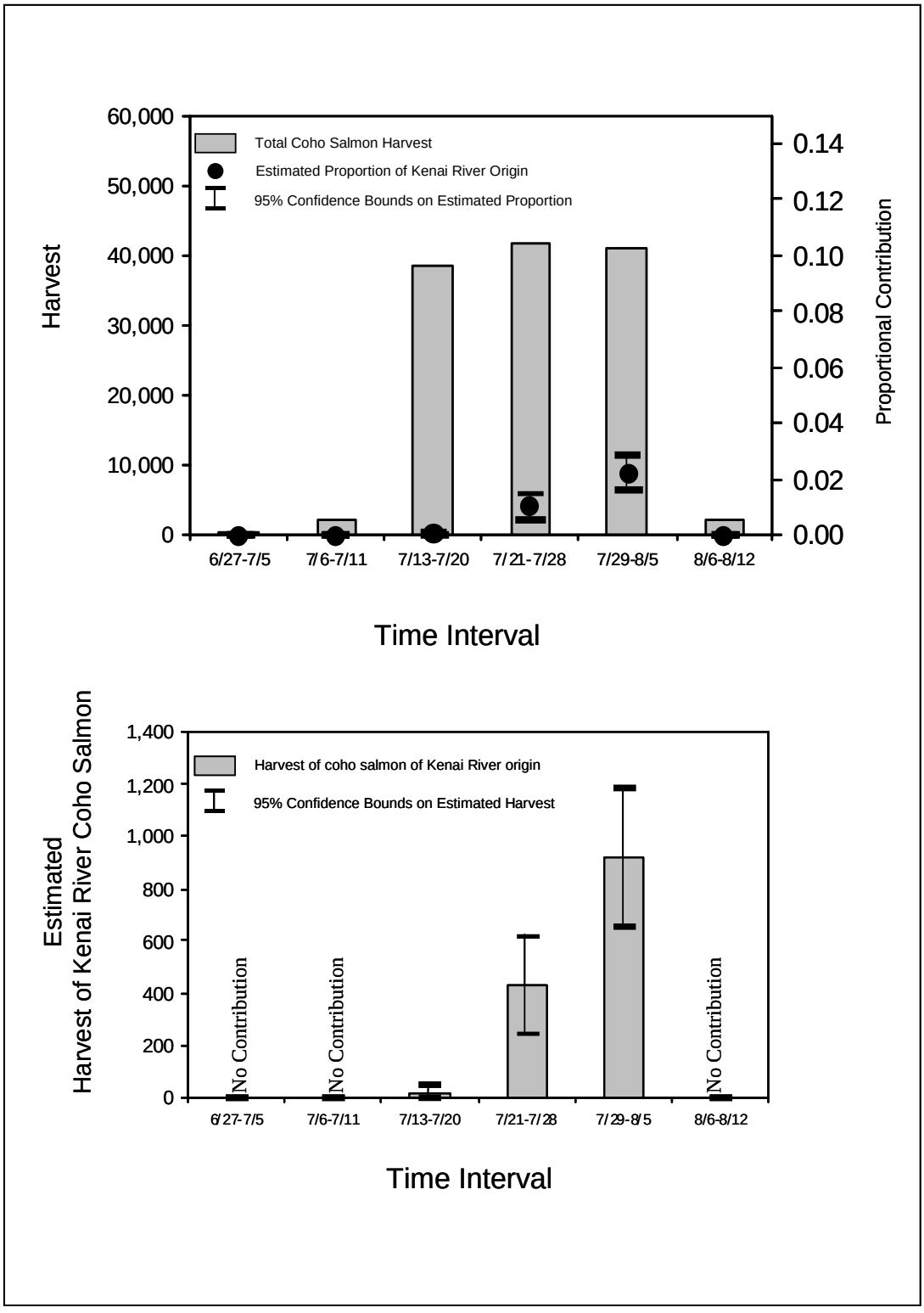

Figure 7.-Temporal trend in proportional contribution of Kenai River coho salmon to the total harvest (top) and trend in absolute contribution (bottom) occurring in the drift gillnet fishery of the Central District of Upper Cook Inlet, 2002.

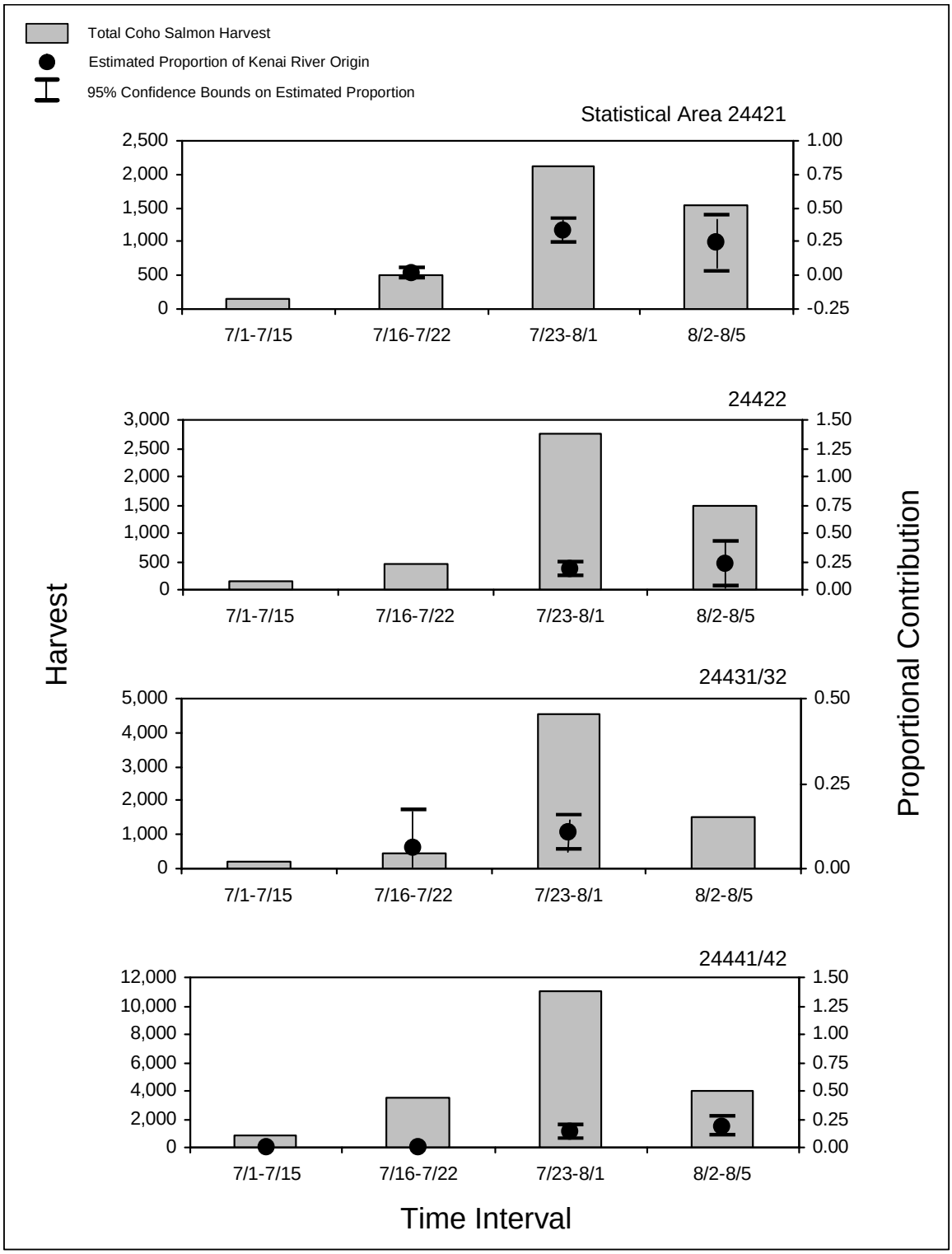

Figure 8.-Temporal trends in total harvest of coho salmon and proportional contribution of coho salmon from the Kenai River to the total harvest occurring in four statistical areas of the Upper Cook Inlet Central District eastside set gillnet fishery during four selected time periods in 2002.

