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Abundance of Adult Coho Salmon in the Kenai River, Alaska, 1999-2003

by

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and

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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

Two-event mark-recapture experiments provided estimates of the adult coho salmon run in the Kenai River in 1999 through 2003. These are the first estimates of this type for Kenai River coho salmon. Fish wheels were used to capture fish near river kilometer (rkm) 31 in 1999 and near rkm 45 in 2000 through 2003. Fish were tagged primarily with spaghetti tags; a sub-sample was radio-tagged and tracked to estimate the portion of all tagged fish that survived tagging and sustained upstream migration. For the recapture event, drift gillnets were deployed from boats between rkm 33.9 and 48.9 in 1999 and between rkm 48.9 and 58.4 in 2000-2003.

Estimated live abundance of coho salmon adults ranged from 22,808 (SE = 5,157) to 155,992 (SE = 20,255) fish; total run ranged from 48,346 (SE = 5,366) to 208,520 (SE = 20,418); and escapement ranged from 7,696 (SE = 5,288) to 133,612 (SE = 20,306). Annual exploitation rate ranged from 0.35 (SE = 0.04) to 0.84 (SE = 0.10) and smolt-to-adult (marine) survival rate ranged from 0.06 (SE = 0.01) to 0.32 (SE = 0.03).

Estimates of exploitation and recent fishery restrictions strongly suggest that there is no immediate threat to the sustainability of the population or the fisheries it supports and that a harvestable surplus exists. However, it is not yet possible to develop a sustained yield management objective based on brood year returns. Therefore, companion projects to estimate the population-specific harvest should be continued through 2007. Adult abundance estimation should also be continued through 2007 to provide additional information to eventually set or refine escapement goal ranges. Ancillary information suggests that cumulative fish wheel catch rates can discern weak runs from strong, but evaluation of abundance indexing error was not possible; catch rate cannot be used to index coho salmon abundance as a precise, in-season management tool or as an alternative to experiments designed to estimate abundance.

Key words: coho salmon, *Oncorhynchus kisutch*, Kenai River, mark-recapture, abundance, escapement, fish wheel, drift net, radio telemetry

INTRODUCTION

Wild coho salmon Oncorhynchus kisutch spawn and rear in freshwater drainages of Upper Cook Inlet, Alaska (UCI, Figure 1). As they return to spawn, they are harvested in marine mixed-stock commercial and sport fisheries, as well as freshwater sport and personal-use fisheries. Cook Inlet ranks first in the 1990-2002 mean sport harvest of coho salmon among all regions of Alaska, sixth in commercial harvest, and sixth in overall harvest (Figure 2).

In 1991, the Alaska Department of Fish and Game (ADF&G) initiated the first program to assess the status of UCI coho salmon stocks (Meyer et al. *Unpublished*). A primary component of the program involved the wild population of coho salmon from the Kenai River, selected because it has consistently supported the largest annual freshwater sport harvest among all Alaskan drainages, accounting for about 17% of the total coho salmon sport-harvested in Alaska on average (Mills 1979-1980, 1981a-b, 1982-1994; Howe et al. 1995, 1996, 2001 a-d; Walker et al. 2003; Jennings et al. 2004, 2006a-b). The population also contributes to commercial marine fisheries in UCI and, to a lesser degree, to marine sport and inriver personal use fisheries. Despite the substantial harvest, the harvest rate on the Kenai River population was unknown when the assessment program was initiated.

The initial goals of the assessment program were to determine if harvest by existing fisheries was threatening sustained yield and to develop a sustained yield management objective (Meyer et al. *Unpublished*). To achieve these goals, annual estimates of adult production and harvest were needed. A substantial decline in production associated with increasing exploitation would signal the need for conservation actions. Furthermore, a sustained yield management objective could be developed from an analysis of the relationship between escapement, total return, and harvest.

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

Commercial harvest estimates (A) have been made annually since 1993 through a coded wire tag (CWT) release and recovery program (Carlon and Hasbrouck 1994, 1996-1998; Carlon 2000, 2003; Massengill and Carlon 2004a-b, 2007a-b). Inriver sport and personal use harvests (B) have been estimated annually by angler surveys (Mills 1979-1980, 1981a-b, 1982-1994; Howe et al. 1995, 1996, 2001 a-d; Walker et al. 2003; Jennings et al. 2004, 2006a-b). Prior to 1999, estimates of total return and spawning escapement (C) were unavailable due to technical limitations of sonar enumeration equipment (Bendock and Vaught 1994). Although a mark-recapture experiment was considered as an alternative method for estimating escapement, the experiment was postponed because of indications that coho salmon are excessively sensitive to handling-induced stress associated with mark-recapture experiments in intertidal zones (Vincent-Lang et al. 1993). Therefore, the total adult return (and harvest rate) remained unknown.

In lieu of adult production and exploitation information, annual smolt production has been monitored as an indicator of the population status. Annual smolt estimates are produced as ancillary information in the companion project that estimates commercial harvest. The four earliest smolt estimates (1992-1995) revealed a decline in smolt abundance between the first two estimates (1992-1993) and the second two (1994 and 1995) (Carlon and Clark *Unpublished*). Although the cause was unknown, the decline generated concern for the sustainability of historical harvests. A precautionary management plan was therefore developed and was first in effect during the 1997 fishing season (Alaska Fish and Game Laws and Regulations Annotated, 1997-1998; 5AAC 21.357). A subsequent review of information in 2000 (Clark et al. *Unpublished*) recommended additional precautions in response to a short-term decline in UCI commercial harvests of coho salmon and a more restrictive management plan was developed prior to the 2000 fishing season (Alaska Fish and Game Laws and Regulations Annotated, 2000-2001; 5AAC 21.357).

Unprecedented emergency restrictions to commercial and sport coho salmon fisheries were implemented throughout UCI during the 1997 fishing season. These restrictions were implemented in response to weak commercial harvests early in the season and marine test fishery indications that the overall return to UCI was substantially below average (Ruesch and Fox 1998). Because the abundance of Cook Inlet populations was unknown, the emergency actions were imposed to protect all populations (including that of the Kenai River) and were more restrictive than specified in the Kenai River Coho Salmon Management Plan. This situation heightened the concern for fishery sustainability, demonstrated the unfavorable nature of managing without quantified objectives, and renewed interest in estimating adult abundance.

Therefore, the feasibility of implementing a mark-recapture experiment to estimate adult abundance was explored in 1998, and annual mark-recapture experiments were implemented in 1999 through 2003. This report documents results of the feasibility study and the mark-recapture experiments.

OBJECTIVES

The single objective of the experiment in all years was to estimate the abundance of adult coho salmon migrating past a selected point in the Kenai River. In 1999, the selected point was river kilometer (rkm) 30.7; during 2000 through 2003, the point was approximately rkm 45.0.

SECTION I – FEASIBILITY STUDY

In 1998 we investigated the feasibility of fulfilling the basic sample size requirements of a mark-recapture experiment, specifically, to determine if a substantial number of coho salmon could be captured for tagging and whether they would survive capture and handling.

A two-event, mark-recapture experiment was the preferred method for estimating abundance because the technique is well-known, widely used, and the primary analysis methods are well established within the Alaska Department of Fish and Game and fisheries science in general (Seber 1982; Labelle 1994; Arnason et al. 1996; Schwarz and Taylor 1998). In addition, the Kenai River is compatible with the logistical requirements of implementing such a technique. Other methods such as visual surveys or weirs were deemed impractical because the Kenai River and some of its tributaries are glacially occluded and coho salmon spawn both in the mainstem and in most tributaries over a substantially protracted period. Recent developments in hydroacoustic enumeration techniques hold promise for differentiating coho salmon from intermingled pink *O. gorbuscha* and sockeye *O. nerka* salmon, but remain under evaluation in the Kenai River and elsewhere (Debby Burwen, Alaska Department of Fish and Game, Anchorage, Personal Communication).

METHODS

Fish wheels were chosen to capture fish because they had been successfully used to apportion hydroacoustic counts of Kenai River sockeye salmon near rkm 31 and because coho salmon were frequently captured at the site during the later stages of the sockeye salmon migration. The location is also approximately 10 km upstream from marine tidal influence, a factor that is considered important in susceptibility to handling stress (Vincent-Lang et al. 1993). In 1998, fish wheel operation for the sockeye salmon hydroacoustic project was extended through August and September when most of the coho salmon migration is thought to occur.

Two fish wheels, one adjacent to each bank of the river, were operated between August 7 and September 30, 1998. Captured coho salmon were tagged with radio tags or spaghetti tags. Fish were selected for radio tagging systematically from the catch although the selection interval changed over the course of the run as necessary to ensure that the supply of radio tags on hand was not exhausted before September 30. Radio-tagged fish were relocated within the Kenai River drainage by fixed telemetry stations, by aircraft, and at weirs on two tributaries.

RESULTS

The two fish wheels were fished for a mean 13 hours per day between August 7 and September 30. A total of 666 coho salmon were captured and all were tagged, 435 with radio tags and 231 with spaghetti tags. Because the selection interval for radio tags versus spaghetti tags changed over the course of the run, distribution of tags was non-random. However, the tags were distributed over the entire run, so that representatives from all temporal migration strata were radio tagged. Overall, 65% of the catch was radio-tagged.

About 60% of the radio-tagged fish were relocated at numerous and disparate spawning destinations or at locations substantial distances upstream from the initial tagging location. The remaining 40% were verified to have perished after tagging, or were tracked to locations downstream from the tagging location and did not reestablish upstream migration.

CONCLUSIONS

Based on the tagging results, it appears that few coho salmon spawn downstream of the tagging location, and it is inferred that fish tracked downstream but not verified dead nevertheless succumbed to handling stress.

The feasibility study showed that coho salmon can be caught by fish wheels throughout the period fished and that the majority could survive to migrate to disparate and distant locations within the drainage. Although the 40% "failure" rate was probably due to handling-induced mortality, we believed that this degree of handling-induced effect could be overcome logistically or accounted for analytically. Therefore, full-scale implementation of two-event, mark-recapture experiments began in 1999.

SECTION II – MARK-RECAPTURE EXPERIMENTS

METHODS

STUDY DESIGN

River kilometer 30.7 (Figure 3) was chosen for the capture and tagging location in 1999 because of the feasibility results and because it nearly coincides with a geographical stratum boundary of the Statewide Harvest Survey (SWHS). During 2000-2003, the tagging location was moved upstream to rkm 45.0 based on higher catch rates there by additional fish wheels tested during the 1999 experiment. This tagging location is approximately mid-way between SWHS stratum boundaries. In 1999, the recapture reach was between rkm 33.9 (Soldotna Bridge) and rkm 48.9 (Funny River tributary confluence). In 2000-2003, the recapture reach was further upstream, between rkm 48.9 and rkm 58.4 (Moose River tributary confluence). We assumed that about half of the SWHS stratum harvest occurred upstream from the tagging location in 2000-2003.

During all study years, the tagging event consisted of capturing coho salmon by fish wheels and tagging them with either a spaghetti tag or radio tag daily in August and September. The recapture event consisted of resampling the population primarily with drift gillnets deployed from riverboats over the upstream recapture reach daily from August through early October. Other gear-types such as fish wheels, hook-and-line with artificial lures, beach seines, and set gillnets were tested experimentally, supplementing drift gillnet catches.

Based on the feasibility work, some of the tagged fish were expected to fail to sustain upstream migration due to capture and handling-induced stress. Ignoring this artificial phenomenon would have led to the presumption that more tagged coho salmon were available for recapture than actually were available. The number of tagged fish that became unavailable to recapture was estimated and subtracted from the total number tagged to ensure unbiased estimation of abundance at the fish wheel tagging location.

Radio telemetry was used each year to determine how many tagged fish succumbed to handling stress. A tacit assumption in this adjustment is that failure to migrate upstream after tagging was due only to handling stress. The assumption is supported by the observed sensitivity of coho salmon to handling and tagging-induced stress in the 1998 feasibility work and other studies

(Vincent-Lang et al. 1993). The majority of fish captured in each year's tagging event were tagged with a spaghetti tag while a sub-sample was tagged with a radio tag. Radio-tagged fish were considered surrogates for the spaghetti-tagged sample and their migratory fates relative to the recapture reach were determined through telemetry. The total number of tags released was then adjusted to account for tagged fish that did not migrate upstream or did not sustain upstream migration after tagging.

Because the annual study objective was to estimate abundance over a two-month period and because tagging and recapture data were collected daily, each annual experiment produced two-sample, temporally stratified data. Each tag released in the tagging event was uniquely numbered to permit identification of the date of release and recovery. Various models were tested for their suitability in producing accurate estimates based on such data with computer software (Stratified Population Analysis System Version 1.2, commonly referred to as "SPAS") developed by Arnason et al. (1996). The software automates and enhances standard and accepted analytical procedures first documented by Schaefer (1951) and followed by Chapman and Junge (1956), Darroch (1961), Ricker (1975), Seber (1982), Plante (1990), and Banneheka (1995). The procedure tested the validity of assumptions necessary for accurate estimates from a pooled Lincoln-Petersen estimator ("PPE"). If assumptions of the PPE were fulfilled, the PPE estimate generated by the SPAS software was chosen for its much smaller mean squared error; data pooling provided a much higher degree of precision than the alternatives. If assumptions of the PPE were violated, SPAS was used to produce a maximum-likelihood Darroch estimator of abundance ("ML Darroch" described by Plante [1990]). This estimator is robust to mixing of temporal groups of tagged fish across multiple recapture event temporal strata (see Seber [1982] for example).

Regardless of the model selected, each annual estimate was of the number of live fish migrating upstream of the tagging location in the river. Although the SPAS software does not specifically account for tagging mortality, the application of radio telemetry results to adjust the number of tagged fish provided a *defacto* modification of the procedure. Deducted tagged fish were added to the resultant estimate of fish migrating past the fish wheel to produce an estimate of the number migrating to the tagging location.

The estimated sport harvest from the SWHS occurring upstream of the tagging location was subtracted from the estimated number of live fish migrating past the fish wheel to produce estimated escapement. Estimates of sport, personal-use, and commercial harvest downstream of the tagging location were added to the estimate of the number arriving at the tagging location to produce an estimate of the total return and harvest rates. Estimates of smolt abundance were available from a companion study (Carlon and Hasbrouck 1994, 1996-1998; Carlon 2000, 2003; Massengill and Carlon 2004a-b, 2007a-b), allowing for marine survival to be estimated.

ESTIMATION PROCEDURES AND ASSUMPTION TESTING

A modified Lincoln-Petersen model was used to estimate the abundance of live coho salmon migrating past the tagging location ($\hat{N}$) if model assumptions were satisfied; otherwise, the ML Darroch estimator was used. The Lincoln-Petersen model was modified as follows:

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

where

M = the number of fish tagged at the tagging location and released,

C = the number of fish examined for marks in the recapture reach,

R = the number of tagged fish recaptured in the recapture reach, and

$\hat{p} = \sum_{i=1}^{L} \phi_i w_i$ the estimated proportion of fish tagged at the tagging location that reestablished and sustained upstream migration after release to at least the mid-point of the recapture reach or were recaptured in the recapture reach,

where

ϕ_i =proportion of uncensored radio tags that sustained upstream migration in week i,
w_i =proportion of all tagged fish that were tagged in week i,
L = number of weeks over which tagging was conducted,

$M\hat{p}$ = number of tags applied at the fish wheels that sustained upstream migration after tagging and release, and

$\hat{p}$ weights the weekly proportions of uncensored radio tags that sustained upstream migration by the proportion of total marks released each week.

The variable M accounted for the occasional coho salmon that was severely injured or stressed during capture or handling:

$$M = M' - D, \qquad (2)$$

where

M' = the total number of coho salmon tagged, and

D = the number of tagged fish discounted due to injury or stress.

Radio-tagged fish were censored if there was no post-tagging information, i.e., when a transmitter was never relocated after release. Censored fish were simply disregarded when estimating p.

The upstream migrants used in calculating the term ϕ_i in the statistic $\hat{p}$ included fish that migrated into the recapture reach, tagged fish that were captured by anglers upstream of the tagging location but downstream of the recapture reach, and fish that sustained upstream migration but favored the Funny River as a spawning destination. We assumed that untagged fish experienced these fates at a similar rate as tagged fish. Upstream migrants that moved downstream immediately after tagging but resumed their migration after a recovery interval were considered as having "sustained upstream migration".

The variance of $\hat{N}$ was estimated from the sample variance of 5,000 simulated estimates of $\hat{N}$ ($\hat{N}^*$, the asterisk denoting a simulated value). For each simulation, each of the $\hat{N}$ fish returning to the tagging location was stochastically assigned to one of the eleven possible fates described in Table 1. The assignment of fish to the eleven fates was made in two parts. The first generated fates for fish not receiving radio tags and the second generated fates for fish receiving radio tags. The simulation required two parts because of the restriction that the number of radio tags applied each year was predetermined and the fish stochastically assigned to radio tag fates (fates 6, 7, 8, 9, and 10) were required to sum to that number (and simultaneously, that the non-radio tagged fish summed to the remainder). The radio tag simulation was also complicated by the fact that $\hat{p}$ in Equation 1 had to be simulated ($\hat{p}^*$) based on weekly fate assignments.

Assignment of the non-radio tagged fish was straightforward and involved simply generating a multinomial random vector of corresponding fates ($f_1^*, f_2^*, f_3^*, f_4^*, f_5^*, f_{11}^*$). Each of the multinomial probabilities used in the generation was calculated as the proportion of the non-radio tagged fish represented by the corresponding fate in the actual data.

In the radio tag simulation, radio tags were assigned by week, with the weekly rate equal to the rate of deployment over weeks in the data. Weekly multinomial random vectors of radio tag fates were generated ($f_{6i}^*, f_{7i}^*, f_{8i}^*, f_{9i}^*, f_{10i}^*$, for week i) with each multinomial probability used in the weekly generation calculated as the proportion of the radio tagged fish represented by the corresponding fate in the associated weekly data. For example, the fate 7 probability for week 4 was calculated as the proportion of radio tags in the data that were deployed in week 4 that met fate 7. The simulated weekly random vectors of radio tag fates were used to calculate weekly simulated upstream migrations (ϕ_i^*) and then simulated $\hat{p}^*$'s. The proportions of total tagged fish by week were not simulated and the w_i from the data were used in calculation of $\hat{p}^*$.

An overall fate vector, representing fates 1 through 11, for each simulation was obtained by combining the non-radio random vector of fates with the radio random vector of fates added over weeks.

Simulated versions of Equation 1 components were calculated for each simulation:

$$M^* = \hat{N} - f_1^* - f_2^*, \tag{3}$$

$$R^* = f_4^* + f_7^*, \tag{4}$$

$$C^* = f_2^* + R^*, \tag{5}$$

$$\hat{p}^* = \sum_{i=1}^{L} \phi^*_i w_i \tag{6}$$

where

$$\phi_i^* = \frac{f_{6i}^* + f_{7i}^* + f_{8i}^*}{f_{6i}^* + f_{7i}^* + f_{8i}^* + f_{10i}^*} \tag{7}$$

$\hat{N}^*$ was then calculated as

$$\hat{N}^* = (M^*\hat{p}^* + 1)\frac{C^* + 1}{R^* + 1} - 1, \tag{8}$$

The estimated variance of $\hat{N}$ was then calculated as the sample variance of the simulated abundance estimates over the 5,000 simulations:

$$\hat{Var}(\hat{N}) = \frac{\sum_{b=1}^{5000}(\hat{N}_b^* - \overline{N}^*)^2}{4999}, \tag{9}$$

where:

$\overline{N}^*$ = the mean over all simulated estimates $\hat{N}_b^*$.

Seber (1982) outlines the following assumptions necessary for unbiased estimates of abundance (using the modified Lincoln-Petersen model in Equation 1):

1. The population is closed, that is, no additions (recruitment or immigration) or losses (mortality or emigration) occur between sample areas.
2. (a) All coho salmon have an equal probability of capture by fish wheels at the tagging location OR (b) during sampling in the recapture reach OR (c) tagged fish mix completely with untagged fish prior to migrating into the recapture reach.
3. Tagging does not affect capture probability at the recapture reach.
4. Marks (tags) are not lost between sampling events.
5. All tagged fish recaptured in the recapture reach are correctly identified and recorded.

With respect to assumption 1, each year's population of coho salmon was considered closed during the study. Emigration from the mainstem into the Funny River and harvest mortality were assumed to have affected tagged and untagged fish equally. In addition, mortality due to tagging was corrected by using telemetry data ($\hat{p}$ in Equation 1). A small amount of data from the beginning and end of the recapture event was culled to adjust for travel time between the tagging site and the recapture reach. Recaptures of tagged fish (both types of tags) were used to estimate a median time between tagging and vulnerability to capture in the recapture reach. The number of days' data culled from the beginning (c_b) and end (c_e) of the recapture event was calculated as:

$$c_b = u - v$$
$$c_e = w - u \tag{10}$$

where

u = median number of days between tagging and recapture of tagged fish in the recapture reach,

v = number of days between the day on which the first fish (tagged or untagged) was captured in the recapture event and the first day of tagging, and

w = number of days between the day on which the last fish (tagged or untagged) was captured in the recapture event and the last day of tagging.

No days were culled if either c_b or c_e were negative or if recaptures were lost due to culling. Culling days in this manner prevented the inclusion of fish sampled on days during which there was a zero (or very low) probability of recapturing a tagged fish.

With respect to assumption 2, tagging and recapture efforts were scheduled in a consistent manner to maximize the likelihood of homogeneity in capture probability among individuals. Fish wheels were scheduled to operate during the same hours each day over the course of each annual experiment. Drift netting effort was distributed spatially over the entire recapture reach and adjacent to each riverbank. This scheduling tended to equalize the number of drift-netting hours expended in each week and helped to ensure that a similar amount of effort within each hour of the day among weeks was expended. There was approximately a 13 and 9 km distance between the tagging and the mid-point of the recovery areas in 1999 and 2000-2003, respectively, that facilitated mixing of tagged and untagged fish within and between strata.

Despite these procedures, changes in catchability were anticipated over the season due to variable environmental factors such as fish abundance, water depth, velocity, and transparency. In addition, mechanical, personnel, and logistical constraints were expected to disrupt the planned distribution of tagging and recapture effort in an unpredictable manner. The three conditions of assumption 2 were therefore assessed with two chi-square tests.

First, we tested the hypothesis that the tagged to untagged ratios were consistent among temporal strata of the recapture event (commonly referred to as the "equal proportions test"; Arnason et al. 1996). A non-significant result meant either that probabilities of capture were similar among tagging strata or that movement probabilities from tagging strata to recapture strata were independent of tagging strata, i.e., mixing occurred.

Second, we tested the hypothesis that the ratios of recaptured fish to those not recaptured were consistent among tagging event temporal strata (commonly referred to as the "mixing test"; Arnason et al. 1996). A non-significant result meant either that probabilities of capture were similar among recapture strata or that movement probabilities from tagging strata to recapture strata were independent of tagging strata (mixing).

Temporal tagging and recapture strata used in the above tests were generally formed from seven-day periods beginning on the day the first fish was tagged and ending on the last day a fish was captured in the recapture event. If either test produced an insignificant result, then tagging data were pooled over tagging strata and recapture data pooled over recapture strata to provide the pooled Lincoln-Petersen estimate of abundance at the tagging location. It is noted that a non-significant equal proportions test must be accompanied by an assumption regarding identical closure among release strata (Schwarz and Taylor 1998); this assumption is considered reasonable in our study. If both tests produced significant results, the "ML Darroch" model described by Arnason et al. (1996) was used to estimate abundance and its variance. The variability in the estimate of $\hat{p}$ was not incorporated in this variance estimate. This omission is not thought to have affected our results appreciably; a simulation showed the variability induced by our estimation of the proportion of upstream migration to be relatively small.

During years for which the ML Darroch model was selected, tagging and recapture data were stratified as described above. Attempts were sometimes made to partially pool recapture and tagging strata to a) overcome numerical problems in estimation, b) overcome inadmissible estimate (e.g. estimates with negative variances, c) overcome significant goodness-of-fit test results and d) to improve precision while maintaining fit. It was important during the pooling exercise to ensure that we did not remove the original data structure that dictated that we stratify in the first place, i.e. that structure responsible for the significant equal proportions and mixing tests. To this end, the equal proportions and mixing tests were re-examined after each partial pooling scenario to ensure they were still significant. Pooling was subject to constraints that included the relative number of tagging and recapture event strata and putative similarity of within-stratum capture probabilities.

The first pooling constraint was that the number of recapture event strata (t) chosen had to equal or exceed the number of tagging event strata. Schwarz and Taylor (1998) point out that under this condition, the stratified abundance estimator is consistent for the population at the tagging site regardless of whether the population is closed between tagging and recapture events. This observation is germane to our study since our objective pertains to the abundance at the tagging site and there is a sport fishery and a spawning location (Funny River) occurring between the tagging and recapture locations. Although we assumed that these conditions did not violate the assumption of closure (as previously described), this constraint was applied to ensure robustness of the model. We maximized our ability to meet the second constraint by ensuring that we pooled only adjacent strata, for which probability of capture is more likely to be similar than for strata temporally far apart. We also examined stratum-specific probability of capture estimates from the original stratified data analysis to help with this effort; these comparisons were, however, hindered by low stratum-specific precision of the capture probability estimates.

The first and second "or" conditions of Lincoln-Petersen assumption 2 can also be violated if capture probabilities vary substantially among individuals of different sizes (possibly as a result of gear selectivity in either sampling event). Size-specific variation in capture probability may require stratification of abundance estimates by size to maintain accuracy at the expense of precision. A standard battery of Kolmogorov-Smirnov (KS) two-sample tests was therefore implemented to determine if size selectivity could be detected in either sampling event. Two KS tests were applied to test for heterogeneity of capture probability by size in the tagging and recapture events following procedures outlined in Appendix A1. The combined results of these tests indicated whether size-selective sampling (and thus heterogeneity of capture probability among individuals) occurred and dictated whether size-stratification of the estimate was necessary. If outcomes of the first two KS tests indicated that size-selective sampling occurred in the second event and it was uncertain if it occurred in the first, a third KS test was used to examine the probability of capture (by size) in the first event by comparing the length frequency distribution of fish recaptured to that of all those captured (and measured) in the second event. Regardless of the statistical conclusions about length selectivity drawn from this battery of tests, means and plots of cumulative length distributions were also inspected for meaningful differences to determine if test results may have been simply due to large (or small) sample sizes. Length data collected on dates culled from the recapture event were excluded from length comparisons to synchronize length comparisons with the data used to estimate abundance,. Note that this procedure culls a small number of length measurements only from fish associated with model parameter "C" (fish examined for marks in the recapture event).

Based on the substantial mortality rate detected in the feasibility study in 1998, it was expected that assumption 3 – that tagging does not affect capture probability in the recapture reach – would be violated. This violation was compensated for primarily by the application of radio tags, allowing estimation of mark-induced mortality $(1-\hat{p})$. Because there was no way to assess whether tagging had more subtle effects on fish behavior , and therefore, probability of capture in the recapture event, sub-lethal effects (if any) were partially compensated for by choosing drift-netting as the primary recapture gear. Drift-netting is an active technique that does not rely solely on fish behavior (as do passive gear types). Even so, an active gear could not compensate for a possible tagging-induced reduction in migratory rate (relative to untagged fish). Such an effect would be expected to increase the probability of capture in the recapture reach (relative to untagged fish). Therefore, sub-lethal, stress-induced effects were minimized by careful, rapid handling and tagging of fish. In addition, artificially and severely injured or stressed fish were excluded from the tagged sample used to estimate live fish abundance, but were accounted for in the estimate of total abundance.

Assumptions 4 and 5 were not tested but were addressed as follows. The tag wound (skin puncture points and discoloration) served as a secondary mark to assess tag loss (assumption 4). Anal fin punches used as a secondary mark in 1999 were difficult to discern because inter-fin ray tears of anal fin tissue were frequently caused by gillnets. In addition, punching the anal fin increased handling time during the tagging process. Few, if any, tags were expected to be lost because radio transmitters and spaghetti tags used previously on Chinook and coho salmon in the Kenai River were associated with a low (< 1%) tag loss rate (Alexandersdottir and Marsh 1990; Hammarstrom and Hasbrouck 1998, 1999). Anecdotally, no tag loss has been detected in *ad hoc* observations of carcasses at spawning destinations. Assumption 5 was considered fulfilled because the tag types chosen were highly visible and field personnel were instructed in proper data recording procedures.

Several relevant response variables were statistically tested to determine if it was valid to pool radio- and spaghetti-tagged fish. First, a 2x2 contingency table and chi-square statistic were used to test for independence between tag type and recapture rate. Note that this test also provided an indirect method to detect sub-lethal effects on probability of capture; using two tag types in a mark-recapture experiment. A significant difference between recapture rates would suggest a violation of assumption 3 (if recapture rates are different between tag types, one or neither rate represents the probability of capture for the untagged population). Next, a KS test was conducted to test the null hypothesis that the length distributions of radio-tagged coho salmon were similar between those that sustained upstream migration after release and those that did not (a differential by size would invalidate pooling tag types and require size-stratified estimates of $\hat{p}$). Length distributions of radio- and spaghetti-tagged fish were then compared with KS tests. A 2x2 contingency table and chi-square statistic were then used to test for independence between tag type and bank of recapture. Finally, the median number of days between release and recapture was visually inspected for substantial differences between tag types, there were too few radio tag recaptures to perform statistical tests.

A final battery of statistical tests was applied to determine if tagging data could be pooled regardless of the bank of capture. Chi-square tests were used to test the following hypotheses: that bank of initial capture and the tendency to migrate upstream were independent (a necessary condition prior to testing the next three hypotheses); that bank of initial capture and the tendency to be recaptured were independent; that bank of initial capture and bank of recapture were independent; and that the tagged-to-untagged ratios and bank of capture in the recapture event were independent. The hypothesis that length distributions of fish caught on each bank were not different was tested with two, two-sample KS tests, comparing tagging event lengths for the first test and recapture event lengths for the second test.

Because at least one of the two tests described by Arnason et al. (1996) was not significant in 1999 and 2000, the PPE was considered a consistent estimator for those years. Because both tests produced significant test statistics for the 2001 through 2003 experiments, ML Darroch estimators were considered consistent estimators for those years.

The estimated abundance of the total return to the fish wheel ($\hat{N}_{TF}$)was estimated as:

$$\hat{N}_{TF} = \hat{N} + M(1-\hat{p}) + D \tag{11}$$

where $\hat{N}$ is the estimated abundance of fish migrating past the fish wheels (Lincoln-Petersen or ML-Darroch), $M(1-\hat{p})$ represents the estimated number of tagged fish that were released but perished due to handling, and D is the number of tagged fish discounted due to injury or stress (as defined previously).

If the Lincoln-Petersen abundance estimate was chosen, the variance of $\hat{N}_T$ was estimated from the simulation described above as:

$$\hat{V}(\hat{N}_{TF}) = \frac{\sum_{b=1}^{5000}(\hat{N}^*_{TFb} - \overline{N}^*_{TF})^2}{4999}, \tag{12}$$

where $\hat{N}^*_{TFb}$ was calculated according to Equation 11 using the simulated values, $\hat{N}^*$, M^*, and $\hat{p}^*$. The simulation accounted for the (negative) covariance between $\hat{N}$ and $\hat{p}$. D constituted a very minor component of the abundance and was not simulated.

If the ML Darroch abundance estimate was chosen, the variance of $\hat{N}_{TF}$ was estimated as:

$$\hat{V}(\hat{N}_{TF}) = \hat{V}(\hat{N}) + M^2\hat{V}(\hat{p}) \tag{13}$$

where $\hat{V}(\hat{N})$ was obtained from the SPAS computer output and $\hat{V}(\hat{p})$ was estimated from simulation as described above. The covariance between $\hat{N}$ and $\hat{p}$ was ignored; simulation showed this to be negative and its omission is therefore conservative (estimated variance is biased high).

Total run ($\hat{N}_T$) was estimated as:

$$\hat{N}_T = \hat{N}_{TF} + \hat{H}_{SD} + \hat{H}_C + \hat{H}_P \tag{14}$$

where

H_{SD} = sport harvest of Kenai River coho salmon downstream of capture-tagging location approximated in 1999 as the Statewide Harvest Survey estimate of the sport harvest occurring downstream from the Soldotna Bridge at rkm 33.9 (this estimate includes a small, unknown harvest occurring between the capture-tagging location and the Soldotna Bridge) and approximated in 2000-2003 as:

$H_{SD} = H_{SL} + ½(H_{SM})$, where

> H_{SL} = the Statewide Harvest Survey estimate of the sport harvest occurring In the Kenai River downstream from the Soldotna Bridge and
>
> H_{SM} = the Statewide Harvest Survey estimate of the sport harvest occurring in the Kenai River between the Soldotna Bridge and its confluence with the Moose River (rkm 58.4).

H_C = commercial harvest of Kenai River coho salmon (estimated by companion coded wire tag project), and

H_P = personal use/subsistence harvest of Kenai River coho salmon (estimated from permit return data),

with

$$\hat{V}(\hat{N}_T) = \hat{V}(\hat{N}_{TF}) + \hat{V}(\hat{H}_{SD}) + \hat{V}(\hat{H}_C) + \hat{V}(\hat{H}_P) \tag{15}$$

where $\hat{V}(\hat{H}_{SD})$ was obtained directly from the Statewide Harvest Survey in 1999 as $\hat{V}(\hat{H}_{SL})$ and calculated in 2000-2003 as $\hat{V}(\hat{H}_{SD})$ = $\hat{V}(\hat{H}_{SL}) + 0.5^2\hat{V}(\hat{H}_{SM})$, $\hat{V}(\hat{H}_C)$ was obtained from the companion coded wire tag project (Carlon and Hasbrouck 1994, 1996-1998; Carlon 2000, 2003; Massengill and Carlon 2004a-b, 2007a-b), and $\hat{V}(\hat{H}_P)$ was obtained from the personal use project (Reimer and Sigurdsson 2004).

Escapement ($\hat{E}$) was estimated as:

$$\hat{E} = \hat{N}_{TF} - \hat{H}_{SU} \tag{16}$$

where

H_{SU} = sport harvest of Kenai River coho salmon upstream of capture location (estimated by Statewide Harvest Survey)

with

$$\hat{V}(\hat{E}) = \hat{V}(\hat{N}_{TF}) + \hat{V}(\hat{H}_{SU}) \tag{17}$$

Exploitation rate ($\hat{E}R$) was estimate by:

$$\hat{E}R = \frac{\hat{H}_T}{\hat{N}_T} \tag{18}$$

where

$$\hat{H}_T = \hat{H}_{SD} + \hat{H}_{SU} + \hat{H}_C + \hat{H}_p \tag{19}$$

with variance estimated as :

$$\hat{V}(\hat{E}R) = \left[\frac{\hat{H}_T}{\hat{N}_T}\right]^2 \left[\frac{\hat{V}(\hat{H}_T)}{\hat{H}_T^2} + \frac{\hat{V}(\hat{N}_T)}{\hat{N}_T^2} - 2\hat{\rho}\frac{\hat{V}(\hat{H}_T)^{1/2}}{\hat{H}_T}\frac{\hat{V}(\hat{N}_T)^{1/2}}{\hat{N}_T}\right] \tag{20}$$

where $\hat{\rho}$ was an anticipated correlation between the total harvest estimate and the total run; this was calculated as the sample correlation coefficient between the estimate of the total run and the estimate of the total harvest from 1999-2003 and

$$\hat{V}(\hat{H}_T) = \hat{V}(\hat{H}_{SD}) + \hat{V}(\hat{H}_{SU}) + \hat{V}(\hat{H}_C) + \hat{V}(\hat{H}_P) \tag{21}$$

Smolt-to-adult marine survival from year i to year i+1 was estimated as:

$$\hat{S}_i = \frac{\hat{N}_{T_{i+1}}}{\hat{N}_{Smolt_i}} \tag{22}$$

with variance according to Goodman (1960):

$$\hat{V}(\hat{S}_i) = \hat{N}_{T_{i+1}}{}^2 \hat{V}\left[\frac{1}{\hat{N}_{Smolt\,i}}\right] + \left[\frac{1}{\hat{N}_{Smolt\,i}}\right]^2 \hat{V}(\hat{N}_{T\,i+1}) - \hat{V}(\hat{N}_{T\,i+1})\hat{V}\left[\frac{1}{\hat{N}_{Smolt\,i}}\right] \tag{23}$$

where:

$$\hat{V}\left[\frac{1}{\hat{N}_{Smolt\,i}}\right] \approx \frac{1}{\hat{N}^4_{Smolt_i}} \hat{V}(\hat{N}_{Smolt\,i})\,. \tag{24}$$

CATCH RATE INDEX

The estimated abundances also provided a means with which to evaluate the utility of fish wheel catch rates as an index of coho salmon abundance. The annual catch rate was estimated as:

$$CR = \sum_{i=1}^{D} \frac{c_i}{h_i} \tag{25}$$

where

c_i = coho salmon catch during day *i*,

h_i = number of hours fish wheels operated during day *i*, and

D = number of days fish wheels operated during the season.

