Fishery Data Series No. 07–69

Assessment of Coho Salmon from the Kenai River, Alaska, 1999

by

Rob Massengill

November 2007

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Measures (fisheries)

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

Mathematics, statistics

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

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ABSTRACT

In spring 1998, 101,728 wild coho salmon *Oncorhynchus kisutch* smolt were captured in the Kenai River drainage, marked with an adipose finclip and injected with a coded wire tag (CWT), and released. Marked adults were recovered from selected commercial fisheries of Upper Cook Inlet (UCI), Alaska. In summer 1999, 125,343 coho salmon were harvested among all UCI commercial fisheries, 22,605 were examined from the Northern District fishery (72% of the harvest from this area), 33,158 were examined from Central District drift gillnet fishery (51% of the harvest in this area), and 4,149 were examined from the Central District eastside set gillnet fishery (36% of the harvest in this area). A total of 1,567 adipose–clipped fish were observed in the unmixed fishery samples, of which 1,539 were recovered, 1,433 bore a decodable CWT, and 185 were identified as being of Kenai River origin. In the Kenai River in fall 1999, using fish wheels and drift gillnets, a total of 2,476 coho salmon were captured and examined, 313 were missing the adipose fin, and 299 bore a Kenai River CWT. Significant 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 and accurate estimates of commercial harvest of Kenai River–bound coho salmon. However, a point estimate of the overall tagged proportion of the return ($\hat{\theta}$=0.121, SE = 0.007) was generated from a subset of inriver data, as were estimates of the potential minimum ($\hat{\theta}$=0.097, SE = 0.007) and maximum return ($\hat{\theta}$=0.179, SE = 0.014). Three resulting harvest estimates were compared to evaluate the impact of the temporal variation on commercial harvest estimates. The evaluation indicated that harvest estimates based on the overall tagged proportion are practical for assessment and planning purposes, but should be qualified. An estimated 2,928 (SE = 297) coho salmon of Kenai River origin were harvested by the Central District eastside set gillnet fishery, 820 (SE = 134) by the Central District drift gillnet fishery, and 171 (SE = 49) by all Northern District set gillnet fisheries for a total of 3,919 (SE = 330). Kenai River origin coho salmon represented 25% of the total eastside set gillnet harvest of coho salmon, 1.3% of the drift gillnet harvest, and 0.5% of the Northern District set gillnet harvest. Based on the number of live smolt released with an adipose clip at the Moose River in 1998 and the number of adult coho salmon examined for adipose fin status in the Kenai River fish wheel samples in 1999, an estimated 797,798 (SE = 41,940) smolt emigrated from the Kenai River in 1998.

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 annually, adults are harvested in mixed–stock commercial and sport marine fisheries. Sport and personal use harvests also occur in fresh water. Cook Inlet ranks first in the 1989–1998 average sport harvest of coho salmon among all regions of the state and fifth in commercial harvest (Figure 2).

In 1991, the Alaska Department of Fish and Game (ADF&G) initiated a program to assess the status of UCI coho salmon stocks (Meyer et al. *Unpublished*). 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; Mills 1979–1980, 1981a–b, 1982–1994) and account for an average of about 1 of every 5 coho salmon sport–harvested from Alaskan waters. The population also contributes to commercial marine fisheries that occur along migratory approach routes to the Kenai River in UCI and, to a lesser degree, marine sport and inriver personal use fisheries.

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

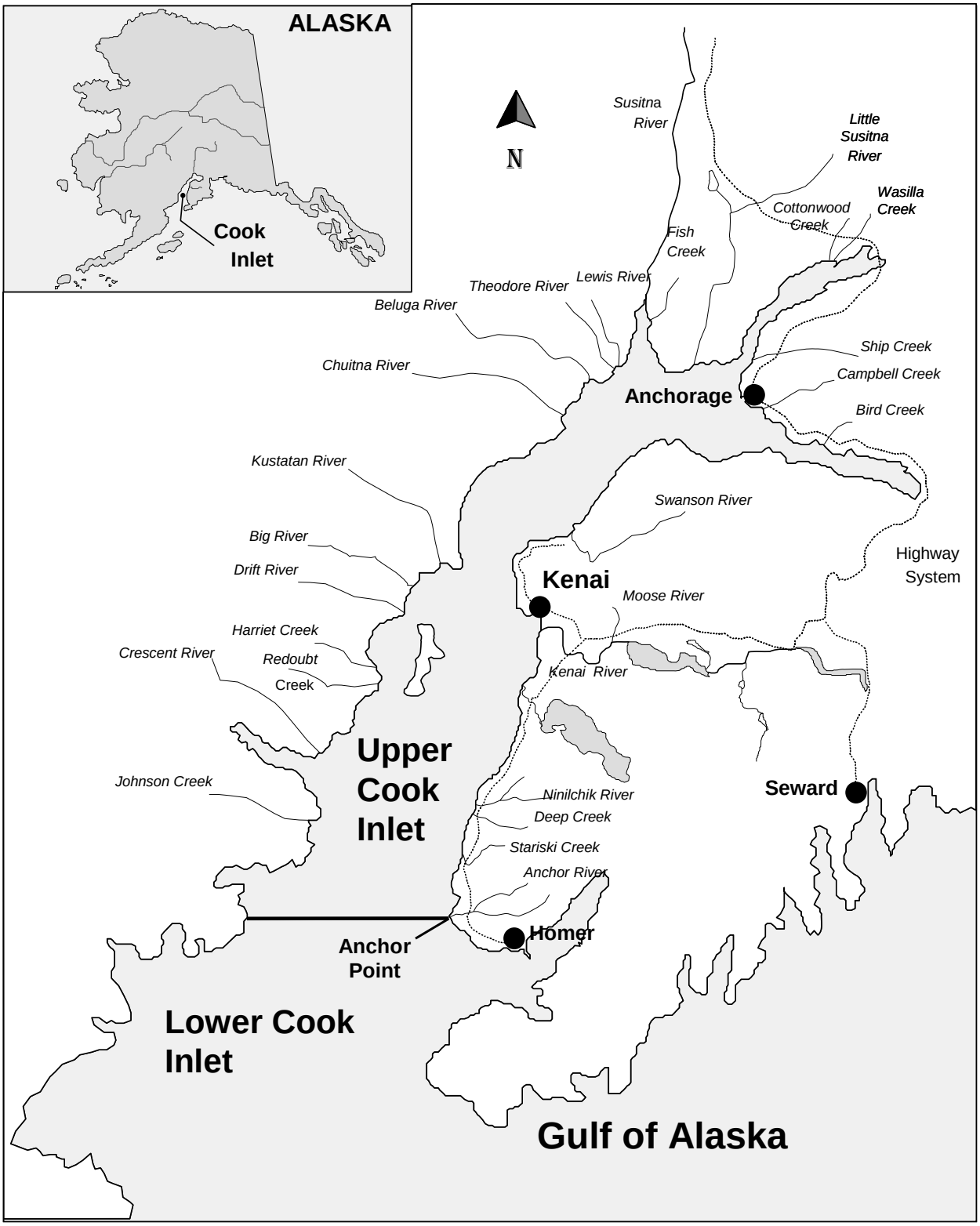

Figure 1.–The Cook Inlet Basin with selected tributaries known to support coho salmon.

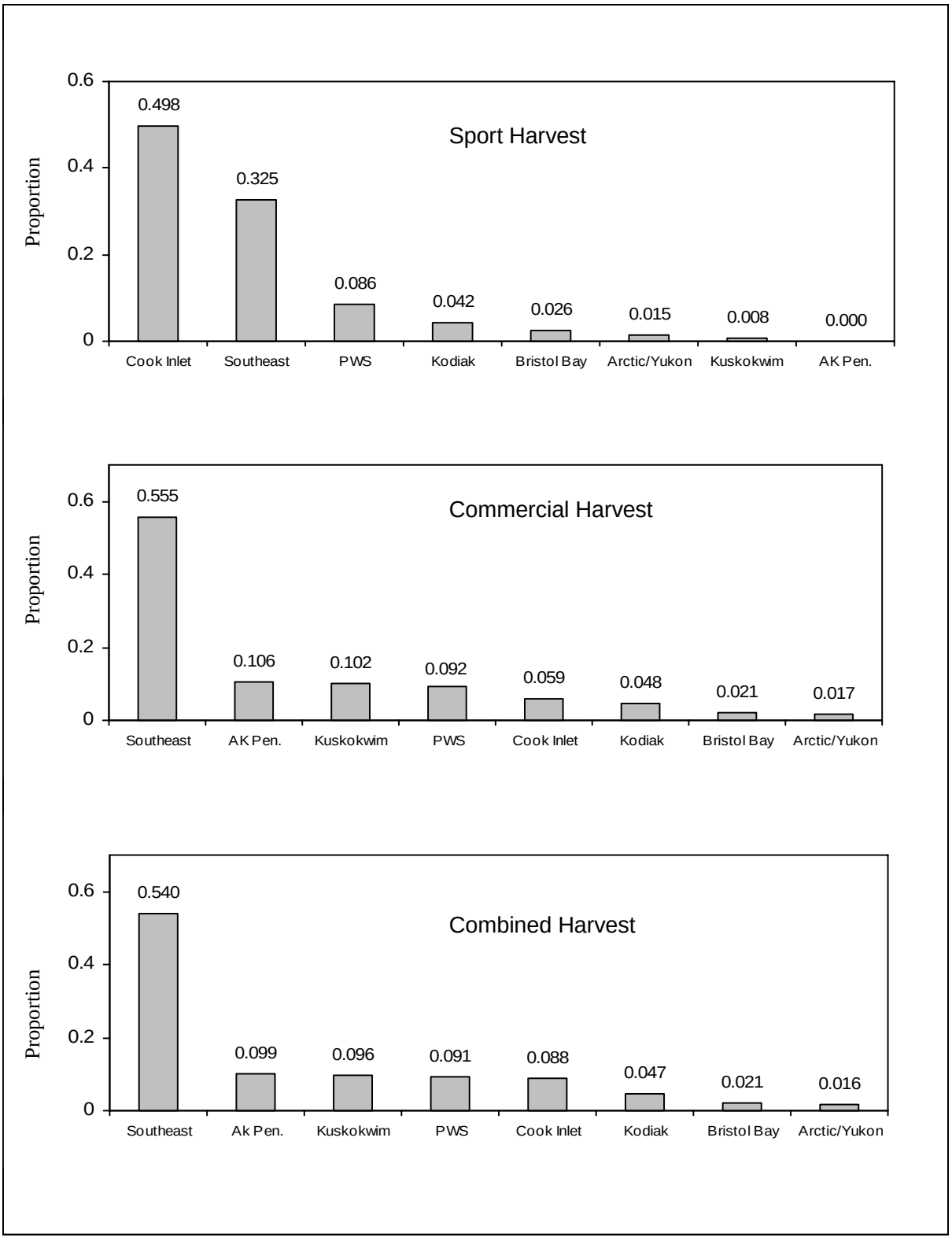

Figure 2.–Average proportions by region of the statewide commercial and sport harvests of coho salmon, 1989–1998.

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 a need for conservation actions. A long–term record of exploitation 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 adult 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). Inriver sport and personal use harvests (B) are estimated annually by angler surveys (Hammarstrom 1977, 1978, 1988–1992; Howe et al. 1995–1996, 2001 a–d; King 1993; Mills 1979–1980, 1981a–b, 1982–1994). Prior to 1999, technical problems (Bendock and Vaught 1994) prevented the estimation of spawning escapements (C), and therefore, total adult production and exploitation remained unknown until then.

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 Alaska Board of Fisheries response was to develop and adopt a management plan for Kenai River coho salmon. The first Kenai River Coho Salmon Management Plan (Alaska Fish and Game Laws and Regulations Annotated, 1997–1998; 5 AAC 21.357) was adopted in spring 1997 and was in effect for the 1997 fishing season.

Adult exploitation rate and production are estimated in a companion project (J. Carlon, ADF&G, Division of Sport fish, Soldotna, personal communication) which uses a mark–recapture experiment, providing a source of samples for this project. This report documents the 1999 population–specific commercial harvest of coho salmon and the 1998 smolt abundance estimates. This report is the seventh in a series documenting commercial harvest of coho salmon since 1993 and smolt abundance from the Kenai River since 1992 (Carlon 2000, 2003; Carlon and Hasbrouck 1994, 1996–1998).

STUDY AREA

Smolt were captured for marking in 1998 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 the companion study to estimate the adult coho salmon population size, two fish wheels were operated near rkm 30.8 and a drift gillnetting effort was conducted in the mainstem Kenai River between rkm 35 and 50. The catches of adult coho salmon made during the companion study provided data essential to achieving objectives documented in this report. A weir was operated on the Russian River (Kenai River tributary at rkm 118) throughout the duration of the coho salmon return in 1999 as another source for examining adults within the drainage. Samples of adults commercially harvested in the drift and eastside set gillnet fisheries of the Central District and the set gillnet fisheries of the Northern District were examined at processing plants and buying stations located along the UCI coastline in 1999. The statistical area from which examined fish were harvested was recorded when possible (Figure 4).

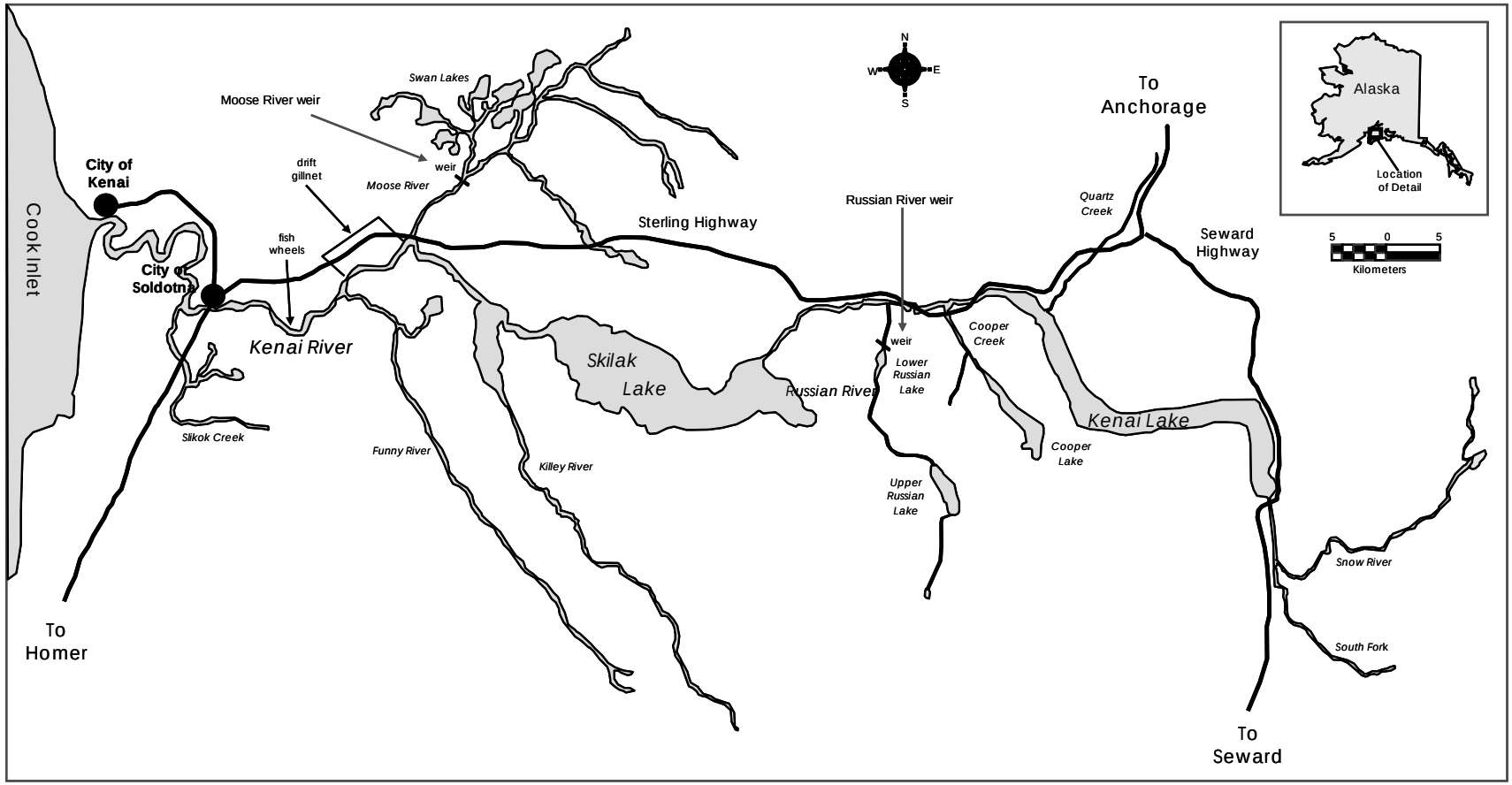

Figure 3.–Kenai River drainage including the Moose River weir site where marked coho salmon smolt were released in 1998, and the Kenai River fish wheel, gillnetting, and weir sampling locations in 1999.