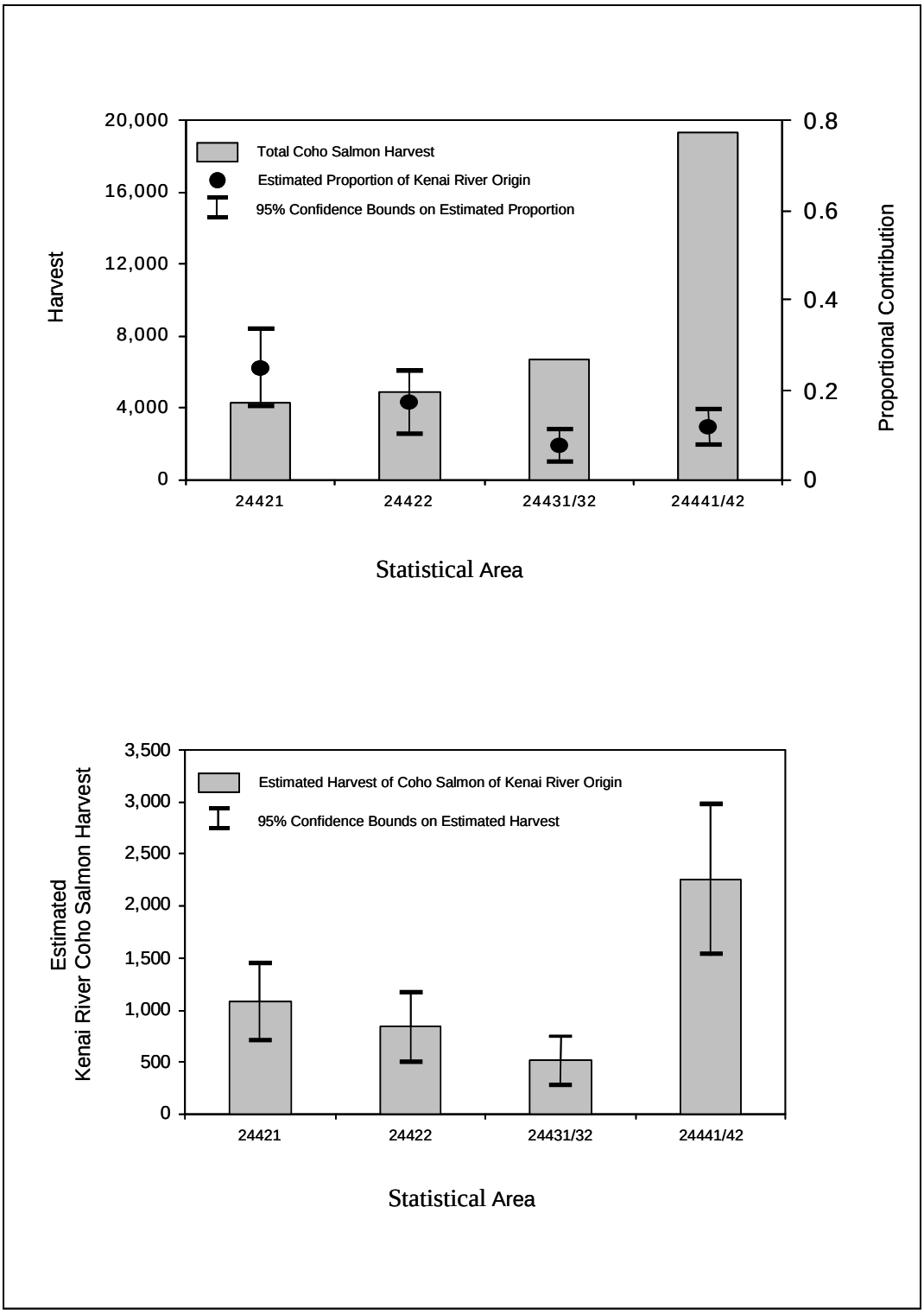

Figure 9.-Geographic trends in total coho salmon harvest and proportional contribution of coho salmon of Kenai River origin (top) and in estimated number of coho salmon of Kenai River origin (bottom) harvested among statistical areas in the eastside set gillnet fishery of the Central District of Upper Cook Inlet, 2002.

Table 5.-Sensitivity of commercial harvest estimates to maximum temporal variations in the tagged proportion estimated from samples of coho salmon captured by fish wheels from the Kenai River, 2002.

Fishery	Total Harvest	Pooled Marked Proportion (0.229) Estimated Contribution [a]	Marked Proportion: Minimum (0.112) Estimated Contribution [a]	Difference from Pooled	% Difference from Pooled	Difference from Pooled as % of Total Harvest	Marked Proportion: Maximim (0.381) Estimated Contribution [a]	Difference from Pooled	% Difference from Pooled	Difference from Pooled as % of Total Harvest
Central District Drift Gillnet	125,831	1,370	2,813	1,443	105%	1%	827	-543	-40%	0.4%
Central District East Side Set Gillnet [b]										
244-21	4,317	1,075	2,204	1,129	105%	26%	648	-427	-40%	10%
244-22	4,846	837	1,717	880	105%	18%	504	-333	-40%	7%
244-31/32	6,710	515	1,057	542	105%	8%	311	-204	-40%	3%
244-41/42	19,280	2,261	4,637	2,376	105%	12%	1,363	-898	-40%	5%
Combined	35,153	4,688	9,615	4,927	105%	14%	2,826	-1,862	-40%	5%
Northern District Set Gillnet	50,292	57	121	64	112%	0%	37	-20	-35%	0.04%
Total [c]	211,276	6,115	12,549	6,434	105%	3%	3,690	-2,425	-40%	1%

[a] Kenai River population-specific harvest estimate.

[b] By statistical area and combined.

[c] Sum of estimates for Central District drift gillnet, Central District east side 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).

the largest point estimate of commercial harvest (12,549) and the commercial harvest estimated under the pooled scenario (6,115) - relative to harvest magnitudes and total return - illustrates the intrinsic value of the estimates regardless of bias. The largest estimate represents 6% of the total UCI commercial harvest (excluding the Central District areas of Kalgin Island set and the west-side set where interception of Kenai River bound coho salmon is negligible) as opposed to 2.9% 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 7.0% (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 18% of the combined sport and personal use harvest of coho salmon from the Kenai River as opposed to 9% under the pooled scenario, showing that within Kenai River specific harvests, the commercial harvest is also relatively small. Further, the extreme estimate represents 7.3% of the preliminary estimate of the total 2002 adult coho salmon return (Carlon and Evans *In prep*) as opposed to 3.6% for the pooled estimate.

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 in 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 the UCI commercial fisheries. 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).

The point estimate of commercial harvest of Kenai River-bound coho salmon in the two Central District fisheries in 2002 was 6,115 (excluding the Kalgin Island and westside set gillnet fisheries) and represents 60% of the 1993-2001 average (Table 6). Reasons contributing to this below average harvest likely include new 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

Table 6.-Estimated harvest of coho salmon of Kenai River origin in UCI marine commercial fisheries, 1993-2002.

