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Inriver Abundance and Distribution of Spawning Susitna River Sockeye Salmon *Oncorhynchus nerka*, 2006

by

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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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INRIVER ABUNDANCE AND DISTRIBUTION OF SPAWNING SUSITNA RIVER SOCKEYE SALMON *ONCORHYNCHUS NERKA*, 2006

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ABSTRACT

The escapement of sockeye salmon *Oncorhynchus nerka* to the Susitna River is not well known. The Susitna River sockeye salmon stock is managed based on a combined sonar and fish wheel escapement estimate at river kilometer (rkm) 7 on the Yentna River, a major tributary of the Susitna River. During 1999-2005, Yentna River sockeye salmon escapement estimates were below the sustainable escapement goal 5 of 7 years. In 2006, capture-recapture experiments using passive integrated transponder (PIT) tags, fish wheels, and weirs were conducted to estimate sockeye salmon escapement in the entire Susitna River independent of the combined sonar and fish wheel estimate. Radiotelemetry was used primarily to identify spawning areas throughout the Susitna River drainage, and was also used to estimate sockeye salmon abundance. Three abundance estimates of sockeye salmon ≥400 mm (mideye-to-fork length) passing Sunshine (on the mainstem Susitna River at rkm 116) derived for the entire season were 93,161, 107,000, and 128,105 fish. The abundance estimate of 107,000 fish (95% CI = 49,180-164,820) passing Sunshine, based on Flathorn (Susitna River at rkm 31) PIT-tag releases, had the most evidence for meeting the abundance model conditions, and was not significantly different ($P = 0.65$) from the estimate of 93,161 fish (95% CI = 80,053-106,268) based on radio tags recovered at Larson and Byers lakes. The third estimate could not be statistically compared because the variation could not be accurately quantified. Two abundance estimates of sockeye salmon ≥400 mm (mideye-to-fork length) were derived for the Yentna River at rkm 7: 417,750 fish (95% CI = 261,930-573,570) for 29 July onward based on PIT tags and 311,197 fish (95% CI = 252,000-391,000) for the entire season based on radio tags. The two estimates could not be statistically compared because the time periods were different. The Yentna abundance estimate using PIT tags had the most evidence for meeting the abundance model conditions, but it still had weaknesses. The counts from four weirs in the Yentna River drainage showed that the true sockeye salmon abundance in the Yentna River was at least 126,218 fish, so the Yentna sonar and fish wheel estimate of 92,896 fish in 2006 was biased low. The terminal distribution of radio-tagged sockeye salmon suggests that most fish spawned in major lake systems and the remainder in various tributaries without lakes throughout the Susitna River drainage. Radio-tag tracking showed no sockeye salmon spawning downstream of Yentna or Sunshine in 2006. Recommendations for 2007 include estimating sockeye salmon abundance using only radio tags, deploying them from Yentna and Sunshine, and using weirs on the major lakes as the recapture locations.

Key words: sockeye salmon, *Oncorhynchus nerka*, Susitna River, Yentna River, escapement, abundance, capture-recapture, fish wheel, weir, radiotelemetry, passive integrated transponder (PIT) tag

INTRODUCTION

The Susitna River sockeye salmon *Oncorhynchus nerka* run is a major contributor to the sockeye salmon run in Upper Cook Inlet (UCI). Management of the Susitna River sockeye salmon run is based on a combined sonar-fish wheel estimate of the escapement to the Yentna River, a tributary that is a major producer of sockeye salmon (Shields 2007; Westerman and Willette. 2007). The sockeye salmon escapement to the entire Susitna River drainage is estimated to be 1.95 times the Yentna escapement (Tobias and Willette 2004). The basis for this expansion factor is a combination of capture-recapture estimates of the sockeye salmon passing Sunshine (Susitna River at river kilometer (rkm) 116) and sonar-fish wheel estimates of the sockeye salmon passing Yentna (Yentna River, rkm 7) and Susitna Station (Susitna River, rkm 37) during 1981-1985 (Fox 1998). The current sustainable escapement goal of 90,000-160,000 for Yentna River sockeye salmon was set by the Alaska Department of Fish and Game (ADF&G) in 2002 (Hasbrouck and Edmundson. 2007).

Between 1999 and 2005, estimated sockeye salmon escapements were below the sustainable escapement goal 5 of 7 years. As a result, ADF&G, with participation from the Cook Inlet Aquaculture Association (CIAA), decided to estimate the sockeye salmon escapement in the entire Susitna River drainage in 2006 using capture-recapture techniques that were independent of the sonar-fish wheel estimate. The independent escapement estimate may allow: (1) estimation of the total annual run of Susitna River sockeye salmon when escapement estimates and genetics-based, stock-separation catch estimates are combined, (2) evaluation of the accuracy of the Yentna River sockeye salmon sonar-fish wheel estimate, and (3) proportional estimates of the Yentna River contribution to the entire Susitna River sockeye escapement.

There were two primary objectives for this study in 2006. The first objective was to estimate the inriver abundance of adult sockeye salmon (escapement) migrating upstream of Flathorn (Susitna River, rkm 31), Yentna, and Sunshine using capture-recapture experiments (Figure 1). The second objective was to identify sockeye salmon spawning areas in the Susitna River drainage using radiotelemetry.

STUDY AREA

The Susitna River drainage comprises 49,210 km^2 and originates in the Alaska Range north of Anchorage (Figure 1). It flows generally south from the Alaska Range for approximately 400 km before entering UCI west of Anchorage. There are three major tributaries within the drainage and numerous sockeye salmon nursery lakes. The largest tributaries are the Yentna, Chulitna, and Talkeetna rivers. Most of the sockeye salmon produced within the Talkeetna drainage are thought to come from Larson and Stephan lakes. Numerous small lakes contribute to sockeye salmon production in the Chulitna drainage, but Byers Lake is thought to have the greatest production potential (King and Walker 1997). The Yentna drainage has at least 12 lakes known to support sockeye salmon, of which Chelatna, Shell, Hewitt, and Judd are thought to provide the most production potential (King and Walker 1997).

METHODS

Two-event capture-recapture experiments were used to estimate the abundance of adult sockeye salmon (Seber 1982). The experimental design allowed abundance estimates to be generated for the entire Susitna drainage, the mainstem Susitna drainage only, or only the Yentna drainage, through the combination of three marking strata and four recapture strata:

	Marking Strata	Recapture Strata	Abundance Model
1	Flathorn fish wheels	Yentna and Sunshine fish wheels	Pooled or stratified estimate for entire Susitna drainage
2	Flathorn fish wheels	Weirs in the upper Yentna and mainstem Susitna drainages	Pooled or stratified estimate for entire Susitna drainage
3	Yentna fish wheels	Weirs in the Yentna drainage	Pooled or stratified estimate for Yentna drainage summed with 4 below to estimate entire Susitna drainage
4	Sunshine fish wheels	Weirs in the mainstem Susitna drainage	Pooled or stratified estimate for mainstem Susitna drainage summed with 3 above to estimate entire Susitna drainage

MARK EVENTS-PIT TAGS

Four fish wheels at Flathorn were operated daily from 3 July through 17 August 2006 (Table 1), with operating times distributed throughout each day. One fish wheel was operated on each bank of the two channels at the Flathorn site (Figure 2). Each fish wheel was operated with a picket weir to direct migrating salmon offshore and into the fish wheel. Each fish wheel had 2x2-m baskets that were adjusted as needed to fish ≤0.3 m from the river bottom.

All uninjured sockeye salmon ≥400 mm (mideye-to-fork (MEF) length) captured at Flathorn were injected with a 7-mm passive integrated transponder (PIT, manufactured by BioMark™) tag, had their adipose fin removed (to identify PIT-tagged fish), were measured MEF length, had their sex determined by inspection of external characteristics, and then released. Scales for age determination and an axillary process for genetic stock identification were also taken from a subsample of captured sockeye salmon. The results of the genetic stock identification are reported in Habicht et al. (2007). PIT-tag codes were collected using a Destron Fearing 2001F tag reader. All other salmon species captured in the fish wheels were counted and released.

Two fish wheels were operated at both Yentna (the location of the sonar site) and Sunshine, one on each bank (Figure 1). Fish wheels were operated daily at Yentna from 7 July through 18 August and at Sunshine from 8 July through 18 August. Picket weirs were operated at both fish wheels for the entire season at Yentna, and one weir was operated for part of the season at Sunshine (Table 1). Sampling shifts at both sites were scheduled so that breaks did not exceed 4 hours, and the start times of the shifts systematically rotated so that all times of day were sampled over the course of each week. The fish wheels at Yentna and Sunshine were used to recapture fish marked at Flathorn. In addition, a subsample of unmarked sockeye salmon ≥400 mm MEF length received a PIT tag, an upper left operculum punch, was measured MEF length, and had their sex determined by inspection of external characteristics. Scales for age determination and an axillary process for genetic stock identification were also taken from a subsample of captured sockeye. Sockeye salmon released without PIT tags at the Yentna and Sunshine fish wheels received an upper right operculum punch to allow detection of fish that held downstream of the wheels while recovering, and thus were subject to duplicate sampling. PIT-tag codes were collected using a Destron Fearing 2001F tag reader. All other salmon species captured in the fish wheels were counted and released.

Whenever possible, sockeye salmon were taken immediately out of the fish wheel live box, tagged, and released. Fish wheels were checked and any sockeye salmon captured were tagged at least every 2 hours at Flathorn, and every 30 minutes at Sunshine and Yentna during sampling shifts. All efforts were made to minimize capture and handling-induced stress. When sampling shifts were done the fish wheels were stopped to avoid holding-induced mortality.

RADIO-TAG DEPLOYMENT

There were 250 sockeye salmon marked with PIT tags and inserted with radio transmitters: 100 at Flathorn and 75 each at Yentna and Sunshine. At each site, the number of radio tags applied each day was determined preseason based on the historical sockeye salmon run timing, as measured by fish wheel catch on both banks combined. At Yentna, the pre-determined number of radio tags applied on a given day was apportioned between banks (north and south) in proportion to the previous day's bank-specific fish wheel catch, irrespective of time, sex, or size on each bank. At Flathorn and Sunshine, the pre-determined number of radio tags applied on a given day were applied to every *n*th fish, where *n* was equal to the previous day's total sockeye salmon catch divided by the total number of tags to deploy on the current day, irrespective of bank, fish wheel, sex, or size.

Radio transmitters used were manufactured by Advanced Telemetry Systems, Inc. (ATS) and operated on several frequencies within the 151.000 to 151.999 MHz range. Each frequency had several different transmitting patterns ("pulse codes"), resulting in 250 uniquely-identifiable transmitters. The transmitters were 42x17 mm, cylinder-shaped, equipped with a 30-cm antenna, and weighed 14 g in air. The minimum battery life of the transmitters was 90 days. Each transmitter was equipped with an activity monitor as a mortality indicator. The activity monitor changed the signal pattern to an inactive mode (Eiler 1995) if the transmitter was inactive for 4 hours.

The radio tag was inserted through the fish's mouth into the stomach using a plastic tube (0.7-cm diameter) until the tag was no longer visible. The fish were not anesthetized during tag insertion and were immediately released after processing. Small sockeye salmon (<400 mm MEF length) were not radio tagged.

Every fish with a radio tag also received a PIT tag, was measured MEF length, had its sex determined from external characteristics, received a secondary mark (adipose finclip at Flathorn or an upper left operculum punch at Yentna and Sunshine), and had its left axillary process removed and preserved for genetic analysis.

Recovery Events-Flathorn PIT Tags at Yentna and Sunshine

The number of marked and unmarked sockeye salmon examined at Yentna and Sunshine were recorded each time the fish wheel live boxes were checked. If a secondary mark from the Flathorn marking event (adipose finclip) was observed, the fish was scanned for a PIT tag and examined for a radio tag (i.e., an antenna protruding from the mouth).

Between 28 July and 11 August, mid-channel and nearshore drift gillnetting was conducted at Sunshine and Yentna to determine the relative abundance of sockeye salmon in these areas. Successive drifts were made in sampling lanes at specified distances from shore. Monofilament drift gillnets were 9 to 27-m long and 5 to 10-m deep, with 11.88-cm stretch mesh.

Recovery Events-PIT Tags at Weirs

CIAA counted sockeye salmon passing through weirs at Chelatna, Hewitt, Shell, and Judd lakes in the Yentna drainage, and Byers and Larson lakes in the mainstem Susitna drainage (Figure 1). Automated, electronic, PIT-tag detection and recording systems were set up to scan all fish for PIT tags at the Chelatna, Judd, and Larson lake weirs using rectangular 30x50-cm PIT-tag antennas affixed to the upstream gate on the live box at each weir. Hand-held PIT-tag detection systems were used at Hewitt, Shell, and Byers lakes.

At weirs with automated PIT-tag detection systems, the PIT-tag readers were maintained and tag detection tests were conducted each day during operation. Prior to counting each day, tag detection tests were conducted to estimate the PIT-tag detection rate at the weir. Detection tests consisted of passing 50 PIT tags contained in plastic vials through an antenna twice per day (100 tests per day). The vials were filled with water such that they were neutrally buoyant and would naturally move through all regions of the detection field.

At Hewitt, Shell, and Byers lakes, a dip net was used to examine a sample of fish that passed upstream of the weir. Fish with secondary marks (adipose finclips from Flathorn and upper left operculum punches from Yentna and Sunshine) were examined with a hand-held PIT-tag detector to obtain the PIT-tag number.

MEF length, scale (age determination), sex, and secondary mark information were collected from fish samples passing through each weir. Trap loads or dip net loads of fish were sampled systematically at each weir. An axillary process was also collected for genetic stock identification.

RADIO-TAG RELOCATION

Radio-tagged sockeye salmon movement upriver was tracked at 11 remote tracking stations and by aerial surveys throughout the Susitna River drainage. Tracking stations were placed along primary travel corridors on the mainstem Susitna River and major tributaries (Table 2; Figure 3). Tracking station equipment consisted of an ATS Model 4500 receiver and data logger, a satellite uplink (Campbell Scientific, Logan, Utah), and a self-contained power system. The equipment was housed in an enclosure and attached to a 9-m mast.

An ATS Model 200 antenna switch was coupled with two antennas at each tracking station. One antenna was oriented downstream, and the other upstream. Signal strength and time of reception were recorded separately for each antenna and provided information on direction of travel. "Reference" radio tags were continuously detected at each station to assure proper station operation. Information was recorded at 10-minute intervals.

The ATS receiver detected radio-tagged fish and recorded signal strength, activity pattern of the transmitter (active or inactive), date, time, and location of each fish in relation to the station (i.e., upriver or downriver from the site). Radio-tagged fish were considered to have passed a tracking station when the recorded signal strength indicated the transition from the downriver antenna to the upriver antenna. The first tracking stations were located approximately 5 km upriver from the tagging sites.

Migration rates for radio-tagged sockeye salmon were calculated using the date and time fish passed between tracking stations. Fish tracked to terminal reaches of the drainage were classified as distinct spawning populations. The terminal reaches were also assumed to be the spawning reaches.

Because tracking sites were located in isolated areas, data were transmitted every hour by satellite uplink to a geostationary operational environmental satellite system and relayed to a receiving station near Washington, D.C. (Eiler 1995; Appendix A1). Data transmissions were monitored during the field season via the internet.

Each station was visited periodically and data were downloaded as a comma-delimited file to a handheld computer using a Microsoft^{TM} compatible custom program. Each record in the file contained site code, download date and time, radio frequency and pulse code, date and time of detection, antenna number, and signal strength.

A fixed-wing aircraft was used to conduct aerial surveys of the Susitna River drainage. The aircraft was equipped with a computer-controlled receiver and two, 4-element Yagi receiving antennas, one mounted on each side of the aircraft and oriented forward. Tracking receivers contained an integrated global positioning system to identify and record locations. Automatically recorded data included: date and time of decoding, frequency and pulse code, latitude and longitude, signal strength, and activity mode of each decoded transmitter. Data were also recorded on a form during the survey as a backup to the automated recording system and to track the number of radio tags detected during each survey.

DATA ANALYSIS-ESTIMATION OF ABUNDANCE

Abundance of sockeye salmon migrating into the Susitna River drainage was estimated as the sum of estimates from two-event, closed population, capture-recapture experiments, with each experiment representing a separate component of the entire run. Chapman's modification of the Petersen model (Seber 1982) was used to estimate abundance $\hat{N}$ for each experiment (stratum) such that:

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

where M is the number of fish captured and marked during event "1," C is the number of fish inspected for marks during event "2," and R is the number of C that possessed marks applied during event 1. The variance of the abundance estimate was estimated as:

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

Each experiment represented a stratum of the population defined by time and location to meet conditions for producing an accurate estimate of abundance.

The general conditions necessary for Equation 1 to provide an accurate estimate of abundance are described in Seber (1982) as follows:

(a) every fish in a stratum has an equal probability of being marked in event 1, or every fish in the same stratum has an equal probability of being inspected for marks in event 2, or marked fish are mixed completely with unmarked fish in the stratum between events; and

(b) there are no mark-induced behaviors (including tag-induced mortality); and

(c) fish did not lose their marks between events and all marks are recognizable; and

(d) there is no immigration or mortality (emigration) between events.

To test whether condition *a* was met, two chi-square tests were performed with the following null hypotheses: (1) proportions of marked fish in samples from event 2 were constant over recovery strata (e.g., time strata at recovery fish wheels); and (2) the probability of recapture in event 2 was constant over marking strata (e.g., time strata at marking fish wheels). If the null hypothesis of either test was not rejected, the pooled abundance estimate (Equation 1) was considered sufficient; otherwise, a temporally or spatially stratified estimate was considered using the Stratified Population Analysis System (SPAS) software program (Arnason et al. 1996).

Because condition *a* is relevant to attributes other than when and where salmon are captured, the possibility of size selective sampling was investigated. The hypothesis that fish of different sizes were captured with equal probability in the first event was tested using a Kolmogorov-Smirnov (K-S) two-sample test ($\alpha = 0.05$) to compare size distributions of fish captured in the second event with that of recaptured fish. The hypothesis that fish of different sizes were captured with equal probability in the second event was tested using a K-S two-sample test ($\alpha = 0.05$) to compare size distributions of marked and recaptured fish. If size selectivity was found in both events, then the mark-recapture estimate was stratified by size. Condition *b* was tested using radiotelemetry. The proportion of radio-tagged fish that did not resume upstream migration after tagging was assumed to be an estimate of tag-induced mortality, and the number of marked fish in the first event was adjusted accordingly. The tag loss component of condition *c* was assessed using double marks. The tag detection component of condition *c* was assessed from daily tag detection tests at weirs, but it was not assessed at fish wheel recapture sites. Condition *d* was assumed to be met for fish tagged at all sites because there were no other sources of salmon entering the river upstream of these sites (immigration), and there were no large, inriver salmon fisheries in the Susitna River (mortality and emigration), and the entire Susitna drainage was the study area, so no fish could leave the study area (emigration).

Strata were defined to ensure conditions *a-d* were met within each stratum, and then estimates across relevant strata were summed to provide an estimate for the relevant drainage. Estimated variances were likewise summed. Drift gillnetting at Yentna and Sunshine provided evidence that most sockeye salmon passed by these sites near shore and were available to the fish wheels. Evidence of mortality (emigration) between events would indicate estimated abundance is germane to event 1 (the downstream event). Evidence of immigration (recruitment) would indicate estimated abundance is germane to event 2 (the upstream event). When recruitment and mortality do not occur simultaneously, Equation 1 provides a consistent estimate of abundance.

A Darroch model was used to estimate the abundance of sockeye salmon passing Sunshine using Larson Lake weir as the recapture site. SPAS software developed specifically for stratified mark-recapture experiments was used for the analysis (Arnason et al. 1996). There were three temporal tagging strata (20 July-26 July, 27 July-31 July, 1 August-13 August) and three temporal recovery strata (22 July-30 July, 31 July-4 August, 5 August-17 August) initially established. A lag of 4 days was used between tagging and recovery strata to account for the mean migration time between Sunshine and the Larson Lake weir.

The χ^2 and G^2 goodness-of-fit statistics were computed to evaluate model fit (Arnason et al. 1996). The factors considered when evaluating strata to pool were: (1) eliminate strata with expected recaptures of <5, (2) pool adjacent strata with similar initial capture or recapture probabilities, and (3) minimize the standard error of the estimate. When a large change occurred in the G^2 statistic or standard error (i.e., greater than 1 SE) during pooling, the abundance estimate was considered questionable and dropped (Arnason et al. 1996). Strata were also dropped if the number of tags released or recaptured was small. This was necessary to minimize the number of cells with <5 recaptures expected.

While not designed for this purpose, radiotelemetry data were used to estimate the abundance of sockeye salmon migrating past Yentna and Sunshine. The Yentna abundance estimate was based on radio-tagged sockeye salmon that passed the lower Yentna tracking station, the sockeye salmon weir counts at Judd and Shell lakes, and the radio tags detected above the Judd and Shell lake weirs. Similarly, the Sunshine abundance estimate was based on radio-tagged sockeye salmon that passed the Sunshine tracking station, the sockeye salmon weir counts at Larson and

Byers lakes, and the radio tags detected above the Larson and Byers lake weirs. For each estimate, the stream reaches above the weirs were considered distinct recovery strata that enabled testing for deviations of equal probability of capture at the marking sites. A chi-square test of the null hypothesis of equal marked proportions among recovery strata was conducted to test this assertion. If the null hypothesis was not rejected, the pooled Petersen method was used to estimate the total abundance of sockeye salmon derived from radio-tag recoveries (Seber 1982). Because the sample size was relatively small, an inverse cube root transformation of the estimate was used to calculate the confidence interval (Arnason et al. 1991).

DATA ANALYSIS-DISTRIBUTION OF RADIO TAGS

A weighted terminal distribution of radio-tagged sockeye salmon was calculated to allow tags from all tagging sites to be pooled. The tags applied at Yentna and Sunshine were weighted by the proportion of the total tags applied at Flathorn that migrated up each drainage. A weighted terminal distribution of radio-tagged sockeye salmon within the Yentna and mainstem Susitna drainages was also estimated to adjust for the disproportional application of radio tags in relation to fish wheel catch. The tags applied at Yentna and Sunshine were weighted by the catch per hour of sockeye salmon during each week at each tagging site (Willette et al. 2003).

RESULTS

ABUNDANCE-FISH WHEEL TO FISH WHEEL

Capture-recapture conditions were sufficiently met such that sockeye salmon abundance passing Sunshine was estimated using three different data sets, and sockeye salmon abundance passing Yentna was estimated using two different data sets (Table 3). At Flathorn, 4,441 sockeye salmon were caught in the four fish wheels, of which 3,872 were marked and PIT tagged (Table 4). Generally low numbers of PIT-tagged sockeye salmon were recaptured at the Yentna and Sunshine fish wheels, with no valid recaptures at Yentna before 29 July.

Instead of one pooled-abundance estimate for Flathorn, two completely separate fish wheel to fish wheel estimates were constructed, one for the mainstem Susitna River and one for the Yentna River, based on PIT-tag and radio-tag migration patterns and travel times. All but 1 of the 149 PIT-tag recaptures from the Flathorn fish wheels in the eastern channel were recaptured in the mainstem Susitna drainage, at either the Sunshine fish wheels or the Larson Lake weir (Table 5). Thus, the Flathorn eastern two fish wheels were used as the capture event and the Sunshine fish wheels as the recapture event for the mainstem Susitna drainage abundance estimate. All but 2 of the 112 PIT-tag recaptures from the Flathorn fish wheel on the west bank of the western channel were recaptured in the Yentna drainage, at either the Yentna fish wheels or the Chelatna or Judd lake weirs (Table 5). Consequently, only the westernmost Flathorn fish wheel was used as the capture event and the Yentna fish wheels as the recapture event for the Yentna drainage abundance estimate. PIT and radio-tagged fish released from the fish wheel on the east bank of the west channel at Flathorn were recaptured at sites up both the Yentna and Susitna drainages, so PIT tags applied at that fish wheel were excluded from the analyses. It was assumed that fish following the east bank of the west channel at Flathorn entered their respective drainages and intermixed sufficiently with the marked fish from the other wheels at Flathorn before reaching any of the recapture sites.

Relocations of radio-tagged sockeye salmon indicated little or no mortality between sampling events, suggesting part of condition *b* was met (see *Spawning Distribution and Migration Timing* below). Of the 38 fish at Yentna and the 19 fish at Sunshine that were missing an adipose fin, all contained a PIT tag, thus meeting condition *c*.

The abundance estimate of 107,000 (95% CI = 49,180-164,820) sockeye salmon ≥400 mm MEF length at Sunshine for the season was based on 11 recaptures of 680 sockeye salmon marked at the east channel fish wheels at Flathorn and 1,892 unmarked sockeye salmon caught at Sunshine (Tables 6 and 7). Transit times of PIT-tagged fish between Flathorn and Sunshine were relatively uniform (Figure 4), with a median of 4.75 days and an average of 5.4 days (SD = 2.0 days). The uniform migration rates permitted precise stratification of the data by season (Table 6). The tagged fraction at Sunshine increased over time, but was not significant ($P = 0.12$). Similar recapture rates early (0.014) and late (0.017) in the season indicated that probabilities of capture at Sunshine did not vary appreciably during the season (Table 6). K-S tests also showed no evidence of size selectivity in either of the fish wheel events ($P = 0.99$ in both cases). Thus, abundance of sockeye salmon passing Sunshine was estimated without stratifying by size or season using PIT-tagged sockeye salmon released at the east channel Flathorn fish wheels and recaptured at the Sunshine fish wheels. Most fish at Sunshine were believed to pass up the east bank because few (35) sockeye salmon were caught in the west fish wheel at Sunshine (Table 6) and only one was caught during 3 hours of drift gillnetting.

The abundance estimate of 417,750 (95% CI = 261,930-573,570) sockeye salmon ≥400 mm MEF length up the Yentna River using PIT-tagged fish marked at the westernmost Flathorn fish wheel and recaptured at the Yentna fish wheels is a minimum estimate because no valid recaptures from Flathorn occurred before 29 July in the Yentna River fish wheels (Tables 8 and 9). Only four fish were captured at Yentna before 29 July that had a missing adipose fin, but the PIT tags were either shed, the fish were not scanned, or the tags did not appear in the Flathorn PIT-tag database. Therefore, there is no abundance estimate before 29 July at Yentna. Of the 112 fish caught and marked in the westernmost fish wheel at Flathorn and subsequently recaptured upstream, all but 2 were recaptured in the Yentna River and its tributaries (Table 5). Of these recaptured fish, 38 were caught in the Yentna fish wheels. All 38 were caught 29 July or later and all were marked at Flathorn on or after 28 July. The location and period for which the Yentna estimate is germane is therefore Flathorn beginning 28 July or, equivalently, Yentna beginning 29 July. At Yentna, 3,572 sockeye salmon were caught in the fish wheels before 29 July and 7,146 from 29 July onward (Table 8). A completely stratified Petersen model was used to estimate abundance beginning 29 July at Yentna because proportions of marked fish and probabilities of recapture changed between two time strata ("early" and "late," $P < 0.05$) within the period at Yentna beginning 29 July. The early time stratum at the Yentna fish wheels covered 29 July through 5 August and the late time stratum covered 6 August through 18 August. Transit times of recaptured fish between Flathorn and the Yentna fish wheels were relatively uniform (median of 0.81 and average of 1.6 days, SD = 2.0; Figure 4), indicating that a pooled Petersen estimate could be calculated for each of the early and late strata beginning 29 July. The estimates (and variances) from the early and late strata were summed to provide the estimate for the period beginning 29 July at Yentna.

No stratification by fish size was indicated because fish recaptured beginning 29 July had a similar size distribution as the marked population for that time ($P = 0.34$). However, size distribution of sockeye salmon caught at the west bank of the west channel fish wheel at Flathorn was skewed to fish smaller than those caught at Yentna ($P = 0.015$) beginning 29 July. Most catches of salmon other than sockeye salmon (coho *O. kisutch*, chum *O. keta*, and pink salmon

O. gorbuscha) occurred before 29 July. In 11.4 hours of drift gillnetting between the fish wheels on the Yentna River, only 6 sockeye salmon were caught, and all were netted a few feet offshore of the north bank fish wheel.

ABUNDANCE-FISH WHEEL TO WEIR

An estimated 128,105 sockeye salmon ≥400 mm MEF length migrated past Sunshine, based upon PIT-tag releases at the Sunshine fish wheels and recaptures at the Larson Lake weir. Of the 1,425 sockeye salmon PIT-tagged at Sunshine from 20 July to 13 August, 543 were recaptured at the Larson Lake weir. Daily PIT-tag detection test rates ranged from 85 to 100% with 100% detection on 12 of 18 days. The number of recaptured sockeye salmon with tags was not adjusted for tag detection. However, the PIT-tag detection system was not operational 21 July–30 July due to an electronic problem with the antenna. Therefore, the number of tagged sockeye recaptured during this time was estimated assuming the recapture probability was the same as the 31 July to 4 August period. The final model pooled recapture strata for the periods beginning 22 July and 31 July (Table 10). The G^2 statistic for this model indicated no significant difference ($P = 0.51$) between observed and fitted recaptures. Capture probability declined slightly between the two temporal strata used in the analysis ($P < 0.01$). If the actual number of tags passing the weir before 31 July was greater than estimated, the population estimate would be biased high. However, the marked fraction also increased over time at the weir ($P < 0.01$). If this was due to tagged fish lagging behind untagged fish, the population estimate could be biased high. The mean migration time for PIT-tagged fish from Sunshine to Larson Lake weir was 4.37 days (SE = 2.2 days). Confidence intervals were not reported for this abundance estimate because of the extrapolation of recaptures into earlier strata.

The Larson Lake weir was the only weir in the mainstem Susitna drainage that provided enough PIT-tag data for analysis, so there is no information on the probability of capture at Sunshine for other stocks, which would help assess condition *a*. However, few sockeye salmon were caught on the west bank at Sunshine and none were captured by gillnetting there or in the center of the river, suggesting that most sockeye at Sunshine migrated along the east bank. This migration pattern makes it likely that different stocks were tagged equally, if not at the same rate through time. Radio-tagging results, while sparse, show timing of sockeye salmon at Stephan Lake (about 80 km upstream of Larson Lake) had a similar median tagging date at Sunshine (about 27 July) to those of Larson Lake origin.

The abundance of sockeye salmon passing Flathorn was not estimated using data from Larson Lake weir because there was an unequal capture probability between banks in the east channel at Flathorn. The tendency for PIT-tagged sockeye salmon from the western fish wheel of the eastern channel at Flathorn to travel to Larson Lake was about 1.5 times greater than for fish tagged at the eastern most fish wheel. This suggested some stock separation among banks at Flathorn. Without confidence that fish were PIT-tagged proportionally among banks at Flathorn, the Larson Lake weir was not used as a recapture event.

The capture-recapture experiment for the Yentna drainage using PIT tags released from the Flathorn or Yentna fish wheels and recaptured at the Chelatna and Judd lake weirs did not meet the conditions necessary for an accurate estimate. At both weir sites, the number of PIT-tagged sockeye salmon passing through the weirs was substantially less than expected, based on the number of radio-tagged fish in each lake. Of the 1,296 fish PIT-tagged at Yentna, 1.5% were detected at Chelatna and 1.5% were detected at Judd Lake. Yet, of the 140 radio-tagged sockeye salmon migrating past the lower Yentna tracking station, 17.9% were detected in Chelatna Lake and 17.9% were detected in Judd Lake. During the 9 August aerial telemetry survey, 15 radio-tagged fish were detected in Chelatna Lake, but only 2 (13%) of the PIT tags that should have been in these fish were detected passing through the weir. However, the Chelatna Lake weir was only operated between 27 July and 10 August due to flooding, so some fish may have entered the lake prior to weir operation. Also on the 9 August aerial survey, one radio-tagged fish was detected in Judd Lake while the PIT tag injected into this fish was not detected passing through the weir. Daily PIT-tag detection tests at both lakes indicated that tag detection was generally above 90% (Appendices B1 and B2).

Because the number of sockeye salmon moving through the Judd Lake weir during the last 3 days of operation was 1.2%, 0.3%, and 0.2% of the final weir count (Appendix B1), salmon passage through the weir appeared nearly complete when the weir was removed on 21 August. Yet, during an aerial telemetry survey on 28 August, 10 of 24 (42%) radio-tagged fish that eventually entered Judd Lake were below the weir.

A hand-held PIT-tag antenna was used at the Shell Lake weir, but did not produce enough recaptures for analysis. Hewitt Lake weir was operated from 30 July until 10 August, when flooding stopped operations prematurely, and not enough fish were examined to be useful.

ABUNDANCE-RADIOTELEMETRY

There were an estimated 93,161 (95% CI = 80,053–106,268) sockeye salmon ≥400 mm MEF length that migrated past Sunshine, based on radio tags detected in Larson and Byers lakes. The data from these two lakes were pooled because marked proportions did not differ ($\chi^2 = 0.07$, df = 1, $P = 0.79$) between recapture locations (condition *a*). The marked sample ($n = 107$) consisted of 32 fish radio tagged at Flathorn and 75 fish radio tagged at Sunshine (Table 11). The terminal destination of these fish was determined from aerial surveys. A paired comparison test indicated that the Sunshine estimate based upon PIT-tag releases at Flathorn was not different from the Sunshine estimate based upon radio tags detected in Larson and Byers lakes ($P = 0.65$).

An additional estimate of the sockeye salmon passing Yentna was calculated using radio tags detected in Judd and Shell lakes. Using these data, there were 311,197 (95% CI = 251,568–391,264) sockeye salmon ≥400 mm MEF length that migrated past Yentna. The data from these two lakes were pooled in the analysis, because marked proportions did not differ ($\chi^2 = 3.12$, df = 1, $P = 0.08$) between recovery strata (condition *a*). The marked sample ($n = 140$) consisted of 66 fish radio tagged at Flathorn and 74 fish radio tagged at Yentna (Table 12). The terminal destination of 135 of these fish was determined from aerial surveys. The other five fish were detected migrating upstream past the fixed radiotelemetry station at Skwentna, but were not located during subsequent aerial surveys. There were two radio-tagged fish located in Shell Creek during the last aerial survey on 5 October that were assumed to have moved up into Shell Lake.

The abundance estimate at Yentna based on Flathorn PIT-tag releases was substantially greater than the radio-tag estimate at Yentna, but a statistical comparison could not be made because the PIT-tag estimate was only for the period after 28 July at Yentna. However, a comparable radio-tag abundance estimate was constructed by assuming a constant travel time for radio-tagged fish from Flathorn (or Yentna) to each of the weirs (this is essentially what was assumed for the single Petersen estimate using radio tags) and stratifying the estimate by time (before 29 July and 29 July onward at Yentna). Travel time was assumed to be 13 days from Flathorn to Judd Lake (from the PIT-tag data), 12 days from Yentna to Judd Lake (from the PIT-tag data), 9 days from

Flathorn to Shell Lake (based on the relative distance from Flathorn to Judd Lake vs. Flathorn to Shell Lake), and 8 days from Yentna to Shell Lake. These travel times resulted in all radio-tagged fish passing by their respective weirs while the weirs were still in operation, which allowed abundance estimates to be calculated. The stratification dates for the count at each weir are different because the travel time was different to each, and only the date of marking for the radio tags was known. The variety of possible estimates for the period before 29 July at Yentna was fairly consistent when both weirs were used for the recovery: 205,424 when only Flathorn radio tags were used and 202,025 when only Yentna radio tags were used (Table 13). The results were similar at Yentna for 29 July onward, with an estimate of 94,506 using Flathorn radio tags and about 97,206 using Yentna radio tags. From these analyses there are comparable estimates between Flathorn PIT tags (417,750; 95% CI = 262,000-574,000) and Flathorn radio tags for 29 July onward (94,506; 95% CI = 50,000-139,000).

Radio-tag abundance estimates of the sockeye salmon migrating past Sunshine and Yentna may be biased due to unequal probabilities of capture among individuals in the capture events (condition *a*). At Flathorn, 98% of the radio-tagged fish that migrated up the Yentna River were tagged in the west channel, and 91% of these were tagged on the west bank. Similarly, 82% of the radio-tagged fish that migrated up the Susitna River were tagged in the east channel. At Sunshine, all of the radio tags were applied on the east bank. At Yentna, 93% of the radio tags were applied on the south bank.

Radio tags were applied relatively early in the sockeye salmon run at Yentna, as indicated by fish wheel catch per hour (CPUE; Figure 5). Radio-tagged fish in Judd and Shell lakes also exhibited a relatively early run timing past Yentna (Figure 5). These fish were therefore more likely to receive a tag than the majority of fish migrating later in the run, and may not have been representative of all Yentna stocks. Similar conditions occurred at Sunshine. However, weighting the number of tags recaptured at each weir by weekly catch per hour in fish wheels at tagging sites did not substantially change the tag recapture numbers (7-21% difference; Appendix C1). Thus, the radio-tag abundance estimates may be biased low because of higher capture probabilities in the marking event for fish migrating to recovery strata, but the error appears to be small.

Although capture probabilities may have varied among individuals in the marking event, radio-tagged fish still may have mixed with the untagged fish. Ninety-five percent of the Flathorn PIT tags recaptured at Sunshine crossed the channel from the opposite bank or from the west channel at Flathorn. Conversely, only 23% of the Flathorn PIT tags recaptured at Yentna crossed the channel from the opposite bank. The relatively short distance between Flathorn and Yentna may have limited mixing.

Uncertainty regarding the final destination of some radio-tagged fish introduced uncertainty into the abundance estimates. Abundance estimates using radiotelemetry are based on the assumption that surveys adequately determine the final destination of radio-tagged fish, and that all radio-tagged fish eventually reach their final spawning site. The erratic behavior of some radio-tagged fish suggests there was a tagging effect, but none could be verified. Tagged fish detected in the lakes were assumed to be part of the lake population even if they were later detected below the lake. This assumption seemed reasonable because salmon typically move downstream after spawning. However, two radio-tagged fish detected in Shell Lake or Shell Creek on 28 August were later detected 10.5 km upstream of Shell Creek in the Skwentna River on 5 October. These fish were assumed to be destined for the Skwentna River and not Shell

Lake, because they moved a substantial distance upstream in the Skwentna River. Two radio-tagged fish included in the recovery strata at Shell Lake were detected in Shell Creek below the weir during the last aerial survey on 5 October. These fish were assumed to be destined for Shell Lake, but this was not verified. Both of these fish were tagged at Yentna during the third week in July, and their apparent late arrival into Shell Creek suggests that tagging may have affected their behavior. Five tagged fish that migrated upstream past the tracking station at Skwentna were not located during subsequent aerial surveys, so it is possible these fish entered Judd or Shell lakes undetected.

SPAWNING DISTRIBUTION AND MIGRATION TIMING

Between 8 July and 18 August 2006, 250 sockeye salmon were radio tagged at the Flathorn, Yentna, and Sunshine fish wheel sites combined (Table 14). All but one radio-tagged fish moved upriver (Table 15). Ten (4.0%) radio-tagged fish were not assigned to a spawning location, and one (0.4%) was never relocated. The fates of these 11 fish were unknown.

Comparison of sockeye salmon CPUE in fish wheels and the number of radio tags applied each week indicated that the radio-tagging schedule was skewed earlier than the sockeye salmon run timing (Figure 5). However, when CPUE was compared with the timing of radio-tagged sockeye salmon migrating upstream (Figure 5), the run timing of tagged fish was earlier than untagged fish to a lesser extent at Sunshine than at Yentna. There were no differences ($P > 0.05$) between the lengths of radio-tagged fish and PIT-tagged fish at any of the fish wheel sites.

A probable spawning location was identified for the majority of radio-tagged fish. Of the 250 radio-tagged fish, 239 (96%) could be assigned to a final spawning location or smaller tributary. For the 10 fish not assigned to a spawning location, 3 were tagged at Flathorn, 4 at Yentna, and 3 at Sunshine:

1. For the Flathorn fish, one fish passed the Yentna (no other information available) and the other two fish moved only 5-10 km upriver before stopping in the Susitna mainstem. An inactive transmitter mode (mortality indicator) was detected during aerial surveys after 13 days for one fish and after 32 days for the other two fish.
2. For the four Yentna fish, two moved at least 85 km up the Yentna River before migrating back down to the Susitna River near Flathorn. A third fish traveled upstream of the lower Yentna before moving back down the Susitna River and into Cook Inlet where a mortality indicator signal was detected 8 days later. The fourth fish migrated up the Yentna River near the mouth of the Skwentna River (60 km). A mortality indicator signal was detected 44 days later, but the location did not appear to be a spawning site.
3. All 3 Sunshine fish migrated at least 80 km further up the Susitna River mainstem (confirmed during aerial flights) but were not associated with a spawning area.

One fish tagged at Flathorn migrated up the Yentna River (23 km) before turning back and continuing its migration up the Susitna and Chulitna rivers to a small lake near Swan Lake.

Aerial surveys were conducted over the mainstem Susitna drainage on 2 August, 26 August, 1 September, 11 September, and 6 October 2006, and over the Yentna drainage on 9 August, 28 August, 7 September, and 5 October 2006. These surveys located 242 (96.8%) radio-tagged fish between tracking stations and upriver of tracking stations on terminal tributaries. All fish locations were corroborated by available tracking station records.

Radio-tagged sockeye salmon traveled throughout the Susitna River drainage (Table 16; Figure 3). There were 100 fish radio tagged at Flathorn, of which 66 migrated up the Yentna River and 34 continued up the mainstem Susitna River (Table 17). Of the 66 tagged fish that migrated up the Yentna River, 65 were recorded in terminal tributaries: 24 tags in the Skwentna River mainstem (or smaller tributaries), 23 tags in the Yentna River mainstem (or smaller tributaries), 12 tags in the Talachulitna River drainage, 5 tags in the Kichatna River drainage, and 1 tag in the Kahiltna River drainage (Table 18, Figure 6). Of the 34 tagged fish that migrated up the Susitna River, 23 traveled to the Talkeetna River drainage and 9 to the Chulitna River drainage. There were 75 fish radio tagged at Sunshine, and 72 were tracked to terminal tributaries including 65 in the Talkeetna River drainage and 7 in the Chulitna River drainage (Table 18).

Radio-tagged fish detected by the tracking stations were also detected during aerial surveys. All fish radio tagged at Flathorn and Sunshine were detected by tracking stations located immediately upstream. Only one fish tagged at Yentna was not detected by the tracking station located immediately upstream. All 9 tagged fish passing the upper Yentna tracking station were recorded, as were the 2 Kahiltna fish passing the Kahiltna tracking station, the 32 Flathorn-tagged fish passing the Sunshine tracking station, the 6 tagged fish passing the Kichatna tracking station, and the 86 tagged fish passing the Skwentna tracking station.

Although not installed until 26 July, the Talachulitna tracking station recorded 28 of 33 fish that were later found upstream during aerial surveys. Some sockeye salmon that were radio-tagged early could have passed prior to that time. The Chulitna tracking station only recorded 9 of 16 fish later found upstream during aerial surveys, but the station was not functional until 4 August and was vandalized on 22 August, resulting in lost data. To minimize future vandalism, information about the project is now posted at each station (Appendix A1). The electronics at the Talkeetna tracking station were destroyed and the data lost by a flood on 19 August. After the electronics were replaced only two late-tagged fish were recorded. The upper Susitna tracking station did not record any fish passage. Three fish were recorded upstream of the upper Susitna tracking station during the aerial surveys on 2 August, but the station was not activated until 3 August.

The weighted terminal distribution of radio-tagged sockeye salmon indicated that 66.9% of the run spawned in lakes and 33.1% spawned in streams. Of those fish spawning in lakes, 84.4% spawned in Larson, Chelatna, Shell, and Judd lakes (Figure 7).

The terminal distribution also indicated that sockeye salmon were strongly bank oriented at the tagging sites. For the Flathorn fish wheels, all sockeye salmon tagged at the west bank of the west channel fish wheel went up the Yentna River and all those tagged at the east bank of the east channel fish wheel continued up the Susitna River. Sockeye salmon tagged at the Flathorn west bank of the east channel and east bank of the west channel fish wheels were located in both drainages. The majority of sockeye salmon were radio tagged at the west bank of the west channel fish wheel at Flathorn (Table 17), the south fish wheel at Yentna, and the east fish wheel at Sunshine.

Most sockeye salmon passing by Flathorn exhibited similar run timing, although some differences by stock were observed. The Talkeetna River and Skwentna River stocks were present throughout the return, but the Talkeetna River stocks peaked the week beginning 16 July and the Skwentna River stocks peaked beginning 23 July (Figure 8). Sockeye salmon in the

Yentna and Talachulitna River displayed a timing pattern similar to the Skwentna River, while Chulitna River sockeye salmon more closely patterned the Talkeetna River timing.

The response of radio-tagged fish was to delay resuming upriver movement or to slow swimming speeds immediately after release. Flathorn fish movement averaged 5.6 km/day past the tracking station immediately upstream of the tagging site (Table 19). Yentna fish averaged 3.4 km/day and Sunshine fish averaged 4.4 km/day. Movement rates for Flathorn fish after passing the initial tracking station averaged 11.2 km/day for mainstem Susitna-bound fish and 13.6 km/day for Yentna-bound fish and an overall average of 12.8 km/day (Table 20). For Flathorn fish recorded at upriver stations, the overall average speed was 11.1 km/day (Table 21). While some stocks were slower, the sample sizes were small. The tagged Yentna and Sunshine fish combined averaged 10.5 km/day (Table 22).

DISCUSSION

ABUNDANCE

Capture-recapture abundance estimates of sockeye salmon escapement could only be generated separately for the Yentna and mainstem Susitna rivers. All three estimates for Sunshine were similar, and the Flathorn to Sunshine PIT-tag estimate of 107,000 fish (95% CI = 49,180-164,820) had the most evidence for meeting the necessary conditions for the capture-recapture experiment (Table 3). Results were more complicated and wide-ranging for the Yentna abundance estimates. All necessary conditions for each Yentna capture-recapture experiment with PIT tags or radio tags either were not met or could not be fully evaluated. The Yentna experiment that used the Flathorn to Yentna PIT tags during 29 July–18 August had the most evidence for meeting the necessary conditions, but this estimate (417,750 fish; 95% CI = 261,930-573,570) is not for the entire season, is imprecise (relative precision = 37%), and has small sample sizes (39 total recaptured PIT tags at Yentna) that give the statistical tests low power.

Because neither immigration nor emigration occurred (condition *d*), the abundance estimates for Yentna and Sunshine are germane at Flathorn. Radiotelemetry did not document any sockeye salmon spawning sites between Flathorn and Sunshine. With radio tags inserted in 34 sockeye salmon ascending the mainstem Susitna River from releases at Flathorn, there was only a 3% chance of finding no radio tags below Sunshine if 10% of the mainstem Susitna spawning population spawned below Sunshine. Therefore, the Sunshine estimate should be representative of the mainstem Susitna River.

Only 11 PIT-tag recaptures were available for analyses at the Sunshine fish wheels. The low number of recaptures provided a relatively imprecise abundance estimate (relative precision = 54%) and low power to test assumptions. Heterogeneous probability of capture at Sunshine is a possibility given the variation in fish wheel effort at that site (Table 7). For example, if the stratification dates at Flathorn/Sunshine are shifted by a few days, then the recapture rates differ among strata, showing the sensitivity of the analysis to the number of recaptures.

The Flathorn to Yentna fish wheel estimate using PIT tags has possible weaknesses. First, by relying on the marks only applied at the Flathorn westernmost fish wheel, the assumption is that the probability of capture at Yentna is relatively constant within the two temporal strata used for 29 July onward, or fish mixed completely within each temporal stratum. Second, assuming tag detection rates and probability of marked fish before 29 July equal those for 29 July onward, the estimated probability of observing no tags before 29 July at Yentna (in 3,572 fish examined) is close to 0. One possibility is that the marked fraction before 29 July is lower than that estimated for 29 July onward. However, the marked fraction that would yield a reasonable chance of no tags at Yentna before 29 July would lead to unrealistically high abundance estimates before 29 July (Figure 9). Third, tag detection may have been <100% for 29 July onward. The lack of expected tag recoveries at Yentna before 29 July described above was associated with peak catches of sockeye and other species in the fish wheels (Table 9), suggesting that adipose fin clips might have been overlooked because of the large numbers of fish handled. If tag detection was <100% for 29 July onward as well, then the abundance estimate may be biased high. However, all sockeye salmon at Yentna were individually handled, minimizing the risk of overlooking an adipose fin clip.

The aerial surveys conducted while the Chelatna and Judd lake weirs were in operation provided an opportunity to evaluate detection of the PIT tags in radio-tagged fish passing through those weirs. Although this method was limited, it suggests that the relatively low number of PIT-tag recaptures at these lakes may have been due to poor PIT-tag detection or PIT-tag loss (condition *c*). While the tag detection tests at the lakes showed that the PIT detectors generally worked well, it may be that PIT-tag detection in fish was not mimicked by the daily tests. Radio tags also may have interfered with PIT-tag detection. Although the radio-tag manufacturer (ATS) stated there would be no interference between the two tag types within these frequency ranges, electromagnetic fields and metal in the PIT-tag antenna field can reduce PIT-tag detection. Therefore, further tests should be conducted to evaluate whether radio tags interfere with PIT-tag detection.

PIT-tag recapture probabilities at weirs were inversely related ($P = 0.014$) to the distance fish traveled from the tagging site to the weirs (Table 23). This was not due to variable PIT-tag detection among weirs, because fish tagged at near and distant sites were passing through each weir at roughly the same time. Because tag mortality estimated from radio-tagged fish was low, this relationship is likely due to either tag loss or tagged fish lagging behind untagged fish, and thus not reaching the distant weirs before they were removed. Willette et al. (2003) estimated that tag retention in adult sockeye salmon tagged with 11-mm PIT tags and recaptured in gillnets was 98%. Because the sockeye salmon in this study were tagged with smaller PIT tags (7 mm) and were not recaptured in a net (i.e., less handling), it seems unlikely that tag loss could account for the observed relationship. Instead, aerial tracking of radio-tagged sockeye salmon suggested that tagged fish were lagging behind untagged fish, because substantial numbers of radio-tagged fish were found downstream of weirs after the run of untagged fish had tapered off. Underwood et al. (2004) found that recapture probabilities of radio-tagged chum salmon captured in fish wheels were inversely related to distance traveled. Although Underwood et al. (2004) attributed the relationship to handling mortality, our data suggest that tagging may also reduce the migration speed of salmon. Transit times of fish with PIT tags and radio transmitters were generally slower than fish with just PIT tags. For example, median travel time from Flathorn to Sunshine was 4.75 days for PIT tags and 8 days for radio tags, and from Flathorn to Yentna, 0.81 and 1.91 days, respectively. Transit times from Sunshine to Byers and Larson lake weirs, and between the Yentna fish wheels and the Yentna drainage weirs, were less regular than transit times from Flathorn to fish wheels upstream.

Tag loss and poor tag detection are two sources of error typically associated with capture-recapture experiments (part of condition *c*) that likely did not significantly bias the radio-tag abundance estimates. Only one radio-tagged fish lost its tag or the tag was not activated before release, and this fish was excluded from the experiment. All of the radio-tagged fish that migrated upstream past the tracking stations at Yentna and Sunshine were later located in the recovery strata or elsewhere within the drainage, so tag loss and poor tag detection probably did not bias the estimate. Although radio-tagging was skewed toward an earlier run timing, the timing of radio-tagged fish at the lower Yentna tracking station was closer to the run timing of untagged sockeye salmon, estimated using species-apportioned DIDSON sonar (Maxwell et al. *In prep*), indicating that tagged fish lagged behind and provided some temporal mixing with the incoming run (Figure 5).

Unequal probability of capture among stocks migrating up different banks may have been a significant source of error. Todd et al. (2001) found that 63% of dart-tagged sockeye salmon recaptured at Judd Lake (a south-side tributary of the Yentna River) were tagged on the south bank at Yentna, and 83% of sockeye salmon recaptured at Chelatna Lake (a north-side tributary) were tagged on the north bank at Yentna. If fish destined for Judd and Shell lakes (south-side tributaries) tended to migrate along the south bank at Yentna, they may have had a higher probability of being tagged, causing the radio-tag abundance estimates to be biased low. However, Todd et al. (2001) also found otolith-marked fish originating from fry releases at Chelatna Lake were caught on both banks (65% south bank; 35% north bank) at Yentna. In a separate part of that study, 75% of sockeye salmon tagged and released downstream of the Yentna fish wheels were recaptured on the opposite bank. The prevalence or consistency of bank affiliation by sockeye salmon during migration in the Susitna River drainage is not well understood.

The run timing of sockeye salmon in 2006, specifically in the Susitna River, was especially late (Shields 2007; Westerman and Willette. 2007). Heavy rainfall and flooding in mid to late August contributed to an earlier than desired removal of the fish wheels and weirs. This combination of events may have led to incomplete weir counts. The weir counts are the census of untagged fish in some of the abundance experiments, and would bias the radio-tag abundance estimates low.

Species-apportioned sonar estimates of the sockeye salmon abundance passing Yentna in 2006 were 92,896 (Bendix sonar; Shields 2007) and 160,452 (DIDSON sonar; Maxwell et al. *In prep*), which are significantly lower than the capture-recapture abundance estimates for the Yentna drainage (Table 24). Mid-channel drift gillnetting captured few sockeye salmon, suggesting that the nearshore range of the sonar was appropriate for enumerating sockeye salmon. If the species apportionment using the fish wheel catches was not representative of the species composition in the river, it may explain some of the abundance discrepancies. The abundance estimates for other species at Yentna were high enough to substantially affect sockeye salmon abundance estimates. Based on Bendix sonar counts there were 282,920 pink salmon, 11,745 chum salmon, 130,952 coho salmon, and 557 Chinook salmon.

A total of 126,218 sockeye salmon were enumerated passing the four weirs upstream of the Yentna sonar site (Table 24 and Appendix B2). It was expected that the weir counts would be less than the capture-recapture abundance estimates or the sonar counts, because historical aerial surveys (Fox 1998) and this year's radiotelemetry found sockeye salmon in many additional locations in the Yentna drainage. The weir counts are also a minimum count because flooding prevented operating all of the weirs for the entire season, and the late runs may not have been complete when most weirs were removed. As shown by the Yentna weir counts, the end-of-season Bendix sonar estimate of 92,896 fish was biased low in 2006.

SPAWNING DISTRIBUTION AND MIGRATION TIMING

This was the first study to use radiotelemetry to follow sockeye salmon in the Susitna River on a comprehensive scale. In 2006, 34 probable spawning locations were identified and given specific names, but several other probable spawning sites with fewer tagged fish were left unnamed. The terminal distribution of about one-third of the radio-tagged sockeye salmon was in rivers or sloughs, suggesting that a sizeable portion of spawning does not occur in lake systems. Additionally, on-the-ground tracking would be required to document that these are actual spawning sites.

After an initial delay, radio-tagged sockeye salmon appeared to consistently migrate upstream, although migration speed declined with distance traveled. While handling time for a radio-tagged fish is longer than a fish receiving only a PIT tag, most (95.6%) fish appeared to continue upriver to spawning areas. In some cases, radio-tagged fish appeared to lag behind the untagged population passing through weirs, indicating that tagging reduced their migration speed. Operation of fixed radiotelemetry stations at weirs and more frequent aerial surveys would provide the data needed to determine if tagging affected migration speed.

RECOMMENDATIONS

Proposed recommendations for 2007:

1. Eliminate all PIT tagging, and direct monetary savings toward the purchase of radio tags for the capture-recapture abundance experiment.
2. Operate only the Yentna and Sunshine fish wheels as marking sites.
3. Radio tags should be applied in proportion to the actual individual fish wheel catch, i.e., every *n*th fish. This approach will ensure that radio tags are applied in proportion to fish wheel CPUE over time and on each bank. A sufficient number of tags should be purchased to allow for a larger than expected run or, if necessary, reduce the tagging rate inseason.
4. Design the 2007 mark-recapture study as a partially stratified Darroch model, with banks constituting marking strata and lakes with weirs as recapture strata.
5. Operate an additional weir at Stephan Lake off the Talkeetna River.
6. Install radiotelemetry tracking stations at all weirs to monitor radio-tagged sockeye salmon movement through the weirs for the recapture event.
7. Continue extensive drift gillnetting in the center of the river at Sunshine to ascertain mid-river migration.
8. Continue aerial radio-tracking surveys to identify spawning locations.

In addition to providing abundance estimates (when combined with weir counts), extensive radio-tag application will provide precise estimates of sockeye salmon distribution. Precise and representative distribution estimates can be used to estimate sockeye salmon escapement in each tributary to the entire Susitna River drainage, and define the spatial pattern of sockeye salmon production.

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Table 1.-Dates of operation for the Susitna River sockeye salmon fish wheels and their associated weirs by location, 2006.

		Dates of Operation			
		Fish Wheel	Fish Wheel weir		Fish Wheel
Site	Fish Wheel Location	Started	Installed	Removed	Stopped
Flathorn	West Channel, West Bank	7/3	7/14	8/14	8/17
	West Channel, East Bank	7/4	7/15	8/14	8/17
	East Channel, West Bank	7/4	7/27	8/14	8/17
	East Channel, East Bank	7/5	7/27	8/14	8/17
Sunshine	West Bank	7/17	none installed		8/15
	East Bank	7/8	7/24	8/17	8/18
Yentna	North Bank	7/7	7/7	8/18	8/18
	South Bank	7/7	7/7	8/18	8/18

Table 2.–Location of tracking stations used to monitor the movements of radio-tagged sockeye salmon in the Susitna River, 2006.

		Distance (km)	
Drainage	Tracking Station	From Saltwater	From Previous Station
Susitna	Flathorn	40.0	--
	Sunshine	128.3	88.3
	Talkeetna River	156.6	28.3
	Upper Susitna River	165.0	36.7
	Chulitna River	170.7	42.4
Yentna	Lower Yentna River	58.1	18.1
	Kahiltna River	93.7	35.6
	Skwentna River	138.5	80.4
	Talachulitna River	144.9	6.4
	Kichatna River	147.3	89.2
	Upper Yentna River	156.0	98.0

Table 3.-Assessment of our ability to meet capture-recapture model conditions and estimators used.

