Fishery Data Series No. 08-21

Assessment of Coho Salmon from the Kenai River, Alaska, 2006

by

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May 2008

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

Wild coho salmon smolt *Oncorhynchus kisutch* were captured within the Kenai River drainage in spring 2005, marked with an adipose finclip and injected with a coded wire tag (CWT). These fish were recovered as adults from within the Kenai River in 2006. There were 79,932 live smolt released with an adipose finclip at the Moose River in 2005. Based on the 6,034 adult coho salmon examined for adipose fins from Kenai River fish wheel samples in 2006 and the 572 adults in the samples that were missing an adipose fin, an estimated 841,876 (SE = 33,309) smolt emigrated from the Kenai River in 2005.

A fish wheel-based index was used to predict the end-of-season abundance of adult coho salmon passing the Kenai River at river kilometer 45 in 2006 into one of three ordinal categories (low, medium or high). The end-of-season abundance level was classified as "medium" based on an August 1 through September 30 fish wheel log-transformed cumulative catch per unit of effort (LnCCPUE) value of 5.78.

Key words: coho salmon, *Oncorhynchus kisutch*, population assessment, fish wheel, weir, adult abundance, index, coded wire tag, Kenai River, smolt abundance, wild.

INTRODUCTION

BACKGROUND

Wild coho salmon *Oncorhynchus kisutch* spawn and rear in freshwater drainages of Upper Cook Inlet, Alaska (UCI, Figure 1). As they return to spawn, adults are harvested annually in mixed-stock commercial and sport marine fisheries. Sport and personal use harvests also occur in fresh water. Cook Inlet ranks second in the 1995-2005 average sport harvest of coho salmon among all regions of the state, sixth in commercial harvest, and third in overall harvest (Figure 2). UCI coho salmon support the largest sport harvest in the state (Howe et al. 1995-1996, 2001 a-d; Jennings et al. 2004; Jennings et al. 2006a-b; Jennings et al. 2007; Jennings et al. *In prep.*; Mills 1979-1980, 1981a-b, 1982-1994; Walker et al. 2003) contributing about 1 of every 3 coho salmon sport-harvested from Alaskan waters.

The Alaska Department of Fish and Game (ADF&G) initiated a program to assess the status of UCI coho salmon stocks in 1991 (Meyer et al. *Unpublished*). The initial approach was to estimate the annual: (A) population specific harvest in marine commercial fisheries, (B) sport and personal use inriver harvest, and (C) spawning escapement. The sum of these three components (A + B + C) would provide the desired estimate of annual adult production. The sum of the two harvest components (A + B) divided by the estimated production would provide an estimate of exploitation rate. Smolt abundance estimates were originally produced ancillary to commercial harvest estimates but have become integral to the current assessment program.

Commercial harvest estimates (A) have been generated annually since 1993 through a coded wire tag release and recovery program (Carlon 2000, 2003; Carlon and Hasbrouck 1994, 1996-1998; Massengill 2007a-c; Massengill and Carlon 2004a-b; Massengill and Carlon 2007a-b). Inriver sport and personal use fishery harvests (B) are estimated annually by angler surveys (Hammarstrom 1977, 1978, 1988-1992; Howe et al. 1995-1996, 2001 a-d; Jennings et al. 2004; Jennings et al. 2006a-b; Jennings et al. 2007, Jennings et al. *In prep*; King 1993; Mills 1979-1980, 1981a-b, 1982-1994; Reimer and Sigurdsson 2004; Walker et al. 2003). Mark-recapture studies have been used to estimate inriver adult abundance since 1999, when stress-related handling concerns were addressed (Vincent-Lang et al. 1993). Attempts to estimate abundance using sonar have been unsuccessful (Bendock and Vaught 1994).

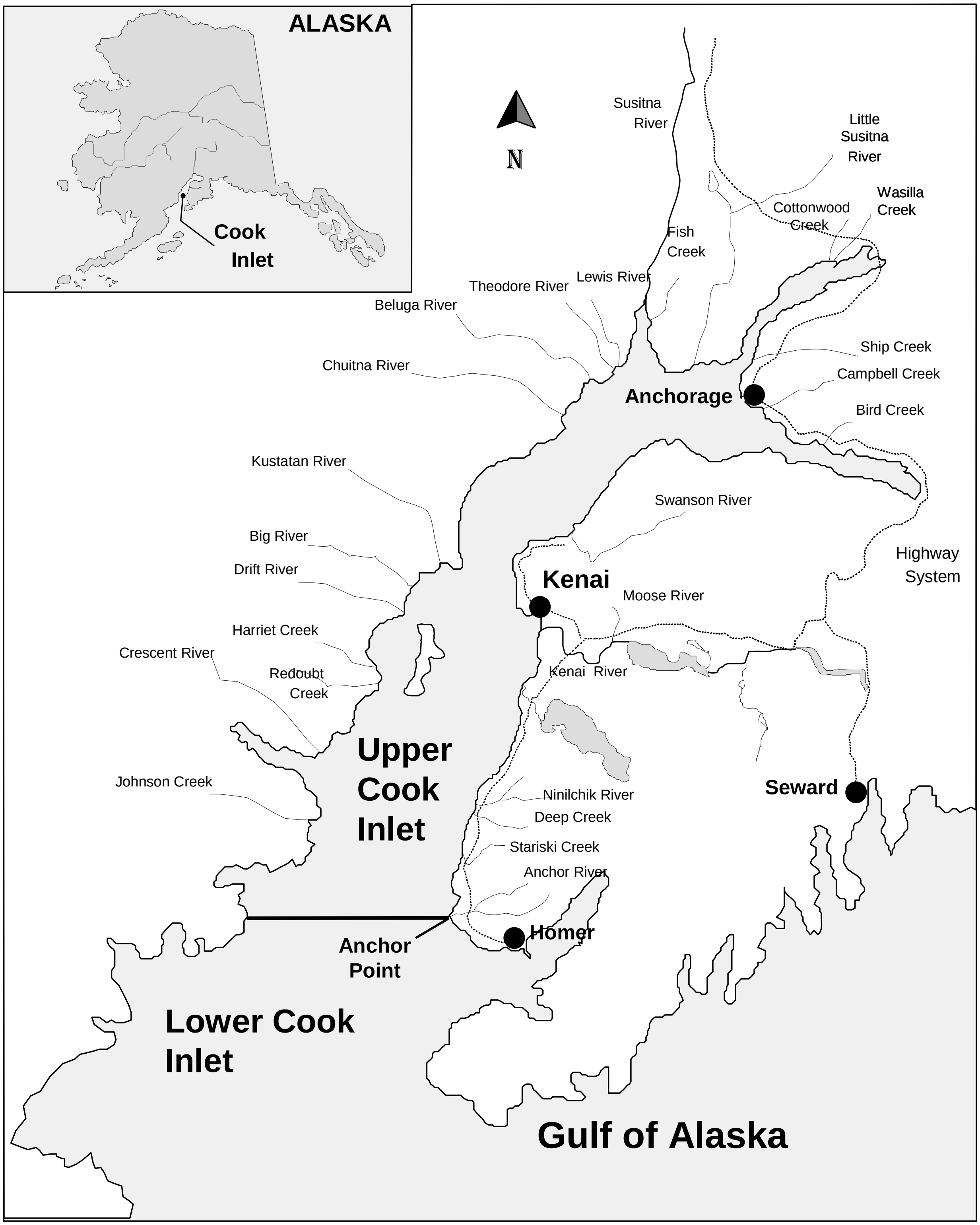

Figure 1.-The Cook Inlet Basin with tributaries known to support coho salmon.

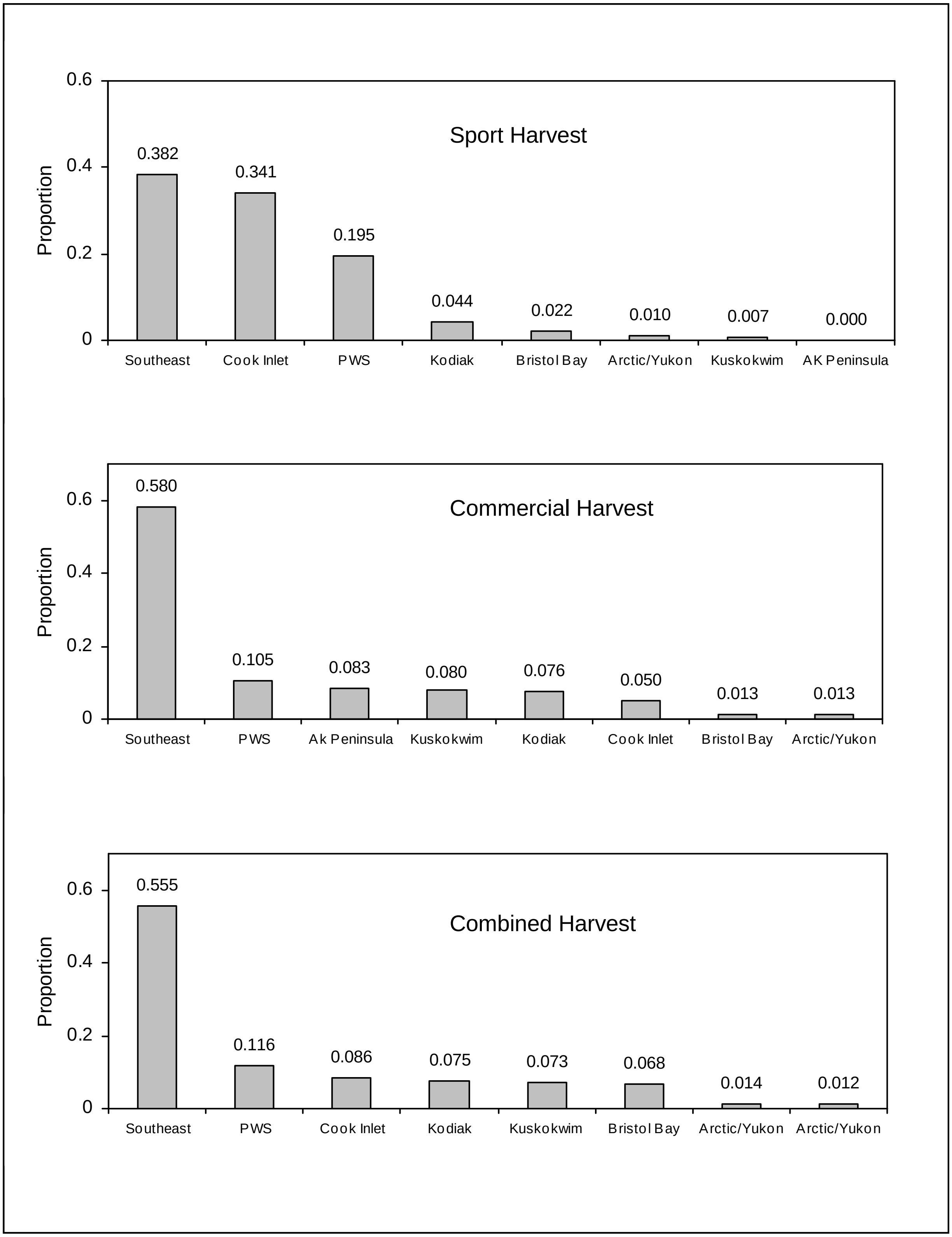

Figure 2.-Average proportions by region of the statewide commercial and sport harvests of coho salmon, 1995-2005.

The Kenai River assessment program revealed an overall decline in smolt abundance between 1992 and 1995 (Carlon and Clark *Unpublished*). The Alaska Board of Fisheries (BOF) responded by developing and adopting the first management plan for Kenai River coho salmon in 1997. A review in 2000 suggested that adult abundance was declining and the BOF responded by adopting the Kenai River Coho Salmon Conservation Management Plan (Alaska Fish and Game Laws and Regulations Annotated, 2000-2001; 5 AAC 21.357). This plan modified the 1997 version and included additional restrictions to both commercial and sport fisheries.

Kenai River coho salmon assessments since 2000 indicate that exploitation rates are sustainable, and adult returns appear to have increased since the late 1990s. The 2005 BOF therefore repealed the Kenai River Coho Salmon Conservation Management Plan thus liberalizing opportunity, to some degree, for both the commercial and sport fisheries. The current management plan is the Kenai River Coho Salmon Management Plan (Alaska Fish and Game Laws and Regulations Annotated, 2006-2007, 5 AAC 56.080). ADF&G eliminated the commercial harvest component of the assessment program after 2005 because recent assessments indicated the harvest is sustainable under current regulations.

The adult inriver assessment work also changed in 2005 from an inriver abundance estimate to an index of abundance by class (low, medium or high). The index provides managers a tool to classify general abundance that is less costly than mark-recapture abundance estimates and produces inseason predictions of abundance and a post-season estimate.

OBJECTIVES

The primary objectives of the study components were to:

1. Estimate the number of coho salmon smolt that emigrated from the Kenai River drainage in 2005.
2. Census the coho salmon smolt emigration from the Moose River from May 15 through June 30, 2005.
3. Index the inriver abundance of adult coho salmon into one of three ordinal levels.

TASKS

1. To collect scales and lengths during the smolt emigration in 2005 and from the adult inriver return in 2006 for archiving and qualitative age analysis.

METHODS

EXPERIMENTAL DESIGN

2005 Smolt Abundance and Census Objectives

The experimental design was a two-event mark-recapture experiment. Smolt were marked with an adipose fin clip and a coded wire tag in the first event, and adults were recaptured during inriver sampling in the second event.

To census the 2005 Moose River coho salmon smolt emigration (a tributary of the Kenai River) a weir was used to trap and count smolt from mid-May to mid- to late June.

2006 ADULT INRIVER INDEX

To index inriver abundance of adult Kenai River coho salmon into one of three ordinal levels (low, medium or high) two fish wheels were operated near river kilometer (rkm) 45 from August 1 through September 30, 2006. Fish wheel effort and coho salmon catch provided a daily cumulative catch per unit of effort (CCPUE). The CCPUE for 2006 was used inseason to periodically predict an end-of-season abundance classification and a final postseason classification. The abundance classifications were determined using a fitted regression of historic (1999-2004) inriver abundance estimates on log-transformed CCPUE (LnCCPUE).

DATA COLLECTION

Smolt Marking in 2005

The Moose River weir was the site of smolt capture and marking in 2005 and is located 7.5 rkm upstream of its confluence with the Kenai River (Figure 3). Before 1994, smolt were captured and tagged at a variety of locations (Carlon 1992; Carlon and Hasbrouck 1993). However, recovery of marked adults indicated that the Moose River was the only suitable location for marking smolt. In addition to providing enough smolt, the adult return timing indicated that smolt marked at the Moose River were also representative of the Kenai River population (Carlon and Hasbrouck 1994).

A weir with a trap was installed in the mainstem of the Moose River on May 17, 2005, to capture smolt as they emigrated downstream from wintering habitats. The weir was a total barrier to fish migration until June 22, 2005. Marking smolt with both coded wire tags (CWTs) and adipose finclips began on May 20 and ended on June 12, 2005.