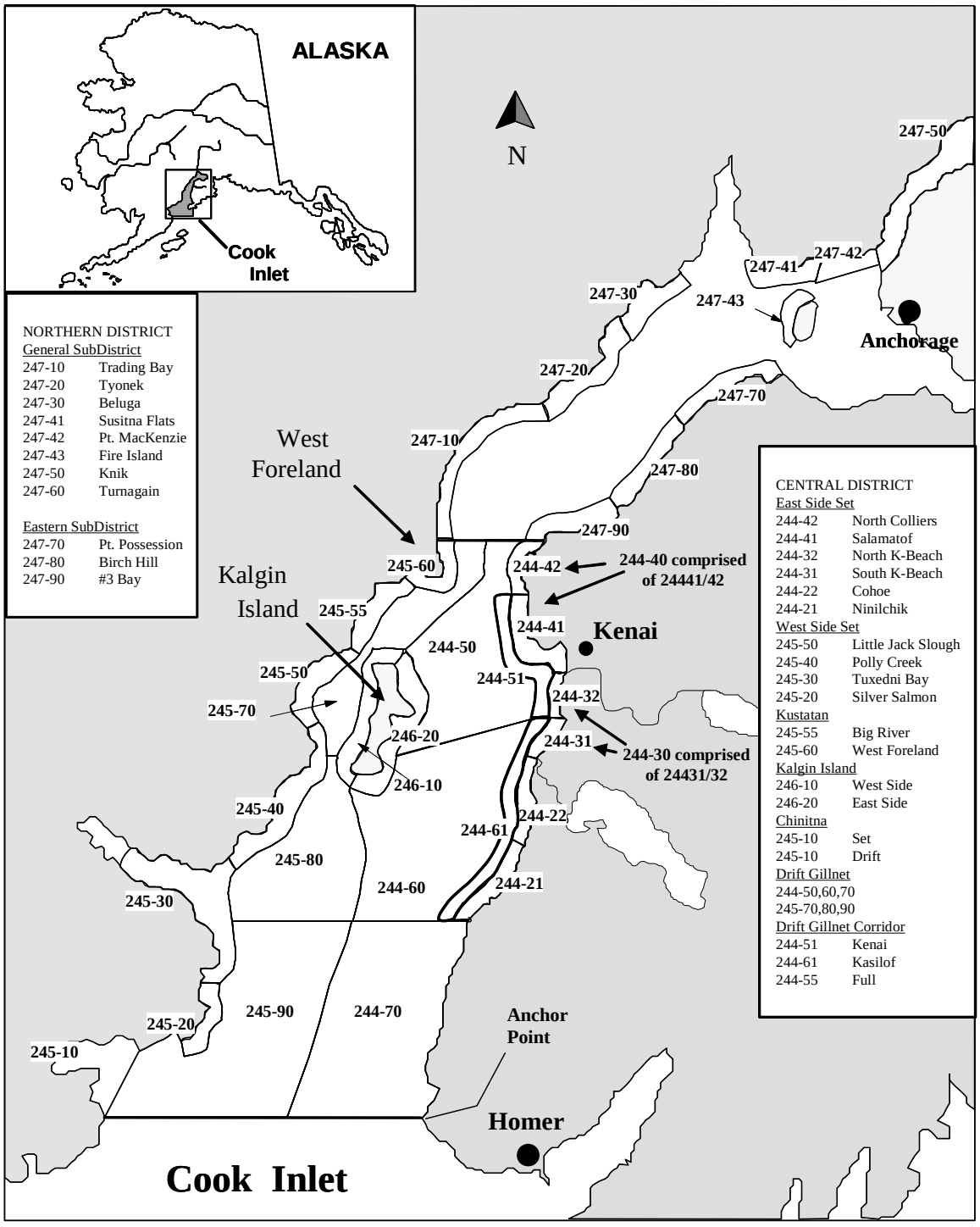

Figure 4.–Upper Cook Inlet statistical areas.

OBJECTIVES

The primary objectives of this study were to:

1. 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 1999, and
2. Estimate the number of coho salmon smolt that emigrated from the Kenai River in 1998.

METHODS

EXPERIMENTAL DESIGN

Commercial Harvest Objective

Coho salmon smolt were captured in the Kenai River drainage in 1998, marked with a CWT, and released. These fish were recovered as adults in 1999 from samples of mixed stock commercial fisheries. The number of tags of Kenai River origin recovered from the commercial fishery was then expanded by the initial tagged fraction to estimate and account for the untagged fish in the samples, and to generate a Kenai River–specific harvest estimate. Total harvest of coho salmon in 1999 commercial fisheries was obtained from the ADF&G commercial fishery fish ticket database system. The commercial harvest was sampled for marked fish at buying stations and processing plants in Cook Inlet. The tagged fraction of the adult return to the Kenai River was estimated by examining inriver fish wheel and drift gillnet samples in 1999.

Smolt Abundance Objective

Smolt abundance was estimated via a two–event mark–recapture experiment, with marking of smolt with adipose finclips constituting the first event and recapturing adults from the inriver return for adipose clips constituting the second event. The smolt abundance estimate was considered accurate if there was no temporal variation in the fraction of adults marked with adipose clips in the inriver return samples. Smolt–to–adult tag loss has been rare, and tests of temporal variation of the tagged fraction, as described for the commercial harvest estimates, were used as a surrogate for testing of the adipose–clipped fraction. A constant marked fraction through time indicates that smolt were marked in proportion to their abundance, (i.e., the smolt marked were representative of, or mixed with, the drainage–wide smolt population). Either condition allows an unbiased estimation of the drainage–wide smolt production.

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

DATA COLLECTION

Data collection occurred during 2 calendar years. Mark–release data were collected when smolt were captured and marked in 1998, and mark–recovery data were collected in 1999 from commercial harvests and from inriver sources (i.e., Kenai River rkm 45.0 fish wheels, drift gillnetting between rkm 30.8 and 50, and the Russian River weir).

Smolt Marking in 1998

Juveniles were captured for marking in 1998 at a single location in the Kenai River drainage. Before 1994, juveniles were captured for tagging at a variety of locations (Carlon 1992; Carlon and Hasbrouck 1993). However, subsequent recoveries of adults marked as juveniles indicated that the Moose River was the only location that provided a suitable sample of smolt for marking (Carlon and Hasbrouck 1994). In addition to providing access to a sufficient number of smolt, the Moose River provided smolt that were representative of the entire Kenai River population with respect to adult return timing (Carlon and Hasbrouck 1994). Therefore, since 1994 juveniles have been marked only at the Moose River.

A weir with a trap was installed in the mainstem of the Moose River at rkm 7.5 to capture smolt for marking as they emigrated downstream from wintering habitats higher in the drainage. The weir was a total barrier to fish migration May 23 through June 27, 1998. Marking smolt with CWTs and adipose finclips began on May 24 and ended on June 10, 1998, but the weir remained in place until June 28 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 tagging 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 head mold for each length group. Head molds were chosen to result in proper and precise tag placement in fish of each length group (Northwest Marine Technologies Inc 1990; Peltz and Hansen 1994). Fish ≤125 mm were tagged using a 30–per–pound head mold, those >125 mm and ≤150 mm were tagged with a 20–per–pound head mold. Rarely were smolt >150 mm captured. These were released untagged because of the excessive time required to sedate and tag them. Because this was a rare occurrence, it is likely that this had no impact on the marked proportion in the subsequent year's return of adults. Tag codes used in 1998 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 and a single tag code was applied to all individuals in the group. The number marked per group ranged from 10,759 to 11,473 depending on the number of tags per tag spool. This resulted in nine tag code groups being released during the emigration. With the exception of a small sample detained each day, all marked fish were released to continue their downstream migration after recovering from anesthesia in an instream holding pen.

Short–term survival and tag retention rates were estimated for smolt marked during each tagging shift by detaining about 200 marked fish in holding pens overnight. These rates were monitored as a quality control measure. Substantial decreases in survival or tag retention would identify the need to adjust capture, handling, or marking procedures. Survival rates were also used to estimate the total number of marked smolt that survived the marking procedure. The number of marked fish that survived and were released is a requirement of the model used to estimate smolt abundance.

Recovery of Marked Adults in the 1999 Return

Three inriver sample sources were examined in 1999 to estimate the tagged proportion of the return: fish wheel catches at rkm 30.8 and 44.5, drift gillnetting catches between rkm 35 and 50, and the return of fish to the Russian River weir. Data from these sources were examined to determine if the recovery of adipose–clipped fish could be used to estimate smolt abundance.

Fish Wheels (Adult Capture Event)

As part of the concurrent mark–recapture experiment to estimate inriver abundance of adults, two fish wheels were operated in the mainstem of the Kenai River at rkm 30.8 to capture adults for marking. This also provided a sample source for examining fish for a missing adipose fin for this study.

Coho salmon were captured and examined for a missing adipose fin from August 1 to September 30 (the last day on which coho salmon were caught). The majority of fish found without an adipose fin were checked with an electronic tag detection wand for the presence of an embedded CWT.

Drift Gillnetting and Fish Wheels (Adult Recapture Event)

Drift gillnets were used between rkm 35 and 50 in the recapture event of the companion capture–recapture experiment to estimate adult abundance in 1999. This also provided a second source of adult coho salmon to examine for a missing adipose fin mark for this study.

Four, two–person crews were scheduled to deploy drift gillnets in the mainstem Kenai River during all daylight hours from August 1 to October 8, such that two to four crews deployed nets each day. Crews operated from riverboats allowing them to rove between riverbanks and over the recapture reach (rkm 35–50) so that effort was widely distributed over the entire reach and throughout the day. Additionally, a two–person crew operated two fish wheels (one adjacent to each river bank) from August 1 to October 8 during most daylight hours.

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 of an adipose fin. The number with and without an adipose fin were recorded each day.

Russian River

Supplemental information was also collected at the Russian River, a tributary to the Kenai River at approximately rkm 118. Sockeye *O. nerka*, coho, and Chinook *O. tshawytscha* salmon spawn in the drainage annually. The Russian River supports an intense, directed sport fishery for sockeye salmon and this return is managed for an escapement goal. A weir is used to census that escapement and is usually operated until about mid–September, the approximate end of the sockeye salmon return. Since 1998, weir operation was extended through early October to enumerate later–returning coho salmon and to examine the Russian River segment of the population for adipose–clipped fish. Fish were not sacrificed for CWT retrieval nor were they detained to check for the presence of a tag with a tag detection wand. Fish were simply counted and visually examined for an adipose fin as they passed through the weir. The Russian River weir is the only facility operated annually within the Kenai River drainage that permits a census of a coho salmon tributary escapement, but escapements were fully enumerated there only four times before 1999 (Carlon 2000, 2003; Marsh 1995; Nelson 1983). A census at the Russian

River weir was deemed valuable during the 1997 return because of the conservation concern that developed that year (Carlon 2000).

Commercial Harvest in 1999

Upper Cook Inlet commercial fisheries typically harvest coho salmon between late June and early September. The fisheries are managed primarily for sockeye salmon through various combinations of time and area restrictions. Fishery management guidelines for all species are described in the Upper Cook Inlet Salmon Management Plan; 1999 management actions are documented by Fox and Shields (2000).

Fisheries selected for sampling during 1999 included the drift gillnet and the eastside set gillnet fisheries of the Central District and the set gillnet fisheries of the Northern District. These areas historically account for most of the UCI coho salmon harvest (Ruesch and Fox 1995). Northern District fisheries typically harvest less than a few hundred coho salmon of Kenai River origin (Carlon 2000, 2003; Carlon and Hasbrouck 1994, 1996–1998), but were sampled to estimate the harvest of hatchery–produced coho salmon stocked in Northern District streams (Bosch and Evans 2006). Harvests in other UCI commercial fisheries have been sampled incidental to this effort in prior years (Carlon 2000, 2003; Carlon and Hasbrouck 1994, 1996–1998).

In 1999, both the Central District drift gillnet and eastside set gillnet fishing seasons opened on July 1 (Fox and Shields 2000). The harvests in both fisheries were examined during most open periods through 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 CWTs from marked fish. Sampling personnel roved among commercial processing locations (main plants and buying stations) and recorded daily totals of the number of coho salmon examined and the number that were missing an adipose fin. Heads were collected from adipose–clipped fish, frozen, and later shipped to the ADF&G Mark, Tag and Age Laboratory (Tag Lab) for retrieval of the embedded CWT. The following information was also recorded: date sold (date harvested), statistical area of harvest when available, and processor. In general, the statistical area of each sampled set gillnet harvest was known. Drift gillnet harvests were typically a mixture of fish from multiple statistical areas. All tag recovery data were keypunched and archived by the Tag Lab. The raw data are accessible via the World Wide Web at URL http://tagotoweb.adfg.state.ak.us

DATA ANALYSIS

Several steps were required before the objectives of estimating smolt production in 1998 and commercial harvest of adult coho salmon of Kenai River origin in 1999 could be achieved. For the estimate of smolt production, the essential steps were: (1) estimate the number of smolt marked in 1998 that survived the marking process, and (2) detect adipose–clipped fish in the 1999 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 adults with CWTs observed inriver in 1999 did not change over time, (2) estimate the proportion of the adult return in 1999 bearing CWTs, and (3) recover CWTs from known sample sizes from the commercial fishery.

Smolt Marking in 1998

Short–term mortality and tag loss were estimated to determine the total number of viable, adipose–clipped and tagged smolt released in 1998. Short–term survival and tag retention for smolt marked during each shift were estimated from a representative sample of about 200 marked smolt that were detained in holding pens for 18 to 24 hours after marking. Short–term survival rate (s_k) for smolt marked and released during marking shift k was estimated as the fraction of smolt that survived the detainment period.

Short–term tag retention rate (b_k) for smolt marked during a shift that survived was estimated as the fraction of surviving smolt that had retained their tags.

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

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

The total number of smolt that were marked, survived, and retained a tag at the Moose River in 1998 was estimated by summing $\hat{m}_k$ over all marking shifts. This number was required to determine when the goal of releasing 95,000 tagged live fish was achieved. 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 clip 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 1999 Return

Estimating the commercial harvest of coho salmon of Kenai River origin in 1999 required estimating the tagged proportion (θ) of the return, i.e., the proportion physically bearing CWTs. The tagged proportion was unknown at the time of smolt marking in 1998, but was estimated when adults returned in 1999 by examining fish from seven different sources. These sources were the coho salmon catch in two fish wheels at rkm 30.8 (one adjacent to each bank), the drift gillnetting catch between rkm 35 and 50 (two banks), the fish wheel catch at rkm 44.5 (two banks), and the return of fish to the Russian River weir.

Estimation of the tagged proportion (θ) from a specific bank at a fish wheel site was a three–step process. The first step involved estimating the adipose finclip rate (y_i) in the returning population sampled at the fish wheel during weekly interval i. The rate was estimated as the proportion of fish examined that were characterized by a missing adipose fin. The second step involved estimating the smolt–to–adult tag retention rate (c_i) in the returning population of adipose–clipped fish sampled at the fish wheel during weekly interval i. This rate was calculated as the proportion of adipose–clipped fish that invoked a signal in a tag–detection wand. We assumed all wands worked and that there were no false negative results.

The third step involved estimating the tagged proportion (θ_i) of the population sampled at the fish wheel during weekly interval i that carried a tag implanted at the Moose River in 1998. This proportion was estimated as:

$$\hat{\theta}_i = \hat{y}_i \hat{c}_i \,. \tag{2}$$

Estimation of the tagged proportion (θ) from each drift gillnetting bank and from the Russian River was calculated similarly, except 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 minimize physically detaining the spawning migration and it was assumed that tag retention rates were 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 sources to provide a more precise estimate of the overall tagged proportion in the 1999 return.

The data collected to estimate the tagged proportion in the 1999 return also provided an important component of the estimator of the number of smolt that emigrated from the Kenai River in 1998. The mark used to estimate smolt abundance was the adipose clip as opposed to the presence of a CWT. The number of adipose–clipped fish recovered in the inriver adult sampling program was recorded and used in the smolt abundance estimate.

Smolt Abundance in 1998

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

$$\hat{N} = \frac{(M+1)(C+1)}{(R+1)} - 1, \tag{3}$$

where:

M = the number of smolt marked with an adipose finclip and surviving to emigrate in 1998,

C = the number of adult coho salmon examined for an adipose clip in the 1999 return sample, and

R = the number of adult coho salmon in the 1999 sample that had an adipose clip.

The variance of the smolt abundance estimate was estimated by:

$$\hat{V}(\hat{N}) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}. \tag{4}$$

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

1. Adult coho salmon examined for marks were a random sample of the inriver return or the marked sample of smolt were a representative sample of the drainage–wide smolt emigration

in 1998 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 1998 were actually smolt,
3. Survival and catchability were the same for marked and unmarked individuals,
4. Adipose fins were not regenerated between the mark and recovery events,
5. There was no natural loss of adipose fins at any time during the life of the population, and
6. Fish were correctly categorized for the presence or absence of an adipose fin when examined at each inriver sampling source.