	Central District		Northern District	
Year	Drift Gillnet	Eastside Set Gillnet	Set GillNet	Total
1993	930	6,806	148	7,884
1994	11,732	14,673	477	26,882
1995	6,956	13,152	582	20,690
1996	2,671	11,856	29	14,556
1997	1,236	2,093	36	3,365
1998	1,974	8,096	175	10,245
1999	818	2,905	171	3,894
2000	531	2,351	83	2,965
2001	282	349	1,303	1,934
Average	3,014	6,920	334	10,268
2002 [a]	1,370	4,688	57	6,115

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

[a] See text for qualifications on these estimates.

the first week of August in the Central District eastside set gillnet fishery (Carlon 2000; Carlon and Hasbrouck 1996-1998, Massengill and Carlon 2004a, b). The additional restrictions imposed by the management plan during the 2002 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 tenth year in a row and since the restrictions were imposed in 2000, the proportion has been lower than average (Carlon and Hasbrouck 1996; 1997; Massengill and Carlon 2004a, b; Figure 10). The inconsequential harvest of the Kenai River population (57 coho salmon) in Northern District fisheries was typical of prior years (Carlon 2000, 2003; Carlon and Hasbrouck 1996; 1997; Massengill and Carlon 2004a, b) and indicates the relatively high contribution to this fishery in 2001 (1,303) was likely an anomaly and not a developing trend.

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.

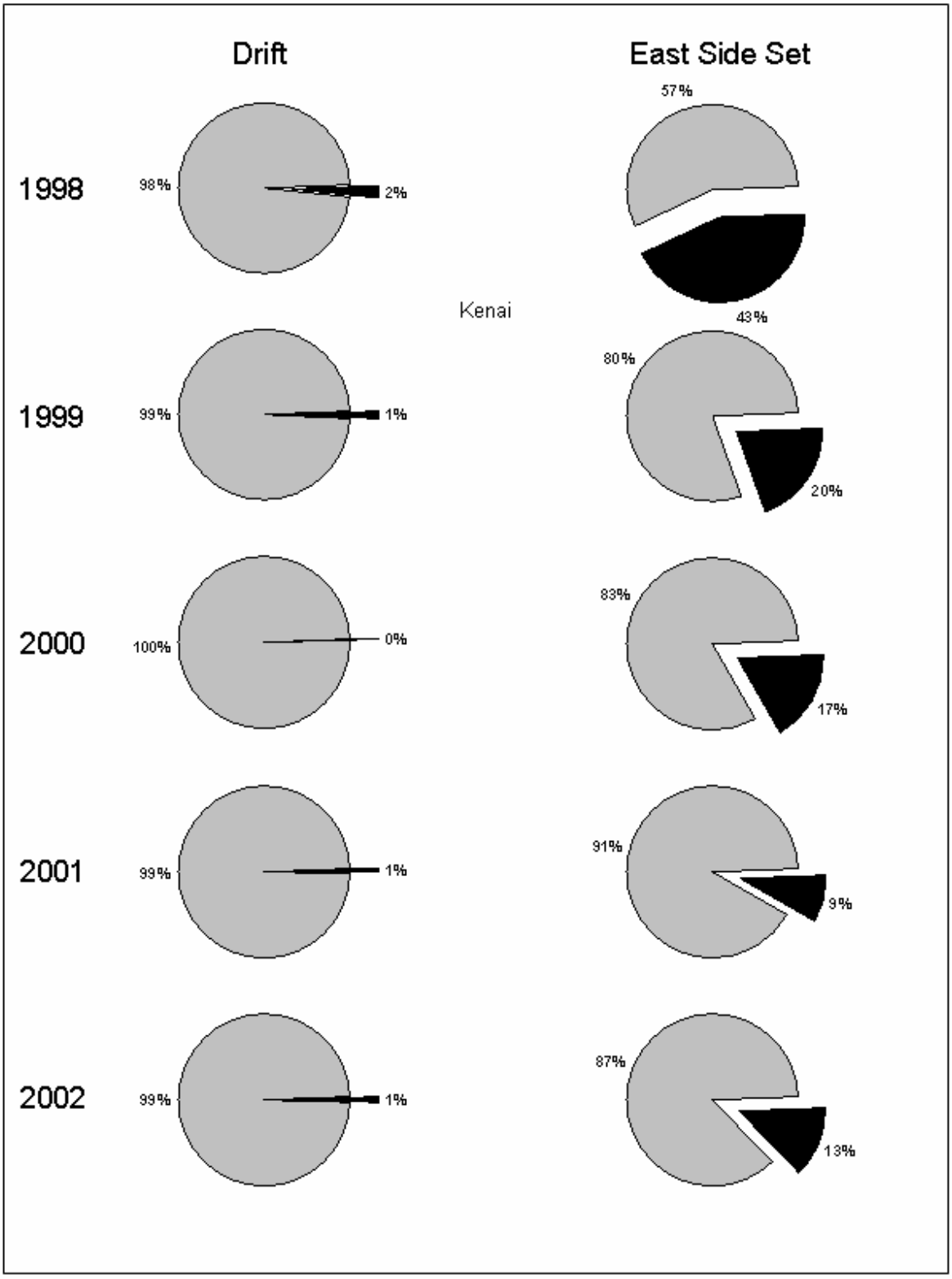

Figure 10.-Contribution of coho salmon from the Kenai River to the drift and eastside set gillnet commercial fisheries of Upper Cook Inlet during the last 5 years (1998-2002).

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. Scrutinizing a record of harvest and resulting smolt abundance was acknowledged as a long-term endeavor, but was favored because of the lack of success in estimating adult abundance and the potential 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 first available smolt production from the first known escapement (1999) will become available in 2003 when the 2002 smolt production will be estimated. Until a series of 'smolt-per-spawner' (or 'return-per-spawner') estimates becomes available, the long-term approach of relating smolt production to parent year harvest will be monitored.

Relationship Between Total Harvest and Smolt Abundance

The newly available estimate of 2001 smolt abundance represents the tenth such annual estimate since 1992 (Figure 11). From 1993 through 2001, nine annual estimates of total adult harvest have also been made (Table 7 and Figure 12). The pairing of these two records produces six pairs of harvest and smolt abundance estimates (Figure 13). The newly available 2001 smolt abundance estimate, when paired with the 1998 total harvest estimate, represents the sixth such pair available to date. While the relationship does not clearly identify a threshold harvest beyond which smolt abundance is significantly, negatively, and consistently impacted, it suggests that the record adult harvest in 1994 may have been excessive. At the very least, it is associated with the 1997 smolt production (Carlon 2003) which remains the lowest on record. This also suggests that precautionary measures adopted under the Kenai River Coho Salmon Conservation Management Plan should be retained until additional information demonstrates that surplus yield is available. Monitoring the harvest-smolt relationship as additional pairs of estimates accrue annually is necessary to determine whether it will be practical for identifying a harvest guideline management objective.

ANCILLARY INFORMATION FROM THE RUSSIAN RIVER

The first coho salmon arrived at the Russian River weir on July 23. A total of 3,260 coho salmon were passed through the weir, with 3,189 examined for adipose fin status, of which 252 (7.9%) 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 provides a representative sample of the entire drainage.