Smolt were the primary lifestage captured and tagged at the Moose River. Although some coho salmon shorter than 100 mm FL were present, they were not marked because they were different in appearance (parr marks highly visible and substantially less silver skin pigmentation). In addition, most scale samples from fish shorter than 100 mm exhibit only one annulus. Most Kenai River coho salmon smolt after 2 years in fresh water and exhibit two scale annuli (Hammarstrom 1988-1992). Further evidence that smolt are correctly identified is that most (>99.9%) CWTs recovered from adults returning to spawn from 1993 through 2004 were implanted in fish emigrating from the Moose River the previous year (Carlon 2000, 2003; Carlon and Hasbrouck 1998; Massengill 2007a-c; Massengill and Carlon 2004a-b, 2007a-b). The recovery of an adult tagged at the Moose River two years prior has never been documented.

Recently observed temporal variation in the marked proportion of the inriver adult return has led to changes in the marking strategy so that tagging is now more evenly distributed throughout the emigration, instead of tagging during the first half of the emigration. Although there is evidence that the return timing of marked adults is independent of the marking date, the evenly distributed tagging strategy removes most doubt that it is the cause of temporal variation observed in the inriver adult samples. The 2005 tagging goal was 3,500 tags per day for three weeks (75,000 total).

Fish captured in the weir throughout each day were partially immobilized by sedating with MS-222 to a level-two anesthesia (Yoshikawa et al. 1988), hand-sorted into 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

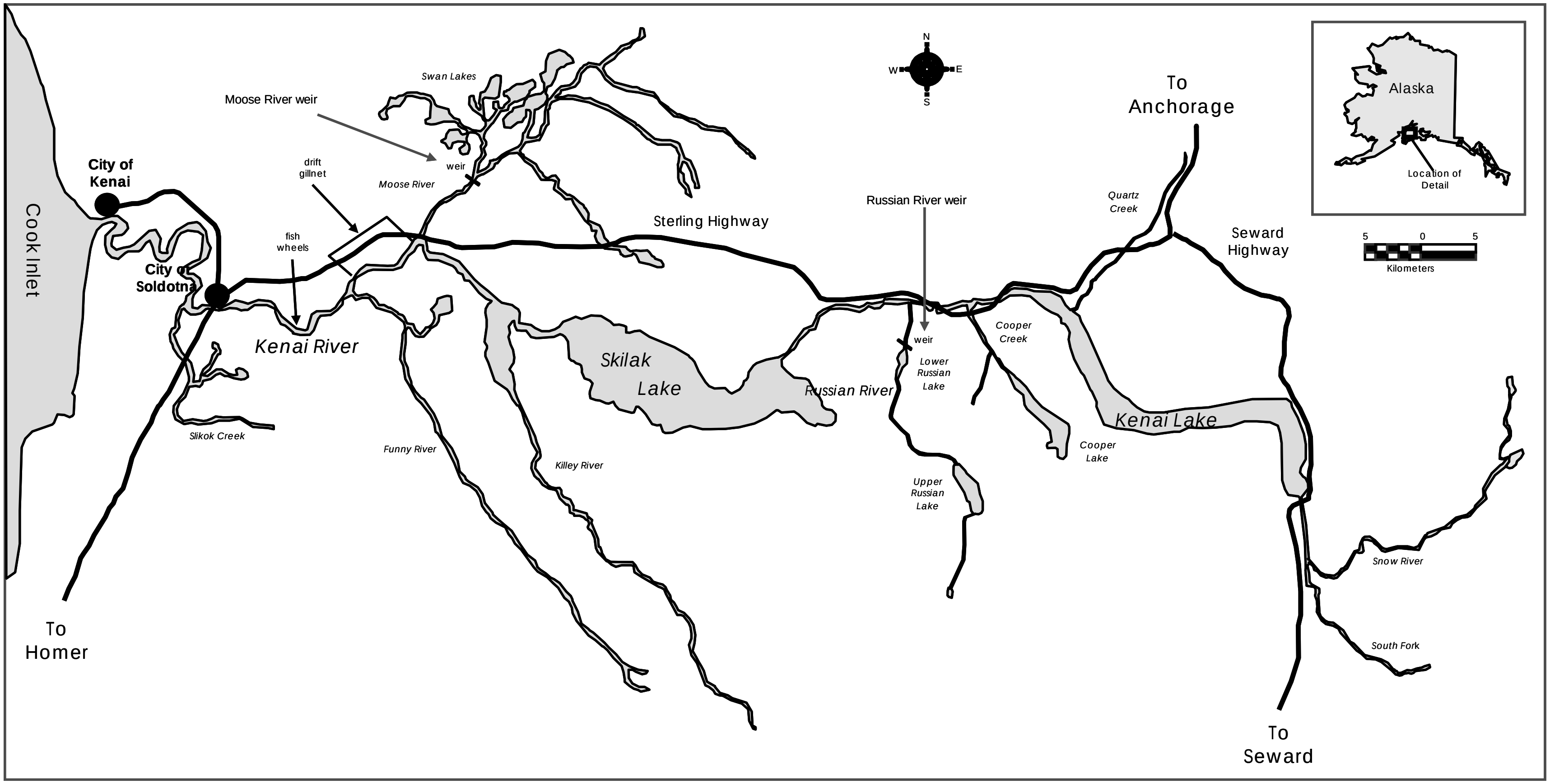

Figure 3.-The Kenai River drainage showing the Moose River weir site where marked coho salmon smolt were released in 2005, and the Kenai River fish wheel location in 2006.

CWT 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 fish were then tagged with a Northwest Marine Technologies® Mark IV tag injector fitted with the optimal head mold. 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. Smolt >150 mm were rarely captured and were released untagged because of the additional time required to sedate them. Because this was rare, it likely had no impact on the marked proportion in the subsequent year's return of adults. Marked fish were released to continue their downstream migration after recovering from anesthesia in an inriver holding pen.

Tag codes released in 2004 were verified visually with a binocular microscope on site and the number of smolt marked each day was recorded. Smolt were batch marked and a single tag code was applied to all individuals in a group.

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 a need to adjust the capture, handling, or marking procedures. Survival rates were used to estimate the total number of marked smolt that survived the marking procedure. Estimating the number of marked fish that survived marking and were released is a requirement of the model used to estimate smolt abundance.

Smolt Age and Length Sampling

Smolt scales were collected and archived in 2005. While current procedures used to determine ages from smolt scales is imperfect, radical changes in age class compositions are believed to be detectable. Although this approach is qualitative, it may provide important perspective when assessing population status. Collecting scales also provides an archive in the event that accurate scale reading techniques are developed.

As a result of the non-sampling related uncertainty regarding the scale reading estimates, placing strict objective criteria on the estimation of age class composition was not warranted, explaining the status of scale collection as a task. Sample size calculations (Thompson 1987) were, however, used to guide the number of scales collected. Assuming an illegibility rate of 15% and perfect identification of scale ages, 150 scales were needed such that, with 95% confidence, the estimates by age group were within 10 percentage points of their true values.

To minimize age and length bias during sampling, samples were collected systematically throughout the coho salmon smolt emigration by randomly sampling 50 smolt midway through each increment of 10,000 smolt passing the weir. This strategy provided a larger sample size (~1,200 samples) than needed.

RECOVERY OF MARKED ADULTS IN THE 2006 RETURN

Two fish wheels were operated in the mainstem of the Kenai River to capture and examine adult coho salmon for missing adipose fins (Figure 3). Each fish wheel (one operated adjacent to each riverbank) was operated daily during most daylight hours from August 1 through September 30 to minimize seasonal sampling bias. From August 1 through September 14, the target effort was to operate each fish wheel 12.5 hours per day. Fish wheel operation was reduced 1 hour each week beginning September 15 to avoid boating at night.

Coho salmon were captured in fish wheels and examined for a missing adipose fin from August 1 through September 30, 2006 (the last day coho salmon were caught). All fish missing an adipose fin were checked with an electronic tag detection wand for the presence of an embedded CWT. A sample of marked fish with no tag detected was sacrificed to determine the rate of false-negative wand results. This was used to adjust the tagged fraction estimate. The false-positive rate was assumed to be zero. Daily fish wheel catches for all species, by bank, were recorded in 2006.

All tag recovery data were submitted electronically and archived by the Tag Lab. The raw data are accessible via the World Wide Web at URL http://tagotoweb.adfg.state.ak.us.

2006 Adult Inriver Index

To collect coho salmon CPUE data two fish wheels were operated at rkm 45. One fish wheel was located on each riverbank because coho salmon migrate along both banks. The fish wheels were operated only during daylight hours when most coho salmon move in the Kenai River. Telemetry data indicate that nearly 90% of coho salmon migrate upriver during daylight hours (Carlon and Evans 2007). To maintain similar operational effort of the fish wheels among years, a relatively constant fish wheel spin rate was maintained by either applying braking methods (to decrease the spin rate), or increasing the paddle surface (to increase the spin rate), or by relocating fish wheels short distances as water levels and velocities changed.

Fish wheel operation was standardized so that stops for crew meal breaks and shift changes occurred only during set times, as first implemented in 2004 (Appendix A1) (Massengill and Evans 2007). The historic (1999-2004) fish wheel effort and catch data used in the regression of abundance on log cumulative CPUE were truncated to include only CPUE data collected during standardized daylight-only operational times.

To minimize handling stress and increase crew safety a two-person crew was used to process coho salmon. Quickly removing other species from the fish wheel livebox also minimized any effects of confinement-induced stress on coho salmon. All coho salmon were inspected in a dip net to check for an adipose fin and a dorsal punch mark. If the fish was missing an adipose fin, or if the fish was selected for age and length sampling, it was placed in a holding tote onboard a riverboat. A bucket was used to add fresh water to the tote. A padded, aluminum cradle device was slipped around the fish to restrain it during marking and age-length sampling. Every adipose finclipped fish received a dorsal fin punch to avoid duplicate sampling. Additionally, every tenth fish (not previously dorsal punched) was sampled for age (scales) and length (FL) and given a dorsal fin punch. An overall coho salmon recapture rate was estimated using the recapture of dorsal fin-punched fish.

DATA ANALYSIS

To estimate smolt production, the essential steps were to: (1) estimate the number of smolt marked in 2005 that survived the marking process, and (2) detect adipose finclipped fish in the 2006 adult inriver return from known sample sizes.

SMOLT MARKING IN 2005

To determine the number of marked smolt released in 2005, short-term survival and tag retention rates were estimated daily from a representative sample of about 200 smolt detained in holding pens for 18 to 24 hours after marking. The 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. The short-term tag retention rate (b_k), for smolt marked during a shift that survived, was estimated as the fraction of surviving smolt that retained their tags. The number of smolt marked with a tag during each shift k (m'_k) was adjusted to account for short-term survival and tag retention to yield an estimate of the total number of tagged smolt that survived and retained a tag in shift k, m_k:

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

The number of smolt that were marked, survived, and retained a tag at the Moose River in 2005 was estimated by summing $\hat{m}_k$ over all marking shifts. This was required to determine when the goal of releasing 75,000 tagged live fish was achieved. The quantities $\hat{s}_k$ and $\hat{b}_k$ also served as real-time quality control measures. The number of smolt marked with an adipose finclip was estimated by summing the individual estimates of the number of marked fish that survived the marking process. This represented the number of fish marked and released in the mark-recapture study to estimate smolt abundance.

SMOLT ABUNDANCE IN 2005

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

$$\hat{N} = \frac{(M+1)(C+1)}{(R+1)} - 1, \qquad (2)$$

where:

M = the number of smolt marked with an adipose finclip that survived to emigrate in 2005,

C = the number of adult coho salmon examined for an adipose finclip in the 2006 return sample, and

R = the number of adult coho salmon in the 2006 sample that had an adipose finclip.

The variance of the smolt abundance estimate was estimated by:

$$V\hat{a}r(\hat{N}) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)} . \qquad (3)$$

This model produces unbiased estimates of abundance when all of the following assumptions are met:

1. Adult coho salmon examined were a random sample of the inriver return or the marked smolt were representative of the drainage-wide smolt emigration in 2005 or there is complete mixing of individuals between the mark and recapture events,
2. All juveniles marked at the Moose River in 2005 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,
6. Fish were correctly categorized for the presence or absence of an adipose fin when examined at the fish wheels, and
7. Inriver adult coho salmon missing an adipose fin originated from the Moose River in 2004.

Independence between the timing of smolt tagging and adult return timing has been observed in both inriver and commercial recoveries (Carlon 2000; Carlon and Hasbrouck 1994, 1996-1998). The independence observed indicates that marked and unmarked fish mixed after tagging. Observations also indicate that emigrating smolt from the Moose River are representative of the entire Kenai River population. While independence between release and return timing does not guarantee representative tagging of the entire Kenai River smolt population, or complete mixing of fish between tagging and recapture, they are consistent with the latter two conditions of assumption 1. Also, the inriver fish wheel samples are assumed to be random because both banks were fished with similar effort throughout the season. Therefore, there is a good chance that at least one of the three conditions of assumption 1 is fulfilled.

The other six assumptions are also likely valid. Experience and observations indicate that most juveniles marked at the Moose River each year are smolt (assumption 2). Although long-term survival and catchability assumptions remain untested for this population, short-term survival of marked smolt has been nearly 100% during all smolt-marking events at the Moose River (assumption 3) (Carlon 2000, 2003; Carlon and Hasbrouck 1994, 1996-1998; Massengill 2007a-c; Massengill and Carlon 2004a-b, 2007a-b). Hatchery-produced coho salmon marked with adipose finclips and CWTs and released in a western Kenai Peninsula drainage experienced similar smolt-to-adult survival as unmarked coho salmon (Vincent-Lang 1993). Thompson and Blankenship (1997) found no regeneration of coho salmon adipose fins after excision if the fin was completely removed at the outset (assumption 4). There has been no quantitative study to estimate the occurrence of naturally missing adipose fins in the Kenai River drainage (assumption 5). However, of more than ~1,500,000 coho salmon juveniles handled since 1991, only occasionally have any been found to be naturally missing the adipose fin. Also, the short-term and long-term tag retention rates have been nearly identical (Carlon 2000, 2003; Carlon and Hasbrouck 1994, 1996-1998; Massengill 2007a-c; Massengill and Carlon 2004a-b; 2007a-b). This supports the supposition that naturally missing adipose fins are rare in coho salmon of the Kenai River drainage. Only 1 of 1,020 (<0.1%) coho salmon heads recovered from the inriver sport fishery (1996-1998) did not originate from the Moose River, and only 2 Moose River tags were recovered in the same year they were released (Carlon 2000, 2003; Carlon and Hasbrouck 1998). Finally, just over 1% of the heads recovered during 1996-1998 had no tag, indicating that tag loss is low (and though rare, presumably results from tag shedding and naturally missing adipose fins). This supports both assumption 6 and 7 that adipose finclipped fish are correctly identified and originate from Moose River releases the previous year.