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

The remaining five assumptions are also likely valid. Previous experience and observations indicate that most juveniles marked at the Moose River each year are smolt (assumption 2). Short–term survival of marked smolt has been nearly 100% during all smolt–marking events at the Moose River (assumption 3) (Carlon 2000, 2003; Carlon and Hasbrouck 1994, 1996–1998), although long–term survival and catchability assumptions remain untested for this wild population. For hatchery–produced coho salmon marked with adipose clips and CWTs and released in a western Kenai Peninsula drainage system the smolt–to–adult survival was no different than that of unmarked coho salmon (Vincent–Lang 1993). Thompson and Blankenship (1997) found no regeneration of coho salmon adipose fins 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 725,000 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); this supports the supposition that naturally missing adipose fins are rare.

Commercial Harvest in 1999

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 Commercial Fisheries Division (CFD) provided the commercial harvest by fishery, date, and statistical area. The Central District commercial harvest data used in this report were provided during the fall of 1999 and may differ slightly (<1,000) from the total Central District harvest data reported elsewhere because of previously unreported fish tickets being reported after the deadline.

Commercial harvest of coho salmon of Kenai River origin was estimated; total harvest, number examined for marks, and number of CWTs recovered were considered known. The proportion of the return bearing marks was estimated by examining the inriver fish wheel catch, the inriver recapture drift gillnetting catch, and the return of adults to the Russian River weir. Based on these data sources, the harvest of coho salmon of Kenai River origin in each commercial fishery stratum *i* was estimated by (Bernard and Clark 1996):

$$\hat{r}_i = N_i \hat{\theta}^{-1} \left(\frac{m_i}{\lambda_i n_i} \right) = N_i \hat{\theta}^{-1} \hat{p}_i \,, \tag{5}$$

where:

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

θ = the proportion of the 1999 Kenai River return marked with CWTs,

m_i = the number of CWTs recovered from commercial fishery stratum *i* and subsequently decoded as the tag of interest, i.e., Moose River 1998 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 CWTs 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 CWTs detected, and

t_i' = the number of CWTs found that were readable as a code released in any coho salmon marking event (not just the Moose River 1998 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):

$$\hat{V}(\hat{r}_i) = \hat{r}_i^2 \left[G(\hat{p}_i) + G(\hat{\theta}^{-1}) - G(\hat{p}_i) G(\hat{\theta}^{-1}) \right], \tag{6}$$

where:

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

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

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

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

Although the number of fish harvested is estimated as a product of pounds purchased by commercial processors and average weight per fish, the overall variance of the number harvested is considered small because the entire harvest is weighed. Therefore, the number of coho salmon harvested by the 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 1999 harvest estimates.

Harvest estimates were based on sample data pooled among processors receiving fish from harvests occurring within the estimation stratum (area and/or time). Bias associated with this pooling is assumed insignificant because of the similarity of the marked proportion among intensively sampled processors in prior years (Carlon 2000, 2003; Carlon and Hasbrouck 1994, 1996–1998). Pooling data among processors in 1999 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 1998

Smolt were marked with CWTs and adipose finclips as they emigrated from the Moose River during May 24 through June 9, 1998; the last release of marked smolt occurred on June 10, 1998 (Appendix A1). During this period, 101,223 smolt were coded wire tagged. Of these, an estimated 101,133 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 100,728 smolt that were released alive with tags. Although marked fish were released as late as June 10 (from the overnight retention and survival sample), marking was discontinued after the marking goal was achieved on June 9, 1998. The weir remained in place until June 27 allowing for a smolt emigration census. The total number of smolt arriving at the weir between May 23 and June 27, 1998 was 187,145.

TAGGED PROPORTION OF THE 1999 RETURN

Adults marked as smolt (with adipose clips and CWTs) at the Moose River in 1998 returned to the Kenai River drainage in 1999. Marked and unmarked adults from all adult sample sources were examined over weekly periods to estimate the proportion of the adult return bearing tags.

Fish Wheels (Capture Effort)

Two fish wheels were used in the capture effort of the companion mark–recapture experiment to estimate adult abundance in 1999. Each fish wheel (one adjacent to each riverbank) was

operated a consistent number of hours per day from August 1 to September 30. Daily hours of operation varied based on fish wheel maintenance requirements, but averaged 14.6 hours per day for the fish wheel adjacent to the north bank and 13.8 hours per day for the fish wheel adjacent to the south bank (Carlon *In prep*). From August 1 to September 30, a total of 443 coho salmon were captured and examined (Table 1 and Appendix A2). A tag detection wand was used to check adipose–clipped fish for tags.

Of the 443 coho salmon captured in fish wheels, 162 were captured in the south bank fish wheel. The weekly tagged proportion in the south bank fish wheel catch ranged from 0.046 (SE = 0.025) to 0.118 (SE = 0.042) (during weeks when catches exceeded 10 coho salmon) and did not vary significantly between weeks (P = 0.45). The overall tagged proportion estimated by pooling the full season of south bank fish wheel data was 0.080 (SE = 0.025).

There were 281 coho salmon captured in the north bank fish wheel. The weekly tagged proportion ranged from 0.071 (SE = 0.049) to 0.241 (SE = 0.048) (during weeks when catches exceeded 10 coho salmon) but did not vary over weekly intervals (P = 0.750). The tagged proportion estimated by pooling the full season of north bank fish wheel data was 0.188 (SE = 0.026). This tagged proportion was significantly different from that estimated for the south bank fish wheel (P = 0.002).

Of the total 443 coho salmon captured in the fish wheels, 69 (0.156) were missing an adipose fin. The overall tag retention rate for fish sampled at the fish wheels (c) was (64/67=0.995); based on handheld tag detection wand results conducted in the field. The weekly tagged proportion ranged from 0.063 (SE = 0.038) to 0.157 (SE = 0.037) (during weeks when catches exceeded 10 coho salmon) and did not vary significantly over weekly intervals (P = 0.318). The tagged proportion estimated by pooling the full season of both banks' fish wheel data was 0.149 (SE = 0.042).

Drift Gillnets and Fish Wheels (Recapture Effort)

From August 1 to October 8, 1999, a total of 2,033 adult coho salmon were captured and examined (Table 1 and Appendix A3). Of the 1,633 coho salmon captured in drift gillnets, 710 were captured along the south bank. After adjusting for tag retention (based on the tag retention rate detected in the fish wheel catch in the capture effort), the weekly tagged proportion in the south bank catch ranged from 0.055 (SE = 0.04) to 0.341 (SE = 0.12) (during weeks when catches exceeded 10 coho salmon) and varied significantly over all weeks during which fish were examined (P = 0.003). The seasonal tagged proportion estimated by pooling all south bank drift gillnetting data was 0.091 (SE = 0.012).

There were 531 coho salmon captured along the north bank in drift gillnets. The weekly tagged proportion ranged from 0.102 (SE = 0.058) to 0.225 (SE = 0.046) (during weeks when catches exceeded 10 coho salmon) and did not vary significantly over all weeks (P = 0.215). The seasonal tagged proportion estimated by pooling all north bank drift gillnetting data was 0.149 (SE = 0.019). This proportion differed significantly from that estimated from the pooled south bank drift gillnetting samples (P = 0.002), but not from the pooled fish wheel (capture effort) samples (P = 0.422).

There were 392 coho salmon captured in drift gillnets but not assigned a bank location because it was unknown, unrecorded, or the fish were caught in the middle of the river. Of these fish, the weekly tagged proportion varied from 0 to 0.158, and did not vary significantly across weeks (P = 0.371).

Table 1.–Recoveries of coho salmon from multiple sources within the Kenai River drainage from August 1 to October 8, 1999, 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 Capture Effort					
08/01 – 08/07	7	1	0.143	1	1	1.000	0.143	0
08/08 – 08/14	36	6	0.167	5	5	1.000	0.167	0
08/15 – 08/21	47	10	0.213	10	10	1.000	0.213	0
08/22 – 08/28	32	7	0.219	7	7	1.000	0.219	0
08/29 – 09/04	14	2	0.143	2	1	0.500	0.071	1
09/05 – 09/11	9	2	0.222	2	2	1.000	0.222	0
09/12 – 09/18	36	5	0.139	5	5	1.000	0.139	0
09/19 – 09/25	79	19	0.241	18	18	1.000	0.241	0
09/26 – 10/02	21	2	0.095	2	2	1.000	0.095	0
Total	281	54	0.192	52	51	0.981	0.188	1
			South Bank Fish Wheel Capture Effort					
08/01 – 08/07	1		0.000			1.000	0.000	0
08/08 – 08/14	3		0.000			1.000	0.000	0
08/15 – 08/21	68	9	0.132	9	8	0.889	0.118	1
08/22 – 08/28	65	4	0.062	4	3	0.750	0.046	1
08/29 – 09/04	18	1	0.056	1	1	1.000	0.056	0
09/05 – 09/11	4		0.000			1.000	0.000	0
09/12 – 09/18	3	1	0.333	1	1	1.000	0.333	0
09/19 – 09/25								
09/26 – 10/02								
Total	162	15	0.093	15	13	0.867	0.080	2
			North Bank Fish Wheel Recapture Effort					
08/01 – 08/07	2	2	1.000			0.955	0.955	0
08/08 – 08/14	38	5	0.132			0.955	0.126	0
08/15 – 08/21	20	3	0.150			0.955	0.143	0
08/22 – 08/28	56	13	0.232			0.955	0.222	1
08/29 – 09/04	17	1	0.059			0.955	0.056	0
09/05 – 09/11	36	8	0.222			0.955	0.212	0
09/12 – 09/18	58	10	0.172			0.955	0.165	0
09/19 – 09/25								
09/26 – 10/02								
10/03 – 10/08								
Total	227	42	0.185			0.955	0.177	2

–continued–

Table 1.–Page 2 of 4.

Weekly Period	Number Examined	Marked Fish Observed	y_i [a]	Marked Fish Checked for a CWT[b]	Number of CWTs Detected	c_i [c]	$Theta_i$ [d]	Estimated CWTs Missing [e]
South Bank Fish Wheel Recapture Effort								
08/01 – 08/07								
08/08 – 08/14	9	1	0.111					
08/15 – 08/21	44	5	0.114			0.955	0.109	0
08/22 – 08/28	73	9	0.123			0.955	0.118	0
08/29 – 09/04	4	2	0.500			0.955	0.478	0
09/05 – 09/11						0.955		
09/12 – 09/18	21	7	0.333			0.955	0.318	0
09/19 – 09/25	14	3	0.214			0.955	0.205	0
09/26 – 10/02	8	1	0.125			0.955	0.119	0
10/03 – 10/08								
Total	173	28	0.162			0.955	0.155	1
North Bank Netting Recapture Effort								
08/01 – 08/07								
08/08 – 08/14								
08/15 – 08/21	9	1	0.111			0.955	0.106	0
08/22 – 08/28	180	20	0.111			0.955	0.106	1
08/29 – 09/04	123	19	0.154			0.955	0.148	1
09/05 – 09/11	85	20	0.235			0.955	0.225	1
09/12 – 09/18	39	9	0.231			0.955	0.220	0
09/19 – 09/25	28	3	0.107			0.955	0.102	0
09/26 – 10/02	24	5	0.208			0.955	0.199	0
10/03 – 10/08	43	6	0.140					
Total	531	83	0.156			0.955	0.149	4
South Bank Netting Recapture Effort								
08/01 – 08/07								
08/08 – 08/14	1		0.000					
08/15 – 08/21	35	2	0.057			0.955	0.055	0
08/22 – 08/28	292	25	0.086			0.955	0.082	1
08/29 – 09/04	179	15	0.084			0.955	0.080	1
09/05 – 09/11	113	9	0.080			0.955	0.076	0
09/12 – 09/18	27	7	0.259			0.955	0.248	0
09/19 – 09/25	28	4	0.143			0.955	0.136	0
09/26 – 10/02	21	1	0.048			0.955	0.045	0
10/03 – 10/08	14	5	0.357					
Total	710	68	0.096			0.955	0.091	3

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Table 1.–Page 3 of 4.

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]
Ambiguous Bank Netting Recapture Effort								
08/01 – 08/07								
08/08 – 08/14	13	0	0.000			0.955	0.000	0
08/15 – 08/21	379	23	0.061			0.955	0.058	1
08/22 – 08/28								
08/29 – 09/04								
09/05 – 09/11								
09/12 – 09/18								
09/19 – 09/25								
09/26 – 10/02								
10/03 – 10/08								
Total	392	23	0.059			0.955	0.056	1
Combined Gear and Banks (Kenai River)								
08/01 – 08/07	10	3	0.300	1	1	1.000	0.300	
08/08 – 08/14	100	12	0.120	5	5	1.000	0.120	0
08/15 – 08/21	602	53	0.088	19	18	0.947	0.083	3
08/22 – 08/28	698	78	0.112	11	10	0.909	0.102	7
08/29 – 09/04	355	40	0.113	3	2	0.667	0.075	13
09/05 – 09/11	247	39	0.158	2	2	1.000	0.158	0
09/12 – 09/18	184	39	0.212	6	6	1.000	0.212	0
09/19 – 09/25	149	29	0.195	18	18	1.000	0.195	0
09/26 – 10/02	74	9	0.122	2	2	1.000	0.122	0
10/03 – 10/08	57	11	0.193	0	0	1.000	0.193	0
Total	2,476	313	0.126	67	64	0.955	0.121	14
Russian River Weir								
08/01 – 08/07								
08/08 – 08/14	13	2	0.154			0.955	0.147	0
08/15 – 08/21	113	8	0.071			0.955	0.068	0
08/22 – 08/28	230	14	0.061			0.955	0.058	1
08/29 – 09/04	304	21	0.069			0.955	0.066	1
09/05 – 09/11	772	78	0.101			0.955	0.096	4
09/12 – 09/18	910	58	0.064			0.955	0.061	3
09/19 – 09/25	314	13	0.041			0.955	0.040	1
09/19 – 09/32	5	0	0.000			0.955	0.000	0
09/26 – 10/02	88	3	0.034			0.955	0.033	0
10/03 – 10/08	5	0	0.000			0.955	0.000	0
Total	2,754	197	0.072			0.955	0.068	9

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Table 1.–Page 3 of 4.

[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 and at the Russian River weir were not checked; the proportion bearing a coded wire tag was assumed to be the same as that verified in the pooled sample of fish wheel–caught fish.

[c] Estimated proportion of adipose–clipped fish bearing a coded wire tag implanted at the Moose River in 1998 based on tag detection results.

[d] Estimated proportion of the number examined bearing a coded wire tag originally implanted at the Moose River in 1998.

[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.

Pooling all 1,633 drift gillnet caught fish (to include north, south, and unassigned bank locations) resulted in a weekly tagged proportion ranging from 0.091 (SE = 0.015) to 0.232 (SE = 0.057) (during weeks when catches exceeded 10 coho salmon) and varied significantly over all weeks during which fish were examined ($P \leq 0.001$). The seasonal tagged proportion estimated by pooling all drift gillnetting data was 0.102 (SE = 0.01).

The two fish wheels used in the recapture effort resulted in the capture and examination of 400 coho salmon. Of these, 173 were caught along the south bank. After adjusting for tag retention (based on the tag retention rate detected in the fish wheel catch in the capture effort), the weekly tagged proportion in the south bank catch ranged from 0.109 (SE = 0.047) to 0.318 (SE = 0.103) (during weeks when catches exceeded 10 coho salmon) and did not vary significantly over weeks during which fish were examined ($P = 0.124$). The seasonal tagged proportion estimated by pooling all south bank fish wheel samples was 0.155 (SE = 0.028). This proportion differed significantly from the pooled drift gillnetting samples ($P = 0.038$), but not the pooled fish wheel capture samples ($P = 0.924$)

The fish wheel operated along the north bank was used to capture 227 coho salmon. The weekly tagged proportion ranged from 0.056 (SE = 0.057) to 0.222 (SE = 0.06) (during weeks when catches exceeded 10 coho salmon) and did not vary significantly across weekly periods ($P = 0.054$). The seasonal tagged proportion estimated by pooling all north bank fish wheel data was 0.177 (SE = 0.029). This proportion did not differ significantly from the pooled south bank fish wheel recapture samples ($P = 0.690$) or from the pooled fish wheel capture samples ($P = 0.422$), but it did differ significantly from the pooled drift gillnetting samples ($P = 0.001$).

Pooling all 400 recapture effort fish wheel samples resulted in a seasonal tagged proportion of 0.167 (SE = 0.021). After adjusting for tag retention (based on the tag retention rate detected in the fish wheel catch in the capture effort), the weekly tagged proportion ranged from 0.109 (SE = 0.047) to 0.248 (SE = 0.049) (during weeks when catches exceeded 10 coho salmon) and did not vary significantly over weeks during which fish were examined ($P \leq 0.710$).

The overall tagged proportion from the pooled seasonal recapture fish wheel samples varied significantly from the pooled recapture drift gillnet samples ($P < 0.001$), but not the pooled seasonal capture fish wheel samples ($P = 0.521$).

Of the total 2,033 coho salmon captured in all recapture samples, 244 (0.120) were missing an adipose fin. The overall pooled tagged proportion for the recapture samples was 0.115 (SE = 0.01). This did not differ significantly from the pooled capture fish wheel proportion of 0.172 ($P = 0.053$). The weekly tagged proportion of the pooled recapture samples ranged from 0.042 (SE = 0.043) to 0.240 (SE = 0.04) and varied significantly over weekly intervals ($P < 0.001$).