Population	Capture/	Tag	Conditions Met					
Estimated	Recapture	Type	a	b	c	d	Model	Comments
Mainstem Susitna	Flathorn/ Sunshine	PIT	Yes	Yes	Yes	Yes	Petersen[a]	1 of 149 recaptured Flathorn east channel tags recaptured in Yentna drainage Unequal capture probability between channels at Flathorn Only 11 recaptured tags limited power to tests assumptions
	Sunshine/ Larson	PIT	?	Yes	Partially	Yes	Darroch	PIT detector at Larson inoperable before 31 July; marked fraction after 31 July used for period before 31 July
	Sunshine/ Larson-Byers	Radio	?	Yes	Yes	Yes	Petersen	Tags not applied in proportion to abundance but marked fractions similar between Byers and Larson
Yentna	Flathorn/ Yentna	PIT	Partially	Yes	?	Yes	Stratified Petersen	Estimate only for period 29 July onward at Yentna 2 of 112 recaptured Flathorn west channel, west bank fish wheel tags recaptured in Susitna drainage; Unequal capture probability between banks at Flathorn; Unequal capture probability over time at Yentna; Tag detection questionable due to lack of recaptures before 29 July.
	Yentna/ Judd-Chelatna	PIT	?	?	No	Yes	No estimate	Tag detection questionable; Chelatna weir only operated for 15 days
	Yentna/ Judd-Shell	Radio	?	?	Yes	Yes	Petersen	Tags not applied in proportion to abundance but marked fractions similar between Judd and Shell; possible marking effect on radio tag migration time.
Entire Susitna	Flathorn/ Judd-Chelatna	PIT	?	?	No	Yes	No estimate	Tag detection questionable; Chelatna weir only operated for 15 days
	Flathorn/Larson	PIT	?	Yes	Partially	Yes	No estimate	PIT detector at Larson inoperable before 31 July; unequal capture probability between banks at Flathorn

[a] Petersen Conditions:

a. Equal capture probability in event 1 or 2, or complete mixing.
b. No mark-induced behavior (including mortality)
c. No tag loss and all tags detected
d. No immigration and emigration between events.

Table 4.-Total daily salmon catch, tags applied, fish wheel spin time, and fish wheel revolutions per minute (RPM) at Flathorn, 2006.

Date	Sockeye Salmon			Other Salmon Species				Total Fish Wheel Spin Time	Daily Average Fish Wheel
	Total	Tags Applied							
	Catch	PIT[a]	Radio	Chinook	Coho	Pink	Chum	(hrs)[b]	RPM[c]
7/3	0	0	0	0	0	0	0	16.0	NA
7/4	1	0	0	0	0	0	0	16.0	NA
7/5	2	0	0	1	0	3	0	37.3	NA
7/6	6	9	0	3	4	1	0	48.1	2.00
7/7	6	7	0	1	7	1	0	29.6	2.00
7/8	0	6	0	NA	NA	NA	NA	4.5	2.00
7/9	7	4	0	1	5	0	3	42.5	2.00
7/10	25	21	0	NA	NA	NA	7	57.9	2.19
7/11	16	14	0	0	3	0	1	55.6	2.43
7/12	9	2	0	0	10	1	1	55.0	2.06
7/13	13	14	1	0	8	4	0	51.7	2.33
7/14	18	15	0	2	23	8	4	64.5	2.04
7/15	23	11	1	2	86	37	25	61.4	2.52
7/16	53	49	3	3	113	82	77	49.3	2.34
7/17	70	45	6	0	78	108	34	45.2	2.25
7/18	97	91	6	1	96	147	8	26.4	2.17
7/19	70	71	4	0	69	49	2	21.5	2.22
7/20	94	67	3	4	50	40	5	38.9	2.66
7/21	120	98	2	0	101	117	12	49.9	2.80
7/22	78	66	2	0	83	131	17	37.8	2.69
7/23	111	95	8	1	119	140	10	38.2	2.43
7/24	93	83	6	0	142	289	6	33.4	2.71
7/25	93	74	7	1	112	260	14	32.5	2.55
7/26	113	94	7	1	93	215	13	34.7	2.35
7/27	154	142	6	0	173	294	5	56.1	2.31
7/28	235	202	7	1	184	364	5	38.9	2.58
7/29	167	142	3	0	150	246	6	35.8	2.45
7/30	145	134	4	0	89	347	11	35.2	2.62
7/31	155	140	2	1	145	266	8	35.9	2.34
8/1	171	151	3	0	130	196	13	36.6	2.44
8/2	243	225	2	1	117	319	27	49.2	2.76
8/3	261	236	1	0	113	247	40	49.7	2.66
8/4	234	205	3	1	87	192	40	48.6	2.81
8/5	229	197	0	1	91	109	25	60.4	2.64
8/6	227	203	3	0	95	145	29	53.7	2.90
8/7	195	166	1	1	71	52	13	39.9	2.89
8/8	118	112	1	0	57	36	18	47.4	2.91
8/9	113	80	1	0	78	45	24	70.8	2.33
8/10	103	97	2	0	68	36	12	70.8	2.60

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Table 4.–Page 2 of 2.

	Sockeye Salmon			Other Salmon Species				Total Fish Wheel Spin Time	Daily Average Fish Wheel
	Total	Tags Applied							
Date	Catch	PIT[a]	Radio	Chinook	Coho	Pink	Chum	(hrs) [b]	RPM [c]
8/11	99	78	1	0	62	24	14	71.8	2.50
8/12	52	47	1	0	28	18	5	63.0	2.86
8/13	127	111	1	0	32	14	4	76.7	2.41
8/14	171	154	1	NA	NA	NA	NA	60.5	2.48
8/15	54	48	0	0	13	3	6	54.2	2.26
8/16	16	20	0	0	4	0	0	38.9	2.17
8/17	54	46	1	0	8	7	8	58.7	2.31
Total	4,441	3,872	100	27	2,997	4,593	552	2,100.2	

[a] Passive Integrated Transponder tag.

[b] Is the daily sum of four fish wheels at Flathorn.

[c] Is the daily average of revolutions per minute for four fish wheels at Flathorn.

Table 5.-Recapture locations of Flathorn passive integrated transponder (PIT) tagged sockeye salmon by fish wheel in 2006.

Flathorn Fish Wheel	PIT Tags Released	Recapture Locations: Mainstem Susitna R. Sunshine Fish Wheels	Mainstem Susitna R. Larson Weir	Yentna R. Yentna Fish Wheels	Yentna R. Chelatna Weir	Yentna R. Judd Weir	Total
West Channel, West Bank	2,627	1	1	38	51	21	112
West Channel, East Bank	511	7	16	1	9	2	35
East Channel, West Bank	470	10	103	0	1	0	114
East Channel, East Bank	256	1	34	0	0	0	35
Total	3,864	19	154	39	61	23	296

Table 6.-Recapture statistics for Flathorn passive integrated transponder (PIT) tags deployed at east channel fish wheels and recaptured at Sunshine fish wheels in 2006.

Stratum [a]	Flathorn PIT Tags Released: East Channel, West bank	Flathorn PIT Tags Released: East Channel, East bank	Flathorn PIT Tags Released: Total	Sunshine Catch: East	Sunshine Catch: West	Sunshine Catch: Total	Flathorn Recaptures	Recapture Rate	Marked Fraction
1	142	75	217	944	10	954	3	0.014	0.003
2	319	144	463	913	25	938	8	0.017	0.009
Total	461	219	680	1,857	35	1,892	11		

[a] Flathorn Stratum 1 occurred from 6 July to 27 July 2006, Stratum 2 from 28 July to 13 August 2006. Sunshine Stratum 1occurred from 11 July to 1 August, Stratum 2 from 2 August to 18 August 2006.

Table 7.-Total daily salmon catch, tags applied, fish wheel spin time, and fish wheel revolutions per minute (RPM) for Sunshine 2006.

	Sockeye Salmon			Other Salmon Species				Total	Daily
	Total	Tags Applied						Fish Wheel Spin Time	Average Fish Wheel
Date	Catch	PIT[a]	Radio	Chinook	Coho	Pink	Chum	(hrs) [b]	RPM [c]
7/8	0	0	0	0	0	0	0	3.0	NA
7/9	4	3	0	6	1	0	1	4.8	NA
7/10	0	0	0	10	5	1	4	7.3	NA
7/11	0	0	0	5	6	1	8	7.9	NA
7/12	3	0	0	4	3	1	7	9.6	3.25
7/13	9	2	0	1	3	3	8	8.2	3.25
7/14	8	2	0	2	4	3	17	14.3	3.13
7/15	3	0	0	0	1	2	5	14.3	3.50
7/16	3	1	1	0	2	0	3	14.5	3.75
7/17	12	4	2	2	2	8	6	20.5	3.75
7/18	14	4	1	3	5	9	16	15.7	3.50
7/19	12	1	1	0	17	20	12	26.1	3.00
7/20	34	11	4	0	7	19	6	24.6	3.00
7/21	97	18	7	0	1	30	20	24.4	2.75
7/22	101	28	8	1	7	51	32	25.2	2.77
7/23	35	0	4	0	10	61	27	25.2	2.85
7/24	31	11	5	0	16	179	70	25.2	2.85
7/25	69	58	4	0	18	270	56	23.0	3.02
7/26	66	59	3	1	13	255	58	20.3	3.00
7/27	63	48	6	0	29	524	63	19.5	3.28
7/28	52	51	3	0	51	695	102	19.9	3.02
7/29	88	34	4	0	63	658	110	19.4	2.75
7/30	84	82	6	0	42	691	103	20.7	3.00
7/31	90	71	1	0	40	312	63	16.6	3.25
8/1	80	80	4	0	51	469	76	14.6	3.04
8/2	89	105	3	1	69	670	86	17.6	3.83
8/3	83	94	0	0	118	689	165	18.0	3.40
8/4	87	85	1	0	150	891	256	16.4	3.75
8/5	133	105	2	0	204	377	152	14.8	3.02
8/6	117	106	1	0	247	506	247	18.2	2.73
8/7	107	101	0	0	192	411	243	30.0	2.49
8/8	65	64	0	0	NA	NA	NA	16.5	2.46
8/9	71	71	0	0	290	233	203	19.4	2.75
8/10	54	55	0	0	129	80	81	17.6	3.25
8/11	46	46	1	1	93	36	41	23.3	3.75
8/12	44	44	1	0	194	72	136	23.0	4.50
8/13	4	4	0	0	32	6	50	26.9	5.38
8/14	1	1	0	0	2	1	5	20.4	5.31
8/15	1	1	1	0	5	0	12	15.0	4.25
8/16	7	7	0	0	24	3	94	14.5	3.75
8/17	15	13	0	0	42	0	227	13.0	4.00
8/18	14	13	1	0	16	1	30	13.9	4.06
Total	1,896	1,483	75	37	2,204	8,238	2,901	742.8	

[a] Passive Integrated Transponder tag.

[b] Is the daily sum of two fish wheels at Sunshine.

[c] Is the daily average of revolutions per minute for two fish wheels at Sunshine.

Table 8.-Recapture statistics for passive integrated transponder (PIT) tags deployed at the Flathorn west channel, west bank fish wheel and recaptured at Yentna fish wheels in 2006.

Stratum [a]		Flathorn PIT Tags Released West Channel, West bank	Yentna Catch North	South	Total	Flathorn Recaptures [b]	Recapture Rate	Marked Fraction
1		632	454	3,118	3,572	0	0.000	0.000
2	Early	1,038	540	3,466	4,006	13	0.013	0.003
2	Late	957	474	2,666	3,140	24	0.025	0.008
Total		2,627	1,468	9,250	10,718	37		

[a] Flathorn Stratum 1 occurred from 7 July to 27 July, and Stratum 2 was divided into an Early (28 July to 4 August) and Late (5 August to 17 August) period. Yentna Stratum 1 occurred from 8 July to 28 July, and Stratum 2 was divided into an Early (29 July to 5 August) and Late (6 August to 18 August) period.

[b] Although a total of 38 Flathorn tagged sockeye salmon were recaptured at Yentna only 37 were used in the analysis due to the way the stratum dates were created.

Table 9.-Total daily salmon catch, tags applied, and fish wheel spin time at Yentna. Measurements of revolutions per minute were not collected at Yentna in 2006.

	Sockeye Salmon			Other Salmon Species				Total Fish Wheel Spin Time
	Total	Tags Applied						
Date	Catch	PIT[a]	Radio	Chinook	Coho	Pink	Chum	(hrs) [b]
7/7	30	0	0	11	46	9	7	16.2
7/8	42	2	1	6	87	15	7	22.2
7/9	56	5	0	4	65	14	1	31.6
7/10	79	7	2	1	146	17	7	30.3
7/11	50	6	1	2	73	12	5	35.4
7/12	33	6	0	2	81	29	6	33.4
7/13	34	4	1	5	44	39	8	35.5
7/14	10	5	1	3	83	57	17	31.5
7/15	57	1	1	3	241	162	54	26.7
7/16	111	5	1	2	430	737	55	29.3
7/17	225	14	4	1	463	721	42	33.7
7/18	332	31	3	4	640	768	21	31.1
7/19	223	40	5	2	337	333	35	29.9
7/20	149	26	3	2	235	428	35	28.0
7/21	174	16	3	1	426	1,121	54	28.2
7/22	248	21	3	1	712	1,614	65	28.7
7/23	237	29	2	0	811	3,632	69	32.9
7/24	274	25	5	0	949	3,755	43	32.6
7/25	404	35	3	1	904	3,121	37	32.4
7/26	273	48	4	1	583	2,011	29	27.1
7/27	531	34	3	0	574	2,173	36	31.5
7/28	897	59	3	1	985	2,369	40	29.3
7/29	770	115	2	0	1,170	3,507	40	32.1
7/30	498	89	3	1	553	2,087	28	29.1
7/31	231	64	2	0	391	1,095	20	30.3
8/1	274	28	1	0	282	1,226	53	26.9
8/2	417	34	3	1	267	1,035	74	29.3
8/3	489	50	1	0	314	773	89	29.3
8/4	430	58	2	0	348	663	105	32.8
8/5	237	55	0	3	196	320	58	32.8
8/6	339	31	2	1	180	271	58	31.8
8/7	313	41	2	1	185	247	73	28.3
8/8	165	37	1	0	199	91	43	28.6
8/9	163	24	2	0	175	85	21	29.2
8/10	134	20	1	4	93	51	17	38.7
8/11	259	16	1	0	84	74	14	34.9
8/12	290	31	1	1	247	126	56	29.2
8/13	412	30	1	1	132	NA	29	39.6
8/14	321	51	1	0	46	72	18	31.3
8/15	NA	39	0	NA	NA	NA	NA	28.8
8/16	NA	0	0	NA	NA	NA	NA	0.0
8/17	296	0	0	0	132	60	55	29.5
8/18	211	0	0	0	102	29	47	27.2
Total	10,718	1,232	75	66	14,011	34,949	1,571	1,277.2

[a] Passive Integrated Transponder tag.

[b] Is the daily sum of two fish wheels at Yentna.

Table 10.-Results from a maximum likelihood Darroch abundance estimate of sockeye salmon passing Sunshine in 2006 based upon passive integrated transponder (PIT) tag recaptures at Larson Lake weir (final pooling) and test results for completing pooling. Stratum dates indicate the beginning of each time period.

(A) Detailed results from analyzing PIT tag data: final pooling.

Release		Observed recaptures with fitted values beneath		
Strata	Fish tagged	22 July and 31 July	5 August	Total
20 July	190	92	2	94
		94.9	2.1	97
27 July	289	120	23	143
		117.1	21.9	139
1 August	946	29	329	358
		29	330	359
Total tags[a]		241	354	595
Total untagged		35,359	21,083	56,442
Marked Fraction		0.007	0.017	
Population size		68,571	59,535	128,105
SE (Population size)		3,766	2,691	4,174
Probability (recapture)		0.516	0.354	
SE (Probability recapture)		0.028	0.016	
G^2 test for goodness of fit:		$G^2 = 0.43$, df = 1, $P = 0.51$		

(B) Test results for completing pooling.

	χ^2	df	*P*-value
Test for complete mixing	23.5	2	<0.01
Test for equal proportions	126	1	<0.01

[a] Tag detector not operational 21 July-30 July, recaptures for this period estimated using probability of recapture during 31 July-4 August.

Table 11.-Summary statistics for radio-tagged sockeye salmon detected migrating upstream past a fixed radiotelemetry station 4.2 km above Sunshine and subsequently detected during aerial surveys in Larson and Byers lakes.

	Number Fish	Recovery strata	
Release Stratum	Radio Tagged	Larson	Byers
Sunshine: 18 July – 30 August	107	64	4
Total Untagged		56,445	3,074

Table 12.-Summary statistics for radio-tagged sockeye salmon detected migrating upstream past a fixed radiotelemetry station 4.5 km above Yentna and subsequently detected during aerial surveys in Judd and Shell lakes.

	Number Fish	Recovery strata	
Release Stratum	Radio Tagged	Judd	Shell
Yentna: 14 July - 19 August	140	24	25
Total Untagged		40,633	69,720

Table 13.-Estimates of sockeye salmon abundance $\hat{N}$ using radio tags from the Flathorn or Yentna fish wheels to the Judd and Shell lake weirs.

Stratum	Radio Tags Released	Weir Count at Judd Lake	Radio Tags at Judd Lake	Weir Count at Shell Lake	Radio Tags at Shell Lake	Judd $\hat{N}$	SE[$\hat{N}$]	Shell $\hat{N}$	SE[$\hat{N}$]	Both $\hat{N}$	SE[$\hat{N}$]
1) Flathorn to Judd and Shell, completely stratified											
Before 29 July	46	32,170	7	37,761	8	189,004	57,383	197,201	56,066	205,424	40,459
29 July onward	20	8,463	3	32,039	5	44,435	17,876	112,139	35,818	94,506	22,589
All	66	40,633	10	69,800	13	247,497	65,310	334,047	76,704	308,294	49,391
Summed						233,439	60,102	309,340	66,531	299,930	46,338
2) Yentna to Judd and Shell, completely stratified											
Before 29 July	51	32,170	11	37,761	6	139,407	33,905	280,517	92,253	202,025	37,472
29 July onward	23	8,463	3	32,039	6	50,783	20,728	109,850	32,684	97,206	22,382
All	74	40,633	14	69,800	12	203,169	45,422	402,697	97,845	306,760	46,372
Summed						190,190	39,739	390,367	97,871	299,231	43,648

Table 14.-Weekly and total number of sockeye salmon captured using fish wheels and radio tagged in the Susitna River drainage, 2006.

Statistical Week	Dates	Site: Flathorn	Yentna	Sunshine	Total
27	2-8 July	0	1	0	1
28	9-15 July	2	6	0	8
29	16-22 July	27	22	24	73
30	23-29 July	43	22	29	94
31	30 July-5August	15	13	17	45
32	6-12 August	10	9	3	22
33	13-19 August	3	2	2	7
Total	2 July-19August	100	75	75	250

Table 15.-Tracking results for sockeye salmon radio tagged in the Susitna and Yentna rivers during 2006.

Tagging Site	Total Number Tagged	Number Moved Upriver [a]	Percent Moved Upriver
Flathorn	100	100	100
Yentna	75	74	98.7
Sunshine	75	75	100
Total	250	249	99.6

[a] Fish recorded upriver from the tagging sites.

Table 16.-Regional distribution of radio-tagged sockeye salmon in the Susitna River drainage during 2006.

		Flathorn		Yentna		Sunshine	
Drainage	Region	Number of Fish	Percent	Number of Fish	Percent	Number of Fish	Percent
Susitna River	Lower Susitna River MS [a]	2[b]	2	3[c,d]	4	0	0
	Talkeetna River	3	3			3	4
	Tributaries	2	2			5	6.6
	Papa Bear Lake	0	0			2	2.7
	Larson Lake	17	17			47	62.7
	Stephan Lake	1	1			8	10.7
	Upper Susitna River MS	0	0			3[e]	4
	Chulitna River	2[f,g]	2			1	1.3
	Tributaries	0	0			1	1.3
	Byers Lake	3	3			2	2.7
	Swan Lake	4[g]	4			3	4
Yentna River	Lower Yentna River MS [h]	1[i]	1	2[j]	2.8		
	Upper Yentna River MS	5	5	4	5.4		
	Lake Creek	1	1	3	4		
	Chelatna Lake	15	15	10	13.3		
	Johnson Creek	0	1	1	1.3		
	Hewitt Lake	2	2	1	1.3		
	Kahiltna River	1	1	1	1.3		
	Lower Skwentna River MS [k]	1	1	0	0		
	Upper Skwentna River MS	6	6	7	9.3		
	Tributaries	4	3	8	10.7		
	Shell Lake	13	13	13	17.3		
	Talachulitna River	1	1	5	6.7		
	Tributaries	1	1	3[l]	4		
	Judd Lake	10	10	13	17.3		
	Kichatna River	5	5	1	1.3		
	Total	100	100	75	100	75	100

[a] Section of the Susitna River from saltwater to the Susitna-Talkeetna River confluence.

[b] Both fish moved only a short distance above the Flathorn tagging site.

[c] Includes two fish that passed Yentna station then back down to Flathorn.

[d] Includes one fish that passed Yentna station then back down to saltwater.

[e] All three fish were located in Upper Susitna but not assigned a final location.

[f] Includes one fish recorded near Lucy Lake.

[g] Includes one fish also recorded at Lower Yentna station.

[h] Section of the Yentna River from the Susitna-Yentna River confluence to the Yentna-Skwentna River confluence.

[i] Includes one fish that passed Yentna station, no other information available.

[j] Includes one fish tagged at Yentna, no information available, the second fish moved near Skwentna River confluence in Yentna River MS.

[k] Section of the Skwentna River from the Yentna-Skwentna River confluence to the Skwentna-Talachulitna River confluence.

[l] Includes one fish located in Movie Lake.

Table 17.-Recapture locations of Flathorn radio-tagged sockeye salmon by fish wheel in 2006.

Flathorn Fish Wheel	Radios Released	Recapture Locations: Mainstem Susitna R.	Yentna R.	Total
West Channel, West Bank	60	1	59	60
West Channel, East Bank	11	5	6	11
East Channel, West Bank	18	17	1	18
East Channel, East Bank	11	11	0	11
Total	100	34	66	100

Table 18.-Terminal distribution (number of fish and percent [in parentheses]) of radio-tagged sockeye salmon in the Susitna River drainage in 2006, by fish wheel.

	Terminal Site															
Tagging Site	Talkeetna River	Larson Lake	Stephan Lake	Chulitna River	Swan Lake	Byers Lake	Yentna River	Chelatna Lake	Hewitt Lake	Kahiltna River	Skwentna River	Shell Lake	Talachu-litna River	Judd Lake	Kichatna River	Total
Flathorn:																
West Channel, West Bank Fish Wheel																
	0	0	0	0	0	0	6	11 (11.3)	2	1	10	13	1	10	4	58
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(6.2)		(2.1)	(1.0)	(10.3)	(13.4)	(1.0)	(10.3)	(4.1)	(59.8)
West Channel, East Bank Fish Wheel																
	0	0	1	0	1	3	0	4	0	0	0	0	0	1	1	11
	(0.0)	(0.0)	(1.0)	(0.0)	(1.0)	(3.1)	(0.0)	(4.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(1.0)	(1.0)	(11.3)
East Channel, West Bank Fish Wheel																
	3	11	0	0	1	1[a]	0	0 (0.0)	0	0	1	0	0	0	0	17
	(3.1)	(11.3)	(0.0)	(0.0)	(1.0)	(1.0)	(0.0)		(0.0)	(0.0)	(1.0)	(0.0)	(0.0)	(0.0)	(0.0)	(17.5)
East Channel, East Bank Fish Wheel																
	2	6	0	1	2[b]	0	0	0 (0.0)	0	0	0	0	0	0	0	11
	(2.1)	(6.2)	(0.0)	(1.0)	(2.1)	(0.0)	(0.0)		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(11.3)
Yentna:																
North Bank Fish Wheel																
	0	0	0	0	0	0	1	1	0	0	2	0	0	1	0	5
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(1.4)	(1.4)	(0.0)	(0.0)	(2.9)	(0.0)	(0.0)	(1.4)	(0.0)	(7.1)
South Bank Fish Wheel																
	0	0	0	0	0	0	7	9	1	1	13	13	5	15[d]	1	65
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(10.0)	(12.9)	(1.4)	(1.4)	(18.6)	(18.6)	(7.2)	(21.4)	(1.4)	(92.9)
Sunshine:																
West Bank Fish Wheel																
	0	0	0	0	0	0	0	0 (0.0)	0	0	0	0	0	0	0	0
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
East Bank Fish Wheel																
	10[c]	47	8	2	3	2	0	0 (0.0)	0	0	0	0	0	0	0	72
	(13.9)	(65.3)	(11.1)	(2.8)	(4.1)	(2.8)	(0.0)		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(100.0)
Total	15	64	9	3	7	6	14	25	3	2	26	26	6	27	6	239
	(6.3)	(26.8)	(3.8)	(1.2)	(2.9)	(2.5)	(5.9)	(10.5)	(1.2)	(0.8)	(10.9)	(10.9)	(2.5)	(11.3)	(2.5)	(100.0)

[a] In small lake near Byers Lake

[b] Includes one fish in small lake near Swan Lake

[c] Includes two fish near Papa Bear Lake

[d] Includes one fish in small lake (Movie) near Judd Lake

Table 19.-Elapsed time by capture week for radio-tagged sockeye salmon traveling between the tagging area and the tracking station immediately upriver in 2006.

Tagging Site	Week Beginning	Number Tags	Average Days	Average Migration Speed (km/day)
Flathorn	7/2	0		
	7/9	2	2.4	2
	7/16	27	1.3	3.7
	7/23	42[a]	0.7	6.9
	7/30	15	0.7	7.1
	8/6	10	0.5	9.1
	8/13	3	0.4	13.5
	Combined	99	0.8	5.6
Yentna	7/2	0[a]		
	7/9	5[a]	2.8	1.6
	7/16	22	1.2	3.9
	7/23	22	1.4	3.3
	7/30	13	1.2	3.8
	8/6	9	1.1	4.1
	8/13	2	1.2	3.9
	Combined	73	1.3	3.4
Sunshine	7/2	0		
	7/9	0		
	7/16	24	0.9	4.7
	7/23	29	1	4.1
	7/30	17	0.8	5.3
	8/6	3	0.9	4.6
	8/13	2	2	2.1
	Combined	75	1	4.4
Total		247	1	4.4

Note: At Flathorn the average distance from four fish wheels to Flathorn was 4.71 km, at Yentna the average distance from both fish wheels to lower Yentna was 4.54 km, and at Sunshine the average distance from both fish wheels to Sunshine was 4.27 km.

[a] Excluding a radio tagged fish not recorded passing the tracking station.

Table 20.-Movement rates (km/day) of sockeye salmon radio tagged at Flathorn during 2006 based on travel time between the Flathorn tracking station and the lower Yentna and Sunshine tracking stations.

Tracking Station	River	Number of Tags	Distance (km)	Average Number of Days	Average Migration Speed (km/day)
Sunshine	Susitna	32[a,b]	88.3	7.9	11.2
lower Yentna	Yentna	66	18.1	1.3	13.6
Combined		98			12.8

[a] Excluding one radio tagged fish not recorded passing the Flathorn tracking station.

[b] Excluding one radio tagged fish not recorded passing the Sunshine tracking station.

Table 21.-Movement rates (km/day) of sockeye salmon radio tagged at Flathorn during 2006, based on fish passage from Flathorn to the furthest upriver tracking station locations.

Tracking Station	Number of Tags	Distance (km)	Average Number of Days	Average Migration Speed (km/day)
Talkeetna	2	116.6	19.7	5.9
Chulitna	5	130.7	17.7	7.4
Kahiltna	1	53.7	19.3	2.8
Skwentna	36	98.5	7.7	12.8
Kichatna	5	107.3	9.1	11.8
Upper Yentna	5	116	24.3	4.8
Combined	54			11.1

Table 22.-Movement rates (km/day) of sockeye salmon radio tagged at Yentna or Sunshine during 2006 based on fish passage from Yentna or Sunshine to the furthest upriver tracking station locations.

Tagging Site	Tracking Stations	Number of Tags	Distance (km)	Average Number of Days	Average Migration Speed (km/day)
Sunshine	Talkeetna	0	28.3		
Sunshine	Chulitna	4	42.4	5.9	7.2
Yentna	Kahiltna	1	35.6	4.3	8.2
Yentna	Skwentna	49	80.4	7.1	11.3
Yentna	Kichatna	1	89.2	8.1	11
Yentna	Upper Yentna	4	98	19	5.2
Combined		59			10.5

Table 23.-Passive integrated transponder (PIT) tag recapture probabilities and distance between fish wheel tagging sites and weir recapture sites.

Tagging Site	Weir Site	Distance from Tagging Site (km)	Recapture Probability
Flathorn	Judd	136.3	0.0079
Yentna	Judd	118.2	0.0147
Flathorn	Chelatna	123.5	0.0193
Yentna	Chelatna	105.4	0.0154
Flathorn	Larson	108.8	0.1877
Sunshine	Larson	40.5	0.3624

Table 24.-Comparison of sockeye salmon escapement estimates in the Susitna drainage, 2006. In the Yentna drainage sockeye salmon were counted at weirs on Judd, Shell, Hewitt, and Chelatna lakes, and in the upper Susitna drainage weirs were operated on Byers and Larson lakes.

			Escapement Estimate		
Population Estimated	Capture/Recapture Site	Method	Point	Lower 95% CI	Upper 95% CI
Mainstem Susitna	Sunshine/Larson-Byers	Radio Tag	93,161	80,053	106,268
Mainstem Susitna	Flathorn/Sunshine	PIT Tag	107,000	49,180	164,820
Mainstem Susitna	Sunshine/Larson	PIT Tag	128,105	-	-
Mainstem Susitna (lakes with weir)	-	Weir[a]	59,519	-	-
Yentna	Yentna/Judd-Shell	Radio Tag	311,197	251,568	391,264
Yentna (29 July onward)	Flathorn/Yentna	PIT Tag	417,750	261,930	573,570
Yentna	-	Bendix Sonar [b]	92,896	-	-
Yentna	-	DIDSON Sonar [c]	160,452	-	-
Yentna (lakes with weir)	-	Weir[a]	126,218	-	-

[a] *Source*: Cook Inlet Aquaculture Association. Soldotna, Alaska. Accessed 10 October, 2006. http://www.ciaanet.org/content_sub.asp?SUB_ID=14&CAT_ID=6.

[b]Shields 2007

[c]Maxwell et al. *In prep*

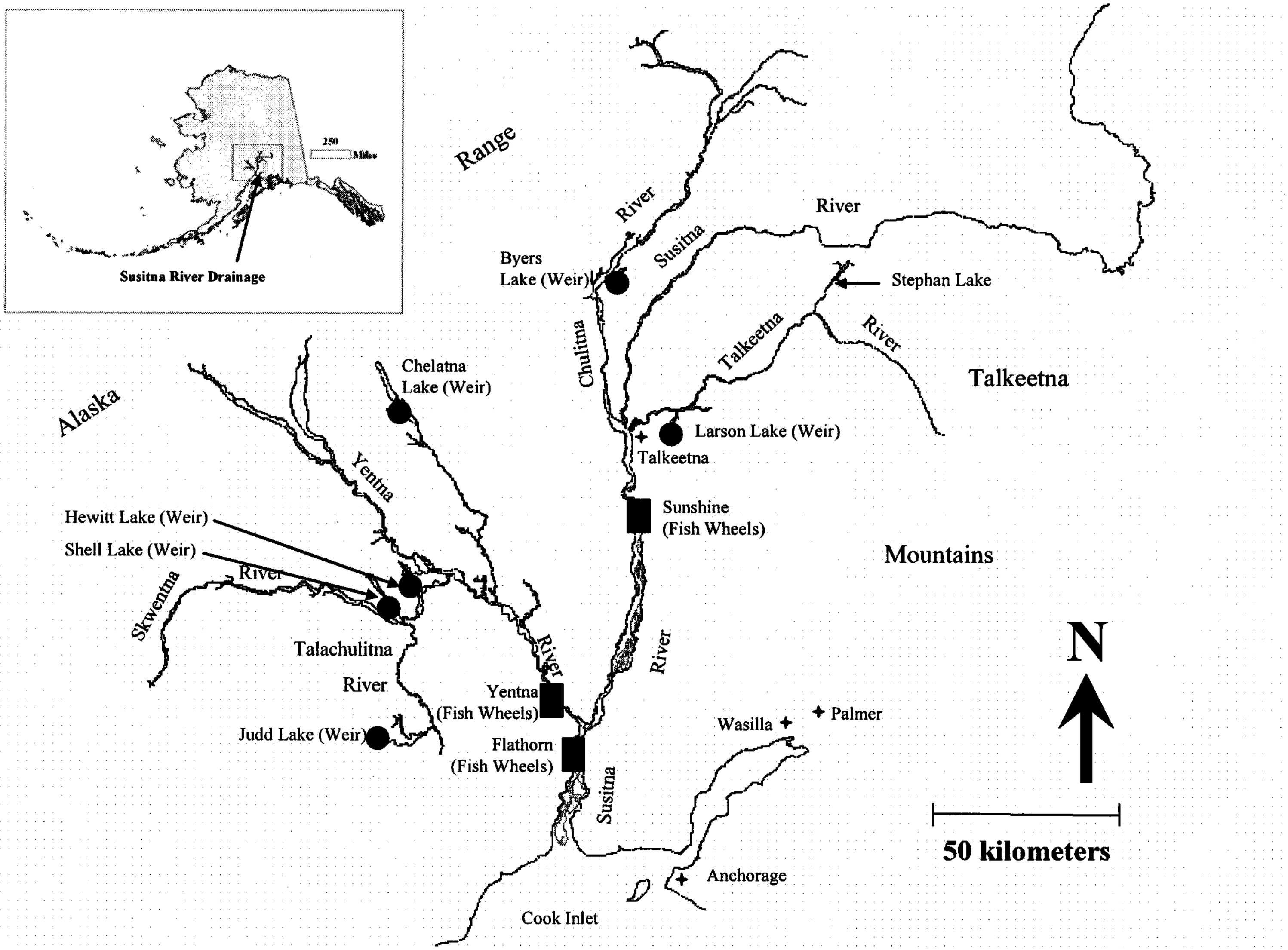


Figure 1.-Susitna River drainage with fish wheel (rectangles) and weir (circles) locations, 2006.

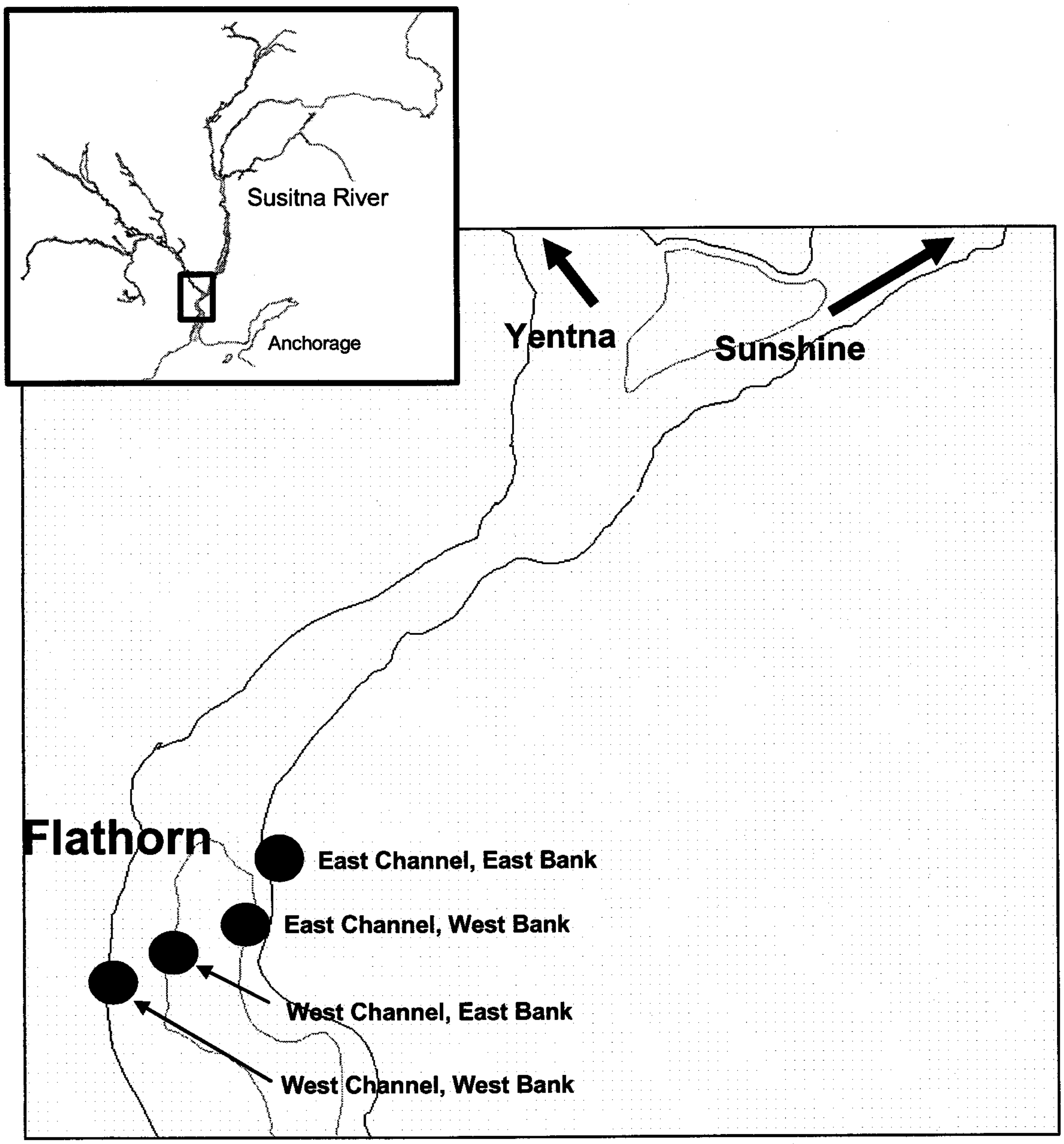


Figure 2.-Location of the four fish wheels on the lower Susitna River at Flathorn, 2006.

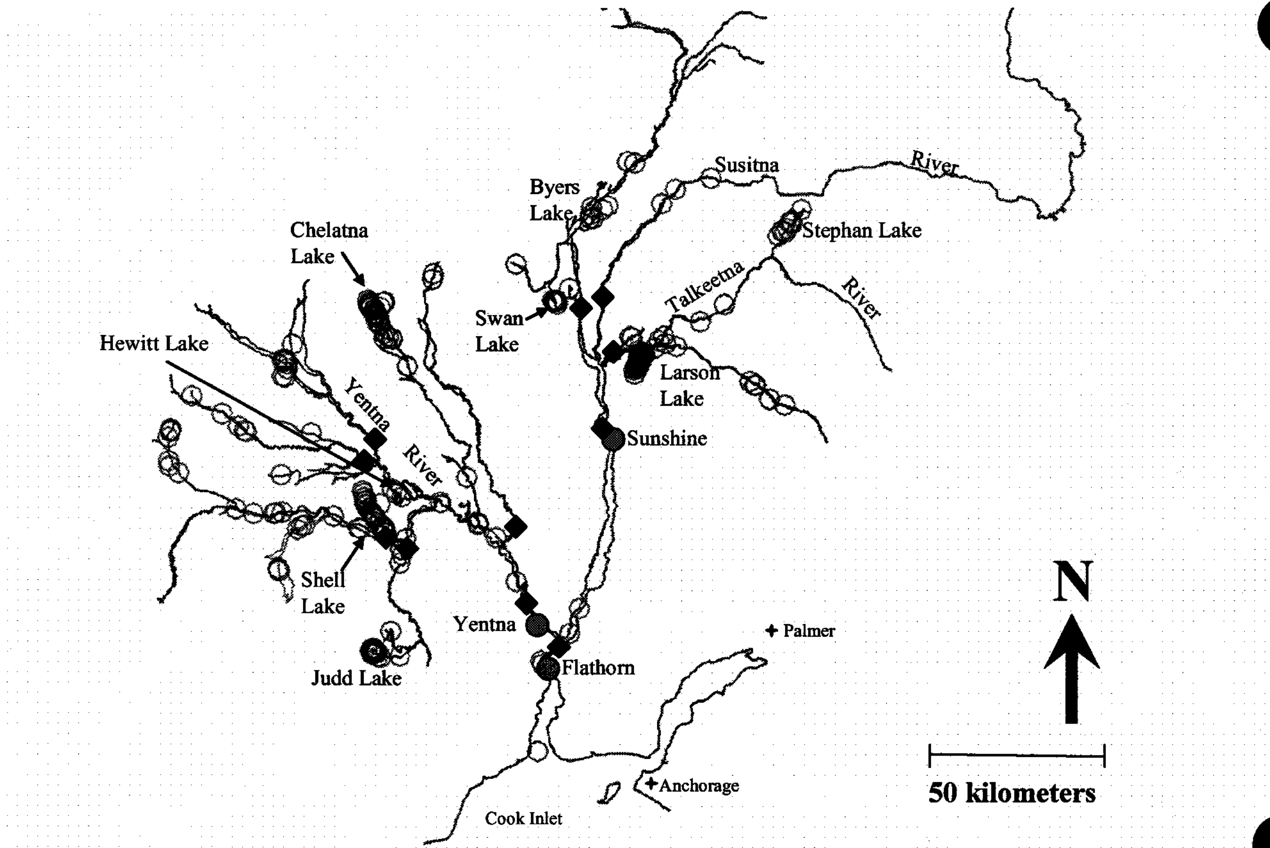
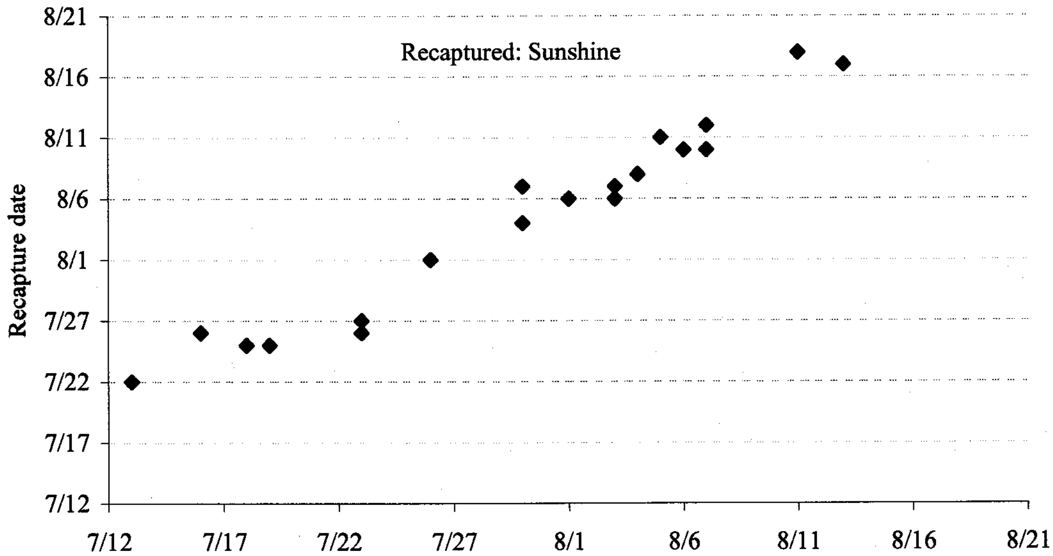


Figure 3.-The Susitna River drainage, the 3 fish wheel marking sites (solid circles), 11 remote radio tracking stations (solid diamonds), and the spawning locations of radio-tagged sockeye salmon (open circles) based on aerial surveys, 2006.



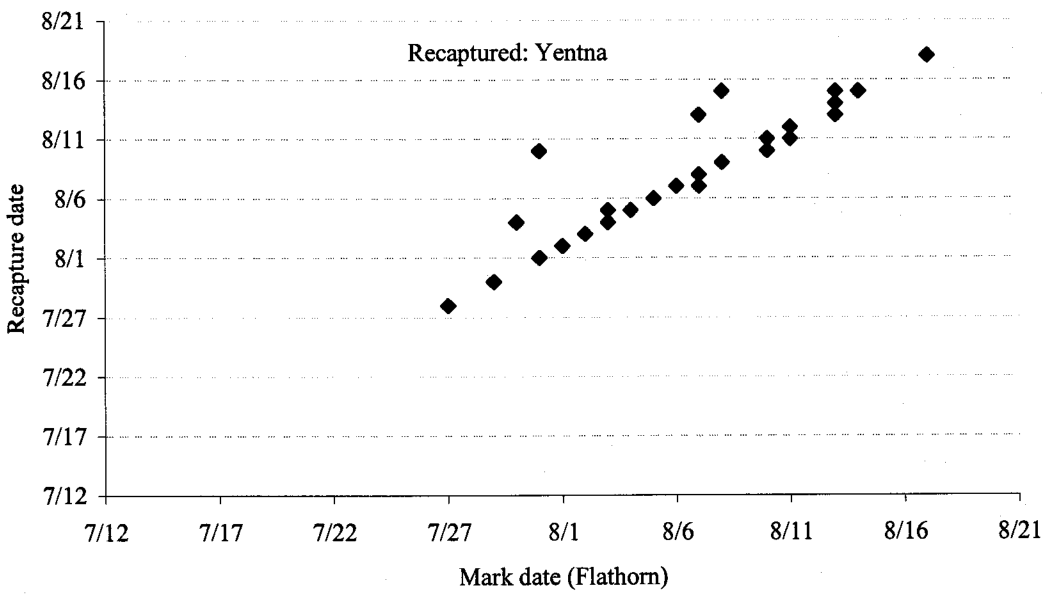


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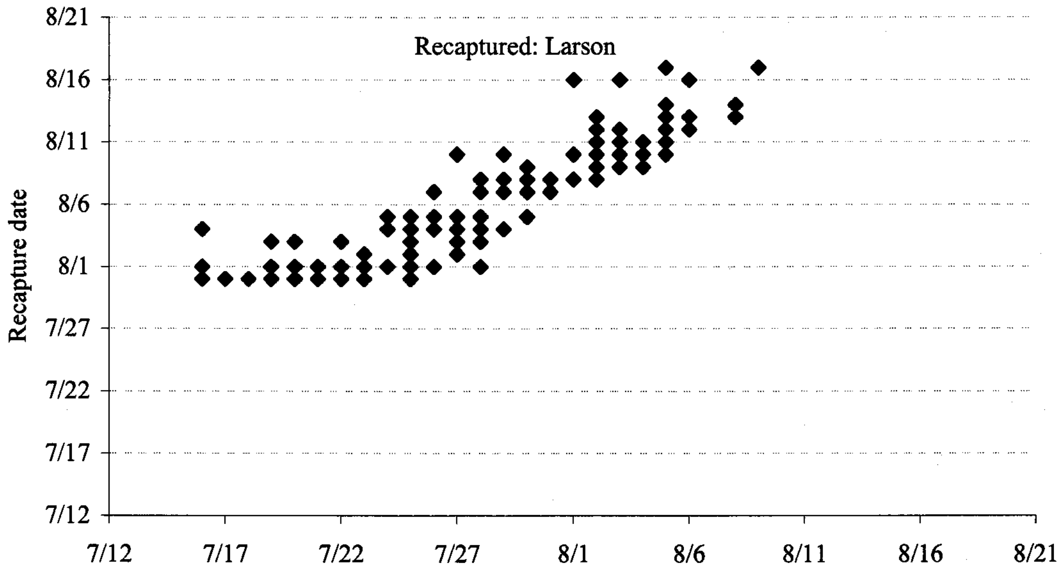
Figure 4.-Travel time of PIT-tagged sockeye salmon from Flathorn to Yentna and Sunshine, and to Larson, Chelatna, and Judd Lake weirs, 2006.



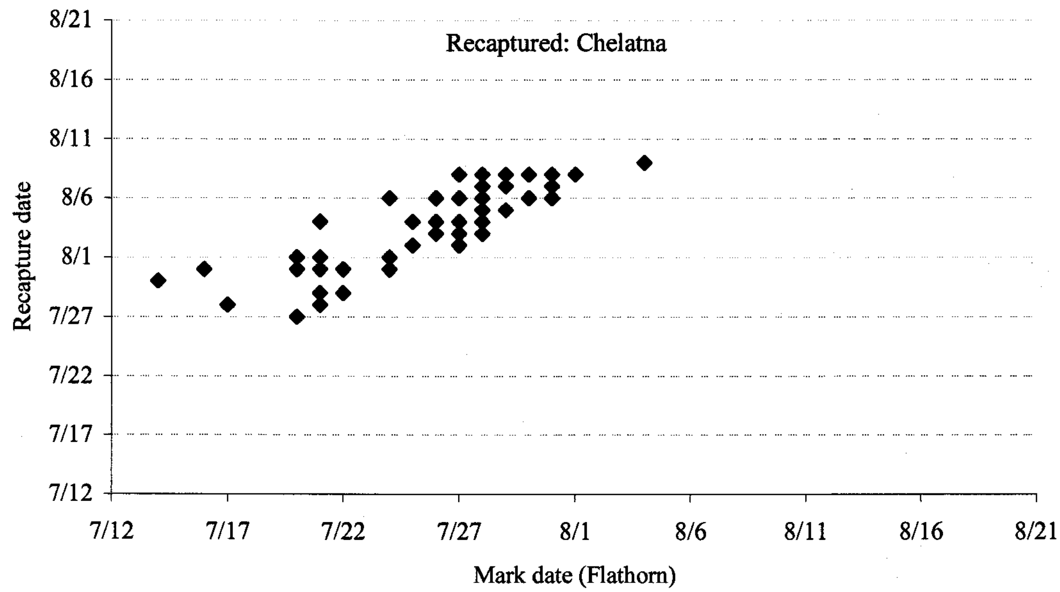


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Figure 4.-Page 2 of 3.

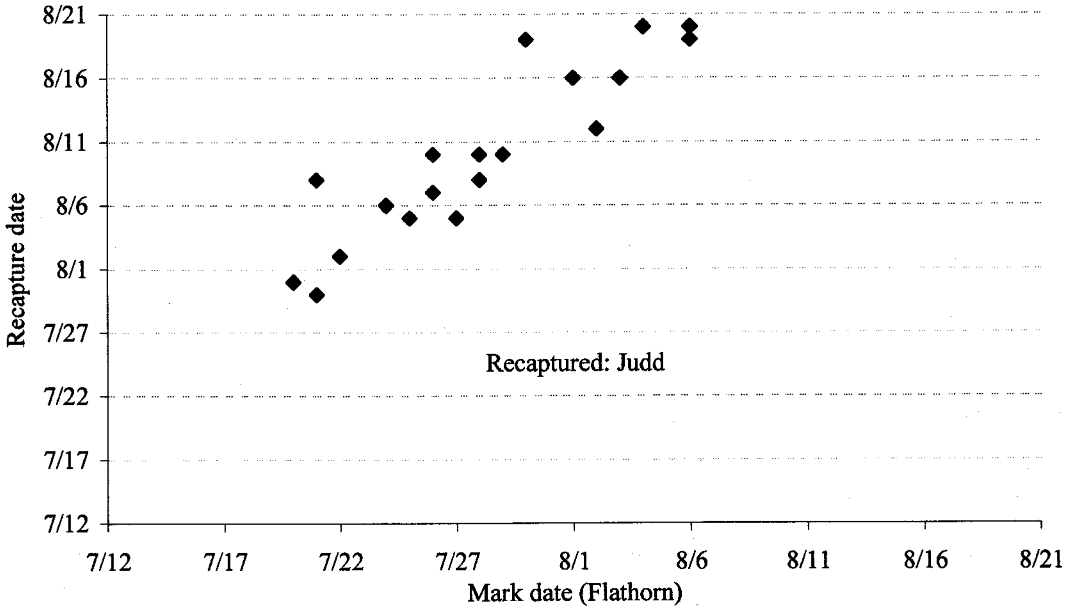


Figure 4.-Page 3 of 3.

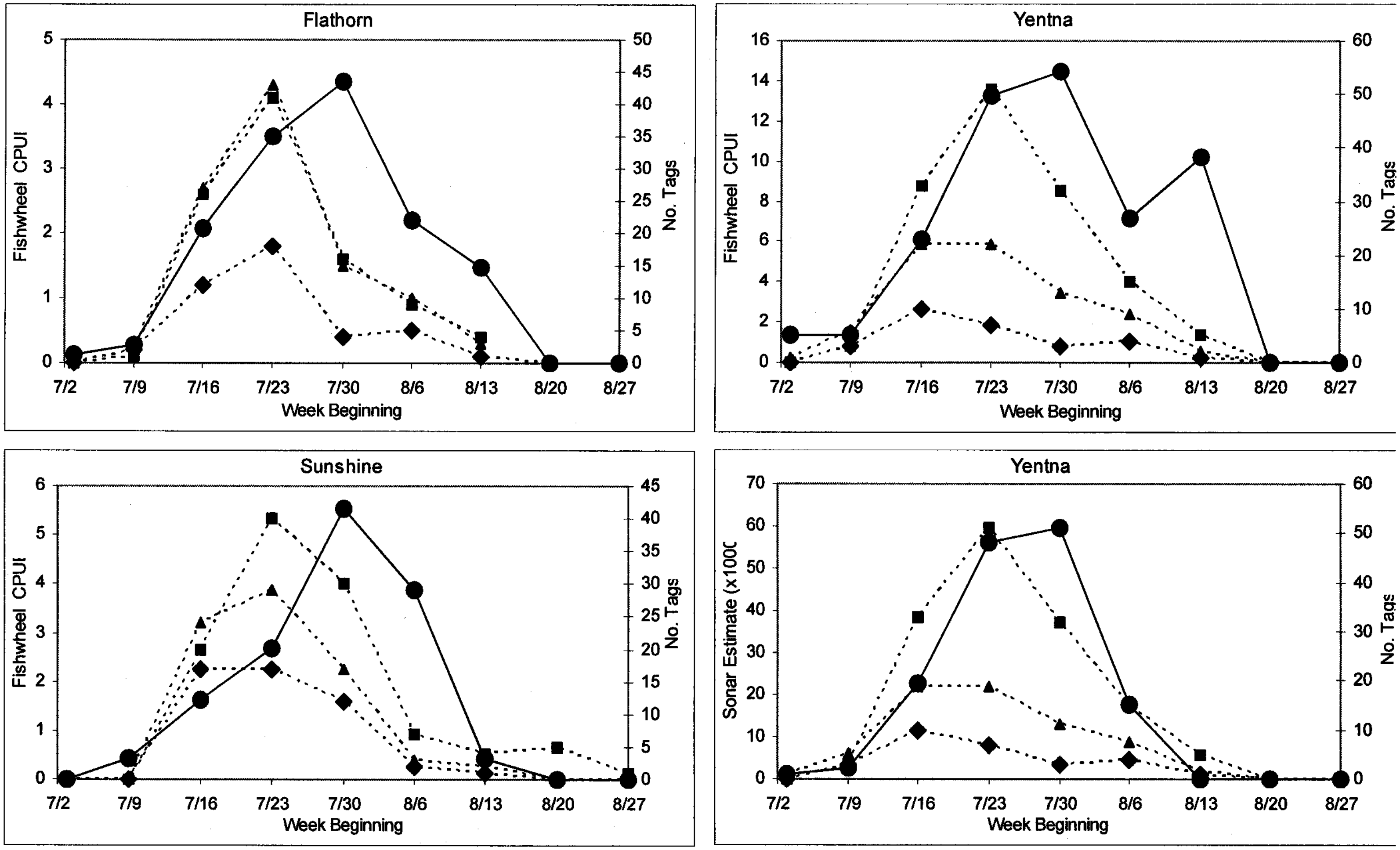


Figure 5.-Comparison of (1) number of radio tags applied to sockeye salmon (solid triangles), (2) number of radio tags applied to sockeye salmon that were subsequently detected in Judd, Shell, Larson, and Byers lakes (solid diamonds), and (3) number of radio-tagged sockeye salmon detected migrating past fixed radiotelemetry stations immediately upstream of tagging sites (solid squares) with sockeye salmon catch per hour (CPUE) in fish wheels (solid circles) at Flathorn, Sunshine, and Yentna.

Note: The lower right panel provides a comparison of the DIDSON sonar estimate (solid circles) for the number of sockeye salmon migrating past the Yentna sonar site (Maxwell et al. *In prep*) with data sets 1-3.

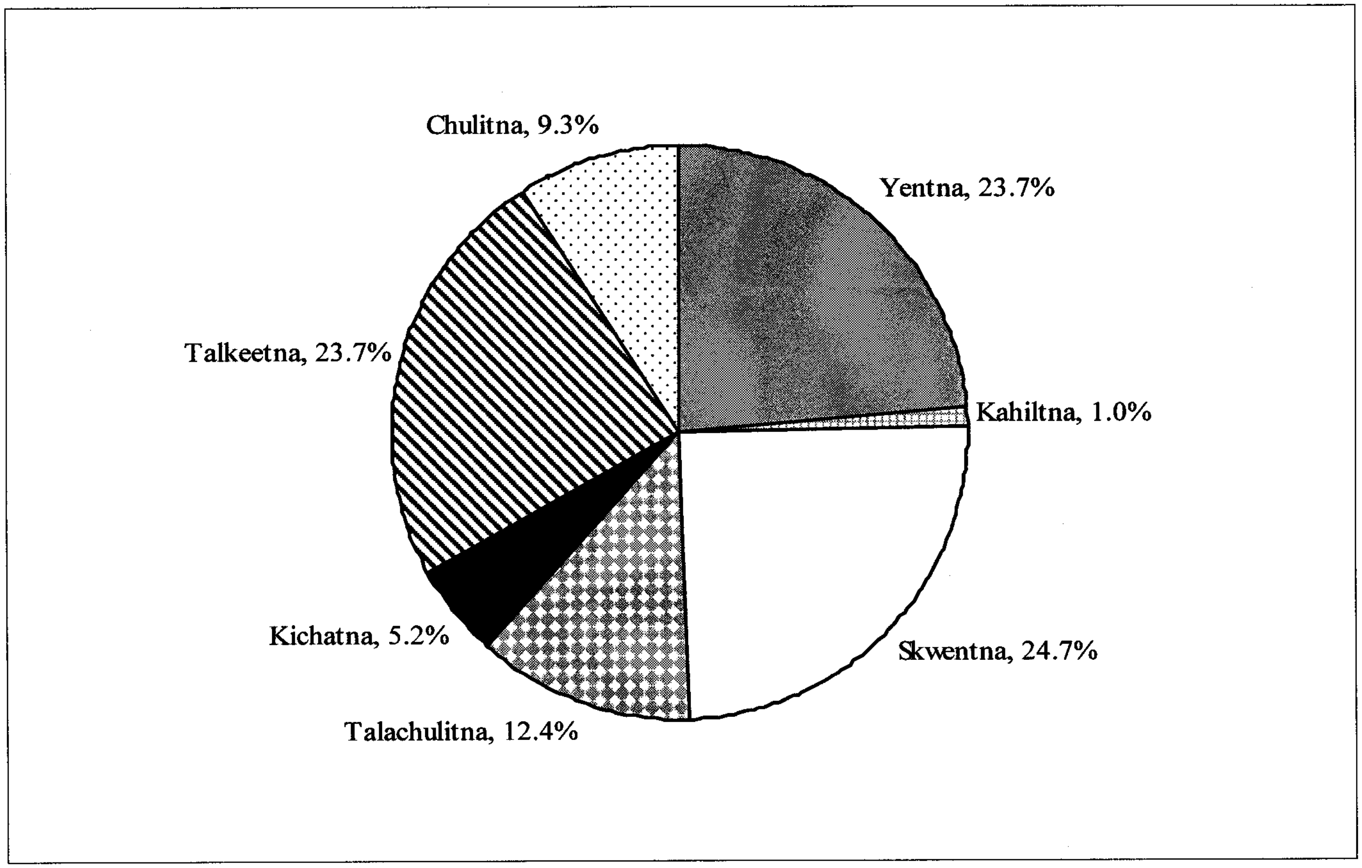


Figure 6.-Terminal distribution of sockeye salmon radio tagged in the lower Susitna River at Flathorn in 2006. Percentages indicate the fraction of the total number of fish that moved upriver to each terminal site.