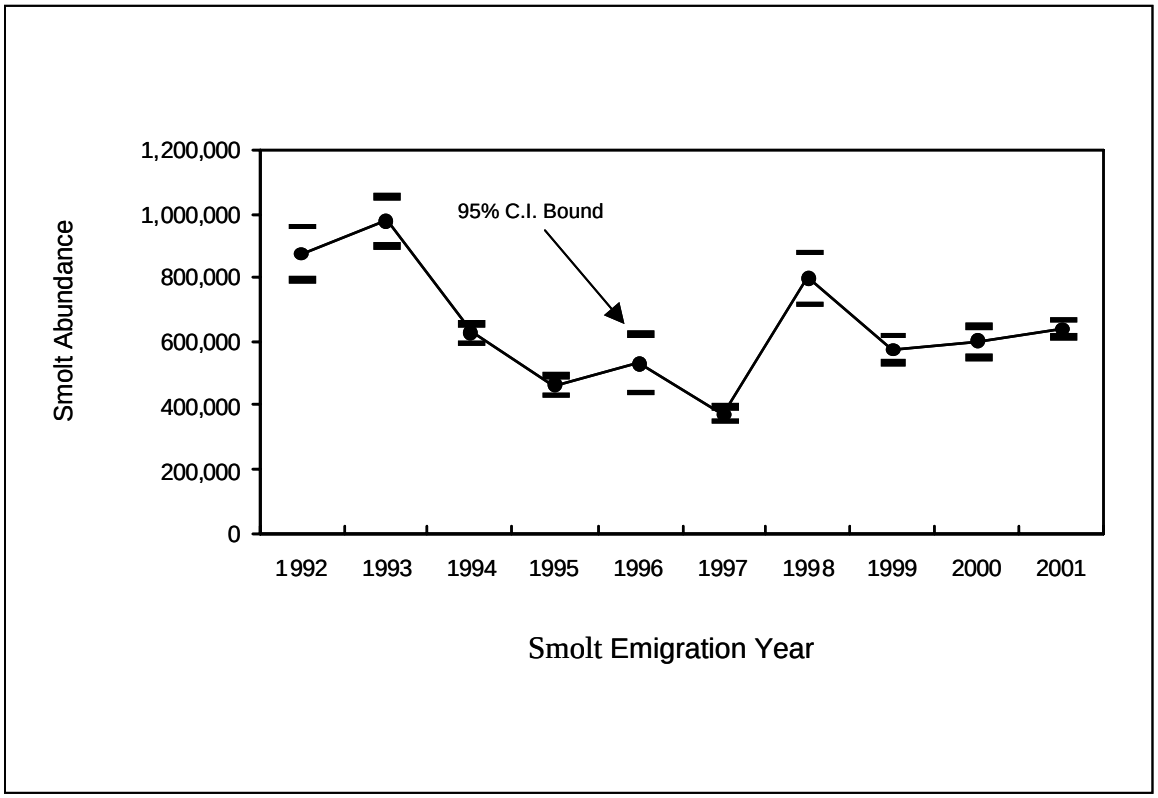

Figure 11.-Estimates of coho salmon smolt abundance in the Kenai River, 1992-2001.

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 six 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.-Estimated total harvest of coho salmon of Kenai River origin in UCI inriver and marine commercial fisheries, 1993-2002.

	Inriver							UCI Marine Commercial[b]				
	Sport[a]					Personal						
	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	26,822	23,743	50,565	2,290	52,855	1,597 [c]	54,452	6,806	930	148	7,884	62,336
1994	45,668	41,170	86,838	4,607	91,445	2,535 [d]	93,980	14,673	11,732	477	26,882	120,862
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	29,464	13,728	43,192	4,599	47,791	1,932 [f]	49,723	11,856	2,671	29	14,556	64,279
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	23,557	8,087	31,637	3,910	35,547	1,009 [g]	36,556	2,905	818	171	3,894	40,450
2000	39,202	9,349	48,551	3,938	52,489	1,449 [g]	53,938	2,351	531	83	2,965	56,903
2001	36,264	13,563	49,827	5,222	55,049	1,555 [g]	56,604	349	282	1,303	1,934	58,538
Average	28,717	15,727	44,443	4,205	48,648	1,434	50,082	6,920	3,014	334	10,268	60,351
2002 [h]	45,567	14,444	60,011	6,093	66,104	1,721 [f,g]	67,825	4,688	1,370	57	6,115	73,940

[a] 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.

[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.

[h] See text for qualifications on commercial harvest estimates.

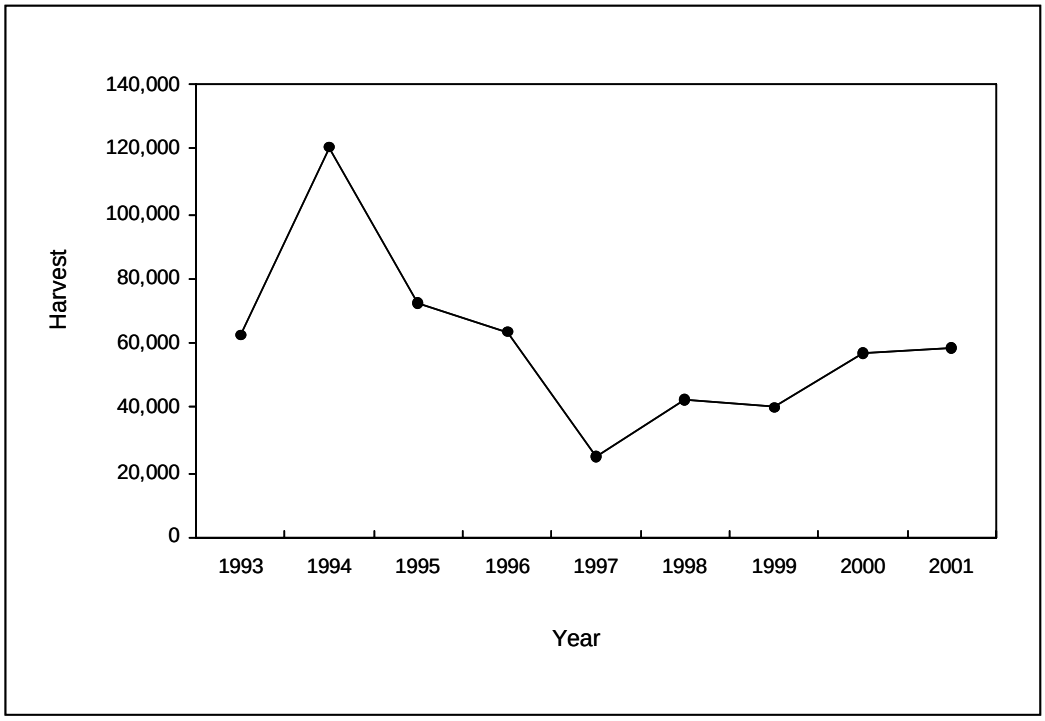

Figure 12.-Estimates of total harvest of coho salmon of Kenai River origin by combining estimates of commercial marine harvest with inriver estimates of personal use, mainstem sport, and Russian River sport harvest, 1993-2001.

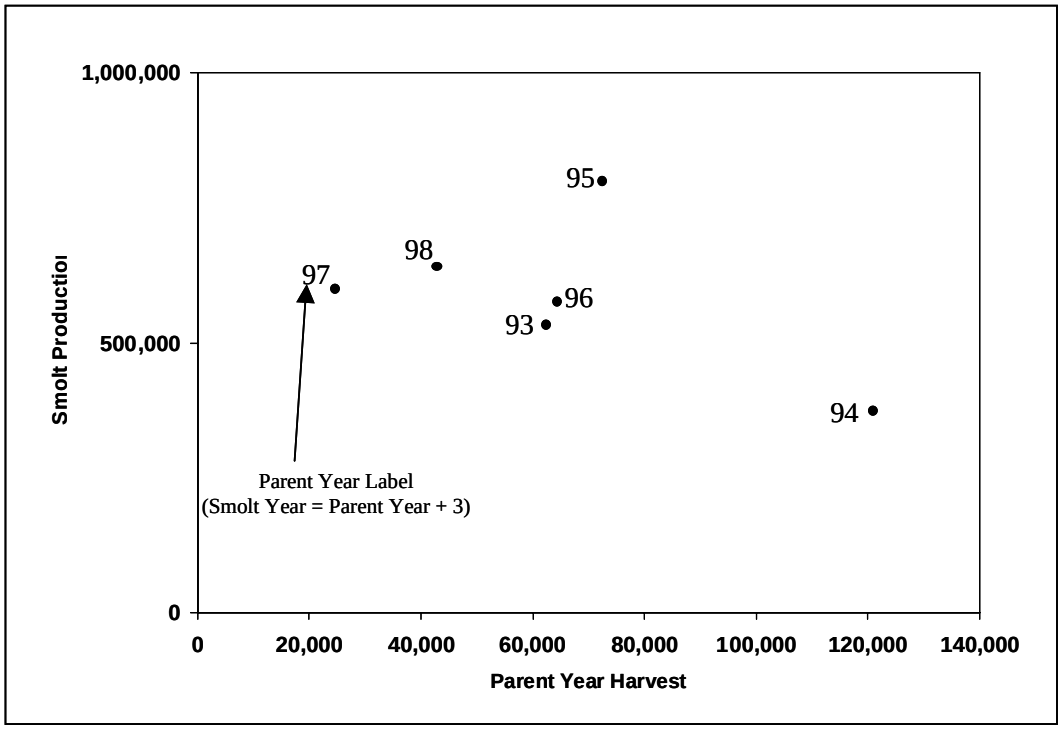

Figure 13.-Available points in the long-term assessment approach of relating smolt production to parent year harvest for coho salmon from the Kenai River, Alaska.