The relationship between CR and abundance over the five years was then evaluated. A relationship between CR and abundance among years might prove to be a useful alternative to the mark-recapture experiment by reducing costs and resource impacts of a mark-recapture experiment.

TAGGING EVENT

Two float-mounted fish wheels were used to capture coho salmon for tagging during all study years with one fish wheel installed adjacent to each riverbank. The fish wheels were a standard, two basket/two-paddle design. To address the study assumption of equal probability of capture for all fish, the fish wheels were operated as consistently as possible among days. Fish wheels were frequently adjusted so that the baskets touched or were close to touching the river bottom as much as possible to consistently minimize that escape route. Although the relationship between fish wheel spin rate and catchability is unknown, fish wheels were moved short distances or adjusted to maintain spin rates between about 3 and 4.5 rpm (spin rates lower than 3 appeared ineffective while spin rates greater than 5 were associated with increased injuries to fish). Fish wheels were scheduled to operate a consistent number of hours each day from August 1 through September 30.

With the exception of 1999, fish were removed from the fish wheel livebox as quickly as possible. In 1999, the fish wheel was left unattended periodically and coho salmon remained in the live box longer than in other years. Also in 1999, handling time took longer as fish were measured from mid-eye to tail-fork; fish were also allowed to recover in a recovery pen instead of being released directly into the river after tagging.

When pink or sockeye salmon catches were overwhelming, fish wheels were stopped while unattended; this occurred occasionally during the last week of August and the first two weeks of September.

In 1999, fish wheels were scheduled to operate continuously for 16 hours during two 8-hour shifts per day. The start time for each shift was randomly selected from one of four hours for each shift (1000-1400 for the first shift and 2400-0400 for the second shift). During all other study years, fish wheels were scheduled to operate between the hours of 0630 and 2130 because this period was identified from the 1999 diurnal experiment as the period when over 90% of the coho salmon catch occurred (Carlon Unpublished Data). Fish wheels were generally not operated during lunch breaks and shift changes unless unscheduled maintenance resulted in down-time for which the additional fishing time could partially compensate.

All captured fish other than coho salmon were identified by species, enumerated, and released. All coho salmon captured were transferred via dip net from the fish wheel trap box into a holding tank filled with river water. A padded restraining device (Larson 1995) was used to hold fish during measuring and tagging. Each fish was tagged with an external spaghetti or radio tag, measured for length, and released.

In 1999, MEF lengths were recorded; in all other years FL was recorded (to the nearest 10 mm in all years) to reduce handling. In 1999, all tagged coho salmon were released into an inriver recovery trough anchored in low velocity water near each riverbank. In 2000, coho salmon catch rates were substantially greater than in 1998 and 1999 and it became impractical to move every tagged fish to the recovery trough, so fish were released directly into the river after tagging. Inseason radio telemetry data indicated that radio tagged fish released in this manner were surviving at least as well as those released in 1999 and the release practice was continued throughout the 2000 season. The subsequent discovery that the mortality rate was reduced by at least 50% relative to that of 1999, led to implementing the immediate release practice in all subsequent study years even though other study design and handling changes likely contributed to the reduced mortality rate as well.

Uniquely numbered, 30.5 cm long, Floy FT-4 spaghetti tags were used. Tags were applied about 1-2 cm below and 3-4 cm anterior to the posterior insertion of the dorsal fin. Those fish that were artificially injured or stressed during capture or tagging were categorized as ‘discounted’ and were tagged prior to release with a spaghetti tag so that if recaptured, they could be disregarded (although none were recaptured). Advanced Telemetry Systems (ATS) radio tags, broadcasting in the 151-152 MHz band, were used.

In 1999, Model F2120 tags, measuring about 19 mm by 50 mm by 9 mm and weighing about 16 g, were used. The attachment devices were two malleable nickel pins protruding from the epoxy body of each radio tag, with one anchored in the anterior portion of the tag and one posterior. Each pin was inserted into a 16-gauge, medical spinal needle to facilitate penetration of skin and muscle tissue. Needles (with radio tag pins inserted) were pushed through the fish such that the radio tag was affixed parallel to the insertion of the dorsal fin and immediately below it. The spinal needles were removed from the far side of the fish and a 25mm diameter numbered Petersen disk was slipped onto each pin extruding from the fish. Each disk was slid down the needle and held snugly against the skin and the pins were cut off about 15-20mm from the disk. The tag was secured to the fish by twisting the end of each pin into a Petersen knot such that each knot was finished snugly against each disk.

In 2000 through 2003, Model F2110 tags, measuring about 19 mm by 40 mm by 9 mm and weighing about 14 g, were used. Radio tags were affixed parallel to the insertion of the dorsal fin and immediately below it and secured with a Petersen disk. The attachment devices were two Teflon®-coated, 18-8 braided stainless steel wire ropes measuring 0.8 mm (0.032") in diameter. The same insertion technique and location used in 1999 was employed. However, the transmitters were secured in place using #3 single-barrel, anodized steel fishing leader sleeves crimped onto the cables using lineman's pliers such that the Petersen disk and transmitter were held securely in place. The radio tags used during 2000 through 2003 were 2 g lighter primarily because a smaller battery was chosen in favor of the unnecessarily long-lived (and larger) battery used in 1999.

Radio tags were released throughout August and September in all study years. A fixed number of radio tags was scheduled for release each day. Two hundred tags were on hand for release in 1999, 2000, and 2001 for a scheduled daily release of 3-4 radio tags over 61 days in an attempt to distribute 50 tags over each of four semi-monthly periods. In 2002 and 2003, the number was lowered to 122 (2 per day, 30 or 32 per period) to reduce cost after an analysis indicated precision of estimates would not be degraded (unpublished data).

Time of day criteria were also applied when selecting fish for radio tagging. In 1999, time criteria were selected to distribute radio tags throughout each fishing day. On days when 3 tags were to be released, one each was released early in the first shift, toward the end of the first shift, and near the middle of the second shift. When four tags were to be released, the early and middle of the first shift were selected as were the middle and end of the second shift. On "catch-up" days, additional "catch-up" fish were selected by convenience. In all other years, ½-hour periods for radio tagging fish were randomly selected throughout the day.

A size criterion was applied to select fish for radio tagging. During each week of sampling, lengths were collected from all captured coho salmon and the 33rd and 67th percentiles of the prior week's length distribution were used as boundaries to divide the length distribution into three groups (< 33rd percentile, ≥ 33rd percentile and < 67th percentile, and ≤ 67th percentile). As coho salmon were captured, one fish from each of the three length groups was tagged when 3 fish were scheduled for tagging on a given day. Quartiles were used whenever 4 fish were scheduled for tagging and the median was used when 2 were scheduled. If a fish of the proper size was not captured during a randomly scheduled ½-hour period, the next captured fish meeting the size criterion was selected for radio tagging.

Mid-channel water column transparency near the fish wheel location was measured daily with a Secchi disk of standard design. Water temperatures and river discharge rates were collected at the USGS gaging station 15266300 (Soldotna Bridge).

RADIO TELEMETRY

Radio tagged fish were relocated with data-recording telemetry stations installed along stream banks (Figure 4), receiver-equipped boats, trucks, and from fixed or rotary wing aircraft. A binomial fate relative to the recapture reach was assigned to each relocated fish: reestablished and sustained upstream migration toward the recapture reach after tagging or did not.

RECAPTURE EVENT

Drift gillnets deployed from outboard-powered riverboats were the primary gear to resample the population each year. Drift gillnet specifications were intended to capture fish by entanglement rather than by wedging fish into a single mesh space permitting fish to be more easily removed upon capture and decreasing injury. Drift gillnets were standardized early in 1999 to the following specifications: Miracle Brand® type MS-43, knotted multi-strand monofilament with color designation R14. The stretched mesh dimension was 4.75” and nets were 29 meshes deep and 5 fathoms long.

Field personnel attempted to expend drift netting effort along each bank of the river within the recapture reach and along the extent of the reach to ensure that effort was not concentrated in time or space. Early results in 1999 indicated that fish tended to migrate in near-shore waters. Therefore, most fishing effort was bank-oriented.

Drift gillnets were deployed almost every day from August 1 through early October. Drift gillnetting effort was scheduled to distribute effort evenly over each weekly period during the studies in an effort to satisfy assumption 2 of the pooled Lincoln-Petersen estimator. As few as two work shifts and as many as four were scheduled on any given day with a total 20 scheduled each week. Possible work shift times included a morning shift (0600-1400 hrs), a mid-day shift (1000-1800 hrs), and an evening shift (1400-2200 hrs). During each week, eight of each of the morning and evening shifts were scheduled and four of the mid-day shifts were scheduled.

Fish wheels, hook-and-line sport fishing techniques, seining, and set gillnets were also used to a limited extent.

The number of fish captured other than adult coho salmon was recorded and the fish were released. Each coho salmon received a dorsal fin punch with a standard one-hole paper punch to ensure that recapture event sampling was accomplished without replacement. The fish was inspected for the presence of a prior dorsal fin punch and for the presence of a tag or a tag wound indicating tag loss. If a tag wound was present, the type of wound (radio or spaghetti) was recorded. If a tagged fish was captured, the tag type and tag number were recorded. As many recaptured fish as possible were measured as previously described. Whenever possible, the fork-length of all recaptured fish was to be measured. In practice, recaptured fish were not always measured; when not measured, the measurement recorded when the fish was initially tagged was substituted in length selectivity tests. Every 10th newly captured coho salmon was measured

DATA ARCHIVING

A comprehensive list of data files collected during the five annual experiments is contained in Appendix B1. Archived files are managed by the Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services Section in Anchorage, Alaska.

RESULTS

TAGGING AND RECAPTURE SUMMARY

Tagging Event

During the tagging events, river discharge ranged from 4,290 to 15,920 cfs (Figure 5). Average discharge was: 12,960 CFS in 1999, 8,835 CFS in 2000, 15,920 CFS in 2001, 11,560 CFS in 2002, and 10,860 CFS in 2003. The river stage fluctuated over a range of about 0.50 m or under in 1999 and 2002, and over 0.50 m in 2000, 2001, and 2003 (Figure 6). Water transparency averaged 0.9 m in all years except 2002 when the average was 1.2 m (Figure 7).

In all years, both fish wheels were operated daily from August 1 through September 30, except in 2000 when they were operated through October 6. In 1999, the north bank fish wheel was not operated on September 30, and in 2002 neither fish wheel was operated on August 3. In 1999-2001, over 1,700 hours of fish wheel effort were expended annually; in 2002 and 2003, less than 1,500 hours were expended (Table 2). Catch rate was highest in 2002 (6.047 coho salmon per hour) and lowest in 1999 (0.260 coho salmon per hour).

In 2000, the catch rates increased substantially during the last week of September, so we extended the tagging event through October 6 to explore the possibility of substantial numbers of fish migrating after September. However, fish wheel catch rates declined substantially during the last few days of September and through October 6 when the tagging event was ended. The fish wheels were frequently stopped because of the overwhelming abundance of pink salmon from August 28 through mid-September, 2000 and August 21 through mid-September, 2002. In 2002, this resulted in a substantial reduction to total effort, but catch and CPUE were high.

In 1999, 451 coho salmon were captured (Table 3). Four were tagged fish that were recaptured in the fish wheels and 18 were injured or stressed and were discounted. The remaining 429 coho salmon were included in the tagged sample; 187 were tagged with radio tags and 242 were tagged with spaghetti tags. The tagging goal for radio tags was not met in 1999 because catches of coho salmon were unexpectedly low. Fish were radio tagged in all semi-monthly periods and were distributed within each period.

In 2000, 3,520 coho salmon were captured. Twelve fish escaped handling prior to tagging and 74 were tagged fish that were recaptured. Thirty-three fish were injured or stressed, seven had adipose fin clips and were sacrificed for CWT recovery, and nine had fin punches. The remaining 3,385 coho salmon were included in the tagged sample: 205 were tagged with radio tags, including 198 released during August and September and seven released during the October extension, and 3,180 were tagged with spaghetti tags.

In 2001, 2,846 coho salmon were captured. Seventy-eight escaped prior to tagging, 79 were tagged fish that were recaptured, 10 were injured, two were sacrificed for CWT recovery, and 10 had fin punches. The remaining 2,667 coho salmon were included in the tagged sample: 200 were tagged with radio tags and 2,467 with spaghetti tags.

In 2002, 7,025 coho salmon were captured; 316 escaped handling prior to tagging, 138 were tagged fish that were recaptured, 11 were injured, 15 were sacrificed for CWT recovery, and five were captured with fin punches. The remaining 6,540 coho salmon were included in the tagged sample: 122 were tagged with radio tags and 6,418 were tagged with spaghetti tags.

In 2003, 2,536 coho salmon were captured. Nine escaped handling prior to tagging, 45 were tagged fish that were recaptured in the fish wheels, 16 were injured, three were sacrificed for CWT recovery, and one had a fin punch. The remaining 2,462 coho salmon were included in the tagged sample: 122 were tagged with radio tags and 2,340 were tagged with spaghetti tags.

Species other than coho salmon were also captured each year (Appendix C1). In 2000, almost 83,000 pink salmon were captured, and about 64,000 in 2002. Catches of sockeye salmon ranged from about 3,000-8,000 fish. Other species included Chinook *O. tshawytscha*, chum *O. keta*, Dolly Varden *Salvelinus malma*, rainbow trout and steelhead *O. mykiss*, and whitefish spp.

Recapture Event

Effort was expended daily in the recapture reach during the following periods: August 9 through October 8, 1999, except August 12, August 13, and September 13; August 1 through October 13, 2000 except August 6; August 1 through October 5, 2001 except August 4 and 5; August 2 through October 4, 2002 except August 3 and 4; and August 1 through October 5, 2003 except August 2 and 3. Distribution of gillnetting effort among river kilometers was relatively even across the recapture reach as was temporal distribution through the day.

Drift gillnetting effort ranged from 206.0–322.5 hours during the recapture events (Table 4). Drift gillnet catch was lowest in 1999 and highest in 2002. Catch rates ranged from 7.18–25.77 coho salmon per hour fished. In 1999, two experimental fish wheels were operated for 916.3 hours with a catch of 406 coho salmon. In 2000, an additional 69.5 hours was expended experimentally with set gillnets, catching 365 coho salmon. Only thirty four coho salmon were caught with hook-and-line. In 2001, 43.9 hours of set gillnetting effort was expended experimentally and 188 coho salmon were caught, and nine additional coho salmon were captured with hook-and-line. In 2002, a beach seine was tested experimentally on a single day catching eighty two coho salmon, a single set gillnet was tested on a single day and one coho salmon was caught and examined, and 238 coho salmon were captured with hook-and-line. In 2003, a single set gillnet was tested experimentally on one day but no coho salmon were caught, and six coho salmon were caught with hook-and-line.

In 1999, a total of 2,238 coho salmon were captured. There were 140 instances in which coho salmon (both tagged and untagged) were caught multiple times, leaving 2,098 unique fish that were examined for marks (Table 5). Twenty-two (1.0%) had marks, 14 with radio tags and 8 with spaghetti tags. The exact time of capture and tagging was recorded for 14 fish (Appendix D1). The mean time between tagging and recapture for these was 6.5 days over a range of 8.1 days (minimum of 2.7 days, maximum of 10.8 days) with a median of 5.9 days.

In 2000, a total of 3,456 coho salmon were captured: 164 fish in set gillnets, 34 fish with hook-and-line, and 3,057 fish with drift gillnets. There were 155 instances in which coho salmon (both tagged and untagged) were caught multiple times and 140 escaped prior to examination, leaving 3,161 unique fish that were examined for marks; 93 had spaghetti tags and five had radio tags. The exact date and time of both tagging and recapture was known for 97 tagged fish (Appendix D2). The mean time between tagging and recapture for these fish was 5.9 days over a range of 39.3 days (minimum of 0.7 days, maximum of 40.0 days) with a median of 3.8 days.

In 2001, 5,297 coho salmon were captured in all gears combined: 5,100 in drift gillnets, 188 in set gillnets and 9 with hook-and-line. There were 308 instances in which coho salmon (both tagged and untagged) were caught multiple times; capture history was unknown for 10 coho salmon for which fin punch data were not recorded; and 310 coho salmon escaped prior to examination. This left 4,669 unique fish that were examined for marks and 121 (2.6%) had marks: 108 with spaghetti tags and 13 with radio tags. The exact date and time of both tagging and recapture was known in all cases (Appendix D3). The mean time between tagging and recapture for these 121 fish was 4.5 days over a range of 31.6 days (minimum of 0.4 days, maximum of 32.0 days) with a median of 3.1 days.

In 2002, 5,629 coho salmon were captured with all gears combined: 5,308 coho salmon in drift gillnets and 321 in other gear. There were 283 instances in which coho salmon (both tagged and untagged) were caught multiple times. Prior capture history was unknown for two coho salmon because fin punch data were not recorded. Additionally, 199 coho salmon escaped prior to examination leaving 5,145 unique fish that were examined for marks. Two-hundred forty-one (4.7%) were carrying marks: 235 with spaghetti tags and six with radio tags. The exact date and time of both tagging and recapture was known in all cases (Appendix D4). The mean time between tagging and recapture for these 241 fish was 5.6 days over a range of 30.5 days (minimum of 0.4 days, maximum of 30.9 days) with a median of 4.0 days.

In 2003, 3,976 coho salmon were captured in all gears combined: Drift gillnets caught 3,790, and six with hook-and-line. There were 304 instances in which coho salmon (both tagged and untagged) were caught multiple times, 20 coho salmon for which prior capture history was unknown because fin punch data were not recorded, and 159 coho salmon escaped prior to examination, leaving 3,493 unique fish that were examined for marks. Of these, 119 (3.4%) had marks, 115 with spaghetti tags and four with radio tags. The exact date and time of both tagging and recapture was known in all cases (Appendix D5). The mean time between tagging and recapture was 5.7 days over a range of 37.5 days (minimum of 0.7 days, maximum of 38.2 days) with a median of 4.0 days.

During the recapture event, over 9,000 pink salmon were captured in 2000, and over 14,000 in 2002. Over 1,000 sockeye salmon were captured each year, and about 1,300 rainbow trout were captured in 2003. Other species included Chinook and chum salmon, Dolly Varden, steelhead, whitefish, lake trout, and longnose sucker.

Radio Telemetry

In 1999, 187 radio tags were released. Five were never relocated and were therefore censored and 71 (39% of the uncensored sample) did not migrate upstream, leaving 111 (61%) that did migrate upstream (Appendix E1-E5). Date and time of entry into the recapture reach was determined for 96 of the upstream migrants. The mean time between tagging and entry into the recapture reach for these fish was 2.4 days over a 14.2-day range (minimum 0.2 days, maximum 14.5 days) with a median of 1.7 days.

In 2000, 205 radio tags were released. One was never relocated and was therefore censored, 35 (17% of the uncensored sample) did not migrate upstream, leaving 169 (83%) that did Date and time of entry into the recapture reach was determined for 95 of those. The mean time between tagging and entry into the recapture reach for these fish was 4.2 days over a 23.9-day range (minimum 0.3 days, maximum 24.2 days) with a median of 2.7 days.

In 2001, 200 radio tags were released. One was never relocated and was therefore censored and 42 (21% of the uncensored sample) did not migrate upstream, leaving 157 (79%) that did). Date and time of entry into the recapture reach was determined for 148 of those. The mean time between tagging and entry into the recapture reach for these fish was 2.8 days over a 16.5-day range (minimum 0.2 days, maximum 16.7 days) with a median of 1.7 days.

In 2002, 122 radio tags were released. None were censored but 18 fish (15% of the sample) did not migrate upstream, leaving 104 (85%) tagged fish that did. Date and time of entry into the recapture reach was determined for 92 of those The mean time between tagging and entry into the recapture reach for these fish was 3.2 days over a 28.1-day range (minimum 0.2 days, maximum 28.3 days) with a median of 2.1 days.

In 2003, 122 radio tags were released. Five were never relocated and were therefore censored and 14 (12%) did not migrate upstream, leaving 103 (88%) that did. Date and time of entry into the recapture reach was determined for 34 of those . The mean time between tagging and entry into the recapture reach for these fish was 5.5 days over a 20.8-day range (minimum 0.2 days, maximum 21.0 days) with a median of 1.9 days.

EXPERIMENTAL ASSUMPTION TESTS AND ABUNDANCE ESTIMATES

Pooling Data Over Tag Type

Statistical tests indicated that mark-recapture data collected from fish tagged with either tag type (radio or spaghetti) could be pooled in all years. The results of the tests comparing radio and spaghetti tags are as follows:

1. **Recapture Rate**: Annual recapture rates ranged from 2.4% to 7.5% for radio tags and from 2.9% to 4.9% for spaghetti tags, but recapture rates did not differ significantly between tag types in any year (Table 6).

2. **Overall Length Distributions**: Cumulative length distributions of each tag type were similar within all years. Although significant statistical differences were detected in 2000 and 2002 (Table 7), the mean fish length for each tag type differed by less than 17 mm in all years, and all cumulative length distributions were similar in shape in all years (Figure 8). This indicates that the KS tests likely detected small differences because sample sizes provided the power to do so; length comparisons therefore suggest additional similarity between tag types.

3. **Bank of Recapture**: Although sample sizes were relatively small for tests of independence between tag type and bank of recapture, test results suggest that radio and spaghetti tagged fish distributed between banks after tagging and release in a similar fashion. No significant differences were detected in the test for independence between tag type and bank of recapture (Table 8).

4. **Length Distributions of Upstream Migration**: There were no significant differences detected in cumulative length distributions between radio-tagged fish that sustained upstream migration after tagging and those that did not (Table 9). Furthermore, except for 2002, there were no significant differences detected between length distributions of radio tagged fish that sustained upstream migration and spaghetti-tagged fish that were recaptured. (Table 10). The difference detected in 2002 was likely a result of the overall (but inconsequential) difference between tag type length distributions as reported above.

5. **Travel Time**: The median number of days elapsed between release and recapture could not be calculated for each tag type in 1999 because exact time of release was not recorded in that year. For 2000-2003, the absolute differences between tag type-specific medians were 1.0, 0.3, 0.7, and 2.7 days, respectively. These differences were inconsequential relative to the study duration and were another indication that both tag types behaved similarly.

The results described in 1-5 above suggested that pooling tag types and considering them as a single mark was appropriate in all study years. In addition, the results failed to demonstrate any consequential "between tag-type" differences; between tag-type differences would suggest sub-lethal tagging effects on fish behavior and possible violation of experimental assumption 3.

Pooling Data Over Banks

Examination of pooled data further suggested that pooling between riverbanks was also appropriate in all years and in both the tagging and recapture events. The test results were as follows:

1. **Upstream Migration**: Tests of the null hypothesis that upstream migration of radio tagged fish was independent of river bank of initial capture were not significant for any year (Table 11).

2. **Recapture Rate**: With the exception of 2002, tests of the null hypothesis that recapture rates were independent of bank were not significant (Table 12). Although significant (P = 0.028), the difference in the proportion of recaptured tags between banks of initial capture in 2002 was small (0.041 for the north bank versus 0.030 for the south bank).

3. **Length Distribution**: Significant differences in cumulative length distributions were detected by KS tests for fish tagged on the north bank versus those tagged on the south all years except 2001 (Table 13). However, mean fish lengths differed between banks by less than 18 mm in all years and cumulative length distributions were similar in shape (Figure 9). This indicates that KS tests likely detected inconsequential differences because sample size provided the power to do so.

4. **Bank to Bank Mixing**: Fish tagged adjacent to either river bank mixed across banks between events as indicated by the lack of significant results in tests for independence between bank of initial capture and bank of recapture (Table 14).

Further examination of the recapture effort supported the pooling of data across banks in all years. No bank-related differences were detected in the tagged proportions in the samples of fish examined in the recapture event (Table 15), indicating that tagged fish mixed between banks and that the pooling over riverbank was appropriate for the tagging event. Finally, significant differences were detected between bank-specific length distributions of fish captured in the recapture event (Table 16). Again, bank-specific mean lengths and bank-specific cumulative frequency distributions indicated that actual differences were inconsequential (with a maximum difference of 32 mm; Figure 10) despite statistical test results. Therefore, mark and recapture data were pooled across riverbanks. Furthermore, this pooling was considered another failure to demonstrate differential (between bank) tagging effects; between bank differences would suggest a violation of assumption 3.

Proportion Surviving to Sustain Upstream Migration ($\hat{p}$)

From 1999 through 2003, a total 187, 205, 200, 122, and 122 fish were tagged with radio tags, respectively (Table 17). No more than five fish were censored in any year and between 61% and 88% of the uncensored radio tagged sample survived and sustained upstream migration ("upstreamers") after tagging. After weighting weekly rates of "upstreamers" to account for all marks released each week (radio and spaghetti tags), estimates of the proportion of all tagged fish surviving to sustain upstream migration ($\hat{p}$) ranged among years from 0.591 to 0.923.

Data Culling and Standard Mark-Recapture Assumption Testing

During 1999-2003, untagged fish examined on the first 2, 4, 2, 4, and 4 days, respectively, were culled. This represented totals of 5, 64, 3, 9, and 13 untagged fish, respectively. During 1999-2003, untagged fish examined on the last 2, 3, 2, 0, and 1 days, respectively, were culled (zero days means that no end-of-season culling was required in 2002). This represented totals of 23, 17, 92, 0, and 1 untagged fish, respectively. Of the total sample of coho salmon examined in each annual recapture event, culled fish represented 1.8%, 2.6%, 2.0%, 0.2%, and 0.4%, respectively.

The "equal proportions" statistical tests produced significant results for all years except 1999 (Table 18), so for 2000-2003 we cannot conclude that there was homogeneity in capture probabilities over tagging event strata or that probability of movement to recapture strata was independent of initial capture strata. The "mixing" statistical tests were significant for 2001, 2002 and 2003 (Table 19), indicating that we cannot conclude homogeneity of capture probabilities in the recapture event nor that probability of movement to recapture strata was independent of initial capture strata for those years. Because at least one of the test results in 1999 and 2000 was non-significant, the PPE was considered a consistent estimator for those years. Because both tests produced significant test statistics for the 2001 through 2003 experiments, ML Darroch estimators were considered consistent estimators for those years.

KS tests (Appendix A1, Table 20, Figure 11, Figure 12) indicated that there was no size selectivity in 1999. The tests indicated size selectivity in the tagging event during 2000,2001, and 2003, but not in the recapture event. Size selectivity was detected in the recapture event in the 2002 experiment, but not in the tagging event. Although size-selectivity was detected, in no experiment was selectivity detected in both sampling events. Therefore, size stratification was not required in any year.

For convenience, a final summary of results and conclusions of the "equal proportions" tests, the "mixing" tests, and length selectivity tests are presented together in Table 21. Temporal stratification schemes and data used to formulate the five annual estimates are summarized in Table 22, Table 23 - 25..

Abundance, Total Run, Harvest Rate, and Marine Survival

In 1999, abundance at the fish wheel was 23,001 (SE = 5,154) and live abundance was 22,808 (SE = 5,157) coho salmon (Table 26). Sport harvest upstream of the capture location was 15,112 (SE = 1,171) and escapement was 7,696 (SE = 5,288) coho salmon. The total run was 48,346 (SE = 5,366) coho salmon and harvest rate was 0.837 (SE = 0.101). Marine survival was 0.060 (SE = 0.007) (Table 27).

In 2000, abundance at the fish wheel was 89,918 (SE = 9,295) and live abundance was 89,363 (SE = 9,322) coho salmon. Sport harvest upstream of the capture location was 16,621 (SE = 1,165) and escapement was 72,742 (SE = 9,395) coho salmon. The total run was 130,200 (SE = 9,460) coho salmon and harvest rate was 0.437 (SE = 0.036). Marine survival was 0.225 (SE = 0.018).

In 2001, abundance at the fish wheel was 93,524 (SE = 16,502) and live abundance was 92,984 (SE = 16,502) coho salmon. Sport harvest upstream of the capture location was 17,862 (SE = 1,540) and escapement was 75,122 (SE = 16,574) coho salmon. The total run was 134,155 (SE = 16,610) coho salmon and harvest rate was 0.436 (SE = 0.057). Marine survival was 0.223 (SE = 0.029).

In 2002, abundance at the fish wheel was 156,960 (SE = 20,256) and live abundance was 155,992 (SE = 20,255) coho salmon. Sport harvest upstream of the capture location was 22,380 (SE = 1,442) and escapement was 133,612 (SE = 20,306) coho salmon. The total run was

208,520 (SE = 20,418) coho salmon and harvest rate was 0.355 (SE = 0.037). Marine survival was 0.325 (SE = 0.033).

In 2003, abundance at the fish wheel was 99,309 (SE = 36,085) and live abundance was 99,100 (SE = 36,085) coho salmon. Sport harvest upstream of the capture location was 19,185 (SE = 1,372) and escapement was 79,915 (SE = 36,111) coho salmon. The total run was 135,978 (SE = 36,137) coho salmon and exploitation rate was 0.411 (SE = 0.110). Marine survival was 0.217 (SE = 0.058).

CATCH RATE ABUNDANCE INDEX

Annual cumulative catch rates ranged from 15.89 to 439.61, averaging 161.87 (Table 28, Figure 13). A weighted regression of the estimated abundance at the tagging locations on the $\log_e$ of cumulative catch rates appeared to be linear with a positive slope ($P = 0.002$ for H_o slope = 0; R^2=0.96). The weighted regression was used to account for the fact that the abundance estimates were measured with varying precision (ML Darroch vs Pooled Petersen). The positive linear relationship suggests that cumulative catch rate may be of value in qualitatively discerning small runs from large.

DISCUSSION

IMPLICATIONS

Estimates of annual adult coho salmon abundance presented in this report are the first available for the Kenai River population and additional years of estimates are required to develop sustainable management objectives. However, the baseline harvest rate provides an indication that there is no immediate threat to the sustainability of the population or the fisheries it supports.

Point estimates of harvest rate from 1999 through 2003 ranged between 0.35 and 0.84, did not exceed 0.44 in four of five study years, and averaged 0.50. By comparison to other wild coho salmon populations in Alaska, this level is not considered an immediate threat to the sustainability of the population nor the fisheries it supports. Harvest rates ranged between 0.27 and 0.68, averaging 0.46, for the Taku River in Southeast Alaska from 1992-2003 (McPherson et al. 1994-1998; Yanusz et al. 1999, 2000; Jones et al. 2006). Annual harvest rates measured in an aggregate of populations among four other intensively studied indicator streams in Southeast Alaska ranged between 0.40 and 0.71, averaging 0.59 for 1982-2003 (Geiger and McPherson 2004). Geiger and McPherson (2004) also reviewed Southeast Alaska populations in general and reported an "excellent overall condition" with no populations of concern identified. In addition, the first two estimates of harvest rate for a wild population that has supported long-term fisheries in northern Cook Inlet (Cottonwood Creek) were 0.47 and 0.29 for 1999 and 2000, respectively, averaging 0.38 (Namtvedt et al. *In Prep.*). None of these averages is substantially different from the average estimates for the Kenai River and the Southeast Alaska database is extensive enough to conclude that this general level of harvest is at least associated with sustained yield among a wide variety of drainages. Although the 1999 harvest rate was 0.84, the other years were substantially lower.

Another indication that harvest rates pose no immediate threat to sustainability is that the management plans, first implemented in 1997, have imposed restrictions on fisheries that have a long history of exploiting the population. Commercial fisheries in Upper Cook Inlet have harvested mixed populations of coho salmon since the late 1800s (Rigby et al. 1991). An average of about 250,000 coho salmon were harvested annually from 1894-1972, increasing to an average of about 350,000 fish since then. Although it has been demonstrated that the Kenai River population contributes a relatively small portion to the commercial harvest (Carlon and Hasbrouck 1994, 1996-1998; Carlon 2000, 2003; Massengill and Carlon 2004a-b, 2007a-b), it has likely contributed to this fishery for a substantial period. Concurrently, inriver sport harvests have been monitored since 1977, with an increasing trend toward substantial harvests that have sustained the statewide inriver harvest record. This long-term history of commercial and substantial inriver sport harvests occurred during a regulatory regime that was more liberal than that implemented since 1997. Precautionary restrictions have limited the harvest potential, and presumably harvest rate, to a level below that which has been sustained in persistent and substantial fisheries. This is considered an indirect but complimentary indication that current restricted harvest levels are sustainable.

These observations suggest that there is no immediate threat to sustainability, and also suggest that the current management plan is unduly restrictive in most years. Current restrictions to commercial, personal use, and sport fisheries were developed in the absence of a sustained-yield objective; they were designed to reduce harvest potential by a target of 40% in a precautionary response to short-term declines in smolt abundance as reported in 1996 to the BOF (Carlon *Unpublished*) and commercial harvest (Clark et al. *Unpublished*). Moderate harvest rates have been estimated since the full compliment of restrictions was imposed in 2000. The Department in a 2002 BOF report (Yanusz et al. *Unpublished*) recommended that no additional restrictions were necessary to protect the Kenai River population. While acknowledging that a surplus harvest likely exists, ADF&G has no way to quantify it in the absence of a sustained yield management objective.

The great harvest potential demonstrated in 1994 (121,000 coho salmon) and statewide record harvests in subsequent years illustrate that user demand is present. It is therefore prudent to quantify the harvestable surplus to address demand. The surplus can only be identified with the establishment of quantifiable, escapement-based management objectives such as an SEG or BEG. The record 1994 harvest also demonstrates the potential for excessive exploitation; in the absence of a sustained yield management objective, it is difficult for the Department to liberalize fisheries to harvest the surplus. This further suggests that a quantified escapement objective should be pursued.

The time period required to develop sustainable management objectives from adult abundance experiments is unknown, but a reasonable level of information to develop an initial escapement goal this population will be reached when harvest estimates for the 2008 fishing season become available, probably in 2009. Although aging techniques are currently under review, it is believed that the overwhelming majority of coho salmon emigrate from the Kenai River as age 2+ smolt and virtually all return after one year at sea. Under this aging model, five estimates of the harvest of progeny returning from the first five known escapements will have occurred. The relationship between the five annual escapements and subsequent harvests of progeny should provide sufficient information to develop an escapement goal. Until 2008 then, it would be prudent to continue with the suite of projects needed to estimate harvest: SWHS, personal use fishery permit reporting system, and commercial harvest CWT study. In addition, estimates of adult abundance should also be continued to monitor variability in escapements over a longer period. This would increase the data available from which to develop upper and lower bounds for the initial escapement goal resulting in greater precision and confidence in the goal.

Until management objectives are developed, fish wheel catch rates may serve as an interim, low-precision management tool. Over the limited range of five years, the relationship between $\log_e$-transformed cumulative catch rate and estimated abundance was linear with a high degree of variation in point estimates of abundance accounted for by the regression model. We advise that with the limited data in the regression, the model not be used to predict abundance. However, it may be useful as a post-season, relative index for discerning weak returns from strong. During the 1999 through 2003 study period, the estimated abundance at the fish wheel capture locations ranged over one order of magnitude from nearly 23,000 in 1999 to nearly 158,000 fish in 2002. Anecdotal evidence from casual, inseason angler interviews and field observations of the inriver fishery suggest that these returns were associated with low and high angler satisfaction, respectively. In addition, netting catch rates in the recapture reach reflected a corresponding relative difference with 8.8 and 27.3 coho salmon per netting hour during 1999 and 2002, respectively. Fish wheel cumulative catch rates were also indicative of the difference ranging from nearly 16 units in 1999 to nearly 440 in 2002. Although the fish wheel locations (and likely efficiencies) were different between these two years, combined information suggests that fish wheel catch rates have been indicative of run magnitude.

EXPERIMENTAL ISSUES AND QUALIFICATIONS

Regardless of analytical procedures to compensate for tagging-induced mortality and precautions taken in handling fish, abundance estimates produced from modern mark-recapture techniques remain vulnerable to unquantifiable bias from violation of the assumption that tagging does not influence catchability. Numerous studies of the mark-recapture technique have demonstrated substantial bias in abundance estimates from tagging studies because tagged and untagged individuals have not behaved similarly (Hilborn and Walters 1992). Furthermore, researchers have been cautioned when applying mark-recapture abundance estimates because of the uncertainty regarding the potential for increased mortality or differential movement of tagged and untagged fish (Ricker 1975; Schwarz and Taylor 1998). We attempted to remove this uncertainty by correcting for differential mortality with radio telemetry and associated analytical adjustments to the model. In addition, we made substantial efforts to minimize tagging-induced stress, to maximize the number of fish tagged and resampled within logistical constraints, to apply statistical tests to indirectly detect tagging-induced effects, and to verify that radio-tagged fish were capable of reaching disparate spawning destinations. These efforts removed a substantial amount of uncertainty regarding the behavior of tagged and untagged fish and therefore minimized bias.

The year-round inriver return is likely greater than estimated (as are escapement and marine survival) and exploitation rates are likely lower than estimated because an unknown number of coho salmon adults enter the river before and after the mark-recapture experiment. Therefore, estimates presented here pertain only to the segment of the population targeted by the majority of existing fishing effort.