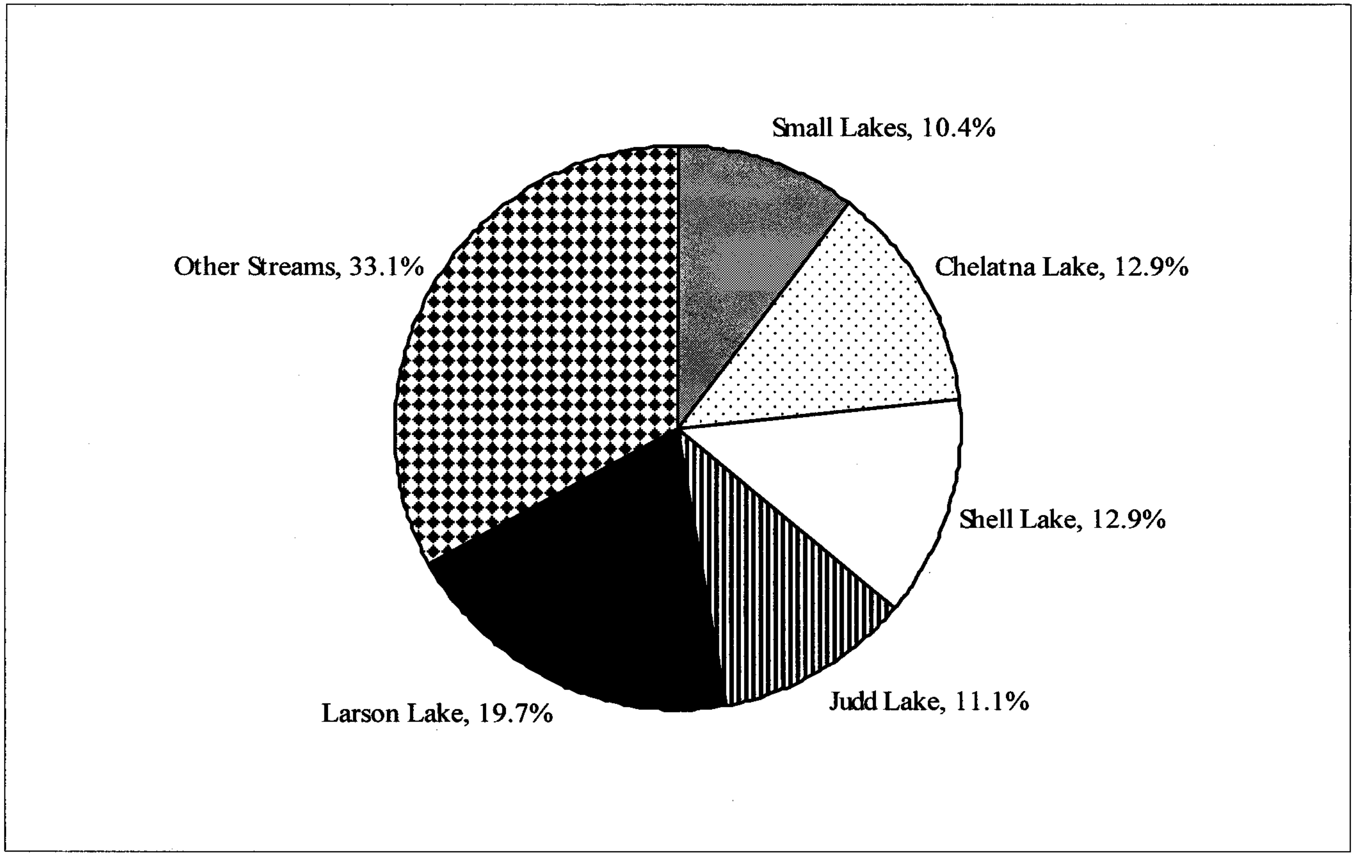


Figure 7.-Weighted terminal distribution of sockeye salmon radio tagged at Flathorn, Yentna, and Sunshine sites in 2006. Percentages indicate the fraction of the total number of fish that moved upriver to each terminal site. Yentna and Sunshine tag data were weighted by the fraction of the total number of Flathorn site radio tags that moved up the Susitna and Yentna drainages.

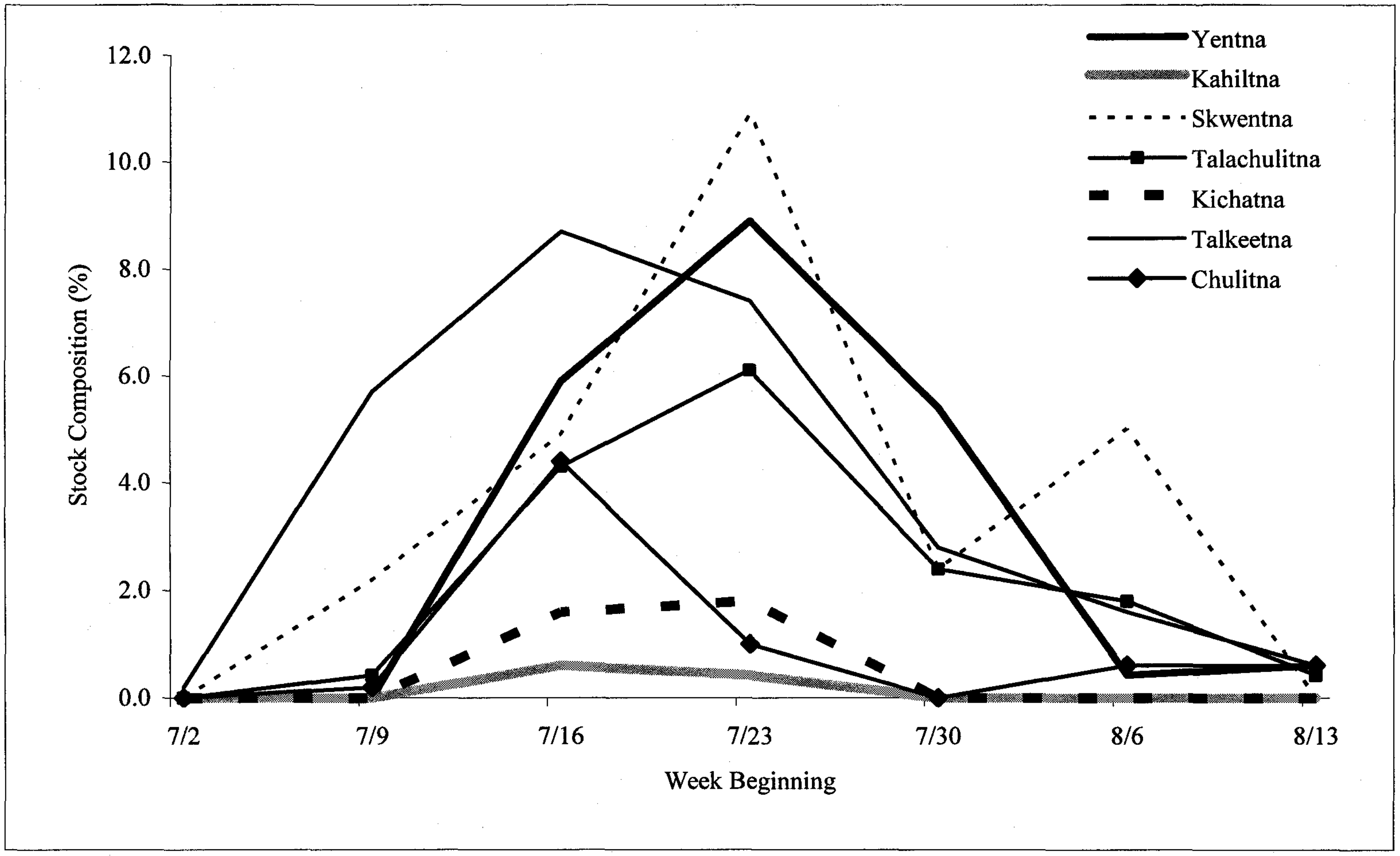


Figure 8.-Run timing by capture week of radio-tagged sockeye salmon passing from the Flathorn tagging site to terminal reaches of the Susitna River drainage in 2006, adjusted for upriver tagging site distances, 1 day at Yentna and 8 days at Sunshine. Yentna and Sunshine tag data were weighted by the fraction of the total number of Flathorn site radio tags that moved up the Susitna and Yentna drainages.

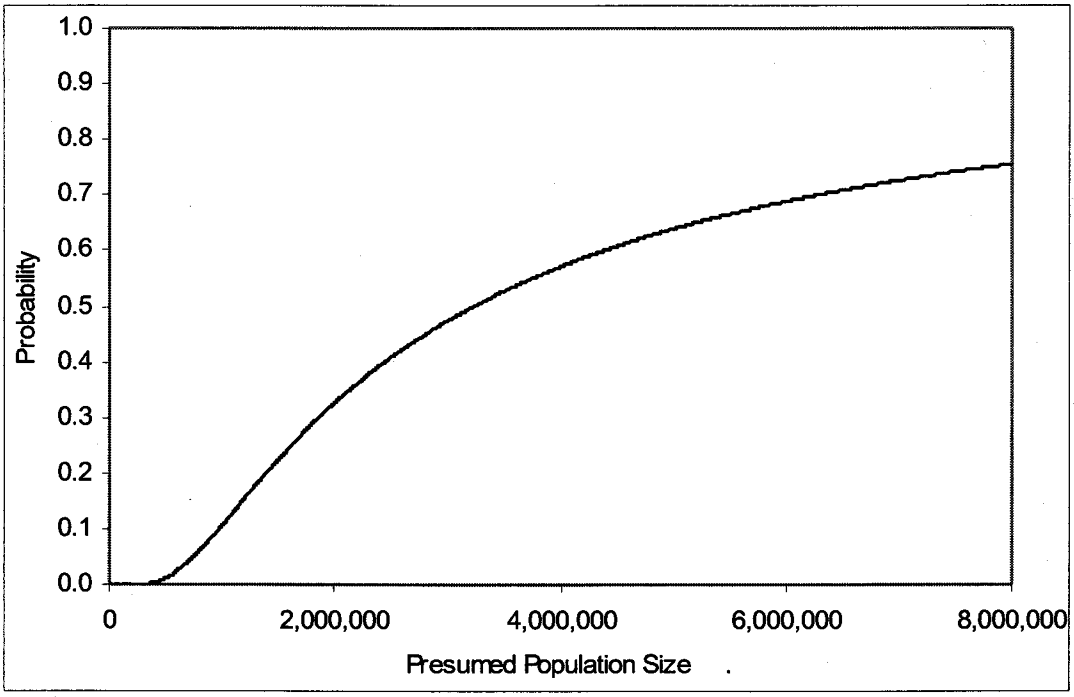


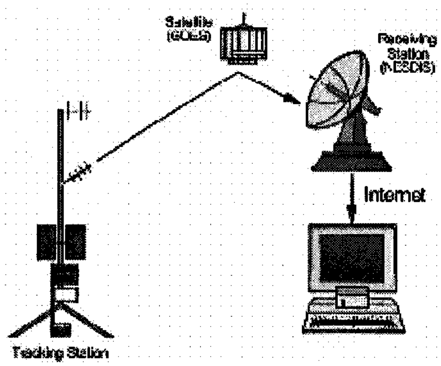
Figure 9.-Probability of detecting zero tags during the period before 29 July at the Yentna fish wheels in relation to presumed sockeye salmon population sizes during that period.

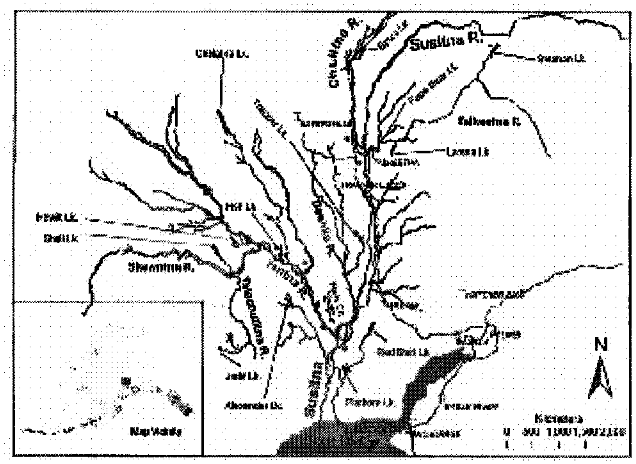
Appendix A1.-Example of project poster placed on tracking stations in 2006.

Susitna River Sockeye Salmon Radio Telemetry Project

This remote tracking station is part of a network of 11 sites that are used to follow the movements of sockeye salmon on their return migration to spawning grounds throughout the Susitna River drainage. Returning adult sockeye salmon are caught near the mouth of the Susitna River and radio tags are inserted in their stomachs. Tracking stations record when the fish moves past the site, and passage records are relayed to a central database. Radio tagged fish can also be tracked from aircraft to locate fish between tracking stations or within spawning tributaries.

This research will provide fishery biologists with a better understanding of the distribution of sockeye salmon in the Susitna River drainage, differences in the migration patterns of distinct stocks, and a yearly estimate of the total adult sockeye salmon population. This knowledge will be used to manage sustainable fisheries of wild sockeye salmon.





Appendix B1.-Daily counts of sockeye salmon, passive integrated transponder (PIT) tag detection rates, and number of PIT tags detected at weirs with automated PIT tag detection systems (Chelatna, Judd, and Larson lakes) during 2006.

Weir Site	Date	Number of Sockeye	PIT Tag Detection Rate	Number PIT Tags Detected
Chelatna	7/27	466	100.0%	2
Chelatna	7/28	337	100.0%	2
Chelatna	7/29	477	100.0%	4
Chelatna	7/30	71	96.0%	1
Chelatna	7/31	1,806	100.0%	10
Chelatna	8/1	1,015	95.0%	8
Chelatna	8/2	568	92.0%	3
Chelatna	8/3	1,027	94.0%	3
Chelatna	8/4	1,918	100.0%	9
Chelatna	8/5	536	99.0%	3
Chelatna	8/6	1,727	98.0%	10
Chelatna	8/7	1,013	98.0%	14
Chelatna	8/8	1,216	87.0%	10
Chelatna	8/9	115	77.0%	1
Chelatna	8/10	923	-	-
Judd	7/20	0	99.0%	0
Judd	7/21	0	100.0%	0
Judd	7/22	0	99.0%	0
Judd	7/23	0	100.0%	0
Judd	7/24	0	98.0%	0
Judd	7/25	92	99.0%	0
Judd	7/26	729	99.0%	0
Judd	7/27	1,042	98.0%	1
Judd	7/28	938	94.0%	6
Judd	7/29	2,141	100.0%	2
Judd	7/30	570	100.0%	3
Judd	7/31	1,802	95.0%	1
Judd	8/1	1,092	93.0%	1
Judd	8/2	4,116	92.0%	2
Judd	8/3	2,596	96.0%	0
Judd	8/4	1,869	87.0%	0
Judd	8/5	2,828	80.0%	2
Judd	8/6	1,584	98.0%	1
Judd	8/7	3,258	83.0%	1
Judd	8/8	3,371	86.0%	3
Judd	8/9	3,416	100.0%	1
Judd	8/10	726	88.0%	4
Judd	8/11	2,797	77.0%	0
Judd	8/12	897	90.0%	1
Judd	8/13	1,297	96.0%	0
Judd	8/14	1,616	76.0%	0
Judd	8/15	632	89.0%	1
Judd	8/16	171	100.0%	2
Judd	8/17	173	88.0%	3

continued

Appendix B1.–Page 2 of 2.

Weir Site	Date	Number of Sockeye	PIT Tag Detection Rate	Number PIT Tags Detected
Judd	8/18	178	98.0%	1
Judd	8/19	490	82.0%	4
Judd	8/20	121	94.0%	2
Judd	8/21	91	92.0%	0
Larson	7/14	3	-	-
Larson	7/15	0	-	-
Larson	7/16	0	-	-
Larson	7/17	0	-	-
Larson	7/18	0	-	-
Larson	7/19	0	-	-
Larson	7/20	0	-	-
Larson	7/21	1	-	-
Larson	7/22	0	-	-
Larson	7/23	117	-	-
Larson	7/24	284	-	-
Larson	7/25	1,514	-	-
Larson	7/26	1,053	-	-
Larson	7/27	648	-	-
Larson	7/28	2,961	-	-
Larson	7/29	1,580	-	-
Larson	7/30	1,815	-	-
Larson	7/31	5,990	**265.0%**	46
Larson	8/1	5,692	92.0%	53
Larson	8/2	3,202	**103.0%**	33
Larson	8/3	4,138	85.0%	46
Larson	8/4	6,364	91.0%	58
Larson	8/5	2,521	93.0%	54
Larson	8/6	3,482	-	-
Larson	8/7	3,750	86.0%	57
Larson	8/8	4,493	100.0%	100
Larson	8/9	1,636	99.0%	39
Larson	8/10	1,369	**102.0%**	40
Larson	8/11	940	**103.0%**	29
Larson	8/12	1,057	100.0%	55
Larson	8/13	835	**101.0%**	35
Larson	8/14	326	100.0%	8
Larson	8/15	439	**101.0%**	9
Larson	8/16	171	98.0%	19
Larson	8/17	64	**101.0%**	5

Appendix B2.-Daily counts of sockeye salmon through the Judd, Shell, Hewitt, Chelatna, Byers, and Larson Lake weirs, 2006.

	West Side (Yentna River) Lakes					East Side (Susitna / Chulitna Rivers) Lakes		
Date	Judd	Shell	Hewitt [a]	Chelatna [b]	Total	Byers	Larson [c]	Total
7/13	0				0	0		0
7/14	0				0	0	3	3
7/15	0	0			0	0	0	0
7/16	0	0			0	0	0	0
7/17	0	0			0	0	0	0
7/18	0	0			0	0	0	0
7/19	0	0			0	0	0	0
7/20	0	0			0	3	0	3
7/21	0	0			0	0	1	1
7/22	0	0			0	0	6	6
7/23	0	10			10	0	117	117
7/24	0	1,130			1,130	0	284	284
7/25	92	2,334			2,426	0	1,514	1,514
7/26	729	7			736	0	1,053	1,053
7/27	1,042	2,325		517	3,884	0	648	648
7/28	938	704		337	1,979	0	2,961	2,961
7/29	2,141	23		477	2,641	0	1,580	1,580
7/30	570	1,117		71	1,758	1	1,815	1,816
7/31	1,802	1,868	57	1,806	5,533	9	5,990	5,999
8/1	1,092	904	6	1,015	3,017	1	5,652	5,653
8/2	4,116	677	444	568	5,805	14	3,202	3,216
8/3	2,596	0	3	1,027	3,626	2	4,138	4,140
8/4	1,869	14,152	510	1,918	18,449	32	6,364	6,396
8/5	2,828	11,086	948	536	15,398	18	3,521	3,539
8/6	1,584	1,424	134	1,727	4,869	49	3,482	3,531
8/7	3,258	5,011	0	1,013	9,282	132	3,750	3,882
8/8	3,371	2,613	337	1,217	7,538	816	4,493	5,309
8/9	3,416	8,278	0	115	11,809	307	1,636	1,943
8/10	726	7,123	74	928	8,851	811	1,369	2,180
8/11	2,797	0	0		2,797	384	940	1,324
8/12	897	2,896			3,793	54	1,057	1,111
8/13	1,297	451			1,748	31	835	866
8/14	1,616	181			1,797	148	326	474
8/15	632	3,252			3,884	136	439	575
8/16	171	1,567			1,738	123	171	294
8/17	173	0			173		64	64
8/18	178	5			183			
8/19	490	662			1,152			
8/20	121				121			
8/21	91				91			
Total	40,633	69,800	2,513	13,272	126,218	3,071	57,411	60,482

[a] High water halted weir operations between 11 and 13 August. Weir crew was removed from site on 14 August.

[b] Crew arrived on 15 July. Weir installation was post poned until 21 July due to high water. The weir was complete on 26 July and normal operations began 27 July. High water again halted weir operations between 11 and 15 August. The weir crew was removed from site on 16 August.

[c] High water halted operations on 18 August and the weir was removed.

Source: Cook Inlet Aquaculture Association. Soldotna, Alaska. Accessed 10 October, 2006. http://www.ciaanet.org/content_sub.asp?SUB_ID=14&CAT_ID=6.

Appendix C1.–Terminal distribution of radio-tagged sockeye salmon within the upper Susitna and Yentna drainages calculated using numbers of radio tags detected migrating upstream past Sunshine and Yentna. The proportion of the total number of tags at each terminal site is indicated, as well as the proportion weighted by the weekly catch per hour in fish wheels at each tagging site.

Upper Susitna drainage

Lake or Stream	Number Tags	Proportion	Weighted No. Tags	Weighted Proportion
Byers Lake	4	0.037	4.4	0.042
Chulitna River	5	0.047	2.7	0.025
Larson Lake	64	0.598	59.6	0.562
Papa Bear Lake	2	0.019	2.8	0.026
Sheep River	7	0.065	5.9	0.055
Stephan Lake	5	0.047	3.7	0.035
Prairie Creek below Stephan Lake	4	0.037	5.4	0.051
Susitna River (Upper)	2	0.019	0.9	0.009
Susitna River (Mainstem)	2	0.019	2.5	0.024
Swan Lake	7	0.065	8.6	0.081
Talkeetna River	5	0.047	9.5	0.090
Total	107	1.000	106.0	1.000

Yentna drainage

Lake or Stream	Number Tags	Proportion	Weighted No. Tags	Weighted Proportion
Chelatna Lake	25	0.179	20.9	0.154
Granite Creek	2	0.014	2.1	0.015
Happy River	3	0.021	3.0	0.022
Hayes River	3	0.021	3.2	0.024
Hewitt Lake	3	0.021	5.7	0.042
Johnson Creek	1	0.007	1.5	0.011
Judd Lake	24	0.171	19.8	0.146
Kichatna River	5	0.036	2.6	0.020
Lake Creek	4	0.029	6.0	0.044
Moose Creek	4	0.029	2.4	0.017
Movie Lake	1	0.007	1.5	0.011
Nakochna River	1	0.007	0.6	0.004
Shell Lake	25	0.179	27.3	0.202
Skwentna River	16	0.114	12.6	0.093
Talachulitna River	8	0.057	12.7	0.094
Trimble River	2	0.014	1.4	0.010
Yentna River	4	0.029	3.5	0.026
Yentna River (W. Fork)	8	0.057	7.1	0.052
Yentna River (E. Fork)	1	0.007	1.5	0.011
Total	140	1.000	135.3	1.000

Fishery Manuscript No. 07-07

Post-season Stock Composition Analysis of Upper Cook Inlet Sockeye Salmon Harvest, 2005-2007

REVISED 1/25/2008

ADDENDUM

The attached addendum, inserted 1/25/08 following page 74 of this manuscript, contains changes due to two errors and one clarification. This addendum contains a description of how the errors were detected, the nature of the errors, the magnitude of the changes which resulted, and a discussion of the effect these changes have on the conclusions of this publication.

by

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December 2007

Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Measures (fisheries)

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

Mathematics, statistics

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

FISHERY MANUSCRIPT NO. 07-07

POST-SEASON STOCK COMPOSITION ANALYSIS OF UPPER COOK INLET SOCKEYE SALMON HARVEST, 2005-2007

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December 2007

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ABSTRACT

Genetic data were collected from sockeye salmon *Oncorhynchus nerka* originating from all major systems in Upper Cook Inlet, Alaska, that produce sockeye salmon. All individuals in the baseline were assayed for genotypes at 45 SNP markers. These DNA-based markers revealed population structure similar to that observed in the previous analyses with allozymes. Simulations indicated that seven regional groups (Kenai River, Susitna River, Yentna River, West Cook Inlet, Kasilof River, Northeast Cook Inlet, and Knik Arm) could be identified in mixtures at high levels of precision and accuracy. Samples taken from within the rivers at fish wheels were analyzed to evaluate the precision and accuracy possible using the baseline of new markers and statistical methods. Sockeye salmon from these drainages are commercially harvested in mixed-stock aggregations in Upper Cook Inlet. Genetic Stock Identification using Bayesian methods with data from 40 to 42 loci were performed to estimate the proportion of source populations in the harvest from set and drift gillnet fisheries during selected periods in the Central District of Upper Cook Inlet from 2005 to 2007. Samples from fisheries were analyzed postseason. Samples from the offshore test fishery were also analyzed. Patterns of stock proportions through time in the fishery were similar to results from allozyme data, indicating that Kenai River fish are present in the harvest later in the season relative to Kasilof River fish. High inter-annual variation in stock composition through space and time was detected, but this high level of variation might have been due, in part, to the unusual nature of the fishery during the 3 years investigated.

Key words: Cook Inlet, sockeye salmon, *Oncorhynchus nerka*, genetic stock identification, GSI, commercial fishery, SNP.

INTRODUCTION

BACKGROUND

Since the early 1990s the Alaska Department of Fish and Game (ADF&G) has actively developed and refined genetic stock identification (GSI; see Box 1 for definition of terms) applications to provide improved stock composition information for management of commercial fisheries. These efforts have encompassed nearly the entire State of Alaska with projects focusing on chum *Oncorhynchus keta*, Chinook *O. tshawystcha*, and sockeye *O. nerka* salmon (e.g. Seeb et al. 2004; Templin et al. 2005; Habicht et al. 2007). ADF&G now conducts GSI projects throughout the state and maintains extensive tissue archives from spawning populations for all three species.

One of the earliest GSI projects was initiated by ADF&G in 1992 for Cook Inlet sockeye salmon following the *Exxon Valdez* oil spill (Seeb et al. 1997). Building on the earlier genetic studies of Grant et al. (1980) and Wilmot and Burger (1985), the project was designed to detect the contribution of Kenai River sockeye salmon to the commercial harvest. Over the course of the project ADF&G sampled approximately 8,300 sockeye salmon from 54 spawning populations between 1992 and 1997 and provided a detailed analysis of the population structure of sockeye salmon in Cook Inlet using allozyme (protein) analyses (Seeb et al. 2000). The data revealed a substantial amount of genetic diversity among populations of Cook Inlet with the diversity distributed both within and among major drainages. The data supported a model of population structure generally organized around the lakes in which juvenile sockeye salmon rear (nursery lakes).

These allozyme data, paired with the GSI statistical methods available at that time, were able to differentiate among populations spawning in the major sockeye salmon-producing regions: Yentna/Susitna, Kenai, and Kasilof rivers, and groups of minor river drainages including those in West Cook Inlet, Northeast Cook Inlet, and Knik Arm. Single-region mixtures of simulated fish (fish were simulated based on population-specific allele frequencies) subjected to GSI, allocated on average 91% to the correct region. However, when samples were taken from fish captured at fish wheels within the Kenai, Kasilof, Susitna, and Yentna rivers, allocations to the local reporting group averaged 85%. In addition, stock composition estimates from fish sampled in drift and set gillnet fisheries showed higher day to day variability than was expected by the fishery managers. This combination of results did not provide the managers with the confidence necessary to use these data for management decisions regarding Cook Inlet sockeye salmon.

Concurrent with these fishery monitoring activities, ADF&G actively focused on research to improve the techniques of GSI, including: 1) development and evaluation of genetic markers for improved resolution of stock identification, 2) development of statistical techniques for more accurate and precise estimation of stock composition, and 3) development of the infrastructure to support high-throughput and low-error genotyping.

Here we report on an initiative begun in July of 2005 to apply improved GSI techniques to estimate the stock composition of sockeye salmon in Upper Cook Inlet (UCI) commercial harvests for selected periods from 2005 through 2007.

Box 1.–Definition of terms commonly used in genetic stock identification of Pacific salmon.

Allele	Alternative form of a given gene or DNA sequence.
Allozyme	Allelic form of a protein enzyme encoded at a given locus. Allozymes are usually distinguished by protein electrophoresis and histochemical staining techniques.
Locus (loci, plural)	A fixed position or region on a chromosome that may contain more than one genetic marker.
Genetic marker	A known DNA sequence that can be identified by a simple assay.
GSI	Genetic Stock Identification: Method using allele frequencies from populations and genotypes from mixture samples to estimates stock compositions of mixtures
Microsatellites	DNA sequences containing short (2–5 base pairs) tandem repeats of nucleotides (e.g. GTGTGTGT)
PCR	The polymerase chain reaction or PCR amplifies a single or few copies of a locus across several orders of magnitude, generating millions of copies of the DNA.
SNP	Single nucleotide polymorphism; DNA sequence variation occurring when a single nucleotide (A, T, C, or G) differs among individuals or within an individual between paired chromosomes.

Note: adapted from Seeb et al. (2007).

IMPROVEMENTS TO GSI TECHNIQUES

Development of Genetic Markers

DNA sequence polymorphisms among individuals provide the basis for GSI. The portion of a DNA sequence that is polymorphic among individuals of a species is called a "genetic marker" (see Box 1). Assays for genetic markers have been developed to allow the inference of the DNA sequence. For example, allozyme markers reflect changes in DNA that code for the formation of protein products. Forms of the marker (alleles) are detected as a result of differences in size or charge of a protein product. Over the last 15 years, allozyme markers have been replaced by markers that directly reflect differences in DNA sequence (Schlotterer 2004). The alleles at these markers reflect either the sequence of nucleic acids in the DNA or varying lengths of particular DNA fragments. These markers have an advantage over allozymes in that they typically do not require lethal sampling, can be chosen to reflect a variety of evolutionary rates and forces, and can be readily automated for high-throughput genotyping.

In the 1990s ADF&G recognized the limitations associated with the Cook Inlet allozyme data and began to evaluate other genetic markers based on DNA as part of the *Exxon Valdez* study (Seeb et al. 1997). A wide range of DNA marker types were evaluated for sockeye salmon. Allendorf and Seeb et al. (2000) compared allozymes, microsatellites (see Box 1), randomly amplified polymorphic DNA markers (RAPDs), and mitochondrial DNA (mtDNA) for Cook Inlet sockeye salmon and found concordance in population structure identified by the different marker types.

At the same time, studies utilizing microsatellites were being conducted on Bristol Bay sockeye salmon by ADF&G (Olsen et al. 2004; Habicht et al. 2004; Habicht et al. 2007). Partially driven by the early results (Habicht et al. 2007) indicating that ADF&G's microsatellite markers might be insufficient to differentiate among some Bristol Bay sockeye salmon stocks, ADF&G began to evaluate single nucleotide polymorphisms (SNPs; Box 1), which are single-base differences at a nucleotide position in a DNA sequence. The human genome project and similar projects on other species have shown that SNPs are ubiquitous throughout the genome. Since SNPs occur throughout the genome in many species, they are likely subject to a wider range of evolutionary rates than microsatellites and are thus useful for addressing a broader range of questions (Brumfield et al. 2003; Morin et al. 2004). Because some SNPs are influenced by natural selection they are particularly valuable for GSI applications where other markers show no differences between geographically close populations. For example, Miller et al. (2001) found that apparent differences in selection for SNPs in the MHC locus resulted in strong genetic distinction between nearby populations of sockeye salmon, in contrast to observations at neutral loci. Similarly, Beacham et al. (2001) demonstrated that SNPs involved in the immune system of salmon could provide as good or better resolution for genetic stock analyses than microsatellites.

SNP applications in GSI studies of Pacific salmon have become increasingly common (Smith et al. 2005b; Smith et al. *In press*; Narum et al. *In review*). ADF&G developed assays for SNP markers for sockeye salmon (Smith et al. 2005a; Elfstrom et al. 2006), and these markers are now used by U.S. laboratories for projects on sockeye salmon by the Pacific Salmon Commission in the Northern Boundary region. This same method has been used by ADF&G in Bristol Bay with sockeye salmon both in-season to estimate relative stock contributions passing through the Port Moller test fishing area, and post-season to estimate the commercial-catch stock contributions in fisheries for brood-tables used to establish escapement goals. This same set of SNPs was used in this study.

Statistical Developments

The 1990s Cook Inlet study (Seeb et al. 2000) used conditional maximum likelihood methods as reviewed in Pella and Milner (1987) and implemented in the software program SPAM (Debevec et al. 2000) to estimate the composition of stocks in mixtures. This method assumes that the baseline populations were accurately and completely represented by the baseline samples.

Research by scientists at the National Marine Fisheries Service Auke Bay Laboratories focused on the uncertainties and error associated with sampling baseline (spawning) populations used in mixture analyses (Pella and Masuda 2001). Conditional maximum likelihood methods do not use the information in the stock-mixture sample to improve the estimates of the baseline allele frequencies. Pella and Masuda (2001) and Koljonen et al. (2005) implemented Bayesian methods that incorporate the information available in the mixture to augment the information in the baseline samples to better estimate the genetic composition of the various stocks in the mixture.

Along with improvements in stock composition estimation techniques, ADF&G investigated methods to detect specific populations in mixtures (Reynolds and Templin 2004a) and to compare mixture estimates (Reynolds and Templin 2004b) using Cook Inlet sockeye salmon.

Infrastructure Improvements

Genotyping technologies for SNPs have been developing at a rapid rate and are now faster than those for any other marker class (Ranade et al. 2001; Melton 2003). SNP genotypes can be assayed by a variety of methods, typically with exceedingly low error rates, and these assays are readily transferred and repeatable across instruments and laboratories. Recently, ADF&G installed highly automated technology to further reduce costs and increase throughput.

The movement to high-throughput analyses has also required ADF&G to develop a laboratory database and implement quality control measures to ensure data integrity and to measure genotyping error rates. Both of these components were used and are reviewed in this study.

MANAGEMENT OF UCI SOCKEYE

Management strategy

Sockeye salmon are commercially harvested in UCI using drift and set gillnets. Drift gillnet fisheries occur in the Central District only; whereas set gillnet fisheries occur in both the Central and Northern Districts on both eastern and western shores (Figure 1). During the season, regularly scheduled fishery openings occur for 12 hours on Mondays and Thursdays beginning at 7:00 AM. Additional fishing time may be allowed via emergency orders depending on the abundance and projected run size of sockeye salmon. The season generally begins in late June and runs through early August for a total of 14 regularly scheduled fishery openings.

In recent years the drift gillnet fleet has been restricted to a smaller portion of the district to reduce the exploitation of specific sockeye salmon stocks. These restrictions to the drift fleet can vary throughout the season and across years. During the most restrictive periods, only the Kasilof River terminal area remains open. Less restrictive periods may open areas south of the northern tip of Kalgin Island or the southern tip of Kalgin Island or the Kenai or Kasilof corridors. East Side Subdistrict (Central District) set gillnet fisheries in the Kasilof Section are also sometimes restricted to within ½ mile from the beach to reduce harvests of Kenai River stocks (Figure 1). Descriptions of the management plans governing these fisheries and details of these restrictions for specific years can be found in the UCI annual management reports (Shields 2007) and in reports to the Alaska Board of Fisheries.

ADF&G uses the catch (number of fish harvested) and escapement (number of fish allowed to spawn) estimates of sockeye salmon in UCI to manage the fisheries. Escapement is estimated with hydroacoustics (sonar) and weirs. Commercial fishery participants in each fishery are required to report their catch. This occurs at various processors or tenders for the drift gillnet fishery and at the buying stations, processors, or tenders for the set gillnet fishery. Although these reports provide overall enumeration of the commercial harvest, an estimate of stock composition (the proportion of fish in the harvest originating from each drainage or area; often the synonym 'stock mixture' is used) of the catch is still required to develop brood tables and estimate escapement goals for specific stocks within the area.

Since 1968, a weighted age-composition allocation method has been used to estimate the stock composition of commercial gillnet sockeye salmon harvests in UCI (Tobias and Tarbox 1999). This method is based on two primary assumptions (1) that age-specific exploitation rates are equal among stocks in the gillnet fisheries (Bernard 1983), and (2) that harvests in specific fisheries are composed of nearby stocks, e.g. harvests in the East Side set gillnet fishery are assumed to be composed of stocks from the Kenai and Kasilof rivers. The age-composition catch allocation method utilizes four data sources: (1) commercial harvests, (2) escapements into major UCI river systems, (3) age composition of harvests, and (4) age composition of escapements. Beginning in 1979, side-looking sonars were used to enumerate sockeye salmon, and fish wheels were used to collect scale samples on all major river systems in UCI (Westerman and Willette 2003). Prior to 1979, uplooking sonar arrays were used on the Kasilof River, and peak ground survey counts on 23 streams were used to index escapements in the Susitna drainage. The age-composition of sockeye salmon harvests has been estimated annually using a stratified systematic sampling design (Tobias and Willette 2004a). A minimum sample (n=403) of readable scales has been used to estimate the age composition of sockeye salmon in each stratum within 5% of the true proportion 90% of the time (Thompson 1987). These various data sources have been used to construct brood tables for the major UCI sockeye salmon stocks beginning with brood year 1968 (Tarbox et al. 1983), but the most consistent methods have been applied since brood year 1979 (Tobias and Willette 2004b).

Description of Fishery 2005 to 2007

From 2005 to 2007, the years depicted in this report, sockeye salmon runs were very different from each other. Salmon run migration patterns and strengths typically vary from year to year. However, in 2005, 2006, and 2007, sockeye salmon runs were substantially atypical. The oddity of these years is described below.

In 2005, the estimated UCI commercial harvest of 5.1 million sockeye salmon was 25% above the preseason forecast, and the total run of sockeye salmon to UCI was 44% more than the preseason forecast (Tobias and Willette *In prep*). Returns to all systems in UCI, with the exception of the Susitna River and Fish Creek, were stronger than expected in 2005. The Kenai River sockeye salmon run was approximately 66% greater than the preseason forecast. The Kasilof River sockeye salmon run was approximately 27% greater than the preseason forecast. The total run to the Susitna River, however, was 66% lower than the forecast. With roughly half of the Susitna River run bound for the Yentna River, the escapement to the Yentna River was significantly short of the escapement goal.

In 2006 preseason forecasts of sockeye salmon runs to the Kenai and Susitna rivers were below average, and inseason projections in early July also indicated a weak run (Shields 2007). As a result, the Central District drift gillnet fishery and the Kenai Section of the East Side Subdistrict set gillnet fishery were closed during late July, and the Northern District set gillnet fishery was closed after July 6. Based on the preseason forecast, ADF&G first managed for an inriver sonar goal range of 650,000 to 850,000 sockeye salmon in the Kenai River, but by August 7 the actual return to the Kenai River was projected to be between 2.2 and 2.5 million, so the inriver goal range was changed to 750,000 to 950,000 fish. The midpoint of the run in 2006 was more than 9 days late, by far the latest run timing observed in UCI. Nearly 530,000 fish passed the Kenai River sonar site after the commercial season ended on August 10, and a total of 860,000 sockeye salmon (or 57%) passed in August, the largest August component of sonar passage on record (Tobias and Willette *In prep*). The final inriver sonar estimate in the Kenai River was 1.5 million sockeye salmon, 550,000 fish over the upper end of the inriver goal range. With the Kasilof River exceeding escapement objectives early in the run, the Kasilof River Special Harvest Area was used aggressively in an attempt to harvest surplus sockeye salmon above escapement needs. In 2006 approximately one-third of the entire inlet harvest was taken within approximately 3 square miles in the Kasilof River terminus. The Kasilof River run was 77% over the forecast, and the Kenai River run was nearly 40% over the forecast. Because these two runs were larger than other systems within the inlet, the inlet-wide run in 2006 was 38% larger than forecasted. Returns to systems other than the Kenai and Kasilof rivers were reasonably close to the forecasted returns.

The run timing in 2007 was fairly typical and for the first time in many years, the Kenai River run projection remained within the same tier throughout the season. This meant the inriver goal for the Kenai River remained the same (750,000 to 950,000). Although the run timing seemed normal, the migration of the fish once in the district was abnormal. For the first time since 1992 the drift fleet had back-to-back periods with a sockeye salmon catch-per-unit-effort (fish per boat per period; CPUE) greater than 1,000. Since 1974, only 6 years experienced drift periods with a CPUE over 1,000. The CPUE for the July 16 and July 19 periods were the 2nd and 5th highest in the fishery. Even more unusual, was that in both of these periods, the drift fleet was restricted to south of the southern tip of Kalgin Island, plus the Kenai and Kasilof Sections (corridor). The offshore test fishery had observed a large number of sockeye salmon entering the district for a few days prior to these openings. After these strong drift gillnet catches, it was anticipated that subsequent set gillnet catches would also increase as this large body of fish made its way to the Kenai and Kasilof rivers. But this did not happen; a "strong push" of sockeye salmon to the beaches was never experienced.

CURRENT STUDY

Although the weighted age-composition catch allocation method has provided the best information available, the associated assumptions may not always be valid, especially the assumption of equal exploitation among stocks. More scientifically defensible estimates of stock compositions are now available using GSI methods. The primary goal of the UCI sockeye salmon genetics project is to estimate the stock composition of the sockeye salmon harvests. Coupled with escapement estimation projects, the results will ultimately provide reliable sockeye salmon estimates of total run (catch + escapement) for brood table development and escapement goal analyses.

We report on an initiative begun in July 2005 to apply the improved GSI techniques to estimate the stock composition of harvests of UCI sockeye salmon. One of the objectives of the project was to sample fisheries across at least 3 years to provide a representation of the interannual natural variability. The current study drew heavily on collection efforts from the 1990s for tissue samples from spawning populations and inriver collections, as well as a large number of individuals collected from mixed stock fisheries and fish wheels during the period from 2005 through 2007. The application differentiates among seven major reporting groups with a high degree of accuracy and precision and elucidates patterns in the stock composition of the harvest for selected openings for the different fisheries over this 3-year period.

METHODS

TISSUE SAMPLING

Baseline

Baseline samples for SNP analysis were collected from spawning populations of sockeye salmon by ADF&G using gill nets and beach seines (Table 1; Figure 2). Most collections were made in the 1990s and reported in Seeb et al. (2000). Collections selected for inclusion in the current study represent all the populations previously identified in Seeb et al. (2000). These populations represent the known genetic diversity both geographic (location) and temporal (early- and late-spawning). Additional collections were made in 2006 from underrepresented areas. Target sample size for baseline collections was 95 individuals across all years to achieve acceptable precision for the allele frequency estimates (Allendorf and Phelps 1981; Waples 1990a).

Mixtures

Fish Wheels

Genetic samples were collected from fish captured in fish wheels operating on the Yentna, Susitna, Kenai, and Kasilof rivers in the 1990s and again in 2005. These fish wheels are all located below the spawning sites in each river (Figure 2) and are thought to capture only fish destined to spawn within the rivers where the fish wheels operate.

Offshore Test Fishery

Genetic samples were collected from the offshore test fish harvests of sockeye salmon taken at six fixed stations from Anchor Point to Red River delta from July 1–August 1, 2006 and July 1-August 2, 2007 (Figure 3). Genetic samples were taken from fish harvested at each station. If less than 30 individuals were harvested at a station, all were sampled. If more than 30 sockeye salmon were harvested at a station, a maximum of 30 were randomly sampled. Samples from multiple stations and dates were combined to form mixtures of 400 individuals.

Commercial Drift and Set Gillnet Fisheries

Commercial fishery harvests were sampled using a stratified systematic sampling design. Area strata were determined *a priori* using established fishery districts and subdistricts (Figures 1 and 4–8). Temporal stratification was determined post season based on catch patterns in each fishery and the number of samples collected. In 2005, harvests were sampled in proportion to the historical average fishery harvest on each date. In 2006–2007, drift gillnet harvests were sampled in proportion to expected harvest, and set gillnet harvests were over sampled to allow for composite samples to be constructed in proportion to actual harvest post season. In 2005, sampling was conducted over 4 weeks, and in 2006–2007 sampling was conducted over 7 weeks (Table 2).

Target sample size within strata was set at 400 fish to estimate stock composition with 90% confidence of being within 5% of true stock proportions (Thompson 1987). Thompson's (1987) sample size estimator only considers uncertainty from sampling error and not uncertainty from genetic assignment error. Therefore, this expected level of precision is conservative because it assumes perfect GSI. Composite samples were constructed by combining samples from all time and area substrata to achieve this sample size goal. In 2006–2007, composite samples were constructed in proportion to actual harvests within substrata. Funding for GSI analysis of UCI sockeye salmon commercial harvests allowed for laboratory analyses of 8,000 samples per year which limited the number of stratum estimates each year. Generally, samples selected for analyses were from the earlier fishing periods (mostly from late June and July) within years.

Drift Gillnet Sampling

In 2005, most of the drift gillnet fishery sampling was conducted at Inlet Salmon's two docks located on the Kenai and Kasilof rivers. From 50 to 200 samples were taken during eight regular drift gillnet fishery openings from July 4 through July 28 (Table 2). During each sample period, 10 to 20 boats were sampled and 5 to 10 samples were collected from each boat. Overall, 63 different boats were sampled from one to four times each. We analyzed samples representing harvest from July 7 to 21 (Table 2).

In 2006–2007, drift gillnet fishery sampling was conducted at three processors (Ocean Beauty, Inlet Salmon, and Icicle Seafoods), which historically accounted for about 60% of the total drift gillnet fishery harvest. At each processor, sampling was conducted in proportion to the harvest expected to be delivered. At Ocean Beauty and Inlet Salmon, as many boats as possible were systematically sampled (i.e., every other boat or every other pair of boats) throughout the delivery period for each fishery opening. The proportion of the catch to sample from each boat was estimated based on the number of boats expected to deliver at each processor and their expected average catch estimated by the processor. The target sample proportion for all processors for each period was set based on a target sample goal of 130 fish from the processor expected to receive the least catch. For example, if the smallest processor was expected to receive 26,000 fish from all boats and we sampled from one half of the catch (i.e., 13,000 fish from sampling every other boat), then the sampling rate needed to be 1% to obtain 130 tissue samples. The same proportion of the catch was then sampled at all processors. During an unloading event, fish were removed from the boats, sorted, weighed and placed in plastic totes. Samples were randomly taken from the totes throughout the unloading of each boat. Because we were sampling in proportion to catch on each boat and sampling throughout the entire delivery period, any pattern in the delivery sequence of boats was correctly weighted. The sampling of the fish from Icicle Seafoods occurred on the day following the period. Icicle Seafoods had at least two tenders which collected sockeye salmon from commercial drift gillnet boats in Cook Inlet during and after the fishery. The tender unloaded in Homer the day after the fishery, and the fish were trucked to its Seward Plant. Crews met the drift gillnet tenders at the dock and sampled at least 130 fish from whichever tenders were available. Since the tenders carried a mix of fish from various boats, samples were taken from as many totes as possible. Temporal strata were identified post season, and composite random samples were constructed in proportion to the actual substratum (fishery/processor) harvests. We analyzed samples representing harvest from June 26 to July 27 in 2006 and from June 25 to July 19 in 2007 (Table 2). The July 24 to 27 openings in 2006 were restricted to the Kasilof Terminal Area (Table 2).

Set Gillnet Sampling

In 2005, set gillnet harvests were sampled in proportion to the historical average fishery harvests on each date. The East Side Subdistict (Central District) set gillnet harvests were sampled from July 4 to August 4. The West Side Subdistrict (Central District) was sampled once, and the Eastern (Northern District) and Kalgin Island (Central District) Subdistricts were sampled twice. Samples collected from General Subdistrict (Northern District) harvests were not sufficient to estimate stock composition because catches from this district were mixed with catches from other districts at the processors. We analyzed samples representing harvest from July 2 to 28 in the Kasilof Section and from July 11 to 26 in the Kenai Section (Table 2).

In 2006–2007, East Side Subdistict (Central District) set gillnet harvests were over sampled to allow for composite samples to be constructed in proportion to actual harvest post season because harvests delivered to buying stations were not known at the time of sampling. Two sections were established for sampling of East Side Subdistrict set gillnet harvests, one north of the Blanchard line (Kenai Section) and one south of the line (Kasilof Section; Figure 1). These two sections were further divided into two substrata each. Each substratum was composed of one or two subsections. Kenai Section was divided into the North/South Salamatof and the

North Kalifornsky (K.) Beach substrata while the Kasilof Section was divided into the South K. Beach and the Cohoe/Ninilchik substrata (Figure 1). We determined substratum sample sizes based on the highest proportion of catch observed in each substratum over the last 5 years. For example, if the harvest in the North/South Salamatof substratum was historically three times that in the North K. Beach substratum during a specific fishery period, then the sample sizes collected from the Salamatof and North K. Beach substrata would be 300 and 100, respectively. In some years, >90% of the harvest in the Kenai Section came from the North/South Salamatof substratum, so 400 samples were collected from this substratum to provide for postseason construction of composite samples in proportion to substratum harvests. Genetic samples were randomly collected at buying stations on the beaches and at processors. Fish were trucked to buying stations about an hour after being picked from the set gillnets at every high and low tide during a period. There were 4 to 6 buying stations near each beach (substratum), and each buying station received fish from different sites within the beach that were then mixed in totes. Crews attempted to sample from all the buying stations twice during a period, obtaining half their sample after the high tide and half after the low tide. Mixtures from the Kasilof and Kenai Sections set gillnet fisheries were pooled within years and then divided into substrata to produce new mixtures for which stock composition estimates were produced. For 2006, we analyzed samples representing harvest from June 26 to July 27 in the Kasilof Section and from July 10 to 17 in the Kenai Section (Table 2). The July 24 to 27 openings were restricted to the Kasilof Terminal Area (Table 2). For 2007, we analyzed samples representing harvest from June 25 to July 21 in the Kasilof Section and from July 9 to 28 in the Kenai Section (Table 2).

Harvests from the West Side and Kalgin Island subdistricts (Central District) were sampled at Pacific Star and Inlet Salmon processors where tenders that purchase fish from these areas were unloaded the morning after each fishery period. ADF&G randomly collected 130 samples from the harvest from each fishing period in 2006 and 100 per period in 2007. None of these samples have been analyzed in the laboratory at this time.

The Kasilof Terminal Area (Central District, East Side Subdistrict) was established at the mouth of the Kasilof River to target the harvest of Kasilof River sockeye salmon (Figure 4). Genetic samples were collected from the Kasilof Terminal Area harvest in 2006 and 2007. In 2006, the combined set and drift gillnet harvest was sampled from July 17 to July 23. From July 24 to July 27, set and drift gillnet harvests were sampled separately. Only the two later collections from 2006 have been analyzed in the laboratory at this time.

Tissue Handling

Tissue samples for genetic analysis were collected from sockeye salmon without regard to size, sex, or condition. An axillary process was excised from individual fish and placed in ethanol in either individually labeled 2 ml plastic vials or deep-well plates. For data continuity, tissue samples were paired with age, sex, and length information collected from each fish. These data were collated and archived by Commercial Fisheries Division staff at the ADF&G office in Soldotna.

Laboratory Analysis

Genomic DNA was extracted using a DNeasy® 96 Tissue Kit by QIAGEN® (Valencia, CA). Forty-five sockeye SNP markers were assayed, 3 mitochondrial and 42 nuclear DNA (Table 3).

For all samples except the samples collected in 2007, SNP genotyping was performed in 384-well reaction plates. Each reaction was conducted in a 5-µL volume consisting of 0.10-µL template DNA in 0.7x TaqMan Universal Buffer (Applied Biosystems), 900 nM of each polymerase chain reaction (PCR) primer, and 200 nM of each probe. Thermal cycling was performed on a Dual 384-Well GeneAmp PCR System 9700 as follows: an initial denaturation of 10 min at 95°C followed by 50 cycles of 92° for 15 s and annealing/extension temperature for 1.0 or 1.5 min. Cycling was conducted at a ramp speed of 1°C per s. The plates were read on an Applied Biosystems (AB) Prism 7900HT Sequence Detection System after amplification and scored using AB Sequence Detection software 2.2.

For the samples collected in 2007, SNP genotyping for *One_MHC2_251* and *One_STC-410* was accomplished as described above, while genotyping of the additional 43 markers was performed using the BioMark 48.48 Dynamic Array (Fluidigm http://www.fluidigm.com/biomark_genotyping.htm). The BioMark 48.48 Dynamic Array contains a matrix of integrated channels and valves housed in an input frame. On one side of the frame are 48 inlets to accept the sample DNA from 48 individual fish, and on the other are 48 inlets to accept the assays for up to 48 SNP markers. Once in the wells, the components are pressurized into the chip using the NanoFlex 4-IFC Controller. The 48 samples and 48 assays are then systematically combined into 2,304 parallel reactions. In this study, 43 assays were loaded. Each reaction was conducted in a 6.75 nL volume consisting of 1xTaqMan Universal Buffer (Applied Biosystems), 1.5 U AmpliTaq Gold DNA Polymerase (Applied Biosystems), 9 mM of each polymerase chain reaction (PCR) primer, 2 mM of each probe, 1xDA Assay Loading Buffer (Fluidigm), 12.5xROX (Invitrogen), and 0.01% Tween-20. Thermal cycling was performed on a BioMark IFC Cycler as follows: an initial denaturation of 10 min at 95°C followed by 50 cycles of 92° for 15 s and 60° for 1 min. The Dynamic Arrays were read on a BioMark Real-Time PCR System after amplification and scored using BioMark Genotyping Analysis software (Fluidigm).

Genotypes collected from both instruments were entered into the Gene Conservation Laboratory Oracle database, *LOKI*. Quality control measures included reanalysis of 8% of each collection for all markers to insure that genotypes were reproducible and to identify laboratory errors and measure rates of inconsistencies during repeated analyses. Assuming that the inconsistencies are due equally to errors in original genotyping and errors during the quality control, error rates in the original genotyping can be estimated as ½ the rate of inconsistencies.

STATISTICAL ANALYSIS

Baseline Development

Genotype distributions were tested for deviation from Hardy-Weinberg expectation (H-W), and all pairs of markers were tested for linkage disequilibrium within each collection using GENEPOP (version 3.3; updated version of Raymond and Rousset 1995). Critical values (α=0.01) were adjusted for multiple tests within collections and multiple tests across markers within collection (Rice 1989). If linkage disequilibrium was significant in more than half of the collections, we produced composite haplotypes for each fish by combining the genotypes from these markers and treated them as a single locus in further analyses. Composite haplotypes were used rather than eliminating one of the loci because, for some loci, linkage associations between alleles are not consistent across populations. Eliminating a locus would result in the loss of additional information found in the differences in association between alleles. For each fish, if the genotype for either marker was missing, then the composite-haplotype locus was excluded from further analysis. All mtDNA markers were combined into a single locus.

Collections taken at the same or adjacent sites in different years were pooled following the recommendations of Waples (1990b). Collections made at nearby locations whose fish demonstrate phenotypic similarity were tested for homogeneity using pair-wise exact tests for genetic differentiation (Goudet 1995) calculated in GENEPOP with the following Markov chain parameters: 5000 as the dememorisation number, 1,000 batches, and 1,000 iterations per batch. Collections were pooled if the exact tests indicated homogeneity (collections grouped within sites or pooled collections taken at different sites are referred to as "populations.")

Nei (1978) genetic distances between all pairs of populations were computed, and 1,000 bootstrapped neighbor-joining (N-J) trees were produced by bootstrap resampling loci using PHYLIP version 3.63 (http://evolution.gs.washington.edu/phylip.html) to visualize relationships among populations and test node concordance.

Baseline Evaluation

Simulations

Populations were assigned into seven reporting groups based on geographic structure (e.g. watersheds) and management needs; four that represented the larger drainages (Kenai, Kasilof, Yentna, and Susitna rivers) and three that represented regions with many, smaller drainages (West Cook Inlet, Knik Arm, and Northeast Cook Inlet). Populations were maintained separately within these reporting groups as recommended by Wood et al. (1987). We then assessed the potential of these reporting groups for GSI applications with 100% simulations. To do these simulations, we generated 400 fish based on the population-specific allele frequencies from all the populations within each reporting group. An equal number of fish were generated from each population within each reporting group such that the total for each mixture equaled 400 fish. This process was repeated 1,000 times, and the mean and central 90% of the distribution of estimates were reported as the estimate and the 90% confidence interval. Simulated mixtures were analyzed using SPAM version 3.7b (Debevec et al. 2000; ADF&G 2001). A critical level of 90% correct allocation was used to determine if the reporting group was acceptably identifiable.

Proof Tests

Individuals from known origins, but not included in the baseline, were used as another test of baseline performance. These tests, termed "proof tests", were performed to further examine the baseline using both maximum likelihood and Bayesian analyses. Two hundred fish were randomly sampled without replacement and removed from the baseline from each reporting group. These 200 fish were used to create mixtures that were analyzed to evaluate accuracy and precision of the reporting groups. This analysis does not assume populations are in H-W equilibrium as does the simulation analysis. The proof tests are conservative because the baseline is reduced by the removal of individuals that contribute to the mixtures and, thus, the overall number of individuals in the baseline is reduced. Proof tests allow evaluation of the baseline using both the SPAM and BAYES (Pella and Masuda 2001) methods. For BAYES, the estimation was run using a single chain without thinning with a Markov Chain Monte Carlo sample size of 10,000. Three chains were run beginning with different starting conditions. Inference was based on the posterior distribution based on a combined set of the last 5,000 steps of each chain. The mean of the posterior distribution is reported as the best estimate, and the central 90% of the distribution was reported as the 90% credibility interval. Both a SPAM prior distribution and a flat prior distribution were evaluated for accuracy and precision in the BAYES analyses. For the flat prior, the Dirichlet prior distribution parameters for stock proportions were equal (1/N). For the SPAM prior, the Dirichlet prior distribution parameters for each stock were proportional to the SPAM estimation results.