Russian River Sampling

The Russian River weir was operational from June 11 to October 7, 1999, but the first coho salmon did not arrive at the weir until August 8 (Appendix A4). Between August 8 and October 7, a total of 2,951 coho salmon were passed through the weir and 2,754 were examined for an adipose fin. Of these, 197 (0.071) were missing an adipose fin. The estimated weekly proportion of fish bearing a CWT, adjusted for estimated tag loss, ranged from 0.033 to 0.147 (during weeks when observations exceeded 10 coho salmon) and did vary significantly among weekly periods ($P = 0.025$). The tagged proportion (0.068) estimated by pooling all Russian River weir samples was significantly different from the pooled fish wheel samples ($P < 0.001$), the pooled recapture samples ($P < 0.001$), and the combined pooled capture and recapture effort samples ($P < 0.001$).

Estimate of the Tagged Proportion

Statistically significant temporal variations in the tagged proportion existed in the south bank drift gillnetting recapture samples. Likewise, significant differences in the tagged proportion were detected between riverbanks in both the capture and recapture samples. Therefore, the tagged proportion of the coho salmon population that passed through marine commercial fishery areas was unknown and estimates of commercial harvest could be biased, depending on the actual tagged proportion present in marine commercial fisheries of UCI. However, a point estimate of the overall tagged proportion of the return was made and sensitivity tests conducted to examine the effect of using the observed minimum and maximum tagged proportions on the estimates of harvest in commercial fisheries of interest.

The tagged proportions were significantly different between the recapture gear types (fish wheel and drift gillnets), but not between recapture and capture samples using the same gear type (fish wheels). All capture and recapture samples were pooled together to generate the tagged proportion estimate because it most likely represented the tagged proportion in the commercial fishery, and it increased the sample size substantially. Tag recovery data from the Russian River was not used because of the large difference between the marked proportion found and the marked proportion from the pooled capture/recapture samples.

The overall tagged proportion from pooled capture and recapture samples was used to generate qualified point estimates (and variances) of harvest in commercial fisheries of interest. From these estimates, the minimum and maximum values in the pooled samples were used to calculate extreme bounds.

The overall estimated tagged proportion ($\hat{\theta}$) of the 1999 return was 0.121 (SE = 0.007); $\hat{\theta}^{-1}$=8.3, SE = 1.05). Because of the significant temporal trend in the pooled fish wheel data, this estimate is considered a qualified estimate of the tagged proportion passing through commercial fishing areas as described above. The minimum tagged proportion of 0.097 (SE = 0.007); $\hat{\theta}^{-1}$=10.36, (SE = 1.74) was estimated from samples collected during the first 5 weeks of sampling (August 1–September 4) because no difference was detected in the tagged proportion

among those weeks. The maximum tagged proportion was estimated from samples taken during the last 4 weekly periods (September 5–October 8) and was estimated as 0.179 (SE = 0.014); $\hat{\theta}^{-1}$=5.6 (SE = 1.05).

SMOLT ESTIMATE IN 1998

Sources of data used to estimate smolt abundance were the same as those used to estimate the tagged proportion, i.e., the pooled capture and recapture samples.

Based on the number of live smolt released with an adipose clip at the Moose River in 1998 (101,133), the number of adult coho salmon examined for adipose fin status in the Kenai River fish wheel and gillnetting samples in 1999 (2,476), and the number of adults in the sample that were missing an adipose fin (313), an estimated 797,798 (SE = 41,940) smolt emigrated from the Kenai River in 1998.

COMMERCIAL HARVEST IN 1999

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 1999 Northern District sampling efforts and recoveries of hatchery–produced coho salmon are documented in a companion report (Bosch and Evans 2006).

Inlet–Wide Fisheries

During the 1999 fishing season, 125,343 coho salmon were harvested in commercial fisheries of UCI (Table 2). This harvest was 38% of the 1990–1999 average harvest (Fox and Shields 2000). About 75% of the 1999 UCI commercial harvest was taken in Central District fisheries. Among Central District fisheries, the greatest harvest occurred in the drift gillnet fishery (68.7%); other fisheries ranged from 2.3% to 11.5% of the Central District harvest (Figure 5). The Northern District set gillnet fisheries comprised 25.1% of the total UCI commercial harvest.

Table 2.–Sampling performance and recovery of coded wire tags (CWT) from coho salmon harvested in Upper Cook Inlet commercial fisheries in 1999.

Gillnet Fishery	Harvest	Number Examined	Percent of Harvest Examined	Marked Fish Found[a]	Percent Marked	Heads Recovered	Missing, Lost, or Unreadable	Percent Missing Tag	Heads with Decodable CWT[b]	Number from Cohort Marked at Moose R. in 1998
CENTRAL DISTRICT										
Central District Drift	64,529	33,158	0.51	737	0.02	713	60	0.08	653	42
East Side Set (by Statistical Area)										
244–21	2,149	937	0.44	45	0.05	44	5	0.11	39	38
244–22	2,942	716	0.24	38	0.05	38	0	0.00	38	30
244–30	2,358	584	0.25	36	0.06	36	2	0.06	34	32
244–40	4,230	1,912	0.45	53	0.03	53	2	0.04	51	29
East Side Set Total	11,679	4,149	0.36	172	0.04	171	9	0.05	162	129
Kalgin Island Set[c]	10,842	38	0.00	0						
West Side Set[c]	6,857	125	0.02	1	0.01	1	0	0.00	1	0
Central District Total	93,907	37,470	1	910	0	885	69	0.08	816	171
NORTHERN DISTRICT										
West Side Set	18,838	13,361	0.71	106	0.01	104	18	0.17	86	2
Pt. MacKenzie/Susitna Flats Set	2,259	2,529 [e]	1.12	265	0.10	264	9	0.03	255	0
East Side Set	7,736	4,629	0.60	67	0.01	67	3	0.04	64	12
Fire Island Set	2,603	2,086	0.80	220	0.11	220	7	0.03	213	0
Northern District Set Total	31,436	22,605	0.72	658	0.03	655	37	0.06	618	14
Northern District Total	31,436	22,605	0.72	658	0.03	655	37	0.06	618	14
MIXED CENTRAL DISTRICT STATISTICAL AREAS										
Mixed East Side Set[d]		265		22	0.08	22	2	0.09	20	14
Mixed West Side Set/Kalgin Island Set[d]		3,734		60	0.02	60	4	0.07	56	3
Mixed East Side and Central District Drift[d]		7		0	0.00	0				
Mixed Drift/West Side Set/Kalgin Island Set[d]		1,344		19	0	19	0	0.00	19	0
Mixed Central Total		5,350		101	0.02	101	6	0.06	95	17

–continued–

Table 2.–Page 2 of 3.

Gillnet Fishery	Harvest	Number Examined	Percent of Harvest Examined	Marked Fish Found[a]	Percent Marked	Heads Recovered	Missing, Lost, or Unreadable	Percent Missing Tag	Heads with Decodable CWT[b]	Number from Cohort Marked at Moose R. in 1998
MIXED NORTHERN DISTRICT STATISTICAL AREAS										
Mixed Fire Island and East Side Set[d]		60		0	0.00					
Mixed Pt. MacKenzie/Susitna Flats and		242		34	0.14	34	1	0.03	33	0
Mixed Northern Total		302		34	0.11	34	1	0.03	33	0
MIXED CENTRAL AND NORTHERN DISTRICTS										
Central District West Side Set and Northern District East Side Set		56		1	0.02	1	0		1	0
Mixed Central District Kalgin Island Set and Northern District East Side Set		99		1	0.01	1	0		1	1
Mixed Central District Drift and Northern District East Side Set		337		18	0.05	18	2		16	0
Mixed District Total		492		20	0.04	20	2		18	1
UNKNOWN STATISTICAL AREA/GEAR										
Unknown Statistical Area/Gear		22		4	0.18	4	0		4	4
All Mixed and Unknown Fishery Total		6,166		159	0.03	159	9		150	22
Unmixed Fishery Total[f]	125,343	60,075	0.48	1,568	0.03	1,540	106	0.07	1,434	185
Unmixed Fishery Total (Without Central District Kalgin Island and	107,644	59,912	0.56	1,567	0.03	1,539	106	0.07	1,433	185
Grand Total[g]	125,343	66,241	0.53	1,727	0.03	1,699	115	0.07	1,584	207

–continued–

Table 2.–Page 3 of 3.

[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] These sampling records were not used to produce contribution estimates because this fishery has a history of insignificant interception of Kenai River bound coho salmon, therefore, any sampling of this fishery was incidental to other sampling efforts.

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

[e] Instances when the number of fish sampled exceeds the reported harvest is likely a result of misreporting of the statistical area on a fish ticket(s).

[f] Total for all samples positively assigned to known fisheries throughout Upper Cook Inlet.

[g] Total for all samples including those positively assigned to known fisheries and samples not assigned to known fisheries.

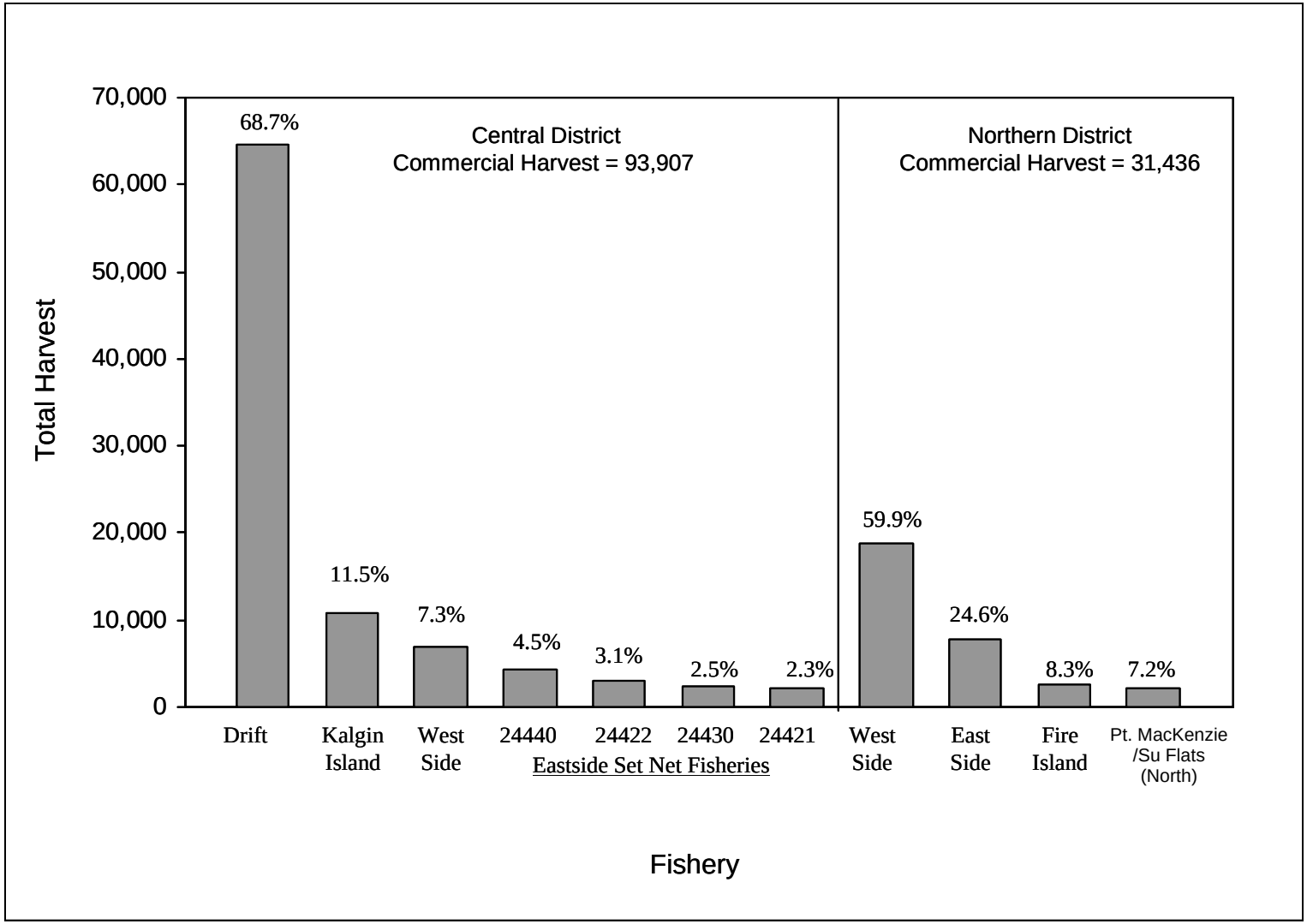

Figure 5.–Coho salmon harvest in 11 Upper Cook Inlet commercial fishery areas with percentage of total harvest by District, 1999.

Of the inlet–wide commercial harvest, 66,241 fish (0.44) were examined for adipose clips. Adipose–clipped fish were found in all regularly sampled fisheries. Exact fishery stratum of harvest (statistical area) could not be identified for 6,166 examined fish (Appendix A5); these fish were sampled from processor deliveries consisting of harvests from multiple statistical areas, unknown areas, or unknown gear types. They were not used to calculate harvest estimates because of the ambiguity of their origin. Of these samples from mixed areas, a total of 159 were found with an adipose clip (0.026), heads were recovered from all of them, and a decodable tag was found in 150. Of the 150 decodable tags recovered, 22 had been implanted in smolt at the Moose River in 1998.

The remaining 60,075 examined fish were positively assigned to fishery strata (Appendix A6). Of these, 1,568 (0.026) were missing the adipose fin and heads were collected from 1,540 of them. Of the 1,540 heads recovered, 1,434 had decodable tags (0.93). All but three tagged fish had originated from UCI release locations in 1998, 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 the Kenai River drainage.

Of the 1,434 decodable tags recovered from adults commercially harvested in known fishery strata, 185 (0.129) were originally released as smolt emigrating from the Kenai River drainage. All 185 were originally implanted in smolt emigrating from the Moose River tributary in 1998. Most (0.92) were recovered from Central District fisheries while 14 were recovered from known Northern District fisheries.

Among the commercial processors receiving at least 100 coho salmon harvested in the Central District eastside set gillnet fisheries, the proportion of the number examined at each processor that carried CWTs implanted in smolt at the Moose River in 1998 did not exceed 0.06 (Figure 6). Among plants processing 100 or more coho salmon harvested in the Central District drift gillnet fishery, the proportion did not exceed 0.002. The proportions did not differ radically among processors, and sampling summaries (and harvest estimates) that follow are based on samples pooled among processors.

Central District Drift Gillnet Fishery

During the 1999 fishing season, 64,529 coho salmon were harvested in the Central District drift gillnet fishery. The 1999 harvest was 37% of the 1990–1999 average (Fox and Shields 2000).

The Central District drift gillnet fishery harvest was sampled during most fishing periods between the first open period on June 28 and the last on August 9. Overall, 51% of the harvest was examined. The harvest occurring on days not sampled accounted for 1.4% of the total harvest.

A total of 33,158 fish were examined and positively assigned to drift fishery temporal strata and used to calculate harvest estimates. Of fish examined, 737 (0.022) were missing the adipose fin and heads were collected from 713. Of the 713 heads recovered, 653 had decodable tags. Of these decodable tags, 608 originated from the 1998 annual release of hatchery–produced smolt among multiple Northern District streams, 2 originated from the 1997 release of hatchery–produced smolt from Northern District streams, 1 from a 1996 wild smolt release from the Deshka River, and the remaining 42 were originally implanted in wild smolt emigrating from the Moose River in 1998. Therefore, of the 33,158 fish examined in this fishery, tags implanted at the Moose River in 1998 were physically recovered from 0.0013.