2006 ADULT INRIVER INDEX

From August 1 to September 30, 2006 (61 days), two fish wheels near rkm 45 in the Kenai River captured adult coho salmon as they migrated upstream to spawn. The cumulative catch per unit of effort (CCPUE) at the fish wheels was calculated as:

$$CCPUE = \sum_{i=1}^{61} CPUE_i = \sum_{i=1}^{61} \frac{c_i}{h_i}. \tag{4}$$

where:

c_i = the catch of coho salmon on day i (estimated as total daily catch multiplied by the complement of the average seasonal recapture rate of the caudal punched subsample of fish), and

h_i = the hours of fish wheel operation on day i.

The adult coho salmon inriver index uses CCPUE to make three inseason predictions of expected end-of-season abundance. There is also a postseason index of abundance. The index was developed to assess inriver coho abundance inseason (although no management or index goals are currently in effect) and to classify postseason abundance. The index provides real-time information and is a less costly assessment tool than recent mark-recapture abundance studies.

This index plotted the 2006 natural-log transformed fish wheel CCPUE (LnCCPUE) data onto a fitted weighted regression of historic LnCCPUE abundance estimates (weighted regression fits are provided in Table 1). The 2006 LnCCPUE values were assigned to one of three ordinal abundance levels. The three levels were within, above, or below 50% of the average 1999-2004 estimates, but do not represent any known biological significance or management objective: low = abundance <50,000; medium = abundance >50,000 and <120,000; high = abundance >120,000.

Table 1.-Fit of weighted regression of estimated abundance on Ln(CCPUE) by temporal interval, 2006.

Period	Equation[a]	R^2	P-value (Ho:Slope=0)
Aug 1-28	$\hat{N}$= -90,722 + 39,456 *Ln(CCPUE)*	0.70	0.038
Aug 1-Sep 11	$\hat{N}$= -105,248 + 39,574 *Ln(CCPUE)*	0.87	0.007
Aug 1-Sep 25	$\hat{N}$= -114,169 + 39,475 *Ln(CCPUE)*	0.91	0.003
Aug 1-Sep 30	$\hat{N}$= -115,531 + 39,410 *Ln(CCPUE)*	0.91	0.003

[a] N^ is the 2006 predicted abundance of adult coho salmon arriving at river kilometer 45 of the Kenai River.

A total of four index regressions were developed as follows: one at 4 weeks (August 1–28), 6 weeks (August 1–September 11), 8 weeks (August 1–September 25), and the end of the season (August 1–September 30). Developing an abundance index before August 28 was assumed to have too much potential for error and was therefore not done.

The regression model was developed using data collected from August 1 through September 30 during all years. In some instances, historic fish wheel data used in the regressions were truncated so that CCPUE was based only on identical dates and fish wheel operating times among years. Some interpolation of CPUE data was needed because the fish wheels were not operated some days between August 1 and September 30, 1999. The interpolated CPUE for day *j* in 1999 was calculated as described in Appendix A2. A summary containing both the actual and adjusted fish wheel data for 1999-2004 is found in Appendix A3.

Model Details

The fitted regression model used to predict coho salmon abundance is relatively sensitive to changes in CCPUE, particularly when late-season CCPUE is small (<200). Conversely, the response of abundance to changes in CCPUE at higher levels (>200) is not as sensitive. Therefore, changes in CCPUE at lower levels will likely change the abundance index more than similar changes at higher levels

A theoretical problem with regressing abundance estimates on LnCCPUE is heterogeneity in the variance of abundance estimates. In fact, variability increased markedly for estimates that were partially stratified. Another likely problem is measurement error in the CCPUE observations; the ability to duplicate CCPUE results exactly in a given year. The first problem was overcome by using a weighted regression, with weights proportional to the inverse of the variance of the abundance estimates. The weighted analysis explains the difference of the fitted line (when displayed on a graph) from one that would be fitted by eye. The 2000-2002 abundance estimates are not within the 90% confidence interval (Figure 4) because abundance estimates with higher variability receive less weight in the fitting process. Nothing was done to mitigate the measurement error in the CCPUE. It is assumed that the effect of this error is small, given the comprehensive schedule of fish wheel operations each year, and that measurement error is likely small compared to the 16-fold range in variation of the 1999-2004 CCPUE. Because the index classifies abundance in one of the three ordinal levels (low, medium or high), the likelihood of misclassification from measurement error is small.

RESULTS

SMOLT MARKING/CENSUS IN 2005

There were 83,735 smolt marked (and released) with CWTs and adipose finclips as they emigrated from the Moose River May 17 through June 20, 2005; the last release of marked smolt occurred on June 12, 2005. The number of smolt marked and released per tag code group ranged from 11,029 to 11,561 depending on the number of available tags.

An estimated 79,932 smolt survived tagging based on an estimated short-term survival rate of 99+%. Although marking was discontinued after the marking goal was achieved on June 12, 2005, the weir remained in place until June 20 to census the smolt emigration. There were 231,480 smolt captured at the weir between May 17 and June 20, 2005. Scale and length samples from 1,250 smolt were collected and archived.

INRIVER RECOVERY OF MARKED ADULTS

Adult coho salmon marked as smolt at the Moose River in 2005 were sampled using fish wheels in the Kenai River near rkm 45 in 2006. From August 1 through September 30, there were 6,034 coho salmon captured in fish wheels and 572 had missing adipose fins (Table 2, Appendix A4).

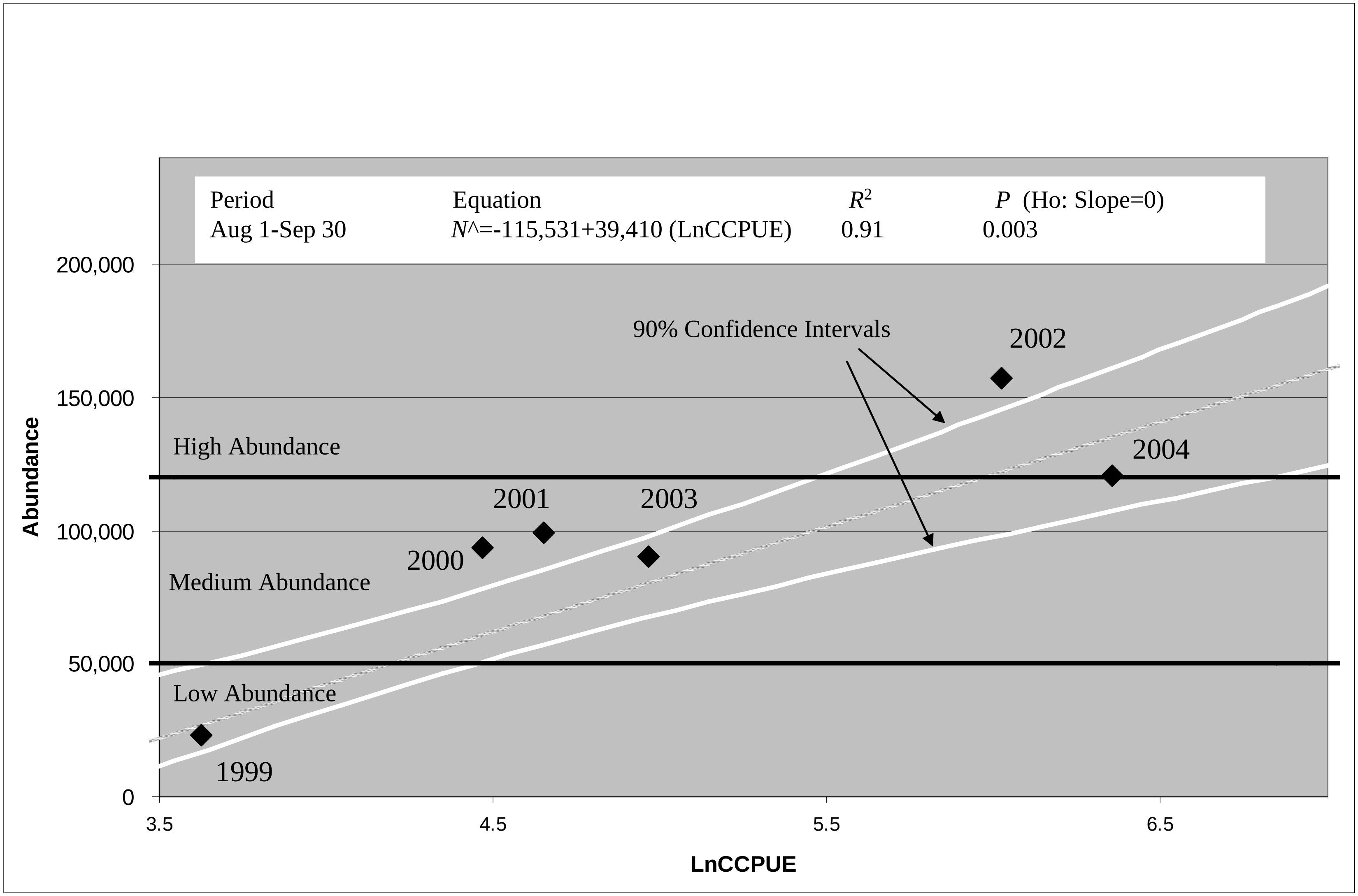

Figure 4.-Regression of 1999–2004 log-transformed fish wheel CCPUE of adult coho salmon at Kenai River river kilometer 45 to abundance estimates.

Table 2.-Coho salmon recoveries from the Kenai River drainage from August 1 through September 30, 2006, with weekly and seasonal marked and tagged proportion estimates by source.

Weekly period	Number examined	Marked fish observed	Marked fraction
	North bank fish wheel		
08/01-08/07	22		0.000
08/08-08/14	33	1	0.030
08/15-08/21	195	10	0.051
08/22-08/28	269	11	0.041
08/29-09/04	286	20	0.070
09/05-09/11	293	42	0.143
09/12-09/18	483	61	0.126
09/19-09/25	438	72	0.164
09/26-09/30	160	20	0.125
Total	2,179	237	0.11
	South bank fish wheel		
08/01-08/07	59	2	0.034
08/08-08/14	180	9	0.050
08/15-08/21	476	14	0.029
08/22-08/28	586	26	0.044
08/29-09/04	548	32	0.058
09/05-09/11	422	38	0.090
09/12-09/18	661	84	0.127
09/19-09/25	665	99	0.149
09/26-09/30	258	31	0.120
Total	3,855	335	0.087
	Russian River weir [a]		
07/24 - 07/30	1	0	0.000
07/25 - 07/31	3	2	0.667
08/01 - 08/07	57	3	0.053
08/08 - 08/14	221	9	0.041
08/15 - 08/21	250	7	0.028
08/22 - 08/28	211	7	0.033
08/29 - 09/04	255	8	0.031
09/05 - 09/11	4	0	0.000
Total	1,002	36	1
	Combined north and south banks fish wheels		
08/01 - 08/07	81	2	0.025
08/08 - 08/14	213	10	0.047
08/15 - 08/21	671	24	0.036
08/22 - 08/28	855	37	0.043
08/29 - 09/04	834	52	0.062
09/05 - 09/11	715	80	0.112
09/12 - 09/18	1,144	145	0.127
09/19 - 09/25	1,103	171	0.155
09/26 - 09/30	418	51	0.122
Total	6,034	572	0.095

[a] Russian River samples were not collected throughout the return, so were not used in calculating the adult marked fraction and are shown here only for perspective.

The bycatch of other species was substantial, in particular, the 63,410 pink salmon captured was nearly 11 times more (Appendix A5) and the 19,482 sockeye salmon captured was more than 3 times the coho salmon catch. Of the 6,034 coho salmon sampled, there were 3,855 captured in the south bank fish wheel, and 2,179 coho salmon captured in the north bank fish wheel.

SMOLT ESTIMATE IN 2005

An estimated 841,876 (SE = 33,309) smolt emigrated from the Kenai River in 2005. This is 13% above the 1992-2004 average of 647,890 and is 87% of the 2002-2004 average of 962,990 (Figure 5).

2006 Inriver Adult Index

The combined fish wheel operating effort from August 1 through September 30, 2006, was 1,136.8 hours (Figure 6, Appendix A6). Daily hours of operation varied based on fish wheel maintenance and available daylight, but averaged 9.1 hours per day for the north bank fish wheel and 9.5 hours per day for the south bank fish wheel. The fish wheel spin rate in revolutions per minute (rpm) was generally maintained between 2.75 and 4.5 rpm. This range is believed to be most efficient at catching fish and is similar to previous years. The average rpm was 3.5 for the north bank fish wheel and 3.8 for the south bank fish wheel (Appendix A7). Kenai River water transparency and river flow (Figure 7) indicate that fishing conditions in 2006 were similar to 1999-2005 (Appendix A8).

There were 6,034 coho salmon caught in the fish wheels from August 1 through September 30, 2006 (Appendices A4-A6); 2,179 coho salmon were captured in the north bank fish wheel and 3,855 by the south bank fish wheel.

The log-transformed CCPUE (LnCCPUE) values for the three inseason prediction periods and the final end-of-season classification in 2006 were 4.73 (August 1-28), 5.30 (August 1-September 11), 5.72 (August 1-September 25), and 5.78 (August 1–September 30) (Appendix A9). All four periods classified a level of abundance defined as medium (>50,000 and <120,000) for coho salmon arriving at rkm 45. The August 1–September 30, 2006, fitted regression plot with 90% confidence intervals is shown in Figure 8.