Fish Wheel Samples

Finally, we analyzed fish captured in the fish wheels operating in the Kenai, Kasilof, Yentna, and Susitna rivers as a further test of the performance of the baseline (Table 4). We used BAYES with a SPAM prior to estimate the composition of the fish wheel samples. Based on the geographic locations of the fish wheels within the rivers, we expected that all fish captured in the fish wheel were spawned within the particular drainage and that no fish from the fish wheels were strays or were "nosing in." This was the most challenging test of the method because fish may have originated from populations not represented in the baseline and the proportion of fish from each population was likely to be in proportion to the relative run strength of each population within the river drainage.

Mixed Stock Analysis

We estimated stock composition proportions from approximately weekly samples from the offshore test fishery and all mixtures outlined in Table 2. In addition, samples from the Kenai and Kasilof sections of the set gillnet fisheries were combined within years and then split out by subsection to estimate stock composition by subsection for each year. Stock compositions for all mixture samples were estimated using BAYES with the SPAM prior, the best performing GSI method identified in the proof test analyses. Once stock compositions and their 90% credibility intervals were estimated for each time/fishery stratum, the estimates were multiplied by the harvest represented by the analyzed sample to determine the best estimate and the 90% credibility interval around the estimate. Estimates and their 90% credibility intervals were tabulated and estimates were graphically represented using stacked bar graphs for ease of interpretation.

Differences in the Baseline Among Analyses

The statistical analyses on different mixtures were performed at different times during the assembly of the baseline and, as a result, the analyses deviated in the number of collections represented by the baseline and in the number of markers screened. A reduced set of baseline collections was used in the proof tests and the fish wheel analyses, whereas all other analyses used the full baseline (Table 1). This reduced set of baseline collections resulted in a two-population reduction in the baseline, both from the Susitna reporting group. In addition, the reduced set of baseline collections reduced the sample sizes for four populations; three in the Yentna reporting group and one in the Susitna reporting group. The smallest set of loci (35 loci), was also used for the fish wheel analyses, followed by the proof tests and the 2005 and 2006 fishery mixtures (40 loci), while the 2007 fishery mixtures contained the full set of loci (42 loci; Table 3).

RESULTS

Baseline Development

Within Population Diversity

Spawning populations of sockeye salmon were collected from throughout Cook Inlet (Table 1; Figure 2). The majority of collections were made during the 1990s. Collection efforts resumed in 2006, and eight collections were made in that year. Most locations were sampled in a single year; only four were collected in multiple years. A total of 5,841 fish collected over spawning areas were analyzed for the baseline. These fish represented 68 collections taken at 62 locations throughout Cook Inlet drainages.

During quality control procedures a total of 500 fish were reanalyzed for all markers for a total of 22,500 comparisons. An inconsistency rate of 0.044% was found in the baseline data. Conformance to Hardy-Weinberg (H-W) equilibrium was tested for all collections. Over all markers and locations, 2,898 H-W tests were performed of which 23 were significant ($p < 0.01$) without the multiple test adjustment. These were spread over 17 markers with no markers out of H-W equilibrium in more than three collections. No collection was out of H-W equilibrium at more than two markers. After adjusting for multiple tests, only one collection (Six Mile Creek) was significant for only one marker (*One_MHC2_190*).

Linkage disequilibrium within each collection yielded significant results within some collections at four marker pairs (# collections before adjustment for multiple tests/# of collections after adjustment for multiple tests): *One_GPDH-201* and *One_GPDH2-187* (17/11); *One_IL8r_362* and *One_KPNA_422* (4/2); *One_MHC2_190* and *One_MHC2_251* (46/45); and *One_TF_ex11-750* and *One_TF_in3-182*(13/5). Of these, only *One_MHC2_190* and *One_MHC2_251* were significantly out of linkage equilibrium in more than half of the collections after adjustment for multiple tests (45 out of 68 collections tested). These two markers were pooled and treated as a composite-haplotype locus.

Patterns of Population Structure

A total of 59 populations were identified after pooling collections taken from similar locations over multiple years and after pooling collections made at nearby sites that exhibited both similar phenotypes and genetic homogeneity (pooled collections and collections taken at different sites are referred to as "populations"; Table 1). In two areas (between Skilak and Kenai lakes and Tustumena Lake), all collections were not pooled despite the high levels of genetic similarity observed in the N-J tree (Figure 9). The decision to keep these separate was based on field observations of discontinuous spawning between Skilak and Kenai lakes and phenotypic differentiation among spawners in Tustumena Lake (Woody et al. 2000). Between Skilak and Kenai lakes, collections from sites 1 and 2 were pooled and sites 4 and 5 were pooled, but not all sites were pooled. In collections from Tustumena Lake (Glacier Flats, Moose, Bear, Nikolai, and Seepage creeks, and sites A and B from shoals), only the sites A and B from shoals were pooled. A more complete analysis of the patterns of population structure revealed by SNPs is underway.

Genetic relationships among baseline populations are shown in the N-J tree (Figure 9). The patterns of genetic similarity between populations are consistent with those revealed by earlier studies and support a model of population structure based on the nursery lake (e.g. Seeb et al. 2000). Straying among spawning areas is usually higher within drainages than among drainages

(Wood et al. 1994) which can result in similarity among salmon spawning within a drainage and higher differentiation among salmon spawning in different drainages.

Kasilof River populations clustered as a single group with little variation among populations, including tributary and lake-shore spawners. Juveniles from these populations all rear in Tustumena Lake.

Kenai River populations rear in numerous lakes within the drainage, and the genetic structure mirrors this complexity. Populations spawning above the falls on the Russian River clustered together, a relationship previously described with allozymes. Populations spawning in the mainstem between Kenai and Skilak lakes (including the Russian River below the falls) use both lakes for their early life history and clustered together in 47% of the trees. Populations rearing in Trail Lake (Johnson, Railroad, and Moose creeks) also form a separate group. Other populations spawning in the Kenai River appear to be more similar to populations within the drainage than to other populations outside the Kenai River. All the Northeastern Cook Inlet populations clustered together with good support.

The rest of the reporting groups contained some populations that clustered and others that did not, however there were no well-supported nodes that included populations from multiple reporting groups. Some of the Northeast populations clustered below well-supported nodes: the Eska, Bodenburg and Jim creek populations in one cluster and the Big Lake, Fish and Six Mile creeks in another cluster. Nancy Lake and Cottonwood Creek populations did not cluster with any other populations.

Several well-supported nodes clustered populations spawning within the Yentna and Susitna rivers. Most of these nodes clustered geographically proximate collections including Hewitt and Whiskey lakes in the Yentna River and Mama and Papa Bear lakes, Talkeetna sloughs, and Larson Creek in the Susitna River. The one exception to this relationship between geographic proximity and clustering is the well-supported cluster that includes Trinity/Movie lakes and the Hewitt/Whiskey lakes within the Yentna River which are geographically farther apart than some of the other populations.

The West Cook Inlet reporting group had only one well-supported cluster and this cluster contained the two Crescent Lake populations. The rest of the populations in this reporting group were below nodes with little support or were highly distinct (West Fork Coal Creek and Chilligan River).

BASELINE EVALUATION

Simulations

Sets of populations were combined into seven reporting groups based on geographic structure (e.g. watersheds) and management needs. Four reporting groups represented the primary drainages (Kenai, Kasilof, Yentna, and Susitna rivers), and three groups contained populations from regions with many smaller tributaries separated by saltwater (West Cook Inlet, Knik Arm and Northeast Cook Inlet). These reporting groups are similar to those used in the allozyme analyses in Seeb et al. (2000).

Evaluating the utility of the baseline for estimating stock composition began with a series of 100% simulations to ascertain the precision and accuracy of the reporting groups. These simulations indicated that these reporting groups can be identified with an average of better than 97% accuracy (Table 5). For these simulations, even the lower bound of the confidence interval was above the 90% threshold.

Proof Tests

Analyses of fish of known origin taken out of the baseline and used as mixtures (proof tests) also demonstrated high correct allocations for every reporting group (Table 6; Figure 10). In these tests, mixtures created from 200 genotypes from a single region showed correct allocations of 90% (Susitna River) or better using SPAM. When the Bayesian methods were applied accuracy and precision improved to almost complete identifiability (99% or better correct allocation).

Fish Wheel Samples

A total of 1,330 individuals from seven collections sampled from fish captured in fish wheels were assayed for genotypes at the SNPs in the baseline. During quality control procedures a total of 112 fish were reanalyzed for all markers for a total of 5,040 comparisons. No inconsistencies were found in the mixture data. Stock composition estimates for these samples showed low (generally < 2%) contribution of populations outside the drainage where the fish wheels operated (Table 7; Figure 11). The Kenai River and Kasilof River fish wheel collections allocated above 98% to those rivers for both the samples collected in 1992–1994 and samples taken in 2005. The 1992 Yentna River fish wheel sample allocated above 99% to the Yentna River, while the 2005 sample allocated 94% to the Yentna River with most of remaining identified as coming from the Susitna River. The Susitna River fish wheel allocated 98% to Susitna River, with the remaining portion identified as coming from the Yentna River.

MIXED STOCK ANALYSIS

During quality control procedures a total of 1,378 fish were reanalyzed for all markers for a total of 62,010 comparisons. An inconsistency rate of 0.098% was found in the mixture data.

Offshore Test Fishery

A total of 3,474 fish captured in the offshore test fishery in 2006 and 2007 were successfully genotyped (Table 8; Figure 12). The sets of individuals sampled each year were divided into four periods in 2006 (1,385 individuals) and five periods in 2007 (2,089 individuals). In each of the 2 years, a consistent pattern was seen in the distribution of stocks over time; the proportion of Kasilof River sockeye salmon decreased, and the proportion of Kenai River sockeye salmon increased. The percentage of West Cook Inlet populations fluctuated between 5% and 11% with an exception of the early period in 2007 when it was 25% of the sample. The Yentna River was estimated to make up a larger portion (range: 6–15%) of the samples than the Susitna River (range: 0–7%). Northeast Cook Inlet populations were not detected in any of the test fishery samples.

<u>See addendum.</u> The percent of West Cook Inlet populations in the early period of 2007 should be 17% (not 25%).

Commercial Fishery Sampling

A total of 39,242 fish were sampled for tissue suitable for genetic analysis from commercial catches from throughout the Cook Inlet Central District in 2005, 2006 and 2007. These fish represented 230 individual collections. Of these fish, 12,306 fish from 102 of the collections were subsampled to create 35 mixtures for which the stock composition and stock-specific harvest were estimated (Table 9; Figures 13–22). These mixtures had sample sizes ranging between 266 and 444 fish.

Drift Gillnet

We observed a general pattern of increasing proportions of Kenai River and decreasing proportions of Kasilof River sockeye salmon in drift gillnet fishery harvests within season for each of the 3 years (Table 9). However, the estimated percentage of Kenai River sockeye salmon in drift gillnet harvests varied tremendously among years from 22–72% during the first period in July to 41–90% during the last period sampled (Table 9). For each of the 3 years of the study, estimated harvests of Kenai River sockeye salmon peaked during July 11–19. The estimated percentage of Yentna River sockeye salmon varied from 2–13%, with the peak occurring during the first period in July in 2005 and 2006 and on July 16, 2007. In 2005 and 2006 the percentage of West Cook Inlet sockeye salmon in the harvest fluctuated from 0–5%, but in 2007 this reporting group accounted for 31% of the harvest at the beginning of the season (June 25–28) before falling back to near 5% two periods later (July 7–9). During all periods, the combined contribution of the Susitna, Knik, and Northeast Cook Inlet reporting groups did not exceed 5%.

> See addendum. The estimated percent of Yentna River sockeye salmon varied from 2–15% (not 2–13%) and peak occurred during the first period in July for all years (not just 2005 and 2006). The percentage of West Cook Inlet sockeye salmon in the harvest in 2007 accounted for 23% (not 31%), before falling back to 6% (not 5%) two periods later on July 9–12 (not July 7–9).

Set Gillnet

Kasilof River fish dominated the harvest in the Kasilof Terminal Area (93–96%) with Kenai River sockeye salmon comprising the remainder (3–7%; Table 10; Figures 15 and 16).

> See addendum for text clarification of how to interpret Kenai and Kasilof Section vs. substrata results.

Within the East Side set gillnet fishery, we did not observe a consistent pattern of decreasing abundance of Kasilof River and increasing abundance of Kenai River sockeye salmon (Tables 11 and 12; Figures 17–20). The percent of harvest for Yentna River sockeye salmon in the East Side set gillnet harvests were as follows: 1) Kenai Section on July 16–19, 2005 (3%) and July 21–28, 2007 (12%), and 2) Kasilof Section on June 25–July 5, 2007 (6%) and July 16–21, 2007 (4%). The 90% credibility intervals for these estimates did not include zero.

> See addendum. The percent of Yentna River sockeye salmon in the Kenai Section during the July 21–28, 2007 period is 13% (not 12%) and the percent in the Kasilof Section on June 25–July 5, 2007 is 7% (not 6%).

Further examination of stock compositions in four statistical substrata within the East Side set net fishery were performed on mixtures ranging in size from 189 to 1,335 fish. These mixtures revealed that Yentna River sockeye salmon were primarily harvested in the Cohoe/Ninilchik and North/South Salamatof substrata (Table 13; Figures 21 and 22).

DISCUSSION

This report reviews an initiative to expand and improve on earlier ADF&G studies to estimate the stock composition of sockeye salmon in Upper Cook Inlet. ADF&G focused on research to improve the techniques of GSI as applied to Cook Inlet sockeye salmon. These efforts addressed three areas: 1) development and evaluation of genetic markers for improved resolution, 2) development of statistical techniques for more accurate and precise estimation of stock composition, and 3) development of the infrastructure to support high-throughput and low-error genotyping.

Here we report on the development and evaluation of the baseline and the results from harvest sampling for the period from 2005 through 2007. ADF&G anticipates that this report will be the first of a series on GSI studies in Cook Inlet.

BASELINE DEVELOPMENT

The pattern of similarity between populations revealed by these SNPs is similar to the pattern revealed by other marker types (Seeb et al. 2000; Allendorf and Seeb 2000). The populations from the Kenai and Kasilof rivers form a large cluster with internal structure. All markers surveyed have shown little genetic heterogeneity among populations spawning in the Kasilof River drainage (Burger et al. 1997), although phenotypic diversity was observed by Woody et al. (2000). While Burger et al. (1995) detected a distinct late run of river spawners at the outlet of Tustumena Lake, no outlet spawners were included in either the allozyme or SNP baselines. Within the Kenai River drainage three main groups were found: 1) Skilak and Kenai lakes, 2) Hidden, Tern, and Trail lakes, and 3) Russian Lake.

Variation is also found among the populations within the remaining regions: Susitna and Yentna rivers, Knik Arm, Northeast Cook Inlet, and West Cook Inlet. Unlike the Kenai and Kasilof drainages, there are no large nursery lakes that support multiple tributary-spawning populations. These systems tend to have a number of isolated smaller lakes. The close affinity of the Yentna and Susitna slough spawners may indicate common ancestry and a high level of historical gene flow similar to the "river-type" sockeye salmon described by Gustafson and Winans (1999).

Temporal stability of allele frequencies, which allows the use of baseline samples collected over many years, is typical for selectively neutral genetic markers when population sizes are large (e.g. Beacham et al. 2006; Habicht et al. 2007). In this study, the majority of baseline collections were made in the early 1990's, or three sockeye salmon generations ago. Baseline populations sampled for this study represented the primary spawning areas from throughout the Cook Inlet drainage and represented large populations (>1,000 fish/population). General temporal stability of allele frequencies was indicated by the lack of differences among years within the few populations where samples were collected over multiple years. In addition, samples taken from fish wheels over 10 years apart allocated to rivers in which the fish wheels operated. The only allocations outside of the river in which the fish wheel operated were observed from the Yentna River to the Susitna River for the 2005 collection and vice-versa for the single Susitna collection. Four hypotheses may explain this outside-river allocation: 1) "nosing-in" of fish from the other drainage, 2) similarities between the slough spawners in the two rivers as seen in the N-J tree (Figure 9), 3) incomplete baseline coverage of slough-spawning sockeye salmon, and 4) temporal changes in allele frequencies within one or both of these rivers. These data do not resolve among these alternatives.

Currently, SNPs have been screened on 59 populations in this region with an average of 99 individuals per population. This represents an initial baseline and contains more populations but fewer fish per population than the allozyme baseline which had 54 populations with an average of 188 individuals analyzed per population. This new baseline has additional representation in the Kenai, Susitna and Yentna rivers, and Knik Arm. It is the intent of ADF&G to continue to expand the baseline to achieve greater coverage. In addition, although previously reported with allozyme markers that allele frequencies within these populations were temporally stable, we will continue to monitor for changes in SNP allele frequencies as the opportunities arise. In particular, we will monitor for changes at loci such as *MHC* that are likely influenced by selection (Aguilar and Garza 2007).

IMPROVEMENT OF THE GSI MODEL

The new SNP data and statistical methods demonstrated a significant improvement in the performance of the GSI model from the 1990s, which was based on allozymes and maximum likelihood methods (SPAM). These DNA-based markers (SNPs) and the Bayesian estimation methods (BAYES) provided unprecedentedly high levels of accuracy and precision of the stock composition estimates (Tables 5 and 6). In the 1990s GSI was unable to clearly distinguish between contributions from the Yentna and Susitna rivers and even when these reporting groups were combined 100% simulations showed average correct allocations of 91%. The updated baseline and methods can now distinguish between the Yentna and Susitna rivers with average correct allocations above 99%.

Improvement due to marker type and statistical analysis can be measured using the fish wheel samples. In the 1990s, samples were collected from sockeye salmon captured in fish wheels as a test of the method (Seeb et al. 2000). Using the information available at that time, estimated stock compositions averaged 85% to the river in which the fish wheel operated. When some of these same samples from fish wheels were reanalyzed using the new SNP baseline and the old statistical method (SPAM), the allocations improved: 1) Kenai from 82% to 99%; 2) Yentna from 82% to 86%; 3) Susitna from 77% to 95%; and 4) Kasilof from 85% to 98% (this study; data not shown). When the Bayesian estimation method was used with the SNP data, estimates further improved to 98%, 100%, 98%, 100%, respectively (Table 7). Improvement in estimation using Bayesian statistical methods have also been observed in stock composition estimates of Atlantic salmon (Koljonen et al. 2005).

DIFFERENCES IN THE BASELINE AMONG ANALYSES

Over the course of the project there were small changes in the baseline used to complete analyses (Tables 1 and 3). The fish wheel analyses used the smallest set of loci (35 loci), followed by the proof tests and the 2005 and 2006 fishery mixtures (40 loci), while the 2007 fishery mixtures contained the full set of loci (42 loci; Table 3). In addition, the baseline contained seven fewer collections (only two fewer populations) for both the proof tests and the fish wheel analyses.

The differences in the baseline information used for the different analyses are unlikely to significantly affect the results because the differences were minor. This is supported by the results of the fish wheel analyses. If anything, the effect of using fewer SNPs and fewer populations would likely lead to conservative estimates in the performance of the fish wheels, because the fish wheels used the smallest baseline with the smallest number of loci. Even with the smaller dataset, the fish wheel analyses produced very high allocations to the river in which they operated.

DIFFERENCES IN SAMPLING DESIGNS AMONG YEARS

Four sampling design changes were implemented after the 2005 season to improve the accuracy and precision of estimates of stock composition of the commercial catch. First, in the drift gillnet fishery, we sampled at three of the major processors and sampled every other boat throughout the period when fish were delivered to each processor to provide a representative sample of the entire drift fishery harvest. Second, we sampled the drift fishery harvest in proportion to the catch on each boat and throughout the unloading of each boat. This design should have correctly weighted any pattern in the delivery sequence among and within boats. Third, we attempted to sample all of the buying stations along the East Side beaches after the high and low tides to obtain samples throughout each statistical area and over time during each fishery opening. Fourth, we over-sampled the East Side set gillnet fishery and constructed random samples in proportion to harvest after the season when catches were known. This approach coupled with sampling throughout the fishery by time and area should have provided a more representative sample of the East Side set gillnet harvest. Finally, since we over-sampled the set gillnet fisheries, we have additional archived samples that can be analyzed to investigate the effect of sampling error on our stock composition estimates in specific cases.

APPLICATION OF DATA TO BROOD TABLE REFINEMENT

The primary goal of this project was to accurately estimate the stock composition of commercial harvests in Upper Cook Inlet for each year. Knowledge of the composition of the mixed-stock catch is critical to determine the total run of each stock, especially when sockeye salmon stocks in Upper Cook Inlet can be exploited at rates up to 70%. The current age-composition method for estimating stock composition probably underestimates the productivity of some stocks and overestimates the productivity of other stocks. This directly affects fisheries management in a postseason fashion through the assessment and development of escapement goals. The primary management directive is to meet those escapement goals.

With the accuracy demonstrated for GSI, the stock composition estimates available from this project will allow an improved understanding of stock productivity as more years of data become available. To date, estimates from GSI provide the highest quality information ever available for stock compositions of the commercial harvest. But, genetic analyses of currently unanalyzed commercial fishery samples will be required before these stock composition estimates can be incorporated into brood tables. These laboratory analyses are scheduled for the near future. When GSI estimates of stock composition are available for the entire catch taken during the 3 years of this study, estimates will be compared to those obtained using the weighted age-composition catch allocation method.

PATTERNS IN FISHERY STOCK COMPOSITIONS

Interannual variability in run strength and timing among stocks and environmental conditions contributed to the variability in these stock composition estimates. For example, the estimated Kenai River sockeye salmon run was 5.5 million in 2005, 2.5 million in 2006, and 3.1 million in 2007 (Tobias and Willette *In prep*); whereas, the UCI sockeye salmon run past the offshore test fishery transect was 2 to 9 days late (Shields and Willette 2007 *In prep*) during each of the 3 years of this study (mean dates past the transect: July 21, 2005, July 24, 2006, July 17, 2007). These run strength and run timing differences produced some of the patterns observed in the stock compositions. For example, 2006 showed lower proportions of Kenai River fish in all fisheries compared with 2005 and 2007.

Within the offshore test fishery, the most prominent temporal pattern is the decreasing trend in the proportion of Kasilof River fish and an increasing trend in the proportion of Kenai River fish. This pattern might be expected based on the early run timing of the Kasilof River fish relative to Kenai River fish. This is the first analysis of the stock composition of fish captured in the offshore test fishery.

Stock composition estimates from the offshore test fishery compiled in this study can not be used to estimate total run by stocks because of how the samples were selected for tissue collection. First, genetic samples were not collected in proportion to abundance. In the test fishery, genetic samples were collected from all sockeye salmon harvested when the catch was <30 sockeye salmon, but when the catch was >30 sockeye salmon, only 30 samples were collected for genetic analysis. Since catches tended to be higher near the center of the inlet (Shields and Willette 2007), this sampling protocol resulted in stock composition estimates giving insufficient weight to harvests within the primary migratory pathway. Stock composition estimates will be weighted by CPUE in the test fishery in the future to correct for this bias. Secondly, collections were only made in July, and stock compositions before (June) and after (August) the test fishery are unknown. Projections of stock compositions into June and August may introduce significant bias into any estimates of total run by stock, because no stock composition estimates are available from these time periods and a significant percentage of the total UCI run comes during August in some years (2005–20%; 2006–35%; 2007–17%). Test fishery and genetic data could be used to estimate total run by stock in the future, but sampling would need to begin in mid June and end in mid to late August and may need to be collected at additional stations closer to shore.

Within the Central District drift gillnet fishery, many of the patterns observed in this study were also observed by Seeb et al. (2000). For example, the general pattern of increasing proportions of Kenai and decreasing proportions of Kasilof sockeye salmon in drift gillnet fishery harvests during the season is similar to that observed by Seeb et al. (2000). The estimated peak harvest dates of Kenai sockeye salmon were also in concordance to those observed by Seeb et al. (2000) who observed peak harvests of Kenai sockeye salmon between July 15–20, 1995–1996. Finally, both Seeb et al. (2000) and this study showed high variation in the estimated proportion of Kenai sockeye salmon in drift gillnet harvests among years.

Estimated peak harvests of Susitna/Yentna sockeye salmon in the drift gillnet fishery have generally occurred between July 10–16, but the estimated numbers of this stock taken were highly variable among years. In our study, the estimated peak harvests of Susitna/Yentna sockeye salmon in drift gillnet harvests occurred on July 11–14, 2005, July 3–6, 2006, and July 16, 2007 (Table 9; Figure 14). However, the drift gillnet fishery was restricted to the corridor after July 6, 2006, so the early peak date that year is not representative of harvests in the broader Central District fisheries (Figures 5–8). Seeb et al. (2000) estimated that peak proportions and harvests of Susitna/Yentna sockeye salmon in the drift gillnet fishery occurred on July 10, 1995, July 15, 1996, and July 14, 1997. However, Seeb et al. (2000) estimated that Susitna/Yentna sockeye salmon comprised an average of 16% (range 3–35%) of drift gillnet harvests. Whereas in our study, Susitna/Yentna sockeye salmon comprised an average of 7% (range 0–15%) of drift gillnet harvests. Higher estimated contributions for this stock in the 1990's may have been due to misclassification of Kenai River fish as Susitna/Yentna River fish as observed in the Kenai fish wheel samples using allozymes (Seeb et al. 2000), or higher relative abundance of this stock at that time (Tobias and Willette *In prep*). In the drift gillnet fisheries we sampled, the estimated total harvests of Susitna/Yentna sockeye salmon were 20,154 in 2005, 10,418, 2006, and 159,793 in 2007. Variation in the numbers of Susitna/Yentna River fish captured each year was likely due to several factors. A weak run in 2005 (Tobias and Willette *In prep*) and a severely restricted fishery in 2006 (Shields 2007) were consistent with the relatively low harvests of this stock in those years. The cause for the higher proportion of Susitna/Yentna stocks in 2007 is unclear, but may be related to the abnormal run entry patterns discussed in the "Distribution of Fishery – 2005 to 2007" section of the Introduction. In addition, in 2005 and 2006, analyzed samples represented only 65% and 43% of the catch, respectively, while in 2007, the samples represented 79% of the catch (Table 2; Figure 14). Due to this restricted representation of the catches, the estimated Susitna/Yentna River fish catches represent minimum estimates of the

See addendum. The estimated peak harvests of Susitna/Yentna sockeye salmon in drift gillnet harvests occurred on July 2–5, 2007 (not July 16, 2007). The estimated total harvests of Susitna/Yentna sockeye salmon is 175,827 (not 159,793) in 2007.

total harvests. Further analyses of samples representing all drift gillnet fishery openings each year will be required to estimate the full harvest.

Within the Kasilof Terminal Area (Central District, East Side Subdistrict) drift and set gillnet fisheries the estimated stock composition of sockeye salmon harvested was dominated by Kasilof River fish. The high proportions of Kasilof River fish in this fishery were expected based on the proximity of the fishery to the mouth of the Kasilof River. Kenai sockeye salmon comprised a higher percentage of the drift (7%) than set (3%) gillnet harvests in this area (Table 10). A model based upon size and age data estimated a slightly lower percentage of Kenai sockeye salmon in the drift (3%) and set (1%) gillnet harvests in this area during this same time period.

Within the East Side Subdistrict (Central District) set gillnet fishery, we did not observe a consistent pattern of decreasing abundance of Kasilof River and increasing abundance of Kenai River sockeye salmon in July as described by Bethe et al. (1980) using scale pattern analysis (SPA). Such a pattern is somewhat evident in the Kenai Section in 2006 and in the Kasilof Section in 2005 and 2007, but it is not evident in the Kasilof Section in 2006 and the Kenai Section in 2005 and 2007. There are three potential explanations for this lack of a consistent pattern in the Kasilof Section in 2006: 1) the relatively strong Kasilof River (1.6 million) and weak Kenai River (2.5 million) sockeye salmon runs that year (Tobias and Willette *In prep*); 2) the inefficacy of the SPA for estimating stock compositions of UCI sockeye salmon due to the highly variable freshwater rearing environments occupied by sockeye salmon in this area (Waltemyer 1995; Waltemyer et al. 1996); and 3) changes in fishing patterns between the 1970s and 2006.

Yentna River sockeye salmon contributed to the East Side set gillnet harvests and most of these sockeye salmon were harvested in the substrata farthest from the Kenai and Kasilof river mouths (Table 13). Since these estimated harvests of Yentna River sockeye salmon in the East Side Subdistrict set gillnet fishery were highly variable over time, it is difficult to project when or under what conditions this stock may be harvested in this fishery in the future. These results are in concordance with previous allozyme-based GSI estimates that Susitna/Yentna sockeye salmon comprised 1–6% of East Side Section set gillnet harvests (Seeb et al. 2000). The SNP GSI results support the conclusions from the SPA that Susitna/Yentna sockeye salmon have contributed 0–28% of the East Side Subdistrict set gillnet harvests (Bethe et al. 1980; Cross et al. 1986).

INCORPORATING PATTERNS OF FISHERY STOCK COMPOSITIONS INTO FUTURE MANAGEMENT

Stock composition by time and area may be affected by multiple variables that are under management control including the flood stage fished, geographic boundaries or restrictions within districts, and timing of fishing within the season. Understanding the relationship between stock compositions and these variables may provide information for managers to modify how the fisheries are prosecuted to achieve their goal of harvesting surplus production while meeting escapement goals for all stocks.

Both inter- and intra-annual variation in stock composition of fisheries will need to be examined before clear relationships between management actions and stock composition of the harvest are realized. The interannual variation of stock compositions in the harvest over the 3 years analyzed in this project provide guidance on the range of inter-annual variability in stock compositions among the fishing strata as they are prosecuted. Specific experimental designs will be necessary to investigate each potential management action separately while controlling the other variables under management control. For example, to investigate how drift gillnet fishing restricted to the corridor affects stock composition of the harvest, the experimental design would require the analysis of fish caught in the corridor and in the full district during the same time periods within years and over multiple years. These specific experimental designs will likely require a combination of commercial and test fishing coupled with GSI. If commercial catches are used in this experimental design, steps will be required to ensure the catch is coming from consistent locations within strata because fishing is often prosecuted differently within strata over time depending on where fishers expect to gain the highest profit. Evaluation of multiple years will be required because of the inter-annual variability of stock-specific run strengths, run timings, and residence times of sockeye salmon in the district (Mundy et al. 1993). Here we have demonstrated that the new GSI methods have the potential to resolve these issues. To date, the funding for this project was targeted toward estimating the stock composition of the commercial harvest, as it was prosecuted, as a first step toward brood table refinement and evaluation of management strategies.

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Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

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TABLES AND FIGURES

Table 1.–Tissue collections of sockeye salmon in the Upper Cook Inlet genetic baseline including the year sampled and the number of individuals analyzed from each collection and their assigned reporting group for genetic stock identification.

Map No.	Pop. No.	Reporting Group	Location	Sub-location	Analysis set	Sample Year	N
1	1	West	Crescent Lake	Site 1	a,b	1994	48
1	2			Site 2	a,b	1994	47
2	3		Little Jack Creek		a,b	2006	95
3	4		Wolverine Creek		a,b	1993	95
4	5		McArthur River		a,b	1993	95
5	6		Chilligan River		a,b	1992	95
6	7		West Fork Coal Creek		a,b	1993	95
7	8		Packers Lake		a,b	1992	95
8	9	Yentna	Puntilla Lake		a,b	2006	95
9	10		Red Salmon Lake		a,b	2006	95
10	11		Shell Lake		a,b	1993	94
11	12		Judd Lake		a,b	1993	95
12	13		Trinity and Movie Lakes		a,b	1992	95
12	13				a	1993	95
13	14		Hewitt Lake		a,b	1992	49
13	14				a	2006	65
14	15		Whiskey Lake Outlet		a,b	2006	58
15	16		West Fork Yentna River slough		a,b	1992	96
15	16				a	1993	100
16	17		Chelatna Lake		a,b	1993	95
17	18	Susitna	Susitna River sloughs		a,b	1995	50
17	18				a	1996	6
17	18				a	1997	95
18	19		Byers Lake		a,b	1993	95
19	20		Swan Lake		a,b	2006	95
20	21		Stephan Lake		a,b	1993	95
21	22		Larson Creek		a,b	1993	95
22	23		Mama and Papa Bear Lakes		a	1997	50
23	24		Talkeetna River sloughs		a,b	1997	79
24	25		Birch Creek		a	1993	67
25	26	Knik	Nancy Lake		a,b	1993	95
26	27		Big Lake		a,b	1992	95
27	28		Fish Creek		a,b	1993	95
28	29		Cottonwood Creek		a,b	1993	95
29	30		Eska Creek		a,b	2006	95

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Table 1.–Page 2 of 2.

Map No.	Pop. No.	Reporting Group	Location	Sub-location	Analysis set	Sample Year	N
30	31		Bodenburg Creek		a,b	2006	95
31	32		Jim Creek		a,b	1997	95
32	33		Six Mile Creek		a,b	1997	95
33	34	Northeast	Daniels Lake		a,b	1993	95
34	35		Bishop Creek		a,b	1993	95
35	36		Swanson River		a,b	1997	95
36	37	Kenai	Johnson Creek		a,b	1997	88
37	38		Railroad Creek		a,b	1997	95
38	39		Moose Creek		a,b	1994	95
39	40		Ptarmigan Creek		a,b	1993	95
40	41		Tern Lake		a,b	1993	95
41	42		Quartz Creek		a,b	1993	95
42	43		Upper Russian River Early	Lower Lake Outlet	a,b	1992	96
43	43			Goat Creek	a,b	1997	95
42	44		Upper Russian River Late	Lower Lake Outlet	a,b	1993	95
44	45			Upper Lake Bear Creek	a,b	1997	95
45	46			Upper Lake South Shore	a,b	1999	95
46	47			Upper Lake North Shore	a,b	1999	95
48	48		Lower Russian River		a,b	1993	94
49	49		Kenai River, between Skilak	site 1	a,b	1994	47
50	49		and Kenai lakes	site 2	a,b	1994	48
51	50			site 3	a,b	1994	143
52	51			site 4	a,b	1994	48
53	51			site 5	a,b	1994	95
54	52		Hidden Creek		a,b	1993	95
55	53		Skilak Lake outlet		a,b	1992	96
56	54	Kasilof	Glacier Flats Creek		a,b	1994	95
57	55		Moose Creek		a,b	1992	96
58	56		Bear Creek		a,b	1993	95
59	57		Nikolai Creek		a,b	1992	95
60	58		Seepage Creek		a,b	1994	95
61	59		Tustumena Lake	site A	a,b	1994	48
62	59			site B	a,b	1994	48

Note: Map numbers correspond to sampling sites on Figure 2, unique population numbers represent all the collections that contribute to single population, and the analysis set denotes what collections were included and are as follows: (a) simulation and mixture analyses, and (b) proof test and fish wheel analyses.

Table 2.–Tissue collections for genetic analysis from fish captured in the Upper Cook Inlet fisheries in 2005, 2006, and 2007.

Sub-strata [a]	Restrictions[b]	Date(s) Sampled	Harvest Represented	Harvest Dates Represented	Mixture Date(s)	Sample Size Analyzed	Sample Size Collected
			Central District Drift Gillnet				
	1	7/4/05	63,795	7/4			100
	1	7/7/05	112,174	7/7	7/7	200	200
	1	7/11/05	244,130	7/11	7/11-14	200	200
	1	7/14/05	176,127	7/14		200	400
	2,3,4,5	7/18/05	230,353	7/18	7/18-21	200	200
	2,3,4	7/21/05	142,653	7/21		200	200
	2,3,6	7/25/05	127,842	7/25			50
	7	7/28/05	262,056	7/28			50
	2,3,7	8/1/05	38,493	8/1			50
	1	6/26/06	13,352	6/26	6/26-29	135	460
	1	6/29/06	25,083	6/29		265	448
	1	7/3/06	35,007	7/3	7/3-6	192	538
	1	7/6/06	32,491	7/6		208	600
	2,3	7/10/06	1,650	7/10	7/10-13	154	400
	2,3	7/13/06	1,544	7/13		46	152
	2,3	7/17/06	26,418	7/17	7/17	300	589
	1	7/31/06	89,680	7/31			507
	1	8/2/06	56,418	8/2-5			520
	1	8/7/06	19,154	8/7			520
	1	8/10/06	13,928	8/9-11			513
	1	6/25/07	5,658	6/25	6/25-28	109	412
	1	6/28/07	15,728	6/28		291	460
	1	7/2/07	22,201	7/2	7/2-5	105	455
	1	7/5/07	61,693	7/5		295	466
	2,3,4	7/9/07	102,853	7/9	7/9-12	156	530
	2,3,4	7/12/07	190,338	7/12		244	499
	2,3,4	7/16/07	481,878	7/16	7/16	400	611
	2,3,4	7/19/07	439,023	7/19	7/19	400	526
	2,3,6	7/23/07	127,247	7/23			460
	2,3,6	7/26/07	62,192	7/26			460
	2,3,7	7/30/07	84,275	7/30			413
	2,3,8	8/2/07	35,780	8/2			404
	2,3,8	8/6/07	15,926	8/6			368
	2,3	8/9/07	26,455	8/9			419

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Table 2.–Page 2 of 7.

Sub-strata[a]	Restrictions[b]	Date(s) Sampled	Harvest Represented	Harvest Dates Represented	Mixture Date(s)	Analyzed	Collected
Kasilof Terminal Area Drift Gillnet (Central District, East Side Subdistrict)							
	9	7/24/06	118,160	7/24		187	200
	9	7/25/06	54,078	7/25	7/24-27	56	200
	9	7/26/06	14,196	7/26		21	100
	9	7/27/06	16,432	7/27		36	200
Kasilof Terminal Area Drift/Set Gillnet (Central District, East Side Subdistrict)							
	9	7/17/06	21,094	7/16-17			100
	9	7/19/06	4,651	7/18-19			100
	9	7/20/06	36,275	7/20			100
	9	7/22/06	21,929	7/21-22			100
	9	7/23/06	39,415	7/23			100
	9	7/27/07	3,464	7/27			100
Kasilof Terminal Area Set Gillnet (Central District, East Side Subdistrict)							
	9	7/24/06	68,098	7/24		182	200
	9	7/25/06	51,187	7/25	7/24-27	93	200
	9	7/26/06	24,493	7/26		51	100
	9	7/27/06	21,739	7/27		74	200
Kasilof Section Set Gillnet (Central District, East Side Subdistrict)							
a	1	7/4/05	62,603	7/2-4		50	50
b	1	7/4/05	29,881	7/2-4	7/2-9	50	50
a	1	7/7/05	58,873	7/6-9		50	50
b	1	7/7/05	26,398	7/6-9		50	50
a	1	7/11/05	71,035	7/11-15		50	50
b	1	7/11/05	27,858	7/11-12	7/11-15	200	200
b	1	7/14/05	15,253	7/13-15		156	156
a	1	7/18/05	63,369	7/16-21	7/16-18	50	50
b	1	7/18/05	50,641	7/16-18		200	200
b	1	7/21/05	21,824	7/19-21		200	200
a	1	7/25/05	154,327	7/23-28	7/19-28	50	50
b	1	7/25/05	47,054	7/23-26		50	50
b	1	7/28/05	41,644	7/27-31			50
a	1	8/1/05	95,176	7/30-8/4			50
b	1	8/4/05	36,597	8/1-7			50
a	1	6/26/06	19,285	6/26		66	200
b	1	6/26/06	8,270	6/26	6/26-7/1	81	100
a	1	6/29/06	57,478	6/29-7/1		193	200
b	1	6/29/06	29,772	6/29-7/1		60	60

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Table 2.–Page 3 of 7.

Sub-strata[a]	Restrictions[b]	Date(s) Sampled	Harvest Represented	Harvest Dates Represented	Mixture Date(s)	Analyzed	Collected
a	1	7/3/06	17,752	7/2-3		67	200
b	1	7/3/06	6,992	7/2-3	7/2-8	44	130
a	1	7/6/06	45,909	7/6-8		169	200
b	1	7/6/06	31,858	7/6-8		120	120
a	1	7/10/06	13,979	7/10		142	200
b	1	7/10/06	3,290	7/10	7/10-13	34	200
a	1	7/13/06	15,984	7/12-13		200	200
b	1	7/13/06	2,840	7/12-13		24	67
a	10	7/15/06	80,250	7/15		177	300
b	10	7/15/06	63,467	7/15	7/15-16	131	250
a	10	7/16/06	45,690	7/16		92	200
a	1	7/17/06	17,110	7/17		50	200
b	1	7/17/06	10,701	7/17	7/17-22	27	200
a	10	7/20/06	54,600	7/19-22		179	200
b	10	7/20/06	52,781	7/19-22		144	210
a	1	7/31/06	9,906	7/31-8/1			130
b	1	7/31/06	10,461	7/31-8/1			130
a	1	8/2/06	14,334	8/2-5			130
b	1	8/2/06	26,145	8/2-5			130
a	1	8/7/06	4,707	8/6-9			200
b	1	8/7/06	11,767	8/6-9			130
a	1	6/25/07	6,466	6/25		23	200
b	1	6/25/07	1,901	6/25		7	118
a	1	6/28/07	45,499	6/28-30		160	200
b	1	6/28/07	9,525	6/28-30	6/25-7/5	35	130
a	1	7/2/07	16,501	7/2		58	200
b	1	7/2/07	2,516	7/2		9	130
a	1	7/5/07	26,545	7/4-5		93	200
b	1	7/5/07	4,661	7/4		15	130
a	1	7/9/07	76,393	7/9		170	200
b	1	7/9/07	3,291	7/9	7/9-12	17	188
a	1	7/12/07	42,464	7/11-12		95	200
b	1	7/12/07	12,527	7/11-12		18	200
a	1	7/16/07	57,649	7/16		97	250
b	1	7/16/07	27,218	7/16	7/16-21	46	187
a	1	7/19/07	115,143	7/18-21		193	250
b	1	7/19/07	38,127	7/18-21		64	200
a	1	7/23/07	45,486	7/22-23			250
b	1	7/23/07	23,371	7/22-23			200
a	1	7/26/07	28,088	7/25-28			200

-continued-

Table 2.–Page 4 of 7.

Sub-strata[a]	Restrictions[b]	Date(s) Sampled	Harvest Represented	Harvest Dates Represented	Mixture Date(s)	Analyzed	Collected
b	1	7/26/07	23,639	7/25-28			200
a	1	7/30/07	18,739	7/30-31			130
b	1	7/30/07	12,452	7/30-31			130
a	1	8/2/07	11,090	8/2-5			130
b	1	8/2/07	4,775	8/2-5			130
a	1	8/6/07	16,187	8/5-7			130
b	1	8/6/07	6,648	8/5-7			130
a	1	8/9/07	10,446	8/8-9			130
b	1	8/9/07	8,864	8/8-9			130
Kenai Section Set Gillnet (Central District, East Side Subdistrict)							
c	1	7/11/05	40,134	7/11-12	7/11-12	200	200
d	1	7/11/05	100,348	7/11-12		50	50
c	1	7/14/05	14,712	7/13-14	7/13-14	200	200
d	1	7/14/05	27,137	7/13-14		50	50
c	1	7/18/05	92,841	7/16-19	7/16-19	200	200
d	1	7/18/05	129,636	7/16-19		50	50
c	1	7/21/05	27,702	7/20-23	7/20-26	200	200
d	1	7/21/05	229,936	7/20-24		50	50
c	1	7/25/05	22,676	7/24-26		50	50
c	1	7/28/05	27,630	7/27-30			50
d	1	7/28/05	190,259	7/25-31			50
c	1	8/1/05	25,298	7/31-8/1			50
c	1	8/4/05	34,905	8/3-7			50
d	1	8/4/05	197,568	8/1-7			50
c	1	7/10/06	2,833	7/10	7/10-13	67	200
d	1	7/10/06	6,960	7/10		165	403
c	1	7/13/06	975	7/13		25	106
d	1	7/13/06	6,058	7/13		143	272
c	1	7/17/06	7,939	7/17	7/17	97	200
d	1	7/17/06	21,789	7/17		303	400
c	1	7/31/06	18,026	7/31-8/1			130
d	1	7/31/06	82,070	7/31-8/1			130
c	1	8/2/06	29,488	8/2-5			130
d	1	8/2/06	77,670	8/2-5			130
c	1	8/7/06	12,468	8/6-9			130
d	1	8/7/06	41,550	8/6-9			200

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Table 2.–Page 5 of 7.

Sub-strata[a]	Restrictions[b]	Date(s) Sampled	Harvest Represented	Harvest Dates Represented	Mixture Date(s)	Analyzed	Collected
c	1	7/9/07	1,652	7/9	7/9-12	62	100
d	1	7/9/07	5,106	7/9		193	300
c	1	7/12/07	795	7/12		30	100
d	1	7/12/07	3,033	7/12		115	300
c	1	7/16/07	1,351	7/16	7/16-19	10	100
d	1	7/16/07	8,272	7/16		64	300
c	1	7/19/07	5,139	7/19		40	100
d	1	7/19/07	37,093	7/19		286	300
c	1	7/23/07	25,867	7/21-23	7/21-28	30	100
d	1	7/23/07	183,402	7/21-23		215	350
c	1	7/26/07	26,204	7/26-28		31	100
d	1	7/26/07	105,336	7/26-28		124	300
c	1	7/30/07	14,061	7/30-31			130
d	1	7/30/07	54,201	7/30-31			130
c	1	8/2/07	4,323	8/1-2			130
d	1	8/2/07	43,823	8/1-2			130
c	1	8/6/07	10,041	8/5-7			130
d	1	8/6/07	45,861	8/5-7			130
c	1	8/9/07	8,152	8/8-9			130
d	1	8/9/07	29,934	8/8-9			130
		Kalgin Island Subdistrict Set Gillnet (Central District)					
	1	8/6/05	36,467	8/4-11			100
	1	6/26/06	2,867	6/23-26			109
	1	6/29/06	1,291	6/29			117
	1	7/3/06	1,375	7/3			100
	1	7/6/06	560	7/6			77
	1	7/10/06	861	7/10			112
	1	7/13/06	471	7/13			53
	1	7/17/06	1,656	7/17			101
	1	7/20/06	1,434	7/20			112
	1	7/24/06	3,271	7/24			118
	1	7/27/06	2,690	7/27			80
	1	7/31/06	4,503	7/31-8/1			85
	1	8/3/06	4,130	8/3			93
	1	8/10/06	6,106	8/7-10			100
	1	8/16/06	3,731	8/14-17			100
	1	6/25/07	2,754	6/22-25			100
	1	6/28/07	2,364	6/28			100
	1	7/2/07	2,642	7/2			100
	1	7/5/07	2,894	7/5			100

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Table 2.–Page 6 of 7.

Sub-strata[a]	Restrictions[b]	Date(s) Sampled	Harvest Represented	Harvest Dates Represented	Mixture Date(s)	Analyzed	Collected
	1	7/9/07	2,461	7/9			100
	1	7/12/07	1,395	7/12			100
	1	7/16/07	575	7/16			85
	1	7/19/07	3,148	7/19			100
	1	7/23/07	4,596	7/23			100
	1	7/26/07	5,196	7/26			100
	1	7/29/07	4,596	7/29-31			100
	1	8/2/07	3,533	8/2			100
	1	8/6/07	2,234	8/6			100
	1	8/9/07	8,809	8/9-13			100
Western Subdistrict Set Gillnet (Central District)							
	1	7/11/05 7/21/05	12,127	7/11-21			100
	1	6/26/06	810	6/19-26			132
	1	6/29/06	2,137	6/29-7/1			128
	1	7/3/06	2,682	7/3			116
	1	7/6/06	2,444	7/5-6			100
	1	7/10/06	3,280	7/8-10			102
	1	7/13/06	4,477	7/12-13			108
	1	7/17/06	3,764	7/17-18			83
	1	7/20/06	5,151	7/20-22			119
	1	7/24/06	1,492	7/23-25			105
	1	7/27/06	3,236	7/26-27			85
	1	7/31/06	1,695	7/29-31			46
	1	6/25/07	2,666	6/18-25			100
	1	6/28/07	1,926	6/28			100
	1	7/2/07	3,592	7/1-2			100
	1	7/9/07	5,709	7/7-9			100
	1	7/5/07	5,951	7/4-5			100
	1	7/12/07	6,465	7/10-13			100
	1	7/16/07	2,510	7/14-16			100
	1	7/19/07	8,639	7/18-20			100
	1	7/23/07	4,540	7/21-23			100
	1	7/26/07	6,287	7/25-26			100
	1	7/30/07	2,167	7/27-30			100
	1	8/2/07	1,704	8/2-6			100
	1	8/9/07	3,675	8/9-20			100
Eastern Subdistrict Set Gillnet (Northern District)							
	1	7/14/05 7/18/05	2,396	7/14-18			100
	1	7/3/06	463	7/3			50

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Table 2.–Page 7 of 7.

Sub-strata[a]	Restrictions[b]	Date(s) Sampled	Harvest Represented	Harvest Dates Represented	Mixture Date(s)	Analyzed	Collected
	1	7/6/06	619	7/6			40
	1	8/7/06	713	8/7			250
	1	8/10/06	696	8/10			198
	1	7/2/07	326	7/2			33
	1	7/5/07	419	7/5			40
	1	7/9/07	393	7/9			40
	1	7/12/07	222	7/12			28
	1	7/16/07	229	7/16			40
	1	7/19/07	1,466	7/19			40
	1	7/23/07	1,280	7/23			40
	1	8/9/07	2,138	8/9-20			80
General Subdistrict Set Gillnet (Northern District)							
	1	7/18/05	3,250	7/18			30

Note: Corresponding restrictions to the fisheries and substrata are provided when applicable.

[a] a-Cohoe/Ninilchik; b-South K. Beach; c-North K. Beach; d-North and South Salamatof.

[b] (see Figures 1 and 4–8) 1-No Restrictions; 2-Kasilof Corridor; 3-Kenai Corridor; 4-Area 1; 5-Area 2; 6-South of Blanchard line; 7-South of north end of Kalgin Island; 8-South of a line from Collier's Dock / Northwest Point on Kalgin Island / Latitude 60.5208°N to western shore; 9-Kasilof Terminal Area; 10-within 1/2 mile of shore.

Table 3.–Forty five single nucleotide polymorphism markers used for this project with subsets noted for each analysis.

Marker	Marker Set [a]	mtDNA	Linked Markers	H_s	F_{st}	Reference [b]
One_ACBP-79	1,2,3			0.429	0.139	A
One_ALDOB-135	1,2,3			0.219	0.099	A
One_CO1	1,2,3	yes		NA	NA	A
One_ctgf-301	1,2,3			0.066	0.035	A
One_Cytb_17	1,2,3	yes		NA	NA	A
One_Cytb_26	1,2,3	yes		NA	NA	A
One_E2-65	1,2,3			0.359	0.166	B
One_GHII-2165	1,2,3			0.239	0.152	A
One_GPDH-201	1,2,3			0.463	0.067	B
One_GPDH2-187	1,2,3			0.177	0.096	B
One_GPH-414	1,2,3			0.399	0.067	A
One_hsc71-220	1,2,3			0.286	0.146	A
One_HGFA-49	1,2,3			0.260	0.097	B
One_HpaI-71	1,2,3			0.352	0.103	A
One_HpaI-99	1,2,3			0.139	0.121	A
One_IL8r-362	1,2			0.097	0.206	C
One_KPNA-422	1,2,3			0.260	0.118	A
One_LEI-87	1,2,3			0.448	0.091	A
One_MARCKS-241	1,2,3			0.051	0.096	C
One_MHC2_190	1,2,3		1	NA	NA	A
One_MHC2_251	1,2,3		1	NA	NA	A
One_Ots213-181	1,2,3			0.226	0.060	A
One_p53-534	1,2,3			0.065	0.242	A
One_ins-107	1,2,3			0.429	0.108	B
One_Prl2	1,2,3			0.452	0.094	A
One_RAG1-103	1,2,3			0.085	0.131	A
One_RAG3-93	1,2,3			0.111	0.080	A
One_RFC2-102	1,2,3			0.331	0.145	B
One_RFC2-285	1,2,3			0.080	0.105	B
One_RH2op-395	2,3			0.001	0.002	A
One_serpin-75	1,2,3			0.045	0.178	B
One_STC-410	1,2,3			0.314	0.230	A
One_STR07	1,2,3			0.344	0.158	A
One_Tf_ex11-750	1,2,3			0.355	0.169	A

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Table 3.–Page 2 of 2.

Marker	Marker Set [a]	mtDNA	Linked markers	Hs	Fst (W&C)	Reference [b]
One_Tf_in3-182	1,2,3			0.046	0.101	A
One_U301_92	2,3			0.265	0.083	A
One_U401-224	1,2,3			0.457	0.082	C
One_U404-229	1,2			0.037	0.097	C
One_U502-167	2			0.049	0.065	C
One_U503-170	1,2			0.143	0.077	C
One_U504-141	1,2			0.394	0.088	C
One_U508-533	1,2			0.091	0.281	C
One_VIM-569	1,2,3			0.228	0.132	A
One_ZNF-61	1,2			0.276	0.182	C
One_Zp3b-49	1,2,3			0.144	0.392	B

Note: Expected heterozygosity (Hs) and Fst for baseline samples and reference are listed for each marker. MtDNA markers are noted, and linked markers are numerically coded by linkage group. Composite haplotype loci were assembled for both of these marker classes for use in GSI analyses.

[a] 1) 2005 and 2006 mixtures, proof tests; 2) 2007 mixtures and simulations; 3) fish wheel.

[b] A) Elfstrom et al. (2006); B) Smith et al. (2005a); C) ADF&G unpublished data.

Table 4.–Tissue collections of sockeye salmon sampled for genetic studies taken from fish captured in fish wheels operated within four of the major drainages into Cook Inlet, Alaska.

Map No.	River	Location	Date	N
101	Kasilof	Kasilof River (fish wheel, rkm 11.3)	7/22/1992-7/23/1992	190
			7/11/2005-7/20/2005	190
102	Kenai	Kenai River (fish wheel, rkm 30.6)	7/31/1994-8/1/1994	190
			7/11/2005-7/20/2005	190
103	Yentna	Yentna River (fish wheel, rkm 6.5)	7/15/1992	190
			7/9/2005-8/12/2005	190
104	Susitna	Susitna River (Sunshine fish wheel, rkm 116)	7/26/1992	190

Note: Map numbers correspond to fish wheel sites on Figure 2.

Table 5.–Allocation proportions (90% confidence interval) for mixtures of simulated fish that originate from all populations that contribute to each reporting group (100% simulations).

Reporting Group	West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
West	**0.97**	0.01	0.01	0.00	0.00	0.01	0.00
	(0.95 - 0.99)	(0.00 - 0.03)	(0.00 - 0.02)	(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.02)	(0.00 - 0.00)
Yentna	0.00	**0.98**	0.02	0.00	0.00	0.00	0.00
	(0.00 - 0.01)	(0.95 - 0.99)	(0.00 - 0.04)	(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.00)
Susitna	0.00	0.02	**0.97**	0.00	0.00	0.00	0.00
	(0.00 - 0.01)	(0.00 - 0.04)	(0.94 - 0.99)	(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.01)
Knik	0.00	0.00	0.00	**0.99**	0.00	0.00	0.00
	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)	(0.98 - 1.00)	(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.01)
Northeast	0.00	0.00	0.00	0.00	**0.99**	0.00	0.00
	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)	(0.97 - 1.00)	(0.00 - 0.01)	(0.00 - 0.00)
Kenai	0.00	0.00	0.00	0.00	0.00	**0.98**	0.01
	(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.00)	(0.97 - 1.00)	(0.00 - 0.03)
Kasilof	0.00	0.00	0.00	0.00	0.00	0.02	**0.98**
	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.04)	(0.96 - 1.00)

Note: Baseline frequencies from SNP loci were used to generate the simulated fish used in the mixtures. Mixed stock analyses were performed using SPAM.

Table 6.–Allocation proportions (SPAM; 90% confidence interval, BAYES; 90% credibility interval in parentheses) for mixtures of 200 known fish that were removed from the baseline populations that contribute to each reporting group (proof tests).

Reporting Group	West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
				SPAM			
West	**0.94**	0.05	0.01	0.00	0.00	0.00	0.00
	(0.87 - 1.00)	(0.04 - 0.06)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.05)	(0.00 - 0.01)
Yentna	0.00	**1.00**	0.00	0.00	0.00	0.00	0.00
	(0.00 - 0.01)	(0.94 - 1.00)	(0.00 - 0.07)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)
Susitna	0.01	0.05	**0.92**	0.00	0.00	0.02	0.00
	(0.00 - 0.02)	(0.04 - 0.06)	(0.86 - 0.98)	(0.00 - 0.00)	(0.00 - 0.01)	(0.02 - 0.02)	(0.00 - 0.01)
Knik	0.00	0.01	0.00	**0.97**	0.01	0.01	0.00
	(0.00 - 0.04)	(0.00 - 0.01)	(0.00 - 0.01)	(0.91 - 1.00)	(0.00 - 0.02)	(0.01 - 0.02)	(0.00 - 0.01)
Northeast	0.02	0.03	0.00	0.04	**0.90**	0.02	0.00
	(0.00 - 0.03)	(0.02 - 0.03)	(0.00 - 0.05)	(0.03 - 0.06)	(0.86 - 0.95)	(0.01 - 0.02)	(0.00 - 0.02)
Kenai	0.00	0.01	0.00	0.01	0.00	**0.98**	0.00
	(0.00 - 0.01)	(0.01 - 0.01)	(0.00 - 0.01)	(0.01 - 0.01)	(0.00 - 0.00)	(0.91 - 1.00)	(0.00 - 0.02)
Kasilof	0.00	0.00	0.00	0.01	0.00	0.00	**0.99**
	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.02)	(0.00 - 0.00)	(0.00 - 0.02)	(0.94 - 1.00)
				BAYES:Flat prior			
West	**0.99**	0.00	0.00	0.00	0.00	0.00	0.00
	(0.98 - 1.00)	(0.00 - 0.02)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.01)
Yentna	0.00	**0.99**	0.00	0.00	0.00	0.00	0.00
	(0.00 - 0.01)	(0.98 - 1.00)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)
Susitna	0.00	0.00	**0.99**	0.00	0.00	0.01	0.00
	(0.00 - 0.01)	(0.00 - 0.03)	(0.95 - 1.00)	(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.03)	(0.00 - 0.01)
Knik	0.00	0.00	0.00	**0.99**	0.00	0.00	0.00
	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)	(0.97 - 1.00)	(0.00 - 0.01)	(0.00 - 0.02)	(0.00 - 0.01)
Northeast	0.00	0.00	0.00	0.00	**0.99**	0.00	0.00
	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.02)	(0.97 - 1.00)	(0.00 - 0.01)	(0.00 - 0.01)
Kenai	0.00	0.00	0.00	0.01	0.00	**0.99**	0.00
	(0.00 - 0.01)	(0.00 - 0.02)	(0.00 - 0.01)	(0.00 - 0.03)	(0.00 - 0.00)	(0.96 - 1.00)	(0.00 - 0.01)
Kasilof	0.00	0.00	0.00	0.00	0.00	0.00	**0.99**
	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.02)	(0.97 - 1.00)
				BAYES:SPAM prior			
West	**1.00**	0.00	0.00	0.00	0.00	0.00	0.00
	(0.99 - 1.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)
Yentna	0.00	**1.00**	0.00	0.00	0.00	0.00	0.00
	(0.00 - 0.00)	(1.00 - 1.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)
Susitna	0.00	0.00	**1.00**	0.00	0.00	0.00	0.00
	(0.00 - 0.00)	(0.00 - 0.01)	(0.98 - 1.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.02)	(0.00 - 0.00)

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Table 6.–Page 2 of 2.