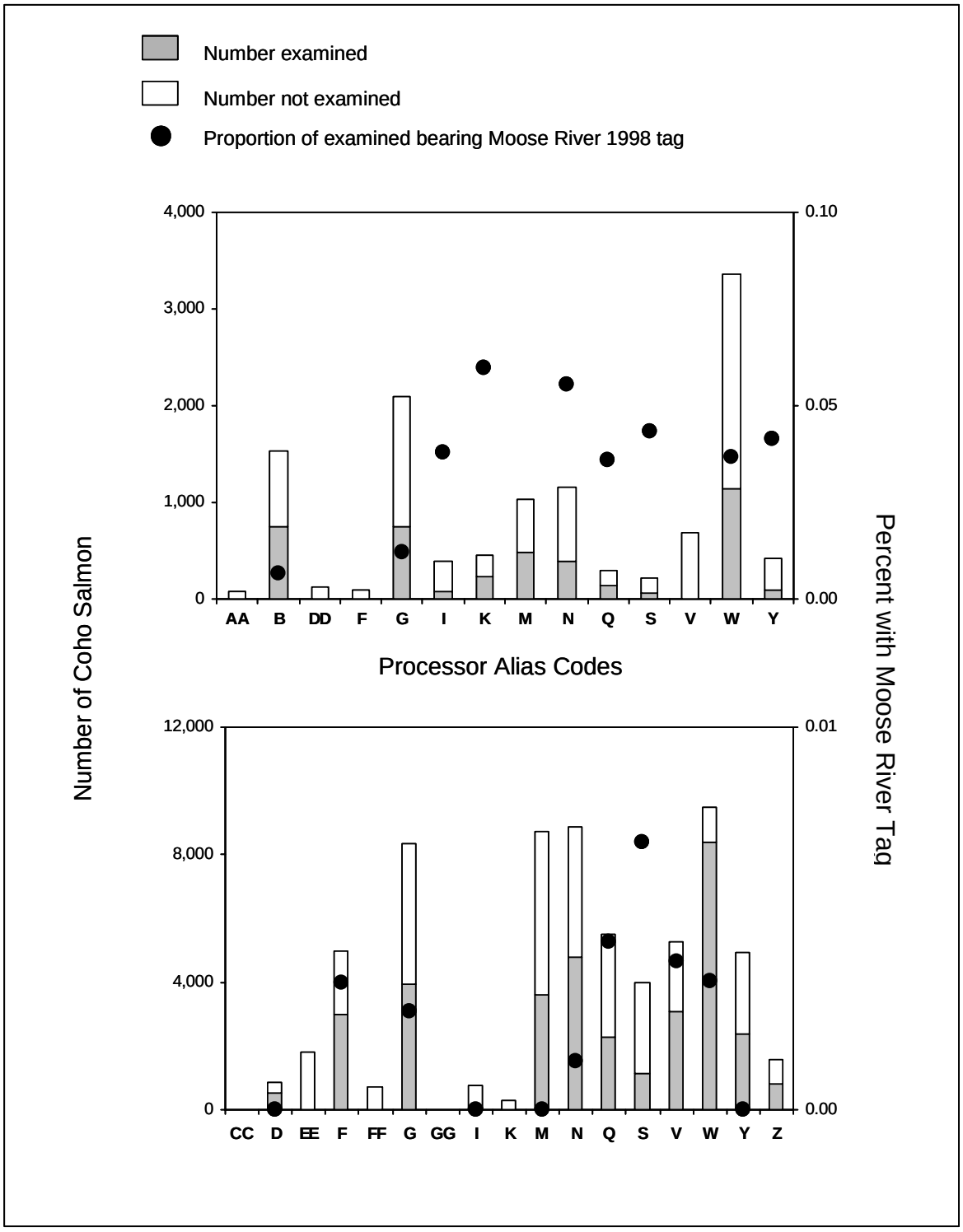

Figure 6.–Number of coho salmon harvested and processed in 1999 in the eastside set gillnet fishery (top) and Central District drift fishery including Alaska Department of Fish and Game Offshore Test Fishery (bottom) of Upper Cook Inlet by commercial processor (alias name), and proportion of examined fish that were originally marked at the Moose River in 1998.

The first recoveries of fish bearing Moose River CWTs occurred on July 19, some 21 days after the first fishing period. Coho salmon marked at the Moose River were recovered on 5 of the 17 sampled days between July 12 and the last open fishing period on August 9.

Central District Eastside Set Gillnet Fishery

During the 1999 fishing season, 11,679 coho salmon were harvested in the Central District eastside set gillnet fishery. The 1999 harvest was 36% of the 1990–1999 average (Fox and Shields 2000).

Between the first open period on July 1 and the last on August 12, the Central District eastside set gillnet fishery harvest was sampled on 19 of the 27 days on which fishing occurred. Overall, 23% of the harvest (4,149 fish) was examined and positively assigned to spatial–temporal strata. The combined eastside harvest occurring on days not sampled accounted for 23% of the total harvest. Coho salmon originating from the Kenai River drainage were found on 10 of the 19 days sampled.

Of the 4,149 fish examined and assigned to fishery strata, 172 (0.053) were missing the adipose fin and heads were collected from all but one. Of the 171 heads recovered, nine (0.06) had no decodable tag. Of the 162 with decodable tags, 33 originated from the 1998 annual release of hatchery–produced smolt among multiple Northern District streams, and the remaining 129 were originally implanted in wild smolt emigrating from the Moose River in 1998. Therefore, of the 4,149 fish examined in this fishery, tags implanted at the Moose River in 1998 were physically recovered from 0.031.

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 8.1% to 8.7% among statistical areas. Coho salmon marked at the Moose River in 1998 were recovered from all statistical areas in 1999. The first recovery of Moose River tags occurred on July 24 in statistical area 24421, on July 27 in statistical areas 24430 and 24440, and on August 2 in statistical area 24422. The portions of fish examined in 1999 that had been marked as smolt at the Moose River in 1998 were 0.041, 0.042, 0.055, and 0.015 for statistical areas 24421, 24422, 24430, and 24440, respectively.

Northern District Gillnet Fisheries

During the 1999 fishing season, a total of 31,436 coho salmon were harvested among all Northern District set gillnet fisheries. The 1999 harvest was 36% of the 1990–1999 average (Fox and Shields 2000).

Sampling of the harvest in the Northern District occurred during most fishery openings beginning on June 6. Although specific Northern District fisheries were not sampled on several days near the beginning and end of the fishing season, collectively, it was sampled the most intensively of all UCI fisheries with 22,605 fish examined (72% of the harvest) from unmixed district samples. The harvest occurring on days not sampled accounted for 1.9% of the total harvest. Coho salmon tagged as smolt in the Kenai River drainage fish were found on 5 of the 17 sampled days.

Of the 22,605 fish examined and assigned to fishery strata, 658 (0.029) were missing the adipose fin and heads were collected from all but 3. Of the 655 heads recovered, 37 (0.056) had no tag, resulting in a total of 618 decodable tags. Of these decodable tags, 604 originated from the 1998 annual release of hatchery–produced smolt among multiple Northern District streams and the

remaining 14 were originally implanted in wild smolt emigrating from the Moose River in 1998. Therefore, of the 22,605 fish examined among Northern District fisheries, tags implanted at the Moose River in 1998 were physically recovered from 0.06.

Commercial Harvest Estimates

Based on commercial catch sampling data and the point estimate of the tagged proportion of the 1999 adult return to the Kenai River, a set of commercial harvest estimates was generated for UCI commercial fisheries in 1999. An estimated 820 (SE = 134) coho salmon of Kenai River origin were harvested by the Central District drift gillnet fishery (Table 3), 2,928 (SE = 297) by the Central District eastside set gillnet fishery (Table 4), and 171 (SE = 49) by all Northern District set gillnet fisheries (Appendix A6) for a total of 3,919 (SE = 330) during 1999. Coho salmon of Kenai River origin comprised 1.3% of the total drift gillnet harvest, 25.1% of the total eastside set gillnet harvest, and 0.5% of the total Northern District set gillnet harvest in 1999.

Table 3.–Estimated harvest, and associated standard errors, of coho salmon of Kenai River origin in the commercial drift gillnet fishery of the Central District of Upper Cook Inlet during selected time intervals, 1999.

Interval	Total Harvest	Estimated Harvest of Coho Salmon of Kenai River Origin	Standard Error	Portion of Total Harvest
06/28 – 07/12	720	0		
07/13 – 07/22	16,285	17		
07/23 – 07/29	20,593	99	41	0.005
07/30 – 08/09	26,931	704	127	0.026
Total	64,529	820	134	0.013

The first coho salmon of Kenai River origin were detected in the Central District drift gillnet harvest on July 19. The contribution of Kenai River origin fish to the harvest was minimal throughout the commercial drift gillnet season with the greatest proportional contribution (1.7%) occurring during the last 2 days of July and the first 9 days in August (Figure 7).

The first coho salmon of Kenai River origin were detected in the Central District eastside set gillnet harvest on July 24. The harvest of 957 coho salmon before July 19 represents 8% of the total harvest in this fishery. In general, the portion of the harvest comprised of coho salmon of Kenai River origin and the total harvest was greater during the latter half of the fishing season (Figure 8).

Table 4.–Total harvest and estimated contribution of coho salmon of Kenai River origin to the eastside set gillnet fishery of Upper Cook Inlet by statistical area and selected time intervals, 1999.

Interval	Total Harvest	Estimated Contribution	Standard Error	Portion of Total Harvest
		Statistical Area 244–21		
06/28 – 07/12	18	0		
07/13 – 07/22	197	0		
07/23 – 07/29	345	40	29	0.116
07/30 – 08/09	1,589	562	102	0.354
Total	2,149	602	106	0.280
		Statistical Area 244–22		
06/28 – 07/12	17	0		
07/13 – 07/22	212	0		
07/23 – 07/29	357	0	0	
07/30 – 08/09	2,356	1,000	198	0.424
Total	2,942	1,000	198	0.340
		Statistical Area 244–30		
06/28 – 07/12	26	0		
07/13 – 07/22	173	0		
07/23 – 07/29	145	22	22	0.152
07/30 – 08/09	2,014	843	165	0.419
Total	2,358	865	167	0.367
		Statistical Area 244–40		
06/28 – 07/12	32	0		
07/13 – 07/22	283	0		
07/23 – 07/29	502	48	48	0.096
07/30 – 08/09	3,413	413	89	0.121
Total	4,230	461	101	0.109
		Combined Statistical Areas		
06/28 – 07/12	93	0		
07/13 – 07/22	865	0		
07/23 – 07/29	1,349	110	98	0.082
07/30 – 08/09	9,372	2,818	554	0.301
Total	11,679	2,928	297	0.251

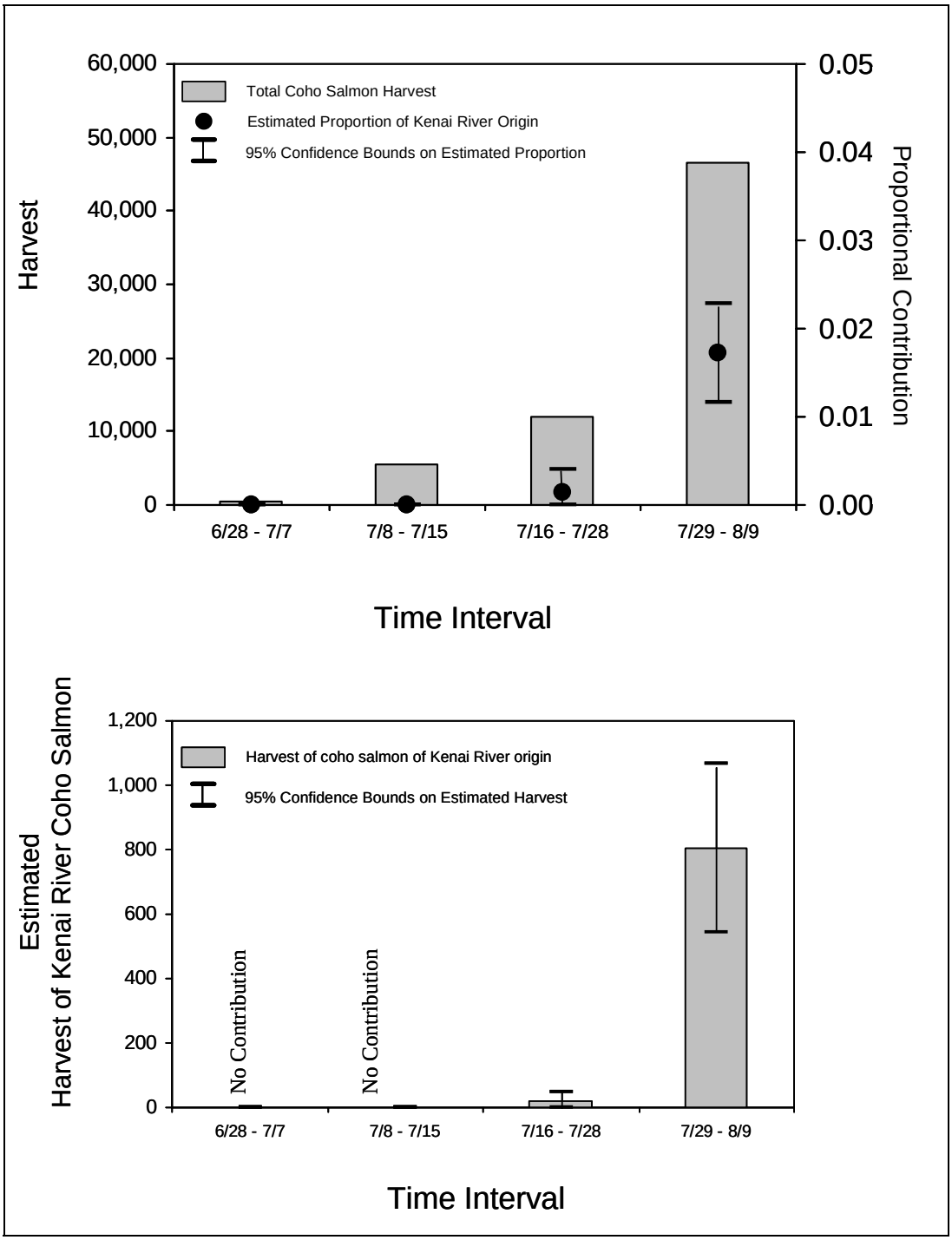

Figure 7.–Temporal trend in proportional contribution of Kenai River coho salmon to the total harvest (top) and trend in absolute contribution (bottom) occurring in the drift gillnet fishery of the Central District of Upper Cook Inlet, 1999.

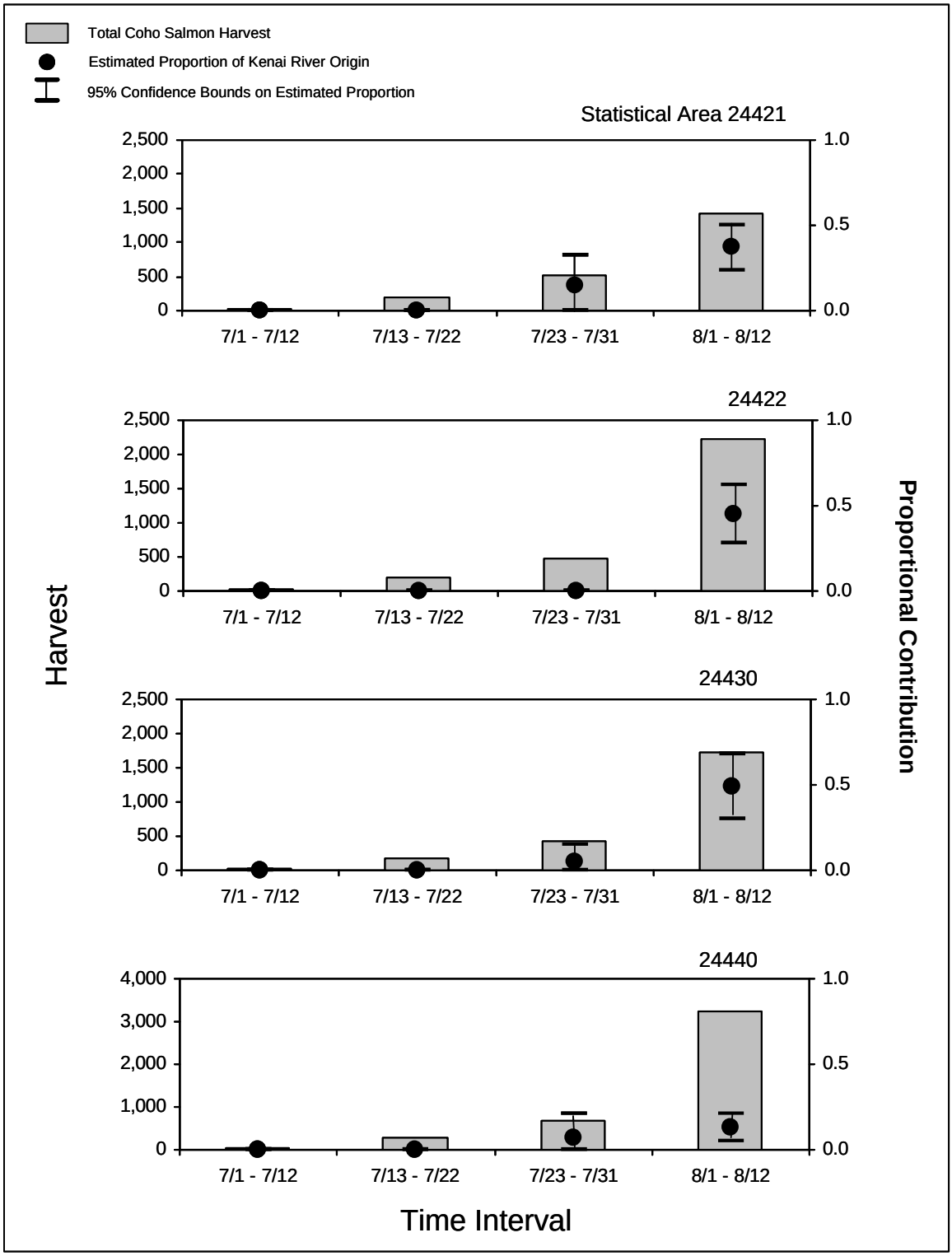

Figure 8.–Temporal trends in total harvest of coho salmon and proportional contribution of coho salmon from the Kenai River to the total harvest occurring in four statistical areas of the Upper Cook Inlet Central District eastside set gillnet fishery during four selected time periods in 1999.