Factors influencing capture probabilities in the five experiments are unknown and untested. However, the efficiency of fish wheel and drift gillnetting gear are commonly thought to be influenced by water level, velocity, and transparency among other factors. The greatest range in water levels occurred in 2003, as did the lowest water level and the longest, consistent decrease in water level. The water transparency trend in 2003 was also anomalous relative to other study years as it was generally increasing throughout the season. These factors may have induced more variation in capture probabilities in 2003.

Significant changes to the tagging effort strategy and procedures that occurred between 1999 and all other years likely contributed to a substantial increase in the proportion of tagged coho salmon that sustained upstream migration after tagging. Most of the fish that failed to sustain upstream migration were discovered to have died, presumably from capture and tagging-induced stress. In 1999, the weighted "mortality" rate was about 40% while it averaged 14% during the other four study years, never exceeding 20%. At least seven factors were modified between the 1999 and subsequent experiments and are therefore associated with the improvement:

1. First, the fish wheels used to capture and mark fish were relocated upstream approximately 15 river kilometers. This was done in response to the relatively higher catch rate of fish wheels operated experimentally at the upstream location during the 1999 study. The more upstream location used in 2000-2003 may have provided additional time for fish to acclimatize to freshwater and perhaps be less susceptible to stress.

2. The fish wheels were only periodically checked throughout the day in 1999 but were closely attended in other years with many of the fish tagged and released immediately upon capture. Captured coho salmon spent minimal or no time in the fish wheel holding trap before tagging and release.

3. Tagged fish were released into an inriver recovery trough in 1999 and directly into the river in subsequent years.

4. The radio tag used in 1999 was slightly larger in volume and weight (16 g) than the tag used in subsequent years (14 g).

5. The attachment method changed from rigid, nickel pins to flexible cables. The attachment method may have been more important than the volume and weight reduction, which were minimal relative to fish weight, because the rigid pins used in 1999 often resulted in an excessively tight fit with substantial compression of the musculature in the vicinity of the tag and its anchoring Petersen disk. The flexible cables permitted a snug fit with no excessive compression.

6. In 1999, mid-eye to tail-fork lengths were measured while in subsequent years fork lengths were measured. Measuring fork lengths required less handling and the eye of the fish was not touched during measuring.

7. In 1999, an anal fin punch was applied to each fish as a secondary mark prior to release while the tag wounds served as a secondary mark in subsequent years. Eliminating the fin punch minimized handling time and eliminated unnecessary mutilation.

Although the relative influence of these seven factors on mortality is unknown, the combination of modifications is associated with an approximate 65% reduction in mortality, from about 40% to a 4-year mean of 14%.

The rapidity with which a subsample of fish were radio tagged was recorded in 2001. Of 200 coho salmon radio tagged in 2001, 138 were categorized as tagged "immediately" upon capture or not. Of the 138 fish so categorized, one was censored, leaving 137 for which experimental fates were determined. Of 110 fish that were not tagged immediately (spent an unknown amount of time in the fish wheel trap), 22 (20%) did not sustain upstream migration after tagging. Of the 27 fish that were radio tagged immediately, three (11%) failed to sustain upstream migration representing a 45% reduction in the failure rate. Regardless of this apparent reduction, a contingency test of these data indicated that there was independence between immediacy of radio tagging and tendency to sustain upstream migration. Because of the importance and untestable nature of Petersen model assumption 3, a high and variable mortality rate in tagged fish reduces public confidence in the accuracy of final estimates and any potential reduction in mortality and/or its variability is desirable. These data suggest that consistent rapid processing of fish upon capture may improve survival or at least that a more controlled study of this specific factor is justified.

Pooling of data between tag types and banks in all years and in both events greatly simplified the analysis and improved precision. Estimates stratified by sub-categories were not required. Consistent handling and tagging procedures likely both contributed to the validity of pooling and are therefore considered beneficial in such an experiment. Consistency and care in handling and tagging should be a goal in this type of experiment to simplify analyses and improve precision.

Another benefit of careful and consistent handling relates to confidence in the final abundance estimates. Although the experimental model corrects for mortality in the tagged sample, the substantial mortality rate of 40% in 1999 suggests some uncertainty in the accuracy of the 1999 abundance estimate. A failure rate approaching ½ of the tagged sample leads naturally to speculation that migration rates of individuals in the remaining tagged sample (that did sustain upstream migration) may be artificially altered along a continuum of responses: some may be unaffected while others may migrate slower assuming that stress requires energy expenditures normally budgeted for swimming. This would lead to violation of assumption 3: tagged fish migrating slower (on average) than untagged fish would take longer to transit the recapture reach and would therefore be prone to a higher capture probability in the recapture event than untagged fish, a condition that would lead to underestimating abundance. Under this scenario, the 1999 estimate would be more prone to this outcome than subsequent years. In fact, the 1999 radio-tag recapture rate of 0.075 was more than double that for spaghetti tags (0.033) and although not significantly different, the P-value was marginal (0.084) relative to other study years. It should be noted however that although the 1999 estimate has this potential for underestimation, inter-annual comparisons of commercial catch, fish wheel catch rates, and anecdotal observations of the inriver sport fishery indicate that the 1999 return was substantially smaller than other years. The 1999 estimate as presented therefore has value, but because of the un-testable nature of assumption 3, care should be taken when interpreting the 1999 abundance estimate and associated estimates of population dynamics.

Finally, implementation of this experiment required capturing and handling a large number of fish to fulfill study requirements, reaching a maximum of 105,000 fish of all species (a mixture of anadromous salmonids and several resident species) in 2000 and averaging about 49,000 fish between 1999 and 2003. Although the incidental catch by fish wheels was released without additional handling, all of the incidental catch in gillnets had to be handled. Anecdotal observations from multiple sources (the public and numerous field personnel) of dead fish in or downstream from the recapture reach were not uncommon, indicating that, although unquantified, capture-induced mortality was likely not a rare event and that some gear-related, artificial mortality was imposed on coho salmon and other species. The negative impact on populations is unknown, but is considered minimal relative to each population. The immediate mortality of coho salmon measured at the fish wheel (included in the "discounted" fish category) amounted to only several fish each year. In addition, the fish wheels captured between 0.9% and 3.4% of the estimated total return each year. With post-release mortalities (as indicated by the weighted proportion of fish that failed to sustain upstream migration) of the tagged sample ranging from about 8% in 2003 to 41% in 1999, the proportion of the total return represented by post-release mortalities of fish wheel caught fish was consistently less than 1%, ranging from 0.1% to 0.5%.

It is possible that fish caught by drift gillnets were subject to greater mortality because of the mechanics of entanglement capture by gillnets. Although many fish were released from drift gillnets with no visible injuries, many others experienced gear-induced injuries including mechanical skin abrasions, scale loss, fin or eye damage, and extreme body compression with probable internal injury. In fact, observations of dead fish were frequently accompanied by the observation of visible external evidence of such net-induced injuries. Regardless, mortality induced during recapture event sampling is also considered minimal because drift gillnets likely sampled small portions of populations. Among study years, between 2.6% and 4.7% of the estimated coho salmon returns were sampled in the recapture reach.

Regardless of the level of direct mortality induced by the mark-recapture experiment, it guarantees a negative public reaction. Public education regarding the actual extent of the impact to the coho salmon population should continue if the experiment is continued. In addition, parallel development of capture and tagging techniques in the intertidal reach downstream from the inriver sport fishery would be desirable. If handling mortality could be kept to a minimum there, the fishery could function as the recapture method; harvest sampling would be less costly than the current recapture strategy and would eliminate unnecessary mortality and public perception issues.

RECOMMENDATIONS

- Continue with the mark-recapture experiment to estimate adult abundance and escapement.

  Baseline estimates of exploitation indicate that there is no immediate threat to sustainability. A longer time series of annual abundance information is recommended with which to develop escapement goal ranges.

  Concurrently, test and develop techniques to effectively capture coho salmon in the intertidal reach downstream from the sport fishery. The sport fishery could then be used as the recapture event, minimizing costs and potential biological impacts of the current recapture technique. The only other technique to estimate seasonal abundance is fish wheel catch rate at rkm 45. That technique is inadequate for the purpose of developing management goals.

- Continue companion programs that estimate harvest components.

  Companion programs to estimate sport harvest (SWHS), personal-use harvest (permit system reporting), and population-specific commercial harvest (CWT program) should continue through 2007 at a minimum to provide five consecutive years of estimates. Continuation through 2012 would provide ten consecutive harvest estimates that could be paired with estimates of escapement made through 2008.

- Do not use rkm 45 fish wheel catch rates to index inseason abundance.

  Our analysis indicates that the catch rates from the fish wheels located near rkm 45 are of limited value and may only be useful as a low precision post-season indexing tool.

- Evaluate age determination techniques for coho salmon.

  The accuracy of scale pattern analysis for aging coho salmon has recently been questioned. Aging error should be quantified or new techniques should be explored to ensure that harvests can be accurately associated with the proper parent year when developing an escapement goal.

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TABLES AND FIGURES

Table 1.–Possible fates and calculation of expected number by fate of adult coho salmon in the inriver return to the Kenai River as categorized for five annual mark-recapture experiments to estimate abundance, 1999 through 2003.

Fate Code[a]	Description	Expected Value[b,c]	Model Parameter[d]
F01	Never captured.	*N – M – C + R*	
F02*	First captured in recapture reach.	*C - R*	*C*
F03	Marked with a spaghetti tag at the capture location, migrated upstream, was not harvested by the inriver sport fishery between the capture location and the recapture reach, and was not recaptured in recapture reach.	$M(1\text{-}q)p(1\text{-}H/N)[1\text{-}[C/(N\text{-}H)]]$	
F04*	Marked with a spaghetti tag at the capture location, migrated upstream, and was recaptured in the recapture reach.	$M(1\text{-}q)p(1\text{-}H/N)[C/(N\text{-}H)]$	*M, C, and R*
F05*	Marked with a spaghetti tag at the capture location, migrated upstream, and was harvested by the inriver sport fishery between the capture location and the recapture reach.	$M(1\text{-}q)p(H/N)$	*M*
F06*	Marked with a transmitter at the capture location, was not censored, migrated upstream, was not harvested by the inriver sport fishery between the capture location and the recapture reach, and was not recaptured in the recapture reach.	$Mq(1\text{-}\theta)p(1\text{-}H/N)[1\text{-}C/(N\text{-}H)]$	*M*
F07*	Marked with a transmitter at the capture location, was not censored, migrated upstream, and was recaptured in the recapture reach.	$Mq(1\text{-}\theta)p(1\text{-}H/N)[C/(N\text{-}H)]$	*M, C, and R*
F08*	Marked with a transmitter at the capture location, was not censored, migrated upstream, and was harvested by the inriver sport fishery between the capture location and the recapture reach.	$Mq(1\text{-}\theta)p(H/N)$	*M*
F09*	Marked with a transmitter at the capture location and censored.	$Mq\theta$	*M*
F10*	Marked with a transmitter at the capture location, was not censored, and did not sustain upstream migration.	$Mq(1\text{-}\theta)(1\text{-}p)$	*M*
F11	Marked with a spaghetti tag at the capture location and did not sustain upstream migration.	$M(1\text{-}q)(1\text{-}p)$	

[a] Fate codes marked with an asterisk (*) represent fates that were empirically assigned to fish through direct examination of capture, recapture, and telemetry data. The remaining fates were assigned to fish in the simulation procedure used to estimate the variance of abundance estimates.

[b] The intermediate terms q (the proportion of coho salmon captured in fish wheels and marked with a transmitter), θ (the proportion of radio-tagged coho salmon that were censored after release), and p (the proportion of radio-tagged fish that sustained upstream migration after release) in the equations used to generate expected values for all eleven fate categories were directly based on the number of fish empirically assigned to the "*-marked" fate categories.

[c] The term H represents the assumed harvest of all coho salmon occurring in the sport fishery between the capture location and the recapture reach.

[d] Model parameter to which each empirically determined fate category belongs; summing the number of fish in each empirically determined category and aggregating them within the associated model parameter provides the data required of the model (M, C, and R) for the point estimate of abundance. These data were temporally stratified if required by the chosen model.

Table 2.–Fish wheel effort (hrs) and coho salmon catch during marking events, Kenai River, Alaska, 1999-2003.

	Bank			
	North	South	Total	CPUE
1999				
Effort	890.8	843.9	1,734.7	
Catch	288	163	451	0.260
2000				
Effort	826.1	876.2	1,702.3	
Catch	2,641	879	3,520	2.068
2001				
Effort	880.3	855.1	1,735.4	
Catch	871	1,975	2,846	1.640
2002				
Effort	567.4	594.3	1,161.7	
Catch	4,143	2,882	7,025	6.047
2003				
Effort	741.9	704.5	1,446.4	
Catch	305	2,231	2,536	1.753

Table 3.–Effort and tagging summary for coho salmon during the marking event, 1999-2003.

	Year				
Statistic	1999	2000	2001	2002	2003
Caught but Excluded from Marked Sample					
Escaped Prior to Tagging[a]		12	78	316	9
Number Injured During Capture	18	33	10	11	16
Previously Captured by Driftnet [a]	0	9	10	5	1
Radio-Tag Recaptures	1	1	4	6	3
Spaghetti-Tag Recaptures	3	73	75	132	42
Adipose Finclipped Fish Sacrificed [a]	0	7	2	15	3
Total	22	135	179	485	74
Suitable for Tagging					
Tagged with Radio Tags	187	205	200	122	122
Tagged with Spaghetti Tags	242	3,180	2,467	6,418	2,340
Total	429	3,385	2,667	6,540	2,462

[a] Escaped fish were not documented in 1999. Fish captured previously by gillnet did not occur in 1999. Adipose-finclipped fish were not sacrificed for the companion study in 1999.

Table 4.–Summary of effort during the recapture events, 1999-2003.

	1999			2000			2001			2002			2003		
Statistic	North Bank	South Bank	Total	North Bank	South Bank	Total	North Bank	South Bank	Total	North Bank	South Bank	Total	North Bank	South Bank	Total
Drift Gillnet															
Effort (hrs)	151.4	69.9	255.0 [a]	119.6	134.2	253.8	163.3	141.8	305.1	78.5	127.5	206.0	153.7	168.8	322.5
Catch	599	783	1,832 [b]	1,662	1,395	3,057	2,941	2,159	5,100	1,721	3,587	5,308	2,208	1,762	3,970
CPUE	3.96	11.20	7.18	13.90	10.39	12.04	18.01	15.23	16.72	21.92	28.13	25.77	14.37	10.44	12.31
Set Gillnet															
Effort (hrs)				15.7	53.8	69.5	1.3	42.6	43.9	0.2	0.0	0.2	0.0	0.5	0.5
Catch				52	313	365	5	183	188	1	0	1	0	0	0
Hook-and-Line															
Catch				18	16	34	0	9	9	26	212	238	4	2	6
Fish Wheel															
Effort (hrs)	469.5	446.8	916.3												
Catch	231	175	406												
CPUE	0.49	0.39	0.44												
Beach Seine															
Catch										0	82	82			
Total Gear Combined															
Catch	830	958	2,238 [b]	1,732	1,724	3,456	2,946	2,351	5,297	1,748	3,881	5,629	2,212	1,764	3,976

[a] Total includes an additional 33.7 hrs effort for which bank was unspecified.
[b] Total includes an additional 450 fish for which bank was unspecified.

Table 5.–Summary of captures and recaptures of coho salmon during the recaptures events, 1999-2003.

	Year				
Statistic	1999	2000	2001	2002	2003
Coho Salmon Captured Multiple Times[a]					
Untagged Fish Captured Twice	130	146	289	261	283
Untagged Fish Captured Three Times	8	6	15	11	12
Untagged Fish Captured Four Times			1		
Spaghetti-tagged Fish Captured Twice		3	3	3	8
Spaghetti-tagged Fish Captured Three Times				8	1
Radio-tagged fish Captured Twice	2	0			
Untagged Fish with Unknown Prior Capture History			10	2	20
Total	140	155	318	285	324
Coho Salmon Escaping Prior to Examination[b]					
Untagged	0	133	301	180	157
Radio-Tagged	0	0	0	0	0
Spaghetti-Tagged	0	7	9	19	2
Total	0	140	310	199	159
Coho Salmon Captured and Examined[c]					
Untagged	2,076	3,063	4,548	4,904	3,374
Radio-Tagged	14	5	13	6	4
Spaghetti-Tagged	8	93	108	235	115
Total	2,098	3,161	4,669	5,145	3,493

[a] Coho salmon captured multiple times must be subtracted from the Total Catch to determine the number examined in the recpature event because the study was designed to sample without replacement.

[b] Coho salmon escaping prior to examination must also be subtracted from the Total Catch to determine the number examined for tags in the recapture event because these fish were not closely examined and therefore their release date (for recaptured tags) or prior capture status (number of dorsal punches) are unknown. Also, coho salmon that escaped during capture prior to close examination were not documented in 1999, but were in all other years; these categories are included here for tabulation consistency with all other years.

[c] The number of fish closely examined for tag status and prior examination status (number of dorsal punches). These fish constitute model parameter "C" (number of fish examined in the recapture event).

Table 6.–Two by two contingency table data and results of chi-square tests for independence between tag type and recapture rate in five annual mark-recapture experiments to estimate the abundance of coho salmon in the Kenai River, 1999 through 2003.

Tag Type	Number Released and Not Recaptured	Number Recaptured	Proportion Recaptured	χ^2	P-Value	Significance
1999						
Radio	173	14	0.075	2.98	0.084	NS
Spaghetti	234	8	0.033			
2000						
Radio	200	5	0.024	0.03	0.852	NS
Spaghetti	3,087	93	0.029			
2001						
Radio	187	13	0.065	1.46	0.226	NS
Spaghetti	2,359	108	0.044			
2002						
Radio	116	6	0.049	0.24	0.626	NS
Spaghetti	6,183	235	0.037			
2003						
Radio	118	4	0.033	0.37	0.545	NS
Spaghetti	2,225	115	0.049			

Table 7.–Results of comparisons (Kolmogorov-Smirnov) between cumulative relative length distributions of radio-tagged (n1) and spaghetti-tagged (n2) coho salmon captured in fish wheels in the Kenai River, 1999 through 2003.

Year	Radio Tagged Fish (n1)	Spaghetti-Tagged Fish (n2)	Test Statistic (Dmax)	P-Value	Significance	Mean Length by Tag Type[a]	
						Radio	Spaghetti
1999	185	242	0.074	0.558	NS	576.8	571.8
2000	203	3,152	0.134	0.002	S	680.9	692.6
2001	197	2,407	0.046	0.830	NS	650.6	654.1
2002	122	6,384	0.166	0.003	S	654.3	671.1
2003	122	2,334	0.066	0.673	NS	639.0	642.4

[a] In 1999, lengths measured were mid-eye to tail-fork. In all other years, lengths measured were fork lengths.

Table 8.–Two by two contingency table data and results of tests for independence between tag type and bank of recapture in the recapture event of five annual mark-recapture experiments to estimate the abundance of coho salmon in the Kenai River, 1999 through 2003.

	Number Recaptured		Proportion on			
Tag Type	North Bank	South Bank	North Bank	χ^2	P-Value	Significance
1999						
Radio	8	3	0.727	2.53	0.111	NS
Spaghetti	2	6	0.250			
2000						
Radio	2	3	0.400	0.11	0.740	NS
Spaghetti	40	53	0.430			
2001						
Radio	7	6	0.538	0.00	0.959	NS
Spaghetti	62	46	0.574			
2002						
Radio	2	4	0.333	0.15	0.696	NS
Spaghetti	76	159	0.323			
2003						
Radio	2	2	0.500	0.001	0.982	NS
Spaghetti	73	42	0.635			

Table 9.–Results of comparisons (Kolmogorov-Smirnov) between cumulative relative length distributions of radio-tagged fish that sustained upstream migration after marking and those that did not in five annual mark-recapture experiments to estimate the abundance of coho salmon in the Kenai River, 1999 through 2003.

	Sample Size				
Year	Sustained Upstream Migration	Did not Sustain Upstream Migration	Test Statistic (Dmax)	P-Value	Significance
1999	110	70	0.081	0.814	NS
2000	168	34	0.118	0.763	NS
2001	155	41	0.129	0.532	NS
2002	104	18	0.176	0.665	NS
2003	103	14	0.187	0.740	NS

Table 10.–Results of comparisons (Kolmogorov-Smirnov) between cumulative relative length distributions of radio-tagged fish that sustained upstream migration and spaghetti-tagged fish that were recaptured (bottom) in five annual mark-recapture experiments to estimate the abundance of coho salmon in the Kenai River, 1999 through 2003.

	Sample Size				
Year	Radio-Tagged Fish that Sustained Upstream Migration	Spaghetti-Tagged Fish that were Recaptured	Test Statistic (Dmax)	P-Value	Significance
1999	110	8	0.275	0.602	NS
2000	168	92	0.171	0.051	NS
2001	155	107	0.085	0.683	NS
2002	104	235	0.294	<0.001	S
2003	103	115	0.051	0.994	NS

Table 11.–Two by two contingency table data and results of tests for independence between bank of initial capture and the tendency for radio-tagged coho salmon to sustain upstream migration after marking in five annual mark-recapture experiments to estimate abundance of coho salmon in the Kenai River 1999-2003.

Bank of Initial Capture	Number Not Sustaining Upstream Migration[a]	Number Sustaining Upstream Migration	Proportion Migrating Upstream	χ^2	P-Value	Significance
1999						
North	51	86	0.628	0.469	0.493	NS
South	20	25	0.556			
2000						
North	22	133	0.858	3.166	0.075	NS
South	13	36	0.735			
2001						
North	19	65	0.774	0.070	0.786	NS
South	23	92	0.798			
2002						
North	9	49	0.845	0.001	0.977	NS
South	9	55	0.859			
2003						
North	2	21	0.913	0.033	0.857	NS
South	12	82	0.872			

[a] Excludes censored radio tags.

Table 12.–Contingency table data and results of tests for independence between recapture rate and bank of initial capture in five annual mark-recapture experiments to estimate the abundance of coho salmon in the Kenai River, 1999 through 2003.

Bank of Initial Capture	Number Recaptured	Number Released And Not Recaptured	Proportion Recaptured	χ^2	P-Value	Significance
1999						
North	12	259	0.044	0.40	0.526	NS
South	10	148	0.063			
2000						
North	79	2,470	0.031	1.25	0.264	NS
South	19	817	0.023			
2001						
North	38	810	0.045	0.00	0.996	NS
South	83	1,736	0.046			
2002						
North	161	3,749	0.041	4.83	0.028	S
South	80	2,550	0.030			
2003						
North	15	273	0.052	0.03	0.865	NS
South	104	2,070	0.048			

Note: Both tag types pooled.

Table 13.–Results of comparisons (Kolmogorov-Smirnov) between cumulative relative length distributions of coho salmon captured in a fish wheel adjacent to the north bank of the Kenai River and those captured adjacent to the south bank in five annual mark-recapture experiments to estimate the abundance of coho salmon in the Kenai River, 1999 through 2003.

Year	North Bank Fish (n1)	South Bank Fish (n2)	Test Statistic (Dmax)	P-Value	Significance	Mean Length (mm) by Initial Bank of Capture[a] North	South
1999	270	157	0.162	0.009	S	578.4	566.3
2000	2,524	831	0.074	0.002	S	690.4	696.6
2001	818	1,786	0.030	0.662	NS	653.0	654.2
2002	3,904	2,602	0.150	< 0.001	S	677.8	660.2
2003	286	2,170	0.110	0.004	S	651.1	641.3

[a] In 1999, lengths measured were mid-eye to tail-fork. In all other years, lengths measured were snout to tail-fork.

Table 14.–Contingency table data and results of tests for independence between initial bank of capture and bank of recapture for Kenai River coho salmon, 1999 through 2003.

Bank of Initial Capture	Bank of Recapture North	South	Proportion Recaptured Adjacent to Same Bank[b]	χ^2	P-Value	Significance
1999[a]						
North	6	5	0.545	0.073	0.788	NS
South	4	4	0.500			
2000						
North	36	43	0.456	0.720	0.396	NS
South	6	13	0.684			
2001						
North	20	18	0.526	0.214	0.644	NS
South	49	34	0.410			
2002						
North	53	108	0.329	0.013	0.909	NS
South	25	55	0.688			
2003						
North	9	6	0.600	0.001	0.979	NS
South	66	38	0.365			

Note: Both tag types pooled.

[a] Bank of recapture was recorded for 19 of the total of 22 coho salmon recaptured in 1999.

[b] Proportion of the recapture sample for which bank of recapture was the same as bank of initial capture.

Table 15.–Contingency table data and results of tests for independence between bank of capture and the marked proportion of the catch of coho salmon in the recapture event of five annaul mark-recapture experiments to estimate the abundance of coho salmon in the Kenai River, 1999 through 2003.

Recapture Event	Mark Status in Recapture Sample		Proportion			
Bank	Marked	Unmarked	Marked	χ^2	P-Value	Significance
1999						
North	10	758	0.013	0.11	0.743	NS
South	9	883	0.010			
2000						
North	42	1,543	0.026	1.86	0.173	NS
South	56	1,520	0.036			
2001						
North	69	2,494	0.027	0.15	0.701	NS
South	52	2,054	0.025			
2002						
North	78	1,489	0.050	0.35	0.557	NS
South	163	3,415	0.046			
2003						
North	75	1,875	0.038	2.30	0.130	NS
South	44	1,499	0.029			

Note: Both tag types (radio and spaghetti) pooled.

Table 16.–Results of comparisons (Kolmogorov-Smirnov) between cumulative relative length distributions of coho salmon captured along each bank of the recapture reach of the Kenai River in five annual experiments to estimate the abundance of coho salmon, 1999 through 2003.

	North Bank	South Bank	Test			Mean Length (mm) by	
	Fish	Fish	Statistic			Recapture Reach Bank[a]	
Year	(n1)	(n2)	(Dmax)	P-Value	Significance	North	South
1999	117	173	0.111	0.309	NS	576.3	568.9
2000	183	196	0.132	0.060	S	669.8	687.2
2001	294	230	0.128	0.024	S	661.8	671.2
2002	181	405	0.165	0.002	S	679.6	698.2
2003	193	155	0.229	<0.001	S	644.9	676.3

[a] In 1999, lengths measured were mid-eye to tail-fork. In all other years, lengths measured were snout to tail-fork.

Table 17.–Performance of radio-tagged coho salmon, proportion sustaining upstream migration after marking, proportion of all marked coho salmon released, and weighted estimate of the proportion ($\hat{p}$) of marked coho salmon.

Year	Number Spaghetti Tagged	Number Radio Tagged	Censored Radio Tags	Adjusted Tags Released	Radio-tagged Fish Migrating Upstream		$\hat{p}$ [a]
					Number	Proportion	
1999	242	187	5	424	111	0.61	0.591
2000	3,180	205	1	3,384	169	0.83	0.848
2001	2,467	200	1	2,666	157	0.79	0.802
2002	6,418	122	0	6,540	104	0.85	0.856
2003	2,340	122	5	2,457	103	0.88	0.923

[a] Sum of weekly weighted estimates of upstream-migrating coho.

Table 18.–Observations of marked and unmarked coho salmon captured in the recapture events of five annual mark-recapture experiments to estimate the abundance of coho salmon in the Kenai River, 1999-2003, and results of tests for independence between mark status and temporal stratum.

Temporal Recapture Stratum[b]	Number Examined	Number Unmarked	Number Marked	Proportion Marked	χ^2	P-Value	Significance
1999							
8/12-8/26	953	946	7	0.007	3.67	0.453	NS
8/27-9/9	627	617	10	0.016			
9/10-9/16	165	164	1	0.006			
9/17-9/30	183	180	3	0.016			
10/1-10/6	132	131	1	0.008			
Total	2,060	2,038	22	0.011			
2000							
8/5-8/21	1,177	1,165	12	0.010	52.27	< 0.001	S
8/22-9/11	814	795	19	0.023			
9/12-9/25	780	735	45	0.058			
9/26-10/10	309	287	22	0.071			
Total	3,080	2,982	98	0.032			
2001							
8/5-8/15	758	752	6	0.008	36.16	< 0.001	S
8/16-8/22	791	782	9	0.011			
8/23-8/29	881	859	22	0.025			
8/30-9/5	526	499	27	0.051			
9/6-9/12	424	408	16	0.038			
9/13-9/19	445	427	18	0.040			
9/20-9/26	414	400	14	0.034			
9/27-10/3	335	326	9	0.027			
Total	4,574	4,453	121	0.026			
2002							
8/6-8/15	505	501	4	0.008	57.88	< 0.001	S
8/16-8/22	651	648	3	0.005			
8/23-8/29	472	451	21	0.044			
8/30-9/5	381	355	26	0.068			
9/6-9/12	558	530	28	0.050			
9/13-9/19	961	901	60	0.062			
9/20-9/26	1,080	1,017	63	0.058			
9/27-10/4	528	492	36	0.068			
Total	5,136	4,895	241	0.047			
2003							
8/8-8/17	357	353	4	0.011	45.23	< 0.001	S
8/18-8/24	705	671	34	0.048			
8/25-8/31	708	666	42	0.059			
9/1-9/7	498	480	18	0.036			
9/8-9/14	305	291	14	0.046			
9/15-9/21	385	379	6	0.016			
9/22-10/4	521	520	1	0.002			
Total	3,479	3,360	119	0.034			

[a] Generally referred to in mark-recapture experiments as the "equal proportions test" of the hypothesis (and experimental assumption) that a) all fish in the population have an equal probability of capture and marking in the marking event or b) that probability of movement to recapture strata was independent of intital capture strata.

[b] Temporal strata were chosen (independently of strata chosen for final abundance estimates) to ensure that expected values in contingency table cells were >= 5 . In addition, days (and data) were culled from the beginning of the initial recapture stratum and from the end of the final recapture stratum to synchronize the recapture data used in the equal proportions test with the culled data used to produce final estimates, i.e., examined fish that were excluded from the dataset used to produce final estimates were also excluded from the equal proportions tests.

Table 19.–Observations of number of coho salmon captured and marked by temporal marking stratum, number recaptured in the recapture event, and number not recaptured along with results of tests for independence between the recapture status and temporal marking stratum in five annual experiments to estimate the abundance of coho salmon in the Kenai River, 1999 through 2003.

Temporal Marking Stratum[a]	Number Marked	Adjusted Number Marked[b]	Number Not Recaptured	Number Recaptured	Proportion Recaptureed	χ^2	P-Value	Significance
1999								
8/6-8/19	127	75	67	8	0.107	0.59	0.745	NS
8/20-8/26	99	59	54	5	0.085			
8/27-9/30	203	120	111	9	0.075			
Total	429	254	232	22	0.087			
2000								
8/1-8/14	384	326	313	13	0.040	6.91	0.329	NS
8/15-8/21	281	238	233	5	0.021			
8/22-9/4	756	641	625	16	0.025			
9/5-9/11	366	310	302	8	0.026			
9/12-9/18	482	409	395	14	0.034			
9/19-9/25	863	732	699	33	0.045			
9/26-10/6	253	215	206	9	0.042			
Total	3,385	2,870	2,772	98	0.034			
2001								
8/2-8/15	424	340	327	13	0.038	22.46	0.001	S
8/16-8/22	668	536	515	21	0.039			
8/23-8/29	564	452	431	21	0.046			
8/30-9/5	428	343	320	23	0.067			
9/6-9/12	198	159	142	17	0.107			
9/13-9/19	123	99	87	12	0.122			
9/20-9/30	262	210	196	14	0.067			
Total	2,667	2,139	2,018	121	0.057			
2002								
8/2-8/22	1,087	930	902	28	0.030	52.47	< 0.001	S
8/23-8/29	1,214	1,039	1,020	19	0.018			
8/30-9/5	933	799	764	35	0.044			
9/6-9/12	996	853	826	27	0.032			
9/13-9/19	1,192	1,020	944	76	0.074			
9/20-9/26	948	811	762	49	0.060			
9/27-9/30	170	146	139	7	0.048			
Total	6,540	5,598	5,357	241	0.043			
2003								
8/4-8/10	126	116	111	5	0.043	17.49	0.004	S
8/11-8/17	808	746	724	22	0.029			
8/18-8/24	631	582	543	39	0.067			
8/25-8/31	474	438	409	29	0.066			
9/1-9/7	273	252	232	20	0.079			
9/8-9/30	150	138	134	4	0.029			
Total	2,462	2,272	2,153	119	0.052			

[a] Temporal strata were chosen (independently of strata chosen for final abundance estimates) to ensurethat expected values in contingency table cells were >= 5 .

[b] Adjusted to account for the proportion that did not sustain upstream migration (p statistic from Table 22).

Table 20.–Results of Kolmogorov-Smirnov tests comparing length distributions of coho salmon marked (M) in the marking events, recaptured (R) in the recapture event, and captured in the recapture event (C), 1999 through 2003.

	Year				
Statistic	1999[b]	2000	2001	2002	2003
Test Between Coho Salmon Marked (M) and Recaptured (R)					
Marked Fish (M)					
Number	427	3,355	2,604	6,506	2,456
Mean Length (mm)	574	692	654	671	642
Recaptured Fish(R)[c]					
Number	22	97	120	241	119
Mean Length (mm)	567	695	659	684	643
Test Statistics					
D_{max}	0.147	0	0	0.155	0.040
P-Value	0.738	0	0	<0.001	0.990
Significance	NS	NS	NS	S	NS
Test Between Coho Salmon Marked (M) and Captured (C)					
Marked Fish (M)					
Number	427	3,355	2,604	6,506	2,456
Mean Length (mm)	574	692	654	671	642
Captured Fish (C)[d]					
Number	377	390	564	714	457
Mean Length (mm)	571	680	666	689	654
Test Statistics					
D_{max}	0	0	0.097	0.176	0.115
P-Value	0	<0.001	<0.001	<0.001	<0.001
Significance	NS	S	S	S	S
Test Between Coho Salmon Recaptured (R) and Captured (C)[e]					
Recaptured Fish(R)[c]					
Number				241	
Mean Length (mm)				684	
Captured Fish (C)					
Number				714	
Mean Length (mm)				689	
Test Statistics					
D_{max}				0	
P-Value				0.436	
Significance				NS	

[a] Days (and associated length data) were culled from the beginning and end of the recapture event length dataset to synchronize the recapture data used in length comparison tests with the culled data used to produce final estimates, i.e., measured fish that were excluded from the dataset used to produce final estimates were also excluded from category "C" in length comparisons.

[b] Capture length (measured in the marking event) was substituted for missing lengths of recaptured fish and for 5 cases where a suspected transcription error resulted in capture and recapture lengths that differed by 100mm or more.

[c] In 1999, lengths measured were mid-eye to tail-fork. In all other years, lengths measured were fork lengths.

[d] Those fish that were captured in the recapture event, measured, and not culled from the dataset used to generate abundance estimates.

[e] A third comparison (between R and C) was required for the year 2002 based on the combination of results from the other two tests.

Table 21.–Significance of statistical tests of primary assumptions for unbiased abundance estimates from a pooled Petersen estimator, conclusions about capture probabilities drawn from size independent and size-dependent (selectivity) tests, and abundance models selected in five annual mark-recapture experiments to estimate the abundance of coho salmon in the Kenai River, 1999 through 2003.

	Size-Independent Capture Probability Tests			Size Selectivity KS Tests				
Year	Equal Propotions Test	Mixing Test	Differential P (Capture)[a]	M-R	M-C	R-C	Differential P(Capture)[a] by Size	Model Selected[b]
1999	NS	NS	None	NS	NS	[b]	None	Pooled Petersen
2000	S	NS	In Marking Event Only	NS	S	[b]	In Marking Event Only	Pooled Petersen
2001	S	S	In Both Events	NS	S	[b]	In Marking Event Only	ML Darroch
2002	S	S	In Both Events	S	S	NS	In Recapture Event Only	ML Darroch
2003	S	S	In Both Events	NS	S	[b]	In Marking Event Only	ML Darroch

[a] P(Capture) means "probability of capture."
[b] Test unnecessary based on combination of other test results.

Table 22.–Summary of mark release and recovery data used to estimate abundance of coho salmon in the Kenai River with the pooled Petersen Model, 1999 and 2000.

Year	Mark Release Stratum	Recapture Stratum	Total Number Marked	p[a]	Adjusted Number Marked	Number Examined In Recapture Reach	Number of Marked Fish Recaptured by Recapture Stratum
1999	8/06 - 9/30	8/12 - 10/06	429	0.591	253.5	2,060	22
2000	8/01 - 10/6	8/05 - 10/10	3,385	0.848	2,870.5	3,080	98

[a] Estimated proportion of tagged fish surviving and sustaining upstream migration after marking (from Table 17).

Table 23.–Mark release and recovery data and temporal stratification schemes used in five annual mark-recapture experiments to estimate the abundance of coho salmon in the Kenai River, 2001.