Reporting Group	West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
Knik	0.00	0.00	0.00	**1.00**	0.00	0.00	0.00
	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(1.00 - 1.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)
Northeast	0.00	0.00	0.00	0.00	**1.00**	0.00	0.00
	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.01)	(0.99 - 1.00)	(0.00 - 0.00)	(0.00 - 0.00)
Kenai	0.00	0.00	0.00	0.00	0.00	**1.00**	0.00
	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(1.00 - 1.00)	(0.00 - 0.00)
Kasilof	0.00	0.00	0.00	0.00	0.00	0.00	**1.00**
	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(1.00 - 1.00)

Note: New baselines, that excluded the 200 used in the mixture, were used for each mixed stock analysis. Mixed stock analyses were performed using SPAM, BAYES with a flat prior, and BAYES with a SPAM prior. Numbers in bold indicate allocation to the drainage of the fish wheel.

Table 7.–Stock composition estimate for mixtures of fish captured in fish wheels operated on the Kasilof, Kenai, Yentna, and Susitna rivers in 1992, 1994, and 2005.

Date(s)	N	West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
				Kasilof				
7/22-23/92	190	0.00	0.00	0.00	0.00	0.00	0.00	**1.00**
		(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(1.00 - 1.00)
7/11-20/05	190	0.00	0.00	0.00	0.00	0.00	0.00	**0.99**
		(0.00 - 0.02)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.02)	(0.97 - 1.00)
				Kenai				
7/31-8/1/94	190	0.00	0.00	0.00	0.01	0.00	**0.98**	0.00
		(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.04)	(0.00 - 0.00)	(0.95 - 1.00)	(0.00 - 0.03)
7/11-20/05	190	0.00	0.01	0.00	0.00	0.00	**0.99**	0.01
		(0.00 - 0.00)	(0.00 - 0.05)	(0.00 - 0.02)	(0.00 - 0.00)	(0.00 - 0.00)	(0.92 - 1.00)	(0.00 - 0.06)
				Yentna				
7/15/92	190	0.00	**1.00**	0.00	0.00	0.00	0.00	0.00
		(0.00 - 0.00)	(0.96 - 1.00)	(0.00 - 0.03)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)
7/9-8/12/05	190	0.00	**0.94**	0.05	0.01	0.00	0.00	0.00
		(0.00 - 0.01)	(0.77 - 1.00)	(0.00 - 0.20)	(0.00 - 0.05)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)
				Susitna				
7/26/92	190	0.00	0.02	**0.98**	0.00	0.00	0.00	0.00
		(0.00 - 0.00)	(0.00 - 0.06)	(0.94 - 1.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)

Note: Credibility intervals (90%) are included in parentheses. BAYES with a SPAM prior was used to estimate the proportions.

Table 8.–Stock composition estimate and the number of fish successfully screened for mixtures of fish captured in the Cook Inlet offshore test fishery in 2006 and 2007. 2007 REVISED - SEE ADDENDUM

Date(s)	N	West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
				2006				
7/1-9	325	0.11	0.06	0.00	0.01	0.00	0.30	0.51
		(0.08 - 0.15)	(0.04 - 0.10)	(0.00 - 0.01)	(0.00 - 0.02)	(0.00 - 0.00)	(0.24 - 0.36)	(0.45 - 0.58)
7/10-16	266	0.08	0.13	0.07	0.05	0.00	0.34	0.33
		(0.05 - 0.12)	(0.07 - 0.19)	(0.04 - 0.11)	(0.02 - 0.08)	(0.00 - 0.00)	(0.27 - 0.40)	(0.26 - 0.39)
7/17-23	401	0.10	0.09	0.02	0.02	0.00	0.61	0.16
		(0.07 - 0.13)	(0.06 - 0.13)	(0.01 - 0.03)	(0.01 - 0.03)	(0.00 - 0.00)	(0.56 - 0.67)	(0.12 - 0.21)
7/24 - 8/1	393	0.05	0.07	0.03	0.02	0.00	0.70	0.12
		(0.03 - 0.07)	(0.03 - 0.12)	(0.00 - 0.07)	(0.01 - 0.04)	(0.00 - 0.01)	(0.65 - 0.75)	(0.08 - 0.16)
				2007				
7/1-9	374	0.25	0.06	0.01	0.05	0.00	0.40	0.22
		(0.20 - 0.29)	(0.03 - 0.09)	(0.00 - 0.03)	(0.03 - 0.08)	(0.00 - 0.01)	(0.34 - 0.47)	(0.17 - 0.28)
7/10-13	444	0.08	0.15	0.02	0.04	0.00	0.55	0.17
		(0.05 - 0.11)	(0.11 - 0.19)	(0.00 - 0.03)	(0.02 - 0.06)	(0.00 - 0.00)	(0.49 - 0.61)	(0.11 - 0.22)
7/14-18	404	0.07	0.13	0.03	0.02	0.00	0.61	0.13
		(0.05 - 0.10)	(0.09 - 0.17)	(0.01 - 0.07)	(0.01 - 0.04)	(0.00 - 0.00)	(0.55 - 0.67)	(0.09 - 0.18)
7/19-23	429	0.09	0.07	0.04	0.03	0.00	0.65	0.12
		(0.06 - 0.12)	(0.05 - 0.10)	(0.02 - 0.07)	(0.01 - 0.04)	(0.00 - 0.00)	(0.59 - 0.71)	(0.07 - 0.18)
7/24-8/2	438	0.08	0.06	0.05	0.01	0.00	0.69	0.10
		(0.05 - 0.12)	(0.04 - 0.09)	(0.03 - 0.07)	(0.00 - 0.02)	(0.00 - 0.00)	(0.64 - 0.75)	(0.06 - 0.15)

Note: Credibility intervals (90%) are included in parentheses. Proportions are estimated from BAYES using a SPAM prior.

Table 9.–Stock composition estimates (P) and extrapolated harvests (H) from mixtures of fish captured in the Central District drift gillnet fishery in 2005, 2006, and 2007. 2007 REVISED - SEE ADDENDUM

Date	N		West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
						2005			
7/7	200	P	0.03	0.08	0.00	0.03	0.00	0.72	0.13
			(0.01 - 0.06)	(0.05 - 0.11)	(0.00 - 0.00)	(0.01 - 0.06)	(0.00 - 0.00)	(0.65 - 0.79)	(0.08 - 0.20)
		H	3,892	8,794	11	3,634	0	81,012	14,841
			(1548 - 6921)	(5373 - 12698)	(0 - 11)	(1503 - 6428)	(0 - 0)	(72577 - 88730)	(8492 - 22166)
7/11-14	400	P	0.05	0.02	0.00	0.00	0.00	0.88	0.05
			(0.03 - 0.08)	(0.01 - 0.05)	(0.00 - 0.01)	(0.00 - 0.01)	(0.00 - 0.00)	(0.84 - 0.91)	(0.03 - 0.08)
		H	20,509	9,540	504	546	0	368,019	21,139
			(11179 - 31687)	(2437 - 21433)	(0 - 2942)	(0 - 2732)	(0 - 0)	(351209 - 383400)	(10759 - 33032)
7/18-21	400	P	0.02	0.00	0.00	0.01	0.00	0.90	0.06
			(0.01 - 0.04)	(0.00 - 0.01)	(0.00 - 0.02)	(0.00 - 0.03)	(0.00 - 0.00)	(0.86 - 0.93)	(0.04 - 0.09)
		H	8,542	261	1,044	3,767	37	335,370	23,984
			(2201 - 15480)	(0 - 1902)	(0 - 7050)	(0 - 9959)	(0 - 0)	(321382 - 348015)	(13839 - 35398)
						2006			
6/26-29	400	P	0.03	0.03	0.00	0.01	0.00	0.11	0.82
			(0.01 - 0.04)	(0.01 - 0.06)	(0.00 - 0.00)	(0.00 - 0.03)	(0.00 - 0.00)	(0.08 - 0.14)	(0.78 - 0.86)
		H	1,034	1,226	12	523	0	4,059	31,578
			(511 - 1722)	(400 - 2141)	(0 - 77)	(119 - 1088)	(0 - 0)	(2898 - 5354)	(30087 - 32977)
7/3-6	399	P	0.02	0.10	0.02	0.00	0.00	0.22	0.64
			(0.01 - 0.04)	(0.07 - 0.14)	(0.01 - 0.03)	(0.00 - 0.01)	(0.00 - 0.00)	(0.17 - 0.27)	(0.58 - 0.69)
		H	1,438	6,986	1,161	142	0	14,613	43,158
			(472 - 2639)	(4813 - 9328)	(472 - 2099)	(0 - 931)	(0 - 0)	(11353 - 18184)	(39297 - 46803)
7/10-13	200	P	0.02	0.01	0.00	0.00	0.00	0.20	0.77
			(0.00 - 0.04)	(0.00 - 0.02)	(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.02)	(0.14 - 0.27)	(0.70 - 0.83)
		H	52	22	5	1	15	646	2,454
			(0 - 124)	(0 - 74)	(0 - 27)	(0 - 0)	(0 - 58)	(452 - 862)	(2228 - 2650)

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Table 9.–Page 2 of 2.

Date	N		West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
7/17	300	P	0.00	0.02	0.02	0.01	0.00	0.41	0.54
			(0.00 - 0.01)	(0.00 - 0.05)	(0.00 - 0.05)	(0.00 - 0.03)	(0.00 - 0.00)	(0.34 - 0.49)	(0.46 - 0.62)
		H	32	491	515	259	0	10,853	14,268
			(0 - 193)	(0 - 1210)	(69 - 1279)	(11 - 724)	(0 - 0)	(8853 - 12887)	(12245 - 16260)
						2007			
6/25-28	400	P	0.31	0.01	0.00	0.00	0.00	0.30	0.38
			(0.27 - 0.36)	(0.00 - 0.02)	(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.00)	(0.24 - 0.35)	(0.32 - 0.44)
		H	6,734	199	0	28	0	6,320	8,105
			(5843 - 7660)	(43 - 426)	(0 - 0)	(0 - 169)	(0 - 0)	(5150 - 7536)	(6897 - 9335)
7/2-5	400	P	0.13	0.11	0.00	0.02	0.00	0.43	0.30
			(0.09 - 0.17)	(0.07 - 0.15)	(0.00 - 0.02)	(0.01 - 0.05)	(0.00 - 0.00)	(0.37 - 0.50)	(0.24 - 0.36)
		H	10,898	9,463	302	2,030	0	36,293	24,908
			(7936 - 14052)	(6217 - 12844)	(0 - 1342)	(797 - 3784)	(0 - 0)	(30646 - 42023)	(19749 - 30353)
7/9-12	399	P	0.06	0.09	0.02	0.02	0.00	0.56	0.24
			(0.04 - 0.08)	(0.06 - 0.12)	(0.00 - 0.05)	(0.01 - 0.04)	(0.00 - 0.01)	(0.50 - 0.63)	(0.19 - 0.30)
		H	16,419	26,534	7,300	6,186	674	165,067	70,982
			(10320 - 23426)	(18471 - 36326)	(323 - 14689)	(2111 - 11200)	(0 - 3987)	(146097 - 184007)	(54358 - 88544)
7/16	400	P	0.04	0.13	0.02	0.03	0.00	0.64	0.15
			(0.02 - 0.06)	(0.09 - 0.17)	(0.01 - 0.04)	(0.01 - 0.04)	(0.00 - 0.00)	(0.58 - 0.69)	(0.10 - 0.20)
		H	17,492	61,632	10,987	12,143	0	306,715	72,956
			(8096 - 29009)	(44333 - 80281)	(4530 - 19275)	(5493 - 20480)	(0 - 0)	(278429 - 334231)	(50115 - 97243)
7/19	398	P	0.02	0.10	0.00	0.04	0.00	0.72	0.12
			(0.01 - 0.04)	(0.07 - 0.13)	(0.00 - 0.00)	(0.02 - 0.06)	(0.00 - 0.00)	(0.65 - 0.78)	(0.07 - 0.19)
		H	10,185	43,332	44	15,498	0	315,262	54,658
			(4434 - 17605)	(30556 - 57863)	(0 - 0)	(7815 - 24717)	(0 - 0)	(285365 - 343755)	(29546 - 82053)

Note: Credibility intervals (90%) are included in parentheses. The number of fish successfully screened from each stratum (N) is indicated. BAYES with a SPAM prior was used to estimate the proportions. The 90% confidence intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values above zero.

Table 10.–Stock composition estimates (P) and extrapolated harvests (H) from mixtures of fish captured in the Kasilof Terminal Area drift and set gillnet fisheries (Central District, East Side Subdistrict) in 2006.

Date	N		West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
						Drift Gillnet			
7/24-27	300	P	0.00	0.00	0.00	0.01	0.00	0.03	0.96
			(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.02)	(0.00 - 0.00)	(0.01 - 0.06)	(0.93 - 0.98)
		H	61	0	20	1,724	0	7,039	194,041
			(0 - 365)	(0 - 0)	(0 - 0)	(0 - 4220)	(0 - 0)	(2881 - 12395)	(188341 - 198606)
						Set Gillnet			
7/24-27	400	P	0.00	0.00	0.00	0.00	0.00	0.07	0.93
			(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.04 - 0.10)	(0.90 - 0.96)
		H	414	0	0	0	0	11,404	153,699
			(17 - 1258)	(0 - 0)	(0 - 0)	(0 - 0)	(0 - 0)	(7018 - 16403)	(148667 - 158118)

Note: Credibility intervals (90%) are included in parentheses. The number of fish successfully screened from each stratum (N) is indicated. BAYES with a SPAM prior was used to estimate the proportions. The 90% credibility intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values above zero.

Table 11.–Stock composition estimates (P) and extrapolated harvests (H) from mixtures of fish captured in the Kasilof Section set gillnet fishery (Central District, East Side Subdistrict) in 2005, 2006, and 2007. 7/19-28, 2005 AND 2007 REVISED - SEE ADDENDUM

Date	N		West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
2005									
7/2-9	200	P	0.00	0.00	0.00	0.00	0.00	0.17	0.83
			(0.00 - 0.00)	(0.00 - 0.02)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.11 - 0.24)	(0.76 - 0.89)
		H	36	871	0	0	0	29,632	147,217
			(0 - 53)	(18 - 2666)	(0 - 0)	(0 - 0)	(0 - 0)	(18895 - 41915)	(134827 - 158060)
7/11-15	406	P	0.00	0.00	0.01	0.00	0.00	0.48	0.50
			(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.02)	(0.00 - 0.00)	(0.00 - 0.00)	(0.43 - 0.54)	(0.45 - 0.55)
		H	23	422	936	0	0	55,292	57,473
			(0 - 11)	(11 - 1495)	(0 - 2351)	(0 - 0)	(0 - 0)	(49528 - 61239)	(51537 - 63237)
7/16-18	250	P	0.00	0.00	0.00	0.00	0.00	0.38	0.62
			(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.32 - 0.44)	(0.56 - 0.68)
		H	0	0	0	0	0	43,312	70,686
			(0 - 0)	(0 - 0)	(0 - 0)	(0 - 0)	(0 - 0)	(36666 - 50039)	(63960 - 77322)
7/19-28	300	P	0.00	0.00	0.00	0.00	0.00	0.43	0.57
			(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.36 - 0.50)	(0.50 - 0.64)
		H	0	282	0	0	0	75,287	100,582
			(0 - 0)	(0 - 1480)	(0 - 0)	(0 - 0)	(0 - 0)	(63996 - 87230)	(88657 - 111874)
2006									
6/26-7/1	400	P	0.00	0.00	0.00	0.00	0.00	0.13	0.87
			(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.10 - 0.16)	(0.84 - 0.90)
		H	23	57	0	0	0	14,867	99,846
			(0 - 80)	(0 - 482)	(0 - 0)	(0 - 0)	(0 - 0)	(11733 - 18369)	(96333 - 103003)
7/2-8	400	P	0.00	0.02	0.00	0.01	0.00	0.08	0.89
			(0.00 - 0.00)	(0.00 - 0.05)	(0.00 - 0.00)	(0.00 - 0.03)	(0.00 - 0.00)	(0.05 - 0.11)	(0.85 - 0.92)
		H	62	2,030	10	1,251	10	8,160	90,999
			(0 - 400)	(0 - 5085)	(0 - 0)	(0 - 3362)	(0 - 0)	(5167 - 11666)	(87329 - 94085)

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Table 11.–Page 2 of 2.

Date	N		West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
7/10-13	400	P	0.00	0.00	0.00	0.00	0.00	0.14	0.86
			(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.1 0 - 0.18)	(0.82 - 0.89)
		H	4	0	14	4	0	5,031	31,036
			(0 - 7)	(0 - 0)	(0 - 115)	(0 - 11)	(0 - 0)	(3779 - 6425)	(29650 - 32285)
7/15-16	400	P	0.00	0.01	0.00	0.00	0.00	0.16	0.83
			(0.00 - 0.00)	(0.00 - 0.03)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.13 - 0.20)	(0.79 - 0.86)
		H	19	1,951	0	0	0	30,854	156,564
			(0 - 0)	(0 - 4849)	(0 - 0)	(0 - 0)	(0 - 0)	(24187 - 37995)	(149328 - 163382)
7/17-22	400	P	0.00	0.00	0.00	0.01	0.00	0.13	0.86
			(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.02)	(0.00 - 0.00)	(0.10 - 0.16)	(0.82 - 0.89)
		H	257	14	0	1,663	0	17,237	116,022
			(0 - 1000)	(0 - 0)	(0 - 0)	(554 - 3231)	(0 - 0)	(13005 - 21820)	(111290 - 120388)
						2007			
6/25-7/5	399	P	0.01	0.06	0.00	0.02	0.00	0.13	0.79
			(0.00 - 0.02)	(0.03 - 0.08)	(0.00 - 0.00)	(0.01 - 0.03)	(0.00 - 0.00)	(0.09 - 0.18)	(0.74 - 0.84)
		H	863	6,271	0	2,022	0	14,656	89,789
			(80 - 2159)	(3738 - 9203)	(0 - 0)	(568 - 3908)	(0 - 0)	(9737 - 20291)	(83620 - 95413)
7/9-12	299	P	0.00	0.02	0.00	0.01	0.00	0.48	0.49
			(0.00 - 0.00)	(0.00 - 0.06)	(0.00 - 0.00)	(0.00 - 0.03)	(0.00 - 0.00)	(0.40 - 0.55)	(0.41 - 0.57)
		H	54	2,855	81	1,535	0	64,213	65,950
			(0 - 148)	(108 - 7461)	(0 - 512)	(0 - 3744)	(0 - 0)	(53789 - 74596)	(55688 - 76415)
7/16-21	400	P	0.00	0.04	0.02	0.04	0.00	0.59	0.31
			(0.00 - 0.01)	(0.02 - 0.06)	(0.00 - 0.03)	(0.02 - 0.06)	(0.00 - 0.01)	(0.52 - 0.65)	(0.25 - 0.38)
		H	429	8,930	4,025	9,764	572	139,715	74,704
			(0 - 2881)	(4215 - 14598)	(1167 - 8073)	(5191 - 15050)	(0 - 1905)	(124641 - 154884)	(60082 - 89492)

Note: Credibility intervals (90%) are included in parentheses. The number of fish successfully screened from each stratum (N) is indicated. BAYES with a SPAM prior was used to estimate the proportions. The 90% credibility intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values above zero.

Table 12.–Stock composition estimates (P) and extrapolated harvests (H) from mixtures of fish captured in the Kenai Section set gillnet fishery (Central District, East Side Subdistrict) in 2005, 2006, and 2007. 2007 REVISED - SEE ADDENDUM

Date	N		West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
						2005			
7/11-12	250	P	0.00	0.00	0.00	0.00	0.00	0.67	0.32
			(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.61 - 0.74)	(0.26 - 0.39)
		H	112	140	42	14	0	94,797	45,376
			(0 - 660)	(0 - 941)	(0 - 112)	(0 - 14)	(0 - 0)	(85708 - 103760)	(36455 - 54451)
7/13-14	250	P	0.00	0.00	0.00	0.00	0.00	0.78	0.22
			(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.72 - 0.84)	(0.16 - 0.28)
		H	4	0	0	0	0	32,678	9,160
			(0 - 0)	(0 - 0)	(0 - 0)	(0 - 0)	(0 - 0)	(30196 - 34992)	(6846 - 11642)
7/16-19	250	P	0.00	0.03	0.01	0.01	0.00	0.42	0.53
			(0.00 - 0.00)	(0.01 - 0.05)	(0.00 - 0.04)	(0.00 - 0.02)	(0.00 - 0.00)	(0.36 - 0.49)	(0.47 - 0.6)
		H	22	5,562	2,292	2,069	0	94,330	118,224
			(0 - 0)	(1646 - 11079)	(0 - 7809)	(356 - 4939)	(0 - 0)	(80336 - 108791)	(103719 - 132441)
7/20-26	300	P	0.00	0.00	0.00	0.00	0.00	0.56	0.44
			(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.50 - 0.61)	(0.39 - 0.5)
		H	0	0	0	0	0	156,107	124,207
			(0 - 0)	(0 - 0)	(0 - 0)	(0 - 0)	(0 - 0)	(139568 - 172337)	(107977 - 140746)
						2006			
7/10-13	400	P	0.00	0.00	0.00	0.00	0.00	0.43	0.56
			(0.00 - 0.00)	(0.00 - 0.02)	(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.00)	(0.37 - 0.49)	(0.50 - 0.62)
		H	2	56	0	67	0	7,281	9,419
			(0 - 0)	(0 - 271)	(0 - 0)	(0 - 244)	(0 - 0)	(6281 - 8287)	(8425 - 10407)
7/17	400	P	0.00	0.00	0.00	0.00	0.00	0.75	0.25
			(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.00)	(0.69 - 0.80)	(0.20 - 0.30)
		H	0	0	0	83	0	22,168	7,477
			(0 - 0)	(0 - 0)	(0 - 0)	(0 - 318)	(0 - 0)	(20596 - 23666)	(5990 - 9052)

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Table 12.–Page 2 of 2.

Date	N		West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
						2007			
7/9-12	400	P	0.00	0.01	0.01	0.01	0.00	0.86	0.10
			(0.00 - 0.01)	(0.00 - 0.04)	(0.00 - 0.03)	(0.00 - 0.03)	(0.00 - 0.00)	(0.81 - 0.91)	(0.05 - 0.15)
		H	46	138	109	138	0	9,130	1,026
			(2 - 138)	(4 - 447)	(0 - 314)	(0 - 306)	(0 - 0)	(8550 - 9642)	(547 - 1564)
7/16-19	399	P	0.00	0.02	0.00	0.00	0.00	0.91	0.06
			(0.00 - 0.01)	(0.00 - 0.05)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.86 - 0.96)	(0.01 - 0.12)
		H	119	1,255	0	10	0	47,230	3,241
			(0 - 508)	(78 - 2463)	(0 - 0)	(0 - 0)	(0 - 0)	(44383 - 49973)	(576 - 5989)
7/21-28	400	P	0.00	0.12	0.00	0.04	0.00	0.70	0.14
			(0.00 - 0.00)	(0.08 - 0.16)	(0.00 - 0.01)	(0.02 - 0.07)	(0.00 - 0.00)	(0.64 - 0.75)	(0.09 - 0.19)
		H	0	40,454	613	14,246	0	237,612	47,884
			(0 - 0)	(27537 - 54291)	(0 - 3647)	(6646 - 22698)	(0 - 0)	(217777 - 257209)	(31354 - 65469)

Note: Credibility intervals (90%) are included in parentheses. The number of fish successfully screened from each stratum (N) is indicated. BAYES with a SPAM prior was used to estimate the proportions. The 90% credibility intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values above zero.

Table 13.–Stock composition estimates (P) and extrapolated harvests (H) from mixtures of fish captured in the Kasilof and Kenai Section set gillnet fisheries (Central District, East Side Subdistrict) analyzed by subsections in 2005, 2006, and 2007. 2007 REVISED - SEE ADDENDUM

Dates	N		West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
					Cohoe/Ninilchik 2005				
7/2-28	250	P	0.00	0.00	0.01	0.00	0.00	0.42	0.57
			(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.02)	(0.00 - 0.00)	(0.00 - 0.00)	(0.36 - 0.49)	(0.50 - 0.64)
		H	0	164	3,569	0	0	173,928	232,546
			(0 - 0)	(0 - 164)	(0 - 9148)	(0 - 0)	(0 - 0)	(145829 - 202888)	(203545 - 260728)
					South K. Beach 2005				
7/2-26	906	P	0.00	0.00	0.00	0.00	0.00	0.39	0.61
			(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.35 - 0.42)	(0.58 - 0.64)
		H	0	175	0	0	0	84,674	134,038
			(0 - 0)	(0 - 919)	(0 - 0)	(0 - 0)	(0 - 0)	(77559 - 92095)	(126573 - 141153)
					North K. Beach 2005				
7/11-26	850	P	0.00	0.00	0.00	0.00	0.00	0.65	0.35
			(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.61 - 0.68)	(0.32 - 0.39)
		H	0	20	20	20	0	128,386	69,620
			(0 - 0)	(0 - 119)	(0 - 79)	(0 - 0)	(0 - 0)	(121176 - 135437)	(62589 - 76810)
					North and South Salamatof 2005				
7/11-24	200	P	0.00	0.02	0.00	0.01	0.00	0.82	0.14
			(0.00 - 0.00)	(0.01 - 0.04)	(0.00 - 0.03)	(0.00 - 0.03)	(0.00 - 0.00)	(0.75 - 0.89)	(0.08 - 0.21)
		H	0	9,741	2,046	5,406	0	400,020	69,844
			(0 - 0)	(2533 - 20164)	(0 - 13979)	(195 - 13248)	(0 - 0)	(365439 - 433578)	(37844 - 102428)
					Cohoe/Ninilchik 2006				
6/26-7/22	1335	P	0.00	0.02	0.00	0.01	0.00	0.16	0.82
			(0.00 - 0.00)	(0.01 - 0.03)	(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.00)	(0.13 - 0.18)	(0.79 - 0.84)
		H	294	8,170	0	2,319	0	57,083	300,171
			(0 - 1399)	(5079 - 11593)	(0 - 0)	(920 - 4085)	(0 - 0)	(49243 - 65437)	(291449 - 308268)
					South K. Beach 2006				
6/26-7/22	665	P	0.00	0.00	0.00	0.00	0.00	0.07	0.93
			(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.05 - 0.09)	(0.91 - 0.95)
		H	0	0	0	0	0	15,160	194,811
			(0 - 0)	(0 - 0)	(0 - 0)	(0 - 0)	(0 - 0)	(11065 - 19758)	(190213 - 198885)

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Table 13.–Page 2 of 2.

Dates	N		West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
					North K. Beach 2006				
7/10-17	189	P	0.00	0.00	0.00	0.00	0.00	0.26	0.73
			(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.20 - 0.34)	(0.66 - 0.80)
		H	6	0	0	7	0	3,108	8,627
			(0 - 43)	(0 - 0)	(0 - 0)	(0 - 46)	(0 - 0)	(2300 - 3988)	(7744 - 9437)
					North and South Salamatof 2006				
7/10-17	611	P	0.00	0.00	0.00	0.00	0.00	0.68	0.31
			(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.00)	(0.64 - 0.73)	(0.27 - 0.36)
		H	0	11	0	49	0	23,817	10,929
			(0 - 0)	(0 - 25)	(0 - 0)	(0 - 222)	(0 - 0)	(22267 - 25311)	(9436 - 12467)
					Cohoe/Ninilchik 2007				
6/25-7/21	878	P	0.01	0.05	0.01	0.02	0.00	0.40	0.52
			(0.00 - 0.01)	(0.03 - 0.06)	(0.00 - 0.01)	(0.01 - 0.03)	(0.00 - 0.00)	(0.35 - 0.45)	(0.47 - 0.57)
		H	2,707	17,748	2,088	8,352	155	155,631	200,019
			(735 - 5452)	(11368 - 24978)	(0 - 5336)	(4756 - 12682)	(0 - 928)	(136259 - 175350)	(180416 - 219507)
					South K. Beach 2007				
6/25-7/21	205	P	0.00	0.02	0.01	0.00	0.00	0.46	0.50
			(0.00 - 0.00)	(0.00 - 0.07)	(0.00 - 0.04)	(0.00 - 0.02)	(0.00 - 0.00)	(0.37 - 0.55)	(0.41 - 0.59)
		H	0	2,345	878	259	0	46,291	49,993
			(0 - 0)	(0 - 6824)	(0 - 3691)	(0 - 1556)	(0 - 0)	(37223 - 55340)	(41223 - 58752)
					North K. Beach 2007				
7/9-28	203	P	0.01	0.02	0.01	0.00	0.00	0.59	0.38
			(0.00 - 0.02)	(0.00 - 0.04)	(0.00 - 0.03)	(0.00 - 0.00)	(0.00 - 0.00)	(0.49 - 0.68)	(0.29 - 0.47)
		H	329	958	665	0	0	35,812	23,238
			(18 - 994)	(116 - 2465)	(0 - 1861)	(0 - 0)	(0 - 0)	(30077 - 41589)	(17515 - 28930)
					North and South Salamatof 2007				
7/9-28	997	P	0.00	0.06	0.00	0.03	0.00	0.87	0.04
			(0.00 - 0.00)	(0.04 - 0.08)	(0.00 - 0.00)	(0.02 - 0.04)	(0.00 - 0.00)	(0.84 - 0.92)	(0.00 - 0.07)
		H	0	19,542	68	9,993	0	299,017	13,621
			(0 - 0)	(13998 - 25702)	(0 - 513)	(6126 - 14237)	(0 - 0)	(285943 - 314349)	(0 - 24847)

Note: Credibility intervals (90%) are included in parentheses. The number of fish successfully screened from each stratum (N) is indicated. BAYES with a SPAM prior was used to estimate the proportions. The 90% credibility intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values above zero.

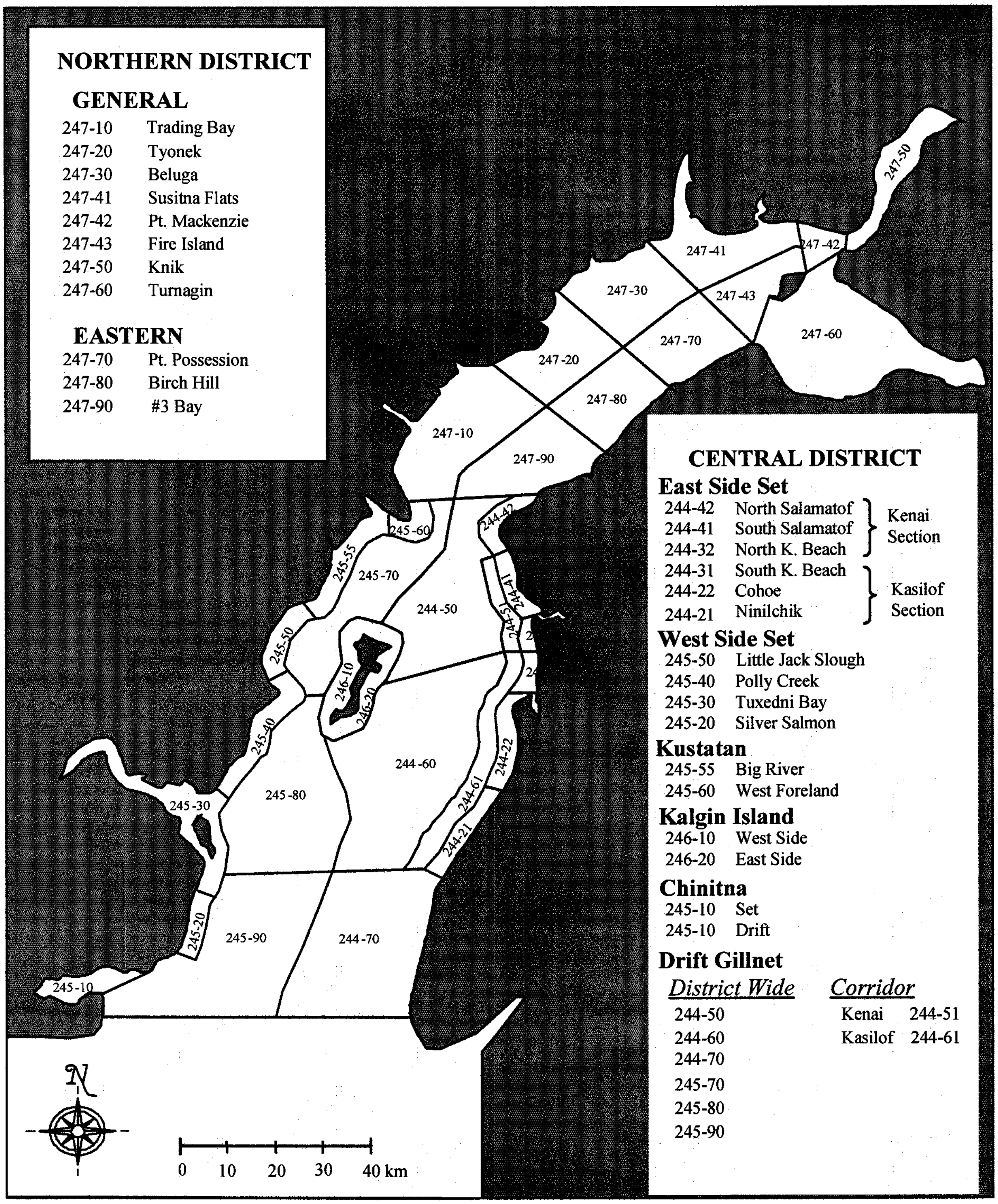

Figure 1.–Map of Upper Cook Inlet showing management fishing boundaries (statistical areas) for subdistricts, sections, and subsections within the Northern and Central Districts for both set and drift gillnet fisheries.

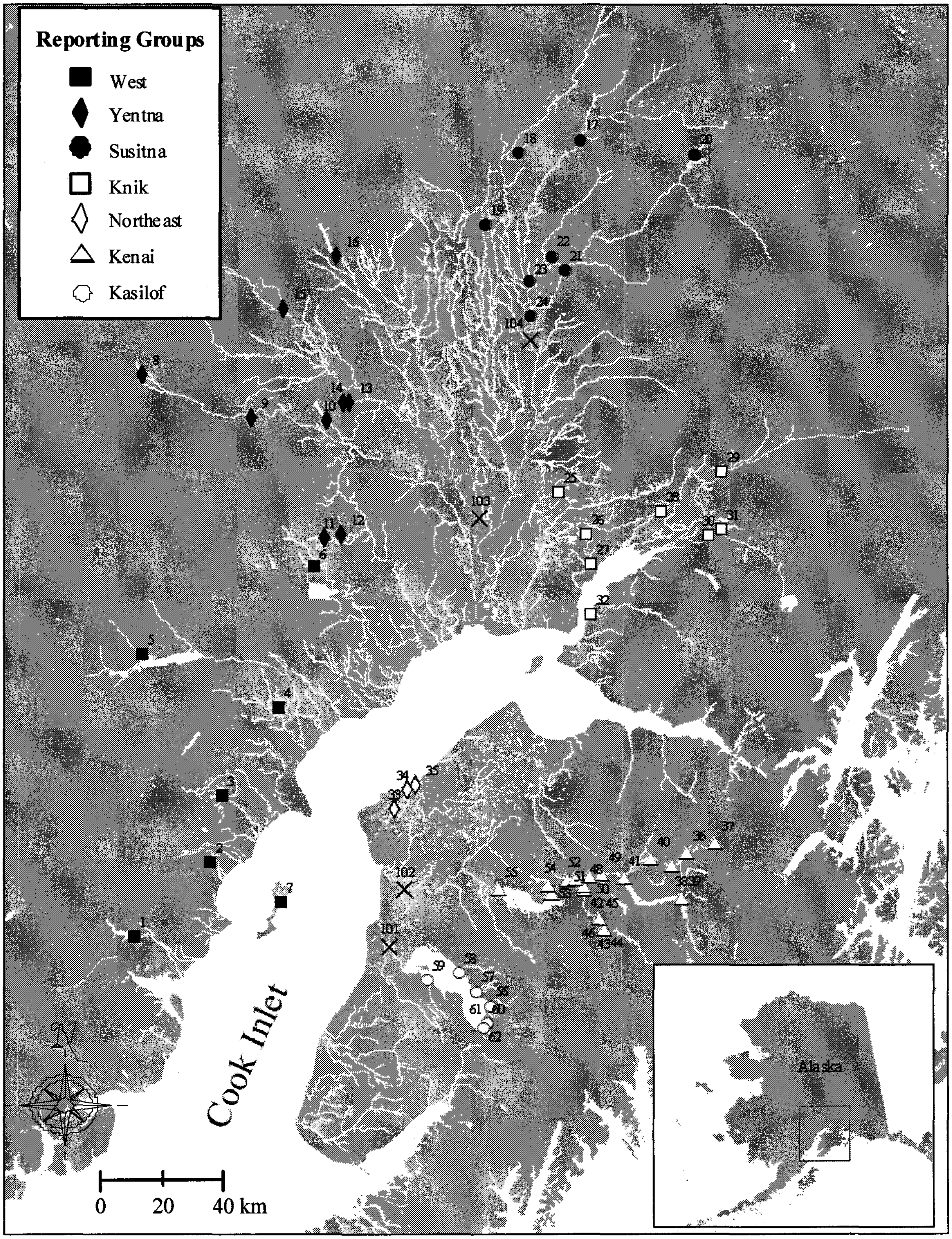

Figure 2.–Sampling locations for sockeye salmon originating from upper Cook Inlet, Alaska, 1992-2006 used to compile a genetic baseline.

Note: Fish wheels are designated by an "X". Symbols identify the seven regional reporting groups (see text).

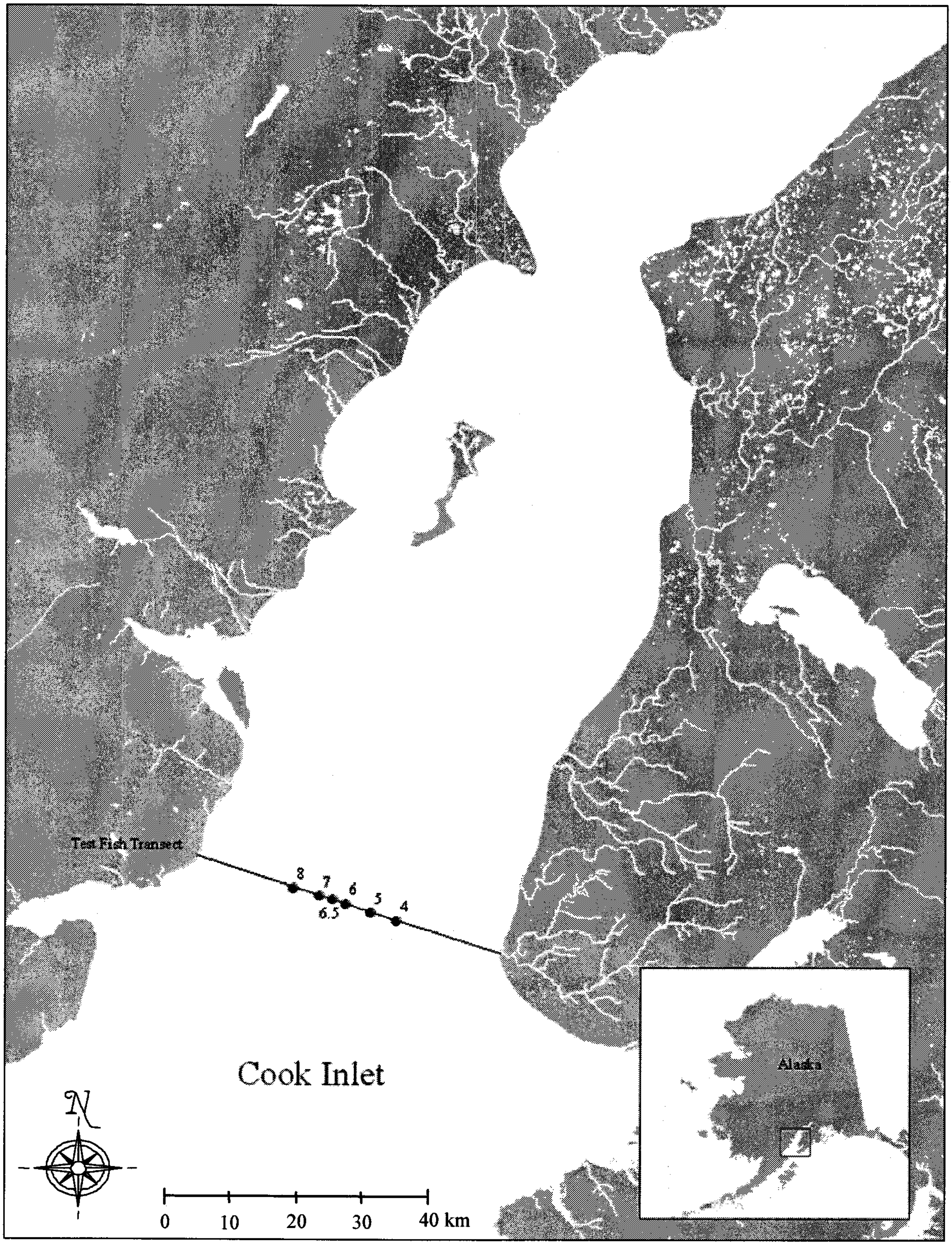

Figure 3.–Offshore test fishery stations for sockeye salmon migrating into Upper Cook Inlet, Alaska.

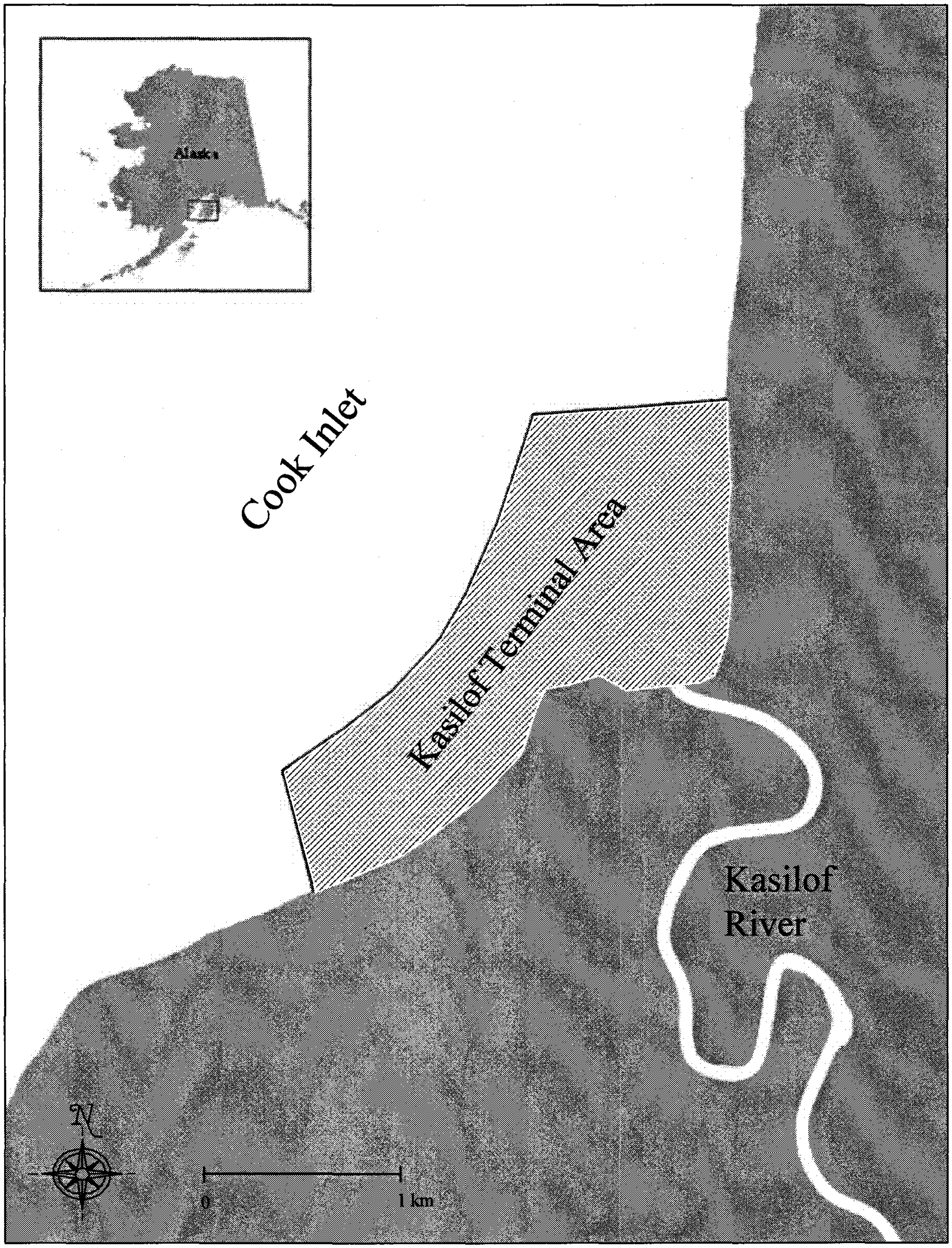

Figure 4.–Map of the mouth of the Kasilof River showing management fishing boundaries for the Kasilof Terminal Area (Central District, East Side Subdistrict).

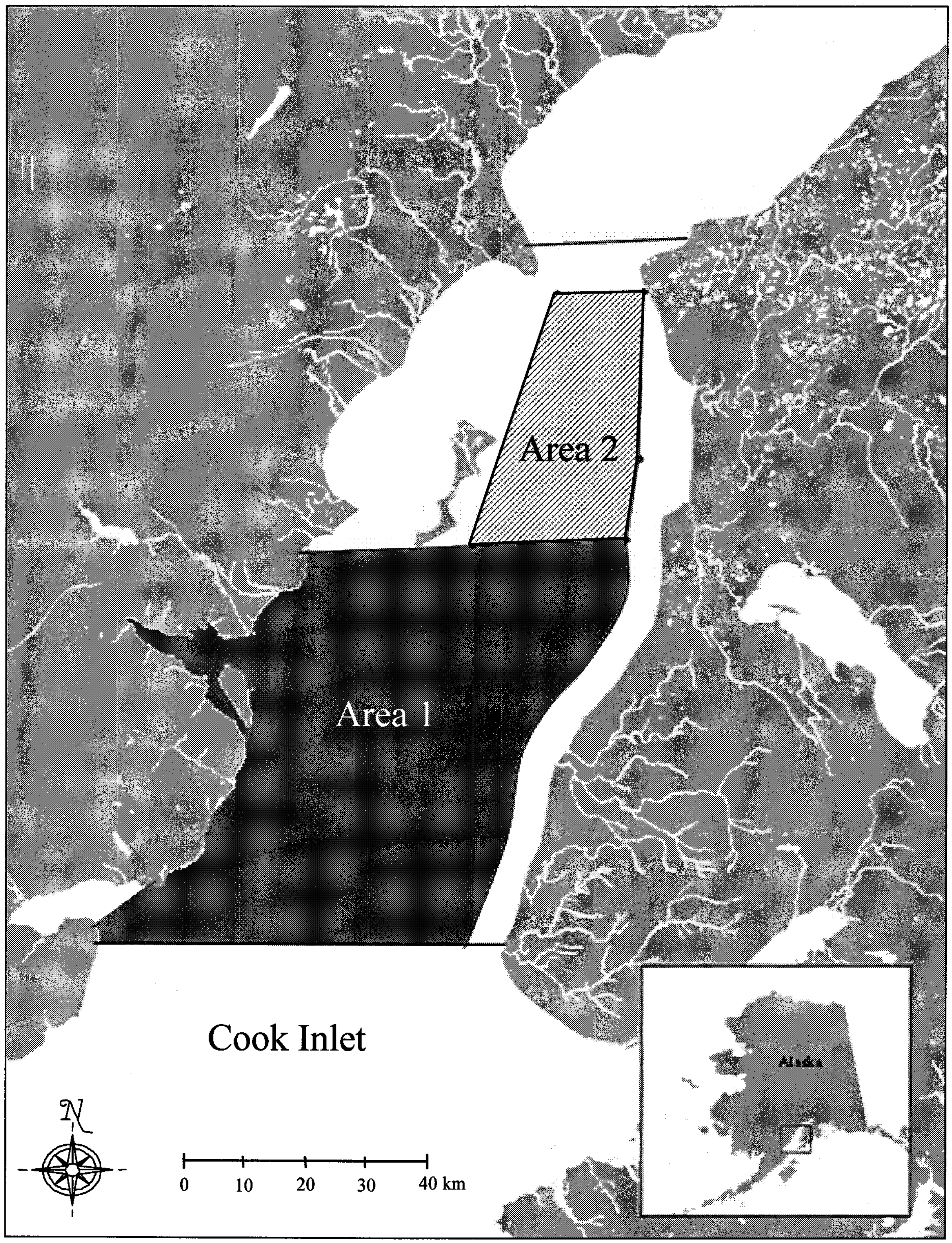

Figure 5.–Map of Central Cook Inlet showing management fishing boundaries for Area 1 and Area 2 for drift gillnet fisheries.

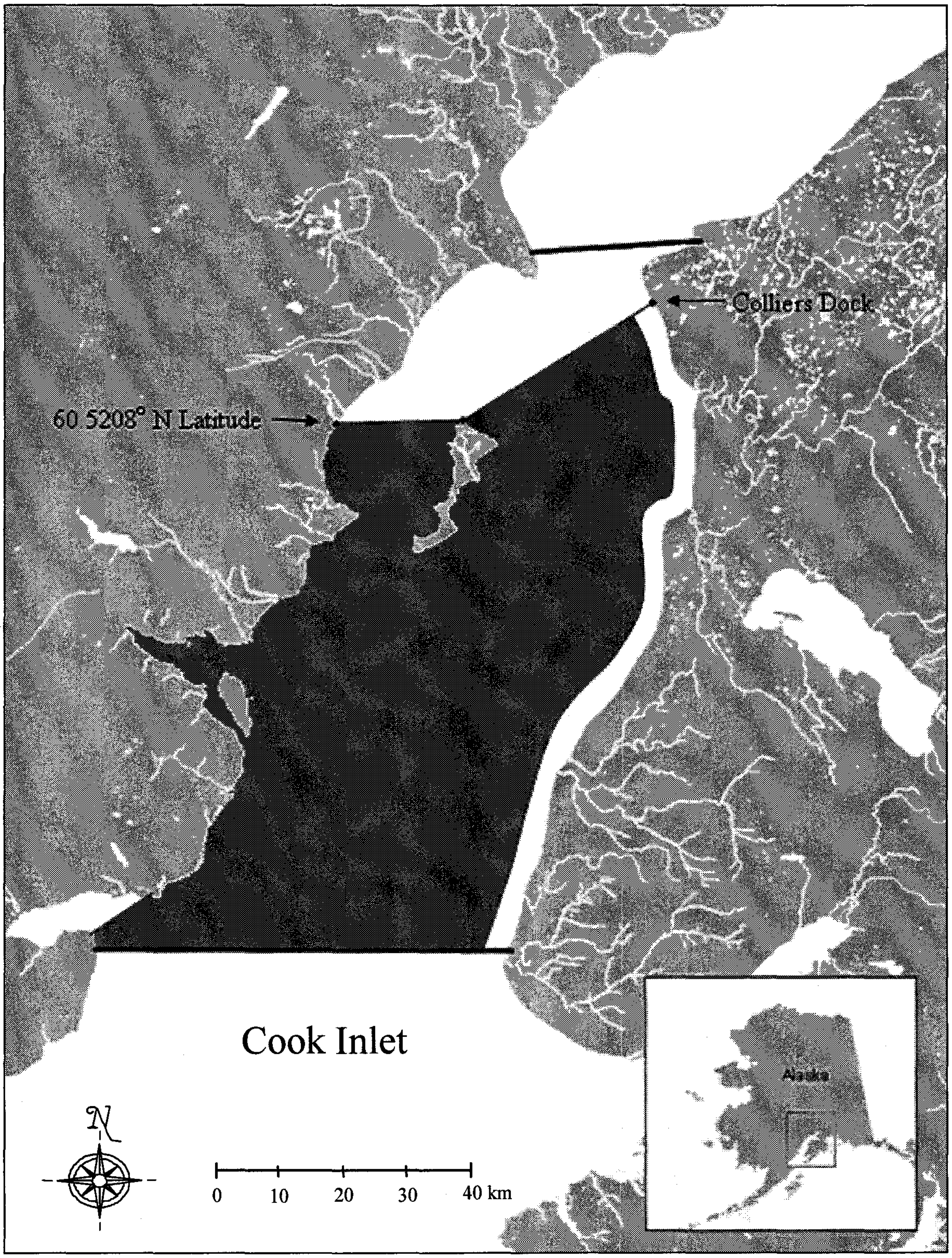

Figure 6.–Map of Central Cook Inlet showing management fishing boundaries for the area south of a line from Collier's Dock to Northwest Point on Kalgin Island to 60.5208° N on the western shore and north of the southern limit of the Central District.

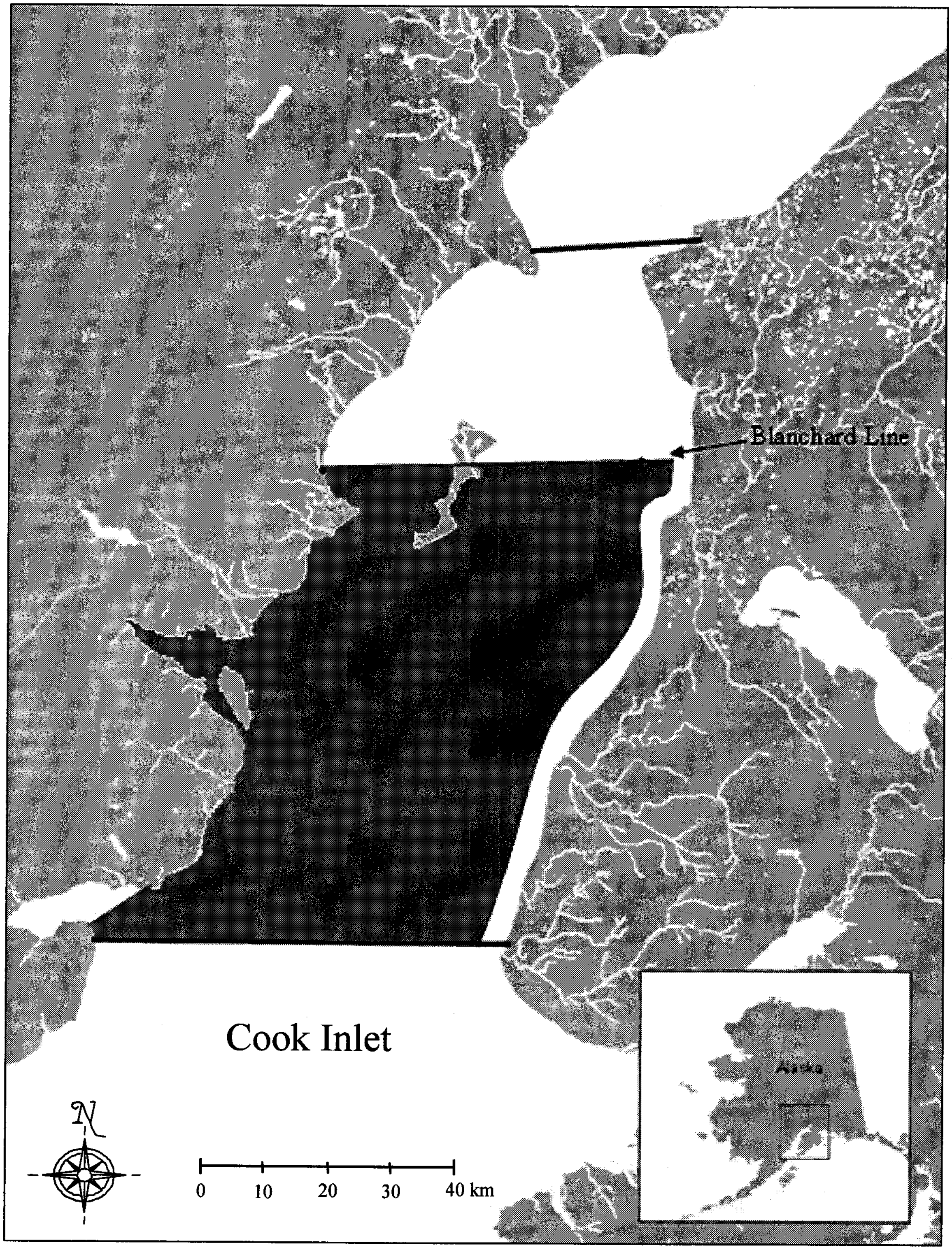

Figure 7.–Map of Central Cook Inlet showing management fishing boundaries for the area south of the Blanchard Line and north of the southern limit of the Central District.