The total coho salmon harvest occurring in the Central District eastside set gillnet fishery ranged from 2,149 in statistical area 24421 to 4,230 in statistical area 24440 (Figure 9). The portion of the seasonal harvest comprised of coho salmon of Kenai River origin ranged from 10.9% to 36.7%.

Meaningful temporal or geographic trends occurring in Northern District commercial fisheries were not detectable because of the inconsequential harvest of 171 coho salmon of Kenai River origin. Only 14 fish bearing a CWT from the Kenai River drainage were detected in the combined Northern District set gillnet fishery, 12 of which came from the eastside set area. The first recovery of a CWT from an adult tagged as a smolt in 1998 at the Moose River occurred on August 9, 1999.

Effect of Variations of the Tagged Proportion on Commercial Harvest Estimates

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

A test 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 (0.121), the minimum proportion from the first 5 weeks (0.097), and the maximum proportion from the last 5 weeks (0.179). The minimum and maximum harvest estimates represent extreme–case scenarios. The minimum and maximum harvest estimates differed from the pooled estimate by +24% and –32%, respectively.

DISCUSSION

COMMERCIAL HARVEST

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

The similarity between the largest point estimate of commercial harvest (4,863) and the commercial harvest estimated under the pooled scenario (3,919), relative to harvest magnitudes and total return, illustrates the intrinsic value of the estimates regardless of the potential bias. The largest estimate represents 4.5% of the total UCI commercial harvest (excluding the Central District areas of Kalgin Island set and the westside set where interception of Kenai River–bound coho salmon is negligible) and 3.6% under the pooled scenario. The similarity reveals the small part that the Kenai River population plays in the overall UCI coho salmon commercial harvest. Managers can reliably state that less than about 4.5% (upper bound of 95% confidence interval associated with lowest tagged proportion) of the 1999 UCI commercial harvest is of Kenai River origin. The largest estimate also represents 7.5% of the 1993–1998 average combined sport and personal use harvest of coho salmon from the Kenai River and 6.1% under the pooled scenario, showing that within Kenai River specific harvests, the commercial harvest was relatively small.

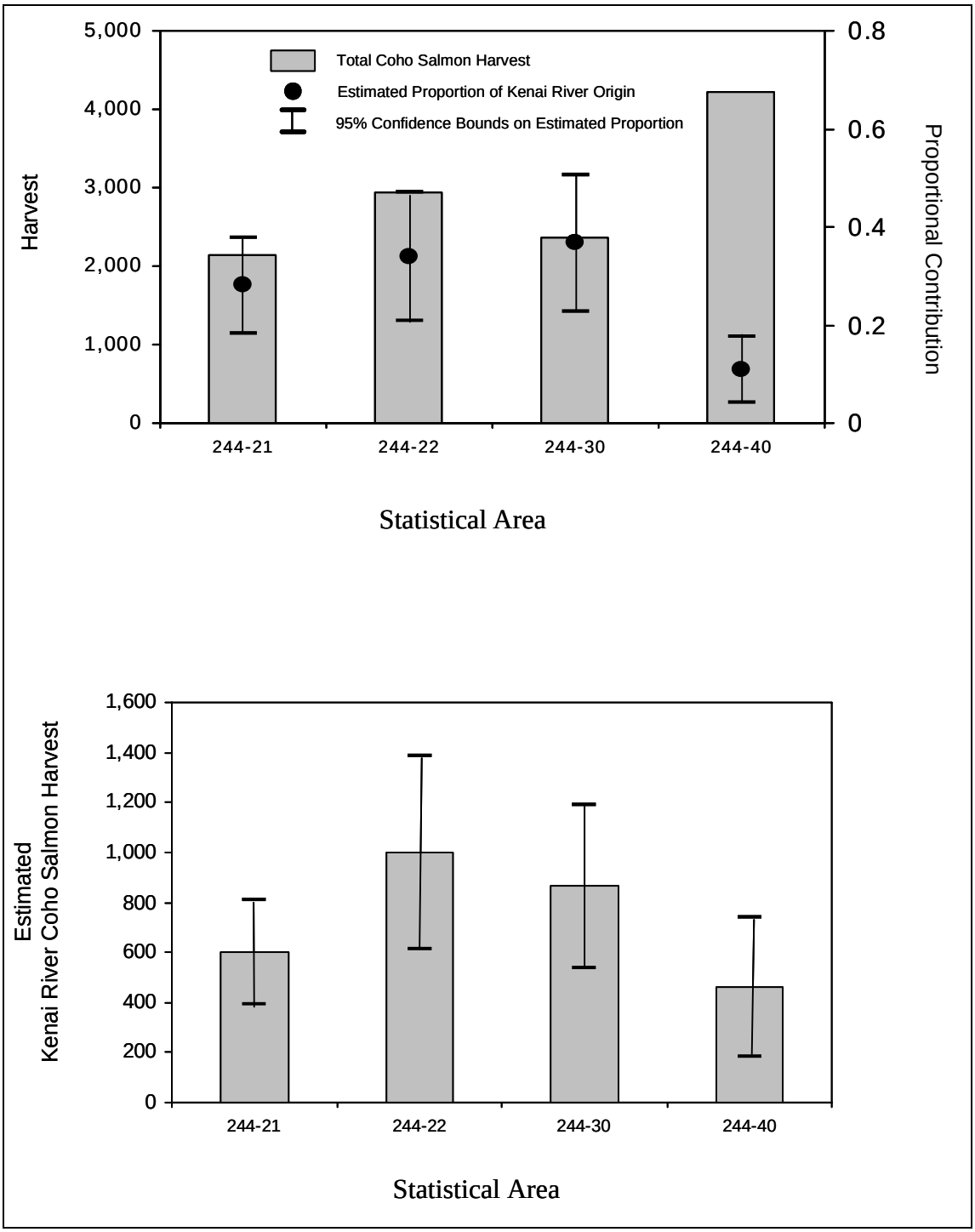

Figure 9.–Geographic trends in total coho salmon harvest and proportional contribution of coho salmon of Kenai River origin (top) and in estimated number of coho salmon of Kenai River origin (bottom) harvested among statistical areas in the eastside set gillnet fishery of the Central District of Upper Cook Inlet, 1999.

Table 5.–Sensitivity of 1999 commercial harvest estimates to variations in the tagged proportion.

Fishery	Total Harvest	Pooled Marked Proportion (0.121) Estimated Contribution [c]	Marked Proportion: Minimum [a] (0.097) Estimated Contribution [c]	Difference from Pooled	% Difference from Pooled	Difference from Pooled as % of Total Harvest	Marked Proportion: Maximum [b] (0.179) Estimated Contribution [c]	Difference from Pooled	% Difference from Pooled	Difference from Pooled as % of Total Harvest
Central District Drift Gillnet	64,529	820	1,017	197	24%	0.3%	554	–266	–32%	0.4%
Central District Eastside Set Gillnet [d]										
244–21	2,149	602	746	144	24%	6.7%	408	–194	–32%	9.0%
244–22	2,942	1,000	1,241	241	24%	8.2%	677	–323	–32%	11.0%
244–31/32	2,358	865	1,075	210	24%	8.9%	584	–281	–32%	11.9%
244–41/42	4,230	461	573	112	24%	2.6%	312	–149	–32%	3.5%
Combined	11,679	2,928	3,635	707	24%	6.1%	1,981	–947	–32%	8.1%
Northern District Set Gillnet	31,436	171	211	40	23%	0.1%	117	–54	–32%	0.2%
Total [e]	107,644	3,919	4,863	944	24%	0.9%	2,652	–1,267	–32%	1.2%

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

[b] The maximum marked proportion determined from the pooled fish wheel data collected from September 5 to October 8.

[c] Kenai River population–specific harvest estimate.

[d] By statistical area and combined areas.

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

The point estimate of commercial harvest of Kenai River–bound coho salmon in the two Central District fisheries in 1999 was 3,748 and represented 27.4% of the 1993–1998 average (Table 6). Reasons for the below–average harvest likely include a below–average adult return coupled with restrictions imposed on commercial fisheries starting in 1997, when the Kenai River Coho Salmon Management Plan was first adopted (Carlon 2000).

Table 6.–Harvest of all coho salmon and coho salmon of Kenai River origin in selected UCI marine commercial fisheries, 1993–1999.

	Central District				Northern District			
	Drift		Eastside Set		Set		Total	
Year	All	Kenai River	All	Kenai River	All	Kenai River	All	Kenai River
1993	121,829	930	43,098	6,806	106,294	148	271,221	7,884
1994	310,114	11,732	68,449	14,673	144,064	477	522,627	26,882
1995	241,473	6,956	44,750	13,152	89,300	582	375,523	20,690
1996	171,434	2,671	40,724	11,856	78,105	29	290,263	14,556
1997	78,662	1,236	19,668	2,093	37,369	36	135,699	3,365
1998	83,338	1,974	18,677	8,096	34,359	175	136,374	10,245
Average	167,808	4,250	39,228	9,446	81,582	241	288,618	13,937
1999	64,529	820	11,679	2,928	31,436	171	107,644	3,919

Note: Sources of harvest of Kenai River–specific coho salmon are: Carlon 2000, 2003; Carlon and Hasbrouck 1996–1998.

A substantial portion of the commercial harvest of Kenai River–bound coho salmon typically occurs during the last week of July and the first week of August in the Central District drift gillnet fishery and the first week of August in the Central District eastside set gillnet fishery (Carlon 2000, 2003; Carlon and Hasbrouck 1996, 1997). The restrictions imposed by the management plan likely had their intended conservation effect of reducing the Kenai River population–specific harvest in commercial fisheries in 1999. The Kenai River population comprised a minority of the total harvest in Central District commercial fisheries for the seventh year in a row (Figure 10), and since the restrictions were first imposed in 1997, the commercial harvest of Kenai River–bound coho salmon has been lower than average. The inconsequential harvest of the Kenai River population (171 coho salmon) in Northern District fisheries was typical of most years (Carlon 2000, 2003; Carlon and Hasbrouck 1996, 1997).

There is concern that if the marked component of the coho salmon harvest in UCI commercial fisheries is removed from catches prior to sale (and therefore unavailable for inspection of an adipose fin and head recovery), the contribution estimates from that harvest would be biased low. Currently, there is no means to ensure that marked coho salmon caught commercially in Cook Inlet are all available at buying stations and processors. However, all salmon not sold but kept as "personal use" fish are required to be recorded on a fish ticket. Fish ticket data indicate that personal use coho salmon comprised 0.5% of the overall 1999 commercial harvest of coho salmon in UCI. In a hypothetical situation in which every UCI personal use coho salmon caught with commercial gear in 1999 (577) had an adipose clip, and assuming the rates for tag loss and Kenai River origin tags was identical to that observed from head recoveries from processors,

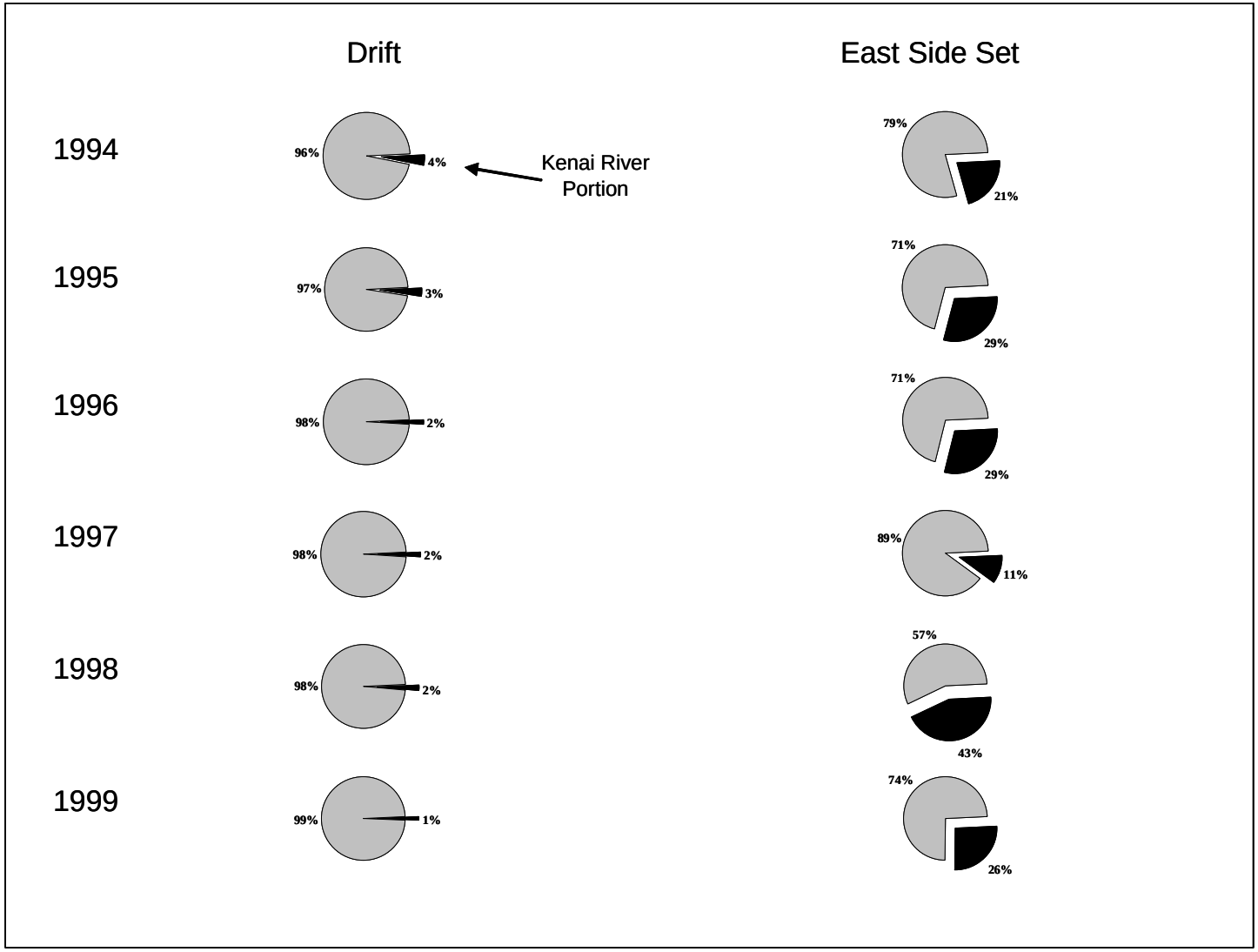

Figure 10.–Contribution of coho salmon from the Kenai River to the drift and eastside set gillnet commercial fisheries of Upper Cook Inlet, 1994–1999.

then the potential exists for the Kenai River commercial harvest contribution estimate to inflate by 37%.

The Alaska Department of Fish and Game Commercial Fish Division conducts annual offshore test drift gillnetting at six locations across the lower UCI Central District to assess and index the strength of the sockeye return throughout the commercial fishing season. Coho salmon incidentally caught in this sampling are inspected for an adipose fin. To date, there has not been an overall higher marking rate (missing adipose fin) for coho salmon in the test netting catches than for catches observed in the overall commercial harvest in UCI. This suggests that selective sorting of commercially caught coho salmon for personal use is not a major problem.

Finally, the Russian River weir likely provided a nearly complete census of the adult coho salmon return to that location in 1999. Daily coho salmon fish passage during the last week of weir operation (October 1–7) totaled 63 fish or 2.1% of the cumulative passage. In 1994, the weir was operated 9 days longer than in 1999 and only 23 coho passed the weir during October 8–16.

SMOLT ABUNDANCE

History

The record of estimated smolt abundance has become an important element of the stock 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 in the spring of 1997. At that time, the first Kenai River–specific management plan was developed, adopted into regulation, and implemented.

The 1999 smolt abundance estimate represents the eighth annual estimate since 1992 (Figure 11). Smolt abundance estimates had been the sole population assessment "barometer" from 1995 to 1998, when smolt abundance had been identified as an alternative to an adult–based population assessment. Developing a time series of harvest estimates and resulting smolt abundance estimates was acknowledged as a long–term endeavor, and was favored because of the lack of success in estimating adult abundance and the potentially high cost of implementing a project to do so. However, the weak 1997 return and the resultant inseason fishery restrictions renewed interest in estimates of adult inriver abundance. A study was conducted in 1998 to test the feasibility of estimating adult abundance. Beginning in 1999, a full–scale mark–recapture experiment to estimate the adult population size was conducted. 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.