DISCUSSION

SMOLT ABUNDANCE

History

The 2005 smolt abundance estimate is the fourteenth annual estimate since 1992. It also represents the fourth estimate of smolt production that can be associated with a parent-year escapement for the Kenai River. Because most Kenai River coho salmon develop into smolt as age-2 smolt, the primary parent year for the 2005 smolt emigration is 2002. The escapement estimate for 2002 is preliminary (Carlon and Evans 2007), but will be about 133,000 adults (the highest recorded during 1999-2004). The 2002 escapement (Figure 9) is associated with the above average production of smolt in 2005. Note that the 1999 adult escapement estimate of 7,700 was unusually low (Carlon and Evans 2007), yet was the primary parent-year class that produced the 2002 smolt population estimated at 626,335 and just 13% below the historical average. Without adult coho salmon abundance estimates, smolt production will provide the

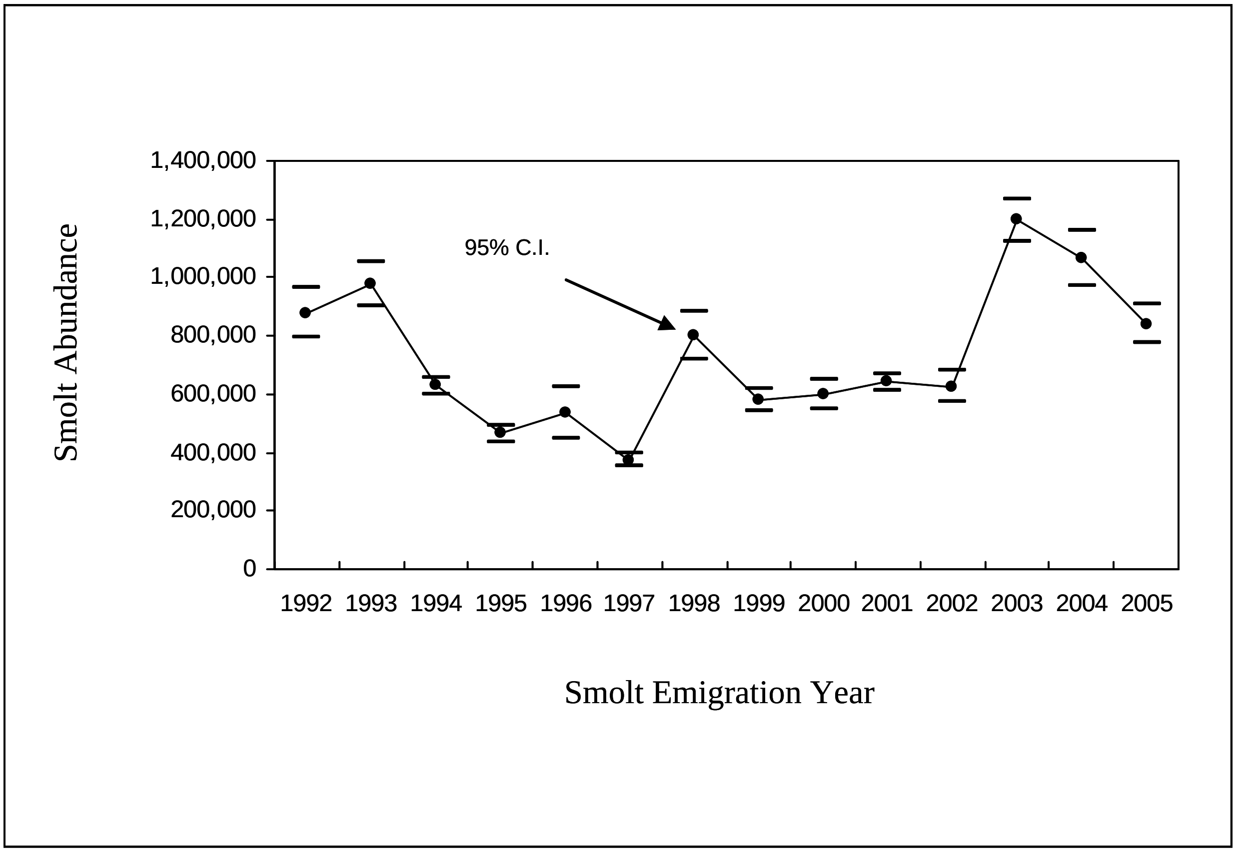

Figure 5.-Coho salmon smolt abundance estimates in the Kenai River, 1992-2005.

only abundance estimate for this population as it did in 1992-1998 and in 2005 (years when inriver abundance and total adult coho salmon return were not estimated).

Relationship Between Total Harvest and Smolt Abundance

Between 1993 and 2005, total annual parent-year harvest (Table 3, Figure 10) of Kenai River coho salmon and smolt production were examined to determine a link between the two (Figure 11). No discernable relationship emerged, but the highest known harvest of Kenai River coho salmon in 1994 is associated with the lowest recorded smolt abundance estimate in 1997 (comprised primarily of offspring from the 1994 parent year).

The 2005 smolt abundance estimate, when paired with the 2002 total harvest estimate, is the tenth available pairing. While the relationship does not identify a threshold harvest beyond which smolt abundance is negatively and consistently impacted, it suggests that the record adult harvest in 1994 may have been excessive. Total adult harvest was not available because the commercial harvest estimate for this project was discontinued in 2006. The final smolt production estimate that can be examined for a link to the total parent harvest estimate (from 2005) is expected in 2008. Because 2005 is the final year that total adult harvest was estimated, 2008 would be the last smolt cohort that could be examined for a link to a known parent harvest.

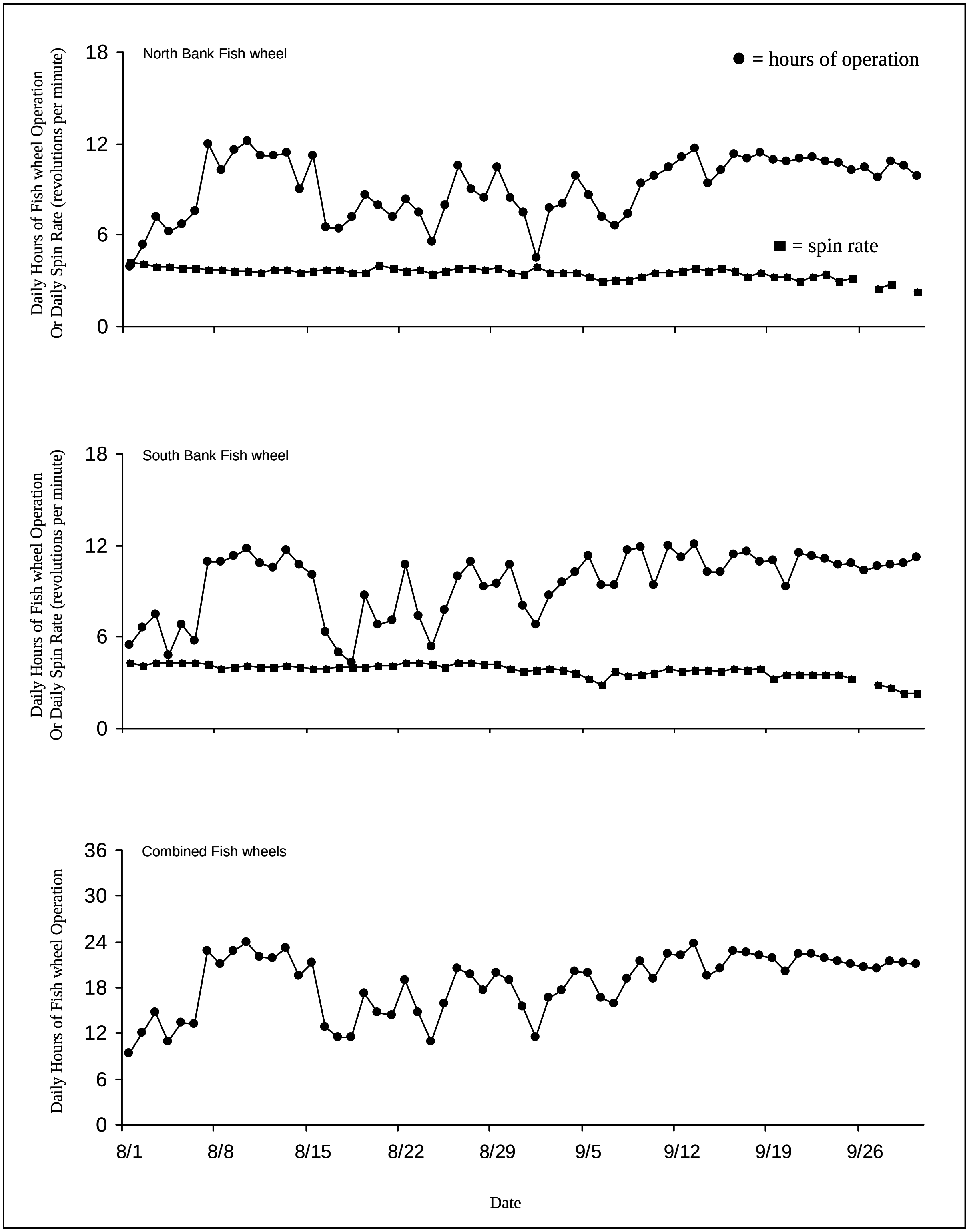

Figure 6.-Daily hours of operation and rotational spin rate for fish wheels operating adjacent to each bank of the Kenai River near river kilometer 45, August 1–September 30, 2006.

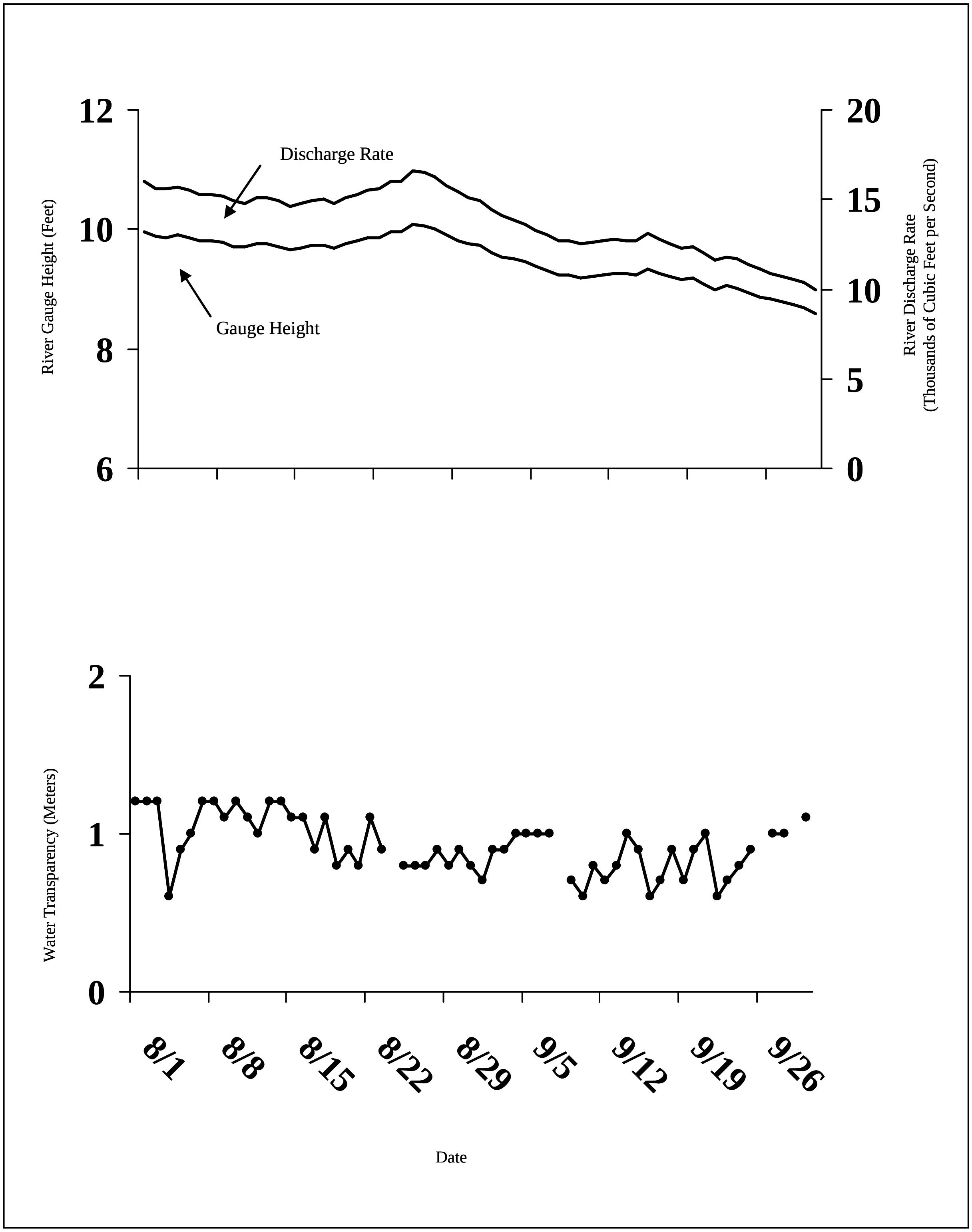

Figure 7.-Daily Kenai River stage and discharge as measured by a USGS gauging station at river kilometer (rkm) 34 (top) and water transparency as measured with a Secchi disk near rkm 45 (bottom), August 1–September 30, 2006.

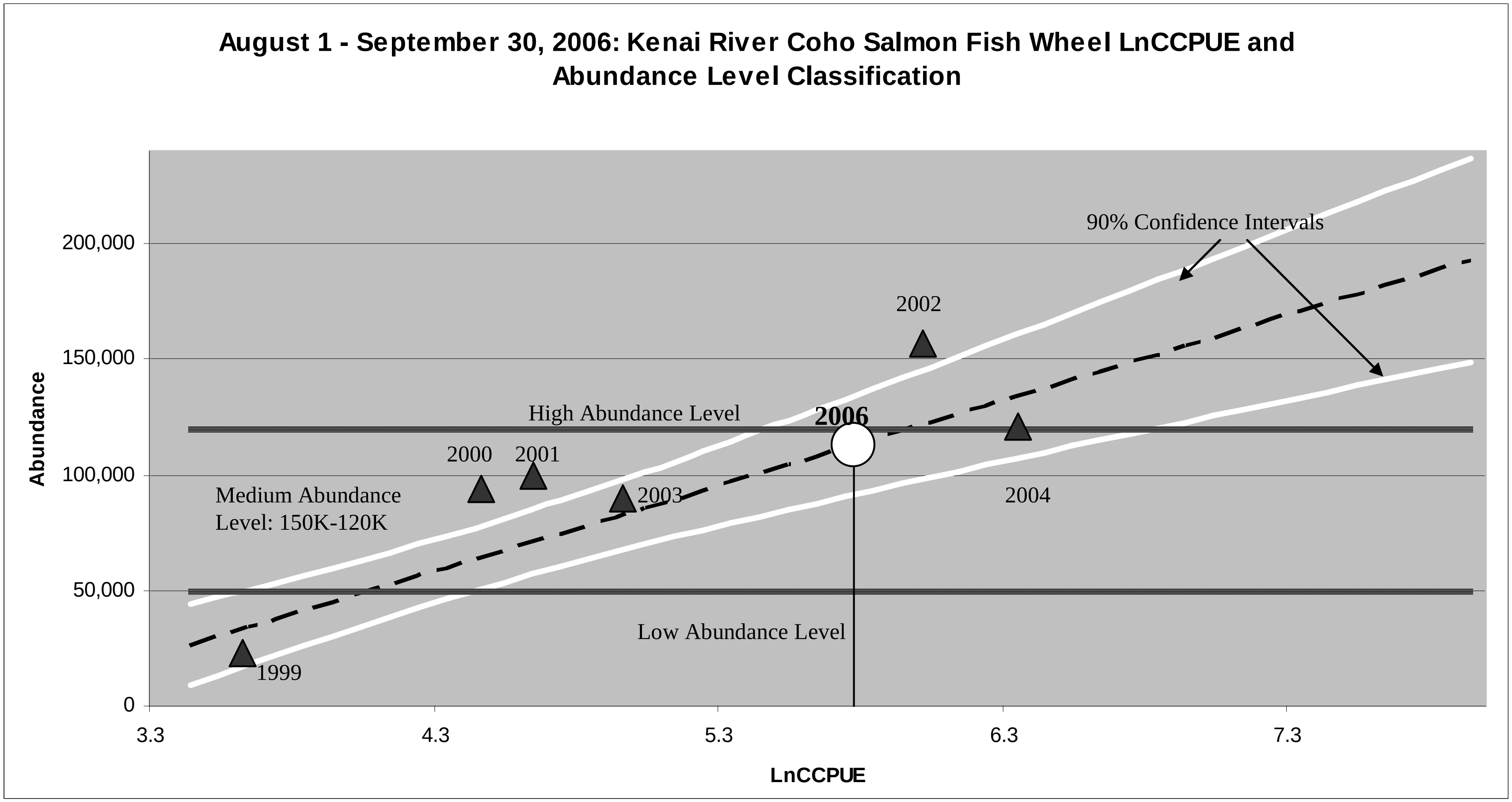

Figure 8.-Regression of the 1999-2004 Kenai River coho salmon fish wheel LnCCPUE to abundance estimates passing river kilometer 45, including a trend line with the 2006 end-of-season abundance classification.