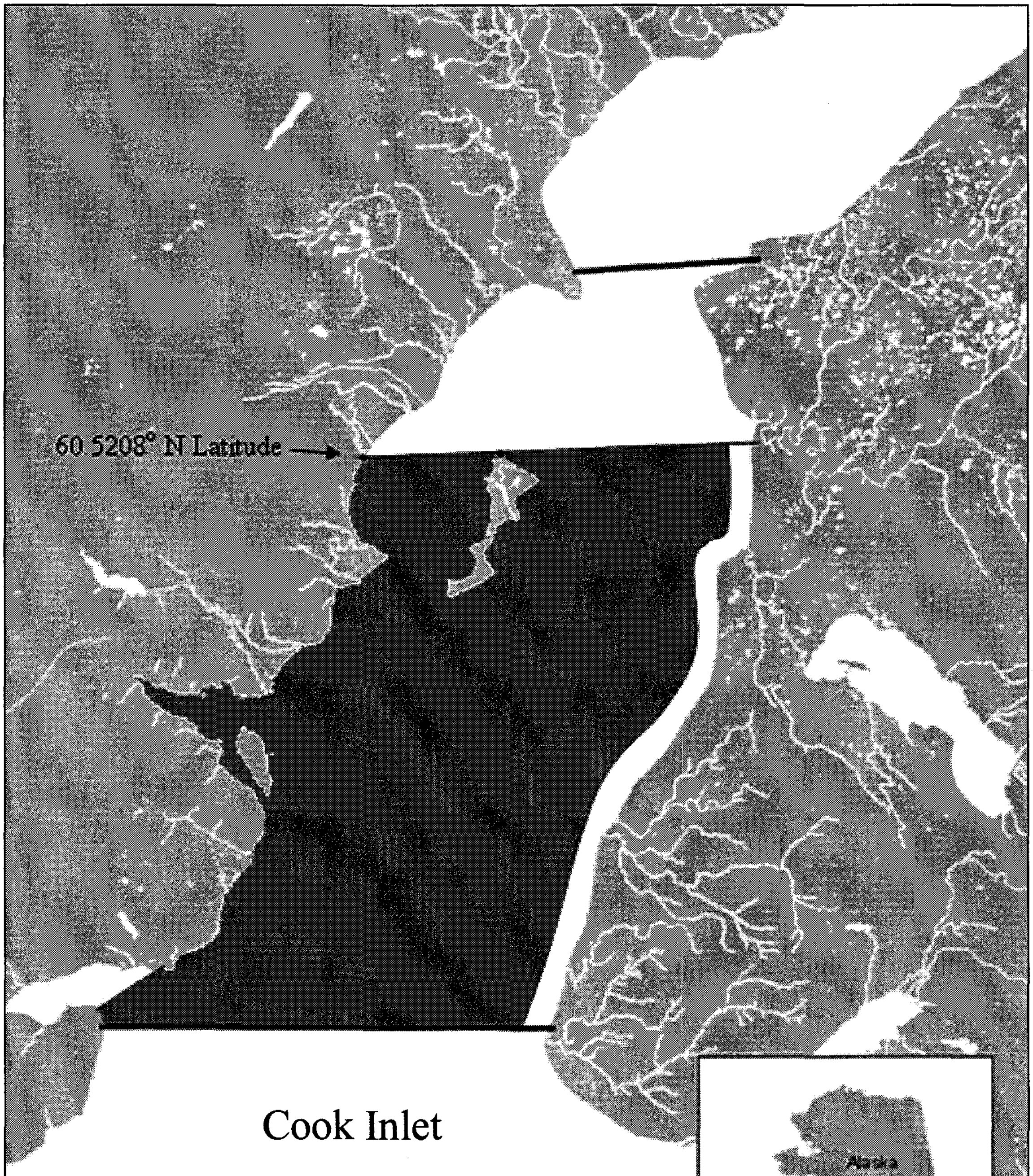

Figure 8.–Map of Central Cook Inlet showing management fishing boundaries for the area south of the longitudinal line that intersects with the north end of Kalgin Island and north of the southern limit of the Central District.

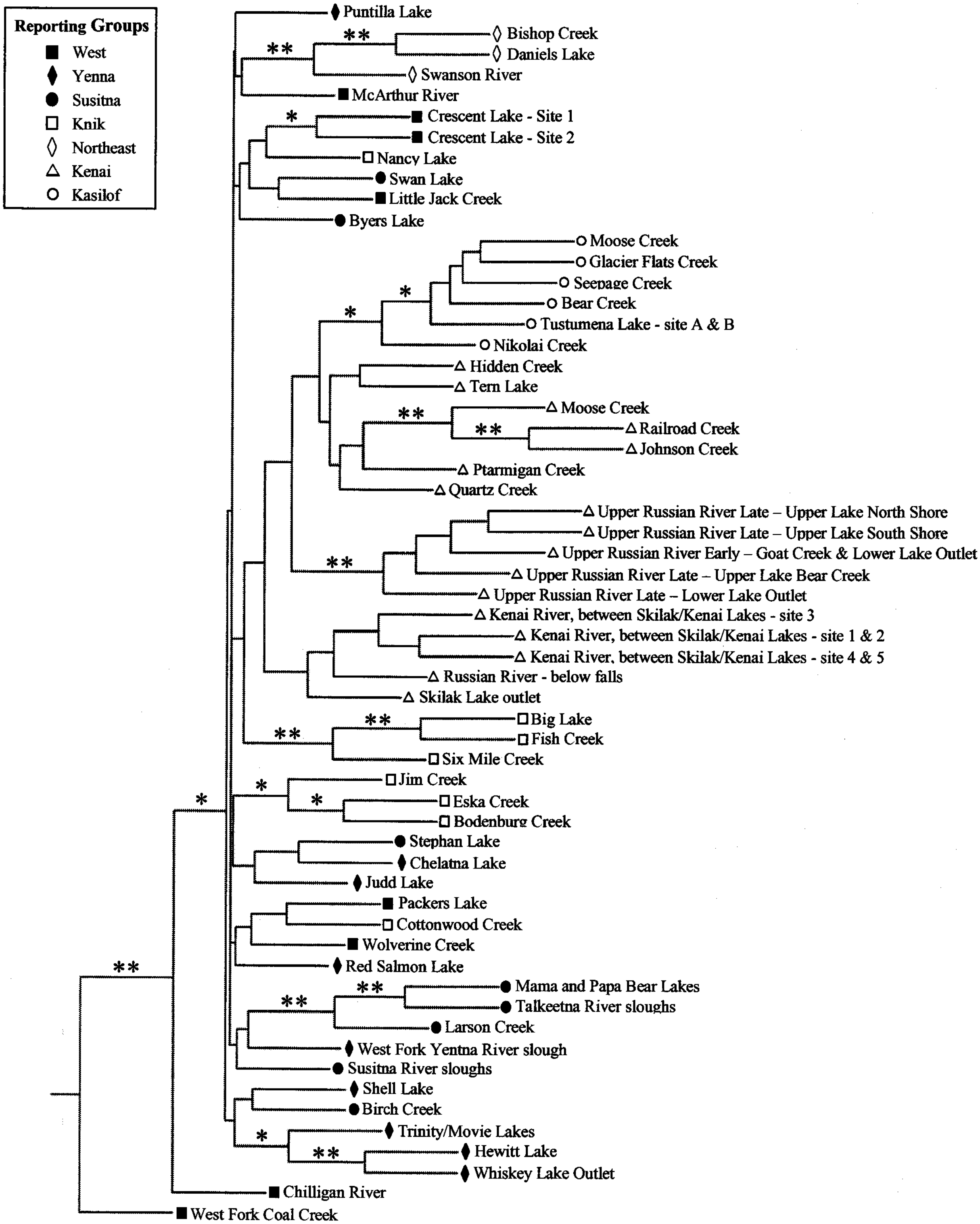

Figure 9.-Consensus N-J tree based on the Nei (1978) genetic distances between sockeye salmon populations sampled from spawning areas in drainages of Cook Inlet, Alaska (see Table 1 for collection details).

*Note:***= 70% consensus nodes: *=50-70% consensus nodes. Reporting group symbols for each collection are included (see text and Figure 2).

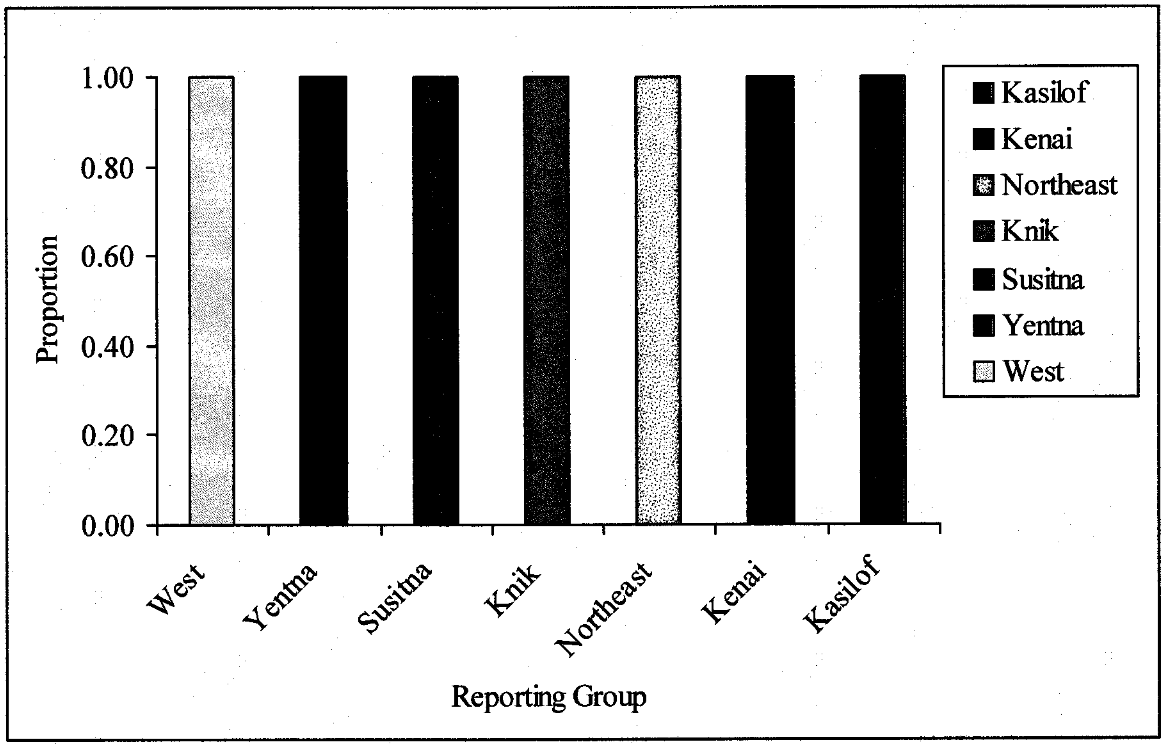

Figure 10.–Stock composition estimates from mixtures of 200 fish from each reporting group.

Note: New baselines were created to determine stock composition estimates for each reporting group, and these baselines excluded the 200 fish used in the mixtures.

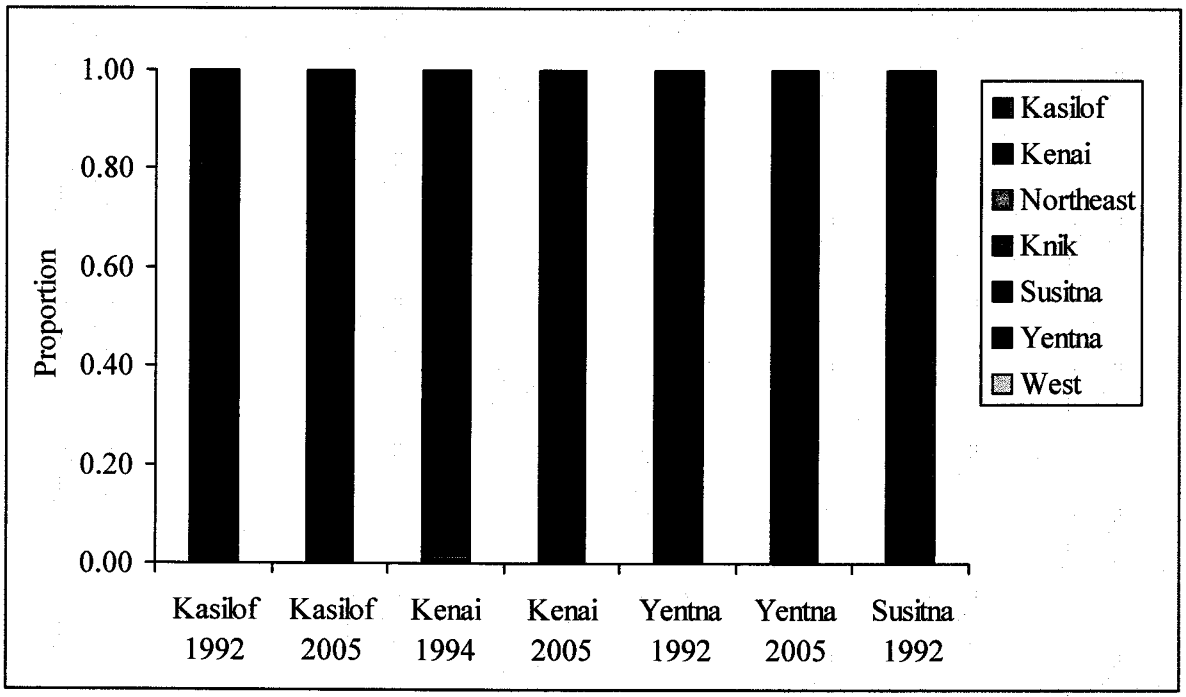

Figure 11.–Stock composition estimates from mixtures captured in fish wheels within four drainages of Cook Inlet in 1992, 1994, and 2005.

Note: BAYES with a SPAM prior was used to estimate the proportions.

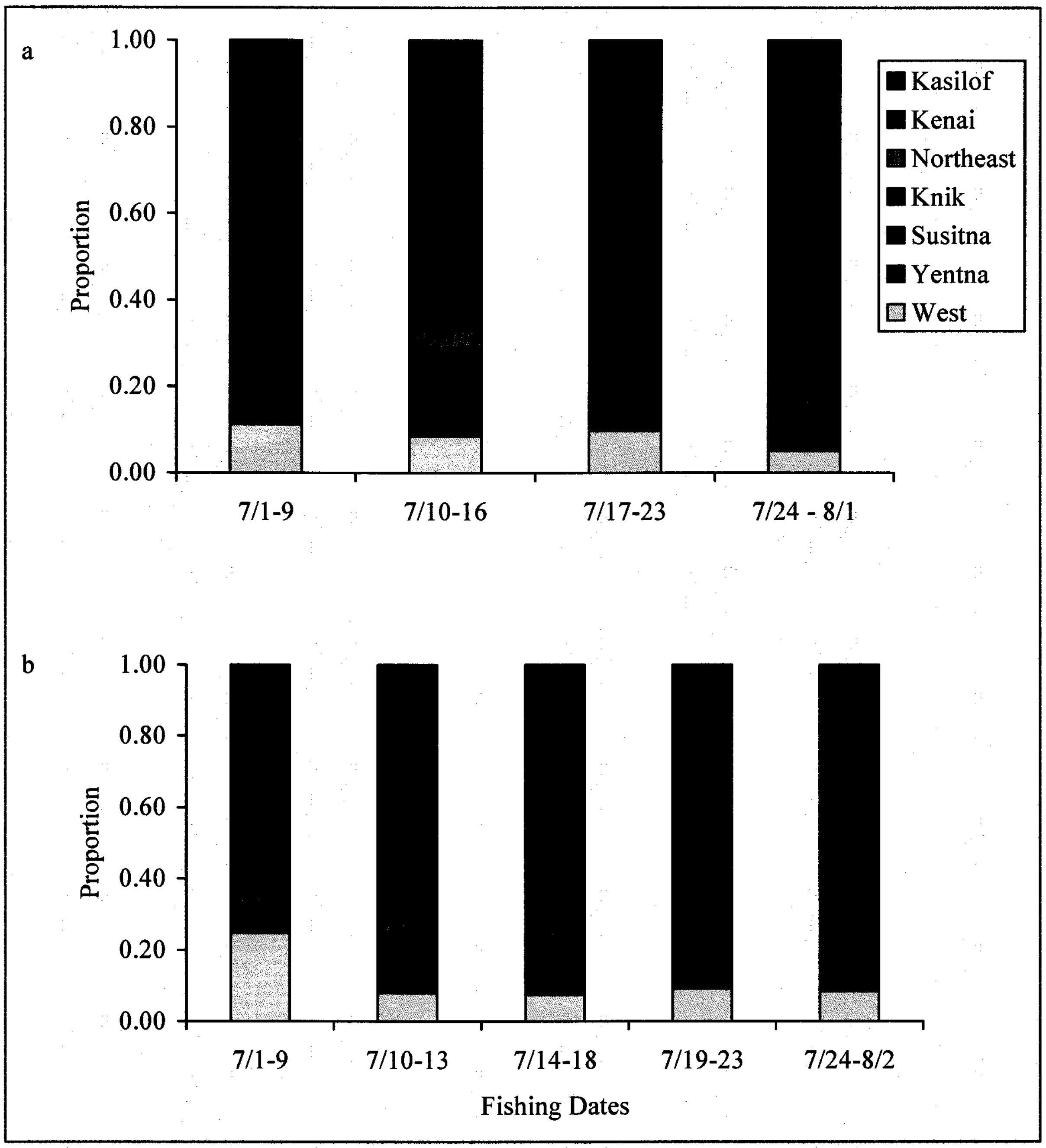

Figure 12.–Stock composition estimates for the Cook Inlet offshore test fishery taken in a) 2006, and b) 2007.
2007 REVISED - SEE ADDENDUM

Note: BAYES with a SPAM prior was used to estimate the proportions.

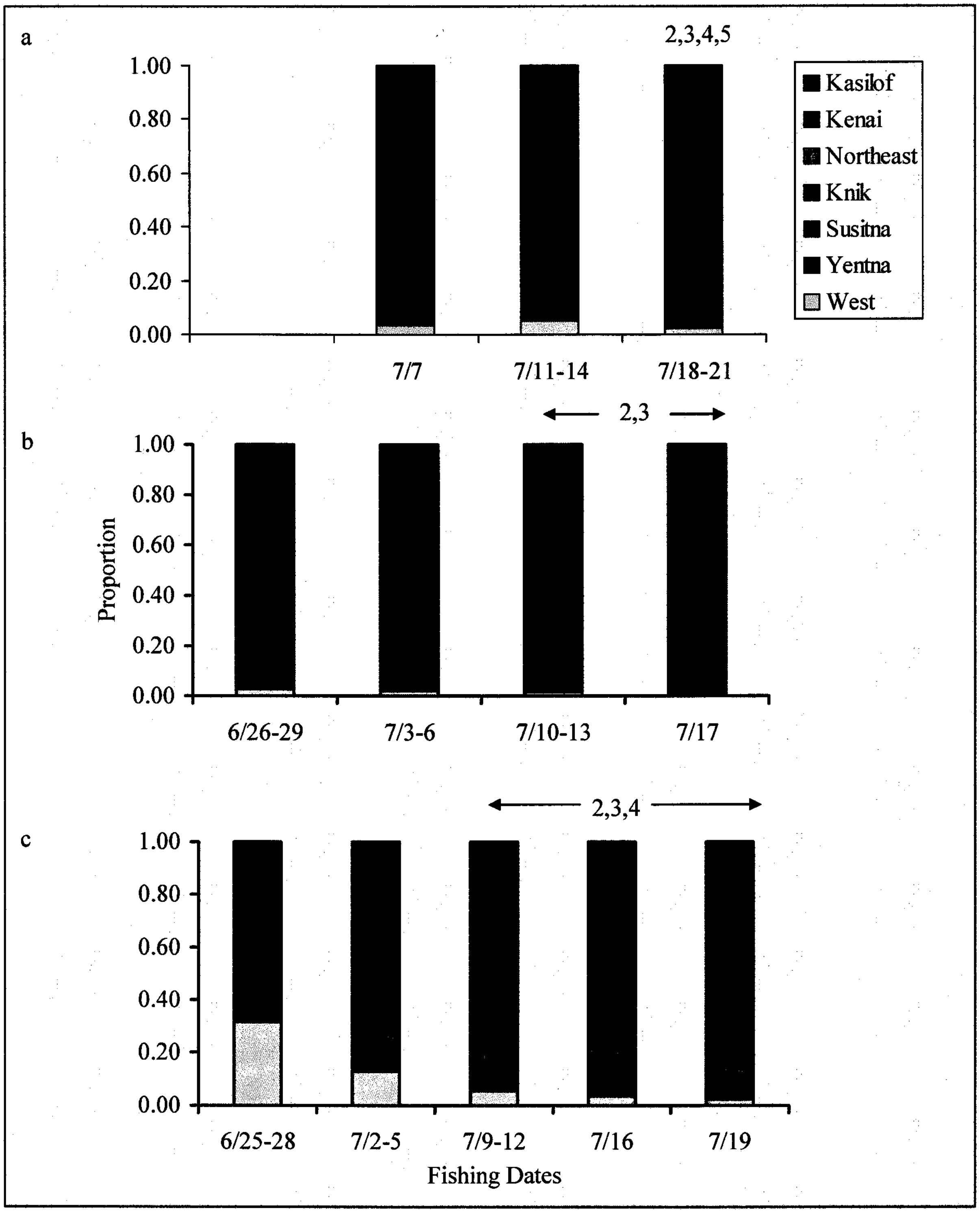

Figure 13.–Stock composition estimates for the Central District drift gillnet fishery from a) 2005, b) 2006, and c) 2007. 2007 REVISED - SEE ADDENDUM

Note: Numbers above the bars indicate fisheries were restricted to particular areas: 2-Kasilof Corridor; 3-Kenai Corridor; 4-Area 1; 5-Area 2 (see Figures 1 and 4–8 and Table 2). BAYES with a SPAM prior was used to estimate the proportions.

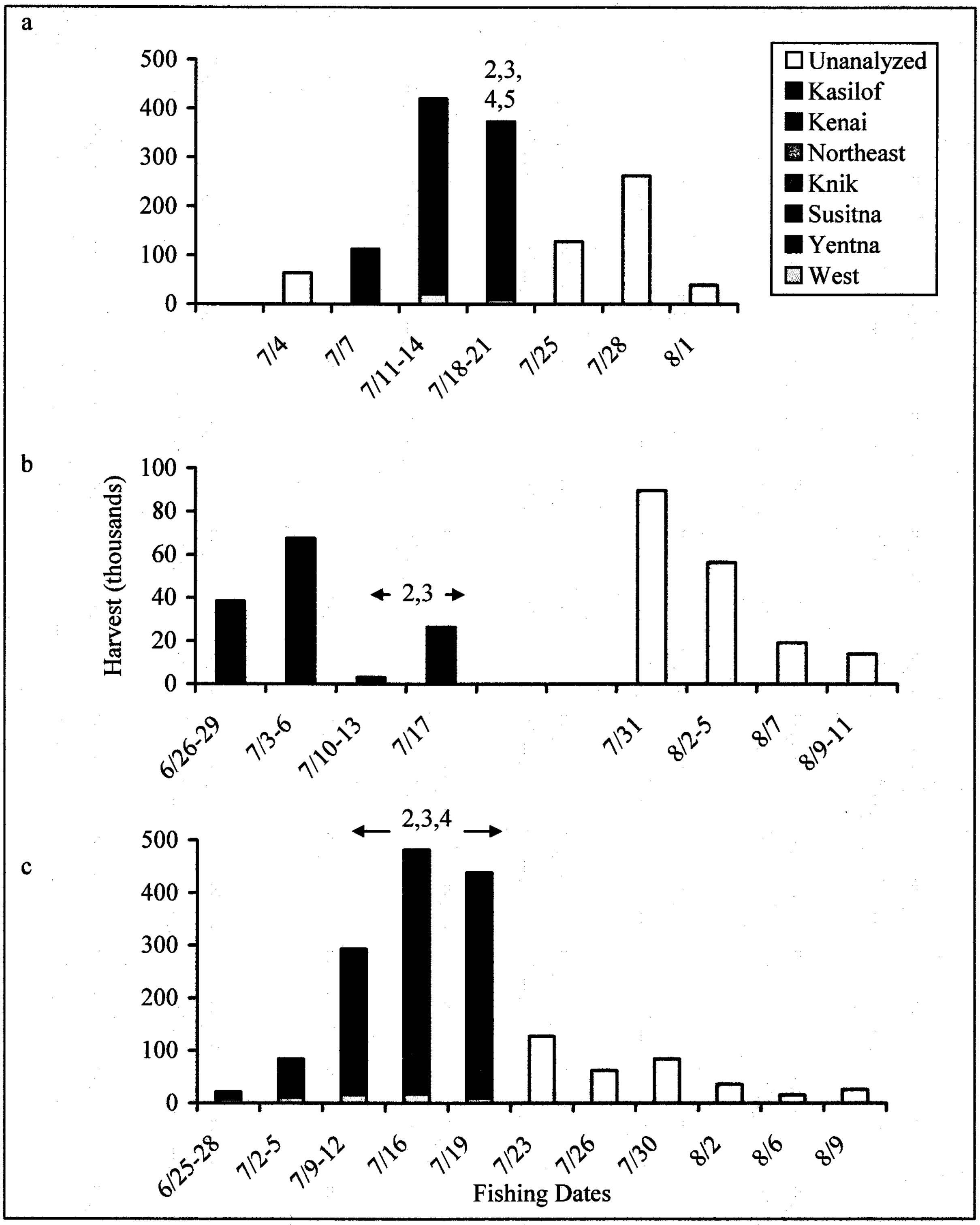

Figure 14.–Harvest by stock estimates for the Central District drift gillnet fishery from a) 2005, b) 2006, and c) 2007. 2007 REVISED - SEE ADDENDUM

Note: Numbers above the bars indicate fisheries were restricted to particular areas: 2-Kasilof Corridor; 3-Kenai Corridor; 4-Area 1; 5-Area 2 (see Figures 1 and 4–8 and Table 2). BAYES with a SPAM prior was used to estimate the proportions.

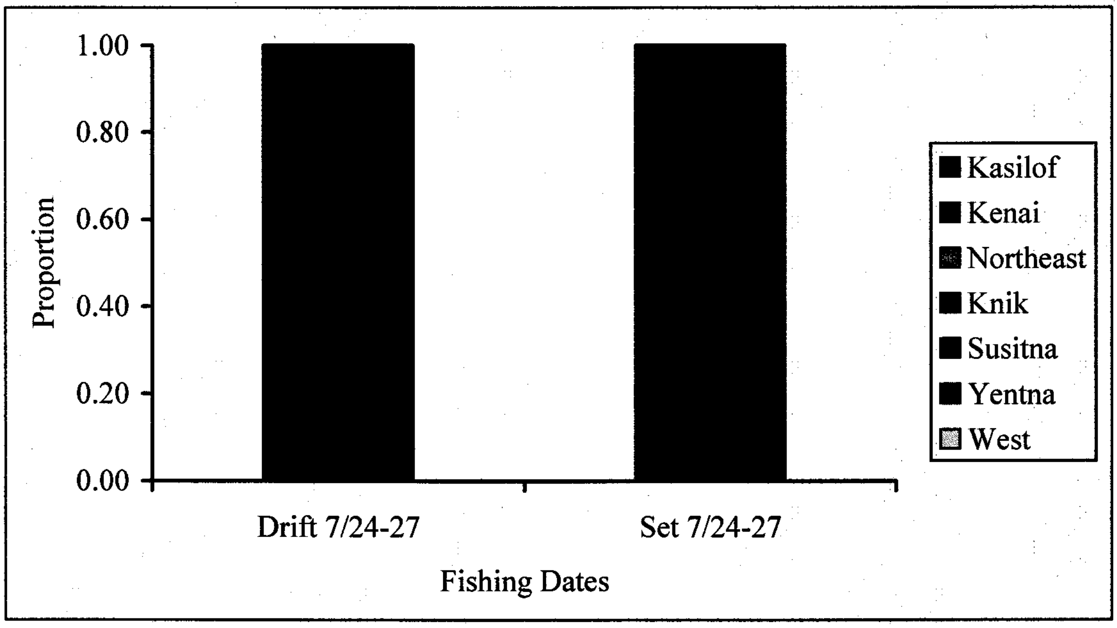

Figure 15.–Stock composition estimates for the Kasilof Terminal Area drift and set gillnet fisheries (Central District, East Side Subdistrict) in 2006.

Note: BAYES with a SPAM prior was used to estimate the proportions.

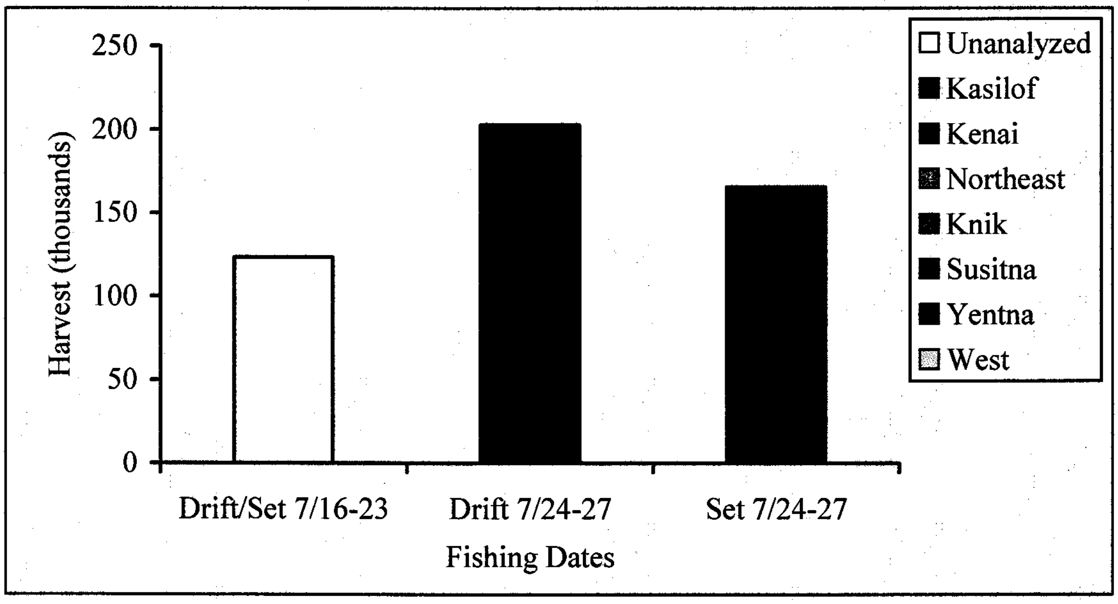

Figure 16.–Harvest by stock estimates for the Kasilof Terminal Area drift and set gillnet fisheries (Central District, East Side Subdistrict) in 2006.

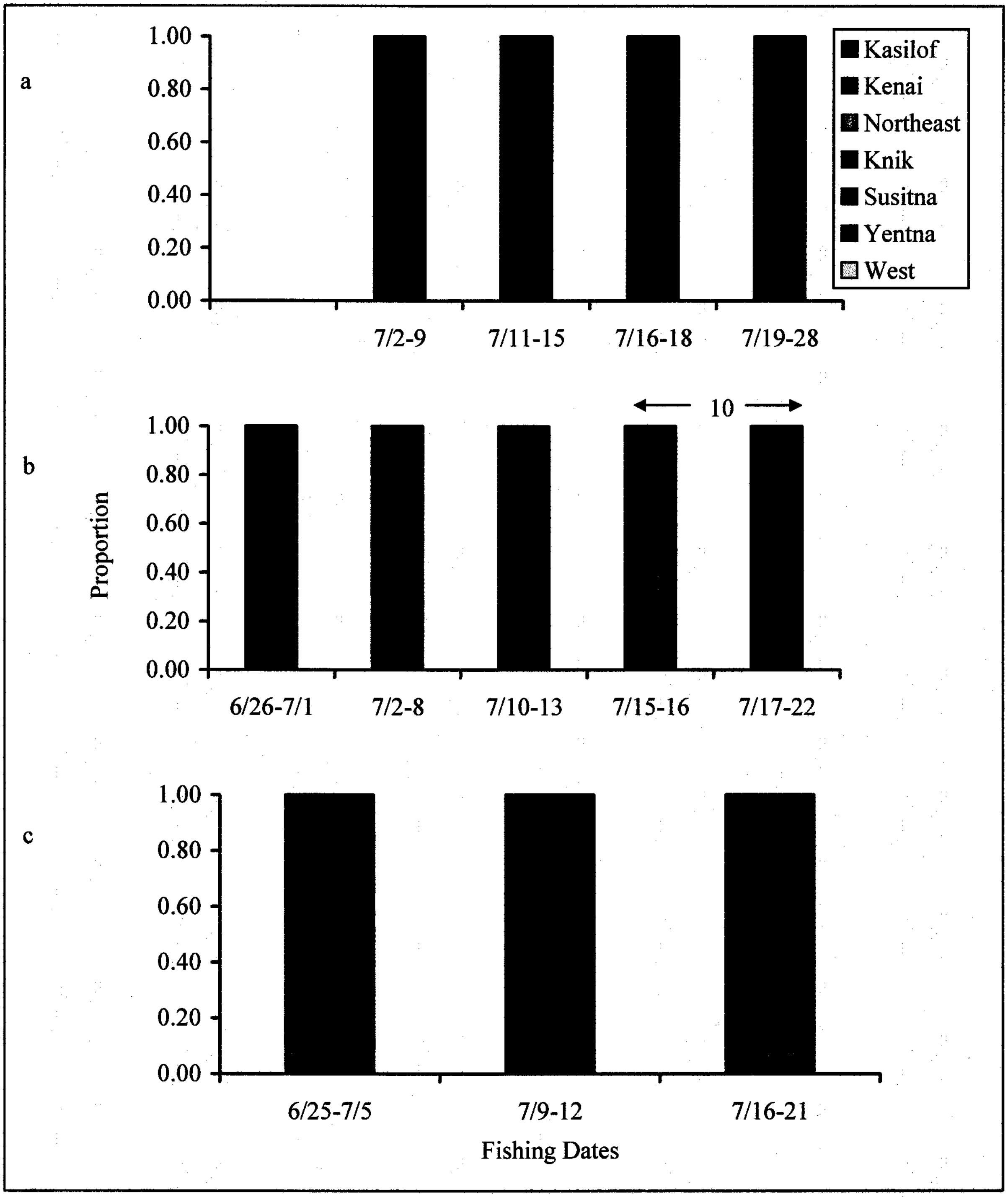

Figure 17.–Stock composition estimates for the Kasilof Section set gillnet fishery (Central District, East Side Subdistrict) from a) 2005, b) 2006, and c) 2007. 2007 REVISED - SEE ADDENDUM

Note: Numbers above the bars indicate fishery restrictions during openings (10- Restricted to within 1/2 mile of shore: see Table 2). BAYES with a SPAM prior was used to estimate the proportions.

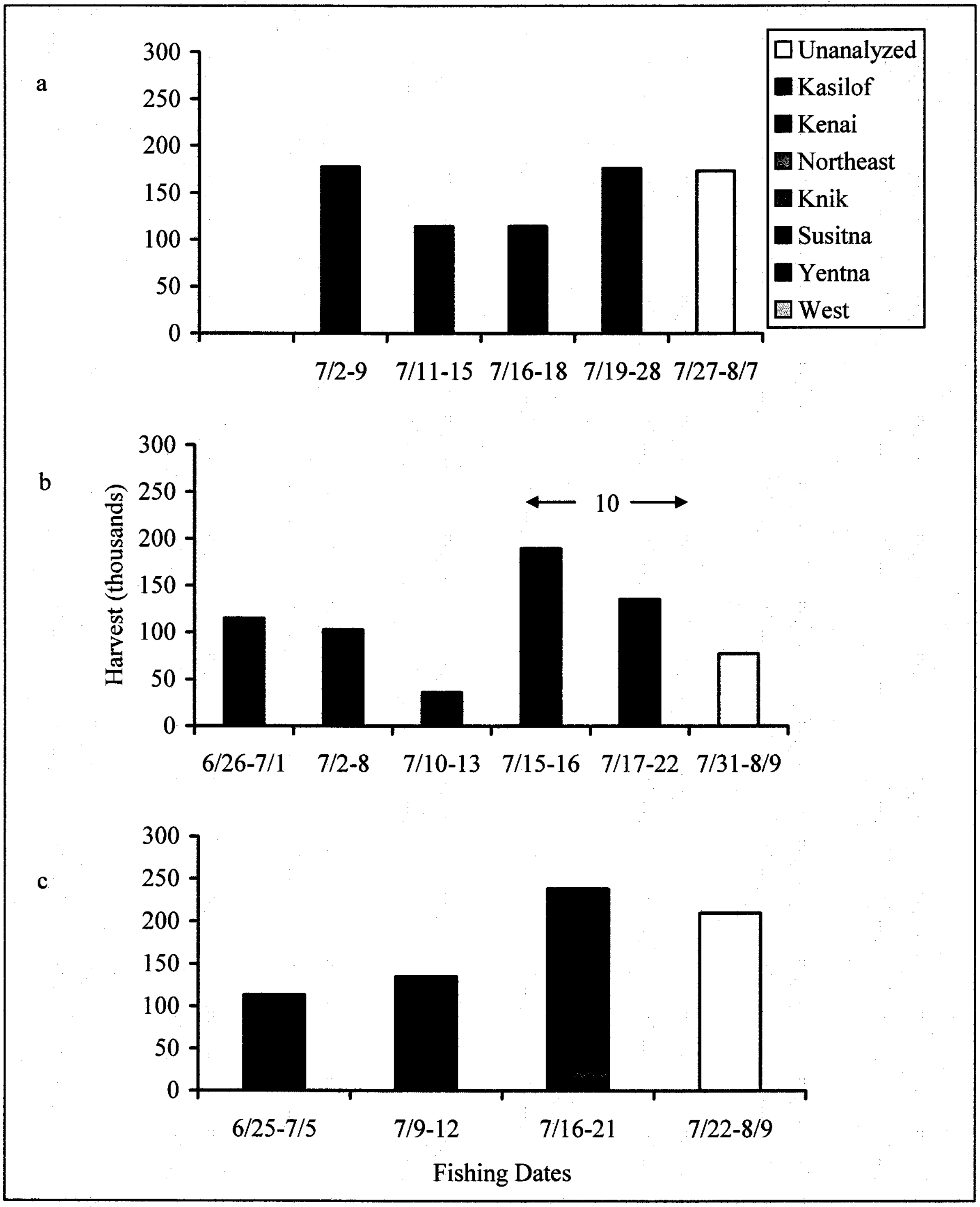

Figure 18.–Harvest by stock estimates for the Kasilof Section set gillnet fishery (Central District, East Side Subdistrict) from a) 2005, b) 2006, and c) 2007. 7/19-28, 2005 and 2007 REVISED - SEE ADDENDUM

Note: Numbers above the bars indicate fishery restrictions during openings (10- Restricted to within 1/2 mile of shore: see Table 2). Fishing dates between subsections sometimes overlapped (see Table 2).

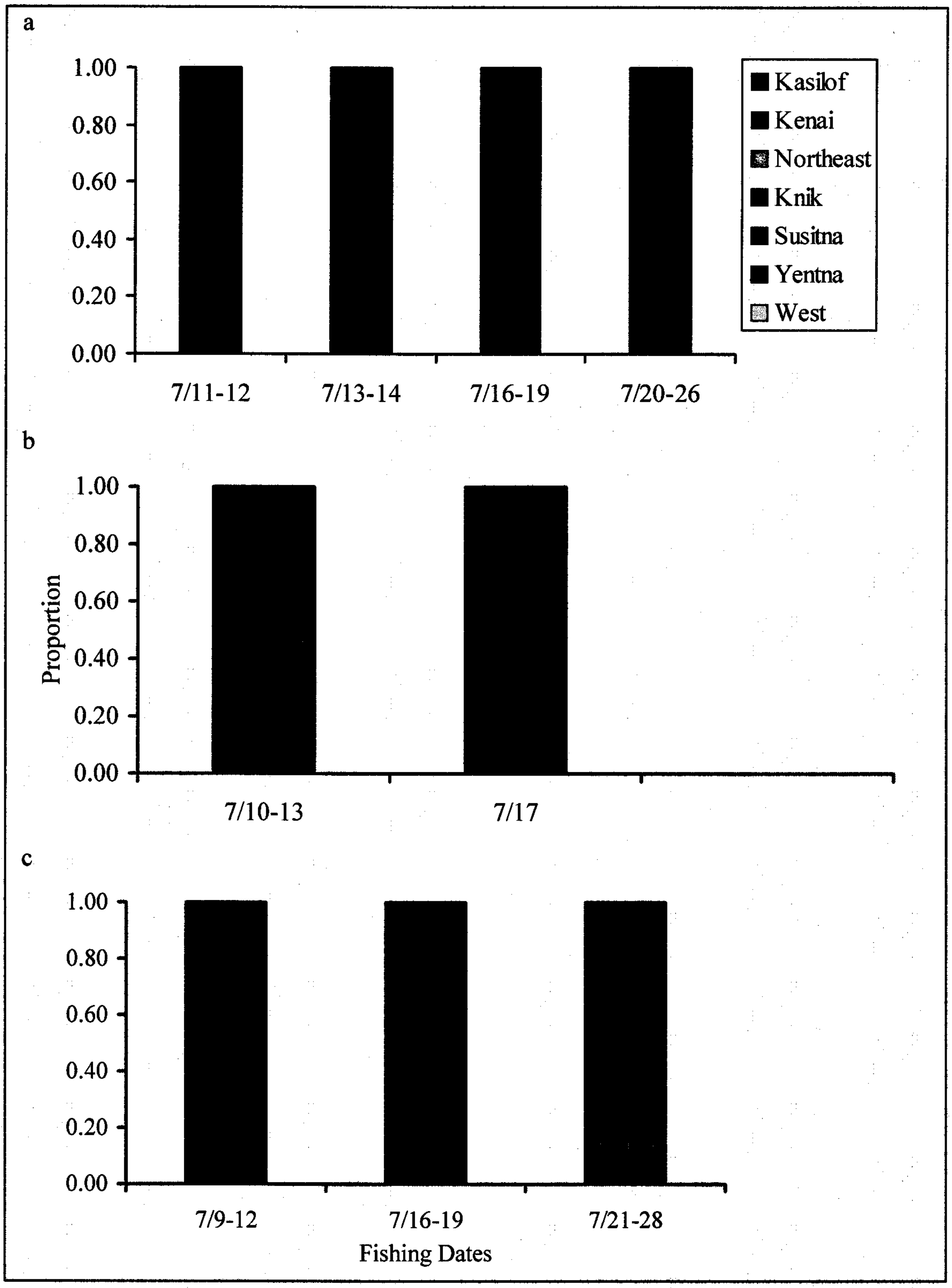

Figure 19.–Stock composition estimates for the Kenai Section set gillnet fishery (Central District, East Side Subdistrict) from a) 2005, b) 2006, and c) 2007.

2007 REVISED - SEE ADDENDUM

Note: BAYES with a SPAM prior was used to estimate the proportions.

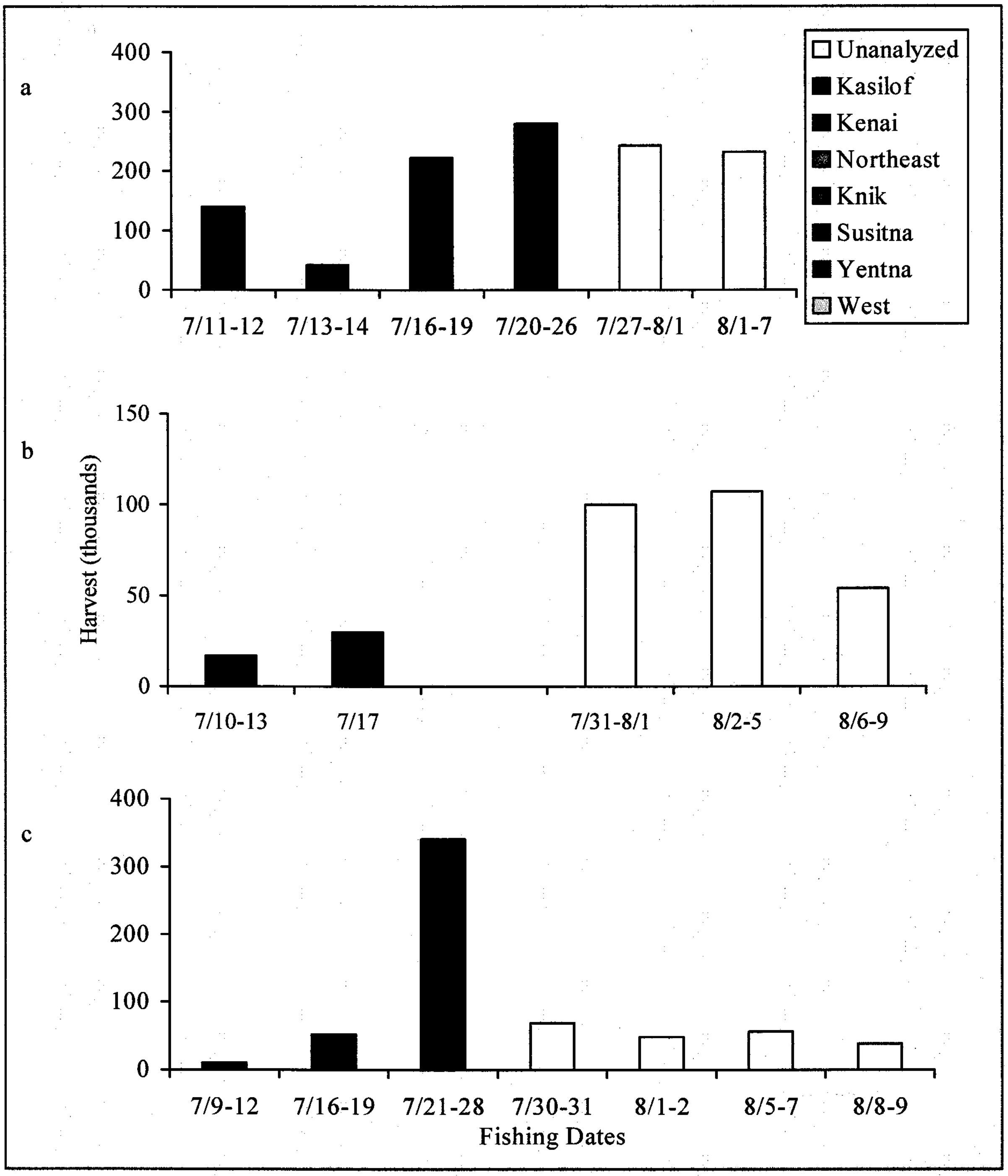

Figure 20.–Harvest by stock estimates for the Kenai Section set gillnet fishery (Central District, East Side Subdistrict) from a) 2005, b) 2006, and c) 2007. 2007 REVISED - SEE ADDENDUM

Note: The 2006 graph has different scale from 2005 and 2007. Fishing dates between subsections sometimes overlapped (see Table 2).

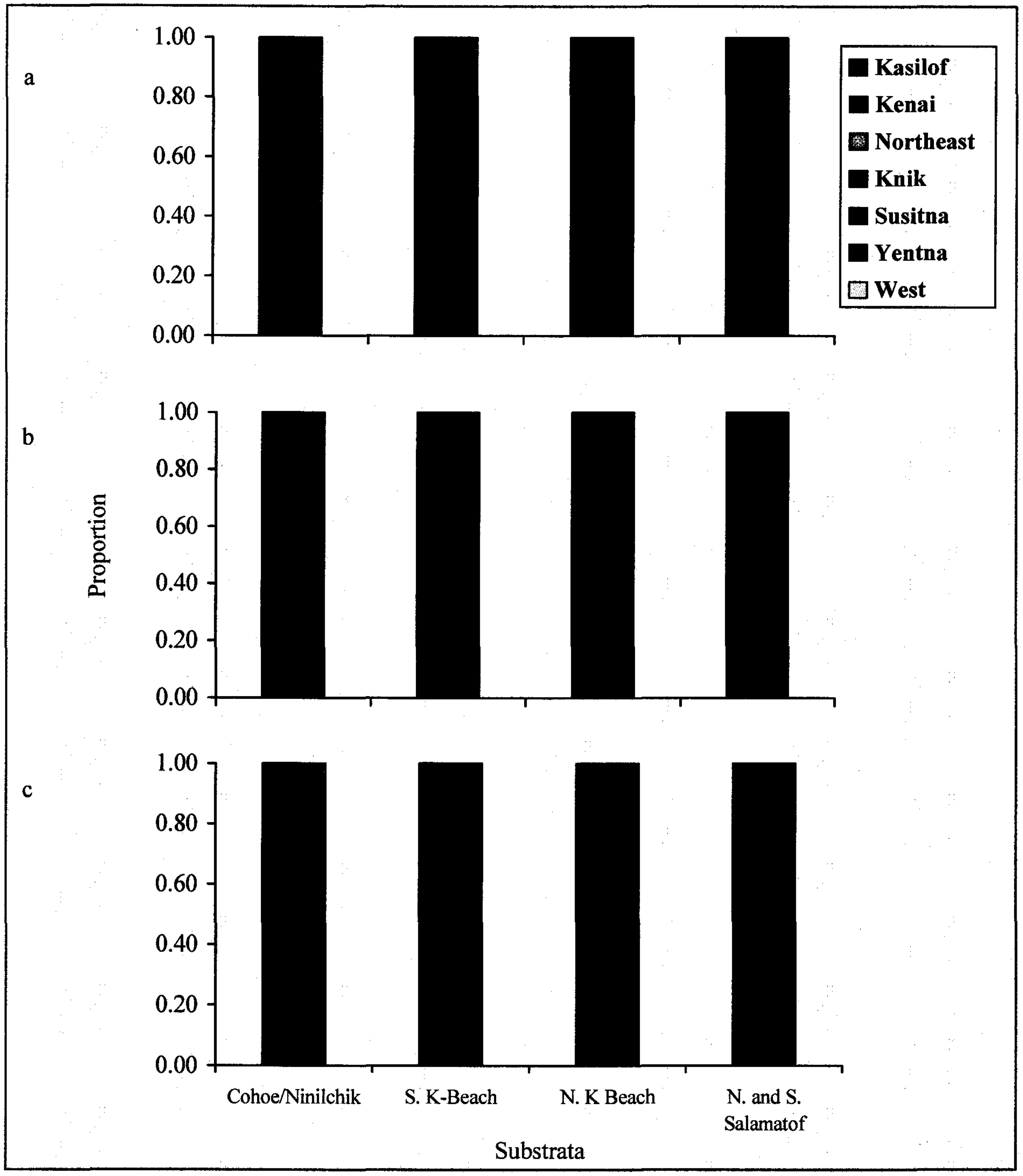

Figure 21.–Stock composition estimates for the Kasilof and Kenai Section set gillnet fisheries (Central District, East Side Subdistrict) divided into substrata from a) 2005, b) 2006, and c) 2007.

Note: There are two substrata for each section and they are displayed from south to north. BAYES with a SPAM prior was used to estimate the proportions. 2007 REVISED - SEE ADDENDUM

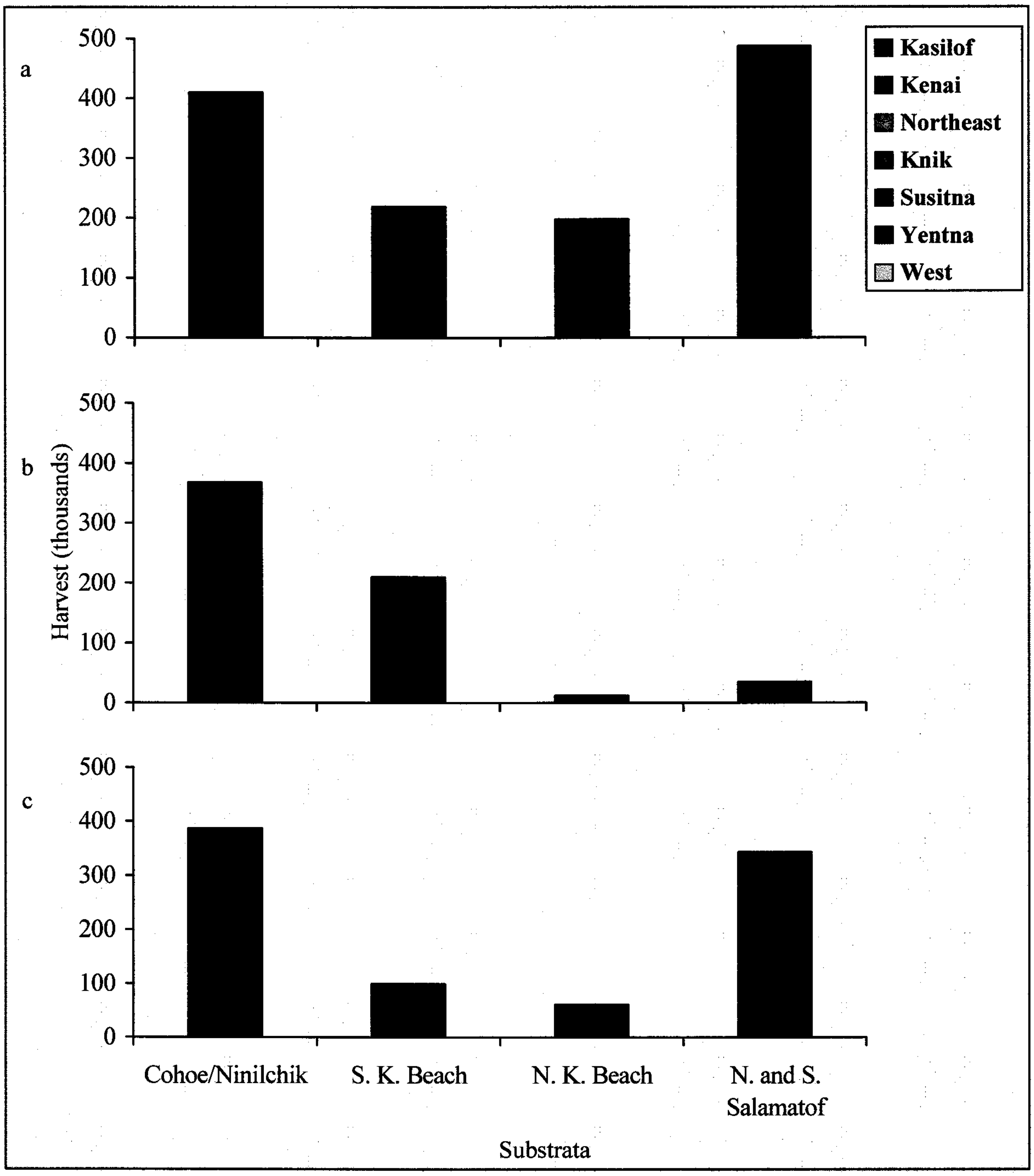

Figure 22.–Harvest by stock estimates for the Kasilof and Kenai Section set gillnet fisheries (Central District, East Side Subdistrict) divided into substrata from a) 2005, b) 2006, and c) 2007.

Note: There are two substrata for each section and they are displayed from south to north.

2007 REVISED - SEE ADDENDUM

ADDENDUM TO
FISHERY MANUSCRIPT NO. 07-07
(JANUARY 25, 2008)

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

DIVISION OF COMMERCIAL FISHERIES

SARAH PALIN, GOVERNOR

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RE: Addendum to Fishery Manuscript No. 07-07

Dear readers of ADF&G Fishery Manuscript No. 07-07 titled "Post-season Stock Composition Analysis of Upper Cook Inlet Sockeye Salmon Harvest, 2005-2007",

This addendum contains changes due to two errors and one clarification. First are changes to the stock composition estimates and associated stock-specific estimates of sockeye salmon captured in the 2007 test and commercial fisheries from Upper Cook Inlet, Alaska. These changes resulted from the addition of data inadvertently excluded from the analysis published in Fishery Manuscript No. 07-07. The second error was due to the miscalculation of the total harvest for a single time period in 2005 of the Kasilof Section set gillnet fishery. This addendum contains a description of how the errors were detected, the nature of the errors, the magnitude of the changes which resulted, and a discussion of the effect these changes have on the conclusions of this publication. In addition, this addendum clarifies how to interpret the results from the subsection analyses of the Kenai and Kasilof Section set gillnet fisheries; these analysis were not weighted by the catch and should only be used to examine differences in stock composition between substrata and not to provide estimates of the catch by subdistricts.

Please use the attached document in conjunction with Fishery Manuscript No. 07-07 for complete information on the 2007 stock composition analyses.

Sincerely,

Christopher Habicht
Project Geneticist
Alaska Department of Fish and Game
Division of Commercial Fisheries
Gene Conservation Laboratory
(907) 267-2169

PREFACE

In reviewing data analyses from Southeast Alaska, the Gene Conservation Laboratory staff discovered that some of the available genetic data were excluded from the analysis. Upon this discovery, the data used in the Upper Cook Inlet analysis of sockeye salmon harvests were checked for the same omitted data. The original analysis was published in Fishery Manuscript No. 07-07 which was prepared for the Alaska Board of Fisheries and was released on December 3, 2007. The same types of data were only omitted from the 2007 mixture samples in these analyses; the baseline data and the 2005 and 2006 harvest data contained the full set of data. This will be referred to as the "first error".

The second error was detected when comparing harvest numbers between Tables 2 and 11 of the original manuscript and noticing a discrepancy in the total number of harvested fish from the Kasilof Section set gillnet fishery in 2005 between the two tables.

The need for clarification on the interpretation of results presented in Table 13 came from staff who noticed differences in the stock-specific harvest numbers between those in Table 13 and those in Tables 11 and 12.

This addendum contains a description of the nature of the error, the magnitude of the changes which resulted, and a discussion of the effect these changes have on the conclusions of this publication. This document should be used in conjunction with the Fishery Manuscript No. 07-07 to provide complete information on the stock composition analyses.