Tag smolt emigration in proportion to abundance.

Significant inriver variations in the adult marked proportion have been detected since 1998 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 2001. Kurt Strausbaugh was the field project leader and participated in all phases of field investigation. Sandee Simons, Jake Glotfelty, James Cannava, Myke Bon, and Stan Walker assisted with all phases of the field investigation, including logistical support, weir operation and maintenance, and smolt tagging and enumeration. "Cotton" and Lorraine Moore granted convenient access to the Moose River as did Jim and Jane Fellman.

The commercial harvest was examined in 2002 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 2001 and 2002. All CF personnel contributed to the successful achievement of study objectives.

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

REFERENCES CITED

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

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

Bosch, D., and D. Evans. 2006. Estimates of commercial and sport harvest and escapement in 1999-2001 of coho salmon stocked into Northern Cook Inlet streams in 1998-2000. Alaska Department of Fish and Game, Fishery Data Series No. 06-25, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds06-25.pdf

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

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

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

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

REFERENCES CITED (Continued)

Carlon, J. A. *Unpublished*. Recovery and application of coded wire tags to coho salmon in the Kenai River drainage, 1995-1996. Operational Plan. Alaska Department of Fish and Game, Division of Sport Fish, Region II, Anchorage.

Carlon, J. A., and R. Clark. *Unpublished*. Stock status of Kenai River coho salmon: A report to the Alaska Board of Fisheries. Wasilla Alaska October Work Session, 1996. Available at Alaska Department of Fish and Game, Division of Sport Fish, Anchorage.

Carlon, J. A. and D. Evans. *In prep*. Abundance of adult coho salmon of Kenai River origin, Alaska, 1999-2003. Alaska Department of Fish and Game, Fishery Data Series report, Anchorage.

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

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

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

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

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

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

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

Fox, J. R., and P. A. Shields. 2003. Upper Cook Inlet commercial fisheries annual management report, 2002. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 2A03-14, Anchorage.

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

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

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

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

REFERENCES CITED (Continued)

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

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

Hammarstrom, S. L. 1992. Angler effort and harvest of coho salmon during the recreational fisheries in the lower Kenai River, 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-36, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds92-36.pdf

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

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

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

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

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

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

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

Jennings, G. B., K. Sundet, A. E. Bingham, and D. Sigurdsson. 2006. Participation, catch, and harvest in Alaska sport fisheries during 2002. Alaska Department of Fish and Game, Fishery Data Series No. 06-34, Anchorage. http://www.sf.adfg.state.ak.us/FedAidpdfs/fds06-34.pdf

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

Massengill, R. *In prep*. Stock assessment of coho salmon from the Kenai River, Alaska, 1999. Alaska Department of Fish and Game, Fishery Data Series report, Anchorage.

Massengill, R., and J. A. Carlon. 2004a. Assessment of coho salmon from the Kenai River, Alaska, 2000. Alaska Department of Fish and Game, Fishery Data Series No. 04-23, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds04-23.pdf

Massengill, R., and J. A. Carlon. 2004b. Assessment of coho salmon from the Kenai River, Alaska, 2001. Alaska Department of Fish and Game, Fishery Data Series No. 04-24, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds04-24.pdf

REFERENCES CITED (Continued)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

REFERENCES CITED (Continued)

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

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

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

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

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

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

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

Ruesch, P. H., and J. Fox. 1996. Upper Cook Inlet commercial fisheries annual management report, 1995. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 2A96-27, Anchorage.

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

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

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

Vincent-Lang, D., and D. McBride. 1989. Stock origins of coho salmon in the commercial harvests from Upper Cook Inlet, Alaska. Alaska Department of Fish and Game, Fishery Data Series No. 93, Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds-093.pdf

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

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

APPENDIX A

Appendix A1.-Number of wild coho salmon smolt captured from the Moose River, marked with an adipose finclip and coded wire tags, and released in 2001, and number identified in the sample of 255 Moose River tagged fish recovered from known UCI commercial fishery strata in 2002.

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 2002 [d]
310182	5/21	5/25	12,296	100.0%	12,296	99.5%	12,235	20
310183	5/25	5/27	11,757	99.9%	11,741	98.3%	11,541	16
310184	5/27	5/28	12,174	100.0%	12,174	99.8%	12,150	16
310185	5/28	5/29	12,029	100.0%	12,029	99.7%	11,993	20
310186	5/29	5/30	12,235	99.9%	12,221	98.8%	12,074	31
310187	5/30	5/31	12,185	99.9%	12,170	99.7%	12,133	18
310188	5/31	6/01	12,013	99.6%	11,960	99.8%	11,936	23
310189	6/01	6/02	12,028	99.8%	12,003	98.9%	11,871	27
310190	6/02	6/04	12,298	100.0%	12,298	99.8%	12,273	27
310229	6/05	6/06	11,266	100.0%	11,266	98.3%	11,074	11
1301030902	6/07	6/08	13,782	100.0%	13,782	98.6%	13,589	22
1301030814	6/08	6/10	13,991	100.0%	13,991	99.4%	13,907	24
Total			148,054	99.9%	147,931	99.2%	146,776	255

[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 and positively decoded.

Appendix A2.-Daily summary of coho salmon adults captured by two fish wheels located along the north and south banks of the Kenai River near river kilometer 44.5 between August 1 and September 30, 2002.

	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	0				09/01	91	25	0	
08/02	0				09/02	92	23	0	
08/03	0				09/03	58	12	0	
08/04	1		0		09/04	56	7	0	
08/05	2		0		09/05	48	14	10	10
08/06	7		0		09/06	148	36	7	7
08/07	2		0		09/07	121	34	0	
08/08	5	1	1	1	09/08	45	16	0	
08/09	11	1	1	1	09/09	69	18	8	8
08/10	4	1	1	1	09/10	96	37	37	36
08/11	1		0		09/11	125	41	40	40
08/12	2		0		09/12	110	43	43	43
08/13	4	1	1	1	09/13	168	62	61	61
08/14	2		0		09/14	180	82	82	82
08/15	1		0		09/15	282	125	125	125
08/16	2		0		09/16	108	36	36	36
08/17	3		0		09/17	66	26	26	26
08/18	7	1	1	1	09/18	52	17	17	17
08/19	70	11	11	11	09/19	84	23	23	23
08/20	72	10	10	9	09/20	103	45	45	45
08/21	80	10	10	10	09/21	95	31	31	31
08/22	86	7	7	4	09/22	123	39	39	39
08/23	75	7	7	6	09/23	69	15	15	15
08/24	89	12	12	12	09/24	95	23	23	23
08/25	90	11	7	6	09/25	123	31	30	30
08/26	76	15	15	15	09/26	80	34	34	34
08/27	81	13	13	13	09/27	27	5	5	5
08/28	74	14	8	8	09/28	21	3	3	3
08/29	101	18	0		09/29	20	4	4	4
08/30	56	3	0		09/30	31	8	8	8
08/31	116	30	0						
Subtotal	1,120	166	105	99		2,786	915	752	751
North Bank Subtotal						3,906	1,081	857	850

-continued-

Appendix A2.-Page 2 of 2.