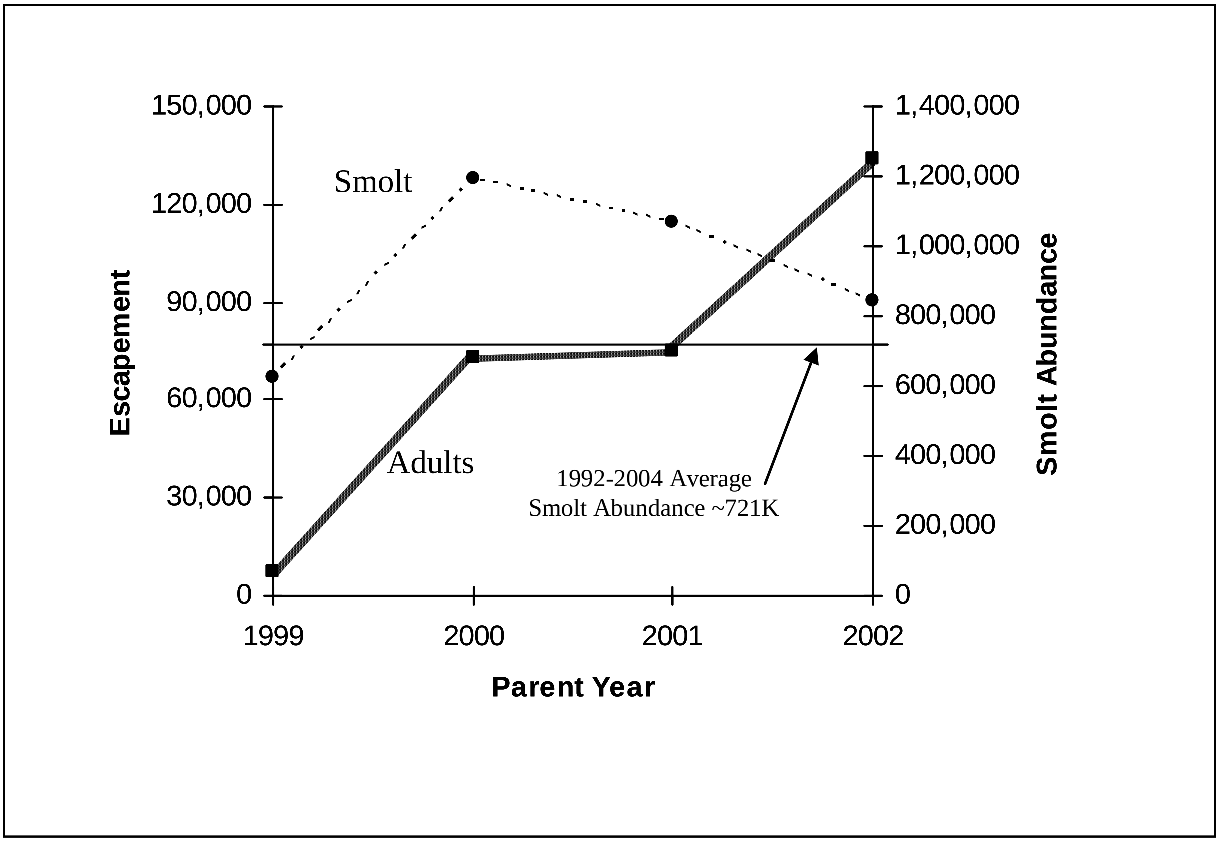

Figure 9.-Kenai River coho salmon smolt production determined from 1999-2002 escapements.

Adult Inriver Index

Variables affecting the fish wheel CPUE also affect the accuracy of the adult inriver abundance index. Although attempts are made to maintain fish wheel location, effort, and spin rate, variables such as water clarity, channel scouring, crew experience, boat traffic, weather, fish behavior, and others, can conceivably affect catch rates.

In 2006, the fish wheels used for the adult coho salmon index project were also used through most of August to capture sockeye for a separate project. Specifically, the fish wheels operated as the recapture event for a two-event mark-recapture experiment designed to estimate the inriver abundance of sockeye salmon in the Kenai River. Conducting the sockeye salmon project concurrently with the index project increased and complicated data recording.

When sockeye passage was intense during the first half of August, the fish wheels were slowed or "braked" by physically restraining the fish wheel rotation to reduce the catch rate to a manageable level. Slowing the fish wheel spin rate allowed the fish to be more easily observed while they were in the fish wheel basket to determine whether or not sockeye were marked. The sporadic and temporary slowing of the fish wheel spin rate had an unknown affect on the CPUE of coho salmon.

Table 3.-Total estimated harvest of Kenai River coho salmon in Upper Cook Inlet (UCI) inriver and marine commercial fisheries, 1993-2005.

	Kenai River								UCI Marine Commercial[c]				
	Sport[a]					Personal							
	Mainstem			Russian		use/	Inriver		Eastside	Drift	Northern	Commercial	Grand
Year	Unguided[a]	Guided	Total	River	Total	subsistence	total	Educational[b]	set gillnet	gillnet	District	total	total
1993	26,795	23,743	50,538	2,290	52,828	1,597 [d]	54,425	427	6,806	930	148	7,884	62,736
1994	45,541	41,170	86,711	4,607	91,318	2,535 [e]	93,853	829	14,673	11,732	477	26,882	121,564
1995	22,596	23,587	46,183	4,077	50,260	1,261 [f]	51,521	868	13,152	6,956	582	20,690	73,079
1996	28,565	14,645	43,210	4,599	47,809	1,932 [g]	49,741	592	11,856	2,671	29	14,556	64,889
1997	13,063	3,107	16,170	4,586	20,756	559 [g]	21,315	191	2,093	1,236	36	3,365	24,871
1998	21,750	5,217	26,967	4,612	31,579	1,011 [g]	32,590	638	8,096	1,974	175	10,245	43,473
1999	23,557	8,087	31,644	3,910	35,554	1,009 [g]	36,563	530	2,905	818	171	3,894	40,987
2000	39,202	9,349	48,551	3,938	52,489	1,449 [g]	53,938	656	2,351	531	83	2,965	57,559
2001	36,264	13,518	49,782	5,222	55,004	1,555 [g]	56,559	572	349	282	1,303	1,934	59,065
2002	45,567	14,444	60,011	6,093	66,104	1,721 [g]	67,825	921	4,688	1,370	57	6,115	74,861
2003	34,783	11,964	46,747	5,197	51,944	1,332 [g]	53,276	464	2,122	330	126	2,578	56,318
2004	51,224	14,845	66,069	6,574	72,643	2,661 [h]	75,304	765	5,921	4,251	977	11,149	87,218
2005	38,115	12,285	50,400	3,868	54,268	2,512 [h]	56,780	489	3,310	1,533	176	5,019	62,288
Mean	32,848	15,074	47,922	4,583	52,504	1,626	54,130	611	6,025	2,663	347	9,021	63,885

[a] Source is Statewide Harvest Survey (Howe et al. 1995 and 1996; Howe et al. 2001 a-d (1996-2000 are revised estimates); Jennings et al. (2004); Jennings et al. (2006 a, b); Jennings et al. (2007); Jennings (In prep); Mills 1994; Walker et al. (2003). Mainstem unguided includes Skilak Lake and Hidden Lake.

[b] Kenai River harvest in the Kenaitze Tribal educational fishery, (Larry Marsh, ADF&G, personal communication) prior to 2002, these harvests include Kasilof and Swanson River harvests.

[c] Carlon (2000, 2003); Carlon and Hasbrouck (1994, 1996-1998); Massengill (2007a, b); Massengill and Carlon (2004 a, b, 2007 a, b).

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

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

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

[g] (Reimer and Sigurdsson 2004).

[h] (Dunker and Lafferty 2007).

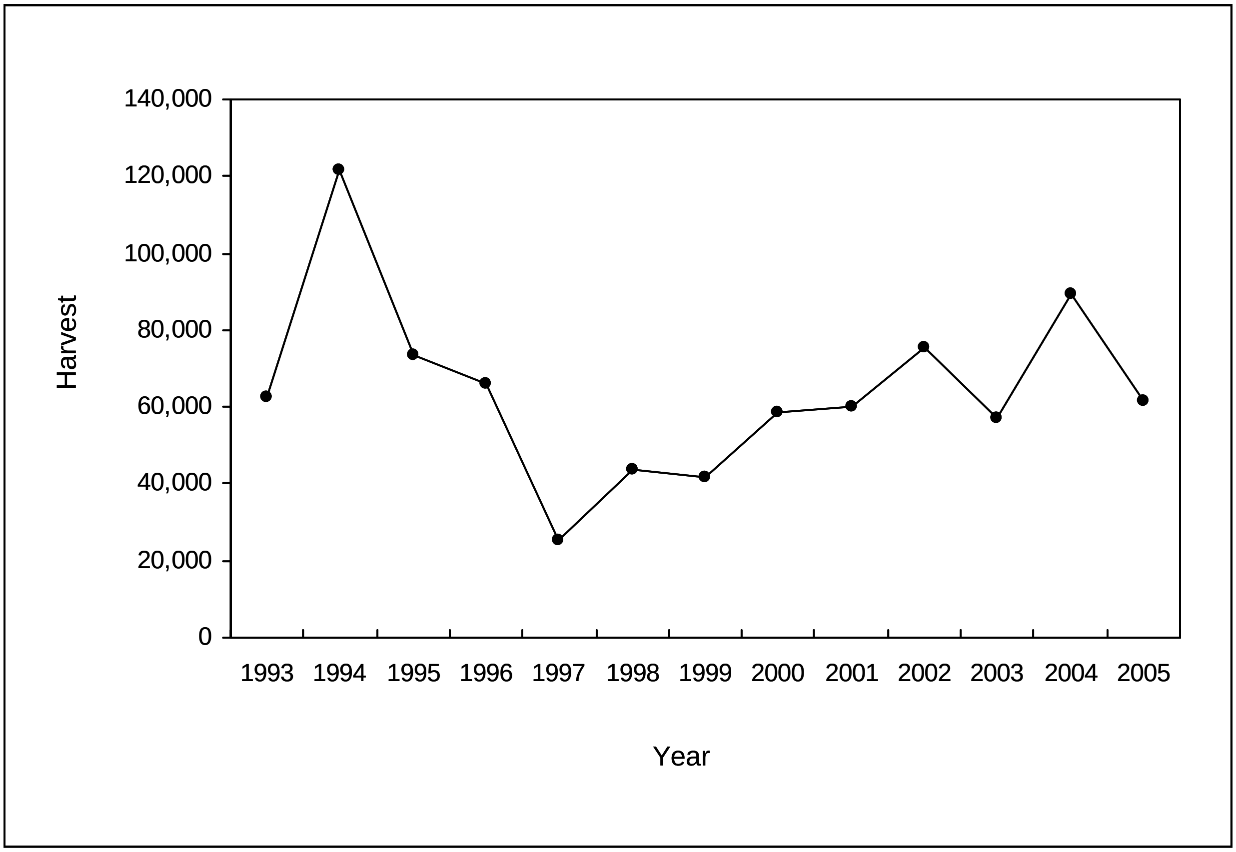

Figure 10.-Annual estimated harvest of Kenai River coho salmon, 1993-2005. Totals include harvest estimates of commercial marine, inriver personal-use, mainstem sport, and Russian River sport fisheries.

To mitigate the potential effects from slowing the spin rate on coho salmon, CPUE measures were discussed inseason, but no resolution was determined. During peak sockeye passage, one fish wheel would often be fished for an hour, and then stopped while the fish wheel on the opposite bank was fished. This alternating fish sampling during peak sockeye periods reduced the number of fish to examine and the need to slow the fish wheels.

To alleviate fish inundation at the fish wheels, a second crew could be added to sample fish (one crew at each fish wheel) during peak sockeye periods, thus providing maximum sample sizes and reducing the need to manually slow the fish wheel rpm. Another alternative would be to provide an additional member for each crew during peak sockeye passage to assist with sockeye salmon sampling and/or data recording.

The index is designed to simply classify abundance into one of three ordinal levels. The index is not generally sensitive to sporadic and subtle sampling-induced changes in CPUE, because drastically changed CPUE values must be sustained for the LnCCPUE to be significantly affected. The primary concern is when the index level approaches a borderline value between two index categories. If this occurs, then marginal changes to rpm and CPUE could affect the end-of-season abundance index. This is especially relevant at lower CCPUE levels (<200).

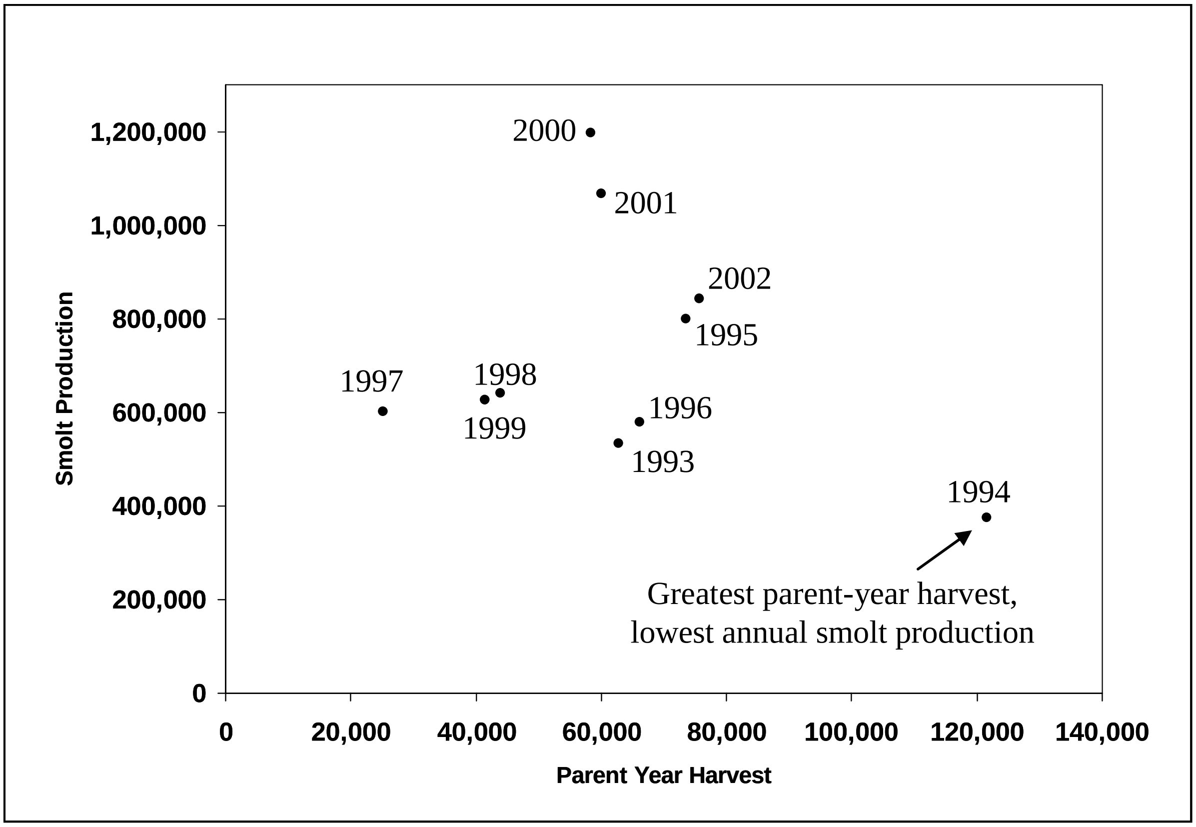

Figure 11.-Parent-year harvest and annual smolt production of Kenai River coho salmon.