INTRODUCTION

FIRST ERROR

The data analysis methods for mixture analyses were described in Fishery Manuscript No. 07-07. All mixture analyses followed these methods except for those mixtures composed of samples collected in 2007, where data omission occurred. The 2007 mixture samples were analyzed using new equipment, as described in the manuscript, and the data omission occurred when this equipment reversed the order of alleles for one marker (*One_MHC2-190*), which is combined with a linked marker (*One_MHC2-251*) to produce composite haplotypes. While the alleles for both loci were correctly scored, during the data analysis, the statistical program eliminated composite haplotypes for all heterozygotes at *One_MHC2-190,* because the new allele order did not exist in the baseline. No incorrect data were used to calculate the original stock composition estimates from the mixtures, but some data were excluded that should have been included. This omission of data only includes the samples from the mixtures collected in 2007. All data in the baseline were complete as were all the data used for analyses from the fish wheel samples and the 2005 and 2006 mixtures from the test and commercial fisheries.

SECOND ERROR

The second error resulted from the exclusion of the harvest taken in the Kasilof Section Set gillnet fishery on July 25, 2005 (Table 2) from the calculations of extrapolated harvest (Table 11; Figure 18a).

CLARIFICATION

A statement clarifying how to interpret results presented in Table 13 as compared to apparently similar data presented in Tables 11 and 12 was added to this addendum after receiving questions about how these data should be used.

METHODS

FIRST ERROR

To correct the first error, all data from the 2007 mixtures were reanalyzed according to the methods outlined in Fishery Manuscript 07-07. Results from these revised analyses were tabulated and graphed and are presented in this addendum. Following this reanalysis, the conclusions of the manuscript were examined to determine if they still reflected the revised results.

SECOND ERROR

To correct the second error, calculations of extrapolated harvest were recalculated using the methods described in the manuscript and Table 11 and Figure 18a were revised with corrected numbers. Following this reanalysis, the conclusions of the manuscript were examined to determine if they still reflected the revised results.

CLARIFICATION

The following text should be included in the Results as the first paragraph in the section titled "Set Gillnet":

> Tables 9, 11, and 12 and corresponding Figures 13–20 were based on sampling fish in proportion to catch within periods. As such, these estimates are the best

estimates of stock-specific catches in the selected periods of the Central District drift, Kasilof Section set, and Kenai Section set gillnet fisheries. The analyses presented in Table 13 were designed to examine differences in the stock composition of catches in the substrata within the Kasilof and Kenai Sections and were not weighed by harvest. Because these estimates are not weighted by harvest, low-harvest periods are treated as equal with periods in which the harvest was many times larger. Table 13 does provide insights on spatial patterns of stock-specific harvest within the Kenai and Kasilof Section set gillnet fishery.

RESULTS

FIRST ERROR

Please refer to the revised tables and graphs presented in this addendum for complete results from the reanalysis of the 2007 mixtures. Most (82%) of the stock-specific estimates from mixtures of fish sampled in 2007 changed 1% or less. A few of the estimates changed by 2% and 3% (9% and 6% of the estimates, respectively). All these revised estimates were within the previously reported 90% confidence intervals.

In two mixtures, estimates changed by more than 3%. The first mixture is the first Upper Cook Inlet offshore test fishery (July 1–9, 2007), where the estimate for West Cook Inlet decreased from 25% to 17%, while the estimate for Yentna increased from 6% to 12%. The test fishery does not represent any commercial harvest. The second mixture is the first sample from the Central District drift net fishery (June 25–28, 2007) where the estimate for West Cook Inlet decreased from 31% to 23% (6,734 to 4,874 fish), while the estimate for Yentna increased from 1% to 11% (199 to 2,265 fish). This mixture represented the sampled drift gillnet period with the smallest harvest in 2007.

SECOND ERROR

The correction of the second error resulted in the addition of 47,054 fish to the extrapolated harvest during the July 19–28, 2005 period of the Kasilof Section set gillnet fishery. The stock composition estimate proportions did not change. Over 99% of this mixture was Kenai River or Kasilof River stocks, so most of these fish (46,979) allocated to these reporting groups. The Yentna reporting group received an additional 75 fish.

CLARIFICATION

The clarification is added to the Results section, but does not change the interpretations provided in the Results or the Discussion sections.

CONCLUSIONS

FIRST ERROR

When taken in totality, the reanalysis for the first error shows small proportional changes among the reporting groups in the numbers of fish represented by changes in the stock composition estimates (see table below). The largest change was a 1.0% increase to the Yentna, followed by a 0.7% decrease to the Kenai, and a 0.4% increase to the West reporting group.

Tabled below are the numbers of sockeye salmon captured in the selected Central District drift gillnet and Kasilof Section and Kenai Section set gillnet fisheries in 2007 that were reported in Tables 9, 11, and 12 in Fishery Manuscript No. 07-07. These are estimated from the total estimated catch per sampled fishery and the stock composition estimates based on genetic data as published in the original report to the Alaska Board of Fisheries (Fishery Manuscript No. 07-07) and as revised with complete genetic data.

Reported in Fishery Manuscript No. 07-07

Fishery	West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
Central District drift gillnet	61,728	141,160	18,633	35,885	674	829,657	231,609
Kasilof Section set gillnet	1,346	18,056	4,106	13,321	572	218,584	230,443
Kenai Section set gillnet	165	41,847	722	14,394	0	293,972	52,151
Total	63,239	201,063	23,461	63,600	1,246	1,342,213	514,203
Percent of catch	2.9	9.1	1.1	2.9	0.1	60.8	23.3

Revised analysis

	West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
Central District drift gillnet	52,984	156,023	19,804	35,572	704	811,633	242,690
Kasilof Section set gillnet	1,292	22,214	4,144	12,937	476	215,382	230,040
Kenai Section set gillnet	126	44,973	668	13,645	0	300,492	43,350
Total	54,402	223,210	24,616	62,154	1,180	1,327,507	516,080
Percent of catch	2.5	10.1	1.1	2.8	0.1	60.1	23.4
Change in percent	-0.4	1.0	0.1	-0.1	0.0	-0.7	0.1
Change in estimated harvest	-8,837	22,147	1,155	-1,446	-66	-14,706	1,877

None of the general patterns in stock compositions discussed in the Results or Discussion sections of Fishery Manuscript No. 07-07 are affected by these changes. The following is a list of changes required to make the prose in the manuscript match the revised results:

- Page 15, Offshore Test Fishery section, line 7: The percent of West Cook Inlet populations in the early period of 2007 should be 17% (not 25%).
- Page 16, Drift Gillnet section, first paragraph, lines 7 and 8: The estimated percent of Yentna River sockeye salmon varied from 2–15% (not 2–13%) and the peak occurred during the first period in July for all years (not just 2005 and 2006).

- Page 16, Drift Gillnet section, first paragraph, lines 10 and 11: The percentage of West Cook Inlet sockeye salmon in the harvest in 2007 accounted for 23% (not 31%), before falling back to 6% (not 5%) two periods later on July 9–12 (not July 7–9).
- Page 16, Set Gillnet section, second paragraph, line 5: The percent of Yentna River sockeye salmon in the Kenai Section during the July 21–28, 2007 period is 13% (not 12%) and the percent in the Kasilof Section on June 25–July 5, 2007 is 7% (not 6%).
- Page 20, Patterns in Fishery Stock Composition, fifth paragraph, line 5: The estimated peak harvests of Susitna/Yentna sockeye salmon in drift gillnet harvests occurred on July 2–5, 2007 (not July 16, 2007).
- Page 20, Patterns in Fishery Stock Composition, fifth paragraph, line 17: The estimated total harvests of Susitna\Yentna sockeye salmon is 175,827 (not 159,793) in 2007.

SECOND ERROR

Rectification of the second error does not change any of the text in the Results or Discussion sections. No patterns are affected by this change because the proportions of the stock composition estimates remain the same.

CLARIFICATION

The addition of the paragraph to the Discussion section should provide the primary explanation for why the sum of the stock-specific harvest numbers from Tables 11 and 12 do not match the sum of stock-specific harvest numbers from Table 13. This clarification should also provide the reader with guidance on what numbers to use in estimating stock-specific harvest in the Kenai and Kasilof Section set gillnet fishery (use Tables 11 and 12, not 13), and how to interpret Table 13.

Table 8.–Revised stock composition estimate and the number of fish successfully screened for mixtures of fish captured in the Cook Inlet offshore test fishery in 2007.

Date(s)	N	West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
				2007				
7/1-9	374	0.17	0.12	0.01	0.06	0.00	0.41	0.24
		(0.12 - 0.22)	(0.07 - 0.16)	(0.00 - 0.02)	(0.04 - 0.09)	(0.00 - 0.01)	(0.35 - 0.47)	(0.18 - 0.29)
7/10-13	444	0.07	0.15	0.02	0.04	0.00	0.54	0.18
		(0.05 - 0.10)	(0.11 - 0.19)	(0.00 - 0.04)	(0.02 - 0.07)	(0.00 - 0.00)	(0.48 - 0.60)	(0.13 - 0.23)
7/14-18	404	0.07	0.13	0.04	0.03	0.00	0.62	0.12
		(0.04 - 0.10)	(0.08 - 0.18)	(0.01 - 0.09)	(0.01 - 0.04)	(0.00 - 0.00)	(0.57 - 0.67)	(0.08 - 0.16)
7/19-23	429	0.08	0.08	0.05	0.03	0.00	0.68	0.09
		(0.06 - 0.11)	(0.05 - 0.12)	(0.02 - 0.08)	(0.01 - 0.04)	(0.00 - 0.00)	(0.63 - 0.73)	(0.06 - 0.13)
7/24-8/2	438	0.07	0.07	0.05	0.01	0.00	0.71	0.09
		(0.05 - 0.10)	(0.04 - 0.10)	(0.03 - 0.07)	(0.00 - 0.02)	(0.00 - 0.00)	(0.66 - 0.76)	(0.06 - 0.13)

Note: Credibility intervals (90%) are included in parentheses. Proportions are estimated from BAYES using a SPAM prior.

Table 9.–Revised stock composition estimates (P) and extrapolated harvests (H) from mixtures of fish captured in the Central District drift gillnet fishery in 2007.

Date	N		West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
					2007				
6/25-28	400	P	0.23	0.11	0.00	0.01	0.00	0.28	0.38
			(0.03 - 0.36)	(0.00 - 0.33)	(0.00 - 0.00)	(0.00 - 0.03)	(0.00 - 0.00)	(0.23 - 0.34)	(0.32 - 0.43)
		H	4,874	2,265	0	137	0	6,078	8,033
			(695 - 7675)	(73 - 7049)	(0 - 0)	(0 - 618)	(0 - 0)	(4908 - 7290)	(6835 - 9260)
7/2-5	400	P	0.10	0.15	0.00	0.03	0.00	0.42	0.30
			(0.07 - 0.14)	(0.11 - 0.19)	(0.00 - 0.01)	(0.01 - 0.05)	(0.00 - 0.00)	(0.35 - 0.49)	(0.24 - 0.36)
		H	8,608	12,517	302	2,206	0	35,235	25,034
			(5990 - 11401)	(9337 - 15948)	(0 - 1250)	(940 - 3935)	(0 - 0)	(29757 - 40798)	(19723 - 30294)
7/9-12	399	P	0.06	0.10	0.03	0.02	0.00	0.55	0.24
			(0.04 - 0.09)	(0.06 - 0.14)	(0.00 - 0.06)	(0.01 - 0.04)	(0.00 - 0.01)	(0.49 - 0.61)	(0.19 - 0.30)
		H	17,533	28,469	7,945	5,893	704	161,314	71,363
			(11083 - 24980)	(18002 - 41926)	(0 - 17152)	(1818 - 11024)	(0 - 4222)	(144250 - 178583)	(55941 - 87312)
7/16	400	P	0.03	0.13	0.02	0.03	0.00	0.64	0.15
			(0.01 - 0.05)	(0.10 - 0.17)	(0.01 - 0.04)	(0.01 - 0.04)	(0.00 - 0.00)	(0.58 - 0.70)	(0.11 - 0.20)
		H	14,023	62,548	11,469	12,673	0	307,968	73,197
			(5831 - 23998)	(46164 - 80715)	(4963 - 19516)	(5831 - 21058)	(0 - 0)	(280212 - 335050)	(50645 - 97580)
7/19	398	P	0.02	0.11	0.00	0.03	0.00	0.69	0.15
			(0.01 - 0.03)	(0.08 - 0.15)	(0.00 - 0.00)	(0.02 - 0.06)	(0.00 - 0.00)	(0.63 - 0.74)	(0.10 - 0.20)
		H	7,946	50,224	88	14,663	0	301,038	65,063
			(2634 - 14751)	(34771 - 66644)	(0 - 44)	(6805 - 24234)	(0 - 0)	(275706 - 325228)	(45088 - 86883)

Note: Credibility intervals (90%) are included in parentheses. The number of fish successfully screened from each stratum (N) is indicated. BAYES with a SPAM prior was used to estimate the proportions. The 90% confidence intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values above zero.

Table 11.–Revised stock composition estimates (P) and extrapolated harvests (H) from mixtures of fish captured in the Kasilof Section set gillnet fishery (Central District, East Side Subdistrict) in 2005 and 2007.

Date	N		West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
						2005			
7/19-28	300	P	0.00	0.00	0.00	0.00	0.00	0.43	0.57
			(0.00 - 0.00)	(0.00 - 0.01)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.36 - 0.50)	(0.50 - 0.64)
		H	0	357	0	0	0	95,398	127,450
			(0 - 0)	(0 - 1875)	(0 - 0)	(0 - 0)	(0 - 0)	(81090 - 110531)	(112339 - 141757)
						2007			
6/25-7/5	399	P	0.01	0.07	0.00	0.02	0.00	0.13	0.78
			(0.00 - 0.02)	(0.04 - 0.09)	(0.00 - 0.00)	(0.00 - 0.03)	(0.00 - 0.00)	(0.09 - 0.17)	(0.73 - 0.83)
		H	898	7,487	11	1,761	0	14,361	89,119
			(102 - 2204)	(4635 - 10714)	(0 - 0)	(364 - 3590)	(0 - 0)	(9748 - 19644)	(83313 - 94640)
7/9-12	299	P	0.00	0.04	0.00	0.01	0.00	0.46	0.49
			(0.00 - 0.00)	(0.00 - 0.07)	(0.00 - 0.00)	(0.00 - 0.03)	(0.00 - 0.00)	(0.39 - 0.54)	(0.42 - 0.56)
		H	13	4,916	13	1,603	0	62,449	65,694
			(0 - 0)	(323 - 10087)	(0 - 0)	(0 - 4404)	(0 - 0)	(53062 - 72159)	(56213 - 74960)
7/16-21	400	P	0.00	0.04	0.02	0.04	0.00	0.58	0.32
			(0.00 - 0.01)	(0.02 - 0.07)	(0.00 - 0.03)	(0.02 - 0.06)	(0.00 - 0.01)	(0.53 - 0.64)	(0.26 - 0.37)
		H	381	9,811	4,120	9,573	476	138,572	75,227
			(0 - 2834)	(4525 - 16789)	(1143 - 8240)	(5025 - 14836)	(0 - 1738)	(125308 - 151812)	(62392 - 88230)

Note: Credibility intervals (90%) are included in parentheses. The number of fish successfully screened from each stratum (N) is indicated. BAYES with a SPAM prior was used to estimate the proportions. The 90% credibility intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values above zero.

Table 12.–Revised stock composition estimates (P) and extrapolated harvests (H) from mixtures of fish captured in the Kenai Section set gillnet fishery (Central District, East Side Subdistrict) in 2007.

Date	N		West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
						2007			
7/9-12	400	P	0.00	0.02	0.01	0.01	0.00	0.86	0.09
			(0.00 - 0.01)	(0.00 - 0.05)	(0.00 - 0.02)	(0.00 - 0.03)	(0.00 - 0.00)	(0.81 - 0.91)	(0.05 - 0.14)
		H	43	162	89	149	0	9,143	999
			(3 - 122)	(21 - 476)	(0 - 227)	(0 - 311)	(0 - 0)	(8607 - 9621)	(570 - 1485)
7/16-19	399	P	0.00	0.03	0.00	0.00	0.00	0.89	0.07
			(0.00 - 0.01)	(0.01 - 0.05)	(0.00 - 0.00)	(0.00 - 0.00)	(0.00 - 0.00)	(0.85 - 0.93)	(0.04 - 0.12)
		H	83	1,665	0	0	0	46,307	3,806
			(0 - 399)	(674 - 2826)	(0 - 0)	(0 - 0)	(0 - 0)	(43921 - 48433)	(1872 - 5994)
7/21-28	400	P	0.00	0.13	0.00	0.04	0.00	0.72	0.11
			(0.00 - 0.00)	(0.09 - 0.17)	(0.00 - 0.01)	(0.02 - 0.06)	(0.00 - 0.00)	(0.67 - 0.77)	(0.08 - 0.15)
		H	0	43,146	579	13,496	0	245,042	38,545
			(0 - 0)	(30366 - 57426)	(0 - 3613)	(6237 - 21573)	(0 - 0)	(228376 - 261469)	(26345 - 51973)

Note: Credibility intervals (90%) are included in parentheses. The number of fish successfully screened from each stratum (N) is indicated. BAYES with a SPAM prior was used to estimate the proportions. The 90% credibility intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values above zero.

Table 13.–Revised stock composition estimates (P) and extrapolated harvests (H) from mixtures of fish captured in the Kasilof and Kenai Section set gillnet fisheries (Central District, East Side Subdistrict) analyzed by subsections in 2007.

Dates	N		West	Yentna	Susitna	Knik	Northeast	Kenai	Kasilof
						Cohoe/Ninilchik 2007			
6/25-7/21	878	P	0.01	0.06	0.00	0.02	0.00	0.37	0.54
			(0.00 - 0.01)	(0.04 - 0.08)	(0.00 - 0.01)	(0.01 - 0.03)	(0.00 - 0.00)	(0.33 - 0.41)	(0.50 - 0.58)
		H	2,513	23,470	773	8,004	116	141,943	209,879
			(657 - 5027)	(16317 - 31435)	(0 - 3480)	(4369 - 12257)	(0 - 851)	(126902 - 157525)	(194103 - 225191)
						South K. Beach 2007			
6/25-7/21	205	P	0.00	0.04	0.01	0.00	0.00	0.45	0.50
			(0.00 - 0.00)	(0.00 - 0.08)	(0.00 - 0.03)	(0.00 - 0.02)	(0.00 - 0.00)	(0.37 - 0.54)	(0.42 - 0.59)
		H	0	3,661	599	389	0	44,994	50,122
			(0 - 0)	(0 - 8121)	(0 - 3312)	(0 - 2165)	(0 - 0)	(36494 - 53664)	(41652 - 58603)
						North K. Beach 2007			
7/9-28	203	P	0.01	0.01	0.01	0.00	0.00	0.61	0.36
			(0.00 - 0.02)	(0.00 - 0.04)	(0.00 - 0.04)	(0.00 - 0.00)	(0.00 - 0.00)	(0.52 - 0.69)	(0.28 - 0.45)
		H	317	811	860	0	0	37,038	21,975
			(18 - 958)	(12 - 2306)	(0 - 2355)	(0 - 0)	(0 - 0)	(31834 - 42254)	(16832 - 27234)
						North and South Salamatof 2007			
7/9-28	997	P	0.00	0.06	0.00	0.03	0.00	0.85	0.06
			(0.00 - 0.00)	(0.05 - 0.08)	(0.00 - 0.00)	(0.02 - 0.04)	(0.00 - 0.00)	(0.82 - 0.88)	(0.04 - 0.08)
		H	0	21,732	68	9,377	0	291,282	19,816
			(0 - 0)	(15948 - 28098)	(0 - 342)	(5921 - 13279)	(0 - 0)	(281186 - 300660)	(12321 - 27927)

Note: Credibility intervals (90%) are included in parentheses. The number of fish successfully screened from each stratum (N) is indicated. BAYES with a SPAM prior was used to estimate the proportions. The 90% credibility intervals of harvest estimates may not include the point estimate for very low extrapolated harvest numbers because less than 5% of iterations had values above zero.

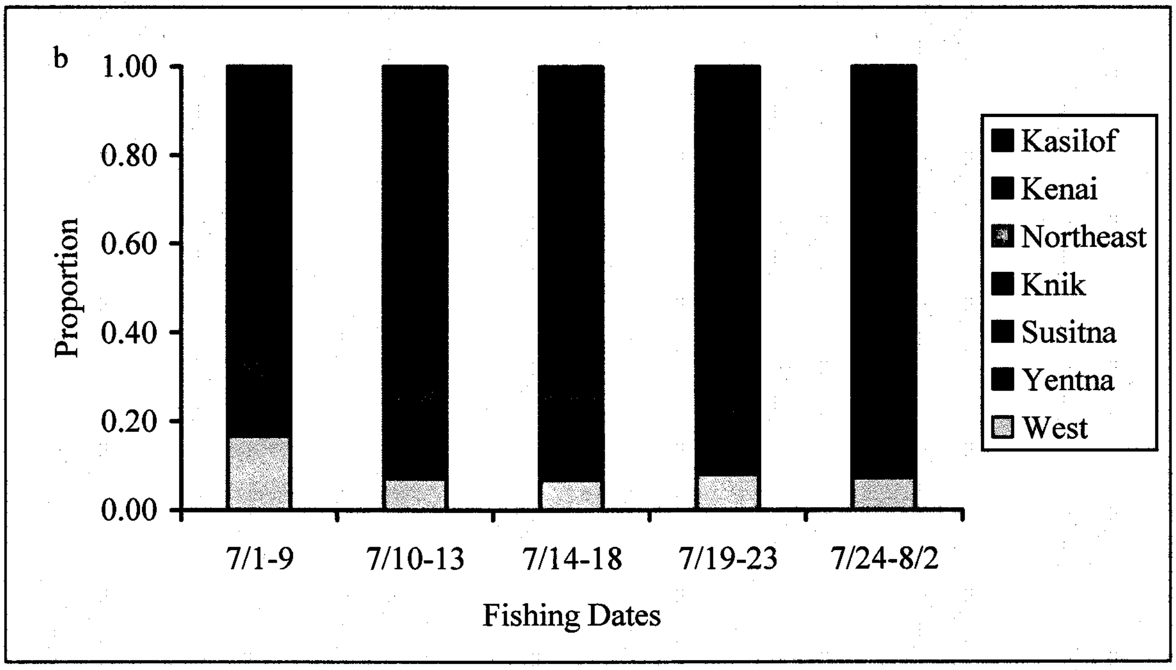

Figure 12.–Revised stock composition estimates for the Cook Inlet Offshore Test Fishery taken in 2007.

Note: BAYES with a SPAM prior were used to estimate the proportions.

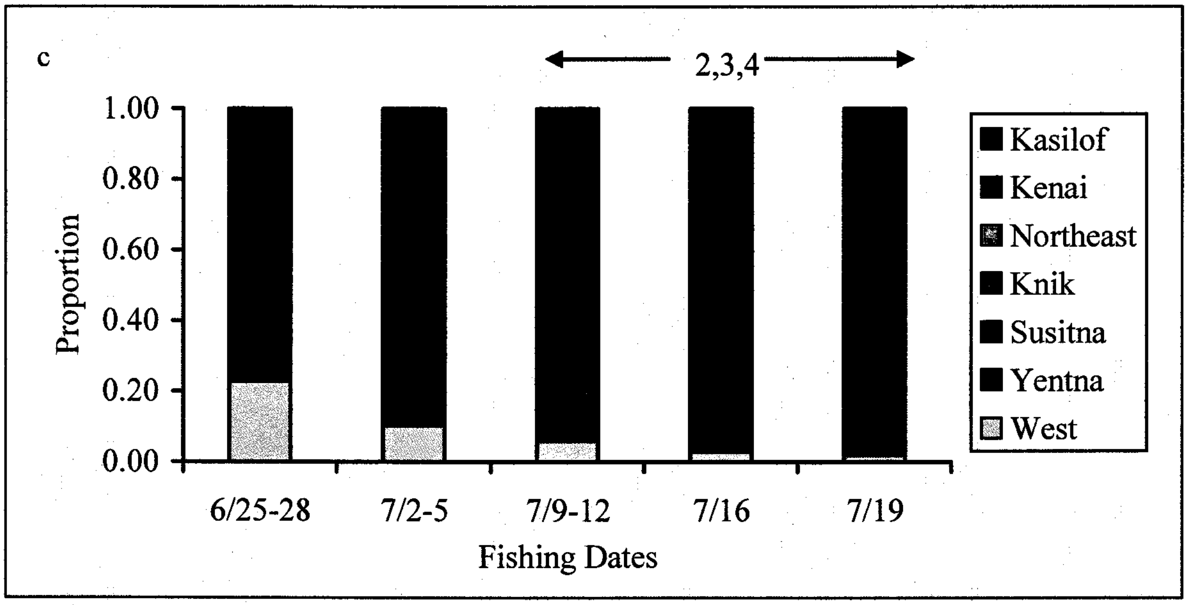

Figure 13.–Revised stock composition estimates for the Central District drift gillnet fishery from 2007.

Note: Numbers above the bars indicate fishery restrictions during openings (2-Kasilof Corridor; 3-Kenai Corridor; 4-Area 1; 5-Area 2: see Figures 2–7). BAYES with a SPAM prior were used to estimate the proportions.

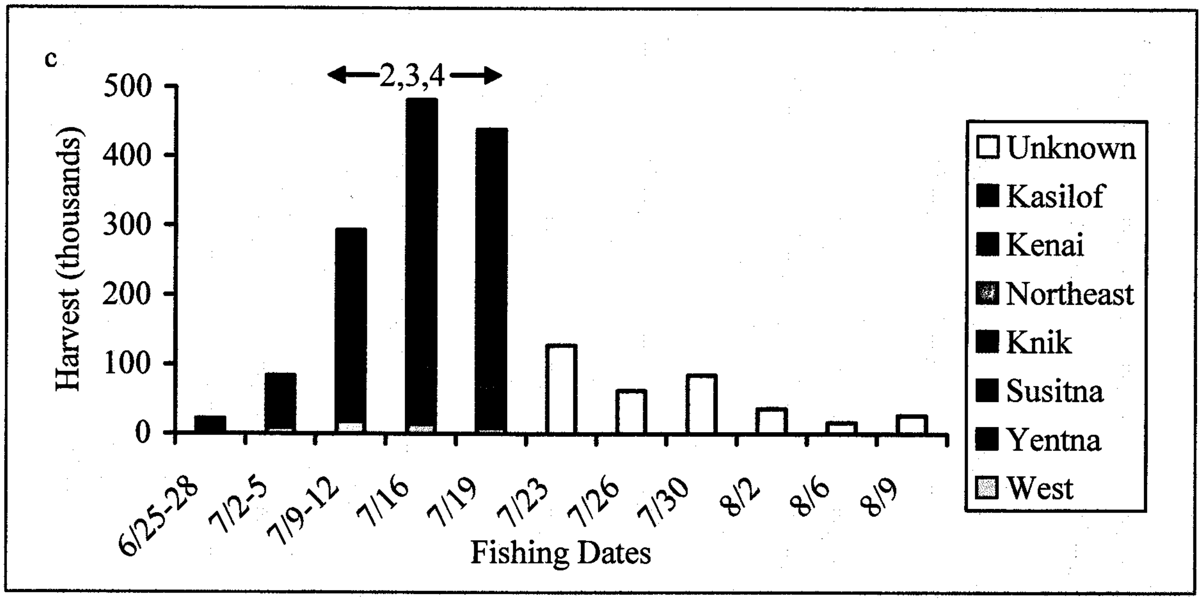

Figure 14.–Harvest by revised stock estimates for the Central District drift gillnet fishery from 2007.

Note: Numbers above the bars indicate fishery restrictions during openings (2-Kasilof Corridor; 3-Kenai Corridor; 4-Area 1; 5-Area 2: see Figures 2–7).

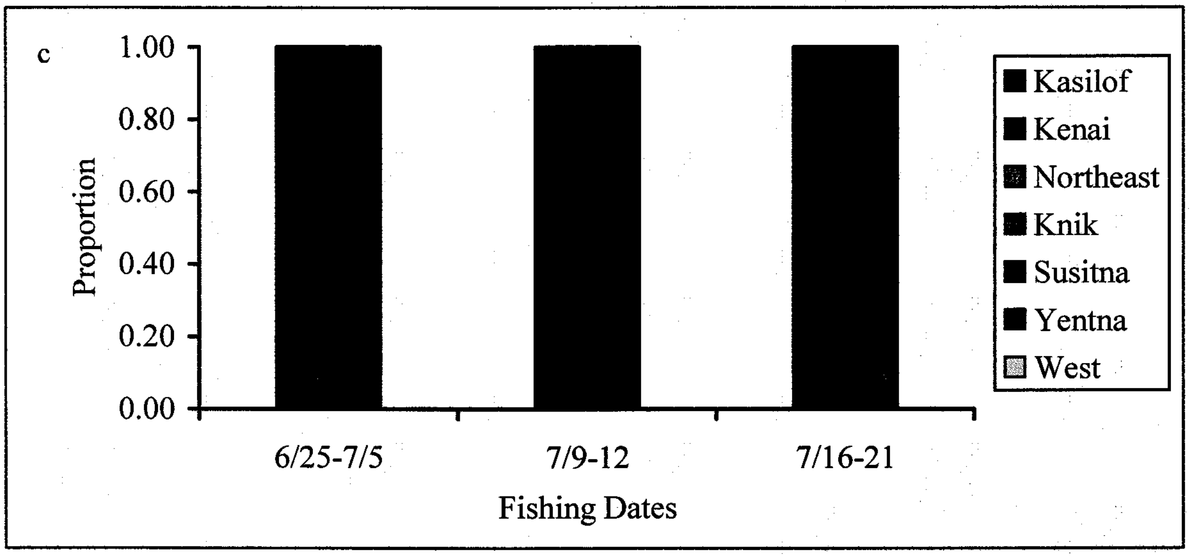

Figure 17.–Revised stock composition estimates for the Kasilof Section set gillnet fishery (Central District, East Side Subdistrict) from 2007.

Note: BAYES with a SPAM prior were used to estimate the proportions.

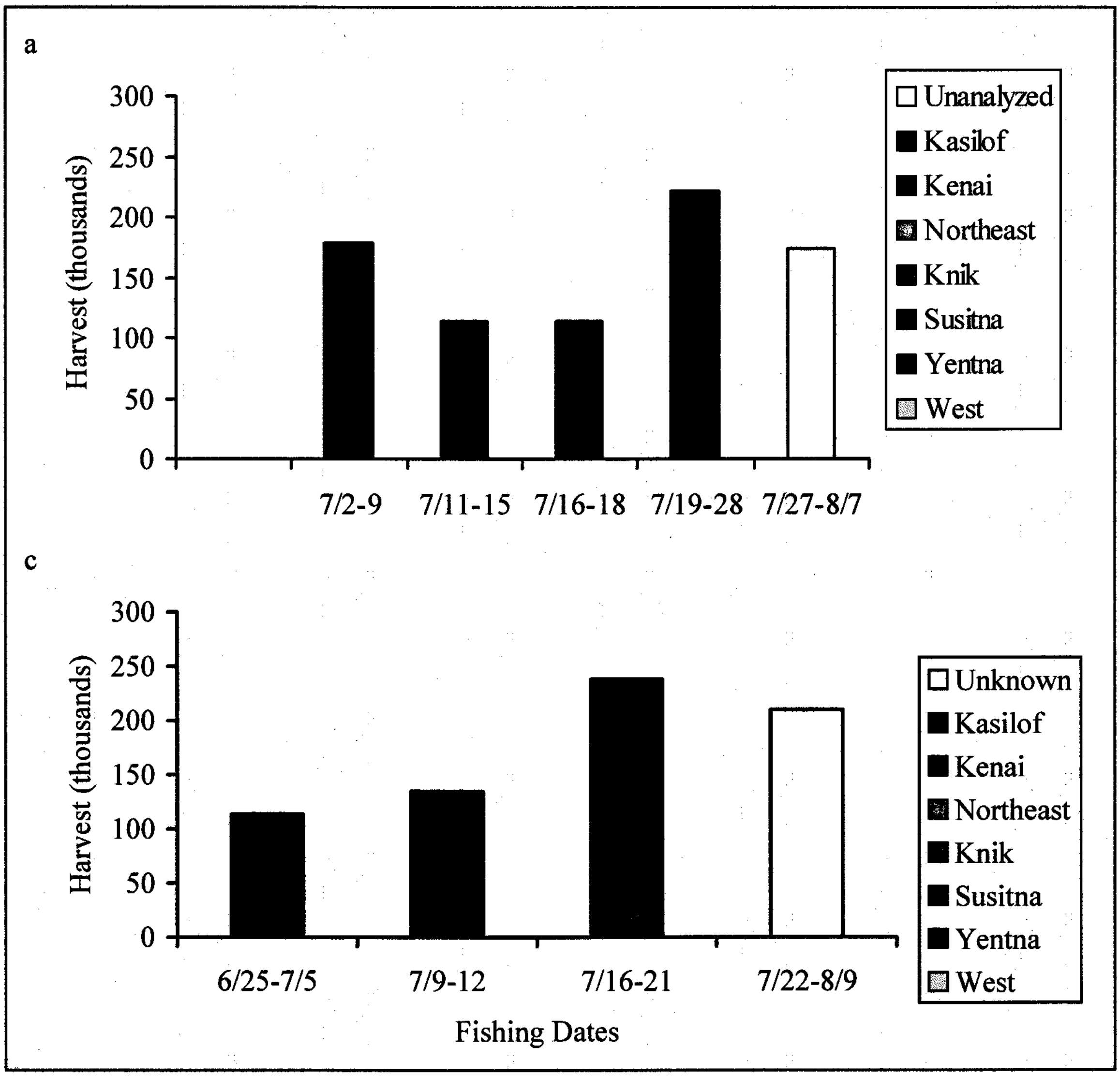

Figure 18.–Harvest by revised stock estimates for the Kasilof Section set gillnet fishery (Central District, East Side Subdistrict) from 2005 (a) and 2007 (c).

Note: Fishing dates between subsections sometimes overlapped (see Table 2).

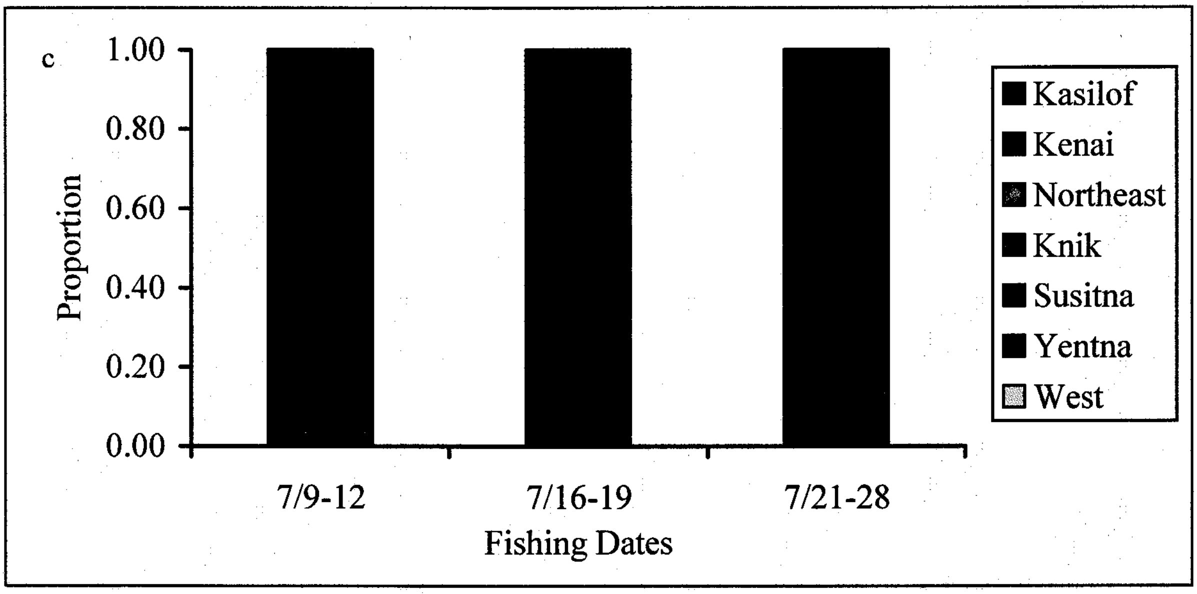

Figure 19.–Revised stock composition estimates for the Kenai Section set gillnet fishery (Central District, East Side Subdistrict) from 2007.

Note: BAYES with a SPAM prior were used to estimate the proportions.

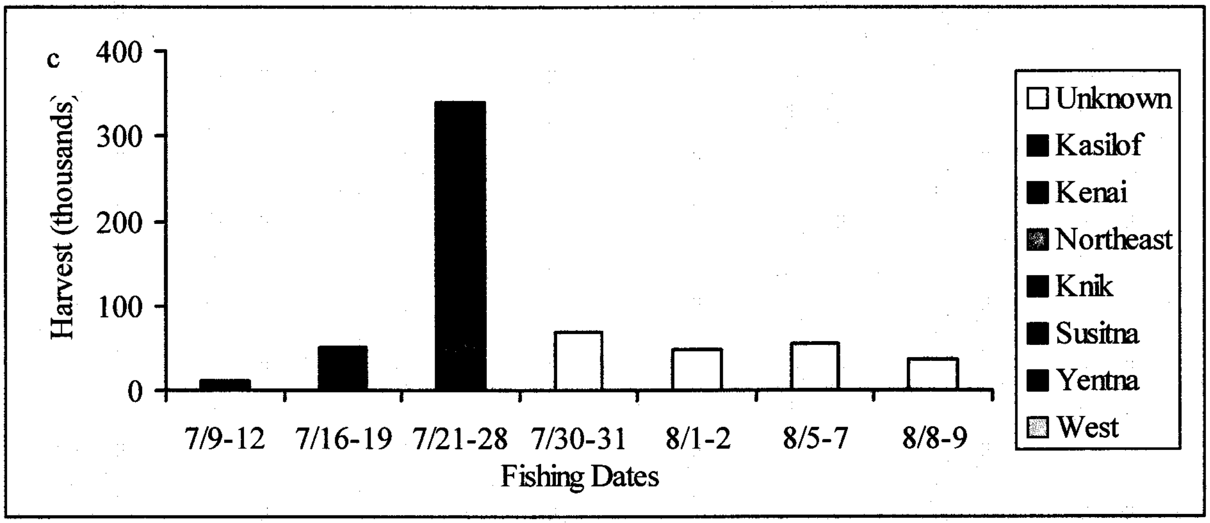

Figure 20.–Harvest by revised stock estimates for the Kenai Section set gillnet fishery (Central District, East Side Subdistrict) from 2007.

Note: Fishing dates between subsections sometimes overlapped (see Table 2).

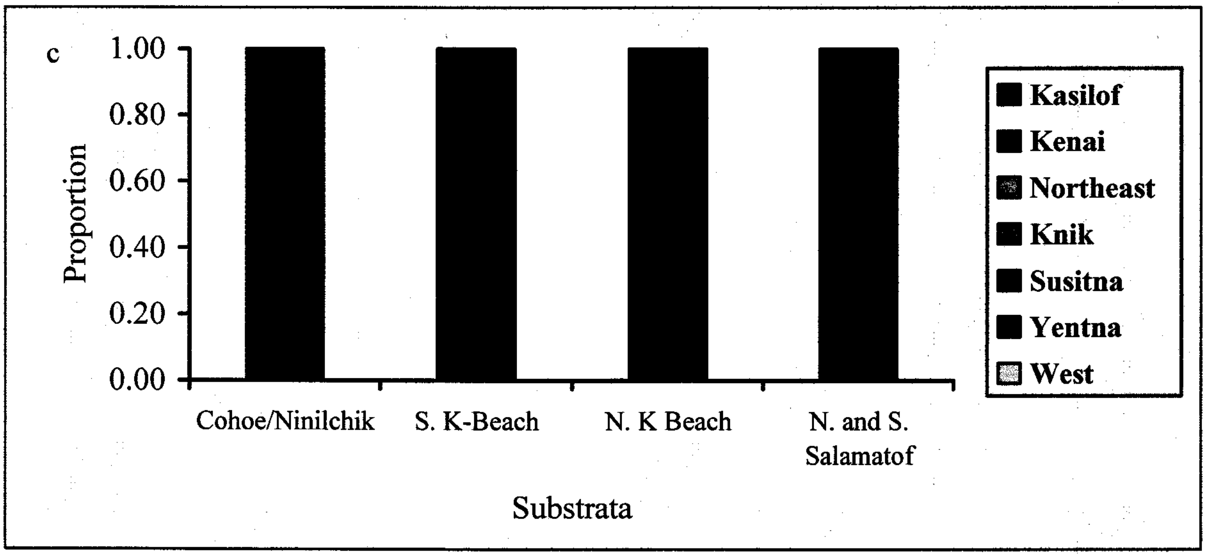

Figure 21.–Revised stock composition estimates for the Kasilof and Kenai Section set gillnet fisheries (Central District, East Side Subdistrict) divided into substrata from 2007.

Note: There are two substrata for each section and they are displayed from south to north. BAYES with a SPAM prior were used to estimate the proportions.

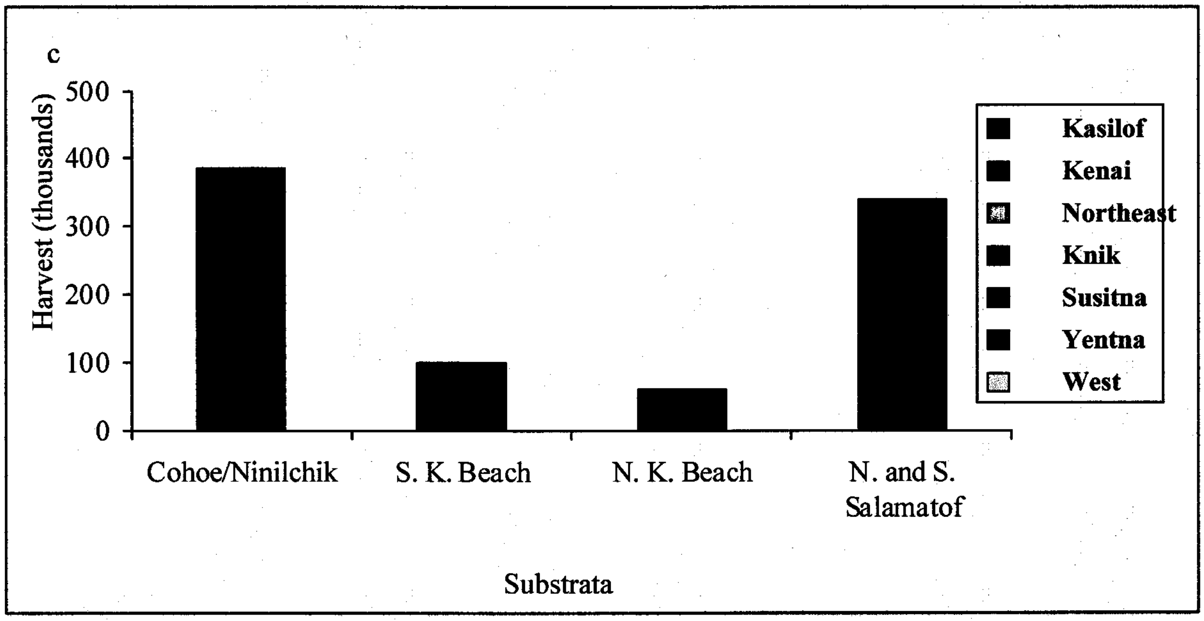

Figure 22.–Harvest by revised stock estimates for the Kasilof and Kenai Section set gillnet fisheries (Central District, East Side Subdistrict) divided into substrata from 2007.

Note: There are two substrata for each section and they are displayed from south to north.

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Upper Cook Inlet Commercial Fisheries Maps

Northern District Sport Fisheries Maps

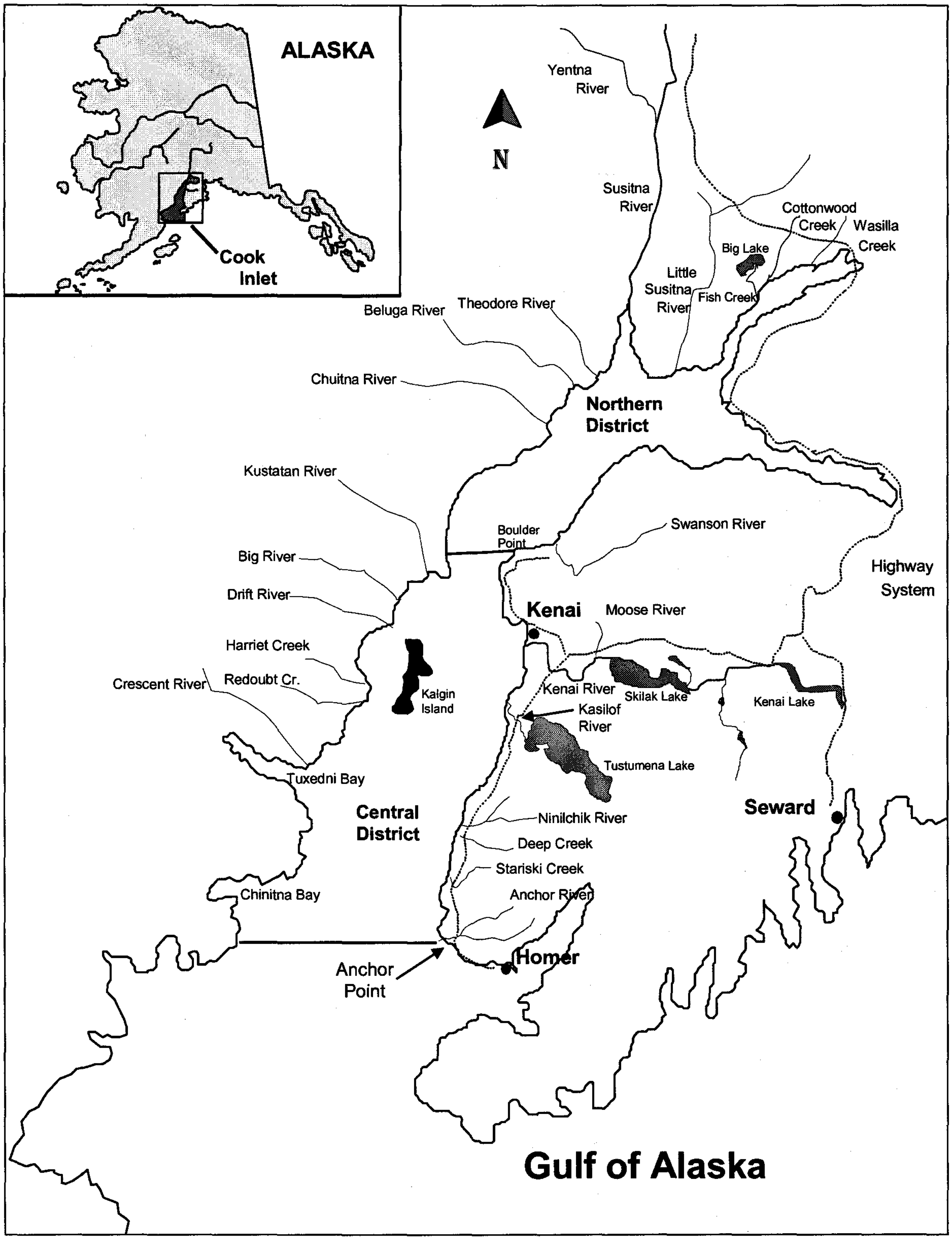


Figure 1.–Upper Cook Inlet Subdistrict commercial fishing boundaries.

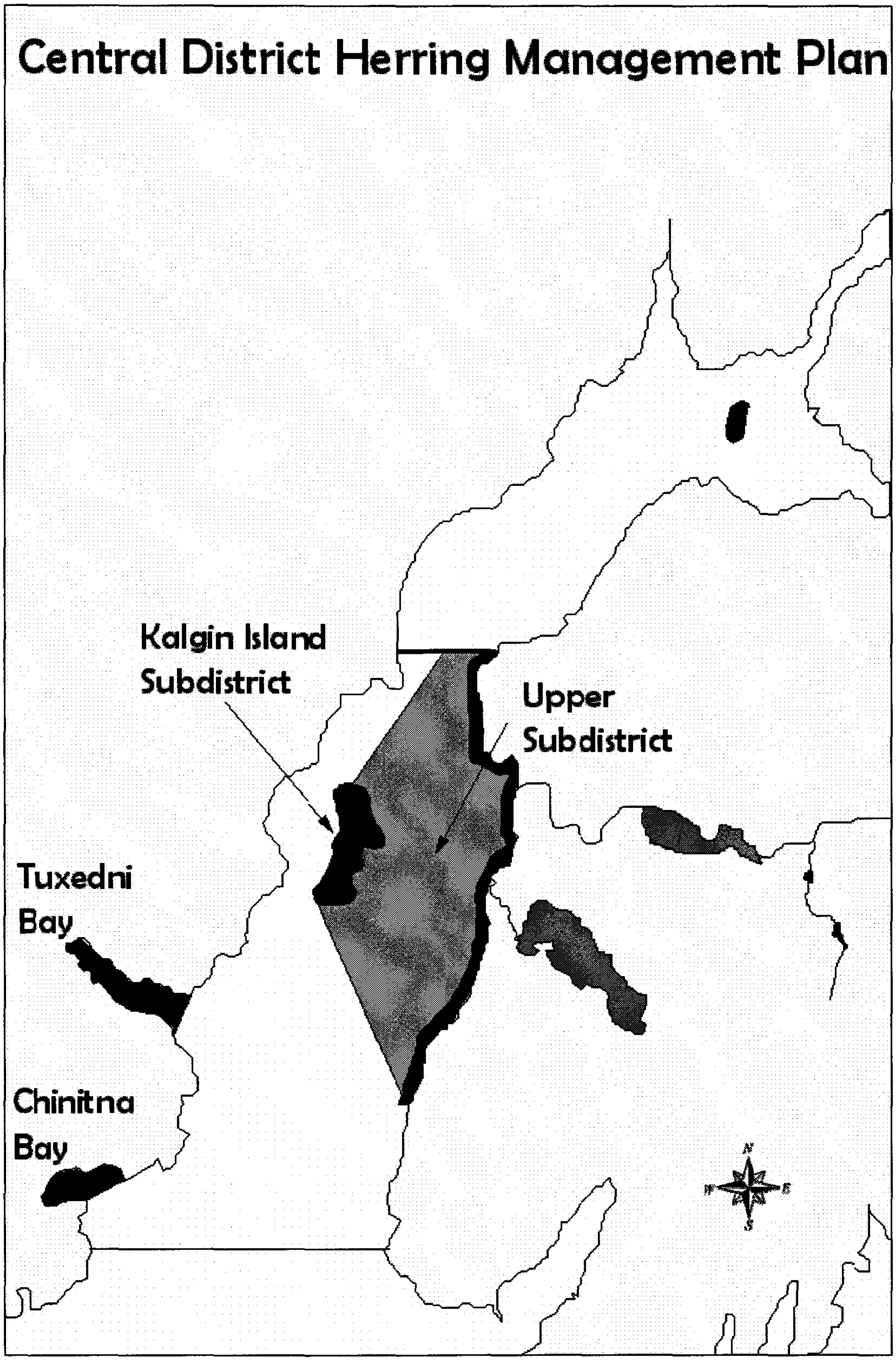


Figure 2.–Cook Inlet Central District herring commercial fishing area.

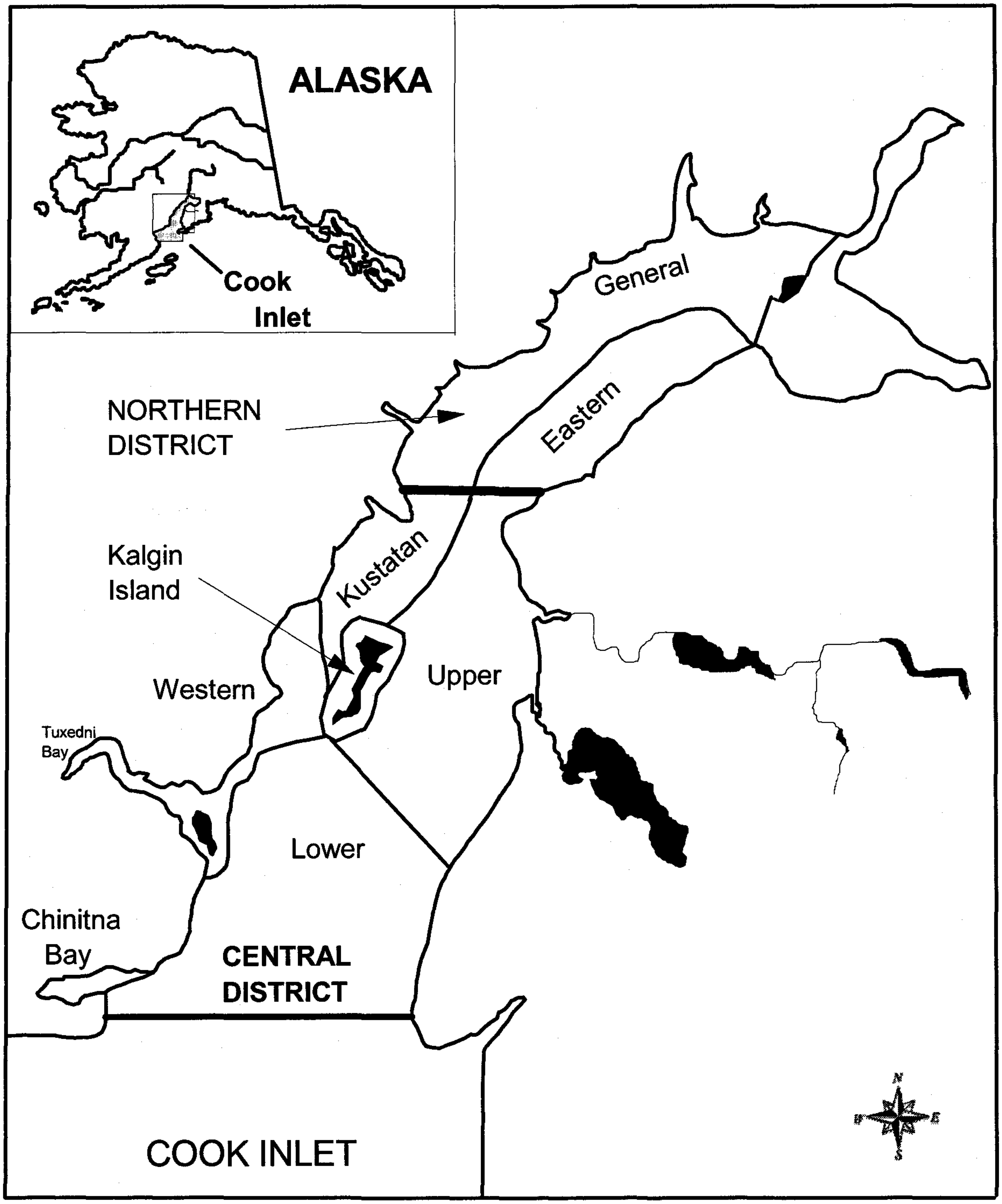


Figure 3.–Upper Cook Inlet Subdistrict commercial fishing boundaries.

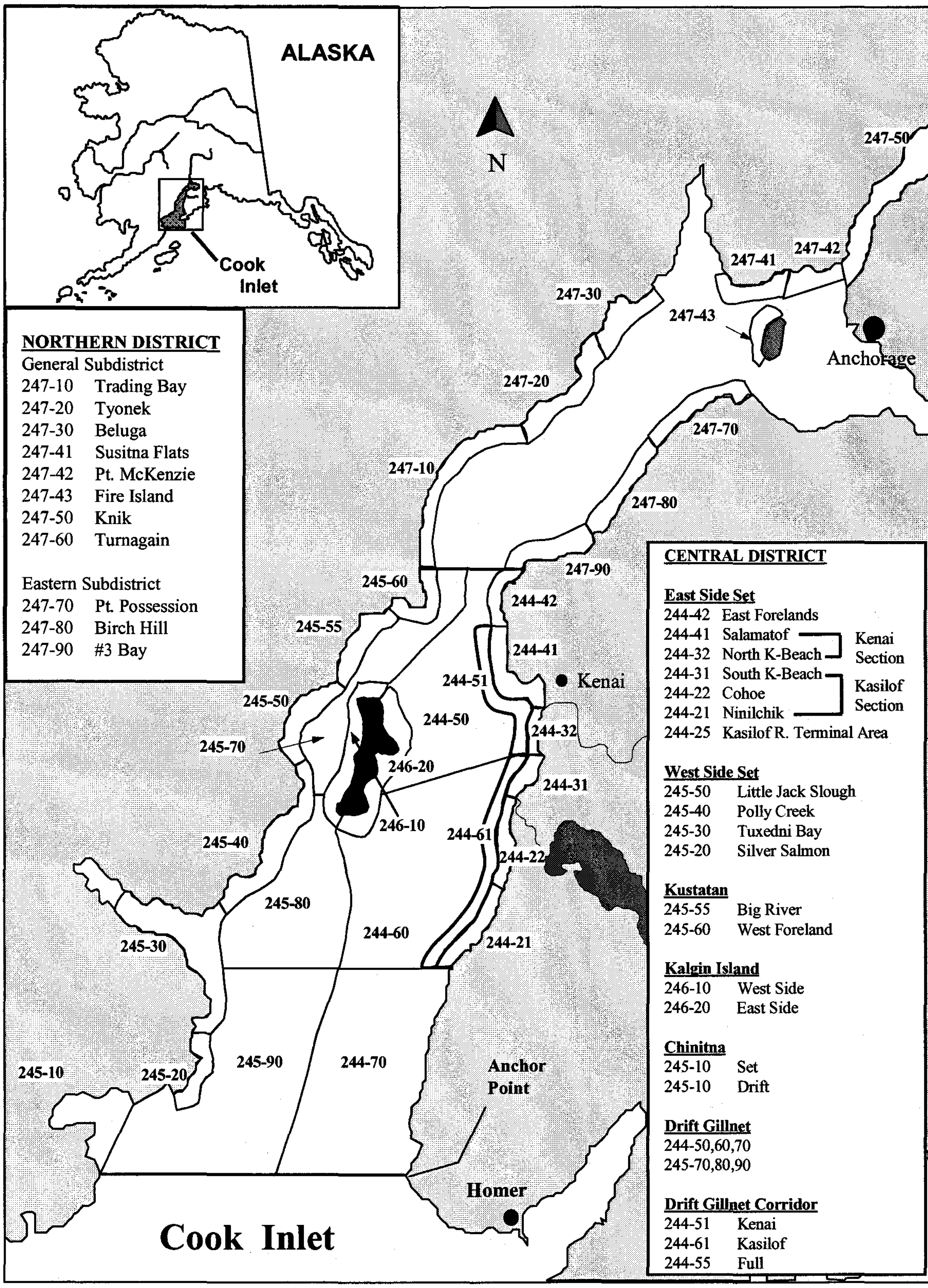


Figure 4.–Upper Cook Inlet statistical areas.