	August					September			
Date	Number Captured and Examined	Marked Fish Observed[a]	Marked Fish Checked with Tag Detector[b]	Coded Wire Tag Detected	Date	Number Captured and Examined	Marked Fish Observed[a]	Marked Fish Checked with Tag Detector[b]	Coded Wire Tag Detected
				South Bank					
08/01					09/01	74	11	0	
08/02	2				09/02	100	21	0	
08/03	0				09/03	72	12	0	
08/04	25	2	0		09/04	15	1	0	
08/05	33	2	2	2	09/05	6		0	
08/06	17		0		09/06	25	5	0	
08/07	20	3	3	2	09/07	36	3	0	
08/08	31	2	2	2	09/08	33	9	0	
08/09	33		0		09/09	45	13	7	7
08/10	23	3	3	3	09/10	22	7	7	7
08/11	31	6	6	6	09/11	37	9	9	9
08/12	9		0		09/12	57	17	17	17
08/13	24	5	5	5	09/13	68	16	16	16
08/14	31	1	1	1	09/14	33	9	9	9
08/15	22	2	2	2	09/15	74	26	26	26
08/16	22	2	2	2	09/16	14	5	4	4
08/17	36	1	1	1	09/17	7	2	2	2
08/18	55	3	3	1	09/18	37	12	12	12
08/19	71	6	6	5	09/19	11	2	2	2
08/20	67	10	10	8	09/20	33	12	12	12
08/21	69	7	7	6	09/21	22	7	7	7
08/22	114	9	9	7	09/22	22	6	6	6
08/23	86	11	11	9	09/23	44	10	10	10
08/24	77	4	4	3	09/24	57	13	13	13
08/25	112	12	10	10	09/25	44	9	9	9
08/26	95	7	7	7	09/26	39	10	10	10
08/27	75	9	9	9	09/27	33	10	10	10
08/28	88	20	6	6	09/28	12	3	3	3
08/29	100	12	0		09/29	15	3	3	3
08/30	74	7	0		09/30	11	2	2	2
08/31	77	11	0						
Subtotal	1,519	157	109	97		1,098	265	196	196
South Bank Subtotal						2,617	422	305	293
Grand Total (both banks)						6,523	1,503	1,162	1,143

[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) operated on the Kenai River between river kilometer 48.9 and 58.4 from August 1 through October 4, 2002.

	August					September-October				
Date[a]	Number Captured and Examined[b]	Marked Fish Observed[c]	Number Captured and Examined[b]	Marked Fish Observed[c]		Date[a]	Number Captured and Examined[b]	Marked Fish Observed[c]	Number Captured and Examined[b]	Marked Fish Observed[c]
	North Bank		**South Bank**				**North Bank**		**South Bank**	
08/01						09/01	5	2	21	4
08/02	1	1	1			09/02	6	2	23	2
08/03						09/03	7	2	36	8
08/04						09/04	13	2	67	17
08/05	2		5	1		09/05	29	10	93	17
08/06	4	1	11	1		09/06	26	9	27	8
08/07	14	2	11	1		09/07	24	2	28	7
08/08	21	3	27	1		09/08	12	2	39	10
08/09	20	3	15	2		09/09	13	3	47	10
08/10	27	6	18	2		09/10	15	3	54	17
08/11	29	5	28	3		09/11	26	9	92	27
08/12	25	10	22	3		09/12	59	22	96	34
08/13	18	4	49	4		09/13	49	16	56	20
08/14	32	6	44	6		09/14	22	4	63	22
08/15	31	5	59	9		09/15	17	8	80	25
08/16	20	3	67	10		09/16	42	18	52	27
08/17	44	5	87	13		09/17	55	21	88	21
08/18	35	6	50	8		09/18	41	15	93	26
08/19	30	6	59	9		09/19	36	11	187	60
08/20	45	12	69	8		09/20	21	8	99	43
08/21	18	2	47	6		09/21	48	16	84	22
08/22	23	5	57	7		09/22	22	11	144	59
08/23	40	7	43	4		09/23	30	12	193	57
08/24	32	9	37	8		09/24	47	15	108	35
08/25	24	6	39	4		09/25	26	4	64	14
08/26	34	8	32	4		09/26	45	10	149	41
08/27	19	4	49	8		09/27	31	14	68	22
08/28	19	7	46	6		09/28	29	12	62	11
08/29	25	8	33	7		09/29	29	11	51	9
08/30	16	3	25	7		09/30	32	9	52	9
08/31	15	3	25	5		10/01	33	10	36	15
						10/02	3	3	12	5
						10/03	8	2	36	5
						10/04	3	1	43	6
Subtotal	663	140	1,055	147			904	299	2,443	715
					Grand Total		1,567	439	3,498	862

[a] Recapture event operational from August 1 through October 4, 2002.

[b] Includes only coho salmon that were assigned a bank location. An additional 79 coho salmon were captured using a seine net on September 18th but were not included in this summary because the effort was strictly experimental and was conducted only to determining the feasibility of seining.

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

Appendix A4.-Daily summary of coho salmon adults examined at the Russian River weir, July 23 through September 10, 2002.

Date	Weir Count	Examined	Marked Fish Observed [a]	Date	Weir Count	Examined	Marked Fish Observed [a]
7/23	1	1	0	8/16	161	149	23
7/24	0	0	0	8/17	34	34	4
7/25	0	0	0	8/18	85	79	7
7/26	0	0	0	8/19	17	16	3
7/27	0	0	0	8/20	93	92	4
7/28	0	0	0	8/21	87	87	11
7/29	1	1	0	8/22	29	28	5
7/30	0	0	0	8/23	0	0	0
7/31	0	0	0	8/24	74	72	15
8/1	0	0	0	8/25	97	94	15
8/2	0	0	0	8/26	0	0	0
8/3	0	0	0	8/27	30	30	2
8/4	0	0	0	8/28	9	9	2
8/5	1	1	0	8/29	8	7	0
8/6	7	7	0	8/30	255	251	12
8/7	4	4	0	8/31	185	181	11
8/8	5	5	0	9/1	388	382	28
8/9	13	13	0	9/2	177	174	13
8/10	15	13	1	9/3	0	0	0
8/11	11	10	1	9/4	28	28	2
8/12	24	24	1	9/5	12	12	0
8/13	9	9	1	9/6	77	76	6
8/14	37	36	1	9/7	502	491	30
8/15	88	87	5	9/8	591	581	39
				9/9	53	53	5
				9/10	52	52	5
Subtotal	216	211	10	Subtotal	3,044	2,978	242
				Grand Total	3,260	3,189	252

[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 2002.

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							
7/15	24421/22	10	0	0	0	0	0
7/17	24421/22	7	0	0	0	0	0
7/18	24421/22	21	0	0	0	0	0
7/22	24421/22	46	1	1	1	1	1
7/25	24421/22	69	3	3	3	3	2
7/28	24421/22	23	0	0	0	0	0
7/29	24421/22	34	4	4	4	4	4
7/15	24421/31	4	0	0	0	0	0
7/26	24421/31	24	0	0	0	0	0
7/22	24431/32/41	60	1	1	1	1	1
Total		298	9	9	9	9	8
West Side and Kalgin Island Set							
08/29/02	24530,24610	366	0	0	0	0	0
07/22/02	24530,24610/20	2,922	8	8	6	6	0
07/25/02	24530,24610/20	1,931	12	11	9	9	0
07/29/02	24530,24610/20	1,889	18	18	15	15	2
08/05/02	24530,24610/20	2,208	13	13	12	12	0
08/08/02	24530,24610/20	1,033	7	7	7	7	0
08/15/02	24530/50,24610	734	2	2	1	1	0
08/19/02	24530/50,24610	471	0	0	0	0	0
Total		11,554	60	59	50	50	2
West Side Set, Kalgin Island Set, and East Side Set							
08/01/02	24530,24610/20,24422/32/41	5,295	58	57	48	48	8
Mixed Central District Total		17,147	127	125	107	107	18

-continued-

Appendix A5.-Page 2 of 2.