Finally, collecting and archiving length and age information from adult and juvenile coho salmon is complicated by the difficulty in discerning years of freshwater development through standard scale aging techniques. Without a reliable means to determine the freshwater age of coho salmon from scales, meaningful brood table construction is not possible. A coho salmon age-validation study could provide a means to accurately decipher age patterns and allow for accurate brood table construction using scales already archived from adult returns and smolt emigrations. It would be prudent to continue to collect and archive Kenai River coho salmon scales and lengths through spring 2007 for smolt and fall 2008 for adults so that scale samples are available from the offspring for all estimated escapement years (1999-2004).

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APPENDIX A

Appendix A1.-Standardized fish wheel operational times used to generate adjusted 1999-2004 fish wheel catch and effort.

	Morning shift				Evening shift				
Date [a]	Start	Stop: before meal break	Restart: after meal break	Stop: end of shift	Start	Stop: before meal break	Restart: after meal break	Stop: end of shift	Daily total hours of effort
8/1-9/7	6:30:00	10:22:30	11:07:30	13:30:00	14:30:00	18:22:30	19:07:30	21:30:00	12.5
9/8-9/14	7:00:00	10:22:30	11:07:30	14:00:00	14:00:00	18:22:30	19:07:30	21:00:00	12.5
9/15-9/21	7:30:00	10:22:30	11:07:30	14:30:00	13:30:00	18:22:30	19:07:30	20:30:00	11.5
9/22-9/30	8:00:00	10:22:30	11:07:30	15:00:00	13:00:00	18:22:30	19:07:30	20:00:00	10.5

Note: The standardized fish wheel operational periods are theoretical; actual operational times can be less due to unpredictable fishing conditions.

[a] Beginning September 8, 2004, the fish wheels were operated between 13:30 and 14:30 hours. Before September 8, 2004, the fish wheels were not operated during this period.

Appendix A2.-Method used to interpolate Kenai River coho salmon catch for days the fish wheels were not operated between August 1 and September 30, 1999.

The first step (square brackets in equation 1) estimated the cumulative CPUE missed on all days the fish wheels did <u>not</u> operate in 1999. The second step assigned a portion of this quantity to day *j* (multiplication by p_j in equation 1):

$$CPUE_j = \left[\frac{T_{99}}{p} - T_{99}\right] p_j, \quad (1)$$

where:

T_{99} = CCPUE for 1999 (i.e., cumulative CPUE for days when wheels operated in 1999),

$$p = \sum_i \bar{p}_i, \quad (2)$$

for *i* denoting days when wheels operated in 1999

where:

$$\bar{p}_i = \frac{\sum_{y=2000}^{2004} p_{yi}}{5}, \quad (3)$$

and

$$p_{yi} = CPUE_{yi} \Big/ \sum_{k=1}^{61} CPUE_{yk}, \quad (4)$$

where $CPUE_{yi}$ is the CPUE for year *y* on day *i*

and

$$p_j = \frac{\bar{p}_j}{\sum_m \bar{p}_m}, \quad (5)$$

for *m* denoting days when the wheels did <u>not</u> operate in 1999.

Appendix A3.-Summary of actual and adjusted fish wheel effort, coho salmon catch, and catch per hour (CPUE) by bank near river kilometer 45, Kenai River, Alaska, 1999-2006.

Year	Data type [a,b]		Temporal interval: North bank fish wheel 8/ 1 - 8/14	8/1 - 8/28	8/1 - 9/11	8/1 - 9/25	8/1 - 9/30	South bank fish wheel 8/ 1 - 8/14	8/1 - 8/28	8/1 - 9/11	8/1 - 9/25	8/1 - 9/30	Combined banks end-of-season grand total
1999 [c,d]	Actual	hours of effort	0.0	12.7	164	302.2	358.7	23.8	99.7	220.3	360.3	403.4	762.1
	Actual	total catch	0	2	60	134	148	9	126	130	165	171	319
	Actual	catch per hour		0.157	0.366	0.443	0.413	0.378	1.264	0.590	0.458	0.424	0.419
	Adjusted	hours of effort											
	Adjusted	total catch											
	Adjusted	catch per hour											0.617
	% change between actual and adjusted CPUE												47.4%
2000 [e]	Actual	hours of effort	188.6	369.2	497.4	659.7	735.8	187.2	379.1	528	708	784.8	1,520.6
	Actual	total catch	331	783	1,372	2,345	2,518	53	108	415	787	828	3,346
	Actual	catch per hour	1.755	2.121	2.758	3.555	3.422	0.283	0.285	0.786	1.112	1.055	2.200
	Adjusted	hours of effort	172.6	339.0	452.4	596.2	655.9	169.8	343.2	477.8	635.1	695.0	1,350.9
	Adjusted	total catch	320	755	1,293	2,182	2,322	46	86	345	661	700	3,022
	Adjusted	catch per hour	1.854	2.227	2.858	3.660	3.540	0.271	0.251	0.722	1.041	1.007	2.237
	% change between actual and adjusted CPUE		5.7%	5.0%	3.6%	3.0%	3.4%	-4.3%	-12.0%	-8.1%	-6.4%	-4.5%	1.7%
2001 [e]	Actual	hours of effort	186.3	397.1	603.9	809.1	880.3	188.5	395.4	597.1	784.8	855.1	1,735.4
	Actual	total catch	176	500	663	821	848	164	923	1,600	1,759	1,819	2,667
	Actual	catch per hour	0.945	1.259	1.098	1.015	0.963	0.870	2.334	2.680	2.241	2.127	1.537
	Adjusted	hours of effort	171.2	365.6	557.1	736.5	794.7	173.3	365.2	552.9	714.1	772.3	1,567.1
	Adjusted	total catch	164	449	578	685	705	153	859	1469	1571	1626	2,331
	Adjusted	catch per hour	0.958	1.228	1.037	0.930	0.887	0.883	2.352	2.657	2.200	2.105	1.488
	% change between actual and adjusted CPUE		1.4%	-2.5%	-5.5%	-8.3%	-7.9%	1.5%	0.8%	-0.8%	-1.8%	-1.0%	-3.2%
2002 [d,e]	Actual	hours of effort	131.0	254.6	352.9	501.5	567.4	141.3	264.8	371.3	527.1	594.3	1,161.7
	Actual	total catch	41	844	2,065	3,731	3,910	277	1,256	1,996	2,520	2,630	6,540
	Actual	catch per hour	0.313	3.315	5.852	7.440	6.891	1.960	4.743	5.376	4.781	4.425	5.630
	Adjusted	hours of effort	128.0	250.1	345.8	475.9	528.7	137.7	266.7	364.2	501.3	554.9	1,083.6
	Adjusted	total catch	33	826	2,027	3,520	3,679	273	1,252	1,978	2,640	2,558	6,237
	Adjusted	catch per hour	0.258	3.303	5.862	7.397	6.958	1.983	4.694	5.431	5.267	4.610	5.756
	% change between actual and adjusted CPUE		-17.6%	-0.4%	0.2%	-0.6%	1.0%	1.2%	-1.0%	1.0%	10.2%	4.2%	2.2%

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Appendix A3.-Page 2 of 2.

			Temporal interval										Combined banks
			North bank fish wheel					South bank fish wheel					end-of-season
Year	Data type [a,b]		8/ 1 - 8/14	8/1 - 8/28	8/1 - 9/11	8/1 - 9/25	8/1 - 9/30	8/ 1 - 8/14	8/1 - 8/28	8/1 - 9/11	8/1 - 9/25	8/1 - 9/30	grand total
2003 [e]	Actual	hours of effort	172.3	338.7	503.9	666.4	741.9	168.6	316.2	479.3	629.9	704.5	1,446.4
	Actual	total catch	37	167	239	278	288	479	1,754	2,123	2,148	2,174	2,462
	Actual	catch per hour	0.215	0.493	0.474	0.417	0.388	2.841	5.547	4.429	3.410	3.086	1.702
	Adjusted	hours of effort	166.5	329.1	488.7	624.9	684.9	165.1	312.5	471.2	599.4	659.4	1,344.3
	Adjusted	total catch	29	143	197	224	231	481	1,749	2,114	2,130	2,154	2,385
	Adjusted	catch per hour	0.174	0.435	0.403	0.358	0.337	2.913	5.598	4.487	3.553	3.266	1.774
	% change between actual and adjusted CPUE		-18.9%	-11.9%	-15.0%	-14.1%	-13.1%	2.5%	0.9%	1.3%	4.2%	5.9%	4.2%
2004 [e,f]	Actual	hours of effort	110.1	197.9	313.4	469.2	526.6	121.4	231.1	353.6	495.2	553.2	1,079.8
	Actual	total catch	252	1,241	2,247	3,663	4,100	577	3,014	4,521	5,028	5,137	9,237
	Actual	catch per hour	2.289	6.271	7.170	7.807	7.786	4.753	13.042	12.786	10.153	9.286	8.554
	Adjusted	hours of effort	108.1	195.4	309.9	465.6	522.9	121.4	230.8	352.0	493.3	551.3	1,074.2
	Adjusted	total catch	238	1,223	2,223	3,639	4,076	577	2,998	4,498	5,005	5,114	9,190
	Adjusted	catch per hour	2.202	6.258	7.173	7.817	7.795	4.754	12.991	12.780	10.147	9.277	8.555
	% change between actual and adjusted CPUE		-3.8%	-0.2%	0.0%	0.1%	0.1%	0.0%	-0.4%	0.0%	-0.1%	-0.1%	0.0%
2005 [g]	Actual	hours of effort	161.7	322.4	489.7	642.6	695.8	168.3	338.6	510.4	673.4	726.6	1422.4
	Actual	total catch	107	1,888	2,683	2,963	3,023	39	954	2,062	2,417	2,494	5,517
	Actual	catch per hour	0.662	5.856	5.479	4.611	4.345	0.232	2.817	4.040	3.589	3.432	3.879
2006 [g]	Actual	hours of effort	125.6	237.6	353.4	505.1	556.3	125.5	235.1	373.8	527	580.5	1136.8
	Actual	total catch	55	519	1,098	2,019	2,179	239	1,301	2,271	3,597	3,855	6,034
	Actual	catch per hour	0.438	2.184	3.107	3.997	3.917	1.904	5.534	6.075	6.825	6.641	5.308

[a] "Actual" hours of effort, total catch, and catch per hour (CPUE) are generated using all data including any collected outside the standardized daily fish wheel operation time periods that were implemented in 2004. "Adjusted" hours of effort, total catch, and CPUE refers to data collected only within the standardized daily fish wheel operation periods.

[b] Totals do not include coho salmon recaptured, escaped, or considered unsuitable for marking (i.e., severely injured or dead) with the exception of 1999 when two recaptured fish are included.

[c] The 1999 fish wheel sites varied in location between river kilometer 43 and 45 and were located slightly downstream of the 2000-2005 sites.

[d] The 1999 adjusted end-of-season grand total CPUE was calculated by including interpolated CPUE for the days when no effort occurred (8/1-8/9, 8/12-8/16, 8/27, 8/30, and 9/13). Adjusted bi-weekly effort and catch data are not available for 1999. In 2002, interpolation was required to estimate CPUE for 8/3 when no effort occurred.

[e] Source of "actual" catch and effort data 1999-2003 from Carlon and Evans (2007) and 2004 from Massengill and Evans (2007).

[f] Although new standardized fish wheel operational times were first implemented in 2004, some truncation of data was required to produce "adjusted" catch and effort data because some fishing still occurred outside scheduled periods.

g The "actual" hours of effort and total catch occurred within strictly observed standardized fishing periods so truncation of the data was not needed to produce "adjusted" catch or effort data.

Appendix A4.-Daily summary of adult coho salmon captured by two fish wheels near river kilometer 45, Kenai River, August 1–September 30, 2006.

	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	1				09/01	42	3	3	3
08/02	2				09/02	46	4	3	3
08/03	5				09/03	41	2	2	2
08/04	5				09/04	46	4	4	4
08/05	2				09/05	27	1	1	1
08/06	5				09/06	72	10	10	10
08/07	2				09/07	33	7	7	7
08/08					09/08	55	7	7	7
08/09	5				09/09	44	7	7	7
08/10	2				09/10	34	6	6	6
08/11	10				09/11	28	4	4	4
08/12	2				09/12	23	5	5	5
08/13	7	1			09/13	32	3	3	3
08/14	7				09/14	65	9	9	9
08/15	30	3			09/15	102	11	11	11
08/16	35	1			09/16	87	8	8	8
08/17	23	1			09/17	100	16	16	16
08/18	17				09/18	74	9	9	9
08/19	19				09/19	59	9	9	9
08/20	46	2			09/20	69	8	8	8
08/21	25	3			09/21	88	14	14	14
08/22	24	3			09/22	73	11	11	11
08/23	26	1			09/23	92	20	20	20
08/24	46	2			09/24	31	6	6	6
08/25	29	3			09/25	26	4	4	4
08/26	66				09/26	53	8	8	8
08/27	41	1			09/27	34	4	4	4
08/28	37	1			09/28	26	4	4	4
08/29	34	1	1	1	09/29	42	4	4	4
08/30	44	3	3	3	09/30	5			
08/31	33	3	3	3					
Subtotal	630	29	7	7		1,549	208	207	207
North bank subtotal						2,179	237	214	214

-continued-

	August					September			
Date	Number captured and examined	Marked fish observed[a]	Marked fish checked with tag detector[b]	Coded wire tag detected	Date	Number captured and examined	Marked fish observed[a]	Marked fish checked with tag detector[b]	Coded wire tag detected
					South bank				
08/01	9				09/01	57	2	2	2
08/02	2				09/02	100	7	2	2
08/03	6				09/03	85	7	7	7
08/04	7	1			09/04	74	4	4	4
08/05	15				09/05	76	5	5	5
08/06	4				09/06	48	3	3	3
08/07	16	1			09/07	39	1	1	1
08/08	16				09/08	65	8	8	8
08/09	11				09/09	73	9	9	9
08/10	19	1			09/10	65	7	7	7
08/11	29	2			09/11	56	5	5	5
08/12	35				09/12	48	6	6	6
08/13	48	4			09/13	74	11	11	11
08/14	22	2			09/14	80	9	9	9
08/15	41	1			09/15	80	10	10	10
08/16	87	3			09/16	122	18	18	18
08/17	56	2			09/17	117	20	20	20
08/18	32				09/18	140	10	10	10
08/19	106				09/19	89	17	17	17
08/20	103	2			09/20	70	9	9	9
08/21	51	6			09/21	97	10	10	10
08/22	51	1			09/22	120	19	19	19
08/23	77	3			09/23	156	25	25	25
08/24	52	2			09/24	61	8	8	8
08/25	78	2			09/25	72	11	11	11
08/26	99	2			09/26	73	13	13	13
08/27	114	2			09/27	61	4	4	4
08/28	115	14	2	2	09/28	48	7	7	7
08/29	61	2	2	2	09/29	52	6	6	6
08/30	103	7	7	7	09/30	24	1	1	1
08/31	68	3	3	3					
Subtotal	1,533	63	14	14		2,322	272	267	267
South bank subtotal						3,855	335	281	281
Grand total (both banks)						6,034	572	495	495

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

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

Appendix A5.-Fish wheel catch by species and bank near river kilometer 45, Kenai River, August 1–September 30, 2006.