Mark Release Stratum	Total Number Marked	Adjusted Number Marked[a]	Number of Marked Fish Recaptured by Recapture Stratum									
			8/5-8/8	8/9-8/15	8/16-8/22	8/23-8/29	8/30-9/ 5	9/6-9/12	9/13-9/19	9/20-9/26	9/27-10/3	Total
8/2- 8/8	116	93	1	2								3
8/9-8/15	308	247		3	4	3						10
8/16-8/22	668	536			5	13	2		1			21
8/23-9/5	992	796				6	25	8	3	2		44
9/6-9/12	198	159						8	9			17
9/13-9/19	123	99							5	7		12
9/20-9/26	196	157								5		5
9/27-9/30	66	53									9	9
Total	2,667	2,139	1	5	9	22	27	16	18	14	9	121
Number Examined			69	689	791	881	526	424	445	414	335	4,574

Table 24.–Mark release and recovery data and temporal stratification schemes used in five annual mark-recapture experiments to estimate the abundance of coho salmon in the Kenai River, 2002.

Mark Release Stratum	Total Number Marked	Adjusted Number Marked[a]	Number of Marked Fish Recaptured by Recapture Stratum						
			8/6-8/15	8/16-8/29	8/30-9/12	9/13-9/19	9/20-9/26	9/27-10/4	Total
8/2-8/15	341	292	4	1					5
8/16-8/29	1,960	1,678		23	13	4	2		42
8/30-9/12	1,929	1,651			41	18	3		62
9/13-9/19	1,192	1,020				38	34	4	76
9/20-9/26	948	811					24	25	49
9/27-9/30	170	146						7	7
Total	6,540	5,598	4	24	54	60	63	36	241
Number Examined			505	1,123	939	961	1,080	528	5,136

Table 25.–Mark release and recovery data and temporal stratification schemes used in five annual mark-recapture experiments to estimate the abundance of coho salmon in the Kenai River, 2003.

Mark Release Stratum	Total Number Marked	Adjusted Number Marked[a]	Number of Marked Fish Recaptured by Recapture Stratum					
			8/8-8/24	8/25-8/31	9/1-9/14	9/15-9/21	9/22-10/4	Total
8/4-8/24	1,565	1,444	38	22	4	2		66
8/25-9/7	747	689		20	26	3		49
9/8-9/14	80	74			2	1		3
9/15-10/4	70	65					1	1
Total	2,462	2,272	38	42	32	6	1	119
Number Examined			1,062	708	803	385	521	3,479

Note: Days (and data) were culled from the beginning of each year's initial recapture stratum (when necessary) to account for the time required for marked fish to migrate into the recapture reach and become vulnerable to recapture gear. Likewise, days (and data) were culled from the end of the final recapture stratum to account for brief periods during which no marked fish were recovered and were not likely to be recovered because of presumed upstream migration and exit from the recapture reach.

[a] Estimated proportion of tagged fish surviving and sustaining upstream migration after marking (from Table 22).

Table 26.–Estimated abundance of coho salmon in the Kenai River during selected time intervals, 1999 through 2003, with estimates of escapement.

	Estimate	Estimate	Total Abundance at Fish Wheels		Capture/Tagging Mortality		Discounted	Live Abundance		Upstream Sport Harvest[e,f]		Escapement	
Year[a]	Type	Interval[b]	Estimate	SE	Estimate[c]	SE	Fish Count[d]	Estimate	SE	Estimate	SE	Estimate	SE
1999	Pooled Petersen	8/ 6 - 9/30	23,001	5,154	175	18	18	22,808	5,157	15,112	1,171	7,696	5,288
2000	Pooled Petersen	8/ 1 - 10/ 6	89,918	9,295	515	93	40	89,363	9,322	16,621	1,165	72,742	9,395
2001	ML Darroch	8/ 2 - 9/30	93,524	16,502	528	88	12	92,984	16,502	17,862	1,540	75,122	16,574
2002	ML Darroch	8/ 2 - 9/30	156,960	20,256	942	235	26	155,992	20,255	22,380	1,442	133,612	20,306
2003	ML Darroch	8/ 4 - 9/30	99,309	36,085	190	74	19	99,100	36,085	19,185	1,372	79,915	36,111

[a] Estimates of abundance pertain to the riverkilometer 31 capture location in 1999 and riverkilometer 45 in 2000-2003.

[b] Estimates of abundance pertain to this temporal interval.

[c] Estimated number of all tagged fish that did not migrate upstream into the recapture reach based on fates of radio-tagged fish (=M(1-p^)).

[d] Atypically injured/stressed fish or adipose finclipped sacrificed fish (from Appendices A3, B3, C3, D3, and E3) ; these fish were excluded from model data.

[e] Source: Statewide harvest Survey. Sport harvest occurring upstream from the locations to which the abundance estimates pertain (in 1999, sum of SWHS estimates upstream of Soldotna Bridge including Skilak Lake, Hidden Lake, and Russian River; in 2000-2003, 1/2 of the SWHS estimate for the river section between the Soldotna Bridge and the Moose River confluence plus all estimated harvest upstream from the Moose River including Skilak Lake, Hidden Lake, and Russian River).

[f] Source: Statewide Harvest Survey. In 2002 and 2003, an "unspecified river reach" category was added to the SWHS for the Kenai River. Prior to calculating the sport harvest upstream from river kilometer 45, the estimates for this unspecified category were apportioned among the four specified mainstem river reaches based on the proportion of the total mainstem harvest represented by the reach-specific harvest reported (standard errors were recalculated according to standard procedures).

Table 27.–Estimates of total return, exploitation, and marine survival for coho salmon from the Kenai River, 1999 through 2003.

	Year				
Estimate	1999	2000	2001	2002	2003
Abundance at Fish Wheels[a]	23,001	89,918	93,524	156,960	99,309
SE	5,154	9,295	16,502	20,256	36,085
Downstream Sport Harvest[b,c]	20,442	35,868	37,142	43,724	32,759
SE	1,454	1,740	1,878	2,516	1,908
Personal Use Harvest	1,009	1,449	1,555	1,721	1,332
SE	108	62	105	96	68
Commercial Harvest[d]	3,894	2,965	1,934	6,115	2,578
SE	326	255	176	499	263
Total Run	48,346	130,200	134,155	208,520	135,978
SE	5,366	9,460	16,610	20,418	36,137
Total Harvest[e]	40,457	56,903	58,493	73,940	55,854
SE	1,898	2,110	2,438	2,934	2,366
Exploitation Rate[f]	0.837	0.437	0.436	0.355	0.411
SE	0.101	0.036	0.057	0.037	0.110
Smolt Abundance in Prior Year[d]	799,687	578,355	601,236	641,693	626,335
SE	42,111	19,884	25,454	14,436	27,409
Marine Survival	0.060	0.225	0.223	0.325	0.217
SE	0.007	0.018	0.029	0.033	0.058

[a] Repeated from Table 28 for convenience.

[b] Source: Statewide Harvest Survey. Sport harvest occurring downstream from the locations to which the abundance estimates pertain (in 1999, sum of SWHS estimates downstream of Soldotna Bridge; in 2000-2003, 1/2 of the SWHS estimate for the river section between the Soldotna Bridge and the Moose River confluence plus all estimated sport harvest downstream from Soldotna Bridge).

[c] Source: Statewide Harvest Survey. In 2002 and 2003, an "unspecified river reach" category was added to the SWHS for the Kenai River. Prior to calculating the sport harvest downstream from river kilometer 45, the estimates for this category were apportioned among the four specified mainstem river reaches based on the proportion of the total mainstem harvest represented by the reach-specific harvest reported (standard errors were recalculated according to standard procedures).

[d] Sources: 1999-Massengill 2007; 2000 and 2001-Massengill and Carlon 2004 *a* and *b*; 2002 and 2003-Massengill and Carlon 2007 *a* and *b*.

[e] Aggregate of all harvest estimates from Tables 28 and 29 (sport, commercial, and personal-use/subsistence); repeated for convenience.

[f] (Estimated Grand Total Harvest) / (Estimated Total Return).

Table 28.–Relationship between the natural logarithm transformation of season-wide, cumulative daily coho salmon catch-per-hour by two fish wheels and mark-recapture point estimates of inriver coho salmon abundance, Kenai River, 1999 through 2003.

Year	Cumulative Fish Wheel Catch Rate Units	ln(Catch Rate)	Estimated Abundance
1999	15.89	2.77	23,001
2000	147.88	5.00	89,918
2001	96.83	4.57	93,524
2002	439.61	6.09	156,960
2003	109.15	4.69	99,309
Average	161.87		

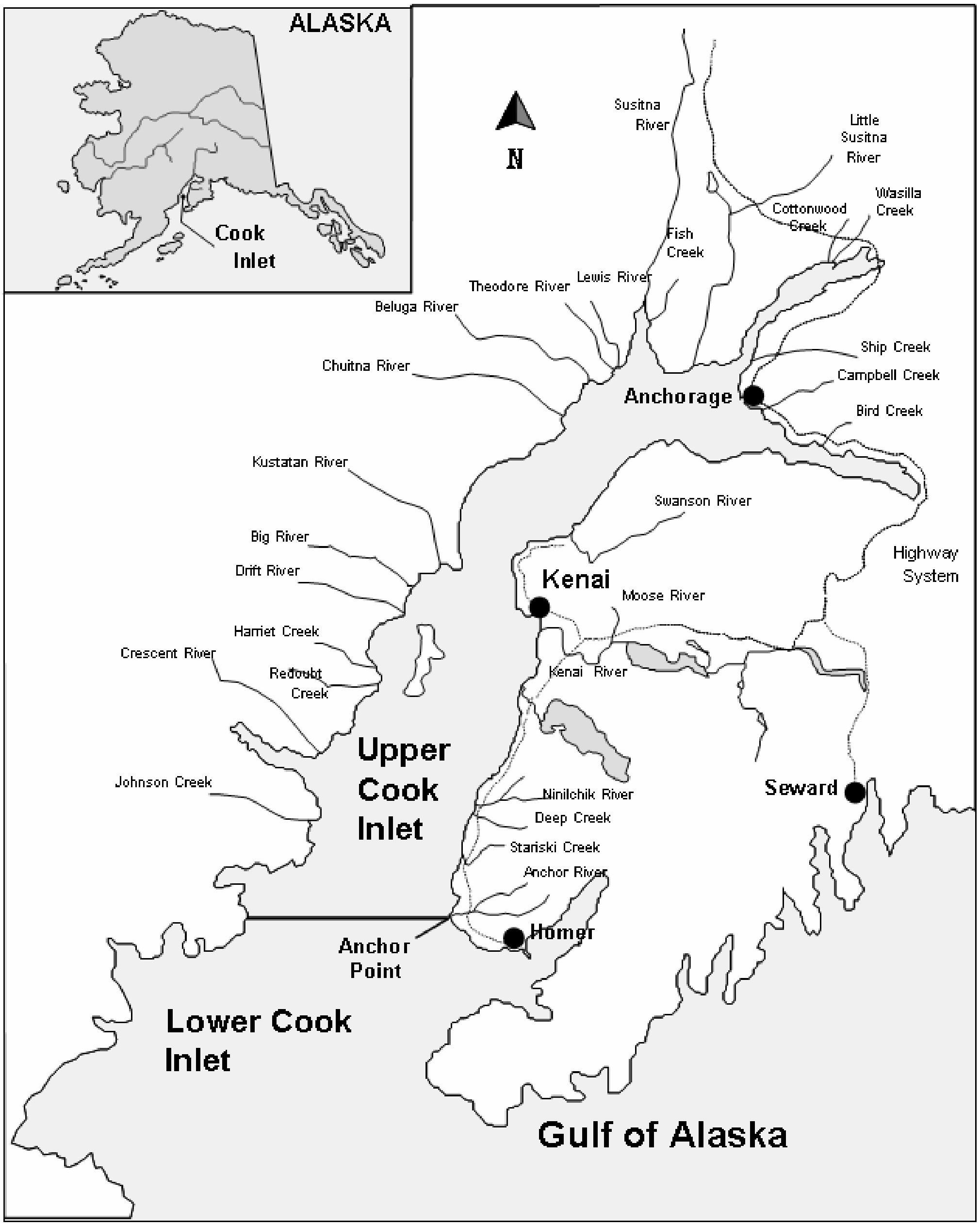
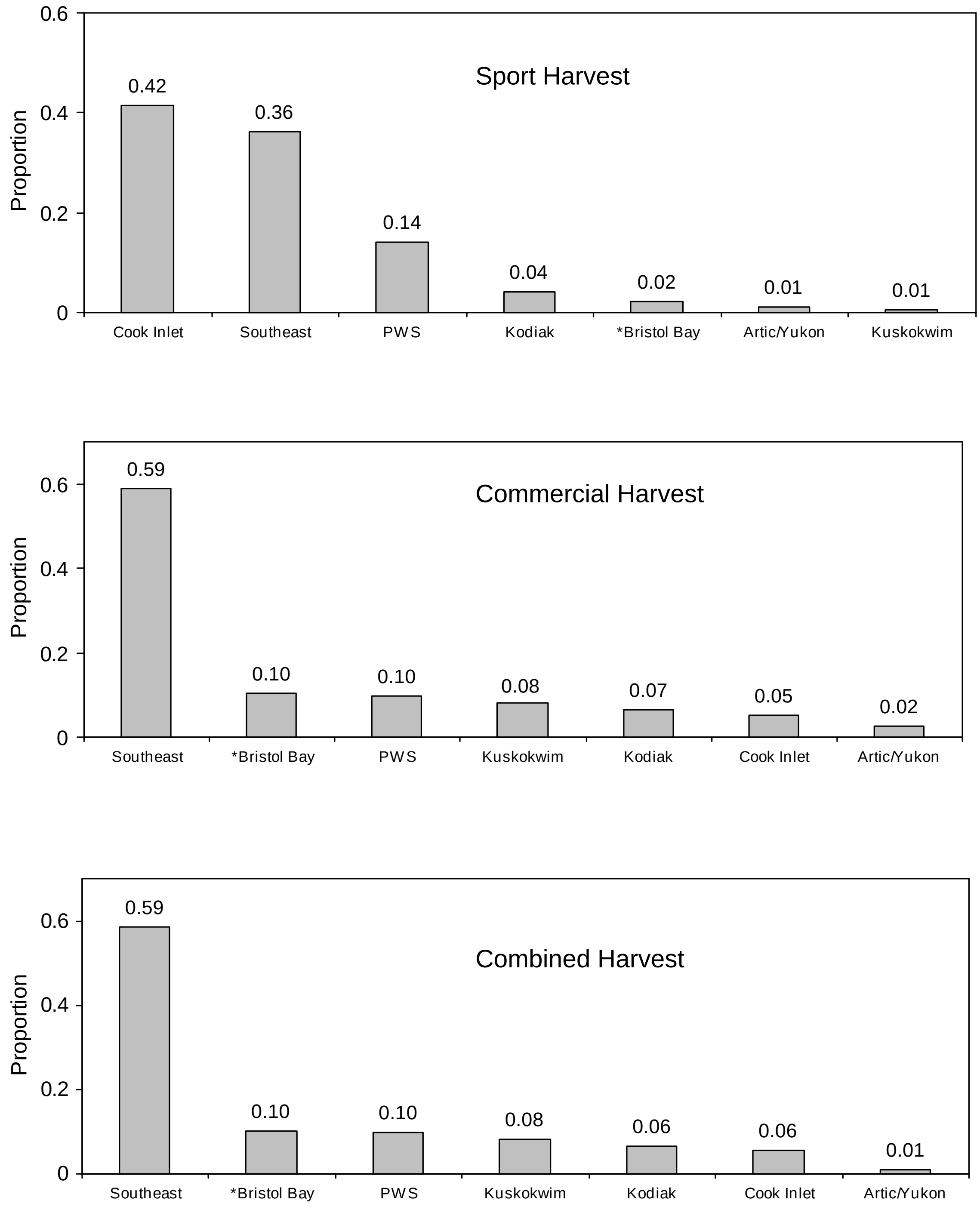


Figure 1.–Schematic map of the Cook Inlet Basin with selected tributaries known to support coho salmon.



* Denotes combined Bristol Bay and Alaska Peninsula geographical areas.

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

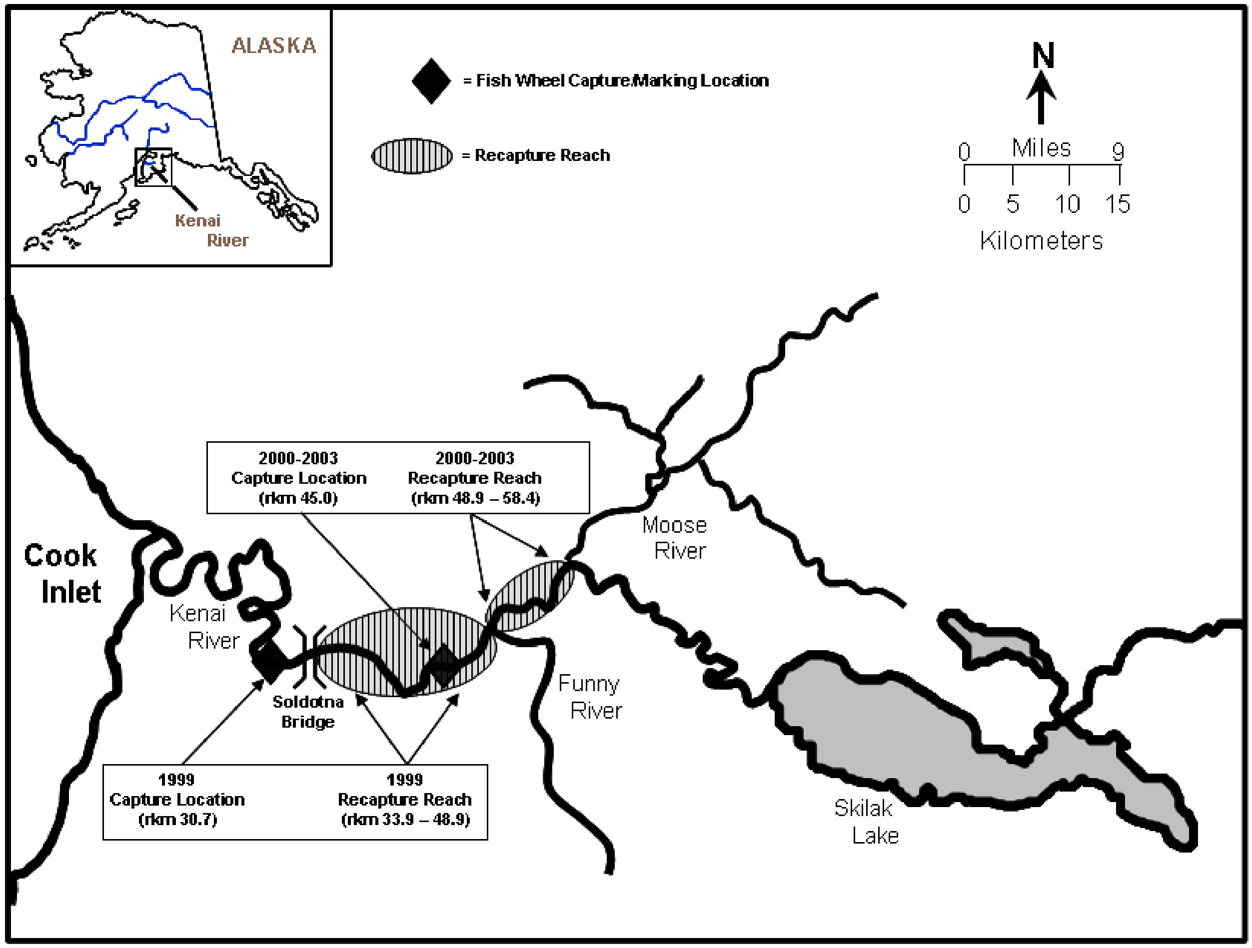


Figure 3.–Schematic map of the Kenai River with capture (marking) and recapture locations used in mark-recapture experiments to estimate the abundance of adult coho salmon, 1999 through 2003.

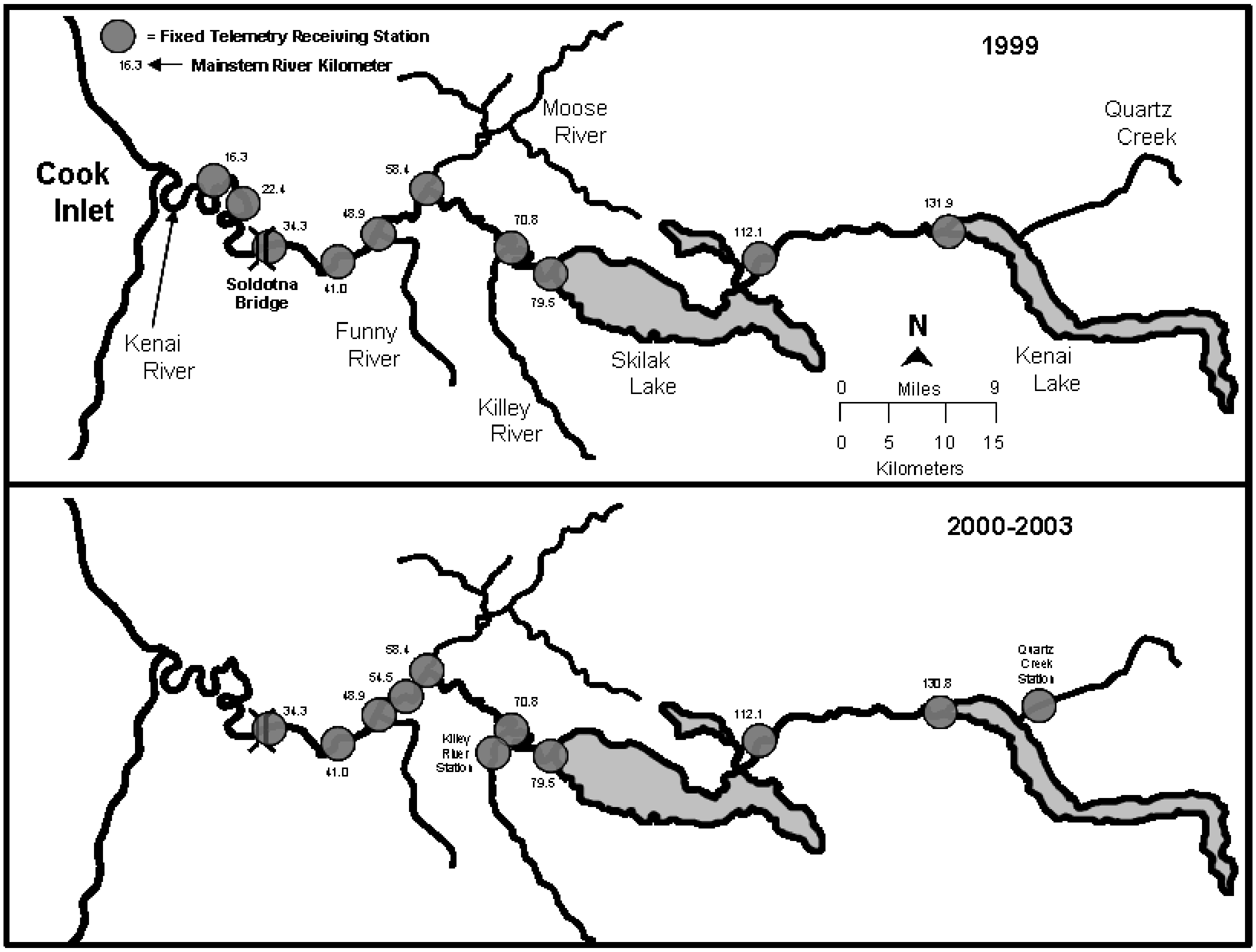


Figure 4.–Schematic map of the Kenai River and fixed telemetry receiving stations installed to detect passage of radio-tagged coho salmon adults in 1999 (top) and 2000-2003 (bottom) mark-recapture experiments to estimate adult abundance (tributary sites were used only in 2003, no sites were installed upstream from rkm 79.5 in 2000, and none were installed upstream from rkm 70.8 in 2001 and 2002).

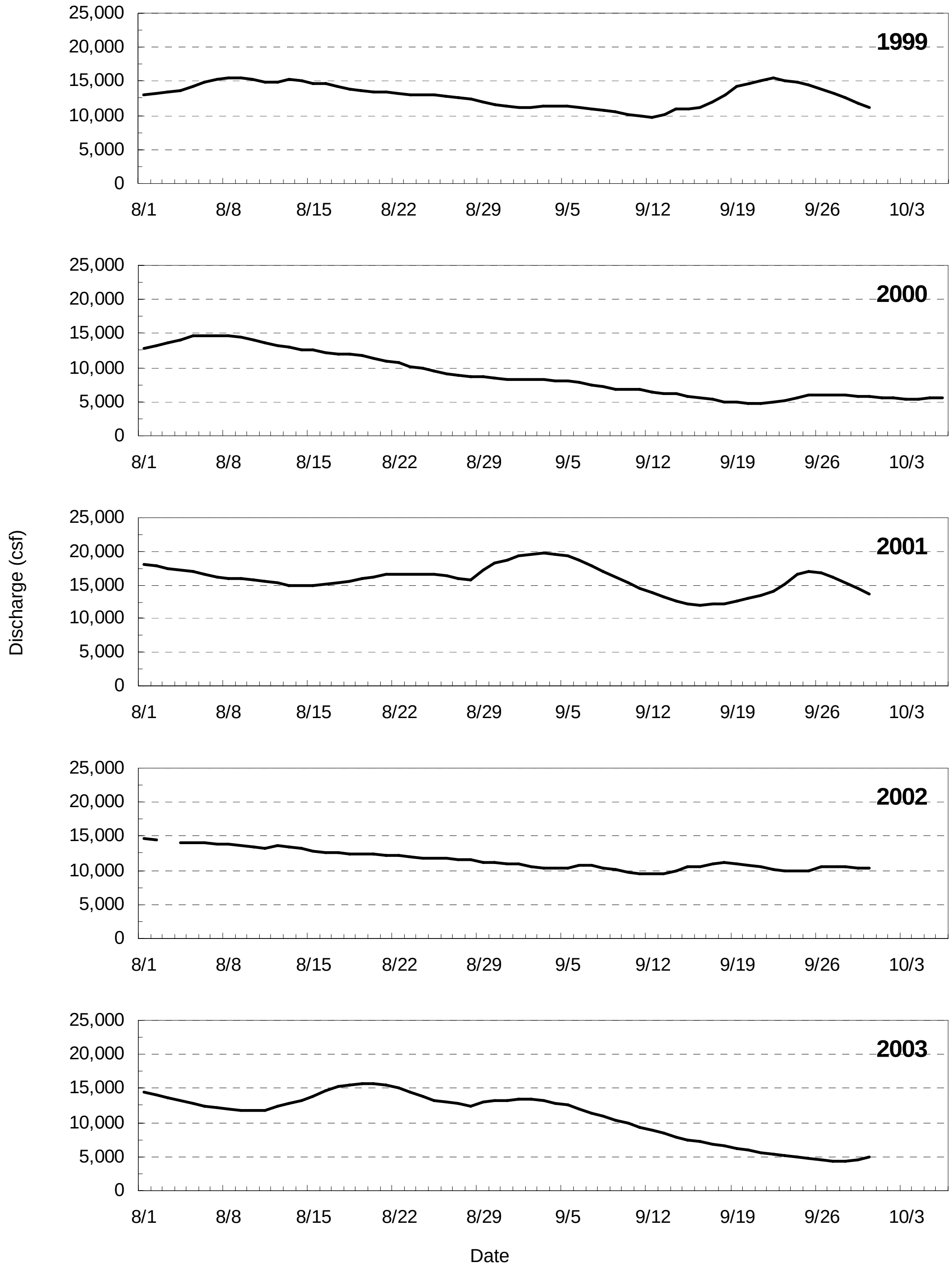
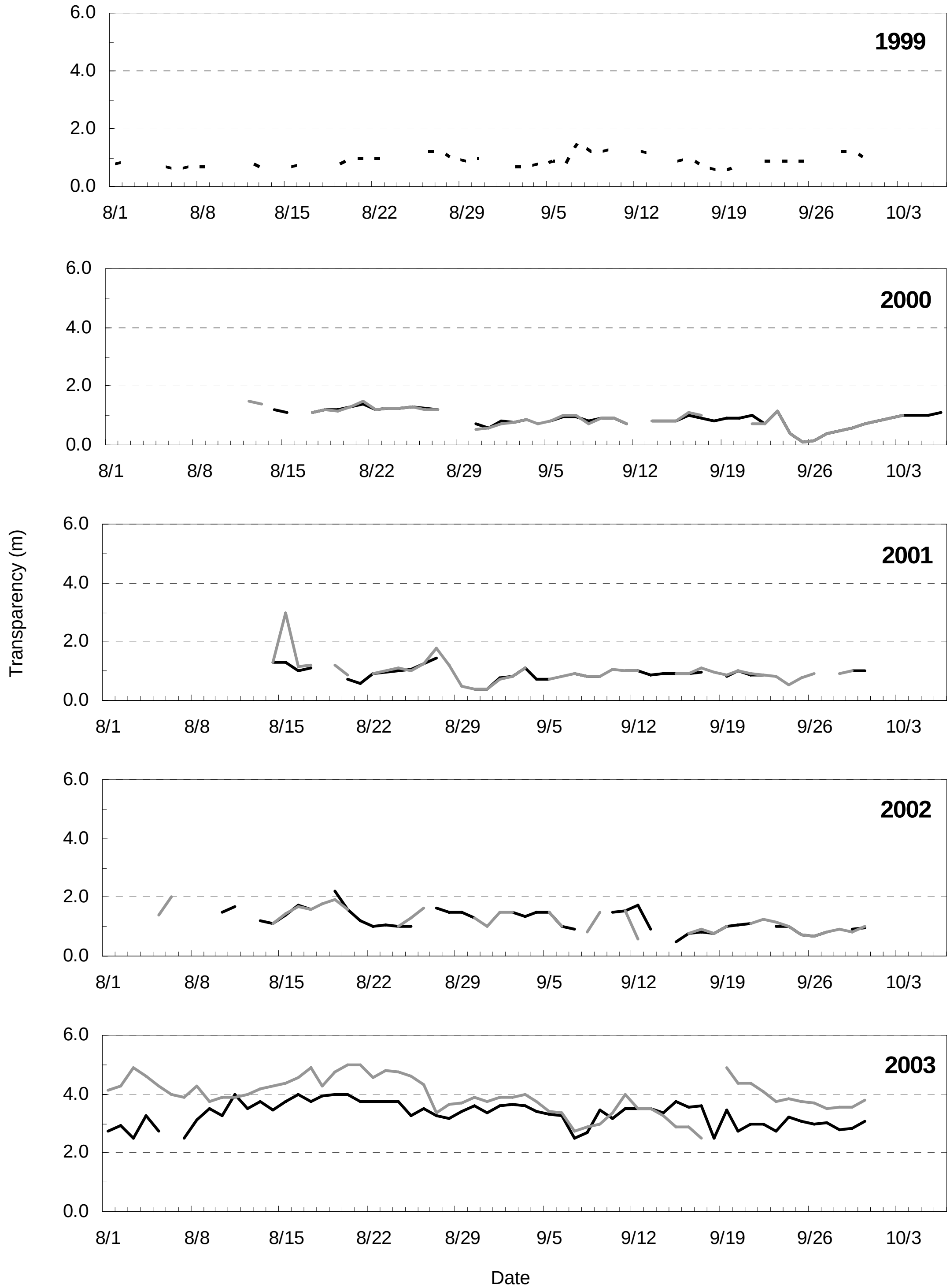


Figure 5.-River discharge (CFS) as measured at the Kenai River bridge at Soldotna (United States Geological Survey River Gaging Station Site 15266300) near river kilometer 45 of the Kenai River, Alaska, 1999-2003.



Note: Gray lines are south bank, black lines are north bank. Bank was unspecified in 1999.

Figure 6.-Water transparency (m) measured by Secci disk near the fish wheels, Kenai River, 1999-2003.

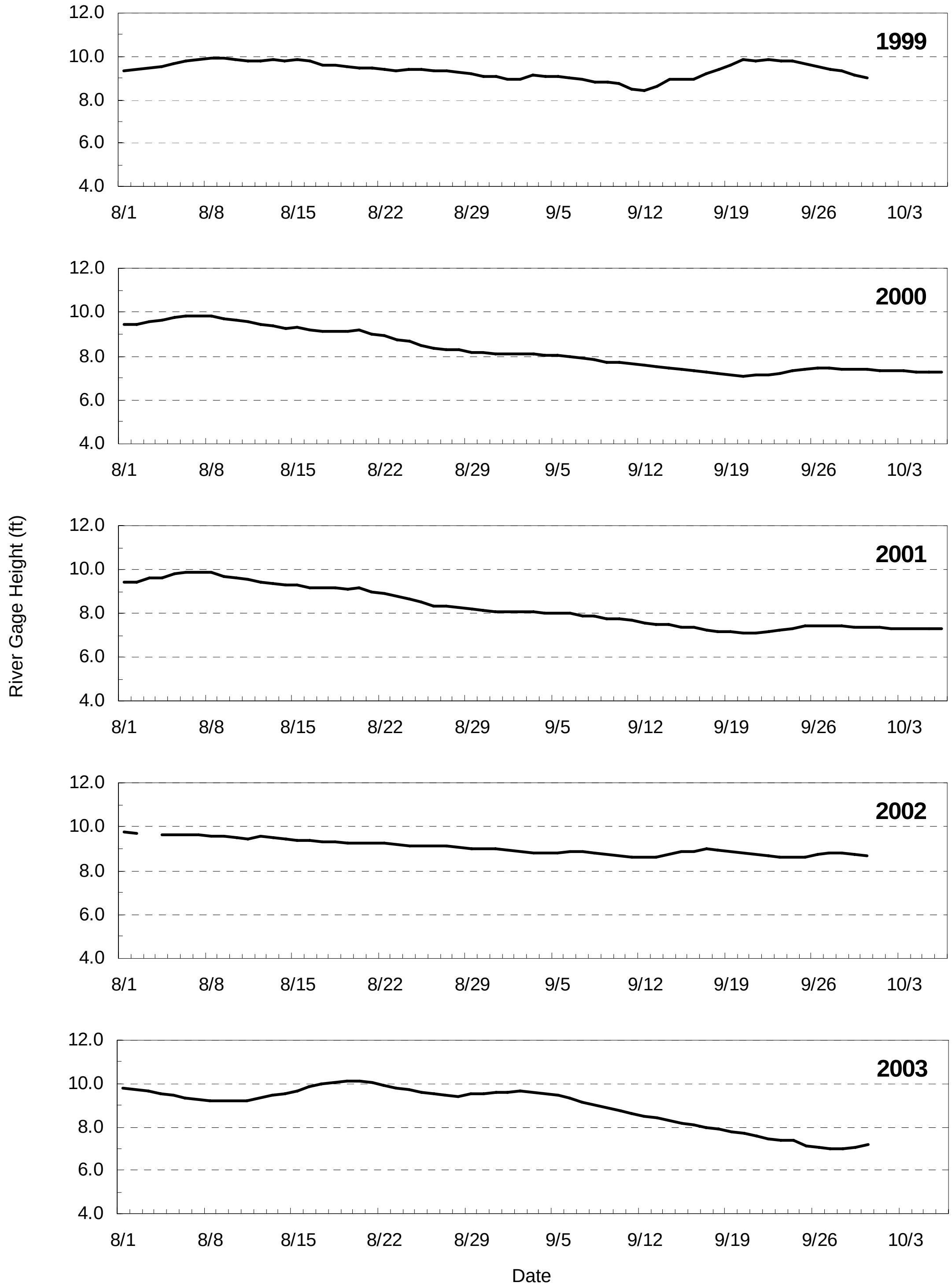


Figure 7.-River gage height (ft) as measured at the Kenai River bridge at Soldotna (United States Geological Survey River Gaging Station Site 15266300), 1999-2003.