Relationship Between Total Harvest and Smolt Abundance

In addition to the seven annual smolt abundance estimates between 1993 and 1999, annual estimates of total adult harvest have also been made (Table 7 and Figure 12). The pairing of these two records produces four pairs of harvest and smolt abundance estimates (Figure 13). The 1999 smolt abundance estimate, when paired with the 1996 total harvest estimate, represents the fourth such pair available to date. While the relationship does not clearly identify a threshold harvest beyond which smolt abundance is significantly, negatively, and consistently impacted, it suggests that the record adult harvest in 1994 may have been excessive. At the very least, it is associated with the 1997 smolt production (Carlon 2003) which is the lowest on record. This

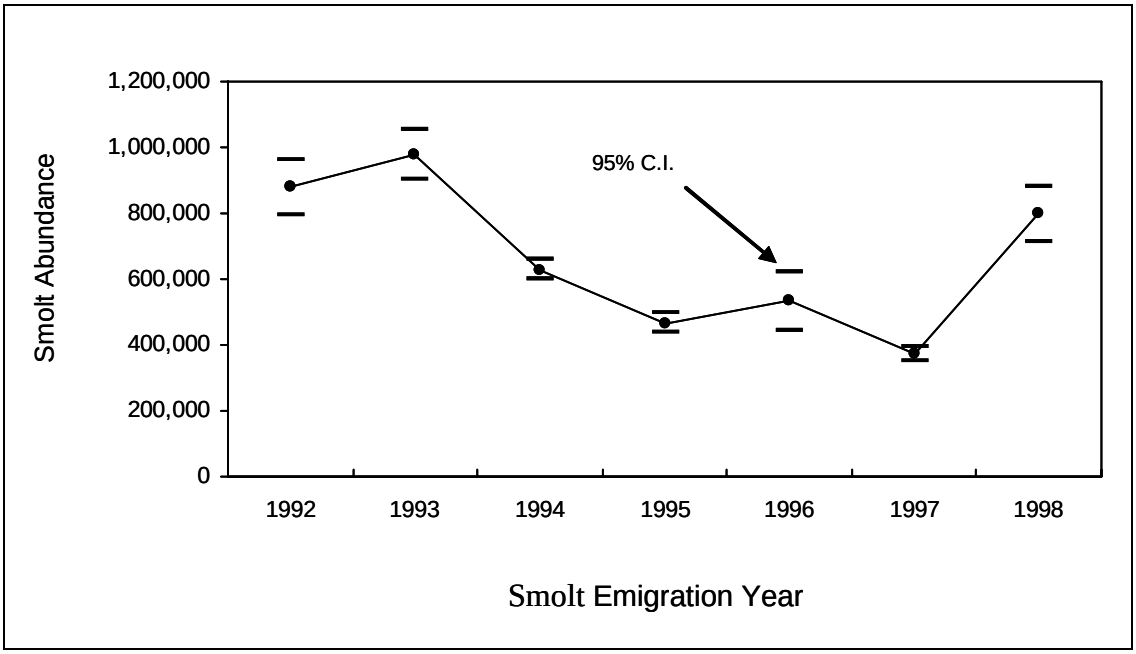

Figure 11.–Estimates of coho salmon smolt abundance in the Kenai River, 1992–1998.

also suggests that some of the precautionary measures adopted under the Kenai River Coho Salmon Conservation Management Plan should be retained until additional information demonstrates that surplus yield is available. Monitoring the adult harvest–smolt relationship as additional pairs of estimates accrue annually is necessary to determine whether it will be practical for identifying a harvest guideline management objective. This relationship, and others developed from the accrual of information from the ongoing assessment program, will eventually provide information with which to modify the management plan or formulate quantitative management objectives.

RECOMMENDATIONS

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

The long–term relationship between total annual fishing mortality and smolt abundance should be monitored to determine if harvest levels are influencing smolt production. Currently, only four pairs of estimates are available and it is not yet possible to establish a link between adult harvest and smolt production. The record harvest of 1994 is 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 relating harvest to smolt production. The record harvest of 1994 demonstrates the substantial harvest potential of sport and commercial fisheries in UCI. More immediate assessment

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

	Inriver											
	Sport[a]					Personal		UCI Marine Commercial[b]				
	Mainstem			Russian		Use/	Inriver	Eastside	Drift	Northern	Commercial	Grand
Year	Unguided[a]	Guided	Total	River	Total	Subsistence	Total	Set Gillnet	Gillnet	District	Total	Total
1993	26,805	23,743	50,548	2,290	52,838	1,597 [c]	54,435	6,806	930	148	7,884	62,319
1994	45,623	41,170	86,793	4,607	91,400	2,535 [d]	93,935	14,673	11,732	477	26,882	120,817
1995	22,663	23,587	46,250	4,077	50,327	1,261 [e]	51,588	13,152	6,956	582	20,690	72,278
1996	28,764	13,728	42,492	4,599	47,091	1,932 [f]	49,023	11,856	2,671	29	14,556	63,579
1997	13,063	3,101	16,164	4,586	20,750	559 [f]	21,309	2,093	1,236	36	3,365	24,674
1998	21,750	5,217	26,967	4,612	31,579	1,011 [f]	32,590	8,096	1,974	175	10,245	42,835
1999	23,550	8,087	31,637	3,910	20,750	1,009 [f]	21,309	11,679	820	171	12,670	24,674
1993–98 Average	26,445	18,424	44,869	4,129	48,998	1,483	50,480	9,446	4,250	241	13,937	64,417

[a] Source is Statewide Harvest Survey (Howe et al. 1995, 1996, 2001a–d; Mills 1994).

[b] Carlon 2000, 2003; Carlon and Hasbrouck 1996–1998.

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

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

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

[f] Reimer and Sigurdsson 2004.

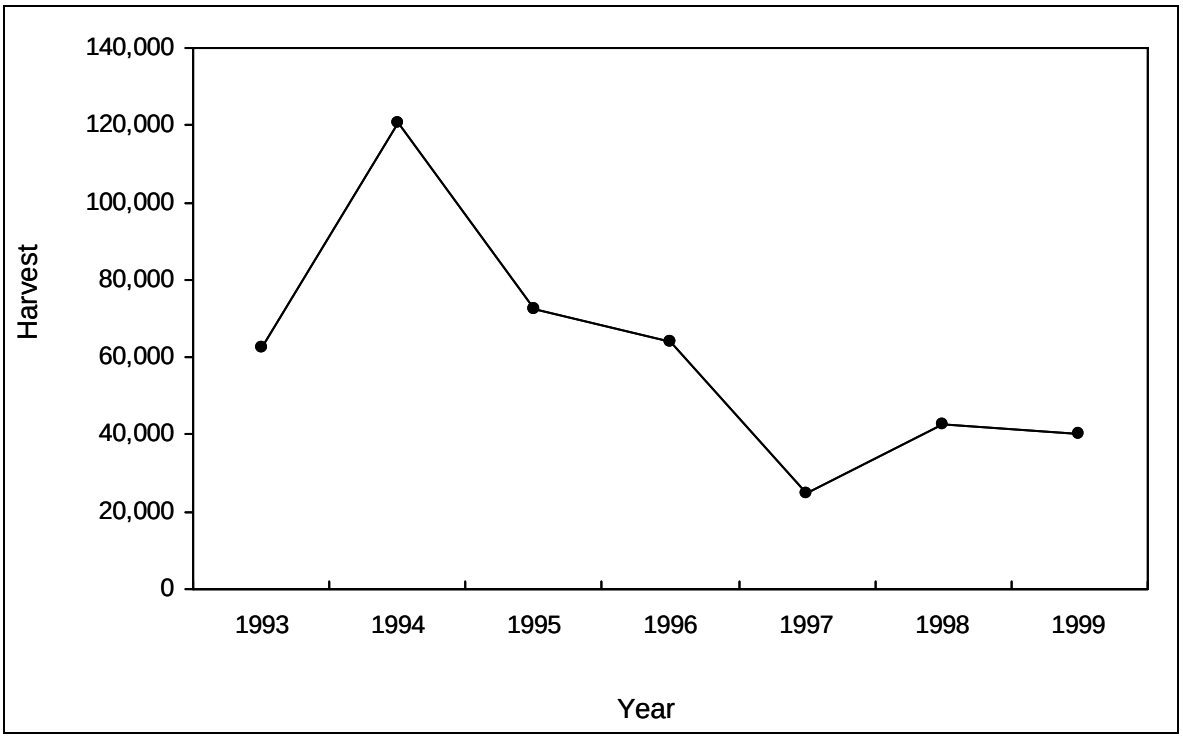

Figure 12.–Estimates of total harvest of coho salmon of Kenai River origin, 1993–1999.

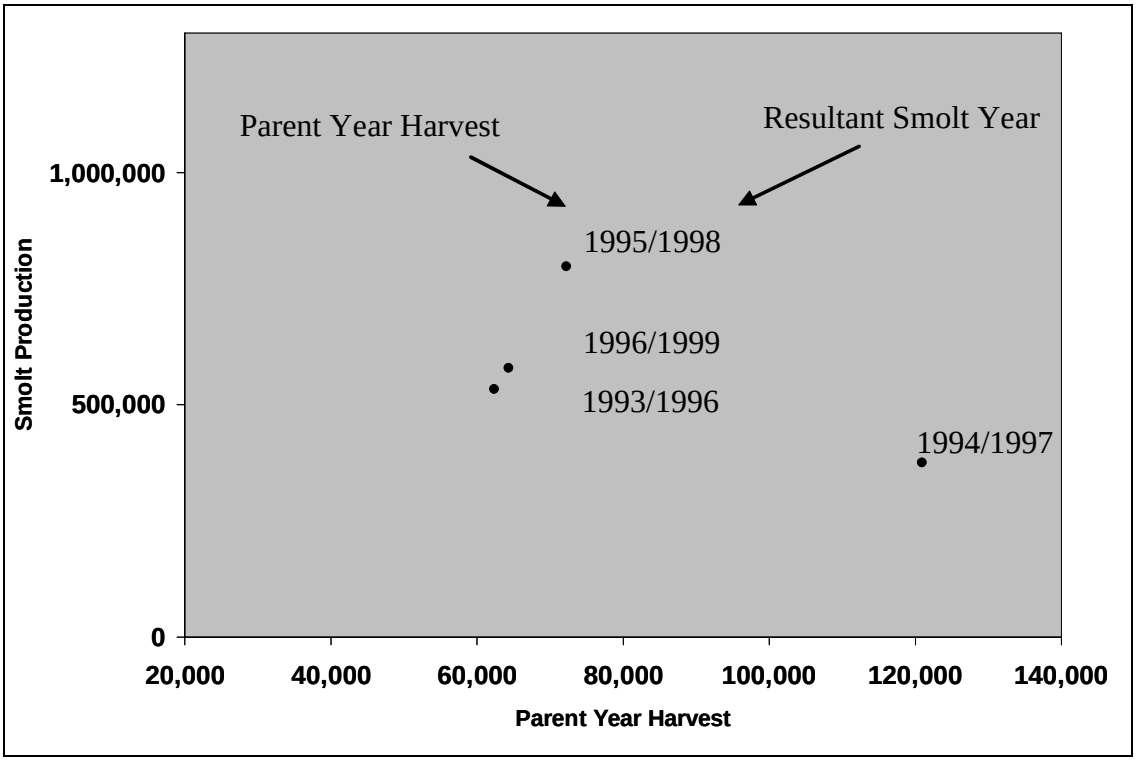

Figure 13.–Parent year harvest and smolt production for coho salmon from the Kenai River, Alaska.

information is desired to supplement the long–term approach. The mark–recapture experiment initiated in 1998 (and repeated in 1999) should be continued to enhance the assessment of the coho salmon population from the Kenai River.

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The commercial harvest was examined in 1999 by technicians of the Commercial Fisheries Division (CFD). Kim Rudge–Karic supervised commercial harvest sampling, provided logistical support, and collated commercial sampling data. Personnel of the CFD Mark, Tag, and Aging Laboratory in Juneau processed all CWT data collected in 1998 and 1999. All CFD personnel contributed to the successful achievement of study objectives.

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APPENDIX A

Appendix A1.–Number of wild coho salmon smolt captured from the Moose River, marked with an adipose finclip and coded wire tag, and released in 1998, and tag codes identified in the sample of 185 Moose River tagged fish recovered from known, unmixed UCI commercial fishery strata in 1999.

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 1999 [d]
312719	05/24	05/30	10,759	100.0%	10,757	99.8%	10,735	22
312720	05/30	06/01	11,282	99.8%	11,263	99.3%	11,184	22
312721	05/31	06/02	11,132	100.0%	11,132	99.9%	11,121	29
312722	06/01	06/04	11,198	100.0%	11,198	99.3%	11,120	14
312723	06/03	06/05	11,342	99.6%	11,296	99.1%	11,194	28
312724	06/04	06/06	11,362	100.0%	11,362	99.8%	11,339	13
312725	06/05	06/07	11,326	99.8%	11,308	99.6%	11,263	20
312726	06/06	06/09	11,473	100.0%	11,468	99.7%	11,434	17
312727	06/08	06/10	11,349	100.0%	11,349	99.9%	11,338	20
Total			101,223	99.9%	101,133	99.6%	100,728	185

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

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

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

[d] Number of tags physically recovered from known fishery areas of UCI by commercial fishing in 1999 and positively decoded as Moose River coho salmon released in 1998.

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, 1999.

	August					September			
Date	Number Captured and Examined	Marked Fish Observed[a]	Marked Fish Checked with Tag Detector[b]	Coded Wire Tag Detected	Date	Number Captured and Examined	Marked Fish Observed[a]	Marked Fish Checked with Tag Detector[b]	Coded Wire Tag Detected
				North Bank					
08/01					09/01	3			
08/02					09/02	1			
08/03					09/03				
08/04	1				09/04	1	1	1	1
08/05					09/05	1			
08/06	2				09/06				
08/07	4	1	1		09/07	1			
08/08	3	1	1	1	09/08	3	1	1	1
08/09	6	1	1	1	09/09	1			
08/10	2			1	09/10	2			
08/11	4	1			09/11	1	1	1	1
08/12	4	2	2		09/12	3	1	1	1
08/13	7	1	1	2	09/13	4			
08/14	10			1	09/14	10	1	1	1
08/15	16	2	2		09/15	3	1	1	1
08/16	13	2	2	2	09/16	2			
08/17	6	2	2	2	09/17	4	1	1	1
08/18	3	1	1	2	09/18	10	1	1	1
08/19	5			1	09/19	18	6	6	6
08/20					09/20	20	3	3	3
08/21	4	3	3		09/21	15	4	3	3
08/22	14	3	3	3	09/22	14	4	4	4
08/23	1	1	1	3	09/23	4			
08/24	2	1	1	1	09/24	3	1	1	1
08/25	4	1	1	1	09/25	5	1	1	1
08/26	2			1	09/26	5	2	2	2
08/27	4				09/27	3			
08/28	5	1	1		09/28	6			
08/29	2			1	09/29	6			
08/30	5	1	1		09/30	1			
08/31	2								
Subtotal	131	25	24	23		150	29	28	28
North Bank Subtotal						281	54	52	51

–continued–

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Date	August: Number Captured and Examined	August: Marked Fish Observed[a]	August: Marked Fish Checked with Tag Detector[b]	August: Coded Wire Tag Detected	Date	September: Number Captured and Examined	September: Marked Fish Observed[a]	September: Marked Fish Checked with Tag Detector[b]	September: Coded Wire Tag Detected
South Bank									
08/01					09/01	2	1	1	1
08/02					09/02	3			
08/03					09/03	2			
08/04					09/04	2			
08/05					09/05	1			
08/06					09/06	2			
08/07	1				09/07	1			
08/08					09/08				
08/09	1				09/09				
08/10					09/10				
08/11					09/11				
08/12	1				09/12				
08/13					09/13				
08/14	1				09/14				
08/15	2				09/15	1	1	1	1
08/16	4				09/16				
08/17	7				09/17				
08/18	11	2	2	1	09/18	2			
08/19	18	4	4	4	09/19				
08/20	14	3	3	3	09/20				
08/21	12				09/21				
08/22	20	1	1	1	09/22				
08/23	13	1	1		09/23				
08/24	6				09/24				
08/25	5				09/25				
08/26	5	1	1	1	09/26				
08/27	8	1	1	1	09/27				
08/28	8				09/28				
08/29	1				09/29				
08/30	2				09/30				
08/31	6								
Subtotal	146	13	13	11		16	2	2	2
South Bank Subtotal						162	15	15	13
Grand Total (both banks)						443	69	67	64

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

[b] Captured coho salmon that were missing an adipose fin and were checked for the presence of a coded wire tag 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 (drift gillnetting and fish wheels) and examined for a missing adipose fin on the Kenai River between river kilometer 35 and 50 from August 1 to October 8, 1999.