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 and Northern District Statistical Areas						
Central District East Side Set, and Northern District Eest Side Set							
08/01/02	24442,24770/80/90	226	6	6	5	5	0
07/18/02	24442,24780/90	103	2	2	2	2	0
Total		329	8	8	7	7	0
Central Distrcit West Side Set, Kalgin Island Set, and Northern District East Side Set							
08/26/02	24530,24610,24770/80/90	792	3	3	1	1	1
Mixed Districts Total		1,121	11	11	8	8	1
Grand Total		18,268	138	136	115	115	19

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 2002, coded wire tag sampling information, and population-specific qualified harvest estimates of coho salmon of Kenai River origin based on recoveries of fish marked at the Moose River in 2001.

Date (2002)[b]	(H) Total Harvest	(n_i) Number Examined [c]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[d]	(t'_i) Decodable Tags[e]	(m_i) Source= Moose R 2001	(r_i) Qualified Harvest Estimate[f]	$V(r_i)$ Variance
Commercial Harvest									
Central District									
Drift Gillnet									
Central									
6/27,7/1	54	2	0	0	0	0	0	0	0
7/4,7/5	392	106	1	1	1	1	0	0	0
7/6,7/8	1,913	525	5	5	5	5	0	0	0
7/11	215	25	0	0	0	0	0	0	0
7/13,7/15	13,494	3,343	56	54	42	42	0	0	0
7/18,7/20	24,849	6,002	72	72	65	65	1	18	306
7/22	28,906	9,867	152	152	136	136	6	77	914
7/25,7/26	11,596	2,104	66	66	62	62	13	312	7,240
7/27,7/28	1,051	238	11	10	9	9	2	42	841
7/29,7/30	20,903	4,194	107	103	98	98	16	361	7,871
7/31,8/1	16,187	3,585	124	124	117	116	24	476	9,119
8/4,8/5	4,035	1,044	16	16	15	15	5	84	1,331
8/8	2,226	976	3	3	2	2	0	0	0
8/12	10	8	0	0	0	0	0	0	0
Total	125,831	32,019	613	606	552	551	67	1,370	27,623
East Side Set									
Statistical Area 24421									
7/1,7/4,7/5,7/6,7/8,7/10,7/11,7/13,7/15	141	22	0	0	0	0	0	0	0
7/17	26	4	0	0	0	0	0	0	0
7/18,7/20	239	19	0	0	0	0	0	0	0
7/22	238	103	1	1	1	1	1	10	90
7/25	347	120	5	5	5	5	5	63	733
7/26	240	91	4	4	4	4	4	46	484
7/27,7/28	525	107	8	8	8	8	7	150	3,078
7/29,7/30	466	158	11	11	10	10	9	116	1,387
7/31,8/1	542	245	34	34	33	31	31	318	3,014
8/4,8/5	1,553	91	6	6	6	6	5	372	27,383
Total	4,317	960	69	69	67	65	62	1,075	36,169

-continued-

Date (2002)[b]	(H) Total Harvest	(n_i) Number Examined [c]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[d]	(t'_i) Decodable Tags[e]	(m_i) Source= Moose R 2001	(r_i) Qualified Harvest Estimate[f]	$V(r_i)$ Variance
				Commercial Harvest					
Statistical Area 24422				**Central District**					
7/4,7/5,7/6,7/8	14	1	0	0	0	0	0	0	0
7/10	2	1	0	0	0	0	0	0	0
7/11	6	1	0	0	0	0	0	0	0
7/13,7/15	144	16	0	0	0	0	0	0	0
7/17	61	9	0	0	0	0	0	0	0
7/18	91	6	0	0	0	0	0	0	0
7/20,7/22	300	78	2	2	2	2	0	0	0
7/25	664	303	18	18	18	18	10	96	831
7/26	479	83	3	3	3	3	3	75	1,803
7/27,7/28	667	168	10	10	10	9	4	77	1,408
7/29,7/30	502	82	3	3	3	3	2	53	1,353
7/31,8/1	443	156	18	18	17	17	16	198	2,278
8/4,8/5	1,473	95	5	5	5	5	5	338	22,576
Total	4,846	999	59	59	58	57	40	837	30,250
Statistical Area 24431/32									
7/6,7/8,7/10,7/11	20	6	0	0	0	0	0	0	0
7/13,7/15	187	26	0	0	0	0	0	0	0
7/17	22	3	0	0	0	0	0	0	0
7/18,7/20	188	50	1	1	1	1	0	0	0
7/22	235	39	1	1	1	1	1	26	650
7/25	1,331	403	6	6	5	5	0	0	0
7/26,7/27	1,368	101	8	8	7	7	0	0	0
7/28,7/29,7/30	1,066	94	7	7	7	7	4	198	9,624
7/31,8/1	791	225	23	23	20	20	19	291	4,223
8/4,8/5	1,502	5	0	0	0	0	0	0	0
Total	6,710	952	46	46	41	41	24	515	14,497

-continued-

Appendix A6.-Page 3 of 9.

Date (2002)[b]	(H) Total Harvest	(n_i) Number Examined [c]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[d]	(t'_i) Decodable Tags[e]	(m_i) Source= Moose R 2001	(r_i) Qualified Harvest Estimate[f]	$V(r_i)$ Variance
				Commercial Harvest					
Statistical Area 24441/42				**Central District**					
7/8	7	1	0	0	0	0	0	0	0
7/11	15	4	0	0	0	0	0	0	0
7/13,7/15	813	140	2	2	2	2	0	0	0
7/18	615	250	3	3	3	3	0	0	0
7/20,7/22	2,866	877	5	5	4	4	0	0	0
7/25,7/26,7/27	5,593	610	15	15	15	15	9	360	14,121
7/28,7/29,7/30	3,481	142	8	8	8	8	8	855	90,976
7/31,8/1	1,900	482	28	28	26	26	17	292	4,781
8/4,8/5	3,990	438	20	20	20	20	19	754	29,550
Total	19,280	2,944	81	81	78	78	53	2,261	139,427
Eastside Set Gillnet Total	35,153	5,855	255	255	244	241	179	4,688	220,343
Kalgin Island Set Area 24610/20									
7/4	42								
7/8	57								
7/11	180								
7/15	1,248								
7/18	3,148								
7/22	2,556								
7/25	2,072								
7/29	3,302								
8/1	4,492								
8/5	2,015								
8/8	792								
8/12	1,107								
8/15	511								
8/19	14								
8/22	160								
8/26	110								
8/29	163								
Total	21,969								