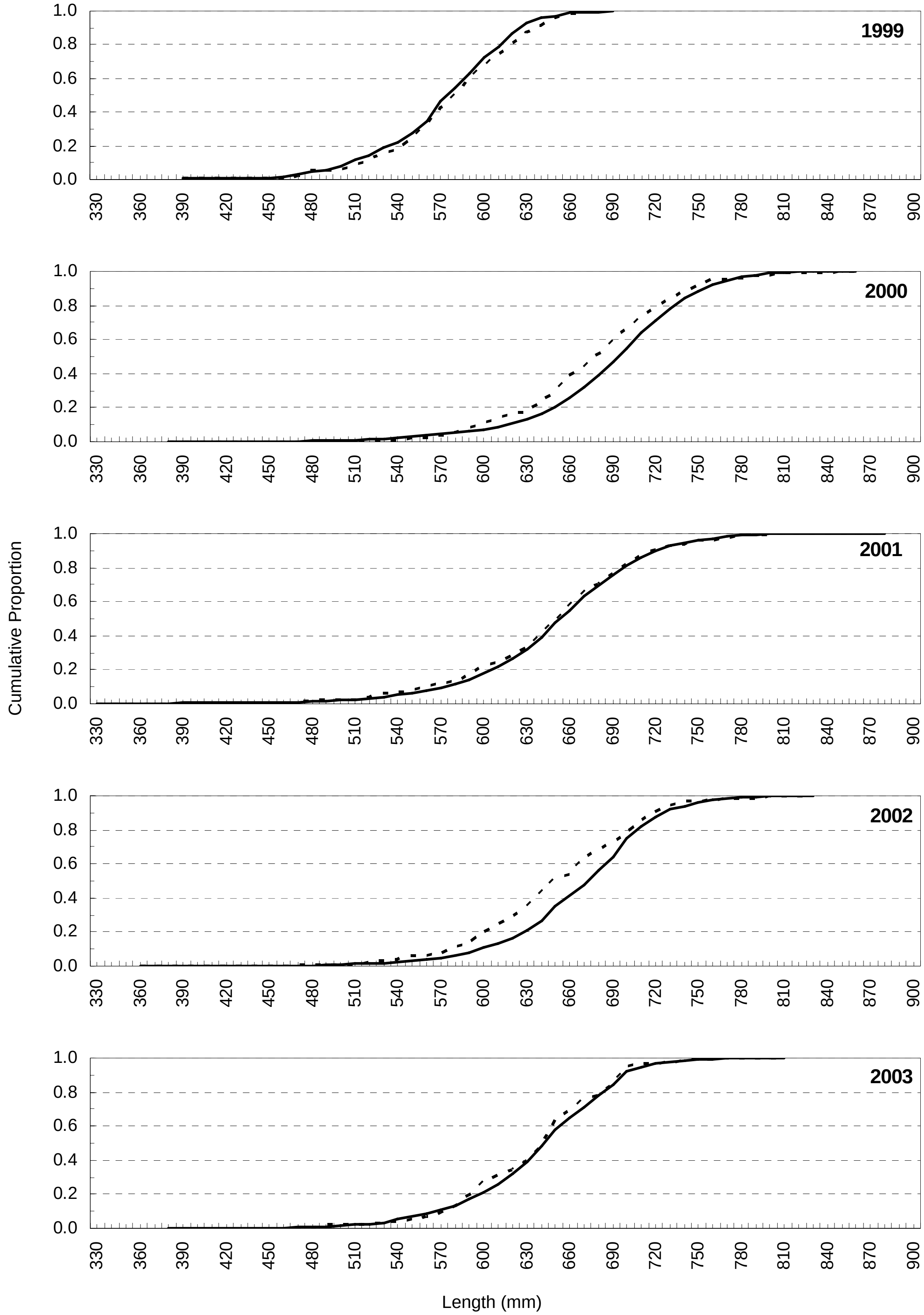


Figure 8.-Comparisons of cumulative length frequency distributions between coho salmon marked with radio tags (dashed lines) and those marked with spaghetti tags (solid lines) in the marking event, 1999-2003.

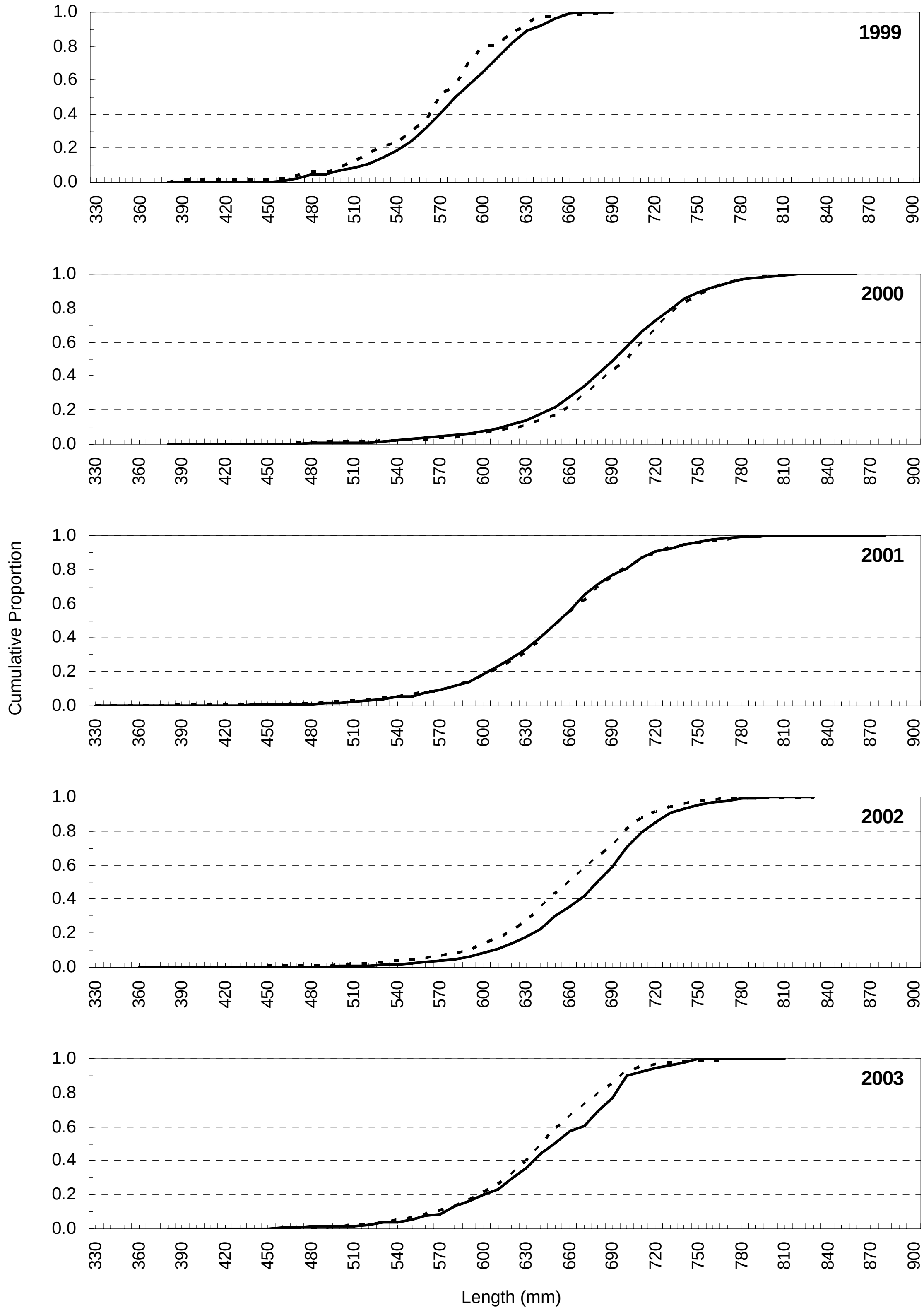


Figure 9.-Comparisons of cumulative length frequency distributions between coho salmon captured by fish wheels adjacent to the north (solid lines) and south (dashed lines) banks of the Kenai River in the marking event, 1999 through 2003.

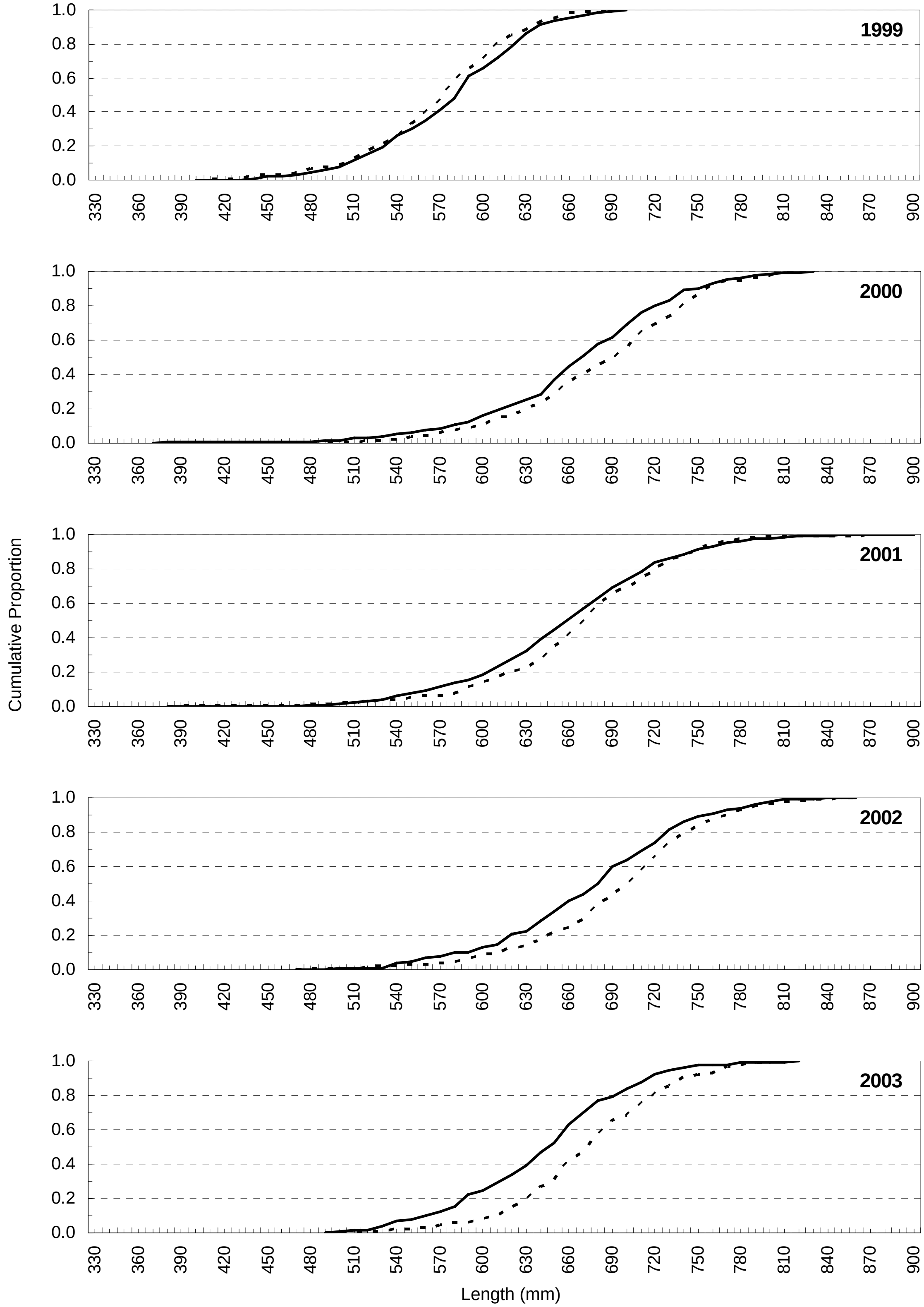


Figure 10.-Comparisons of cumulative length frequency distributions between coho salmon captured adjacent to the north and south banks of the Kenai River in the recapture events, 1999-2003.

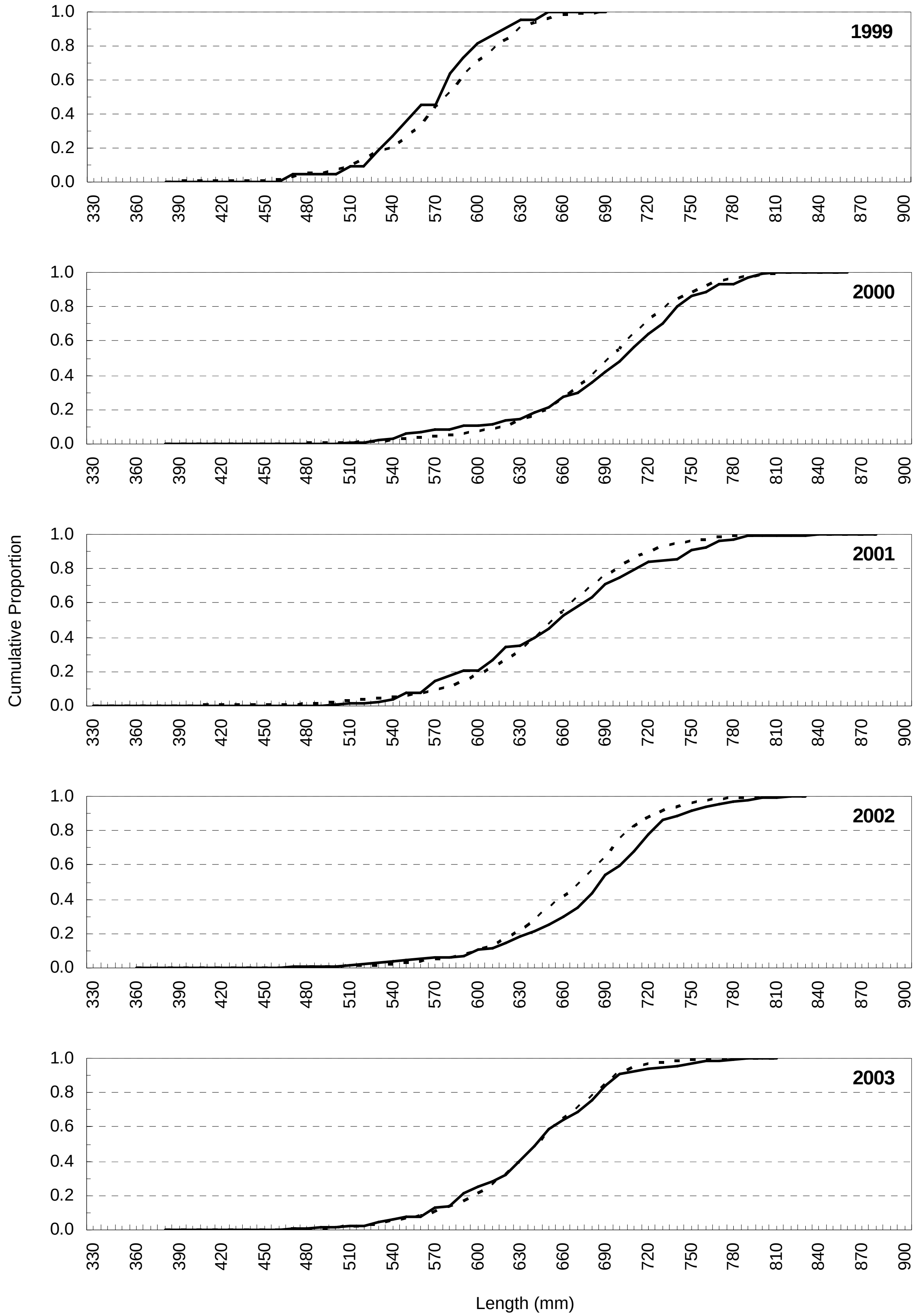


Figure 11.-Comparisons of cumulative relative length frequency distributions between coho salmon marked (dashed lines) and those recaptured (solid lines) in the Kenai River, 1999 through 2003.

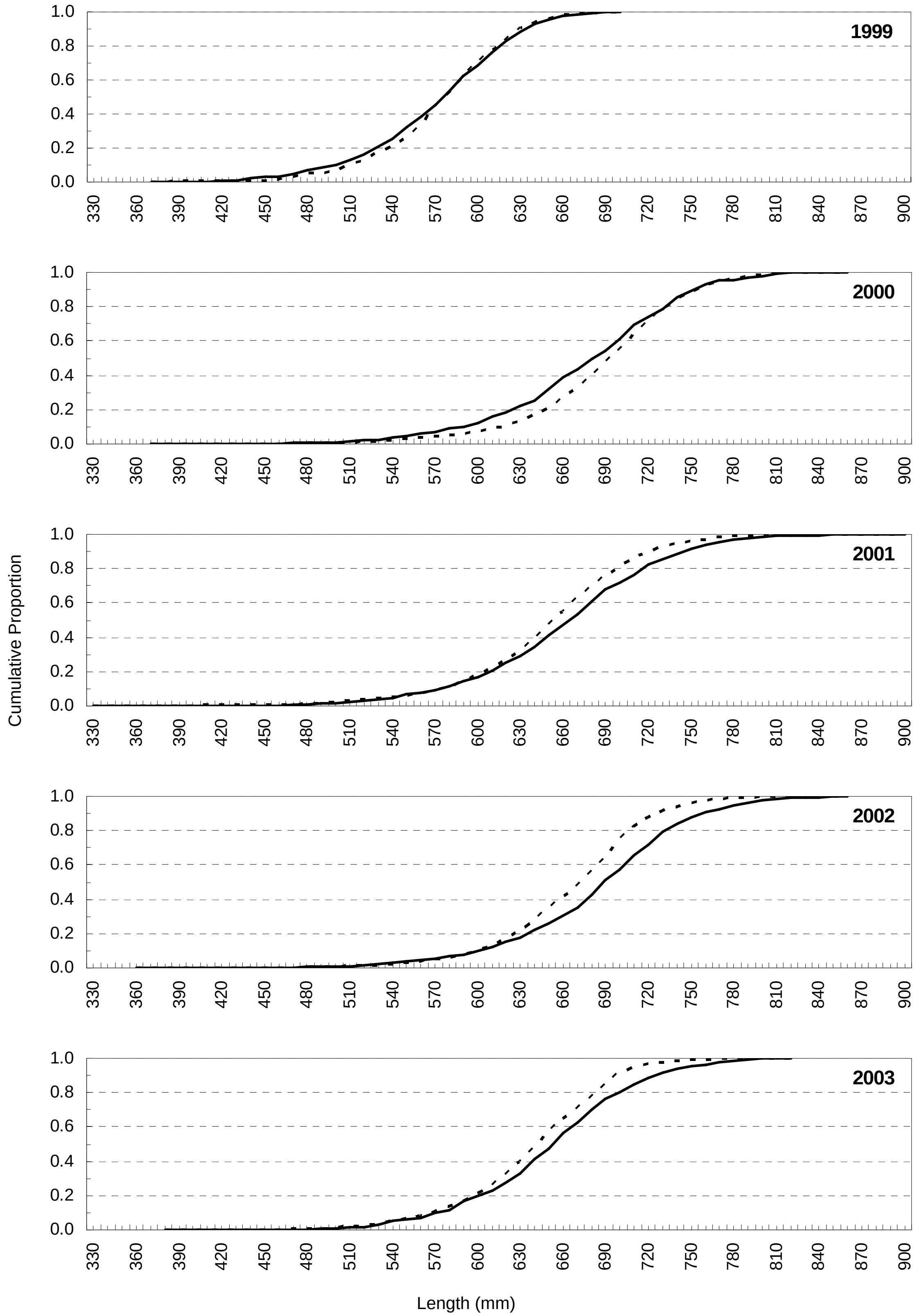


Figure 12.-Comparisons of cumulative length frequency distributions between coho salmon marked and those captured in the recapture event in the Kenai River, 1999-2003.

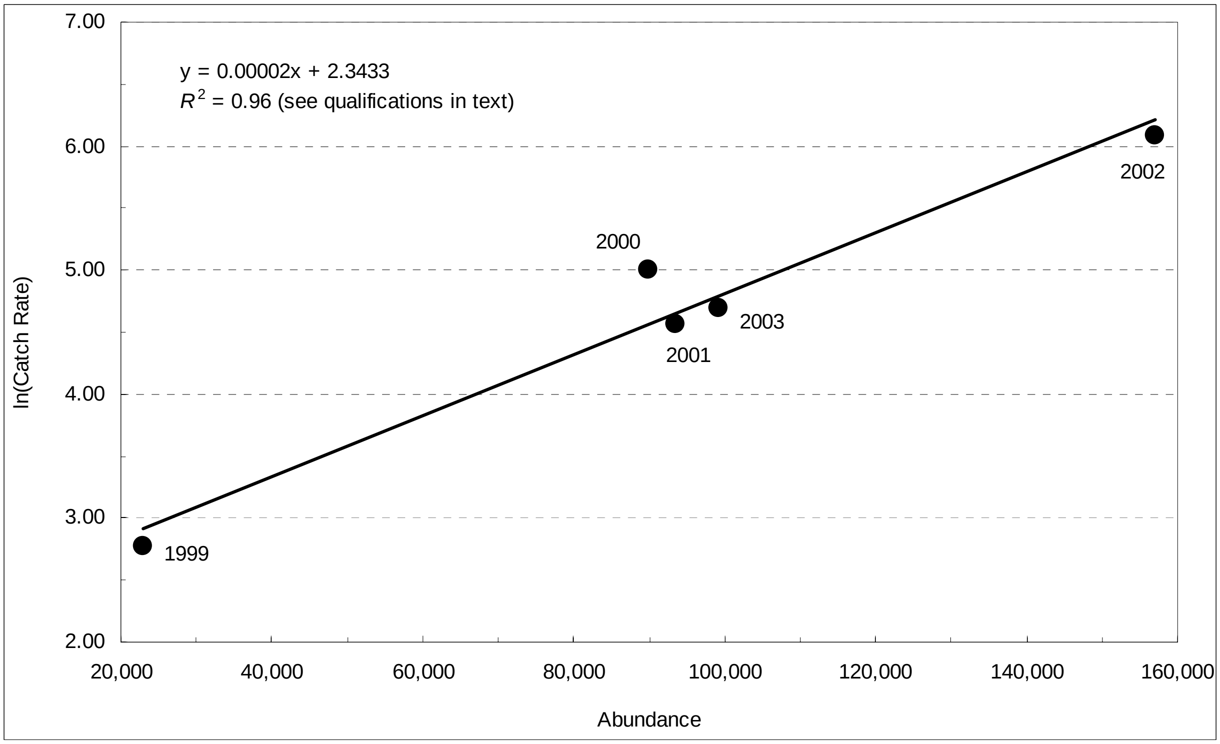


Figure 13.-Relationship between the natural logarithm transformation of season-wide, cumulative daily coho salmon catch-per-hour by two fish wheels and mark-recapture point estimates of inriver coho salmon abundance, Kenai River, 1999-2003.

APPENDIX A

Appendix A1.–Standard Kolmogorov-Smirnov (K-S) test combinations and procedures for alleviating bias due to gear selectivity.

	Result of first K-S test[a]	Result of second K-S test[b]
Case I[c]	Fail to reject H° Inferred cause: There is no size-selectivity during either sampling event.	Fail to reject H°
Case II[d]	Fail to reject H° Inferred cause: There is no size-selectivity during the second sampling event, but there is during the first sampling event.	Reject H°
Case III[e]	Reject H° Inferred cause: There is size-selectivity during both sampling events.	Fail to reject H°
Case IV[f]	Reject H° Inferred cause: There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.	Reject H°

[a] The first K-S test compares lengths of fish marked during the first event (fish comprising model parameter "M") with lengths of fish recaptured during the second event (fish comprising model parameter "R"). H° for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish recaptured during the second event.

[b] The second K-S test compares lengths of fish marked during the first event with lengths of fish captured during the second event (fish comprising model parameter "C"). H° for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish sampled during the second event.

[c] Case I: Calculate one unstratified abundance estimate, and pool lengths and ages from both sampling event for size and age composition estimates.

[d] Case II: Calculate one unstratified abundance estimate, and only use lengths and ages from the second sampling event to estimate size and age composition.

[e] Case III: Completely stratify both sampling events by length and estimate abundance for each length stratum. Add abundance estimates across strata. Pool lengths and ages from both sampling events and adjust composition estimates for differential capture probabilities.

[f] Case IV: Apply a third K-S test comparing lengths of fish recaptured (fish comprising model parameter "R") with all fish captured and measured in the recapture event (fish comprising model parameter "C") to determine if there is length selectivity in the first event. H° for this third test is: The distribution of lengths of fish recaptured is the same as the distribution of lengths of fish sampled during the second event. Under a Case IV scenario, failure to reject the hypothesis of this third comparison implies no selectivity during the first event; calculate one unstratified abundance estimate and pool lengths and ages from the first sampling event for size and age composition estimates. Rejection of the hypothesis requires that two abundance estimates be produced and compared. First, calculate one unstratfied abundance estimate. Second, completely stratify both sampling events by length, estimate abundance for each length stratum, and add estimates across strata. If the unstratified and stratified estimates are similar, choose the unstratified estimate for it's superior precision. If the estimates are dissimilar, assume bias in the unstratified estimate and choose the stratified estimate for its superior accuracy. For either outcome, estimate length and age compositions from the second event and adjust these estimates for differential capture probabilities.

APPENDIX B

Appendix B1.–List of data files collected among five annual mark-recapture experiments to estimate the abundance of coho salmon in the Kenai River, 1999 through 2003.

Year	Type	FileName	File Description	DataMap File
1999	Raw Data	Capture1999.csv	All marking event data collected in 1999.	Capture1999_map.csv
	Raw Data	Recapture1999.csv	Recapture event data collected in 1999.	Recapture1999_map.csv
	Raw Data	FixedStation1999.csv	All radio telemetry data collected by automated stations in 1999.	FixedStation1999_map.csv
	Raw Data	RadioTracking1999.csv	All radio telemetry data collected by mobile tracking efforts in 1999.	RadioTracking1999_map.csv
	Raw Data	MiscRecovery1999.csv	All recoveries of fish marked in 1999 by methods other than the experimental recapture effort (angler returns, weirs, etc.)	MiscRecovery1999_map.csv
	Post-Processed	CTH1999.csv	Comprehensive tag histories ("CTH") for each mark released in 1999 (chronology of all records collected for each mark)	CTH1999_map.csv
	Post-Processed	FishHistory1999.csv	Necessary and sufficient subset of 1999 data for abundance estimation process.	FishHistory1999_map.csv
2000	Raw Data	Capture2000.csv	All marking event data collected in 2000.	Capture2000_map.csv
	Raw Data	Recapture2000.csv	Recapture event data collected in 2000.	Recapture2000_map.csv
	Raw Data	FixedStation2000.csv	All radio telemetry data collected by automated stations in 2000.	FixedStation2000_map.csv
	Raw Data	RadioTracking2000.csv	All radio telemetry data collected by mobile tracking efforts in 2000.	RadioTracking2000_map.csv
	Raw Data	MiscRecovery2000.csv	All recoveries of fish marked in 2000 by methods other than the experimental recapture effort (angler returns, weirs, etc.)	MiscRecovery2000_map.csv
	Post-Processed	CTH2000.csv	Comprehensive tag histories ("CTH") for each mark released in 2000 (chronology of all records collected for each mark)	CTH2000_map.csv
	Post-Processed	FishHistory2000.csv	Necessary and sufficient subset of 2000 data for abundance estimation process.	FishHistory2000_map.csv
2001	Raw Data	Capture2001.csv	All marking event data collected in 2001.	Capture2001_map.csv
	Raw Data	Recapture2001.csv	Recapture event data collected in 2001.	Recapture2001_map.csv
	Raw Data	FixedStation2001.csv	All radio telemetry data collected by automated stations in 2001.	FixedStation2001_map.csv
	Raw Data	RadioTracking2001.csv	All radio telemetry data collected by mobile tracking efforts in 2001.	RadioTracking2001_map.csv
	Raw Data	MiscRecovery2001.csv	All recoveries of fish marked in 2001 by methods other than the experimental recapture effort (angler returns, weirs, etc.)	MiscRecovery2001_map.csv
	Post-Processed	CTH2001.csv	Comprehensive tag histories ("CTH") for each mark released in 2001 (chronology of all records collected for each mark)	CTH2001_map.csv
	Post-Processed	FishHistory2001.csv	Necessary and sufficient subset of 2001 data for abundance estimation process.	FishHistory2001_map.csv
2002	Raw Data	Capture2002.csv	All marking event data collected in 2002.	Capture2002_map.csv
	Raw Data	Recapture2002.csv	Recapture event data collected in 2002.	Recapture2002_map.csv
	Raw Data	FixedStation2002.csv	All radio telemetry data collected by automated stations in 2002.	FixedStation2002_map.csv
	Raw Data	RadioTracking2002.csv	All radio telemetry data collected by mobile tracking efforts in 2002.	RadioTracking2002_map.csv
	Raw Data	MiscRecovery2002.csv	All recoveries of fish marked in 2002 by methods other than the experimental recapture effort (angler returns, weirs, etc.)	MiscRecovery2002_map.csv
	Post-Processed	CTH2002.csv	Comprehensive tag histories ("CTH") for each mark released in 2002 (chronology of all records collected for each mark)	CTH2002_map.csv
	Post-Processed	FishHistory2002.csv	Necessary and sufficient subset of 2002 data for abundance estimation process.	FishHistory2002_map.csv
2003	Raw Data	Capture2003.csv	All marking event data collected in 2003.	Capture2003_map.csv
	Raw Data	Recapture2003.csv	Recapture event data collected in 2003.	Recapture2003_map.csv
	Raw Data	FixedStation2003.csv	All radio telemetry data collected by automated stations in 2003.	FixedStation2003_map.csv
	Raw Data	RadioTracking2003.csv	All radio telemetry data collected by mobile tracking efforts in 2003.	RadioTracking2003_map.csv
	Raw Data	MiscRecovery2003.csv	All recoveries of fish marked in 2003 by methods other than the experimental recapture effort (angler returns, weirs, etc.)	MiscRecovery2003_map.csv
	Post-Processed	CTH2003.csv	Comprehensive tag histories ("CTH") for each mark released in 2003 (chronology of all records collected for each mark)	CTH2003_map.csv
	Post-Processed	FishHistory2003.csv	Necessary and sufficient subset of 2003 data for abundance estimation process.	FishHistory2003_map.csv

[a] All files are in ASCII comma delimited, dynamic field-width format (first row contains field names). All files are archived with an associated data map file. The data map files carry the same filename as the data files and a filename extension of ".dat." Data map files are in the same ASCII comma delimited format and contain a list of field descriptions (by field name and number) and descriptions of data values used in each field unless the values are self-explanatory.

[b] All files are archived in electronic format by the Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services Section in Anchorage, Alaska.

APPENDIX C

Appendix C1.–Catches of species other than coho salmon during the mark and recapture events, 1999-2003.

Year and Event	Sockeye	Chinook	Pink	Chum	Dolly Varden	Rainbow Trout	Steelhead	Whitefish	Longnose Sucker
Mark Events									
1999	8,214	110	188	1	141	54	2	13	
2000	3,169	33	82,953	4	140	33	1	1	
2001	3,412	23	115		216	96	1	1	
2002	3,226	33	64,001	7	220	33	4	4	
2003	4,524	110	10	2	78	75	9	3	
Recapture Events									
1999	1,126	263	27		179	208	3	5	2
2000	1,235	318	9,299		206	343	3	1	
2001	1,162	395	8		241	745	8	1	
2002	1,712	393	14,354	1	442	397	3	3	1
2003	1,861	828	4		248	1,304	24	1	1

APPENDIX D

Appendix D1.–Capture-recapture history of 98 tagged coho salmon recaptured between river kilometers 33.9 and 48.9 (recapture reach) of the Kenai River, Alaska, 1999.

Tag Type	Tag Number	Date and Time of Capture/Tagging[a]	Bank of Initial Capture/Tagging	Date and Time of Recapture	Recapture Bank	Days Between Tagging and Recapture
Radio	00001	08/11 21:00	N	08/17 14:58		5.8
Radio	00020	08/14 18:05	S	08/17 10:38		2.7
Radio	00037	08/15 17:50	N	08/25 17:35	N	10.0
Spaghetti	00033	08/16	N	08/24 16:19	N	
Radio	00044	08/16 10:00	S	08/19 19:26		3.4
Radio	00052	08/18 9:48	S	08/28 8:50	N	10.0
Spaghetti	00088	08/19	S	08/24 8:58	S	
Radio	00057	08/19 16:00	N	08/24 16:43	N	5.0
Radio	00060	08/20 16:55	S	08/27 9:18	S	6.7
Spaghetti	00144	08/23	S	08/30 12:59	S	
Spaghetti	00164	08/25	N	09/02 20:34	S	
Radio	00075	08/25 18:15	S	08/28 12:04	N	2.7
Radio	00076	08/26 10:03	S	09/01 12:59	N	6.1
Spaghetti	00175	08/27	N	09/01 19:28	S	
Radio	00084	08/28	S	09/02 11:11	N	
Spaghetti	00181	08/28 16:15	S	09/07 18:50	S	10.1
Radio	00091	08/30 17:10	N	09/10 12:19	S	10.8
Spaghetti	00192	08/31	N	09/02 10:40	S	
Radio	00126	09/14 18:08	N	09/25 9:45	S	10.7
Spaghetti	00240	09/21	N	09/23 22:00	N	
Radio	00172	09/26 23:50	N	09/29 21:50	N	2.9
Radio	00179	09/28 21:30	N	10/02 17:24	N	3.8
					Median Day	5.9

[a] Times were missing on several days; in these cases, days between initial capture and recapture was not calculated.

Appendix D2.–Capture-recapture history of 98 tagged coho salmon recaptured between river kilometers 48.9 and 58.4 (recapture reach) of the Kenai River, Alaska, 2000.

Tag Type	Tag Number	Date and Time of Capture/Tagging	Bank of Initial Capture/Tagging	Date and Time of Recapture	Recapture Bank	Days Between Tagging and Recapture
Spaghetti	00329	08/03 17:20	N	08/25 9:29	N	21.7
Spaghetti	00338	08/03 21:25	N	08/13 12:15	S	9.6
Spaghetti	00371	08/04 15:22	N	08/20 10:04	N	15.8
Radio	00218	08/06 8:25	N	08/11 19:30	S	5.5
Spaghetti	00483	08/08 11:34	N	08/12 12:50	N	4.1
Spaghetti	00494	08/08 21:31	S	08/12 11:07	N	3.6
Spaghetti	00500	08/09 10:35	N	08/17 12:49	N	8.1
Spaghetti	00503	08/09 12:25	N	09/03 10:56	N	24.9
Radio	00230	08/09 21:10	N	08/11 21:04	N	2.0
Spaghetti	00524	08/09 21:41	N	08/16 20:32	N	7.0
Spaghetti	00525	08/09 21:52	S	08/11 17:31	S	1.8
Spaghetti	00576	08/12 16:30	N	08/14 15:52	S	2.0
Spaghetti	00621	08/13	N	08/23 9:22	N	
Radio	00254	08/15 16:50	N	08/20 11:47	S	4.8
Spaghetti	00661	08/15 18:41	N	08/20 16:52	S	4.9
Spaghetti	00710	08/17 8:23	N	08/25 17:10	S	8.4
Spaghetti	00767	08/18 21:28	N	09/02 15:03	N	14.7
Spaghetti	00864	08/20 19:43	N	08/24 13:37	N	3.8
Spaghetti	00932	08/22 16:45	S	09/14 12:46	S	22.8
Spaghetti	00936	08/22 18:10	N	09/01 13:06	N	9.8
Spaghetti	00946	08/22 19:45	N	08/23 17:21	S	0.9
Spaghetti	01040	08/24 21:11	N	09/06 9:26	N	12.5
Spaghetti	01137	08/29 15:20	N	09/01 19:46	N	3.2
Spaghetti	01190	08/30 17:05	N	10/09 16:10	N	40.0
Spaghetti	01199	08/30 18:56	S	09/10 13:31	S	10.8
Spaghetti	01263	08/31 14:57	N	09/08 8:18	N	7.7
Spaghetti	01368	09/01 11:50	N	09/04 16:55	N	3.2
Spaghetti	01429	09/02 9:55	S	09/07 11:18	N	5.1
Spaghetti	01533	09/03 17:30	N	09/05 11:45	N	1.8
Spaghetti	01537	09/03 18:01	S	09/14 11:52	S	10.7
Spaghetti	01538	09/03 18:03	S	09/23 15:42	S	19.9
Spaghetti	01539	09/03 18:04	S	09/29 10:40	N	25.7
Radio	00847	09/04 9:52	N	09/14 11:03	S	10.1
Spaghetti	01619	09/04 17:05	S	09/11 9:40	S	6.7
Spaghetti	01727	09/07 7:42	N	09/08 10:27	S	1.1
Spaghetti	01734	09/07 9:22	N	09/08 11:07	S	1.1
Spaghetti	01760	09/07 17:49	S	09/17 12:05	S	9.8
Spaghetti	01780	09/07 20:07	S	09/13 12:06	N	5.7
Spaghetti	01868	09/10 11:05	S	09/24 19:20	N	14.3
Spaghetti	01893	09/10 18:15	N	09/11 11:13	N	0.7

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Tag Type	Tag Number	Date of Initial Capture/Tagging	Bank of Initial Capture/Tagging	Recapture Date	Recapture Bank	Days Between Tagging and Recapture
Spaghetti	01932	09/11 14:15	N	09/14 11:03	S	2.9
Spaghetti	01955	09/11 18:28	N	09/15 12:28	S	3.8
Spaghetti	01989	09/12 14:03	S	09/14 20:00	S	2.3
Spaghetti	02000	09/12 15:57	N	09/17 12:43	S	4.9
Spaghetti	00275	09/12 17:23	N	09/15 17:30	S	3.0
Spaghetti	00279	09/12 18:23	S	09/15 17:30	S	3.0
Spaghetti	05455	09/12 21:45	S	09/15 13:46	S	2.7
Spaghetti	05460	09/13 10:05	N	09/14 11:03	S	1.0
Spaghetti	05499	09/13 13:23	N	09/24 12:42	N	11.0
Spaghetti	05477	09/13 18:17	N	09/20 12:40	S	6.8
Spaghetti	08167	09/14 8:25	N	09/15 12:39	S	1.2
Spaghetti	15007	09/15 20:22	N	09/17 12:43	S	1.7
Spaghetti	15011	09/15 20:53	N	09/17 8:20	N	1.5
Spaghetti	02117	09/18 15:48	N	09/24 12:42	N	5.9
Spaghetti	02133	09/18 16:45	N	09/20 12:23	S	1.8
Spaghetti	02146	09/18 18:20	N	09/23 10:37	N	4.7
Spaghetti	02189	09/19 10:19	N	10/07 10:32	N	18.0
Spaghetti	02228	09/19 16:03	N	09/23 10:10	N	3.8
Spaghetti	02243	09/19 20:35	N	09/23 13:32	S	3.7
Spaghetti	02248	09/19 20:53	N	09/22 12:14	S	2.6
Spaghetti	02301	09/20 16:52	S	09/25 10:48	S	4.8
Spaghetti	02341	09/21 8:46	N	09/23 12:35	S	2.2
Spaghetti	02342	09/21 8:50	N	09/22 13:27	S	1.2
Spaghetti	02419	09/21 18:46	N	09/23 14:38	S	1.8
Spaghetti	02444	09/21 19:49	S	09/26 14:49	S	4.8
Spaghetti	02487	09/22 8:00	N	09/26 18:15	N	4.4
Spaghetti	02541	09/22 10:48	S	09/24 12:03	S	2.1
Spaghetti	02643	09/22 17:37	N	09/23 15:48	S	0.9
Spaghetti	02692	09/23 10:23	N	09/27 16:16	N	4.3
Spaghetti	02704	09/23 10:36	N	09/24 10:59	N	1.0
Spaghetti	02715	09/23 10:53	N	09/24 11:54	S	1.0
Spaghetti	02765	09/23 13:02	N	09/27 19:19	S	4.3
Spaghetti	02769	09/23 13:04	N	09/25 13:10	N	2.0
Spaghetti	02778	09/23 13:25	N	09/25 10:24	N	1.9
Spaghetti	02783	09/23 13:35	N	09/25 14:43	S	2.1
Radio	00737	09/23 15:37	N	09/24 13:35	N	0.9
Spaghetti	02812	09/23 16:01	N	09/25 19:21	S	2.1
Spaghetti	02813	09/23 16:03	N	09/24 12:30	S	0.9
Spaghetti	02815	09/23 16:17	N	09/24 17:26	N	1.1
Spaghetti	02833	09/23 17:35	N	09/24 12:43	S	0.8
Spaghetti	02839	09/23 18:55	N	09/24 13:22	N	0.8
Spaghetti	02866	09/23 20:35	N	10/01 13:48	S	7.7

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Tag Type	Tag Number	Date of Initial Capture/Tagging	Bank of Initial Capture/Tagging	Recapture Date	Recapture Bank	Days Between Tagging and Recapture
Spaghetti	02885	09/24 8:19	N	09/25 12:00	N	1.2
Spaghetti	02886	09/24 8:30	S	09/27 16:25	N	3.3
Spaghetti	02919	09/24 14:38	N	09/25 16:08	S	1.1
Spaghetti	02932	09/24 17:26	N	10/10 16:11	N	16.0
Spaghetti	02949	09/24 20:15	N	09/27 14:38	S	2.8
Spaghetti	02967	09/25 10:35	N	09/30 14:49	S	5.2
Spaghetti	05256	09/25 14:46	N	10/01 11:23	S	5.9
Spaghetti	05162	09/26 13:16	N	09/30 13:27	S	4.0
Spaghetti	05177	09/26 14:53	N	10/05 9:49	S	8.8
Spaghetti	05237	09/27 12:10	N	10/01 15:12	S	4.1
Spaghetti	05239	09/27 12:13	N	09/28 19:14	S	1.3
Spaghetti	05259	09/27 15:07	N	10/01 13:48	S	4.0
Spaghetti	05288	09/28 12:32	N	10/01 12:28	N	3.0
Spaghetti	05339	09/29 21:06	N	09/30 18:06	S	0.9
Spaghetti	05361	10/01 20:59	N	10/06 13:52	S	4.7
Spaghetti	05370	10/02 21:30	N	10/06 12:53	N	3.6
Median Days						3.8

[a] Exact time of marking fish 00621 is unknown (data missing).