	North bank fish wheel catch						
	Coho salmon	Sockeye salmon	Chinook salmon	Pink salmon	Rainbow trout	Dolly Varden	Steelhead
08/01/06	1	590		2			
08/02/06	2	635		4			
08/03/06	5	694		5	1		
08/04/06	5	512	1	7			
08/05/06	2	294		3			
08/06/06	5	157		3			
08/07/06	2	292		10			
08/08/06		163		7	1		
08/09/06	5	106	1	12			
08/10/06	2	105		24	1		
08/11/06	10	137		48			
08/12/06	2	135		49		1	
08/13/06	7	205	1	98	1		
08/14/06	7	394		106			
08/15/06	30	567	1	160			
08/16/06	35	315	1	134	2		
08/17/06	23	318	2	221			
08/18/06	17	466	1	197		1	
08/19/06	19	169	1	191	1		
08/20/06	46	155		202			
08/21/06	25	149	1	508		1	
08/22/06	24	194	1	773	3		
08/23/06	26	111	2	939	1		
08/24/06	46	112		1,034			
08/25/06	29	72	4	512	1		
08/26/06	66	134		1,224		1	
08/27/06	41	58	2	1,165			
08/28/06	37	88	1	1,395			
08/29/06	34	38		641			
08/30/06	44	36		590			
08/31/06	33	38		3,171		2	
09/01/06	42	9		2,796			
09/02/06	46	23		1,710			
09/03/06	41	26		1,830			
09/04/06	46	39	3	2,068	1		
09/05/06	27	14		845			
09/06/06	72	12		3,429	1		
09/07/06	33	6		2,644			
09/08/06	55	1		3,015			
09/09/06	44	4		2,466		3	
09/10/06	34	3		2,076		1	
09/11/06	28	1		891	1	1	
09/12/06	23	5		611	1	1	
09/13/06	32	3		906		2	
09/14/06	65	6		713		1	
09/15/06	102	5		811		2	
09/16/06	87	2		421	1		
09/17/06	100	1		601	1	1	
09/18/06	74			192			
09/19/06	59			201			
09/20/06	69			199			1
09/21/06	88	2		38	1		
09/22/06	73	3		30		1	
09/23/06	92			12	1	1	
09/24/06	31			8	2	3	
09/25/06	26	1		4	1		
09/26/06	53	1		12			
09/27/06	34			18	4	1	1
09/28/06	26			19	1	3	
09/29/06	42			5	3	1	
09/30/06	5			5	1		
Total	2,179	7,606	23	42,011	32	28	2

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	South bank fish wheel catch						
	Coho salmon	Sockeye salmon	Chinook salmon	Pink salmon	Rainbow trout	Dolly Varden	Steelhead
08/01/06	9	991		6			
08/02/06	2	711		1			
08/03/06	6	660		7			
08/04/06	7	703		5			
08/05/06	15	1,131	1	7		1	
08/06/06	4	408		2			
08/07/06	16	578	2	10			
08/08/06	16	379		15	1	2	
08/09/06	11	190		26		2	
08/10/06	19	149	3	36		1	
08/11/06	29	146	4	60	2	1	
08/12/06	35	218		35			
08/13/06	48	415		34	1		
08/14/06	22	359	1	18		1	
08/15/06	41	439		76			
08/16/06	87	604	2	73	1		
08/17/06	56	340	1	47		1	
08/18/06	32	239		99		1	
08/19/06	106	372	2	110		1	
08/20/06	103	505		102			
08/21/06	51	291		61			
08/22/06	51	265		66			
08/23/06	77	257	1	131			
08/24/06	52	191	1	254	1		
08/25/06	78	201	1	65			
08/26/06	99	275	1	383	3		
08/27/06	114	180		415	2		
08/28/06	115	142		611	2	1	
08/29/06	61	98		440			
08/30/06	103	111		1,074	1		
08/31/06	68	79		1,120	1		
09/01/06	57	46		908			
09/02/06	100	50	1	1,902	1	1	
09/03/06	85	45		1,203		2	
09/04/06	74	21		775			
09/05/06	76	28	1	926		1	
09/06/06	48	20		1,075			
09/07/06	39	2		1,045	1		
09/08/06	65	2		1,473			
09/09/06	73	2		1,271		2	
09/10/06	65	2	1	1,062		1	
09/11/06	56	5	1	527		3	
09/12/06	48	2	2	370		1	
09/13/06	74	4		479		3	
09/14/06	80	6		683		1	
09/15/06	80	5	1	558		3	
09/16/06	122	4		461		2	
09/17/06	117		1	327			
09/18/06	140		3	209		3	
09/19/06	89	3		230	1	2	
09/20/06	70	1		166		1	
09/21/06	97	1		38			
09/22/06	120			25		1	
09/23/06	156			95		1	
09/24/06	61			14	1		
09/25/06	72			21			
09/26/06	73			27	1	1	
09/27/06	61		1	44	2	1	
09/28/06	48			46	4	1	
09/29/06	52		1	34	5	1	1
09/30/06	24			16	1		
Total	3,855	11,876	33	21,399	32	44	1

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	Combined bank fish wheel catch						
	Coho salmon	Sockeye salmon	Chinook salmon	Pink salmon	Rainbow trout	Dolly Varden	Steelhead
08/01/06	10	1,581	0	8	0	0	0
08/02/06	4	1,346	0	5	0	0	0
08/03/06	11	1,354	0	12	1	0	0
08/04/06	12	1,215	1	12	0	0	0
08/05/06	17	1,425	1	10	0	1	0
08/06/06	9	565	0	5	0	0	0
08/07/06	18	870	2	20	0	0	0
08/08/06	16	542	0	22	2	2	0
08/09/06	16	296	1	38	0	2	0
08/10/06	21	254	3	60	1	1	0
08/11/06	39	283	4	108	2	1	0
08/12/06	37	353	0	84	0	1	0
08/13/06	55	620	1	132	2	0	0
08/14/06	29	753	1	124	0	1	0
08/15/06	71	1,006	1	236	0	0	0
08/16/06	122	919	3	207	3	0	0
08/17/06	79	658	3	268	0	1	0
08/18/06	49	705	1	296	0	2	0
08/19/06	125	541	3	301	1	1	0
08/20/06	149	660	0	304	0	0	0
08/21/06	76	440	1	569	0	1	0
08/22/06	75	459	1	839	3	0	0
08/23/06	103	368	3	1,070	1	0	0
08/24/06	98	303	1	1,288	1	0	0
08/25/06	107	273	5	577	1	0	0
08/26/06	165	409	1	1,607	3	1	0
08/27/06	155	238	2	1,580	2	0	0
08/28/06	152	230	1	2,006	2	1	0
08/29/06	95	136	0	1,081	0	0	0
08/30/06	147	147	0	1,664	1	0	0
08/31/06	101	117	0	4,291	1	2	0
09/01/06	99	55	0	3,704	0	0	0
09/02/06	146	73	1	3,612	1	1	0
09/03/06	126	71	0	3,033	0	2	0
09/04/06	120	60	3	2,843	1	0	0
09/05/06	103	42	1	1,771	0	1	0
09/06/06	120	32	0	4,504	1	0	0
09/07/06	72	8	0	3,689	1	0	0
09/08/06	120	3	0	4,488	0	0	0
09/09/06	117	6	0	3,737	0	5	0
09/10/06	99	5	1	3,138	0	2	0
09/11/06	84	6	1	1,418	1	4	0
09/12/06	71	7	2	981	1	2	0
09/13/06	106	7	0	1,385	0	5	0
09/14/06	145	12	0	1,396	0	2	0
09/15/06	182	10	1	1,369	0	5	0
09/16/06	209	6	0	882	1	2	0
09/17/06	217	1	1	928	1	1	0
09/18/06	214	0	3	401	0	3	0
09/19/06	148	3	0	431	1	2	0
09/20/06	139	1	0	365	0	1	1
09/21/06	185	3	0	76	1	0	0
09/22/06	193	3	0	55	0	2	0
09/23/06	248	0	0	107	1	2	0
09/24/06	92	0	0	22	3	3	0
09/25/06	98	1	0	25	1	0	0
09/26/06	126	1	0	39	1	1	0
09/27/06	95	0	1	62	6	2	1
09/28/06	74	0	0	65	5	4	0
09/29/06	94	0	1	39	8	2	1
09/30/06	29	0	0	21	2	0	0
Total	6,034	19,482	56	63,410	64	72	3

Note: Catch includes only morning and evening shift totals, and not the night shift. The night shift was operated strictly for a companion sockeye salmon project and is outside the standardized sampling times for the coho salmon index study.

Appendix A6.-Coho salmon catch, hours of effort, and catch per hour for two fish wheels operated near river kilometer 45, Kenai River, Alaska, August 1–September 30, 2006.

	Fish wheel coho salmon catch, hours of effort, and catch per hour by river bank									
	North bank			South bank			Combined banks			Cumulative
Date	Catch	Hours	Catch/hour	Catch	Hours	Catch/hour	Catch	Hours	Catch/hour	Catch/hour
08/01/06	1	3.9		9	5.5	1.65	10	9.3	1.07	1.07
08/02/06	2	5.4	0.37	2	6.6	0.30	4	12.0	0.33	1.40
08/03/06	5	7.2	0.70	6	7.5	0.80	11	14.7	0.75	2.16
08/04/06	5	6.2	0.81	7	4.8	1.46	12	11.0	1.09	3.25
08/05/06	2	6.7	0.30	15	6.8	2.20	17	13.5	1.26	4.51
08/06/06	5	7.6	0.66	4	5.7	0.70	9	13.2	0.68	5.19
08/07/06	2	12.0	0.17	16	10.9	1.47	18	22.8	0.79	5.97
08/08/06		10.2	0.00	16	10.9	1.47	16	21.1	0.76	6.73
08/09/06	5	11.6	0.43	11	11.3	0.97	16	22.8	0.70	7.43
08/10/06	2	12.2	0.16	19	11.8	1.61	21	24.0	0.88	8.31
08/11/06	10	11.2	0.89	29	10.8	2.68	39	22.0	1.77	10.08
08/12/06	2	11.2	0.18	35	10.5	3.33	37	21.8	1.70	11.78
08/13/06	7	11.4	0.61	48	11.7	4.09	55	23.2	2.38	14.16
08/14/06	7	9.0	0.78	22	10.7	2.06	29	19.6	1.48	15.63
Subtotal	55	125.6	6.07	239	125.5	24.79	294	251.1	15.63	
08/15/06	30	11.2	2.67	41	10.1	4.07	71	21.3	3.34	18.97
08/16/06	35	6.5	5.38	87	6.3	13.85	122	12.8	9.54	28.51
08/17/06	23	6.4	3.62	56	5.0	11.16	79	11.4	6.95	35.46
08/18/06	17	7.2	2.37	32	4.3	7.53	49	11.4	4.29	39.75
08/19/06	19	8.6	2.21	106	8.7	12.23	125	17.3	7.24	46.99
08/20/06	46	7.9	5.80	103	6.8	15.18	149	14.7	10.12	57.12
08/21/06	25	7.2	3.46	51	7.1	7.22	76	14.3	5.32	62.44
08/22/06	24	8.3	2.89	51	10.7	4.76	75	19.0	3.94	66.38
08/23/06	26	7.5	3.49	77	7.4	10.48	103	14.8	6.96	73.34
08/24/06	46	5.6	8.26	52	5.4	9.60	98	11.0	8.92	82.27
08/25/06	29	7.9	3.66	78	7.8	9.96	107	15.8	6.79	89.06
08/26/06	66	10.5	6.31	99	10.0	9.93	165	20.4	8.08	97.13
08/27/06	41	9.0	4.58	114	10.9	10.51	155	19.8	7.83	104.96
08/28/06	37	8.4	4.4	115	9.3	12.37	152	17.7	8.58	113.54
Subtotal	519	237.6	65.18	1,301	235.1	163.64	1,820	472.7	113.54	