-continued-

Date (2002)[b]	(H) Total Harvest	(n_i) Number Examined [c]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[d]	(t'_i) Decodable Tags[e]	(m_i) Source= Moose R 2001	(r_i) Qualified Harvest Estimate[f]	$V(r_i)$ Variance
				Commercial Harvest					
West Side Set Areas 24520/30/40/50/55/60				**Central District**					
6/28,7/1 through 7/23	4,205	239	0	0	0	0	0	0	0
7/24,7/25,7/26	542	148	0	0	0	0	0	0	0
7/27,7/29,8/1	2,848	824	2	2	2	2	1	15	210
8/5	1,650	1,340	2	2	1	1	1	5	20
8/8	1,160	788	0	0	0	0	0	0	0
8/12	927	786	2	2	1	1	0	0	0
8/15,8/19,8/22,8/26,8/29,9/2	1,704								
Total	13,036	4,125	6	6	4	4	2	20	230
Drift Gillnet and East Side Set Total	160,984	37,874	868	861	796	792	246	6,058	247,966
Central District Total	195,989	41,999	874	867	800	796	248	6,078	248,196
				Commercial Harvest					
				Northern District					
East Side Set Areas 24770/80/90									
7/4,7/8,7/11	98	4	0	0	0	0	0	0	0
7/15	336	137	2	2	2	2	0	0	0
7/18	528	481	5	5	5	5	0	0	0
7/22	713	657	10	10	9	9	1	5	20
8/1	366	165	3	3	3	3	2	19	162
8/5	995	204	4	4	3	3	1	21	420
8/8	911	470	1	1	0	0	0	0	0
8/12	979	593	1	1	1	1	0	0	0
8/15	2,365	929	3	3	3	3	0	0	0
8/19	2,125	791	1	1	0	0	0	0	0
8/22	1,333	168	0	0	0	0	0	0	0
8/26	1,308	148	0	0	0	0	0	0	0
8/29,9/2,9/5,9/9,9/12	1,741	735	1	1	0	0	0	0	0
Total	13,798	5,482	31	31	26	26	4	45	602

-continued-

Date (2002)[b]	(H) Total Harvest	(n_i) Number Examined[c]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[d]	(t'_i) Decodable Tags[e]	(m_i) Source= Moose R 2001	(r_i) Qualified Harvest Estimate[f]	$V(r_i)$ Variance
				Commercial Harvest					
				Northern District					
Fire Island Set Area 24743									
7/8	35	36	2	2	2	2	0	0	0
7/11	25	25	0	0	0	0	0	0	0
7/15	117	117	1	1	1	1	0	0	0
7/18	353	302	21	21	20	20	0	0	0
7/22	287	264	14	14	11	11	0	0	0
8/1	1,082	793	53	53	52	52	0	0	0
8/5	1,224	1,204	109	109	100	100	1	4	12
8/8	1,019	1,000	116	116	106	106	0	0	0
8/12	1,086	1,059	139	139	130	130	1	4	12
8/15	701	640	68	68	65	65	0	0	0
8/19	597	597	30	30	29	29	0	0	0
8/22	370	365	6	6	5	5	1	4	12
8/26,9/9	90	85	4	4	3	3	0	0	0
Total	6,986	6,487	563	563	524	524	3	12	37
Pt. MacKenzie/Su Flats Set Area 24741/42									
7/4,7/8	38	38	2	2	2	2	0	0	0
7/11	50	40	1	1	1	1	0	0	0
7/15	337	265	9	9	6	6	0	0	0
7/18	961	799	37	37	33	33	0	0	0
7/22	2,062	1,602	71	71	61	61	0	0	0
8/1	3,145	2,100	100	99	89	89	0	0	0
8/5	4,761	3,559	204	204	189	189	0	0	0
8/8	1,508	1,100	68	68	61	61	0	0	0
8/12	895	561	55	55	52	52	0	0	0
8/15	679	584	30	30	26	26	0	0	0
8/19	282	52	1	1	0	0	0	0	0
8/22	265	210	12	11	9	9	0	0	0
8/26	74	27	0	0	0	0	0	0	0
8/29,9/2,9/5,9/9,9/16	222	75	0	0	0	0	0	0	0
Total	15,279	11,012	590	588	529	529	0	0	0

-continued-

Appendix A6.-Page 6 of 9.

Date (2002)[b]	(H) Total Harvest	(n_i) Number Examined [c]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[d]	(t'_i) Decodable Tags[e]	(m_i) Source= Moose R 2001	(r_i) Qualified Harvest Estimate[f]	$V(r_i)$ Variance
				Commercial Harvest					
West Side Set Area 24710/20/30				**Northern District**					
7/4,7/8	175	92	1	1	0	0	0	0	0
7/11	24	19	0	0	0	0	0	0	0
7/15	2,543	2,168	2	2	1	1	0	0	0
7/18	6,398	5,571	12	10	6	6	0	0	0
7/22	3,242	3,178	7	7	1	1	0	0	0
8/1,8/5,8/8	1,278	251	0	0	0	0	0	0	0
8/12,8/15	527	163	0	0	0	0	0	0	0
8/29	42	40	0	0	0	0	0	0	0
Total	14,229	11,482	22	20	8	8	0	0	0
Northern District Total	50,292	34,463	1,206	1,202	1,087	1,087	7	57	639
Northern District Total and Central District Drift/East Side Set Total	211,276	72,337	2,074	2,063	1,883	1,879	253	6,115	248,605
Commercial Harvest Grand Total	246,281	76,462	2,080	2,069	1,887	1,883	255	6,135	248,836

-continued-

Appendix A6.-Page 7 of 9.

Date (2002)[b]	(H) Total Harvest	(n_i) Number Examined [c]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[d]	(t'_i) Decodable Tags[e]	(m_i) Source= Moose R 2001	(r_i) Qualified Harvest Estimate[f]	$V(r_i)$ Variance
				Test Fishery					
				Central District					
Set Gill Net Test Fishery[t]									
7/29	25								
Drift Gill Net Test Fishery[g]									
7/1	1	1	0	0	0	0	0	0	0
7/5	5	5	0	0	0	0	0	0	0
7/6	2	1	0	0	0	0	0	0	0
7/7	6	6	0	0	0	0	0	0	0
7/8	1	1	0	0	0	0	0	0	0
7/9	18	18	0	0	0	0	0	0	0
7/10	16	16	0	0	0	0	0	0	0
7/11	64	39	0	0	0	0	0	0	0
7/12	148	101	0	0	0	0	0	0	0
7/13	51	38	0	0	0	0	0	0	0
7/14	22	22	1	1	1	1	0	0	0
7/15	1,236	30	0	0	0	0	0	0	0

-continued-

Appendix A6.-Page 8 of 9.

Date (2002)[b]	(H) Total Harvest	(n_i) Number Examined[c]	(a_i) Adclips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags[d]	(t'_i) Decodable Tags[e]	(m_i) Source= Moose R 2001	(r_i) Qualified Harvest Estimate[f]	$V(r_i)$ Variance
Drift Gill Net Test Fishery[g] (Continued)			**Test Fishery Central District**						
7/16	66	66	0	0	0	0	0	0	0
7/17	85	85	2	2	2	2	0	0	0
7/18	1,260	62	1	1	1	1	0	0	0
7/19	62	55	2	2	2	2	0	0	0
7/20	53	53	1	1	1	1	0	0	0
7/21	61	26	0	0	0	0	0	0	0
7/22	15	15	0	0	0	0	0	0	12
7/23	69	64	0	0	0	0	0	0	0
7/24	41	41	0	0	0	0	0	0	0
7/25	78	78	1	1	1	1	0	0	0
7/26	79	79	3	3	2	2	0	0	0
7/27	230	230	2	2	2	2	1	4	0
7/28	25	12	1	1	1	1	0	0	0
7/29	45	16	0	0	0	0	0	0	0
7/30,8/3	30	24	0	0	0	0	0	0	0
Total	3,769	1,184	14	14	13	13	1	4	12
Test Fishery Total	3,794	1,184	14	14	13	13	1	4	12
Commercial and Test Fishery Total	250,075	77,646	2,094	2,083	1,900	1,896	256	6,139	248,848

[a] 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.

[b] 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.

-continued-

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

[d] Denotes heads with tags magnetically detected.

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

[f] See text for qualifications on harvest estimates.

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

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