Appendix D3.–Capture-recapture history of 121 tagged coho salmon recaptured between river kilometers 48.9 and 58.4 (recapture reach) of the Kenai River, Alaska, 2001.

Tag Type	Tag Number	Date and Time of Capture/ Tagging	Bank of Initial Capture/ Tagging	Date and Time of Recapture	Recapture Bank	Days Between Tagging and Recapture
Spaghetti	03044	08/04 21:05	N	08/09 17:36	S	4.9
Spaghetti	03057	08/05 18:09	N	08/08 12:20	S	2.8
Spaghetti	03087	08/08 13:28	S	08/10 10:58	S	1.9
Spaghetti	03127	08/09 19:32	S	08/14 11:43	S	4.7
Spaghetti	03152	08/10 13:35	N	08/16 17:21	S	6.2
Spaghetti	03177	08/11 17:15	N	08/15 17:29	S	4.0
Radio	00635	08/13 8:20	S	08/15 10:50	S	2.1
Spaghetti	03230	08/14 8:45	N	08/21 10:58	S	7.1
Spaghetti	03270	08/14 17:37	N	08/24 15:48	S	9.9
Radio	00648	08/15 8:36	N	08/21 10:58	S	6.1
Spaghetti	03349	08/15 15:35	S	08/21 16:49	S	6.1
Spaghetti	03357	08/15 17:03	N	08/29 11:55	N	13.8
Spaghetti	03367	08/15 18:41	S	08/23 9:56	N	7.6
Spaghetti	03404	08/16 13:45	S	08/21 19:06	S	5.2
Spaghetti	03412	08/16 15:10	N	08/20 9:03	N	3.8
Radio	00652	08/16 17:07	S	08/28 13:04	N	11.8
Spaghetti	03487	08/17 13:28	S	08/30 7:34	N	12.8
Spaghetti	03520	08/17 17:31	S	08/19 14:54	S	1.9
Radio	00656	08/18 10:27	S	08/21 7:56	N	2.9
Spaghetti	03583	08/18 11:53	N	08/20 12:10	N	2.0
Spaghetti	03596	08/18 13:19	S	08/23 8:14	N	4.8
Spaghetti	03602	08/18 17:00	S	08/24 15:04	N	5.9
Spaghetti	03607	08/18 17:11	S	08/23 16:13	S	5.0
Spaghetti	03651	08/18 20:56	S	09/19 20:16	N	32.0
Spaghetti	03736	08/20 8:22	S	09/02 18:20	N	13.4
Spaghetti	03739	08/20 9:35	N	08/26 7:04	N	5.9
Spaghetti	03796	08/20 20:40	S	08/24 13:01	S	3.7
Spaghetti	03830	08/21 8:37	S	08/23 19:24	N	2.5
Spaghetti	03842	08/21 9:30	S	08/26 6:47	N	4.9
Spaghetti	03849	08/21 9:50	S	08/28 15:18	N	7.2
Spaghetti	03867	08/21 12:35	S	08/24 15:21	N	3.1
Spaghetti	03873	08/21 12:57	S	08/23 20:14	S	2.3
Spaghetti	03962	08/21 21:33	S	08/23 12:08	S	1.6
Spaghetti	03963	08/21 21:35	S	08/24 18:15	N	2.9
Spaghetti	04143	08/24 14:14	N	08/31 12:17	N	6.9
Spaghetti	04154	08/24 17:55	S	08/25 20:58	S	1.1
Spaghetti	04162	08/24 19:26	S	08/29 6:47	N	4.5
Spaghetti	04194	08/25 19:59	S	08/26 20:57	S	1.0
Spaghetti	04197	08/25 20:06	S	08/29 11:48	N	3.7
Spaghetti	04225	08/26 15:17	S	09/01 9:34	N	5.8
Spaghetti	04686	08/30 21:04	S	09/01 9:12	N	1.5
Spaghetti	04729	08/31 10:24	N	09/20 15:02	N	20.2
Spaghetti	04740	08/31 14:35	S	09/13 7:48	N	12.7
Spaghetti	04763	08/31 17:41	S	09/05 9:22	N	4.7
Spaghetti	04781	08/31 19:16	S	09/01 11:47	S	0.7
Spaghetti	04785	08/31 19:46	S	09/06 18:56	S	6.0
Spaghetti	04787	08/31 19:57	N	09/01 14:28	N	0.8
Spaghetti	04794	09/01 8:23	N	09/01 20:10	S	0.5
Spaghetti	04803	09/01 8:50	S	09/02 9:43	S	1.0
Spaghetti	04863	09/01 21:35	S	09/02 19:35	S	0.9
Spaghetti	04874	09/02 12:03	S	09/06 9:38	S	3.9
Spaghetti	04906	09/03 14:30	S	09/04 9:37	N	0.8
Spaghetti	04909	09/03 16:07	S	09/06 8:13	N	2.7
Spaghetti	04929	09/04 10:45	N	09/08 12:54	N	4.1
Spaghetti	04931	09/04 14:33	S	09/06 15:14	N	2.0
Spaghetti	04971	09/05 17:10	N	09/06 20:06	S	1.1
Radio	00715	09/05 20:40	S	09/15 12:30	N	9.7
Radio	00716	09/06 8:12	S	09/09 18:38	N	3.4
Spaghetti	05023	09/06 16:33	S	09/07 14:48	S	0.9
Spaghetti	05025	09/06 16:36	S	09/17 9:04	N	10.7
Spaghetti	05058	09/07 10:19	S	09/08 11:56	S	1.1
Spaghetti	05077	09/07 19:05	S	09/10 20:49	S	3.1
Radio	00725	09/08 12:20	S	09/10 16:17	N	2.2
Spaghetti	05103	09/08 13:40	S	09/15 15:00	N	7.1
Spaghetti	05126	09/09 17:43	S	09/11 18:43	N	2.0
Spaghetti	05127	09/09 17:50	S	09/13 18:24	N	4.0
Spaghetti	05134	09/10 9:17	S	09/13 17:20	S	3.3
Spaghetti	05141	09/10 17:21	S	09/19 19:08	N	9.1
Spaghetti	05143	09/10 19:21	S	09/12 8:34	N	1.6
Radio	00734	09/10 19:28	S	09/17 12:44	S	6.7
Spaghetti	05144	09/10 19:35	S	09/14 12:19	N	3.7
Radio	00735	09/10 21:22	S	09/11 14:31	S	0.7
Spaghetti	05156	09/12 13:08	S	09/17 11:56	N	5.0
Spaghetti	05334	09/12 21:43	S	09/14 19:58	N	1.9
Spaghetti	05168	09/13 21:39	N	09/14 19:42	N	0.9
Spaghetti	05172	09/14 12:15	N	09/15 15:39	S	1.1
Radio	00746	09/14 17:35	N	09/25 8:40	N	10.6
Spaghetti	05180	09/14 19:55	N	09/15 17:29	N	0.9
Spaghetti	05348	09/15 18:30	N	09/21 16:32	N	5.9
Spaghetti	05350	09/15 18:43	S	09/20 17:14	N	4.9

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Spaghetti	04239	08/26 21:33	N	09/21 10:47	N	25.6	Spaghetti	05186	09/16 8:36	N	09/19 14:58	S	3.3
Spaghetti	04250	08/27 9:44	S	08/27 18:58	N	0.4	Spaghetti	05187	09/16 12:25	N	09/22 14:19	N	6.1
Spaghetti	04251	08/27 9:46	S	08/29 6:47	N	1.9	Spaghetti	05193	09/16 21:00	N	09/20 14:49	N	3.7
Spaghetti	04301	08/28 12:08	S	08/31 12:46	N	3.0	Radio	00758	09/18 12:45	N	09/19 15:37	S	1.1
Spaghetti	04302	08/28 12:10	S	09/02 16:18	S	5.2	Spaghetti	05220	09/18 18:29	N	09/25 15:04	N	6.9
Radio	00692	08/28 12:56	N	09/08 12:10	N	11.0	Spaghetti	05237	09/19 13:40	N	09/21 10:58	N	1.9
Spaghetti	04351	08/29 8:51	N	09/17 8:12	N	19.0	Spaghetti	05251	09/20 13:03	S	09/22 12:53	N	2.0
Spaghetti	04397	08/29 12:17	S	08/30 18:00	S	1.2	Spaghetti	05289	09/21 21:31	S	09/23 12:46	N	1.6
Spaghetti	04405	08/29 12:56	S	09/03 16:58	N	5.2	Spaghetti	05360	09/23 16:40	N	09/24 12:26	N	0.8
Spaghetti	04441	08/29 14:57	N	08/31 15:51	S	2.0	Spaghetti	05408	09/24 21:31	S	09/26 13:28	S	1.7
Spaghetti	04462	08/29 16:07	S	08/30 15:48	S	1.0	Spaghetti	05411	09/24 21:35	S	09/25 14:44	S	0.7
Spaghetti	04487	08/29 16:48	S	08/30 16:57	S	1.0	Spaghetti	05453	09/27 13:39	S	10/03 10:48	N	5.9
Spaghetti	04518	08/29 17:53	S	08/31 11:08	S	1.7	Spaghetti	05462	09/27 21:22	N	09/28 13:11	S	0.7
Spaghetti	04534	08/29 19:35	N	09/04 8:22	S	5.5	Spaghetti	05472	09/28 18:20	S	10/02 12:42	N	3.8
Spaghetti	04569	08/29 21:22	S	08/30 15:41	S	0.8	Spaghetti	05473	09/28 18:21	S	10/02 16:09	N	3.9
Spaghetti	04624	08/30 15:14	S	09/01 11:56	N	1.9	Spaghetti	05475	09/28 21:11	N	09/29 15:46	S	0.8
Spaghetti	04638	08/30 15:39	S	08/31 12:57	N	0.9	Radio	00796	09/29 9:54	S	09/30 11:08	S	1.1
Spaghetti	04656	08/30 17:51	S	08/31 11:41	N	0.7	Spaghetti	05485	09/29 16:05	N	10/02 14:47	S	3.0
Spaghetti	04667	08/30 18:07	S	08/31 14:36	S	0.9	Spaghetti	05489	09/29 16:36	S	10/01 15:26	N	2.0
Spaghetti	04682	08/30 20:58	S	08/31 16:18	N	0.8	Spaghetti	05502	09/30 21:16	N	10/01 15:16	S	0.8
Spaghetti	04685	08/30 21:02	S	09/06 11:33	S	6.6							
												Median Days	3.1

Appendix D4.–Capture-recapture history of 241 tagged coho salmon recaptured between river kilometers 48.9 and 58.4 (recapture reach) of the Kenai River, Alaska, 2002.

Tag Type	Tag Number	Date and Time of Capture/ Tagging	Bank of Initial Capture/ Tagging	Date and Time of Recapture	Recapture Bank	Days Between Tagging and Recapture
Spaghetti	05521	08/04 18:02	S	08/09 20:11	N	5.1
Spaghetti	05575	08/06 16:20	N	08/09 21:15	N	3.2
Spaghetti	05607	08/08 7:59	S	08/09 17:18	S	1.4
Radio	00824	08/13 15:37	S	08/14 19:52	S	1.2
Spaghetti	05792	08/14 19:27	S	08/17 12:39	N	2.7
Spaghetti	05885	08/18 9:13	N	08/27 12:55	S	9.2
Spaghetti	05889	08/18 11:35	S	08/25 15:21	N	7.2
Spaghetti	05934	08/18 21:28	S	09/04 16:59	S	16.8
Spaghetti	05938	08/19 6:45	S	08/20 7:41	N	1.0
Spaghetti	05955	08/19 8:57	S	09/05 9:52	S	17.0
Spaghetti	06051	08/19 19:37	N	09/13 11:23	N	24.7
Spaghetti	06063	08/19 20:24	N	08/21 13:52	S	1.7
Spaghetti	06132	08/20 13:04	S	08/24 6:53	N	3.7
Spaghetti	06144	08/20 15:26	N	08/24 12:33	N	3.9
Spaghetti	06155	08/20 16:06	N	08/24 11:22	N	3.8
Spaghetti	06159	08/20 16:15	N	08/31 21:00	N	11.2
Spaghetti	06174	08/20 18:10	N	09/13 11:23	N	23.7
Spaghetti	06180	08/20 19:31	N	08/23 16:36	N	2.9
Spaghetti	06212	08/20 21:28	S	08/24 13:47	S	3.7
Spaghetti	06235	08/21 8:46	N	08/24 15:23	S	3.3
Spaghetti	06332	08/21 18:18	S	08/23 11:07	S	1.7
Radio	00843	08/21 19:55	N	09/04 15:28	N	13.8
Spaghetti	06364	08/22 6:53	S	08/25 7:03	N	3.0
Spaghetti	06371	08/22 7:41	N	08/27 10:10	N	5.1
Spaghetti	06433	08/22 12:33	S	08/24 20:39	N	2.3
Spaghetti	06469	08/22 15:39	S	08/24 11:54	N	1.8
Spaghetti	06476	08/22 15:56	S	09/09 19:17	N	18.1
Spaghetti	06534	08/22 19:47	N	08/26 12:23	N	3.7
Spaghetti	06634	08/23 15:45	S	08/28 15:25	S	5.0
Spaghetti	06659	08/23 17:26	S	08/28 16:26	N	5.0
Spaghetti	06720	08/24 6:57	S	09/10 11:51	N	17.2
Spaghetti	06733	08/24 8:00	S	09/09 13:04	S	16.2
Spaghetti	06762	08/24 12:48	N	09/24 11:02	S	30.9
Spaghetti	06767	08/24 12:55	N	08/27 13:04	S	3.0
Spaghetti	06785	08/24 15:13	N	08/27 12:25	S	2.9
Spaghetti	06800	08/24 15:59	S	08/28 20:24	S	4.2
Spaghetti	07055	08/25 20:14	S	08/29 11:07	N	3.6
Spaghetti	07089	08/26 7:32	N	08/28 13:10	S	2.2
Spaghetti	07098	08/26 8:03	S	09/13 17:04	N	18.4
Spaghetti	07196	08/26 17:32	N	08/31 16:31	N	5.0
Spaghetti	07300	08/26 20:58	N	09/04 10:10	S	8.6
Spaghetti	07511	08/28 17:46	S	09/03 12:45	S	5.8
Spaghetti	07557	08/28 20:42	S	08/30 13:03	N	1.7
Spaghetti	07567	08/28 21:08	S	09/18 14:20	S	20.7
Spaghetti	07644	08/29 11:56	N	08/30 19:15	S	1.3
Spaghetti	07652	08/29 12:40	S	09/22 10:11	N	23.9
Spaghetti	07771	08/29 21:30	S	09/02 17:00	S	3.8
Spaghetti	07786	08/30 10:33	S	09/02 21:25	S	3.5
Spaghetti	07865	08/30 18:06	N	09/22 12:31	S	22.8
Spaghetti	07889	08/30 20:17	S	09/04 10:10	S	4.6
Spaghetti	07891	08/30 20:21	S	09/02 12:43	S	2.7
Spaghetti	07898	08/30 20:57	S	09/05 12:00	S	5.6
Spaghetti	07972	08/31 15:10	N	09/13 8:11	N	12.7
Spaghetti	07990	08/31 16:12	S	09/07 12:02	S	6.8
Spaghetti	08030	08/31 17:30	N	09/04 18:00	S	4.0
Spaghetti	08062	08/31 19:39	N	09/04 10:00	N	3.6
Spaghetti	08069	08/31 19:56	N	09/12 17:09	S	11.9
Spaghetti	08108	09/01 8:34	S	09/11 16:25	S	10.3
Spaghetti	08124	09/01 9:31	N	09/04 11:42	S	3.1
Spaghetti	08156	09/01 12:51	S	09/14 11:20	S	12.9
Spaghetti	08180	09/01 16:00	S	09/07 17:45	N	6.1
Spaghetti	08197	09/01 17:13	N	09/11 16:51	S	10.0
Spaghetti	08201	09/01 17:26	N	09/12 7:53	N	10.6
Spaghetti	08222	09/01 19:30	S	09/12 19:22	N	11.0
Spaghetti	08254	09/01 20:56	N	09/05 11:30	N	3.6
Spaghetti	08268	09/02 7:20	S	09/18 14:20	S	16.3
Spaghetti	08283	09/02 8:09	N	09/03 15:35	S	1.3
Spaghetti	08296	09/02 9:04	N	09/11 19:12	S	9.4
Spaghetti	08312	09/02 10:18	N	09/04 15:28	N	2.2
Spaghetti	08332	09/02 13:01	N	09/04 15:44	S	2.1
Spaghetti	08398	09/02 18:09	S	09/05 9:36	S	2.6
Spaghetti	08409	09/02 19:45	S	09/05 9:25	S	2.6
Spaghetti	08431	09/02 20:45	N	09/05 12:47	S	2.7
Spaghetti	08440	09/02 21:04	N	09/12 17:24	S	9.9
Spaghetti	08444	09/02 21:08	N	09/25 14:55	S	22.7
Spaghetti	08452	09/02 21:25	N	09/09 12:09	S	6.6
Spaghetti	08455	09/03 7:32	S	09/12 7:53	N	9.0
Spaghetti	08483	09/03 12:04	S	09/05 21:09	S	2.4
Spaghetti	08667	09/05 12:10	N	09/05 21:09	S	0.4
Spaghetti	08679	09/05 17:40	N	09/19 18:42	N	14.0
Spaghetti	08680	09/05 18:01	S	09/10 18:51	S	5.0
Spaghetti	08681	09/05 18:10	S	09/13 18:59	N	8.0
Spaghetti	08705	09/06 6:53	N	09/17 12:25	S	11.2
Radio	00878	09/06 12:12	N	09/14 13:01	S	8.0
Spaghetti	08795	09/06 16:28	N	09/11 13:20	S	4.9
Spaghetti	08859	09/06 20:39	N	09/07 15:51	S	0.8
Spaghetti	08865	09/06 20:59	N	09/12 16:42	S	5.8
Spaghetti	08868	09/06 21:09	N	09/08 7:28	S	1.4
Spaghetti	08876	09/07 8:11	N	09/08 12:48	S	1.2
Spaghetti	08887	09/07 8:32	N	09/07 20:32	S	0.5
Spaghetti	08918	09/07 10:37	N	09/09 20:32	N	2.4
Spaghetti	08920	09/07 10:48	S	09/14 16:52	S	7.3
Spaghetti	08937	09/07 11:52	N	09/08 21:05	S	1.4
Spaghetti	08995	09/07 16:19	N	09/11 16:25	S	4.0
Spaghetti	08998	09/07 16:26	N	09/11 16:25	S	4.0
Spaghetti	09001	09/07 16:37	N	09/19 18:50	S	12.1
Spaghetti	09049	09/08 16:37	N	09/14 16:47	S	6.0
Spaghetti	09056	09/08 17:19	S	09/11 16:25	S	3.0
Spaghetti	09118	09/09 8:00	N	09/14 11:15	N	5.1
Spaghetti	09191	09/09 17:49	N	09/18 20:25	N	9.1
Spaghetti	09392	09/11 9:51	S	09/15 8:33	S	4.0
Spaghetti	09401	09/11 10:24	N	09/19 8:22	S	7.9
Spaghetti	09461	09/11 17:47	S	09/12 15:43	S	0.9
Spaghetti	09488	09/11 20:03	N	09/12 17:20	S	0.9
Spaghetti	09508	09/11 21:15	N	09/13 7:49	S	1.4
Spaghetti	09513	09/11 21:20	N	09/18 11:23	N	6.6
Spaghetti	09524	09/12 7:26	N	09/13 8:01	S	1.0
Spaghetti	09646	09/12 18:20	S	09/13 15:51	S	0.9
Spaghetti	09676	09/12 21:09	N	09/22 7:52	S	9.5
Spaghetti	09699	09/13 8:08	N	09/17 11:37	S	4.2
Spaghetti	09751	09/13 9:59	S	09/18 10:46	S	5.0
Spaghetti	09774	09/13 12:36	N	09/17 13:18	S	4.0
Spaghetti	09808	09/13 16:08	N	09/15 15:28	S	2.0
Spaghetti	09817	09/13 16:21	N	09/15 11:51	S	1.8
Spaghetti	09843	09/13 17:13	N	09/18 14:20	S	4.9
Spaghetti	09915	09/13 20:53	S	09/15 8:47	N	1.5
Spaghetti	09931	09/14 9:19	N	09/18 14:20	S	4.2
Spaghetti	09939	09/14 9:48	S	09/17 19:20	S	3.4
Spaghetti	09955	09/14 10:26	N	09/19 7:43	S	4.9
Spaghetti	09966	09/14 12:01	N	09/20 15:35	S	6.2
Spaghetti	09975	09/14 12:39	N	09/17 9:16	N	2.9
Spaghetti	09977	09/14 12:42	N	10/03 16:10	N	19.1

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Tag Type	Tag ID	Date of Initial Capture/ Tagging	Bank of Initial Capture/ Tagging	Recapture Date	Recapture Bank	Days Between Tagging and Recapture
Spaghetti	09995	09/14 15:07	N	09/17 9:16	N	2.8
Spaghetti	10002	09/14 15:16	N	10/01 16:33	N	17.1
Spaghetti	10022	09/14 15:59	N	09/17 8:30	N	2.7
Spaghetti	10048	09/14 16:55	N	09/18 11:55	N	3.8
Spaghetti	10052	09/14 17:03	N	09/22 10:25	S	7.7
Spaghetti	10060	09/14 17:16	N	09/23 15:38	S	8.9
Spaghetti	10071	09/14 17:38	N	09/21 12:53	N	6.8
Spaghetti	10103	09/14 19:49	N	09/23 8:44	N	8.5
Spaghetti	10106	09/14 19:53	N	09/20 7:59	S	5.5
Spaghetti	10152	09/15 7:26	N	09/18 13:10	N	3.2
Spaghetti	10182	09/15 8:18	S	09/20 17:49	S	5.4
Spaghetti	10222	09/15 9:20	N	09/19 12:13	N	4.1
Spaghetti	10235	09/15 9:56	N	09/17 11:37	S	2.1
Spaghetti	10255	09/15 11:23	N	09/18 15:19	N	3.2
Spaghetti	10259	09/15 11:30	N	09/18 11:26	S	3.0
Spaghetti	10263	09/15 11:34	N	09/16 13:23	N	1.1
Spaghetti	10268	09/15 11:43	N	09/18 14:20	S	3.1
Spaghetti	10275	09/15 12:03	S	09/21 12:53	N	6.0
Spaghetti	10285	09/15 12:31	N	09/17 11:37	S	2.0
Spaghetti	10296	09/15 12:49	N	09/19 20:37	S	4.3
Spaghetti	10312	09/15 13:18	S	09/18 10:22	S	2.9
Spaghetti	10326	09/15 15:06	N	09/18 20:09	N	3.2
Spaghetti	10337	09/15 15:18	N	09/18 14:20	S	3.0
Spaghetti	10360	09/15 15:57	N	09/23 9:29	S	7.7
Spaghetti	10372	09/15 16:22	S	09/18 14:20	S	2.9
Spaghetti	10383	09/15 16:44	S	09/23 7:54	S	7.6
Spaghetti	10386	09/15 16:48	S	09/23 8:14	S	7.6
Spaghetti	10392	09/15 17:07	N	09/19 16:46	S	4.0
Spaghetti	10410	09/15 17:39	N	09/17 8:41	S	1.6
Spaghetti	10414	09/15 17:46	N	09/20 8:12	S	4.6
Spaghetti	10415	09/15 17:54	S	09/21 16:06	S	5.9
Spaghetti	10440	09/15 19:32	N	09/23 11:44	S	7.7
Spaghetti	10442	09/15 19:34	N	09/21 13:58	N	5.8
Spaghetti	10470	09/15 20:31	N	09/17 8:41	S	1.5
Spaghetti	10476	09/15 20:37	N	09/18 14:20	S	2.7
Spaghetti	10483	09/15 20:47	N	09/18 14:20	S	2.7
Spaghetti	10501	09/16 7:55	N	09/20 13:06	S	4.2
Spaghetti	10504	09/16 8:01	N	09/26 12:04	S	10.2
Spaghetti	10513	09/16 8:39	N	09/18 14:20	S	2.2
Spaghetti	10534	09/16 10:05	N	09/18 10:18	S	2.0
Spaghetti	10535	09/16 10:06	N	09/19 12:03	S	3.1
Spaghetti	10553	09/16 12:37	N	09/18 12:12	S	2.0
Spaghetti	10569	09/16 15:16	N	09/22 7:47	S	5.7
Spaghetti	10610	09/16 20:30	N	09/26 13:15	S	9.7
Spaghetti	10612	09/16 20:38	S	09/24 12:01	S	7.6
Spaghetti	10626	09/17 12:53	S	09/21 16:39	S	4.2
Spaghetti	10650	09/17 17:13	N	09/25 8:16	S	7.6
Spaghetti	10655	09/17 17:42	N	09/22 11:57	S	4.8
Spaghetti	10662	09/17 19:01	N	09/18 19:07	N	1.0
Spaghetti	10698	09/18 9:38	N	09/24 11:55	S	6.1
Spaghetti	10702	09/18 11:50	N	09/29 9:05	S	10.9
Spaghetti	10718	09/18 15:51	N	09/19 12:48	S	0.9
Spaghetti	10721	09/18 16:16	N	09/25 8:01	S	6.7
Spaghetti	10727	09/18 16:49	S	09/22 13:37	S	3.9
Spaghetti	10733	09/18 17:01	N	09/23 12:55	S	4.8
Spaghetti	10742	09/18 17:51	S	09/23 15:24	S	4.9
Radio	00906	09/18 20:55	N	09/21 16:06	S	2.8
Spaghetti	10793	09/19 9:15	N	09/24 13:18	S	5.2
Spaghetti	10797	09/19 10:00	N	09/21 14:09	N	2.2
Spaghetti	10818	09/19 15:08	N	09/22 12:05	S	2.9
Spaghetti	10821	09/19 15:59	N	09/23 13:02	S	3.9
Spaghetti	10849	09/19 18:09	N	09/23 18:10	S	4.0
Spaghetti	10861	09/19 19:38	N	10/03 16:51	S	13.9
Spaghetti	10884	09/20 7:25	S	09/23 8:01	N	3.0
Spaghetti	10894	09/20 10:22	N	10/02 12:01	N	12.1
Spaghetti	10931	09/20 15:38	N	09/23 16:45	S	3.1
Spaghetti	10934	09/20 15:48	N	09/24 14:15	S	3.9
Spaghetti	10946	09/20 16:22	N	09/22 12:05	S	1.8
Spaghetti	10959	09/20 17:32	S	09/23 12:09	S	2.8
Spaghetti	10963	09/20 17:42	N	09/25 14:29	S	4.9
Spaghetti	11002	09/20 20:57	S	10/02 12:34	N	11.7
Spaghetti	11005	09/20 21:01	S	09/25 14:55	S	4.8
Spaghetti	11010	09/21 7:26	N	09/24 15:02	N	3.3
Spaghetti	11016	09/21 9:32	N	09/27 15:25	N	6.3
Spaghetti	11025	09/21 11:32	N	09/23 13:02	S	2.1
Spaghetti	11045	09/21 15:40	S	09/24 12:23	N	2.9
Spaghetti	11051	09/21 15:54	N	09/29 15:55	N	8.0
Spaghetti	11059	09/21 16:14	N	09/27 11:43	N	5.8
Spaghetti	11073	09/21 17:39	S	09/26 12:04	S	4.8
Spaghetti	11076	09/21 17:42	S	09/23 13:20	S	1.8
Spaghetti	11113	09/21 20:23	N	09/23 16:20	S	1.8
Spaghetti	11156	09/22 10:26	S	09/23 17:54	S	1.3
Spaghetti	11171	09/22 13:16	N	09/27 9:37	N	4.9
Spaghetti	11201	09/22 16:26	N	09/25 8:01	S	2.7
Spaghetti	11208	09/22 16:59	N	09/26 15:47	S	4.0
Spaghetti	11240	09/22 19:35	N	09/25 8:53	N	2.6
Spaghetti	11244	09/22 19:52	N	09/26 17:15	S	3.9
Spaghetti	11258	09/22 20:21	N	09/26 15:47	S	3.8
Spaghetti	11312	09/23 15:54	N	09/26 16:29	S	3.0
Spaghetti	11339	09/23 19:18	N	09/29 9:11	N	5.6
Spaghetti	11374	09/23 20:13	N	09/27 11:12	S	3.6
Spaghetti	11385	09/24 9:27	N	09/28 12:33	S	4.1
Spaghetti	11388	09/24 9:52	N	09/26 7:50	S	1.9
Spaghetti	11409	09/24 13:15	S	09/30 9:11	S	5.8
Spaghetti	11428	09/24 15:45	S	09/26 11:52	S	1.8
Spaghetti	11437	09/24 17:06	S	09/26 9:51	S	1.7
Spaghetti	11447	09/24 17:30	N	10/03 13:08	S	8.8
Spaghetti	11470	09/24 18:14	N	09/27 11:43	N	2.7
Spaghetti	11472	09/24 18:16	N	09/26 10:06	S	1.7
Spaghetti	11493	09/24 19:52	S	09/27 11:12	S	2.6
Spaghetti	11497	09/24 20:02	N	09/28 9:06	N	3.5
Spaghetti	11533	09/25 7:55	N	09/29 13:23	S	4.2
Spaghetti	11541	09/25 8:35	N	09/27 8:28	S	2.0
Spaghetti	11588	09/25 12:46	N	09/29 15:40	N	4.1
Spaghetti	11594	09/25 13:06	N	09/29 11:54	S	4.0
Spaghetti	11618	09/25 15:25	N	10/01 12:11	N	5.9
Spaghetti	11640	09/25 16:42	N	09/28 14:00	N	2.9
Spaghetti	11690	09/25 19:10	S	09/27 12:53	S	1.7
Spaghetti	11714	09/26 9:00	N	09/30 12:30	N	4.2
Spaghetti	11729	09/26 10:05	S	09/28 10:19	S	2.0
Spaghetti	11732	09/26 10:13	N	09/27 11:12	S	1.0
Spaghetti	11759	09/26 15:19	N	09/28 14:17	N	2.0
Spaghetti	11812	09/27 7:40	N	09/30 17:50	N	3.4
Spaghetti	11829	09/27 11:26	N	10/04 11:04	S	7.0
Radio	00925	09/27 16:29	S	10/01 11:20	S	3.8
Spaghetti	11861	09/27 19:43	S	09/29 17:45	S	1.9
Spaghetti	11868	09/27 20:53	N	09/28 14:30	S	0.7
Radio	00911	09/29 18:24	S	10/01 16:02	N	1.9
Spaghetti	11922	09/29 18:26	S	10/04 10:11	S	4.7
					Median Days	4.0

Appendix D5.–Capture-recapture history of 119 tagged coho salmon recaptured between river kilometers 48.9 and 58.4 (recapture reach) of the Kenai River, Alaska, 2003.