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	Fish wheel coho salmon catch, hours of effort, and catch per hour by river bank									
	North bank			South bank			Combined banks			Cumulative
Date	Catch	Hours	Catch/hour	Catch	Hours	Catch/hour	Catch	Hours	Catch/hour	Catch/hour
08/29/06	34	10.4	3.28	61	9.5	6.40	95	19.9	4.77	118.32
08/30/06	44	8.4	5.27	103	10.7	9.64	147	19.0	7.72	126.04
08/31/06	33	7.5	4.40	68	8.0	8.46	101	15.5	6.50	132.54
09/01/06	42	4.5	9.30	57	6.8	8.34	99	11.4	8.72	141.26
09/02/06	46	7.8	5.87	100	8.7	11.45	146	16.6	8.81	150.08
09/03/06	41	8.0	5.15	85	9.6	8.82	126	17.6	7.16	157.24
09/04/06	46	9.9	4.65	74	10.2	7.27	120	20.1	5.98	163.22
09/05/06	27	8.6	3.13	76	11.3	6.75	103	19.9	5.18	168.40
09/06/06	72	7.2	10.07	48	9.4	5.10	120	16.6	7.24	175.64
09/07/06	33	6.6	5.04	39	9.4	4.17	72	15.9	4.53	180.17
09/08/06	55	7.4	7.43	65	11.7	5.55	120	19.1	6.28	186.44
09/09/06	44	9.4	4.66	73	11.9	6.12	117	21.4	5.48	191.92
09/10/06	34	9.9	3.45	65	9.4	6.94	99	19.2	5.15	197.07
09/11/06	28	10.4	2.70	56	12.0	4.65	84	22.4	3.75	200.82
Subtotal	1,098	353.4	139.59	2,271	373.8	263.30	3,369	727.2	200.82	
09/12/06	23	11.1	2.07	48	11.2	4.30	71	22.3	3.19	204.01
09/13/06	32	11.7	2.74	74	12.1	6.10	106	23.8	4.45	208.46
09/14/06	65	9.4	6.95	80	10.2	7.86	145	19.5	7.42	215.88
09/15/06	102	10.2	9.98	80	10.2	7.86	182	20.4	8.92	224.80
09/16/06	87	11.3	7.69	122	11.4	10.69	209	22.7	9.19	234.00
09/17/06	100	11.0	9.06	117	11.6	10.09	217	22.6	9.59	243.59
09/18/06	74	11.4	6.47	140	10.9	12.88	214	22.3	9.60	253.18
09/19/06	59	10.9	5.44	89	11.0	8.12	148	21.8	6.78	259.97
09/20/06	69	10.8	6.37	70	9.3	7.55	139	20.1	6.92	266.88
09/21/06	88	11.0	7.99	97	11.5	8.43	185	22.5	8.22	275.10
09/22/06	73	11.1	6.57	120	11.3	10.67	193	22.4	8.63	283.73
09/23/06	92	10.8	8.52	156	11.1	14.03	248	21.9	11.32	295.04
09/24/06	31	10.7	2.89	61	10.7	5.69	92	21.4	4.29	299.33
09/25/06	26	10.2	2.54	72	10.8	6.66	98	21.1	4.66	303.99
Subtotal	2,019	505.1	224.87	3,597	527.0	384.22	5,616	1,032.1	303.99	
09/26/06	53	10.4	5.12	73	10.3	7.12	126	20.6	6.12	310.11
09/27/06	34	9.8	3.48	61	10.6	5.75	95	20.4	4.66	314.76
09/28/06	26	10.8	2.41	48	10.7	4.51	74	21.4	3.46	318.22
09/29/06	42	10.5	4.02	52	10.8	4.83	94	21.2	4.43	322.65
09/30/06	5	9.9	0.51	24	11.2	2.14	29	21.1	1.37	324.02
Subtotal	2,179	556.3	240.41	3,855	580.5	408.56	6,034	1,136.8	324.02	

Appendix A7.-Daily fish wheel spin rate and water conditions by river bank near river kilometer 45, Kenai River, Alaska, August 1–September 30, 2006.

	Fish wheel spin rate (rpm) by bank		Water transparency (m) by bank		River gauge height[a]	River discharge[a]
Date	North	South	North	South	(ft)	(cfs)
08/01	4.2	4.3	1.2	1.2	9.95	16,000
08/02	4.1	4.1	1.2	1.2	9.88	15,600
08/03	3.9	4.3	1.2	1.1	9.86	15,600
08/04	3.9	4.3	0.6	0.6	9.90	15,700
08/05	3.8	4.3	0.9	0.9	9.86	15,500
08/06	3.8	4.3	1.0	1.0	9.81	15,300
08/07	3.7	4.2	1.2	1.2	9.81	15,300
08/08	3.7	3.9	1.2	1.2	9.78	15,200
08/09	3.6	4.0	1.1	1.1	9.72	14,900
08/10	3.6	4.1	1.2	1.2	9.70	14,800
08/11	3.5	4.0	1.1	1.1	9.76	15,100
08/12	3.7	4.0	1.0	1.0	9.77	15,100
08/13	3.7	4.1	1.2	1.2	9.72	14,900
08/14	3.5	4.0	1.2	1.2	9.65	14,600
08/15	3.6	3.9	1.1	1.1	9.69	14,800
Bi-weekly mean	3.7	4.1	1.1	1.1	9.79	15,227
08/16	3.7	3.9	1.1	1.1	9.73	14,900
08/17	3.7	4.0	0.9	0.9	9.74	15,000
08/18	3.5	4.0	1.1	1.1	9.69	14,800
08/19	3.5	4.0	0.8	0.8	9.76	15,100
08/20	4.0	4.1	0.9	0.9	9.81	15,300
08/21	3.8	4.1	0.8	0.8	9.85	15,500
08/22	3.6	4.3	1.1	1.1	9.86	15,600
08/23	3.7	4.3	0.9	0.9	9.95	16,000
08/24	3.4	4.2			9.96	16,000
08/25	3.6	4.0	0.8	0.8	10.08	16,600
08/26	3.8	4.3	0.8	0.8	10.07	16,500
08/27	3.8	4.3	0.8	0.8	10.02	16,300
08/28	3.7	4.2	0.9	0.9	9.92	15,800
08/29	3.8	4.2	0.8	0.8	9.82	15,400
08/30	3.5	3.9	0.9	0.9	9.76	15,100
08/31	3.4	3.7	0.8	0.8	9.73	14,900
Bi-weekly mean	3.7	4.1	0.9	0.9	9.86	15,550
09/01	3.9	3.8	0.7	0.7	9.62	14,400
09/02	3.5	3.9	0.9	0.9	9.54	14,100
09/03	3.5	3.8	0.9	0.9	9.50	13,900
09/04	3.5	3.6	1.0	1.0	9.45	13,600
09/05	3.3	3.3	1.0	1.0	9.38	13,300
09/06	3.0	2.9	1.0	1.0	9.30	13,000
09/07	3.1	3.7	1.0	1.0	9.23	12,700
09/08	3.1	3.4			9.24	12,700
09/09	3.3	3.5	0.7	0.7	9.19	12,500
09/10	3.5	3.6	0.6	0.6	9.22	12,600
09/11	3.5	3.9	0.8	0.8	9.24	12,700
09/12	3.6	3.7	0.7	0.7	9.26	12,800
09/13	3.8	3.8	0.8	0.8	9.25	12,700
09/14	3.6	3.8	1.0	1.0	9.24	12,700
09/15	3.8	3.7	0.9	0.9	9.33	13,100
Bi-weekly mean	3.5	3.6	0.8	0.8	9.33	13,120
09/16	3.6	3.9	0.6	0.6	9.27	12,800
09/17	3.3	3.8	0.7	0.7	9.21	12,500
09/18	3.5	3.9	0.9	0.9	9.15	12,300
09/19	3.3	3.3	0.7	0.7	9.18	12,400
09/20	3.3	3.5	0.9	0.9	9.09	12,000
09/21	3.0	3.5	1.0	1.0	8.99	11,600
09/22	3.3	3.5	0.6	0.6	9.05	11,800
09/23	3.4	3.5	0.7	0.7	9.01	11,700
09/24	3.0	3.5	0.8	0.8	8.94	11,400
09/25	3.2	3.3	0.9	0.9	8.87	11,100
09/26					8.83	10,900
09/27	2.5	2.9	1.0	1.0	8.78	10,700
09/28	2.8	2.7	1.0	1.0	8.73	10,500
09/29		2.3			8.69	10,400
09/30	2.3	2.3	1.1	1.1	8.59	9,980
Bi-weekly mean	3.1	3.3	0.8	0.8	8.96	11,472
Grand mean	3.5	3.8	0.9	0.9	9.49	13,870

[a] As measured at the Kenai River bridge at Soldotna (U.S. Geological Survey River Gauging Station Site 15266300).

Appendix A8.-Average bi-weekly fish wheel spin rate and water conditions by river bank near river kilometer 45, Kenai River, Alaska, August 1–September 30, 1999-2006.

		Fish wheel spin rate (rpm) by bank		Water transparency (m) by bank		River gauge height[b]	River discharge[b]
Year	Period	North	South	North	South	(ft)	(cfs)
1999[a]	8/1 to 8/15	n/a	3.69	0.72	0.72	9.72	14,573
	8/16 to 8/31	5.13	2.58	0.99	0.99	9.39	13,019
	9/1 to 9/15	4.62	3.16	1.03	1.03	8.88	10,763
	9/16 to 9/30	5.47	4.38	0.88	0.88	9.49	13,480
	Entire season	5.03	3.44	0.91	0.91	9.37	12,960
2000	8/1 to 8/15	5.24	4.18	1.18	1.45	9.57	13,767
	8/16 to 8/31	4.08	3.52	1.15	1.14	8.68	10,161
	9/1 to 9/15	3.48	4.55	0.83	0.81	7.80	7,215
	9/16 to 9/30	3.03	4.39	0.68	0.65	7.28	5,444
	Entire season	3.96	4.15	0.90	0.89	8.34	9,163
2001	8/1 to 8/15	2.61	3.42	1.53	2.43	10.07	16,273
	8/16 to 8/31	3.06	3.28	0.90	1.00	10.11	16,469
	9/1 to 9/15	3.00	3.82	0.86	0.88	10.12	16,573
	9/16 to 9/30	2.93	3.83	0.90	0.89	9.67	14,327
	Entire season	2.90	3.58	0.94	1.03	10.00	15,920
2002	8/1 to 8/15	3.09	3.79	1.45	1.55	9.57	13,757
	8/16 to 8/31	3.63	3.12	1.41	1.47	9.16	11,894
	9/1 to 9/15	3.21	4.04	1.27	1.15	8.76	10,225
	9/16 to 9/30	3.42	4.81	0.88	0.91	8.76	10,489
	Entire season	3.36	3.93	1.22	1.22	9.06	11,560
2003	8/1 to 8/15	3.22	4.17	0.66	0.68	9.44	12,813
	8/16 to 8/31	3.64	4.36	0.71	0.71	9.76	14,188
	9/1 to 9/15	3.35	3.43	0.94	0.94	9.00	10,821
	9/16 to 9/30	3.04	3.76	1.14	1.14	7.44	5,397
	Entire season	3.32	3.94	0.91	0.90	8.92	10,860
2004	8/1 to 8/15	3.49	3.84	1.04	1.00	9.76	14,907
	8/16 to 8/31	3.11	3.62	1.01	1.03	9.39	13,206
	9/1 to 9/15	3.23	3.09	0.94	0.96	8.54	9,712
	9/16 to 9/30	2.91	3.11	0.81	0.81	7.36	5,709
	Entire season	3.18	3.40	0.95	0.94	8.77	10,922
2005	8/1 to 8/15	3.27	4.70	1.26	1.04	9.36	13,367
	8/16 to 8/31	3.14	4.34	0.87	0.81	9.10	12,231
	9/1 to 9/15	3.75	3.52	0.66	0.73	8.69	10,530
	9/16 to 9/30	3.67	3.59	0.82	0.78	8.67	10,353
	Entire season	3.45	4.04	0.92	0.79	8.95	11,630
2006	8/1 to 8/15	3.73	4.11	1.08	1.07	9.79	15,227
	8/16 to 8/31	3.65	4.09	0.88	0.88	9.86	15,550
	9/1 to 9/15	3.46	3.61	0.84	0.84	9.33	13,120
	9/16 to 9/30	3.10	3.26	0.83	0.83	8.96	11,472
	Entire season	3.50	3.78	0.91	0.91	9.49	13,870

[a] Water transparency recorded at river kilometer 31, fish wheel spin rate at river kilometer 43 to 45.

[b] As measured at the Kenai River bridge at Soldotna (U.S. Geological Survey River Gauging Station Site 15266300).

Appendix A9.-Summary of the cumulative fish wheel catch per unit of effort (CCPUE), and the natural log-transformed CCPUE (LnCCPUE) of coho salmon using adjusted data, Kenai River, Alaska, near river kilometer 45, 1999-2006.

		Temporal interval														
		North bank fish wheel					South bank fish wheel					Combined banks fish wheel				
Year		8/ 1 - 8/14	8/1 - 8/28	8/1 - 9/11	8/1 - 9/25	8/1 - 9/30	8/ 1 - 8/14	8/1 - 8/28	8/1 - 9/11	8/1 - 9/25	8/1 - 9/30	8/ 1 - 8/14	8/1 - 8/28	8/1 - 9/11	8/1 - 9/25	8/1 - 9/30
1999 [a,b]	CCPUE											4.46	25.86	30.34	36.19	37.63
	LnCCPUE											1.50	3.25	3.41	3.59	3.63
2000	CCPUE	26.24	63.66	128.16	215.27	227.03	3.37	6.43	36.92	65.11	68.37	14.79	34.86	79.87	135.90	143.40
	LnCCPUE	3.27	4.15	4.85	5.37	5.43	1.21	1.86	3.61	4.18	4.22	2.69	3.55	4.38	4.91	4.97
2001	CCPUE	12.31	32.85	42.16	50.48	52.18	11.32	62.83	108.77	117.43	122.05	11.84	47.78	75.13	83.87	87.07
	LnCCPUE	2.51	3.49	3.74	3.92	3.95	2.43	4.14	4.69	4.77	4.80	2.47	3.87	4.32	4.43	4.47
2002	CCPUE	2.88	116.58	312.42	491.23	507.18	24.34	152.43	270.33	322.00	331.14	13.52	133.71	287.93	399.00	411.33
	LnCCPUE	1.06	4.76	5.74	6.20	6.23	3.19	5.03	5.60	5.77	5.80	2.60	4.90	5.66	5.99	6.02
2003	CCPUE	2.27	11.83	16.78	19.62	20.21	39.62	163.57	195.95	197.37	199.37	20.54	83.17	101.36	103.47	104.76
	LnCCPUE	0.82	2.47	2.82	2.98	3.01	3.68	5.10	5.28	5.29	5.30	3.02	4.42	4.62	4.64	4.65
2004	CCPUE	37.43	197.83	323.18	451.03	489.15	73.89	390.20	566.06	615.12	624.47	58.17	305.68	459.94	550.89	574.55
	LnCCPUE	3.62	5.29	5.78	6.11	6.19	4.30	5.97	6.34	6.42	6.44	4.06	5.72	6.13	6.31	6.35
2005	CCPUE	9.12	163.75	230.93	256.07	261.69	3.23	78.25	170.54	201.10	208.30	6.18	119.86	199.75	228.34	234.75
	LnCCPUE	2.21	5.10	5.44	5.55	5.57	1.17	4.36	5.14	5.30	5.34	1.82	4.79	5.30	5.43	5.46
2006	CCPUE	6.07	65.18	139.59	224.87	240.41	24.79	163.64	263.30	384.22	408.56	15.63	113.54	200.82	303.99	324.02
	LnCCPUE	1.80	4.18	4.94	5.42	5.48	3.21	5.10	5.57	5.95	6.01	2.75	4.73	5.30	5.72	5.78

Notes: Summary of 1999-2004 CPUE includes only standardized daily fish wheel operation periods found in Appendix A1.

1999-2004 summary does not include coho salmon recaptured, escaped, or considered unsuitable for marking (i.e., severely injured or dead).

Fish wheel locations in 1999 were river kilometer 31, and between river kilometer 43 and 45.

CPUE consists of the daily catch divided by the daily hours of fish wheel effort and CCPUE is the cumulative daily CCPUE for a given period.

[a] An explanation of how CCPUE was calculated for days not fished can be found in the Data Analysis section under the "2006 Adult Inriver Indes" heading.

[b] "Adjusted" daily catch and effort are available only for combined banks.