	Fish Wheel Effort					
	August–September					
Date[a]	Number Captured and Examined	Marked Fish Observed[b]	Number Captured and Examined	Marked Fish Observed[b]	Number Captured and Examined	Marked Fish Observed[b]
	North Bank		**South Bank**		**Ambiguous Bank**	
08/01						
08/02						
08/03						
08/04						
08/05						
08/06						
08/07						
08/08						
08/09						
08/10			8	1		
08/11			1			
08/12						
08/13						
08/14						
08/15						
08/16						
08/17			3	1		
08/18			6			
08/19			22	1		
08/20			5	1		
08/21			8	2		
08/22			5			
08/23			10	1		
08/24			23	3		
08/25			16	2		
08/26	2	2	19	3		
08/27						
08/28						
08/29	4					
08/30						
08/31	5					
09/01	8	3	1			
09/02	11		2	2		
09/03	7	2	1			
09/04	3					
09/05	2	1				
09/06	4	1				
09/07	4	1				
09/08	2					

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Fish Wheel Effort						
	August–September					
Date[a]	Number Captured and Examined	Marked Fish Observed[b]	Number Captured and Examined	Marked Fish Observed[b]	Number Captured and Examined	Marked Fish Observed[b]
	North Bank		**South Bank**		**Ambiguous Bank**	
09/09	1					
09/10	3					
09/11	4					
09/12	5	2				
09/13						
09/14	25	6	8			
09/15	5					
09/16	9	2	1	1		
09/17	11	3	3			
09/18	1		9	6		
09/19	6		8	2		
09/20	5					
09/21	5	1	1			
09/22						
09/23	1		2	1		
09/24			3			
09/25						
09/26	6	2				
09/27	3	1	2			
09/28	1		2	1		
09/29			1			
09/30	3		1			
10/01	4		1			
10/02	19	5	1			
10/03	7	3				
10/04	20	3				
10/05	9	1				
10/06	8	2				
10/07	10	1				
10/08	4					
Total	227	42	173	28	0	0
Grand Fish Wheel Total	400	70				

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Drift Gillnetting Effort						
	August–October 8					
Date[a]	Number Captured and Examined	Marked Fish Observed[b]	Number Captured and Examined	Marked Fish Observed[b]	Number Captured and Examined	Marked Fish Observed[b]
	North Bank		**South Bank**		**Ambiguous Bank**	
08/01						
08/02						
08/03						
08/04						
08/05						
08/06						
08/07						
08/08						
08/09						
08/10			1		5	
08/11						
08/12						
08/13						
08/14					8	
08/15			2		9	
08/16	5	1	9	1		
08/17					39	1
08/18					98	4
08/19					81	6
08/20					101	9
08/21	4		24	1	51	3
08/22	40	5	33	3		
08/23	23	4	41	3		
08/24	29	5	33	4		
08/25	30	2	45	4		
08/26	12	1	67	7		
08/27	20	2	48	1		
08/28	26	1	25	3		
08/29	35	4	12	1		

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Drift Gillnetting Effort						
	August–October 8					
Date[a]	Number Captured and Examined	Marked Fish Observed[b]	Number Captured and Examined	Marked Fish Observed[b]	Number Captured and Examined	Marked Fish Observed[b]
	North Bank		**South Bank**		**Ambiguous Bank**	
08/30	24	3	30	3		
08/31	24	4	15	2		
09/01	22	5	23	2		
09/02	7	1	72	5		
09/03	7	1	19	1		
09/04	4	1	8	1		
09/05	9	1	13	1		
09/06	16	4	20	1		
09/07	25	3	14	3		
09/08	6	1	11	1		
09/09	20	8	7	1		
09/10	4	1	26	2		
09/11	5	2	22			
09/12	5	1				
09/13						
09/14	13	4	9	2		
09/15	9	2				
09/16			11	3		
09/17	8	2	6	2		
09/18	4		1			
09/19	5		1			
09/20	4		3			
09/21	6	1	3	2		
09/22	4	1	5			
09/23	7	1	3	2		
09/24			4			
09/25	2		9			
09/26	6	2	1			
09/27	4		3			
09/28	2	1				
09/29	3		3	1		
09/30	6	2	3			
10/01	2		7			
10/02	1		4			
10/03	9	1	2			
10/04	9	1	1	1		
10/05	11	1	6	3		
10/06	7	2	3			
10/07	2		2	1		
10/08	5	1				
Total	531	83	710	68	392	23
Grand Gillnetting Total	Combined Banks 1,633	174				
Grand All Recapture Efforts Total	2,033	244				

[a] Recapture event operational from August 1 to October 5, 1999.

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

Appendix A4.–Daily summary of coho salmon adults examined at the Russian River weir, June 11–October 4, 1999.

Date[a]	Weir Count	Examined	Marked Fish Observed [b]	Date	Weir Count	Examined	Marked Fish Observed [b]
8/1	0			9/1	46	43	3
8/2	0			9/2	33	32	1
8/3	0			9/3	35	34	1
8/4	0			9/4	75	67	8
8/5	0			9/5	168	154	14
8/6	0			9/6	103	90	13
8/7	0			9/7	139	122	17
8/8	2	2		9/8	179	167	12
8/9	0			9/9	157	142	15
8/10	0			9/10	32	31	1
8/11	1	1		9/11	72	66	6
8/12	0			9/12	92	88	4
8/13	4	4		9/13	381	356	25
8/14	8	6	2	9/14	123	118	5
8/15	4	4		9/15	85	78	7
8/16	10	10		9/16	226	212	14
8/17	16	15	1	9/17	61	58	3
8/18	21	18	3	9/18	0	0	0
8/19	17	16	1	9/19	69	63	6
8/20	20	19	1	9/20	12	11	1
8/21	33	31	2	9/21	0	0	0
8/22	23	22	1	9/22	143	143	
8/23	19	18	1	9/23	70	67	3
8/24	37	33	4	9/24	19	16	3
8/25	34	34	0	9/25	14	14	0
8/26	48	45	3	9/26	5	5	0
8/27	43	40	3	9/27	7	6	1
8/28	40	38	2	9/28	13	13	0
8/29	40	38	2	9/29	8	7	1
8/30	53	51	2	9/30	5	5	0
8/31	43	39	4	10/1	33	32	1
				10/2	25	25	0
				10/3	5	5	0
				10/4	0	0	0
Subtotal	516	484	32	Subtotal	2,435	2,270	165
				Grand Total	2,951	2,754	197

[a] Weir was operated from June 11 to October 4, 1999, but the first coho salmon did not arrive at the weir until August 8, 1999.

[b] 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 1999.

Date	Statistical Areas	(n_i) Number Examined	(a_i) Adipose–clips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags	(t'_i) Decodable Tags	(m_i) Source= Moose R 1998
			Mixed Central District Statistical Areas				
East Side Set							
7/27	Mixed(ESS)	4	0				
7/29	Mixed(ESS)	6	0				
7/30	Mixed(ESS)	11	0				
8/3	Mixed(ESS)	4	0				
8/4	Mixed(ESS)	53	4	4	3	3	1
8/5	Mixed(ESS)	20	1	1	1	1	1
8/9	Mixed(ESS)	117	10	10	10	10	7
8/12	Mixed(ESS)	50	7	7	6	6	5
Total		265	22	22	20	20	14
West Side and Kalgin Island Set							
7/19	Mixed(WSS/KIS)	701	11	11	11	11	0
7/22	Mixed(WSS/KIS)	601	9	9	7	7	0
8/5	Mixed(WSS/KIS)	551	13	13	13	13	1
8/9	Mixed(WSS/KIS)	1,449	21	21	20	20	1
8/12	Mixed(WSS/KIS)	432	6	6	5	5	1
Total		3,734	60	60	56	56	3
Central District Drift and East Side Set							
7/19	Mixed(CDD/ESS)	7	0				
Central District Drift, West Side Set, and Kalgin Island Set	Mixed(CDD/WSS/KIS)	1,344	19	19	19	19	0
Mixed Central District Total		5,350	101	101	95	95	17

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Date	Statistical Areas	(n_i) Number Examined	(a_i) Adipose–clips Observed	(a'_i) Heads Recovered	(t_i) Heads with Tags	(t'_i) Decodable Tags	(m_i) Source= Moose R 1998
		Mixed Northern District Statistical Areas					
Northern District East Side and Fire Island Set							
7/16	Mixed(NDF/NDE)	60	0				
8/9	Mixed(NDN/NDW)	242	34	34	33	33	0
Total		302	34	34	33	33	0
		Mixed Central and Northern District Statistical Areas					
7/15	Mixed(WSS/NDE)	56	1	1	1	1	0
8/16	Mixed(KIS/NDE)	99	1	1	1	1	1
8/2	Mixed(CDD/NDE)	337	18	18	16	16	0
Total		492	20	20	18	18	1
		Unknown Gear and/or Statistical Area					
7/12	UnknownMultipleGear/Area	12	0				
8/3	UnknownMultipleGear/Area	10	4	4	4	4	4
Total		22	4	4	4	4	4
Grand Total		6,166	159	159	150	150	22

Note: These data were excluded from analyses and estimates of harvest contribution because of geographic or gear type ambiguity in the sample source.

Appendix A6.–Upper Cook Inlet commercial and coho salmon harvest in 1999, coded wire tag sampling information, and population–specific harvest estimates of coho salmon of Kenai River origin based on recoveries of fish marked at the Moose River in 1998.

Date (1999)[a]	(H) Total Harvest	(ni) Number Examined [b]	(ai) Adipose-clips Observed	(a'i) Heads Recovered	(ti) Heads with Tags[c]	(t'i) Decodable Tags[d]	(mi) Source= Moose R 2002	(ri) Harvest Estimate	V(ri) Variance
Commercial Harvest									
Central District									
Drift Gillnet									
Central									
6/28-7/1	49	11	0						
07/05	316	145	5	5	5	5	0		
7/8-7/9	355	181	2	2	2	2	0		
7/11-7/12	112	73	0						
07/15	4,944	2,295	34	34	29	29	0		
07/19	9,772	4,846	79	78	67	67	1	17	272
07/22	1,457	908	13	13	12	12	0		
7/27-7/28	855	472	7	7	7	7	0		
07/29	19,738	10,345	259	249	227	227	6	99	1,667
7/30-8/1	1,722	844	16	16	15	15	1	17	272
08/02	13,427	8,025	177	171	162	162	6	86	1,248
08/03	299	143	6	6	6	6	1	17	273
08/04	1,085	347	13	13	12	12	3	78	2,016
08/05	7,527	3,574	101	94	86	86	15	281	6,176
08/09	2,871	949	25	25	23	23	9	225	6,130
Total	64,529	33,158	737	713	653	653	42	820	18,055
East Side Set									
Statistical Area 24421									
7/1-7/12	18	5	0						
07/14	5	3	0						
07/15	12	4	0						
7/17-7/19	149	50	1	1	1	1			
07/22	31	18	0						
7/24-7/25	177	55	1	1	1	1	1	27	702
07/27	89	15	0						
07/28	28	18	1	1	1	1	1	13	156
07/29	51	41	0						
07/30	119	26	0						
07/31	57	13	1	1	1	1	1	36	1,261
8/1-8/2	232	74	2	2	1	1	1	26	650
08/03	147	8	0						
08/04	177	171	10	10	10	10	10	86	762
08/05	363	224	14	13	9	9	9	130	1,992
08/09	265	101	6	6	6	6	6	130	2,916
08/12	229	111	9	9	9	9	9	154	2,823
Total	2,149	937	45	44	39	39	38	602	11,264

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Date (1999)[a]	(H) Total Harvest	(ni) Number Examined [b]	(ai) Adipose-clips Observed	(a'i) Heads Recovered	(ti) Heads with Tags[c]	(t'i) Decodable Tags[d]	(mi) Source= Moose R 2002	(ri) Harvest Estimate	V(ri) Variance
Statistical Area 24422									
7/1-7/12	17	1	0						
07/14	7	2	0						
07/15	12	3	0						
7/17-7/19	167	35	0						
07/22	26	21	0						
7/24-7/25	218	27	0						
07/27	91	18	0						
07/28	16	5	0						
07/29	32	11	0						
07/30	101	17	0						
07/31	28	6	1	1	1	1	0		
8/1-8/2	122	42	4	4	4	4	2	48	1,123
08/03	239	35	1	1	1	1	1	57	3,192
08/04	308	86	1	1	1	1	0		
08/05	735	237	13	13	13	13	10	257	7,311
08/09	499	84	7	7	7	7	6	295	15,384
08/12	324	86	11	11	11	11	11	343	12,083
Total	2,942	716	38	38	38	38	30	1,000	39,094
Statistical Area 24430[e]									
7/8-7/12	26	10	0						
07/14	2	1	0						
07/15	5	2	0						
7/17-7/19	152	34	0						
07/22	14	6	0						
7/24-7/25	43	4							
07/27	70	26	1	1	1	1	1	22	463
07/28	5	1	0						
07/29	27	15	0						
07/30	44	10	1	1	1	1	0		
07/31	246	18	0						
8/1-8/2	273	64	7	7	7	7	7	247	9,316
08/03	104	35	3	3	3	3	2	49	1,172
08/04	433	71	2	2	2	2	2	101	5,083
08/05	271	77	2	2	2	2	2	58	1,652
08/09	337	143	18	18	16	16	16	312	7,249
08/12	306	67	2	2	2	2	2	76	2,859
Total	2,358	584	36	36	34	34	32	865	27,796
Statistical Area 24440[f]									
7/8-7/12	32	23	0						
07/15	18	14	0						
07/19	208	119	1	1	1	1			
07/22	57	24	0						
07/27	326	56	2	2	2	2	1	48	2,257
07/29	176	38	1	1	1	1			
07/30	162	35	0						
8/1-8/2	695	162	4	4	4	4	1	36	1,260
08/03	246	85	1	1	1	1	0		
08/04	378	72	1	1	1	1	1	43	1,807
08/05	1,058	715	15	15	14	14	3	37	434
08/09	578	349	17	17	17	17	16	219	3,508
08/12	296	220	11	11	10	10	7	78	877
Total	4,230	1,912	53	53	51	51	29	461	10,143

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Date (1999)[a]	(H) Total Harvest	(ni) Number Examined [b]	(ai) Adipose-clips Observed	(a'i) Heads Recovered	(ti) Heads with Tags[c]	(t'i) Decodable Tags[d]	(mi) Source= Moose R 2002	(ri) Harvest Estimate	V(ri) Variance
Eastside Set Gillnet Total	11,679	4,149	172	171	162	162	129	2,928	88,296
Kalgin Island Set Area 24610/20									
7/5-8/30	10,842	38	0						
Total	10,842	38	0						
West Side Set Areas 24510/20/30/40/50/55/60	6,857	125	1	1	1	1	0		
Total	6,857	125	1	1	1	1	0		
Central District Eastside Set Net and Drift Gillnet Fishery Total	76,208	37,307	909	884	815	815	171	3,748	106,351
Entire Central District Total	93,907	37,470	910	885	816	816	171	3,748	106,351
Northern District									
East Side Set Areas 24770/80/90									
7/8-7/12	30	11	1	1	0				
07/15	72	9	0						
07/19	382	75	1	1	1	1	0		
07/26	499	395	10	10	10	10	0		
08/02	660	128	14	14	14	14	0		
08/05	179	157	7	7	7	7	0		
08/09	595	497	22	22	21	21	4	40	380
08/12	526	206	1	1	1	1	0		
08/16	406	279	3	3	3	3	1	12	132
08/19	1,085	685	3	3	3	3	3	39	485
08/23	1,385	1,118	4	4	3	3	3	31	300
08/26	685	564	1	1	1	1	1	10	90
08/30	519	390	0						
9/2-9/16	713	115	0						
Total	7,736	4,629	67	67	64	64	12	132	1,387
Fire Island Set Area 247/43									
07/12	13	2	0						
07/15	36	30	3	3	3	3	0		
07/19	199	198	25	25	24	24	0		
07/26	131	301	36	36	35	35	0		
08/02	630	501	46	46	44	44	0		
08/05	769	589	67	67	64	64	0		
08/09	691	335	25	25	25	25	0		
08/12	134	130	18	18	18	18	0		
Total	2,603	2,086	220	220	213	213	0		
Pt. MacKenzie/Su Flats Set Area 24741/42									
7/12-7/15	83	19	2	2	2	2	0		
07/19	160	208	11	11	10	10	0		
07/26	251	371	52	52	52	52	0		
08/02	244	389	41	40	39	39	0		
08/05	635	655	67	67	64	64	0		
08/09	610	562	66	66	64	64	0		
08/12	276	325	26	26	24	24	0		
Total	2,259	2,529	265	264	255	255	0		

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Date (1999)[a]	(H) Total Harvest	(ni) Number Examined [b]	(ai) Adipose-clips Observed	(a'i) Heads Recovered	(ti) Heads with Tags[c]	(t'i) Decodable Tags[d]	(mi) Source= Moose R 2002	(ri) Harvest Estimate	V(ri) Variance
West Side Set Area 24710/20/30									
7/1-7/12	461	223	0						
07/15	352	212	0						
07/19	2,592	2,773	9	9	8	8	0		
07/26	4,751	3,132	16	15	13	13	0		
08/02	4,872	3,160	21	21	17	17	0		
08/05	2,947	2,362	29	29	25	25	0		
08/09	928	910	20	20	16	16	1	8	57
08/12	315	92	3	3	2	2	0		
8/16-8/30	1,620	497	8	7	5	5	1	31	930
Total	18,838	13,361	106	104	86	86	2	39	987
Northern District Total	31,436	22,605	658	655	618	618	14	171	2,374
Northern District Total and Central District Drift/East Side Set Total	107,644	59,912	1,567	1,539	1,433	1,433	185	3,919	108,725
Commercial Harvest Grand Tota	125,343	60,075	1,568	1,540	1,434	1,434	185	3,919	108,725

Note: The Central District set gillnet fisheries of Kalgin Island and the West Side were not sampled or were sampled incidentally, therefore, harvests are included here to account for all Upper Cook Inlet commercial harvest.

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

[b] Denotes the number of fish observed for the presence or absence of an adipose finclip mark.

[c] Denotes heads with tags magnetically detected.

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

[e] Combination of statistical areas 244–31and 244–32.

[f] Combination of statistical areas 244–41 and 244–42.

[g] Total includes only unmixed sampling data.