Tag Type	Tag Number	Date and Time of Capture/Tagging	Bank of Initial Capture/Tagging	Date and Time of Recapture	Recapture Bank	Days Between Tagging and Recapture
Spaghetti	00009	8/4/2003 13:07	S	8/8/2003 12:57	N	4.0
Radio	01015	8/8/2003 17:27	N	8/30/2003 12:39	S	21.8
Spaghetti	00075	8/9/2003 12:14	S	9/16/2003 17:49	N	38.2
Spaghetti	00085	8/9/2003 17:43	N	8/19/2003 12:40	N	9.8
Spaghetti	00086	8/9/2003 19:16	S	8/17/2003 9:26	N	7.6
Spaghetti	00181	8/12/2003 8:57	S	8/21/2003 9:28	S	9.0
Spaghetti	00234	8/12/2003 18:22	S	8/28/2003 17:14	N	16.0
Spaghetti	00276	8/13/2003 13:03	S	8/21/2003 19:59	N	8.3
Radio	01025	8/13/2003 15:24	S	8/22/2003 17:01	N	9.1
Spaghetti	00301	8/13/2003 18:12	S	8/19/2003 12:55	N	5.8
Spaghetti	00358	8/14/2003 9:27	S	9/1/2003 11:01	N	18.1
Spaghetti	00410	8/14/2003 16:59	S	8/15/2003 10:52	S	0.8
Spaghetti	00441	8/14/2003 18:00	S	8/18/2003 12:46	S	3.8
Spaghetti	00508	8/15/2003 8:15	S	8/21/2003 7:03	N	6.0
Spaghetti	00605	8/15/2003 16:14	S	8/22/2003 7:15	S	6.6
Spaghetti	00608	8/15/2003 16:17	S	8/19/2003 12:29	N	3.8
Spaghetti	00666	8/15/2003 21:05	S	8/16/2003 12:56	S	0.7
Spaghetti	00690	8/16/2003 9:57	S	8/19/2003 21:03	S	3.5
Spaghetti	00696	8/16/2003 10:17	S	8/18/2003 20:22	N	2.4
Spaghetti	00720	8/16/2003 12:14	S	8/22/2003 19:45	N	6.3
Spaghetti	00725	8/16/2003 12:26	S	8/21/2003 18:26	N	5.3
Spaghetti	00745	8/16/2003 14:55	S	8/20/2003 16:59	S	4.1
Spaghetti	00771	8/16/2003 17:59	S	8/19/2003 20:30	N	3.1
Spaghetti	00806	8/17/2003 8:01	S	8/22/2003 20:17	N	5.5
Spaghetti	00839	8/17/2003 15:16	S	8/25/2003 11:02	N	7.8
Spaghetti	00872	8/17/2003 18:23	S	8/19/2003 9:05	S	1.6
Spaghetti	00909	8/17/2003 21:14	S	8/19/2003 8:45	N	1.5
Spaghetti	00920	8/18/2003 8:20	S	8/22/2003 8:57	S	4.0
Spaghetti	00930	8/18/2003 8:39	S	8/27/2003 11:35	N	9.1
Spaghetti	00942	8/18/2003 11:42	S	8/25/2003 11:31	N	7.0
Spaghetti	00952	8/18/2003 12:39	S	8/21/2003 9:44	N	2.9
Spaghetti	00968	8/18/2003 15:38	S	8/26/2003 7:16	N	7.7
Spaghetti	00980	8/18/2003 16:46	S	8/19/2003 14:54	N	0.9
Spaghetti	00984	8/18/2003 16:53	S	8/21/2003 17:12	N	3.0
Spaghetti	01025	8/18/2003 21:26	S	8/20/2003 18:07	N	1.9
Spaghetti	01027	8/19/2003 7:52	S	8/25/2003 8:57	N	6.1
Spaghetti	01036	8/19/2003 8:10	S	8/20/2003 8:25	N	1.0
Spaghetti	01040	8/19/2003 8:21	S	9/17/2003 12:46	S	29.2
Spaghetti	01059	8/19/2003 10:00	S	8/21/2003 21:12	N	2.5
Spaghetti	01063	8/19/2003 11:15	S	8/27/2003 6:54	S	7.8
Spaghetti	01097	8/19/2003 15:28	S	8/21/2003 17:59	N	2.1
Spaghetti	01135	8/20/2003 9:13	S	8/31/2003 10:47	N	11.1
Spaghetti	01138	8/20/2003 9:24	S	9/8/2003 8:37	N	19.0
Spaghetti	01146	8/20/2003 9:38	S	8/23/2003 13:03	N	3.1
Spaghetti	01157	8/20/2003 9:57	S	8/22/2003 17:24	S	2.3
Spaghetti	01161	8/20/2003 15:39	S	8/26/2003 14:34	S	6.0
Spaghetti	01174	8/20/2003 17:12	S	8/26/2003 16:35	S	6.0
Spaghetti	01209	8/21/2003 8:39	S	8/22/2003 7:30	S	1.0
Spaghetti	01210	8/21/2003 8:42	S	8/26/2003 13:21	N	5.2
Spaghetti	01297	8/22/2003 8:45	S	8/23/2003 11:18	S	1.1
Spaghetti	01298	8/22/2003 8:46	S	8/23/2003 19:18	S	1.4
Spaghetti	01323	8/22/2003 16:32	S	8/23/2003 19:38	N	1.1
Spaghetti	01337	8/22/2003 17:05	S	8/30/2003 9:11	S	7.7
Spaghetti	01351	8/22/2003 18:00	S	9/10/2003 11:20	N	18.7
Spaghetti	01364	8/22/2003 20:36	S	9/1/2003 11:25	N	9.6
Spaghetti	01396	8/23/2003 12:49	S	8/25/2003 13:11	N	2.0
Spaghetti	01397	8/23/2003 12:51	S	8/24/2003 9:46	S	0.9
Spaghetti	01402	8/23/2003 13:16	S	8/29/2003 11:47	N	5.9
Spaghetti	01403	8/23/2003 13:18	S	8/25/2003 12:35	S	2.0
Spaghetti	01422	8/23/2003 18:20	S	8/29/2003 15:39	N	5.9
Spaghetti	01436	8/23/2003 19:45	S	8/24/2003 16:25	N	0.9
Spaghetti	01439	8/23/2003 20:05	S	8/27/2003 15:39	N	3.8
Spaghetti	01442	8/23/2003 20:42	S	8/27/2003 17:14	S	3.9
Spaghetti	01457	8/23/2003 21:46	N	8/26/2003 7:52	S	2.4
Spaghetti	01531	8/24/2003 20:14	S	8/26/2003 13:04	S	1.7
Spaghetti	01538	8/24/2003 20:49	S	8/25/2003 16:35	S	0.8
Spaghetti	01554	8/25/2003 7:00	S	9/9/2003 7:51	S	15.0
Spaghetti	01559	8/25/2003 8:04	S	8/29/2003 9:08	N	4.0
Spaghetti	01563	8/25/2003 8:16	S	8/26/2003 12:58	N	1.2
Spaghetti	01564	8/25/2003 8:26	S	9/16/2003 16:36	S	22.3
Spaghetti	01574	8/25/2003 8:51	S	8/27/2003 20:15	N	2.5
Spaghetti	01583	8/25/2003 9:51	S	8/26/2003 7:00	N	0.9
Spaghetti	01611	8/25/2003 15:44	S	8/26/2003 16:43	N	1.0
Spaghetti	01617	8/25/2003 16:00	N	8/30/2003 8:26	N	4.7
Spaghetti	01626	8/25/2003 16:43	S	9/14/2003 15:38	N	20.0
Spaghetti	01659	8/25/2003 19:53	S	8/28/2003 9:01	N	2.6
Spaghetti	01664	8/25/2003 20:14	S	8/26/2003 16:13	S	0.8
Spaghetti	01670	8/25/2003 20:29	N	8/27/2003 13:47	N	1.7
Spaghetti	01672	8/25/2003 20:32	N	8/28/2003 8:47	N	2.5
Spaghetti	01692	8/25/2003 21:27	N	9/1/2003 11:01	N	6.6
Spaghetti	01711	8/26/2003 8:34	S	8/31/2003 12:01	N	5.1
Spaghetti	01727	8/26/2003 9:25	S	8/28/2003 7:51	N	1.9
Spaghetti	01758	8/26/2003 17:11	S	8/29/2003 11:56	N	2.8
Spaghetti	01759	8/26/2003 17:13	S	9/2/2003 13:15	N	6.8
Spaghetti	01790	8/26/2003 21:10	S	9/12/2003 10:59	N	16.6
Spaghetti	01803	8/27/2003 8:02	S	8/29/2003 12:16	S	2.2
Spaghetti	01808	8/27/2003 8:10	S	8/30/2003 16:15	N	3.3
Spaghetti	01826	8/27/2003 11:47	N	8/30/2003 13:45	S	3.1
Spaghetti	01837	8/27/2003 15:07	S	9/2/2003 13:15	N	5.9
Spaghetti	01873	8/28/2003 13:30	N	8/29/2003 17:08	N	1.2
Spaghetti	01932	8/29/2003 17:37	S	8/30/2003 16:55	N	1.0
Spaghetti	01935	8/29/2003 18:44	S	8/31/2003 15:29	N	1.9
Spaghetti	01983	8/30/2003 21:00	S	8/31/2003 13:01	S	0.7
Spaghetti	01984	8/30/2003 21:05	S	9/1/2003 9:07	N	1.5
Spaghetti	02007	8/31/2003 17:32	S	9/10/2003 16:48	S	10.0
Spaghetti	02013	9/1/2003 8:16	S	9/5/2003 9:29	N	4.1
Spaghetti	02018	9/1/2003 10:10	S	9/6/2003 16:31	N	5.3
Spaghetti	02041	9/1/2003 21:07	S	9/6/2003 11:50	N	4.6
Spaghetti	02042	9/1/2003 21:08	S	9/8/2003 7:32	N	6.4
Spaghetti	02061	9/2/2003 9:50	S	9/18/2003 19:43	S	16.4
Radio	01064	9/2/2003 11:50	S	9/6/2003 10:58	S	4.0
Spaghetti	02068	9/2/2003 12:45	S	9/7/2003 15:31	N	5.1
Spaghetti	02071	9/2/2003 13:30	S	9/3/2003 7:48	S	0.8
Spaghetti	02072	9/2/2003 13:36	N	9/4/2003 7:49	N	1.8
Spaghetti	02074	9/2/2003 14:59	S	9/6/2003 11:40	S	3.9
Spaghetti	02077	9/2/2003 15:21	S	9/5/2003 17:17	N	3.1
Spaghetti	02088	9/2/2003 18:00	S	9/3/2003 12:24	N	0.8
Spaghetti	02100	9/2/2003 21:05	S	9/3/2003 20:02	S	1.0
Spaghetti	02105	9/3/2003 8:00	S	9/12/2003 10:52	S	9.1
Spaghetti	02114	9/3/2003 8:27	S	9/9/2003 15:27	S	6.3
Spaghetti	02130	9/3/2003 17:06	S	9/9/2003 11:20	S	5.8
Spaghetti	02174	9/4/2003 15:42	S	9/10/2003 17:15	N	6.1
Spaghetti	02199	9/4/2003 20:00	N	9/6/2003 18:43	S	2.0
Spaghetti	02221	9/5/2003 13:15	N	9/9/2003 16:56	S	4.2
Spaghetti	02236	9/5/2003 20:06	S	9/17/2003 11:27	S	11.6
Spaghetti	02312	9/11/2003 13:33	N	9/13/2003 16:13	N	2.1
Spaghetti	02316	9/11/2003 21:24	N	9/16/2003 19:48	N	4.9
Spaghetti	02320	9/12/2003 18:13	N	9/13/2003 13:19	S	0.8
Radio	01121	9/30/2003 16:44	S	10/3/2003 12:46	N	2.8
					Median Days	4.0

APPENDIX E

Appendix E1.–Capture history and fates assigned to 187 coho salmon captured from the Kenai River near river kilometer 31 and marked with radio transmitters, August 11 through September 30, 1999.

Order of Capture	Fate Code	Experimental Fate[a]	Tag Number	Capture Date	Capture Time	Capture Bank	Mid Eye - Fork Length (mm)	Days to Enter Recapture Reach[b]
1	F07	Upstreamer	00001	8/11	21:00	N	530	
2	F06	Upstreamer	00002	8/11	21:20	N	480	14.5
3	F10	Downstreamer	00003	8/12	7:30	N	473	
4	F18	Downstreamer	00004	8/12	12:05	S	553	
5	F06	Upstreamer	00005	8/12	19:30	N	565	2.6
6	F10	Downstreamer	00006	8/12	19:43	N	610	
7	F06	Upstreamer	00007	8/12	23:25	N	646	1.6
8	F10	Downstreamer	00008	8/13	9:10	N	547	
9	F10	Downstreamer	00009	8/13	9:19	N	595	
10	F10	Downstreamer	00010	8/13	9:40	N	580	
11	F10	Downstreamer	00011	8/13	15:15	N	645	
12	F10	Downstreamer	00012	8/13	15:55	N	650	
13	F10	Downstreamer	00013	8/13	16:05	N	625	
14	F10	Downstreamer	00014	8/13	19:29	N	577	
15	F18	Downstreamer	00015	8/14	11:00	N	556	
16	F10	Downstreamer	00016	8/14	11:10	N	464	
17	F10	Downstreamer	00017	8/14	11:20	N	584	
18	F18	Downstreamer	00018	8/14	17:30	N	650	
19	F10	Downstreamer	00019	8/14	17:50	N	660	
20	F07	Upstreamer	00020	8/14	18:05	S	625	0.9
21	F06	Upstreamer	00021	8/14	21:00	N	600	4.5
22	F18	Downstreamer	00022	8/14	21:10	N	560	
23	F06	Upstreamer	00023	8/14	21:20	N	594	
24	F18	Downstreamer	00024	8/14	22:15	N	563	
25	F08	Upstreamer	00025	8/14	22:25	N	572	
26	F06	Upstreamer	00026	8/15	2:17	N	575	1.6
27	F06	Upstreamer	00027	8/15	2:25	N	576	13.7
28	F18	Downstreamer	00028	8/15	2:40	N	583	
29	F10	Downstreamer	00029	8/15	3:00	S	587	
30	F06	Upstreamer	00030	8/15	5:22	N	595	5.7
31	F06	Upstreamer	00031	8/15	7:13	N	555	4.3
32	F06	Upstreamer	00032	8/15	14:30	N	564	1.8
33	F10	Downstreamer	00033	8/15	14:45	N	540	
34	F10	Downstreamer	00034	8/15	14:55	N	610	
35	F10	Downstreamer	00035	8/15	15:00	N	566	
36	F06	Upstreamer	00036	8/15	15:16	S	671	1.7
37	F07	Upstreamer	00037	8/15	17:50	N	544	1.0
38	F06	Upstreamer	00038	8/15	18:00	N	560	3.1
39	F18	Downstreamer	00039	8/15	18:10	N	610	
40	F06	Upstreamer	00040	8/15	18:17	N	553	3.9
41	F10	Downstreamer	00041	8/15	18:25	N	559	
42	F06	Upstreamer	00042	8/15	19:30	N	525	5.2
43	F06	Upstreamer	00043	8/16	9:14	N	597	0.5
44	F07	Upstreamer	00044	8/16	10:00	S	600	
45	F10	Downstreamer	00045	8/16	17:05	S		
46	F10	Downstreamer	00046	8/17	7:15	N	626	
47	F10	Downstreamer	00047	8/17	9:31	S	405	
48	F10	Downstreamer	00048	8/17	18:55	S	637	
49	F06	Upstreamer	00049	8/17	19:05	S	586	3.0
50	F10	Downstreamer	00051	8/17	19:13	S	623	
51	F07	Upstreamer	00052	8/18	9:48	S	586	8.3
52	F06	Upstreamer	00053	8/18	10:44	S	527	3.9
53	F09	Censored	00054	8/18	13:02	S	566	
54	F10	Downstreamer	00055	8/19	4:01	N	567	
55	F10	Downstreamer	00056	8/19	7:15	S	566	
56	F07	Upstreamer	00057	8/19	16:00	N	571	
57	F10	Downstreamer	00058	8/20	7:41	S	509	
58	F06	Upstreamer	00059	8/20	9:15	S	577	0.3
59	F07	Upstreamer	00060	8/20	16:55	S	519	4.7
60	F06	Upstreamer	00061	8/21	7:33	N	615	2.8
61	F10	Downstreamer	00062	8/21	15:13	N	561	
62	F10	Downstreamer	00063	8/21	15:20	N	624	
63	F06	Upstreamer	00064	8/22	6:15	N	479	2.4
64	F10	Downstreamer	00065	8/22	9:48	N	608	
65	F06	Upstreamer	00066	8/22	18:10	S	623	3.1
66	F06	Upstreamer	00067	8/23	7:34	S	574	
67	F06	Upstreamer	00068	8/23	16:30	S	579	3.9
68	F06	Upstreamer	00069	8/23	16:40	S	570	3.1
69	F10	Downstreamer	00070	8/24	5:58	S	582	
70	F06	Upstreamer	00071	8/24	8:33	N	606	1.4
71	F06	Upstreamer	00072	8/25	5:21	N	545	0.7
72	F06	Upstreamer	00073	8/25	9:05	S	544	2.9
73	F18	Downstreamer	00074	8/25	18:05	S	600	
74	F07	Upstreamer	00075	8/25	18:15	S	583	0.9
75	F07	Upstreamer	00076	8/26	10:03	S	542	5.0
76	F10	Downstreamer	00077	8/26	10:12	S	385	
77	F10	Downstreamer	00078	8/26	17:55	S	583	
78	F10	Downstreamer	00079	8/27	8:23	N	629	
79	F06	Upstreamer	00080	8/27	15:45	S	512	2.7
80	F06	Upstreamer	00081	8/27	15:50	S	655	1.6
81	F18	Downstreamer	00082	8/28	8:10	S	545	
82	F10	Downstreamer	00083	8/28	8:18	S	508	
83	F07	Upstreamer	00084	8/28	16:15	S	632	6.0
84	F06	Upstreamer	00085	8/29	6:33	N	607	1.3
85	F06	Upstreamer	00086	8/29	18:05	N	631	3.7
86	F10	Downstreamer	00088	8/29	21:45	S	524	
87	F06	Upstreamer	00089	8/30	6:50	N	611	1.5
88	F10	Downstreamer	00090	8/30	7:09	S	581	
89	F07	Upstreamer	00091	8/30	17:10	N	582	
90	F10	Downstreamer	00092	8/30	17:15	N	598	
91	F06	Upstreamer	00093	8/31	6:55	N	597	0.6
92	F10	Downstreamer	00094	8/31	14:50	S	560	
93	F06	Upstreamer	00095	9/1	8:15	S	584	1.3
94	F10	Downstreamer	00097	9/1	10:28	N	558	
95	F06	Upstreamer	00096	9/1	19:05	S	516	3.7
96	F06	Upstreamer	00098	9/2	7:05	S	667	3.3
97	F10	Downstreamer	00099	9/2	19:25	N	511	
98	F10	Downstreamer	00100	9/2	19:40	S	566	
99	F06	Upstreamer	00101	9/3	8:42	S	537	
100	F10	Downstreamer	00102	9/4	10:35	S	586	
101	F10	Downstreamer	00103	9/4	11:19	N	544	
102	F06	Upstreamer	00104	9/6	19:30	S	553	3.0
103	F06	Upstreamer	00105	9/6	22:30	S	529	1.5
104	F06	Upstreamer	00106	9/7	7:47	N	543	4.3

Order of Capture	Fate Code	Experimental Fate[1]	Tag Number	Capture Date	Capture Time	Capture Bank	Mid Eye - Fork Length (mm)	Days to Enter Recapture Reach[2]
105	F10	Downstreamer	00107	9/7	21:45	S	594	
106	F06	Upstreamer	00108	9/8	9:40	N	517	7.9
107	F06	Upstreamer	00109	9/8	18:20	N	501	1.7
108	F06	Upstreamer	00110	9/8	21:39	N	622	3.7
109	F06	Upstreamer	00111	9/9	10:25	N	522	3.2
110	F06	Upstreamer	00112	9/10	4:07	N	585	0.2
111	F09	Censored	00113	9/10	7:29	N	494	
112	F06	Upstreamer	00114	9/11	11:55	N	572	1.5
113	F10	Downstreamer	00115	9/12	9:50	N	462	
114	F06	Upstreamer	00116	9/12	22:40	N	666	0.6
115	F06	Upstreamer	00117	9/12	22:45	N	576	0.6
116	F06	Upstreamer	00118	9/13	18:40	N	651	1.0
117	F06	Upstreamer	00119	9/13	18:45	N	555	0.9
118	F10	Downstreamer	00120	9/13	22:00	N	584	
119	F06	Upstreamer	00121	9/13	22:05	N	597	1.4
120	F10	Downstreamer	00122	9/14	7:52	N	588	
121	F06	Upstreamer	00123	9/14	7:58	N	477	
122	F10	Downstreamer	00124	9/14	8:06	N	648	
123	F06	Upstreamer	00125	9/14	17:50	N	592	1.0
124	F07	Upstreamer	00126	9/14	18:08	N	582	
125	F10	Downstreamer	00127	9/14	18:19	N	549	
126	F06	Upstreamer	00128	9/14	18:33	N	617	0.9
127	F06	Upstreamer	00129	9/14	18:45	N	546	0.8
128	F06	Upstreamer	00130	9/14	20:33	N	634	0.6
129	F10	Downstreamer	00131	9/14	20:45	N	561	
130	F06	Upstreamer	00132	9/15	7:35	N	543	0.6
131	F06	Upstreamer	00133	9/15	18:35	S	580	3.8
132	F06	Upstreamer	00134	9/15	20:28	N	533	
133	F06	Upstreamer	00135	9/15	20:40	N	568	2.0
134	F10	Downstreamer	00136	9/16	7:13	N	462	
135	F06	Upstreamer	00137	9/16	17:20	N	572	1.7
136	F08	Upstreamer	00139	9/17	8:40	N	556	
137	F06	Upstreamer	00138	9/17	19:58	N	531	0.6
138	F10	Downstreamer	00140	9/17	23:30	N	626	
139	F10	Downstreamer	00141	9/17	23:35	N	612	
140	F10	Downstreamer	00142	9/18	18:00	N	608	
141	F10	Downstreamer	00143	9/18	18:05	N	619	
142	F08	Upstreamer	00144	9/18	18:10	N	559	
143	F06	Upstreamer	00145	9/19	4:35	N	616	3.5
144	F10	Downstreamer	00146	9/19	17:05	N	632	
145	F06	Upstreamer	00147	9/19	17:10	N	585	1.7
146	F06	Upstreamer	00148	9/20	8:21	N	618	3.2
147	F06	Upstreamer	00149	9/20	17:15	N	612	2.0
148	F06	Upstreamer	00150	9/20	17:20	N	608	
149	F18	Downstreamer	00151	9/21	15:58	N	563	
150	F06	Upstreamer	00152	9/21	16:06	N	554	0.8
151	F06	Upstreamer	00153	9/21	16:19	N	562	1.8
152	F10	Downstreamer	00154	9/22	16:23	N	581	
153	F06	Upstreamer	00155	9/22	16:42	N	602	3.1
154	F06	Upstreamer	00156	9/22	16:57	N	473	4.5
155	F06	Upstreamer	00157	9/23	15:40	N	622	2.1
156	F06	Upstreamer	00158	9/23	15:50	N	625	2.0
157	F06	Upstreamer	00159	9/23	19:40	N	562	3.7
158	F06	Upstreamer	00160	9/24	13:45	N	626	1.9
159	F06	Upstreamer	00161	9/24	22:30	N	650	
160	F06	Upstreamer	00162	9/24	22:35	N	536	1.5
161	F06	Upstreamer	00163	9/25	8:00	N	659	2.1
162	F06	Upstreamer	00164	9/25	18:40	N	625	0.7
163	F06	Upstreamer	00165	9/25	18:50	N	570	1.8
164	F06	Upstreamer	00166	9/25	22:40	N	605	0.9
165	F10	Downstreamer	00167	9/25	22:50	N	632	
166	F06	Upstreamer	00168	9/26	19:45	N	616	0.7
167	F06	Upstreamer	00169	9/26	19:50	N	522	1.0
168	F06	Upstreamer	00170	9/26	23:40	N	603	2.8
169	F06	Upstreamer	00171	9/26	23:45	N	497	1.6
170	F07	Upstreamer	00172	9/26	23:50	N	508	0.6
171	F06	Upstreamer	00173	9/27	9:10	N	575	0.3
172	F10	Downstreamer	00174	9/27	19:00	N	597	
173	F09	Censored	00175	9/27	19:05	N	592	
174	F06	Upstreamer	00176	9/27	19:10	N		1.6
175	F06	Upstreamer	00177	9/28	11:19	N	614	0.3
176	F09	Censored	00178	9/28	11:41	N	646	
177	F07	Upstreamer	00179	9/28	21:30	N	560	0.7
178	F10	Downstreamer	00180	9/28	22:03	N	565	
179	F10	Downstreamer	00181	9/28	22:15	N	645	
180	F09	Censored	00182	9/28	22:23	N	580	
181	F06	Upstreamer	00183	9/29	17:20	N	635	0.8
182	F06	Upstreamer	00184	9/29	17:35	N	610	0.7
183	F06	Upstreamer	00185	9/29	17:49	N	612	0.8
184	F10	Downstreamer	00186	9/29	18:04	N	620	
185	F06	Upstreamer	00187	9/29	20:40	N	645	0.7
186	F06	Upstreamer	00189	9/29	21:07	N	513	0.7
187	F06	Upstreamer	00190	9/30	23:50	N	560	0.8
							Median Days	1.7

a Experimental fate relative to the mark-recpature expereiment and the recapture reach. "Downstreamers" moved downstream after markinig and never returned to approach or enter the recapture reach while "upstreamers" moved upstream into the recapture reach

b Days elapsed between capture and entry into the recapture reach as detected by the fixed telemetry station at the lower boundary of the recapture reach. Missing values are due to non-detection by telemetry station or inability of automated data querie

Appendix E2.–Capture history and fates assigned to 205 coho salmon captured from the Kenai River near river kilometer 45 and marked with radio transmitters, August 2 through October 6, 2000.

Order of Capture	Fate	Experimental Fate[a]	Tag Number	Capture Date	Capture Time	Capture Bank	Fork Length (mm)	Days to Enter Recapture Reach[b]	Order of Capture	Fate	Experimental Fate[1]	Tag Number	Capture Date	Capture Time	Capture Bank	Fork Length (mm)	Days to Enter Recapture Reach[2]
1	F10	Downstreamer	00201	08/02	8:20	N	700		105	F06	Upstreamer	00815	09/01	21:19	N	670	5.9
2	F06	Upstreamer	00202	08/02	12:30	N	660	7.3	106	F06	Upstreamer	00886	09/02	12:10	S	790	20.2
3	F06	Upstreamer	00203	08/02	15:05	N	700	4.5	107	F06	Upstreamer	00896	09/02	17:53	N	660	
4	F06	Upstreamer	00204	08/03	8:45	S	660	1.4	108	F06	Upstreamer	00897	09/02	20:47	S	640	
5	F10	Downstreamer	00205	08/03	11:31	N	600		109	F06	Upstreamer	00873	09/03	8:45	N	700	
6	F06	Upstreamer	00206	08/03	11:39	N	700		110	F06	Upstreamer	00874	09/03	13:25	N	610	1.1
7	F06	Upstreamer	00207	08/03	14:45	N	570	2.6	111	F06	Upstreamer	00845	09/03	15:25	N	740	5.3
8	F10	Downstreamer	00209	08/03	19:20	N	680		112	F06	Upstreamer	00846	09/04	8:38	N	670	4.5
9	F06	Upstreamer	00210	08/03	21:05	N	760	2.6	113	F07	Upstreamer	00847	09/04	9:52	N	740	
10	F10	Downstreamer	00211	08/04	9:22	N	660		114	F06	Upstreamer	00848	09/04	12:25	S	640	
11	F06	Upstreamer	00212	08/04	11:07	S	640	4.6	115	F06	Upstreamer	00849	09/05	10:55	N	650	
12	F06	Upstreamer	00214	08/05	8:05	N	740	10.2	116	F06	Upstreamer	00850	09/05	12:55	N	720	4.3
13	F10	Downstreamer	00215	08/05	13:49	N	660		117	F06	Upstreamer	00851	09/05	16:40	N	690	4.1
14	F07	Upstreamer	00218	08/06	8:25	N	650	5.4	118	F06	Upstreamer	00852	09/06	9:37	N	550	
15	F10	Downstreamer	00219	08/06	8:30	N	660		119	F06	Upstreamer	00853	09/06	10:54	N	760	
16	F10	Downstreamer	00220	08/06	12:13	S	690		120	F06	Upstreamer	00854	09/06	13:26	N	690	5.4
17	F10	Downstreamer	00286	08/06	16:43	N	680		121	F06	Upstreamer	00855	09/06	17:25	N	710	1.1
18	F06	Upstreamer	00287	08/07	8:56	N	640	4.7	122	F06	Upstreamer	00856	09/07	8:19	N	740	1.3
19	F10	Downstreamer	00288	08/07	12:17	N	620		123	F06	Upstreamer	00858	09/07	17:45	S	730	9.2
20	F10	Downstreamer	00289	08/07	18:30	S	650		124	F06	Upstreamer	00860	09/07	19:44	S	670	3.8
21	F06	Upstreamer	00221	08/08	8:03	N	650	4.4	125	F06	Upstreamer	00861	09/08	8:15	N	750	
22	F06	Upstreamer	00223	08/08	14:50	S	720	9.1	126	F10	Downstreamer	00863	09/08	11:55	S	720	
23	F06	Upstreamer	00224	08/08	17:25	N	620		127	F06	Upstreamer	00866	09/08	20:03	N	690	
24	F06	Upstreamer	00226	08/08	19:56	N	680	3.7	128	F06	Upstreamer	00865	09/08	21:42	N	650	
25	F06	Upstreamer	00227	08/09	7:49	N	640	2.3	129	F06	Upstreamer	00864	09/09	9:45	N	660	12.9
26	F06	Upstreamer	00228	08/09	12:06	N	700	4.1	130	F10	Downstreamer	00820	09/09	13:15	S	690	
27	F06	Upstreamer	00229	08/09	15:20	N	680	4.9	131	F06	Upstreamer	00821	09/09	13:30	S	850	2.1
28	F07	Upstreamer	00230	08/09	21:10	N	580	1.1	132	F10	Downstreamer	00841	09/09	16:53	S	610	
29	F10	Downstreamer	00231	08/10	8:19	N	600		133	F06	Upstreamer	00819	09/09	22:15	S	720	2.9
30	F06	Upstreamer	00232	08/10	12:28	N	700	4.2	134	F06	Upstreamer	00869	09/10	10:35	S	660	2.5
31	F06	Upstreamer	00233	08/10	15:15	N	640	1.2	135	F06	Upstreamer	00868	09/10	10:40	S	710	
32	F06	Upstreamer	00234	08/10	19:40	N	670	4.1	136	F06	Upstreamer	00872	09/10	10:45	S	640	1.3
33	F06	Upstreamer	00235	08/11	7:40	N	750	1.6	137	F10	Downstreamer	00859	09/10	10:55	S	760	
34	F06	Upstreamer	00236	08/11	15:30	N	620		138	F06	Upstreamer	00870	09/11	9:15	S	590	
35	F06	Upstreamer	00237	08/11	20:41	N	690		139	F06	Upstreamer	00857	09/11	13:35	S	760	
36	F06	Upstreamer	00238	08/12	7:48	N	690		140	F06	Upstreamer	00822	09/11	15:08	S	710	6.3
37	F06	Upstreamer	00239	08/12	10:40	N	570	2.2	141	F10	Downstreamer	00823	09/12	9:30	N	640	
38	F10	Downstreamer	00240	08/12	12:00	N	660		142	F06	Upstreamer	00824	09/12	10:15	S	740	2.3
39	F06	Upstreamer	00242	08/12	16:00	N	660	12.2	143	F06	Upstreamer	00826	09/12	16:38	N	690	
40	F06	Upstreamer	00243	08/12	21:36	N	700	5.1	144	F06	Upstreamer	00895	09/13	9:20	N	610	
41	F10	Downstreamer	00244	08/13	9:20	N	650		145	F06	Upstreamer	00875	09/13	13:17	N	750	2.1
42	F10	Downstreamer	00245	08/13	15:00	N			146	F06	Upstreamer	00889	09/13	16:27	S	700	
43	F06	Upstreamer	00247	08/13	16:00	S		1.2	147	F06	Upstreamer	00827	09/14	9:00	N	720	
44	F10	Downstreamer	00248	08/14	8:12	N	680		148	F06	Upstreamer	00829	09/14	14:38	N	680	3.2
45	F10	Downstreamer	00249	08/14	11:18	N	710		149	F06	Upstreamer	00830	09/14	16:46	N	720	
46	F06	Upstreamer	00250	08/15	7:50	N	660	15.5	150	F06	Upstreamer	00832	09/15	8:22	N	580	1.4
47	F06	Upstreamer	00251	08/15	7:56	N	650		151	F06	Upstreamer	00833	09/15	11:06	N	810	
48	F06	Upstreamer	00252	08/15	10:33	N	660	1.4	152	F06	Upstreamer	00834	09/15	20:20	N	720	
49	F06	Upstreamer	00253	08/15	10:37	N	720	3.4	153	F06	Upstreamer	00876	09/16	13:00	S	740	5.8
50	F07	Upstreamer	00254	08/15	16:50	N	520	4.0	154	F06	Upstreamer	00879	09/16	13:10	S	700	1.3
51	F06	Upstreamer	00255	08/16	8:35	N	660	1.5	155	F10	Downstreamer	00877	09/16	13:35	N	610	
52	F06	Upstreamer	00256	08/17	12:00	N	700	5.1	156	F06	Upstreamer	00882	09/17	11:20	S	590	2.4
53	F06	Upstreamer	00257	08/17	13:42	S	550		157	F06	Upstreamer	00880	09/17	11:30	S	730	
54	F06	Upstreamer	00258	08/17	15:08	N	720	7.8	158	F06	Upstreamer	00881	09/17	15:45	N	710	
55	F06	Upstreamer	00259	08/17	20:34	N	640		159	F06	Upstreamer	00825	09/18	11:50	N	710	
56	F06	Upstreamer	00260	08/17	21:34	N	660	2.3	160	F06	Upstreamer	00831	09/18	12:03	N	680	1.4
57	F06	Upstreamer	00261	08/18	7:27	N	640	2.4	161	F06	Upstreamer	00835	09/18	12:28	N	730	3.2
58	F06	Upstreamer	00262	08/18	11:47	N	690		162	F06	Upstreamer	00836	09/19	10:00	S	790	4.2
59	F06	Upstreamer	00263	08/18	21:41	N	670	0.7	163	F06	Upstreamer	00837	09/19	10:17	N	630	0.5
60	F06	Upstreamer	00264	08/19	11:52	S	610	2.6	164	F06	Upstreamer	00839	09/19	10:22	N	700	
61	F06	Upstreamer	00265	08/19	15:50	N	650		165	F06	Upstreamer	00840	09/20	9:14	S	730	1.3
62	F06	Upstreamer	00266	08/19	18:51	N	720		166	F06	Upstreamer	00842	09/20	9:21	N	660	
63	F06	Upstreamer	00267	08/20	8:01	N	660	2.7	167	F06	Upstreamer	00843	09/20	13:23	S	680	1.3
64	F06	Upstreamer	00268	08/20	16:37	N	690	4.9	168	F10	Downstreamer	00878	09/21	8:28	S	720	
65	F06	Upstreamer	00269	08/20	21:21	N	630	0.9	169	F06	Upstreamer	00884	09/21	8:30	S	640	
66	F06	Upstreamer	00270	08/21	15:05	N	600		170	F10	Downstreamer	00885	09/21	10:14	S	760	
67	F06	Upstreamer	00271	08/21	15:23	N	740		171	F06	Upstreamer	00887	09/21	11:51	N	700	1.2
68	F10	Downstreamer	00272	08/21	18:17	N	670		172	F06	Upstreamer	00888	09/22	7:47	S	590	
69	F06	Upstreamer	00273	08/21	19:35	N	660	0.9	173	F06	Upstreamer	00890	09/22	8:02	N	680	0.3
70	F06	Upstreamer	00274	08/22	9:56	N	680	8.7	174	F06	Upstreamer	00891	09/22	8:30	S	770	

-continued-

Appendix E2.–Page 2 of 2.

Order of Capture	Fate	Experimental Fate[a]	Tag Number	Capture Date	Capture Time	Capture Bank	Fork Length (mm)	Days to Enter Recapture Reach[b]
71	F06	Upstreamer	00275	08/22	11:36	N	570	13.5
72	F06	Upstreamer	00277	08/22	15:46	N	660	
73	F06	Upstreamer	00276	08/22	19:29	N	760	24.2
74	F06	Upstreamer	00278	08/23	13:48	N	720	3.3
75	F10	Downstreamer	00279	08/23	17:49	S	650	
76	F06	Upstreamer	00280	08/23	19:22	N	610	1.0
77	F06	Upstreamer	00281	08/23	20:22	N	680	1.0
78	F06	Upstreamer	00282	08/24	8:23	N	700	4.2
79	F06	Upstreamer	00283	08/24	8:36	N	620	
80	F06	Upstreamer	00284	08/24	13:28	N	640	
81	F06	Upstreamer	00285	08/24	17:59	N	670	2.8
82	F06	Upstreamer	00291	08/25	9:30	N	650	
83	F06	Upstreamer	00292	08/25	9:54	N	780	8.9
84	F06	Upstreamer	00293	08/25	10:43	N	630	2.1
85	F06	Upstreamer	00294	08/26	9:35	N	700	
86	F10	Downstreamer	00295	08/26	13:45	S	650	
87	F06	Upstreamer	00296	08/26	17:48	N	560	11.0
88	F06	Upstreamer	00297	08/26	21:00	N	670	3.8
89	F06	Upstreamer	00298	08/27	9:11	N	620	
90	F06	Upstreamer	00299	08/27	17:29	N	710	1.0
91	F06	Upstreamer	00290	08/27	21:25	N	680	2.7
92	F06	Upstreamer	00800	08/28	8:17	N	690	
93	F06	Upstreamer	00801	08/28	8:47	N	530	2.4
94	F06	Upstreamer	00802	08/29	7:23	N	810	2.7
95	F06	Upstreamer	00803	08/29	7:57	N	590	1.2
96	F06	Upstreamer	00804	08/29	8:43	N	680	
97	F06	Upstreamer	00805	08/29	9:20	N	650	2.3
98	F06	Upstreamer	00806	08/30	7:04	N	730	0.8
99	F06	Upstreamer	00807	08/30	8:00	N	600	2.5
100	F10	Downstreamer	00808	08/30	8:58	N	680	
101	F06	Upstreamer	00812	08/31	9:22	N	730	
102	F06	Upstreamer	00813	08/31	9:48	N	580	2.2
103	F10	Downstreamer	00809	09/01	12:13	N	720	
104	F10	Downstreamer	00814	09/01	13:18	N	590	

Order of Capture	Fate	Experimental Fate[1]	Tag Number	Capture Date	Capture Time	Capture Bank	Fork Length (mm)	Days to Enter Recapture Reach[2]
175	F06	Upstreamer	00892	09/22	12:23	S	730	
176	F10	Downstreamer	00893	09/23	13:45	S	740	
177	F06	Upstreamer	00894	09/23	14:00	S	660	
178	F07	Upstreamer	00737	09/23	15:37	N	710	
179	F06	Upstreamer	00738	09/23	18:50	N	690	
180	F06	Upstreamer	00741	09/24	13:15	N	680	
181	F06	Upstreamer	00740	09/24	14:32	N	730	
182	F06	Upstreamer	00739	09/24	14:44	N	790	2.1
183	F06	Upstreamer	00743	09/25	12:38	N	750	
184	F06	Upstreamer	00745	09/25	12:41	N	660	
185	F10	Downstreamer	00744	09/25	12:45	N	700	
186	F06	Upstreamer	00746	09/25	14:38	N	710	
187	F06	Upstreamer	00747	09/25	14:55	S	600	
188	F06	Upstreamer	00748	09/26	9:10	N	710	
189	F06	Upstreamer	00749	09/26	9:13	N	680	
190	F06	Upstreamer	00752	09/27	14:44	S	670	
191	F10	Downstreamer	00753	09/27	14:52	S	730	
192	F09	Censored	00754	09/27	14:57	S	690	
193	F06	Upstreamer	00755	09/27	16:29	N	750	
194	F06	Upstreamer	00750	09/28	10:44	N	710	
195	F06	Upstreamer	00751	09/28	10:47	N	740	
196	F06	Upstreamer	00756	09/28	14:47	N	690	
197	F06	Upstreamer	00760	09/29	10:10	S	710	
198	F06	Upstreamer	00758	09/29	19:22	N	750	
199	F10	Downstreamer	00786	10/03	11:15	N	810	
200	F06	Upstreamer	00788	10/03	11:19	N	690	
201	F06	Upstreamer	00789	10/03	11:24	N	840	
202	F06	Upstreamer	00782	10/04	13:43	N	740	
203	F10	Downstreamer	00781	10/04	21:45	S	590	
204	F06	Upstreamer	00783	10/05	10:26	N	730	
205	F06	Upstreamer	00784	10/06	18:20	N	760	
							Median Days	2.7

[a] Experimental fate relative to the mark-recpature expereiment and the recapture reach. "Downstreamers" moved downstream after markinig and never returned to approach or enter the recapture reach while "upstreamers" moved upstream into the recapture reach

[b] Days elapsed between capture and entry into the recapture reach as detected by the fixed telemetry station at the lower boundary of the recapture reach. Missing values are due to non-detection by telemetry station or inability of automated data querie

Appendix E3.–Capture history and fates assigned to 200 coho salmon captured from the Kenai River near river kilometer 45 and marked with radio transmitters, August 3 through September 30, 2001.

Order of Capture	Fate Code	Experimental Fate[a]	Tag Number	Capture Date	Capture Time	Capture Bank	Fork Length (mm)	Days to Enter Recapture Reach[b]
1	F06	Upstreamer	00601	08/03	16:30	N	630	1.1
2	F06	Upstreamer	00602	08/03	19:00	S	650	1.8
3	F06	Upstreamer	00603	08/03	21:15	S	620	2.5
4	F06	Upstreamer	00604	08/04	11:01	N	710	2.2
5	F10	Downstreamer	00605	08/04	13:26	N	530	
6	F06	Upstreamer	00606	08/04	19:00	N	595	3.0
7	F06	Upstreamer	00607	08/05	7:33	S	640	5.0
8	F10	Downstreamer	00608	08/05	13:00	S	700	
9	F10	Downstreamer	00609	08/05	18:45	S	560	
10	F08	Upstreamer	00610	08/06	11:32	N	700	
11	F06	Upstreamer	00611	08/06	13:10	S	525	1.9
12	F06	Upstreamer	00612	08/06	17:34	S	690	8.7
13	F06	Upstreamer	00613	08/07	9:15	N	630	3.5
14	F10	Downstreamer	00614	08/07	12:20	S	635	
15	F06	Upstreamer	00615	08/07	20:00	S	720	6.9
16	F10	Downstreamer	00616	08/08	10:32	N	635	
17	F10	Downstreamer	00617	08/08	13:20	S	655	
18	F18	Downstreamer	00618	08/08	20:37	S	670	
19	F10	Downstreamer	00619	08/09	11:00	N	670	
20	F10	Downstreamer	00620	08/09	11:45	S	610	
21	F06	Upstreamer	00621	08/09	19:42	N	660	0.9
22	F06	Upstreamer	00622	08/10	10:50	N	705	3.3
23	F06	Upstreamer	00623	08/10	11:25	S	685	2.6
24	F06	Upstreamer	00624	08/10	19:35	N	680	0.9
25	F06	Upstreamer	00625	08/11	7:57	N	560	1.1
26	F18	Downstreamer	00626	08/11	13:35	N	510	
27	F06	Upstreamer	00627	08/11	17:13	N	670	15.8
28	F19	Upstreamer	00628	08/11	17:30	S	640	
29	F06	Upstreamer	00629	08/12	12:23	S	570	
30	F10	Downstreamer	00633	08/12	17:40	S	600	
31	F10	Downstreamer	00634	08/12	17:45	S	645	
32	F06	Upstreamer	00630	08/12	17:50	S	585	
33	F10	Downstreamer	00631	08/12	18:05	N	490	
34	F06	Upstreamer	00632	08/12	18:10	N	575	1.9
35	F07	Upstreamer	00635	08/13	8:20	S	570	1.4
36	F06	Upstreamer	00636	08/13	8:45	S	590	0.7
37	F06	Upstreamer	00637	08/13	9:38	S	520	4.9
38	F06	Upstreamer	00641	08/13	17:35	S	640	
39	F06	Upstreamer	00642	08/13	20:43	N	560	3.0
40	F10	Downstreamer	00643	08/13	21:45	N	630	
41	F06	Upstreamer	00638	08/14	8:32	N	650	
42	F06	Upstreamer	00639	08/14	8:42	N	640	3.5
43	F06	Upstreamer	00640	08/14	10:36	N	640	3.7
44	F10	Downstreamer	00644	08/14	15:45	N		
45	F06	Upstreamer	00645	08/14	16:30	N		1.8
46	F06	Upstreamer	00646	08/14	20:15	N		16.7
47	F06	Upstreamer	00647	08/15	7:34	S	650	3.1
48	F07	Upstreamer	00648	08/15	8:36	N	690	
49	F10	Downstreamer	00649	08/15	11:28	N	590	
50	F06	Upstreamer	00650	08/15	18:37	S	470	2.0
51	F18	Downstreamer	00651	08/16	8:55	N	710	
52	F07	Upstreamer	00652	08/16	17:07	S	570	10.0
53	F06	Upstreamer	00653	08/17	9:50	S	650	3.9
54	F06	Upstreamer	00654	08/17	17:29	S	470	0.6
55	F10	Downstreamer	00655	08/18	7:38	S	470	
56	F07	Upstreamer	00656	08/18	10:27	S	630	0.2
57	F06	Upstreamer	00657	08/18	20:45	S	720	2.6
58	F06	Upstreamer	00658	08/19	7:28	N	600	1.6
59	F06	Upstreamer	00659	08/19	12:58	S	640	
60	F06	Upstreamer	00660	08/19	17:32	S	710	7.0
61	F06	Upstreamer	00661	08/20	8:30	S	600	1.2
62	F06	Upstreamer	00662	08/20	12:30	N	690	0.8
63	F06	Upstreamer	00663	08/20	15:03	N	660	5.7
64	F06	Upstreamer	00664	08/21	8:55	S	640	2.1
65	F06	Upstreamer	00665	08/21	13:05	S	690	1.3
66	F06	Upstreamer	00666	08/21	18:50	S	660	1.6
67	F10	Downstreamer	00667	08/21	21:00	S	560	
68	F06	Upstreamer	00668	08/22	7:29	S	672	1.3
69	F06	Upstreamer	00669	08/22	13:41	S	520	1.3
70	F09	Censored	00670	08/22	17:58	S	680	
71	F06	Upstreamer	00671	08/22	20:25	S	630	10.8
72	F06	Upstreamer	00672	08/23	10:18	S	600	4.4
73	F10	Downstreamer	00673	08/23	11:01	N	650	
74	F10	Downstreamer	00674	08/23	12:02	S	660	
75	F06	Upstreamer	00675	08/23	20:57	S	690	0.7
76	F06	Upstreamer	00676	08/24	10:50	S	700	7.9
77	F06	Upstreamer	00677	08/24	11:27	N	620	8.1
78	F06	Upstreamer	00678	08/24	20:01	S	540	2.8
79	F06	Upstreamer	00679	08/24	20:37	N	660	1.6
80	F06	Upstreamer	00680	08/25	10:20	N	650	2.4
81	F18	Downstreamer	00681	08/25	12:18	S	660	
82	F10	Downstreamer	00682	08/25	19:49	S	700	
83	F10	Downstreamer	00683	08/25	20:22	N	600	
84	F06	Upstreamer	00684	08/26	7:02	N	660	1.1
85	F06	Upstreamer	00685	08/26	8:25	S	700	1.4
86	F06	Upstreamer	00686	08/26	18:50	S	580	3.1
87	F06	Upstreamer	00687	08/26	19:01	S	640	1.0
88	F06	Upstreamer	00688	08/27	7:21	S	660	2.5
89	F06	Upstreamer	00689	08/27	21:02	S	590	12.8
90	F10	Downstreamer	00690	08/27	21:06	S	700	
91	F06	Upstreamer	00691	08/28	12:18	S	650	2.0
92	F07	Upstreamer	00692	08/28	12:56	N	710	10.8
93	F06	Upstreamer	00693	08/28	20:52	S	590	0.9
94	F06	Upstreamer	00694	08/29	13:24	S	660	1.2
95	F06	Upstreamer	00695	08/29	20:15	S	730	2.0
96	F06	Upstreamer	00696	08/29	21:02	N	610	0.9
97	F06	Upstreamer	00701	08/30	10:02	S	590	2.2
98	F06	Upstreamer	00702	08/30	20:51	S	650	4.4
99	F10	Downstreamer	00703	08/31	9:43	S	640	
100	F06	Upstreamer	00704	08/31	20:01	N	690	5.7
101	F06	Upstreamer	00697	09/01	9:16	S	680	0.4
102	F18	Downstreamer	00698	09/01	16:27	S	600	
103	F06	Upstreamer	00699	09/01	16:40	S	660	7.0
104	F06	Upstreamer	00700	09/02	11:39	S	710	0.3
105	F06	Upstreamer	00705	09/02	12:12	S	590	0.3
106	F06	Upstreamer	00706	09/02	18:58	S	670	0.6
107	F06	Upstreamer	00707	09/03	10:20	S	690	2.9
108	F06	Upstreamer	00708	09/03	12:42	S	540	0.9
109	F06	Upstreamer	00709	09/03	21:33	S	670	1.6
110	F10	Downstreamer	00710	09/04	10:30	S	530	
111	F06	Upstreamer	00711	09/04	10:35	S	790	2.1
112	F06	Upstreamer	00712	09/04	21:13	S	640	0.6
113	F06	Upstreamer	00713	09/05	13:30	N	670	2.2
114	F06	Upstreamer	00714	09/05	13:40	S	710	
115	F07	Upstreamer	00715	09/05	20:40	S	750	8.9
116	F07	Upstreamer	00716	09/06	8:12	S	770	3.4
117	F06	Upstreamer	00717	09/06	9:56	S	640	0.4
118	F06	Upstreamer	00719	09/06	16:44	S	670	4.1
119	F06	Upstreamer	00718	09/07	8:33	N	630	0.5
120	F06	Upstreamer	00720	09/07	9:12	N	780	0.4
121	F06	Upstreamer	00721	09/07	11:42	S	600	1.1
122	F06	Upstreamer	00722	09/07	14:46	S	670	1.0
123	F06	Upstreamer	00723	09/07	19:08	S	550	1.1
124	F06	Upstreamer	00724	09/08	11:47	N	660	1.8
125	F07	Upstreamer	00725	09/08	12:20	S	720	2.0
126	F06	Upstreamer	00726	09/08	16:45	S	530	0.7
127	F06	Upstreamer	00727	09/08	16:54	S	670	0.8
128	F06	Upstreamer	00728	09/09	9:24	S	770	1.9
129	F06	Upstreamer	00729	09/09	11:48	S	670	1.3
130	F06	Upstreamer	00730	09/09	17:40	S	610	1.9
131	F06	Upstreamer	00731	09/09	17:47	S	670	2.8
132	F10	Downstreamer	00732	09/10	11:03	S	750	
133	F06	Upstreamer	00733	09/10	17:10	N	690	0.2
134	F07	Upstreamer	00734	09/10	19:28	S	590	5.9
135	F07	Upstreamer	00735	09/10	21:22	S	640	0.6
136	F06	Upstreamer	00736	09/11	12:05	N	640	0.3
137	F06	Upstreamer	00737	09/11	15:00	N	620	0.9
138	F06	Upstreamer	00738	09/11	21:00	N	730	0.7
139	F06	Upstreamer	00739	09/12	9:55	S	660	1.2
140	F10	Downstreamer	00740	09/12	18:05	N	700	
141	F06	Upstreamer	00741	09/12	21:25	N	560	1.6
142	F10	Downstreamer	00742	09/13	11:15	N	710	
143	F06	Upstreamer	00743	09/13	16:55	N	600	0.7
144	F06	Upstreamer	00744	09/13	19:20	N	660	5.7
145	F10	Downstreamer	00745	09/14	10:18	N	770	
146	F07	Upstreamer	00746	09/14	17:35	N	610	9.9
147	F06	Upstreamer	00747	09/14	19:50	N	650	0.9
148	F06	Upstreamer	00748	09/15	8:54	S	760	0.4
149	F06	Upstreamer	00749	09/15	13:52	N	620	1.1
150	F06	Upstreamer	00750	09/15	18:25	N	670	4.1
151	F10	Downstreamer	00751	09/16	10:37	N	670	
152	F06	Upstreamer	00752	09/16	10:52	S	610	1.0
153	F10	Downstreamer	00753	09/16	20:43	N	750	
154	F06	Upstreamer	00754	09/17	10:18	N	630	0.4
155	F10	Downstreamer	00755	09/17	15:55	N	780	
156	F06	Upstreamer	00756	09/17	20:47	S	680	1.8
157	F10	Downstreamer	00757	09/18	9:45	S	600	
158	F07	Upstreamer	00758	09/18	12:45	N	670	1.0
159	F06	Upstreamer	00759	09/18	15:16	S	750	1.0
160	F06	Upstreamer	00760	09/19	13:30	N	700	5.1
161	F06	Upstreamer	00761	09/19	13:36	N	680	2.2
162	F06	Upstreamer	00762	09/20	9:11	N	670	0.9
163	F06	Upstreamer	00763	09/20	11:45	N	640	7.9
164	F06	Upstreamer	00764	09/20	11:55	S	700	1.9
165	F06	Upstreamer	00765	09/20	21:24	N	640	0.7
166	F06	Upstreamer	00766	09/21	10:58	N	710	10.9
167	F06	Upstreamer	00767	09/21	15:12	S	700	2.7
168	F06	Upstreamer	00768	09/21	15:15	S	650	0.7
169	F06	Upstreamer	00769	09/21	18:09	S	570	1.7
170	F10	Downstreamer	00770	09/22	9:10	S	700	
171	F10	Downstreamer	00771	09/22	9:13	S	630	
172	F06	Upstreamer	00772	09/22	16:15	N	720	0.8
173	F06	Upstreamer	00773	09/23	9:06	N	730	5.1
174	F06	Upstreamer	00774	09/23	9:19	S	630	1.3
175	F06	Upstreamer	00775	09/23	16:34	N	690	0.7
176	F06	Upstreamer	00776	09/23	16:50	S	650	4.0
177	F06	Upstreamer	00777	09/23	16:56	S	650	5.9
178	F06	Upstreamer	00778	09/24	9:07	N	740	1.0
179	F06	Upstreamer	00779	09/24	9:21	S	680	1.1
180	F06	Upstreamer	00780	09/24	18:04	N	660	1.0
181	F06	Upstreamer	00781	09/24	21:41	S	670	0.9
182	F06	Upstreamer	00782	09/25	9:02	N	740	0.3
183	F10	Downstreamer	00783	09/25	9:11	S	530	
184	F06	Upstreamer	00784	09/25	14:33	S	620	0.8
185	F18	Downstreamer	00785	09/25	21:28	N	660	
186	F06	Upstreamer	00786	09/26	10:12	N	650	3.0
187	F06	Upstreamer	00787	09/26	10:16	N	810	4.2
188	F06	Upstreamer	00788	09/26	19:35	N	680	0.7
189	F06	Upstreamer	00789	09/27	10:49	N	690	2.3
190	F06	Upstreamer	00790	09/27	10:54	N	730	0.3
191	F06	Upstreamer	00791	09/28	10:18	S	720	0.3
192	F10	Downstreamer	00792	09/28	12:39	S	690	
193	F06	Upstreamer	00793	09/28	12:47	S	620	1.0
194	F06	Upstreamer	00794	09/28	18:25	S	660	1.9
195	F06	Upstreamer	00795	09/29	9:40	N	690	0.4
196	F07	Upstreamer	00796	09/29	9:54	S	650	0.2
197	F06	Upstreamer	00797	09/29	22:10	S	710	1.5
198	F10	Downstreamer	00798	09/30	11:41	N	710	
199	F06	Upstreamer	00799	09/30	15:59	N	660	7.9
200	F06	Upstreamer	00800	09/30	18:39	N	720	0.8
							Median Days	1.7

a Experimental fate relative to the mark-recpature expereiment and the recapture reach. "Downstreamers" moved downstream after markinig and never returned to approach or enter the recapture reach while "upstreamers" moved upstream into the recapture reach

b Days elapsed between capture and entry into the recapture reach as detected by the fixed telemetry station at the lower boundary of the recapture reach. Missing values are due to non-detection by telemetry station or inability of automated data querie

Appendix E4.–Capture history and fates assigned to 122 coho salmon captured from the Kenai River near river kilometer 45 and marked with radio transmitters, August 2 through September 30, 2002.

Order of Capture	Fate Code	Experimental Fate[a]	Tag Number	Capture Date	Capture Time	Capture Bank	Fork Length (mm)	Days to Enter Recapture Reach[b]
1	F10	Downstreamer	00801	08/02	15:09	S	650	
2	F06	Upstreamer	00802	08/04	13:20	S	550	2.1
3	F06	Upstreamer	00803	08/04	14:59	S	650	0.8
4	F06	Upstreamer	00805	08/05	9:20	S	650	3.2
5	F06	Upstreamer	00806	08/05	18:00	S	600	0.7
6	F06	Upstreamer	00808	08/06	9:45	S	610	0.5
7	F10	Downstreamer	00807	08/06	18:00	S	630	
8	F10	Downstreamer	00809	08/07	9:31	S	600	
9	F06	Upstreamer	00810	08/07	16:03	S	630	
10	F06	Upstreamer	00811	08/08	12:00	S	580	
11	F06	Upstreamer	00812	08/08	21:10	S	720	3.9
12	F06	Upstreamer	00813	08/09	12:12	S	650	5.3
13	F06	Upstreamer	00814	08/09	19:54	S	530	7.4
14	F06	Upstreamer	00815	08/10	13:05	S	670	14.1
15	F06	Upstreamer	00816	08/10	17:33	S	600	11.0
16	F06	Upstreamer	00817	08/10	20:10	S	640	3.7
17	F06	Upstreamer	00818	08/11	9:42	S	580	2.3
18	F06	Upstreamer	00819	08/11	11:43	S	550	1.3
19	F06	Upstreamer	00820	08/11	18:07	S	640	4.1
20	F06	Upstreamer	00821	08/11	20:24	S	730	19.7
21	F06	Upstreamer	00822	08/12	9:31	S	570	13.4
22	F06	Upstreamer	00823	08/13	12:22	S	580	1.2
23	F07	Upstreamer	00824	08/13	15:37	S	470	0.8
24	F10	Downstreamer	00825	08/13	17:51	N	690	
25	F08	Upstreamer	00826	08/14	7:14	S	620	
26	F06	Upstreamer	00827	08/14	18:00	S	680	2.8
27	F08	Upstreamer	00828	08/14	20:58	S	600	
28	F06	Upstreamer	00829	08/15	11:25	S	700	7.4
29	F06	Upstreamer	00830	08/15	20:02	S	600	
30	F10	Downstreamer	00831	08/15	20:21	S	630	
31	F06	Upstreamer	00832	08/16	12:36	S	680	0.4
32	F06	Upstreamer	00833	08/16	15:49	S	610	3.0
33	F06	Upstreamer	00834	08/17	13:24	S	600	0.2
34	F06	Upstreamer	00836	08/17	19:42	S	640	3.8
35	F06	Upstreamer	00835	08/18	7:28	S	670	3.2
36	F06	Upstreamer	00837	08/18	17:46	S	570	5.4
37	F06	Upstreamer	00838	08/19	7:51	S	590	1.7
38	F06	Upstreamer	00839	08/19	21:02	S	700	2.8
39	F06	Upstreamer	00840	08/20	8:04	S	540	4.4
40	F06	Upstreamer	00841	08/20	17:37	S	680	5.0
41	F06	Upstreamer	00842	08/21	12:13	S	670	1.8
42	F07	Upstreamer	00843	08/21	19:55	N	580	5.0
43	F06	Upstreamer	00845	08/22	13:08	N	610	3.2
44	F06	Upstreamer	00846	08/22	16:08	N	800	3.1
45	F06	Upstreamer	00847	08/23	9:20	S	630	2.3
46	F06	Upstreamer	00848	08/23	17:04	N	650	2.0
47	F06	Upstreamer	00849	08/24	7:40	S	740	3.4
48	F06	Upstreamer	00850	08/24	17:07	N	610	1.9
49	F06	Upstreamer	00851	08/25	7:34	N	670	1.0
50	F06	Upstreamer	00852	08/25	20:07	S	620	0.9
51	F06	Upstreamer	00853	08/26	12:36	N	600	4.2
52	F06	Upstreamer	00854	08/26	16:23	S	660	1.2
53	F06	Upstreamer	00855	08/27	13:05	S	670	1.0
54	F10	Downstreamer	00856	08/27	15:29	S	590	
55	F06	Upstreamer	00857	08/28	10:01	S	670	4.1
56	F10	Downstreamer	00858	08/28	16:34	N	600	
57	F06	Upstreamer	00859	08/29	11:20	N	720	4.2
58	F10	Downstreamer	00860	08/29	15:11	N	620	
59	F06	Upstreamer	00864	08/30	11:56	N	550	28.3
60	F10	Downstreamer	00865	08/30	21:03	S	630	
61	F06	Upstreamer	00866	08/31	8:19	N	690	2.5

Order of Capture	Fate Code	Experimental Fate[1]	Tag Number	Capture Date	Capture Time	Capture Bank	Fork Length (mm)	Days to Enter Recapture Reach[2]
62	F06	Upstreamer	00867	08/31	20:11	N	640	10.0
63	F06	Upstreamer	00868	09/01	12:07	N	650	
64	F18	Downstreamer	00869	09/01	21:09	N	740	
65	F06	Upstreamer	00870	09/02	13:09	N	640	1.2
66	F06	Upstreamer	00871	09/02	14:54	N	700	3.9
67	F06	Upstreamer	00872	09/03	12:15	N	720	2.9
68	F10	Downstreamer	00873	09/03	16:49	S	610	
69	F06	Upstreamer	00874	09/04	13:33	N	670	2.1
70	F06	Upstreamer	00875	09/04	20:06	N	520	2.3
71	F06	Upstreamer	00876	09/05	8:24	N	520	5.6
72	F06	Upstreamer	00877	09/05	18:06	S	800	0.6
73	F07	Upstreamer	00878	09/06	12:12	N	630	4.6
74	F06	Upstreamer	00880	09/06	20:30	N	710	0.8
75	F06	Upstreamer	00879	09/07	11:18	N	690	1.3
76	F06	Upstreamer	00881	09/07	20:16	S	640	
77	F06	Upstreamer	00882	09/08	16:20	S	620	1.1
78	F06	Upstreamer	00883	09/08	20:49	S	690	0.9
79	F10	Downstreamer	00884	09/09	13:12	N	700	
80	F06	Upstreamer	00885	09/09	20:34	N	630	2.6
81	F06	Upstreamer	00886	09/10	9:39	S	720	1.2
82	F06	Upstreamer	00887	09/10	21:06	N	650	1.0
83	F06	Upstreamer	00888	09/11	13:27	S	650	
84	F06	Upstreamer	00889	09/11	16:10	N	760	2.0
85	F06	Upstreamer	00890	09/12	8:42	N	670	2.0
86	F10	Downstreamer	00891	09/12	16:02	S	710	
87	F06	Upstreamer	00893	09/13	11:35	N	660	0.9
88	F18	Downstreamer	00894	09/13	16:01	N	640	
89	F06	Upstreamer	00895	09/14	9:28	N	670	1.1
90	F06	Upstreamer	00896	09/14	17:25	N	730	3.6
91	F06	Upstreamer	00897	09/15	8:07	S	710	4.3
92	F06	Upstreamer	00898	09/15	16:43	S	650	0.8
93	F06	Upstreamer	00899	09/16	11:21	N	620	3.6
94	F06	Upstreamer	00900	09/16	18:17	N	730	3.9
95	F06	Upstreamer	00902	09/17	11:58	N	720	0.8
96	F06	Upstreamer	00903	09/17	19:46	N	600	1.7
97	F06	Upstreamer	00905	09/18	7:48	N	680	1.3
98	F07	Upstreamer	00906	09/18	20:55	N	670	0.9
99	F10	Downstreamer	00907	09/19	14:57	N	650	
100	F06	Upstreamer	00908	09/19	19:30	N	710	0.7
101	F06	Upstreamer	00909	09/20	13:23	N	640	
102	F06	Upstreamer	00910	09/20	17:11	N	730	
103	F06	Upstreamer	00912	09/21	10:01	N	700	
104	F06	Upstreamer	00913	09/21	20:11	S	720	0.8
105	F06	Upstreamer	00914	09/22	9:10	N	770	0.3
106	F06	Upstreamer	00915	09/22	15:08	N	640	3.9
107	F06	Upstreamer	00916	09/23	10:06	S	710	0.2
108	F18	Downstreamer	00917	09/23	16:45	N	720	
109	F06	Upstreamer	00918	09/24	8:38	N	640	2.4
110	F06	Upstreamer	00919	09/24	20:14	N	710	
111	F06	Upstreamer	00920	09/25	10:02	N	670	0.2
112	F06	Upstreamer	00921	09/25	19:25	N	710	4.3
113	F06	Upstreamer	00922	09/26	12:04	N	670	1.2
114	F06	Upstreamer	00923	09/26	20:13	S	710	0.6
115	F06	Upstreamer	00924	09/27	12:17	N	690	1.0
116	F07	Upstreamer	00925	09/27	16:29	S	660	0.8
117	F10	Downstreamer	00926	09/28	13:15	S	680	
118	F06	Upstreamer	00928	09/28	17:08	N	710	0.8
119	F06	Upstreamer	00929	09/29	12:30	N	690	0.3
120	F07	Upstreamer	00911	09/29	18:24	S	700	1.8
121	F10	Downstreamer	00892	09/30	9:05	N	630	
122	F06	Upstreamer	00901	09/30	19:27	N	740	0.9
							Median Days	2.1

a Experimental fate relative to the mark-recpature expereiment and the recapture reach. "Downstreamers" moved downstream after markinig and never returned to approach or enter the recapture reach while "upstreamers" moved upstream into the recapture reach

b Days elapsed between capture and entry into the recapture reach as detected by the fixed telemetry station at the lower boundary of the recapture reach. Missing values are due to non-detection by telemetry station or inability of automated data querie

Appendix E5.–Capture history and fates assigned to 122 coho salmon captured from the Kenai River near river kilometer 45 and marked with radio transmitters, August 6 through September 30, 2003.

Order of Capture	Fate Code	Experimental Fate[a]	Tag Number	Capture Date	Capture Time	Capture Bank	Fork Length (mm)	Days to Enter Recapture Reach[b]
1	F06	Upstreamer	01000	08/06	17:03	S	595	13.8
2	F10	Downstreamer	01001	08/06	19:35	S	645	
3	F06	Upstreamer	01002	08/06	19:59	S	485	
4	F10	Downstreamer	01003	08/06	20:38	S	600	
5	F06	Upstreamer	01004	08/07	9:10	S	680	1.9
6	F10	Downstreamer	01005	08/07	13:51	N	490	
7	F10	Downstreamer	01006	08/07	15:18	S	650	
8	F06	Upstreamer	01007	08/07	15:20	S	680	
9	F06	Upstreamer	01008	08/07	15:29	S	620	
10	F06	Upstreamer	01009	08/07	16:59	S	610	7.1
11	F10	Downstreamer	01010	08/07	17:23	S	600	
12	F06	Upstreamer	01011	08/07	17:46	S	650	18.6
13	F06	Upstreamer	01012	08/07	19:29	S	530	1.5
14	F06	Upstreamer	01013	08/07	19:35	S	660	
15	F09	Censored	01014	08/08	15:05	S	550	
16	F07	Upstreamer	01015	08/08	17:27	N	650	
17	F06	Upstreamer	01016	08/09	8:48	S	650	
18	F06	Upstreamer	01017	08/09	19:33	S	585	
19	F08	Upstreamer	01018	08/10	8:19	S	680	
20	F10	Downstreamer	01019	08/10	17:36	S	605	
21	F06	Upstreamer	01020	08/11	11:29	S	690	
22	F06	Upstreamer	01021	08/11	20:25	S	550	
23	F06	Upstreamer	01022	08/12	12:18	S	580	
24	F06	Upstreamer	01023	08/12	15:04	S	650	
25	F06	Upstreamer	01024	08/13	12:58	S	600	
26	F07	Upstreamer	01025	08/13	15:24	S	640	8.1
27	F06	Upstreamer	01026	08/14	12:06	S	700	
28	F06	Upstreamer	01027	08/14	20:19	S	590	
29	F10	Downstreamer	01028	08/15	9:47	S	630	
30	F06	Upstreamer	01029	08/15	14:59	S	580	
31	F06	Upstreamer	01030	08/16	10:08	S	650	
32	F06	Upstreamer	01031	08/16	21:03	S	590	
33	F06	Upstreamer	01032	08/17	10:25	S	630	
34	F06	Upstreamer	01033	08/17	16:10	S	600	16.0
35	F06	Upstreamer	01034	08/18	9:00	S	660	8.0
36	F08	Upstreamer	01035	08/18	18:55	S	590	
37	F06	Upstreamer	01036	08/19	8:50	S	650	
38	F06	Upstreamer	01037	08/19	17:28	S	580	
39	F06	Upstreamer	01038	08/20	9:18	S	610	
40	F06	Upstreamer	01039	08/20	19:37	S	620	
41	F06	Upstreamer	01040	08/21	9:07	S	570	
42	F06	Upstreamer	01041	08/21	14:45	S	640	4.1
43	F09	Censored	01042	08/22	13:17	N	600	
44	F06	Upstreamer	01043	08/22	16:49	S	710	
45	F06	Upstreamer	01044	08/23	8:30	N	670	
46	F06	Upstreamer	01045	08/23	19:59	S	600	17.3
47	F06	Upstreamer	01046	08/24	10:09	S	600	
48	F06	Upstreamer	01047	08/24	19:36	S	690	1.5
49	F06	Upstreamer	01048	08/25	9:40	S	650	0.9
50	F06	Upstreamer	01049	08/25	14:58	S	620	
51	F06	Upstreamer	01050	08/26	10:07	S	590	
52	F09	Censored	01051	08/26	15:57	S	700	
53	F06	Upstreamer	01052	08/27	8:59	S	660	6.3
54	F06	Upstreamer	01053	08/27	18:26	S	700	5.9
55	F06	Upstreamer	01054	08/28	12:23	S	670	
56	F06	Upstreamer	01055	08/28	14:50	S	650	
57	F06	Upstreamer	01056	08/29	9:41	S	530	
58	F06	Upstreamer	01057	08/29	15:20	S	700	
59	F06	Upstreamer	01058	08/30	9:05	S	690	
60	F06	Upstreamer	01059	08/30	17:10	S	590	
61	F10	Downstreamer	01060	08/31	13:15	S	630	
62	F18	Downstreamer	01063	09/01	8:12	S	650	
63	F06	Upstreamer	01061	09/01	12:16	S	650	1.1
64	F06	Upstreamer	01062	09/01	14:52	S	630	0.9
65	F07	Upstreamer	01064	09/02	11:50	S	690	
66	F06	Upstreamer	01065	09/02	14:46	S	650	
67	F06	Upstreamer	01066	09/03	8:31	S	700	14.5
68	F06	Upstreamer	01067	09/03	17:41	S	620	21.0
69	F10	Downstreamer	01068	09/04	8:48	S	740	
70	F06	Upstreamer	01069	09/04	19:59	N	640	
71	F06	Upstreamer	01070	09/05	12:13	S	560	
72	F06	Upstreamer	01071	09/05	16:25	S	650	
73	F06	Upstreamer	01072	09/06	13:09	S	570	3.5
74	F06	Upstreamer	01073	09/06	19:47	S	650	
75	F09	Censored	01074	09/07	13:38	N	640	
76	F06	Upstreamer	01075	09/08	15:28	S	640	
77	F06	Upstreamer	01076	09/08	21:16	S	710	1.2
78	F06	Upstreamer	01077	09/09	9:00	S	690	0.7
79	F06	Upstreamer	01078	09/09	9:04	S	580	
80	F06	Upstreamer	01079	09/09	15:39	S	660	
81	F06	Upstreamer	01080	09/10	9:37	S	630	7.0
82	F06	Upstreamer	01081	09/10	17:14	N	730	
83	F06	Upstreamer	01082	09/11	13:30	N	700	
84	F06	Upstreamer	01083	09/11	19:16	N	590	
85	F06	Upstreamer	01085	09/12	8:46	S	700	6.8
86	F06	Upstreamer	01084	09/12	12:59	N	560	
87	F06	Upstreamer	01086	09/13	10:32	S	660	
88	F06	Upstreamer	01088	09/14	10:40	S	700	
89	F06	Upstreamer	01087	09/14	16:22	N	600	
90	F06	Upstreamer	01089	09/14	16:30	N	580	
91	F06	Upstreamer	01090	09/15	18:39	N	640	1.1
92	F10	Downstreamer	01091	09/15	21:00	N	660	
93	F06	Upstreamer	01092	09/16	10:35	N	750	8.3
94	F06	Upstreamer	01093	09/16	21:12	N	630	0.8
95	F06	Upstreamer	01094	09/17	8:08	N	490	0.9
96	F06	Upstreamer	01095	09/17	16:52	N	700	
97	F06	Upstreamer	01096	09/22	20:54	S	640	1.0
98	F06	Upstreamer	01097	09/22	21:00	S	590	1.8
99	F06	Upstreamer	01099	09/23	7:50	S	690	
100	F06	Upstreamer	01100	09/23	7:57	S	640	1.2
101	F06	Upstreamer	01101	09/23	8:05	S	670	
102	F06	Upstreamer	01102	09/23	8:15	S	660	
103	F06	Upstreamer	01098	09/23	8:30	N	610	1.4
104	F06	Upstreamer	01103	09/23	10:10	S	650	1.3
105	F06	Upstreamer	01104	09/23	18:08	S	660	0.8
106	F06	Upstreamer	01105	09/23	18:13	S	670	
107	F06	Upstreamer	01106	09/24	13:22	S	690	
108	F18	Downstreamer	01107	09/24	17:48	S	640	
109	F10	Downstreamer	01108	09/24	20:49	S	700	
110	F06	Upstreamer	01109	09/25	19:55	N	770	
111	F06	Upstreamer	01110	09/25	20:05	S	630	
112	F06	Upstreamer	01111	09/26	18:32	S	670	
113	F06	Upstreamer	01112	09/26	21:21	N	670	
114	F06	Upstreamer	01113	09/27	11:50	N	640	
115	F06	Upstreamer	01114	09/27	19:44	N	700	
116	F06	Upstreamer	01115	09/28	20:35	N	690	
117	F06	Upstreamer	01116	09/29	10:28	S	690	
118	F10	Downstreamer	01117	09/29	11:45	S	610	
119	F09	Censored	01119	09/29	16:06	S	650	
120	F06	Upstreamer	01120	09/29	20:48	N	700	
121	F06	Upstreamer	01118	09/30	11:44	S	670	0.2
122	F07	Upstreamer	01121	09/30	16:44	S	650	
							Median Days	1.9

a Experimental fate relative to the mark-recpature expereiment and the recapture reach. "Downstreamers" moved downstream after markinig and never returned to approach or enter the recapture reach while "upstreamers" moved upstream into the recapture reach

b Days elapsed between capture and entry into the recapture reach as detected by the fixed telemetry station at the lower boundary of the recapture reach. Missing values are due to non-detection by telemetry station or inability of automated data querie