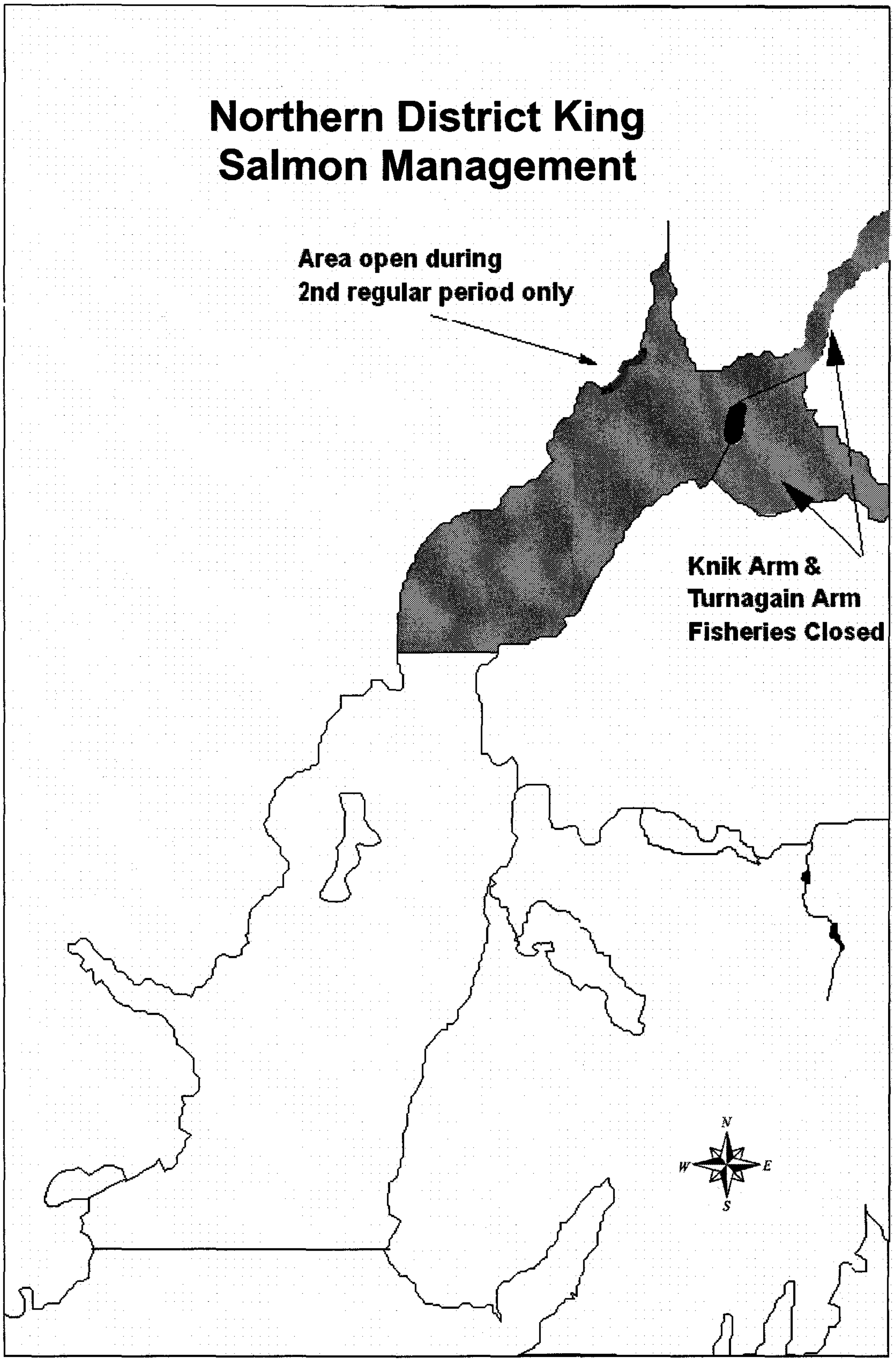


Figure 5.–Upper Cook Inlet Northern District king salmon commercial fishing areas.

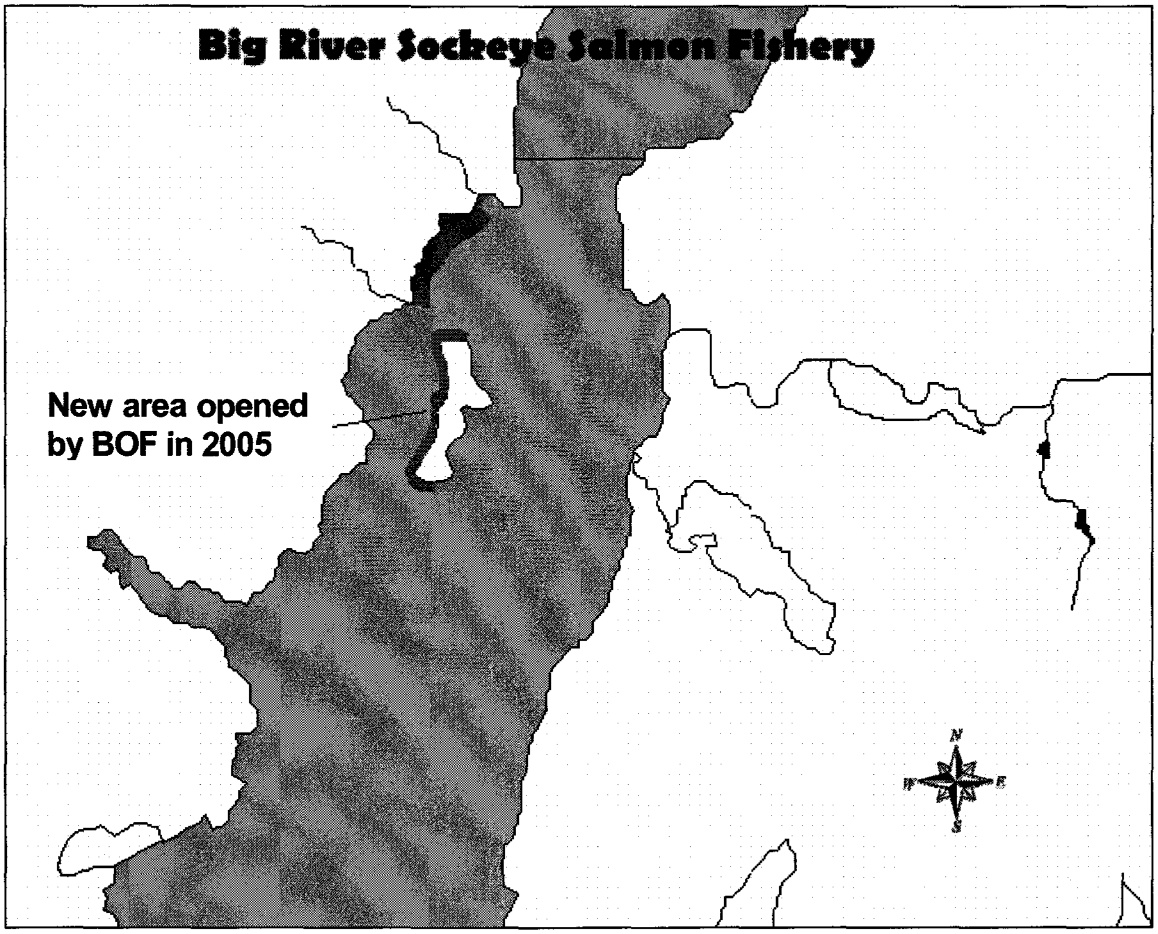


Figure 6.–Big River sockeye salmon management area.

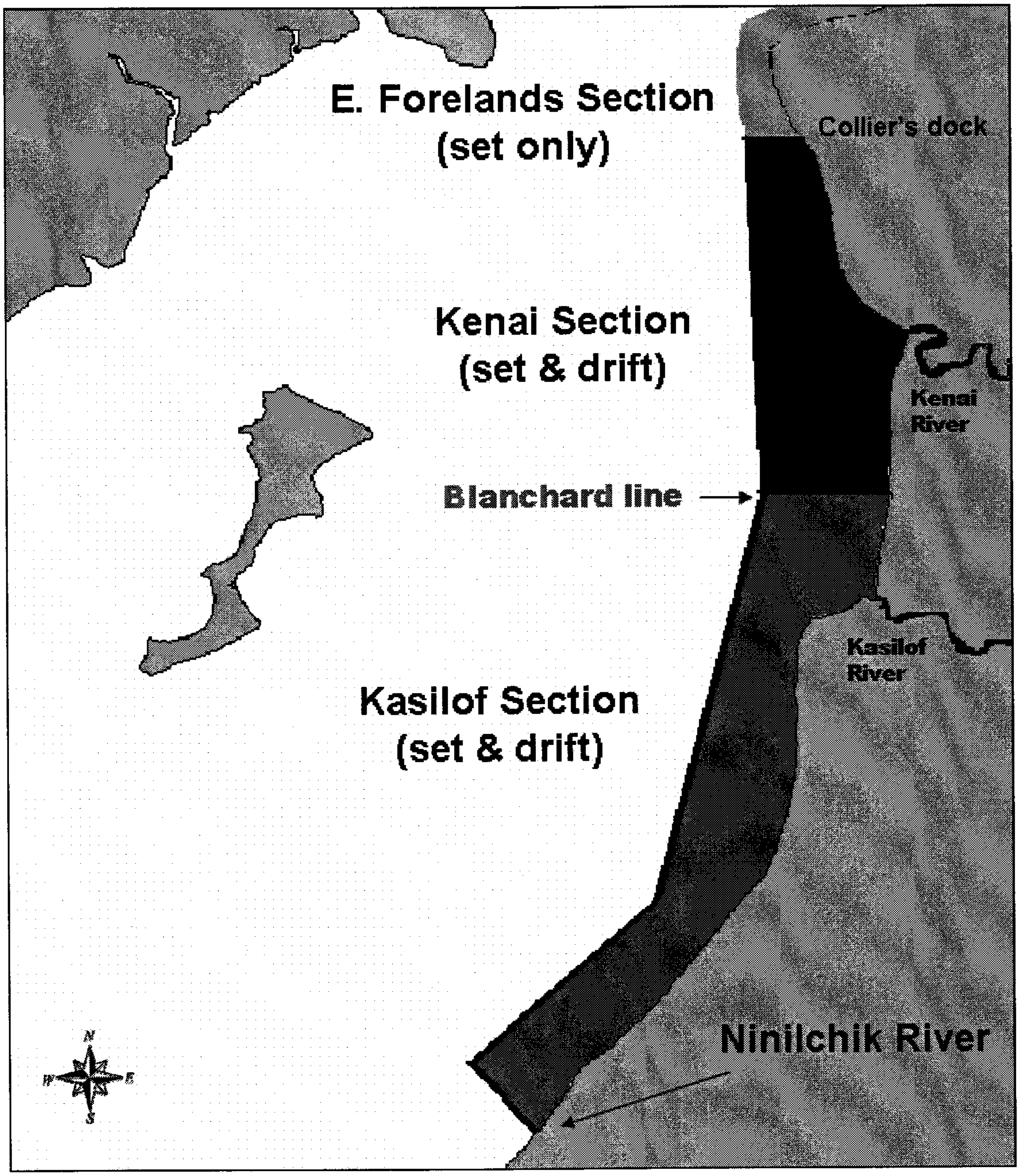


Figure 7.–East Forelands, Kenai and Kasilof sections.

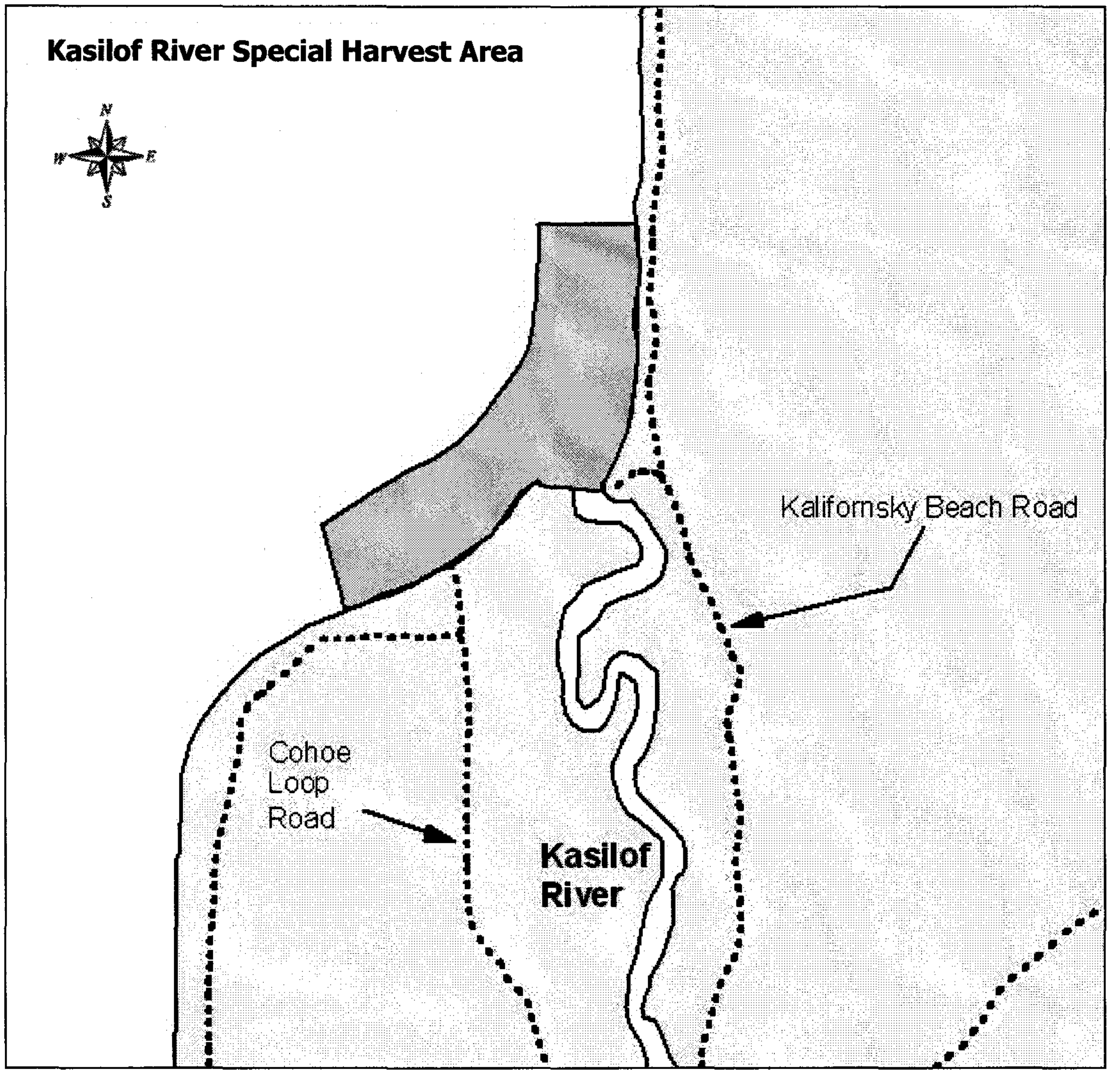


Figure 8.–Kasilof River special harvest management area.

Drift Gillnet Area 1 & Area 2 Descriptions

AREA 2 DESCRIPTION	COORDINATES
1. Southwest Corner	60^0 20.43' N. lat., 151^0 54.83' W. long.
2. Northwest Corner	60^0 41.08' N. lat., 151^0 39.00' W. long.
3. Northeast Corner	60^0 41.08' N. lat., 151^0 24.00' W. long.
4. Blanchard Line Corridor Boundary	60^0 27.10' N. lat., 151^0 25.70' W. long.
5. Southeast Corner	60^0 20.43' N. lat., 151^0 28.55' W. long.

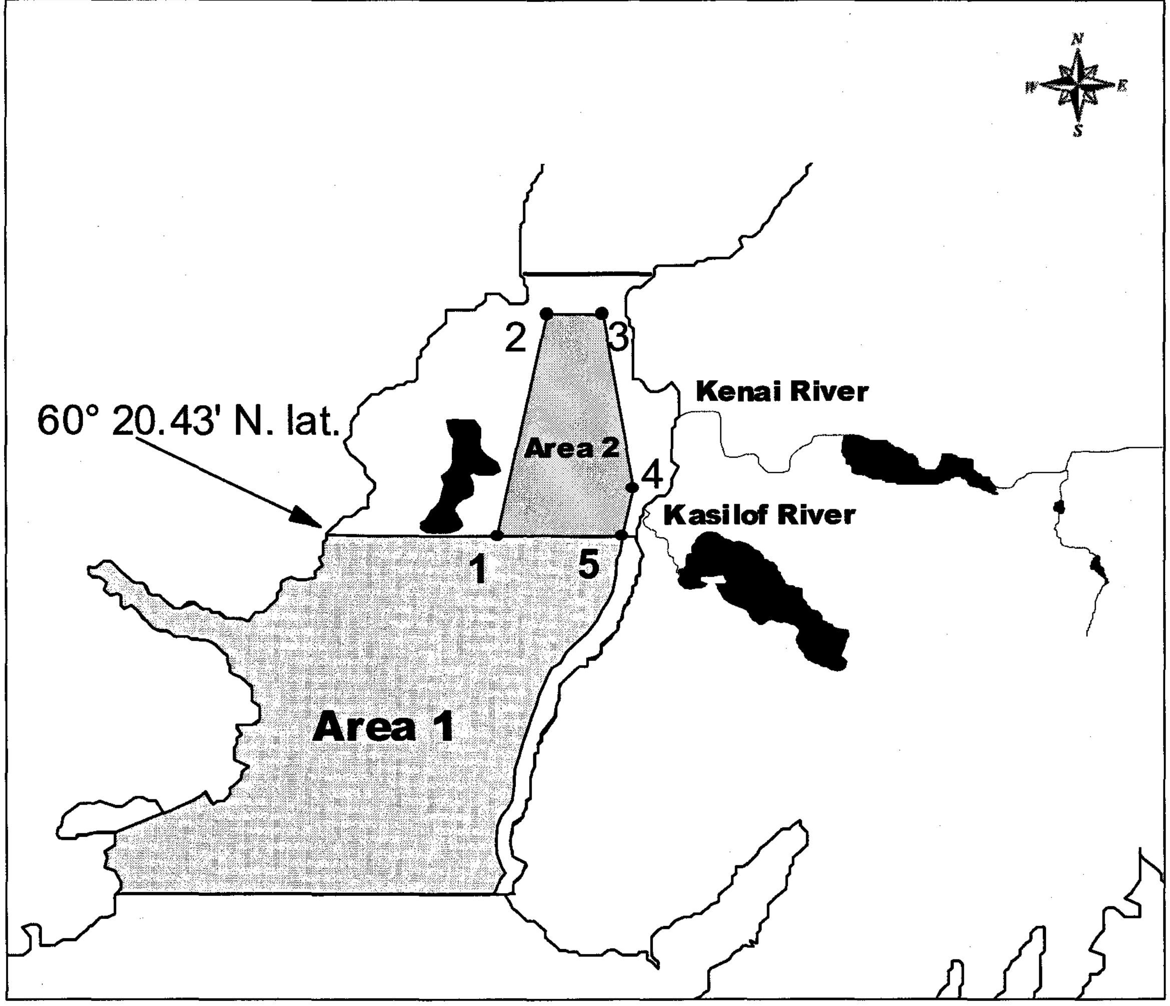


Figure 9.–Upper Cook Inlet drift gillnet Areas 1 and 2.

Drift Gillnet Area 3 & Area 4 Descriptions

AREA 4 LOCATION	COORDINATES
A. Southwest Corner	59^0 46.15' N. lat., 153^0 00.20' W. long.
B. Northwest Corner	60^0 04.70' N. lat., 152^0 34.74' W. long.
C. Northeast Corner (Kalgin Buoy)	60^0 04.70' N. lat., 152^0 09.90' W. long.
D. Southeast Corner	59^0 46.15' N. lat., 152^0 18.62' W. long.

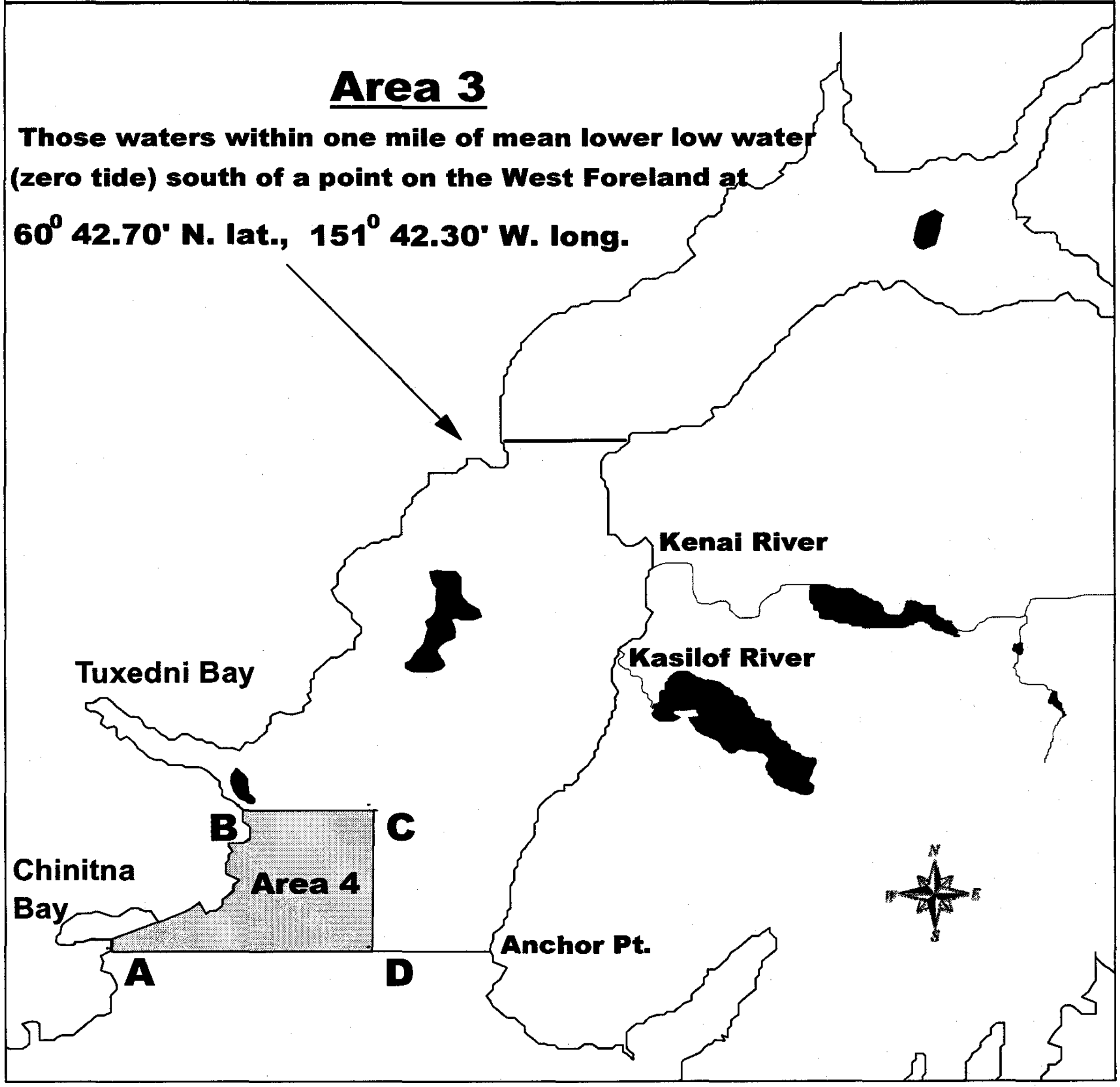


Figure 10.–Upper Cook Inlet drift gillnet Areas 3 and 4.

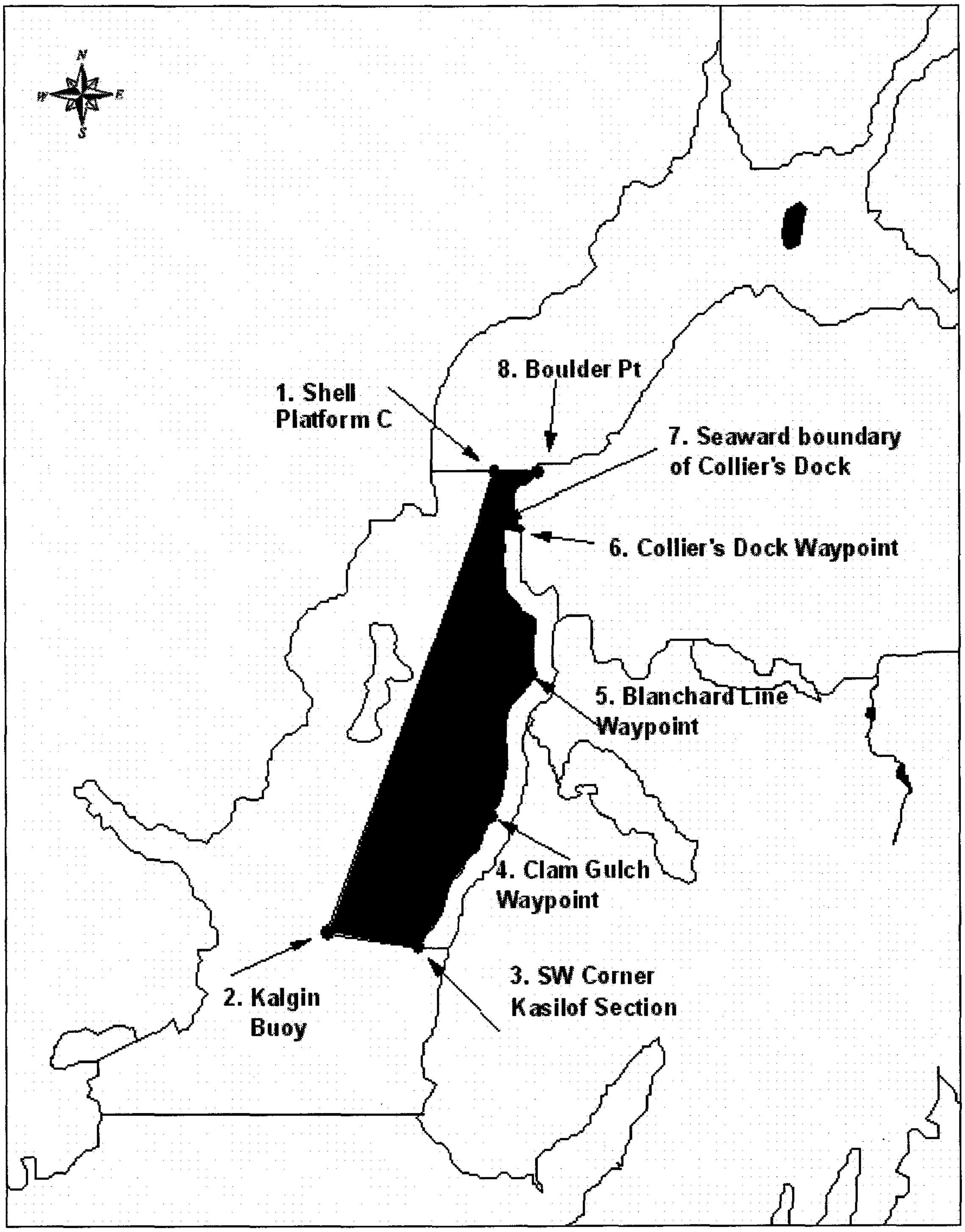


Figure 11.–Pink salmon drift gillnet areas.

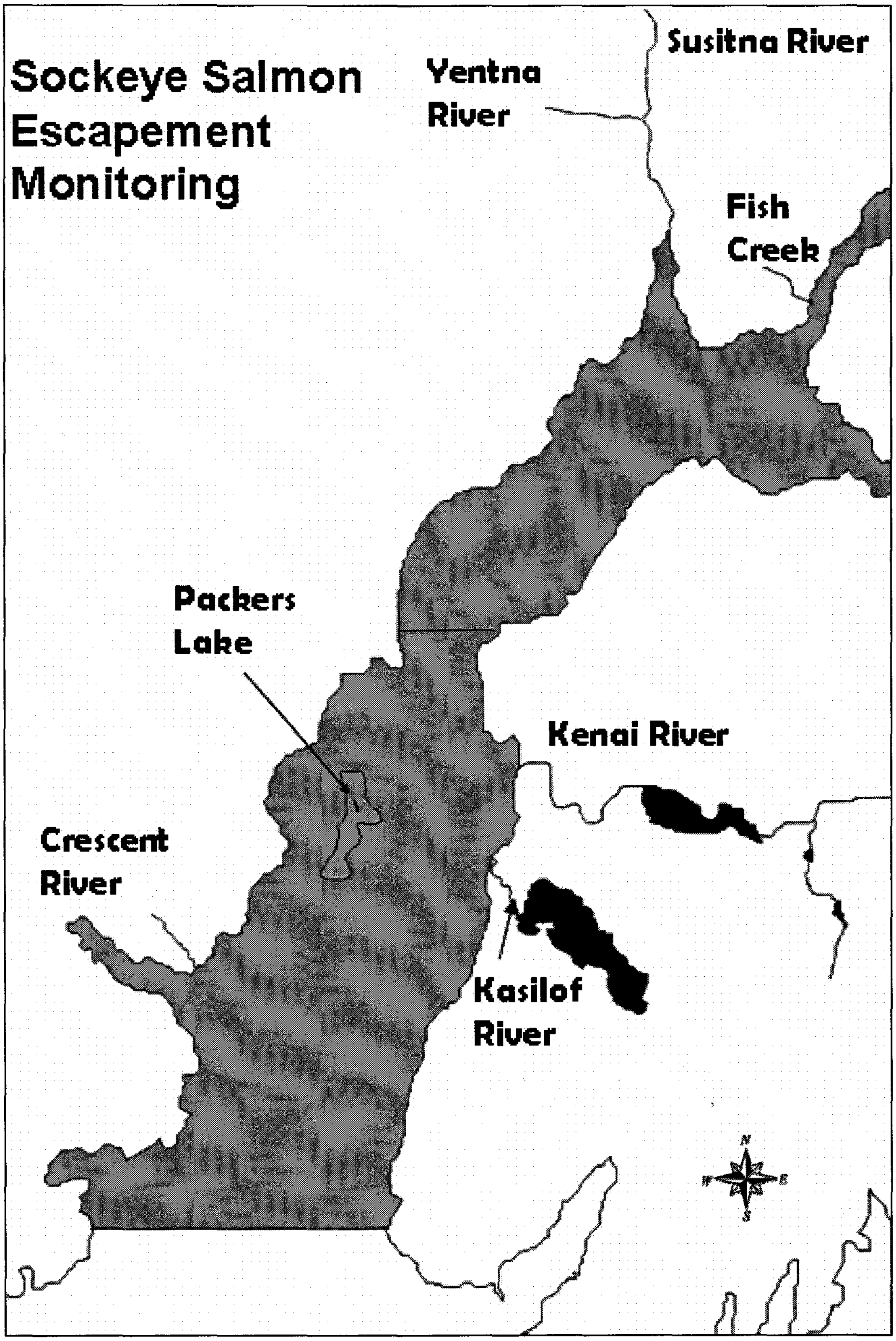


Figure 12.–Upper Cook Inlet sockeye salmon escapement monitoring projects.

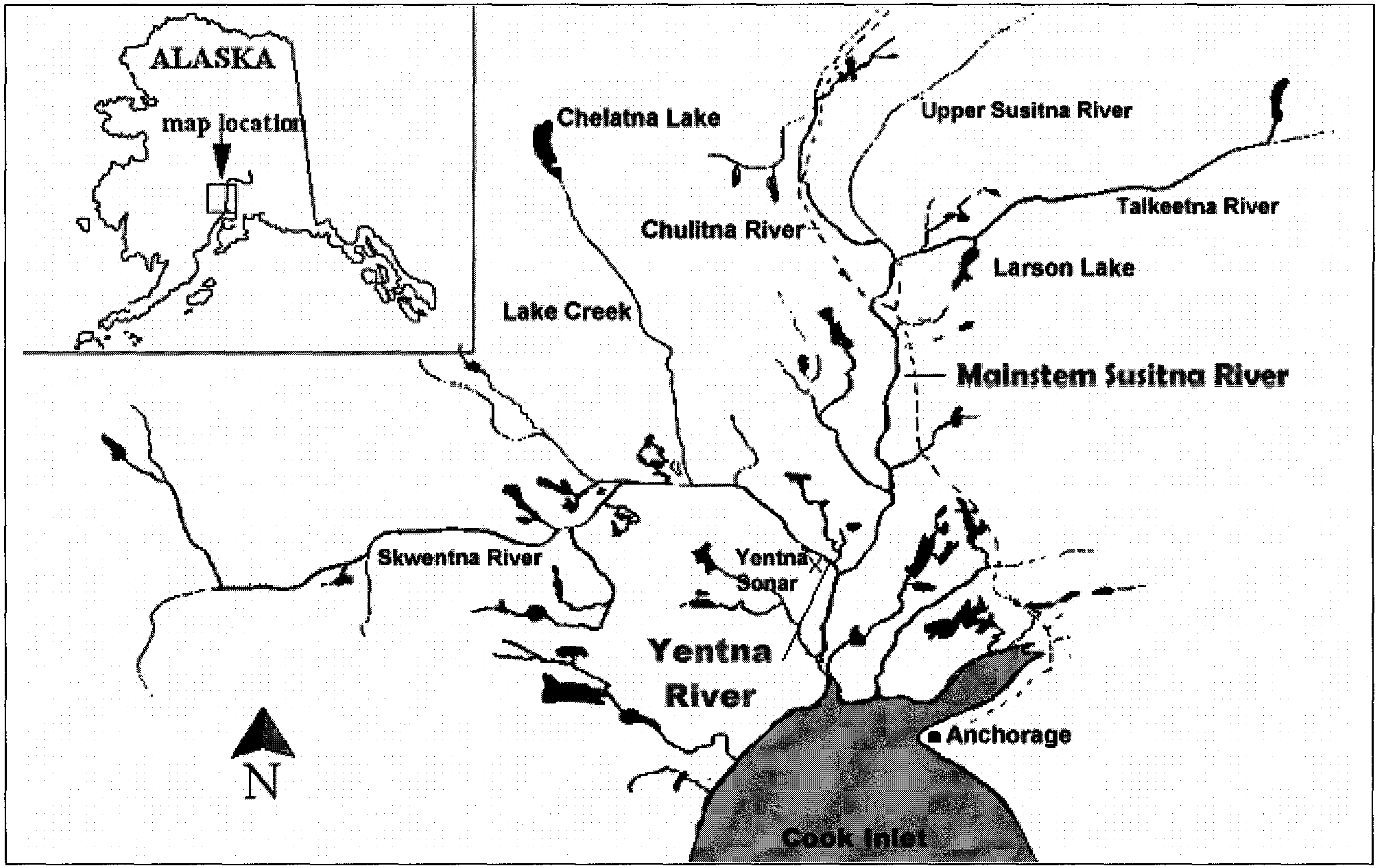


Figure 13.–Upper Susitna River drainage rivers and lakes.

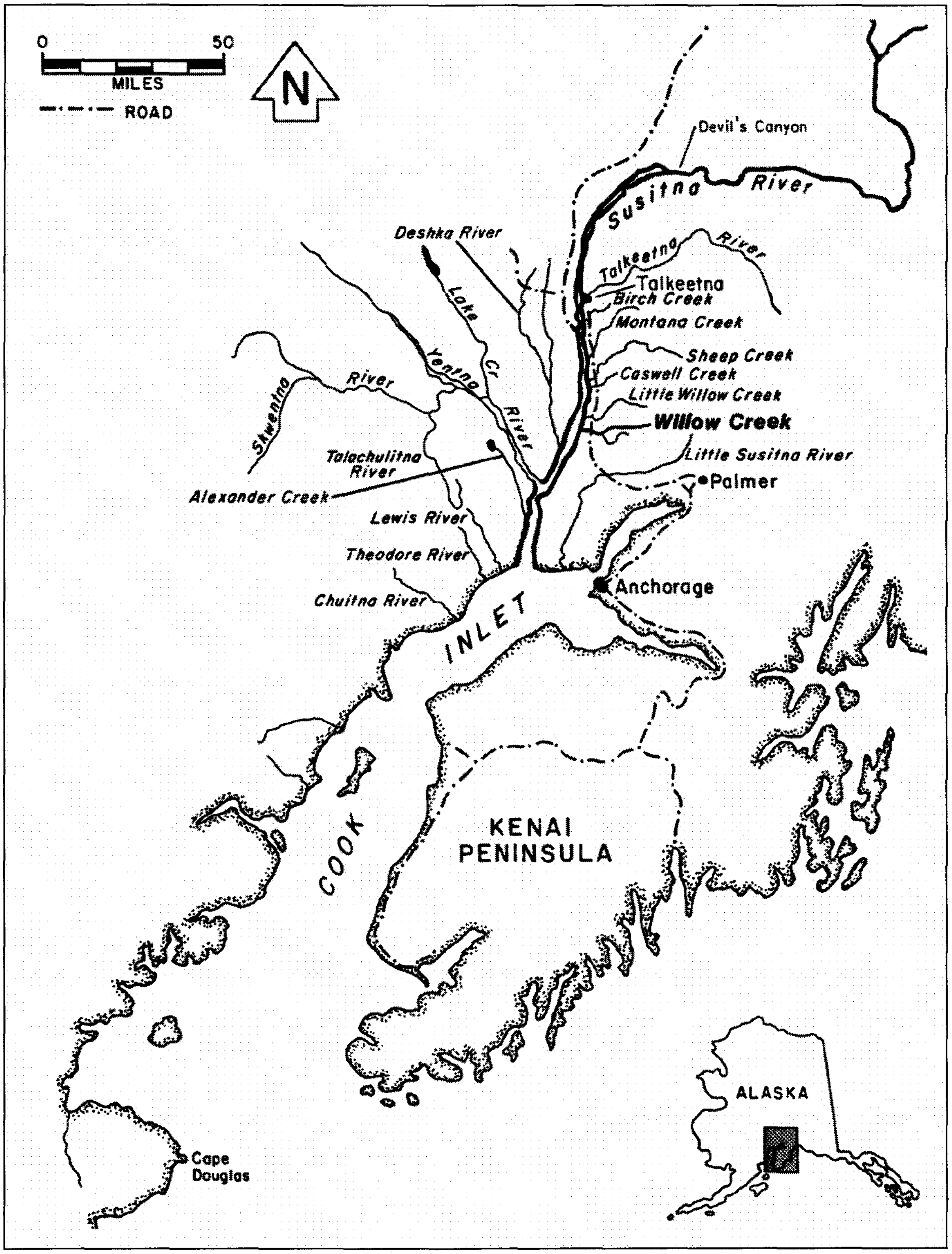


Figure 14.–Susitna River drainage.

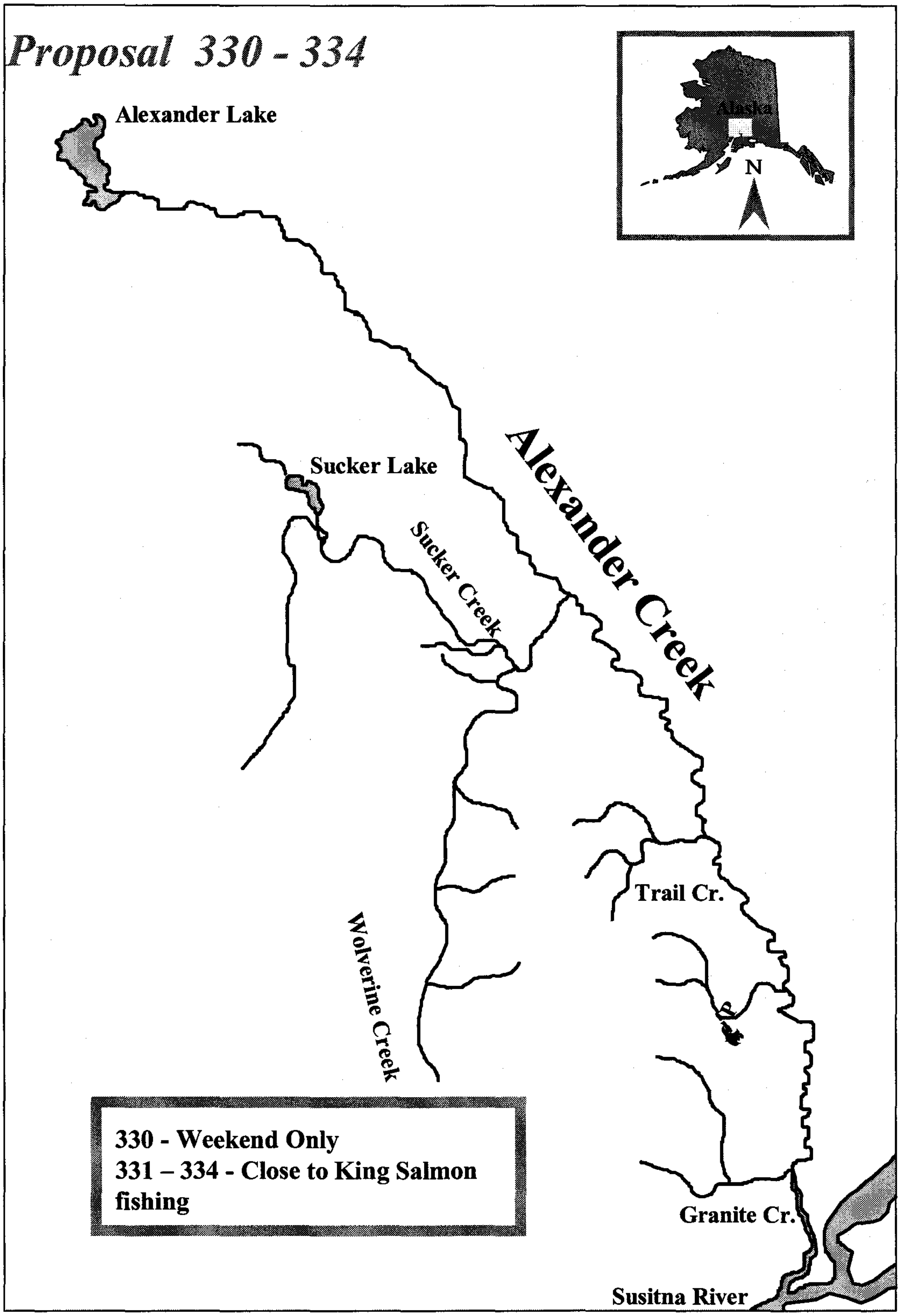


Figure 15.–Alexander Creek.

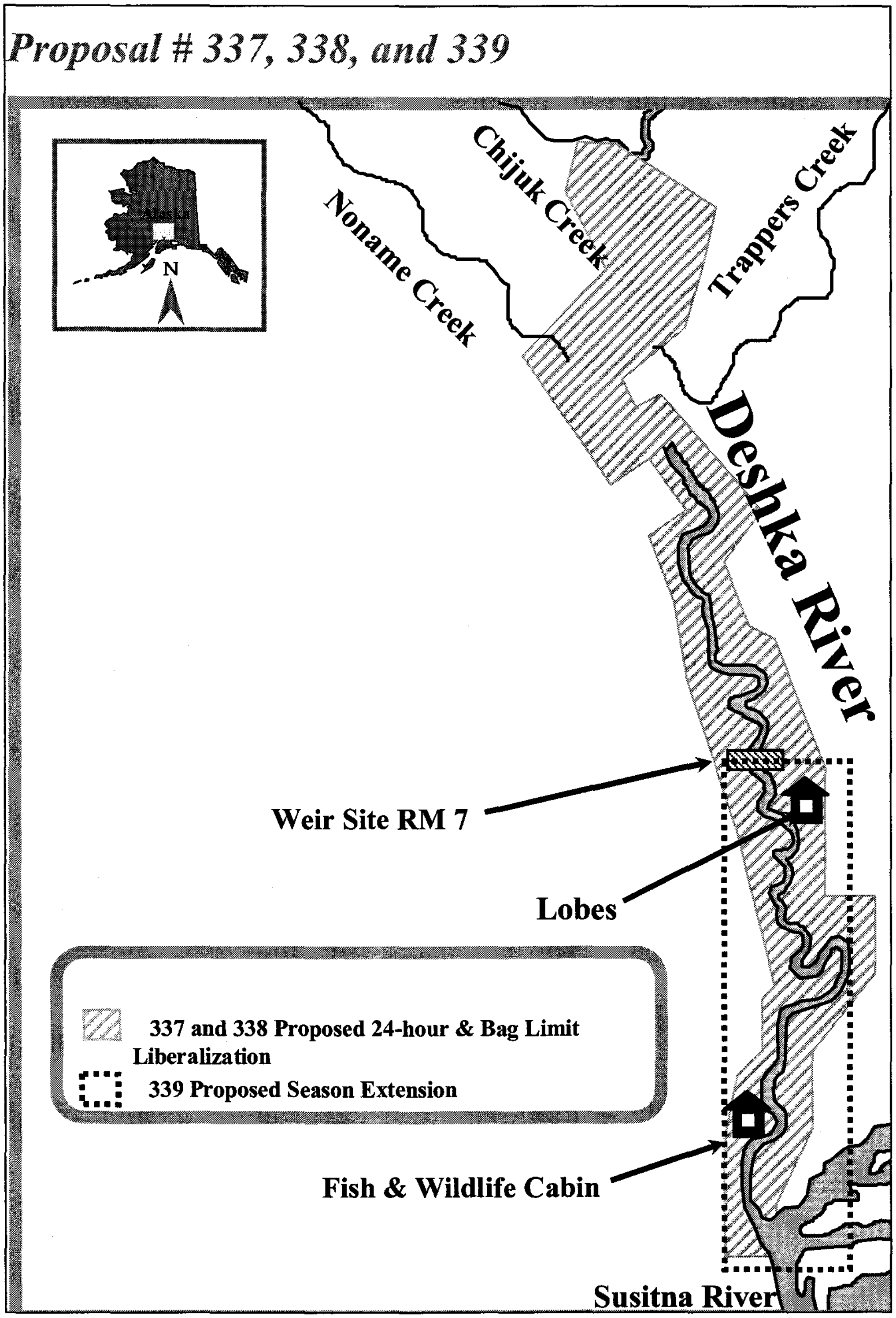


Figure 16.–Deshka River.

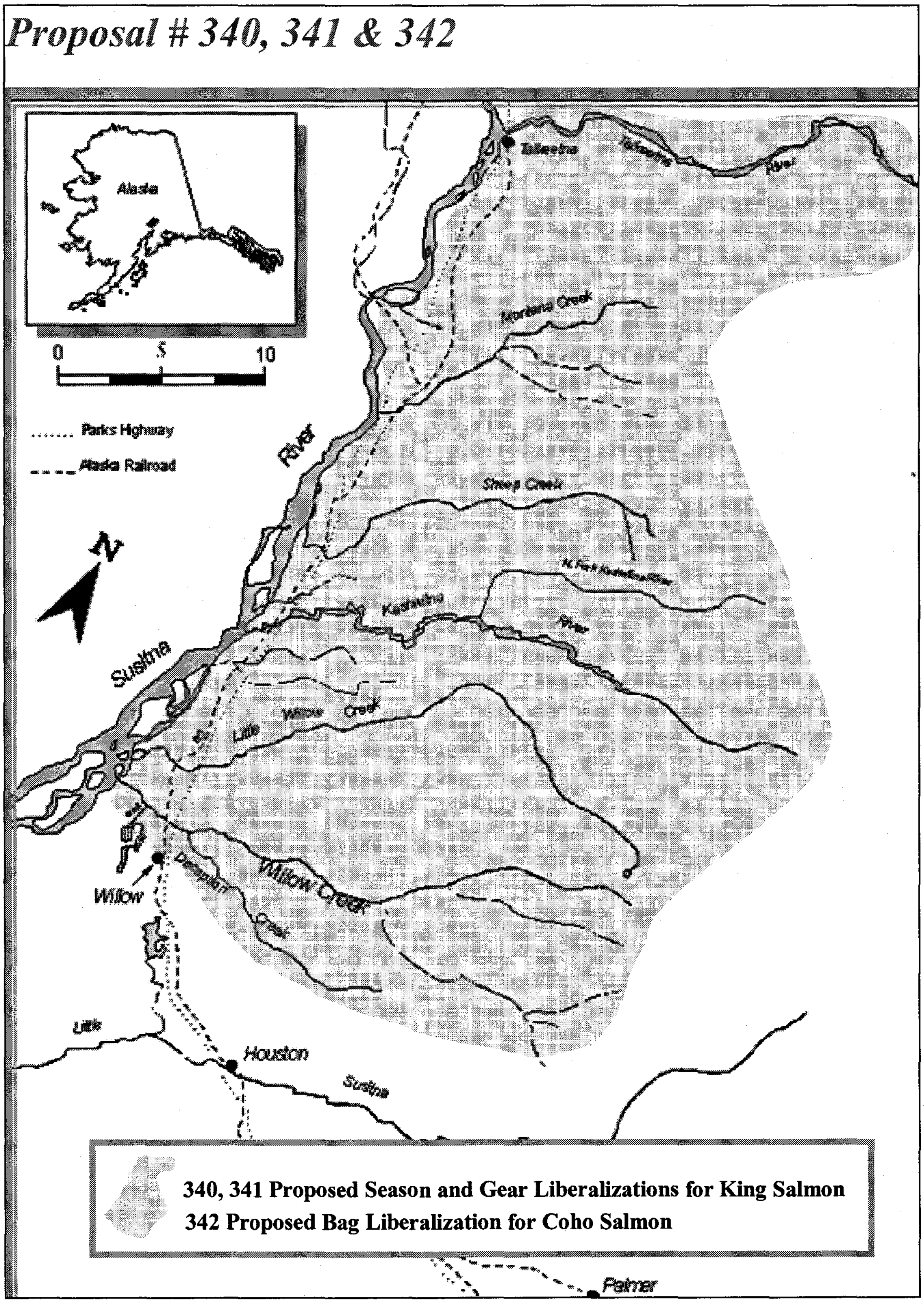


Figure 17.–East side drainage of the Susitna River.

Proposal # 343

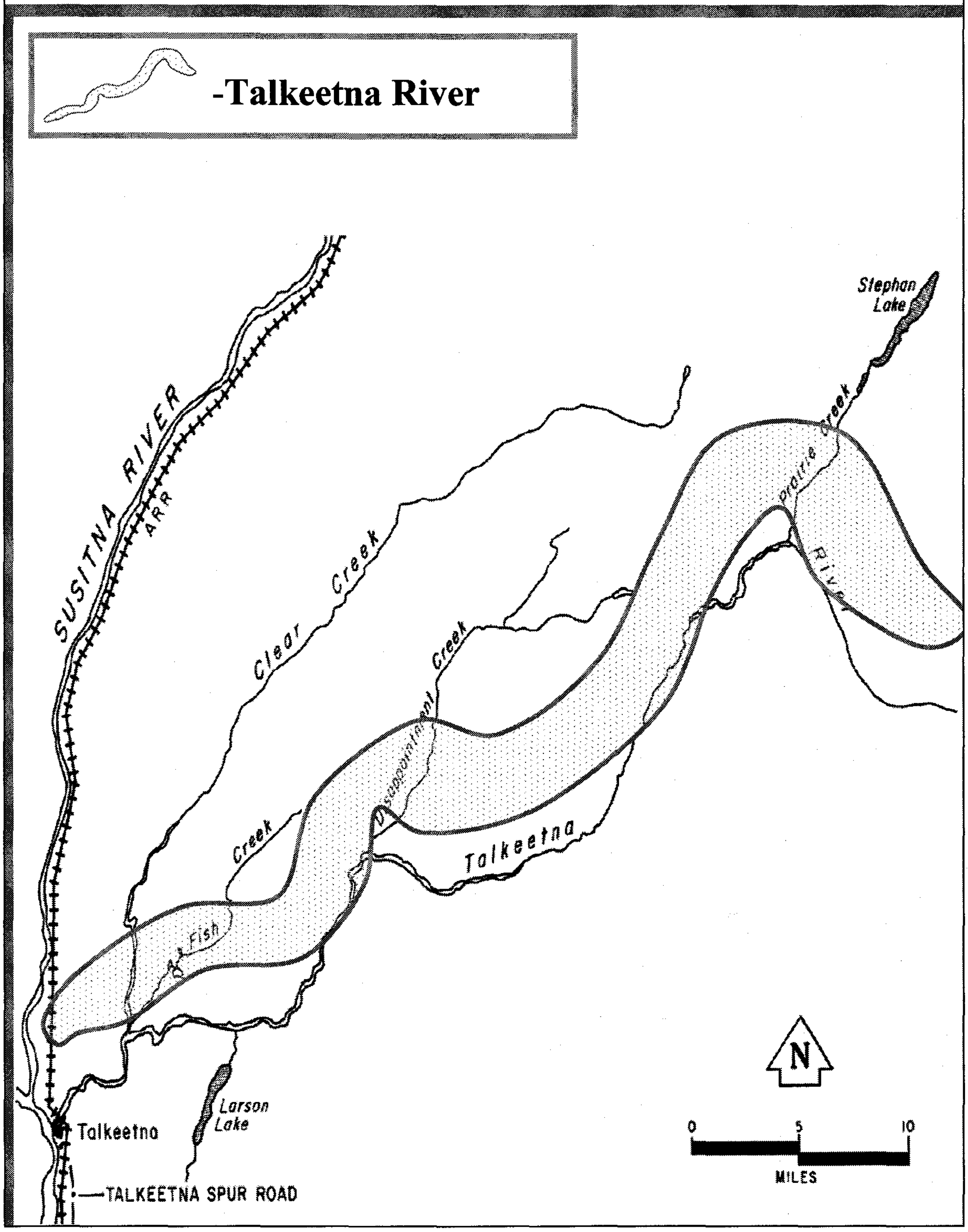


Figure 18.–Talkeetna River.

Proposal # 344

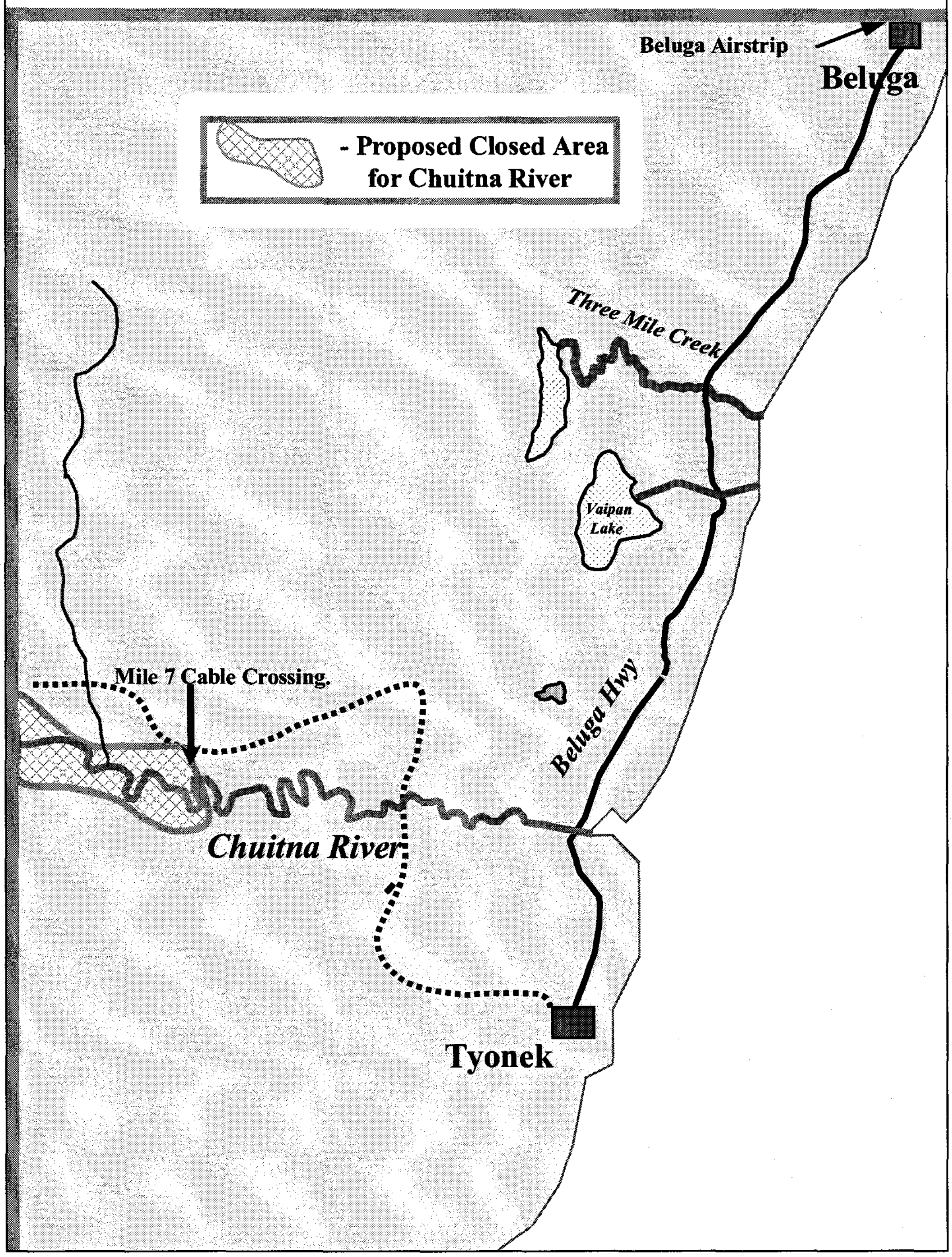


Figure 19.–Chuitna River.

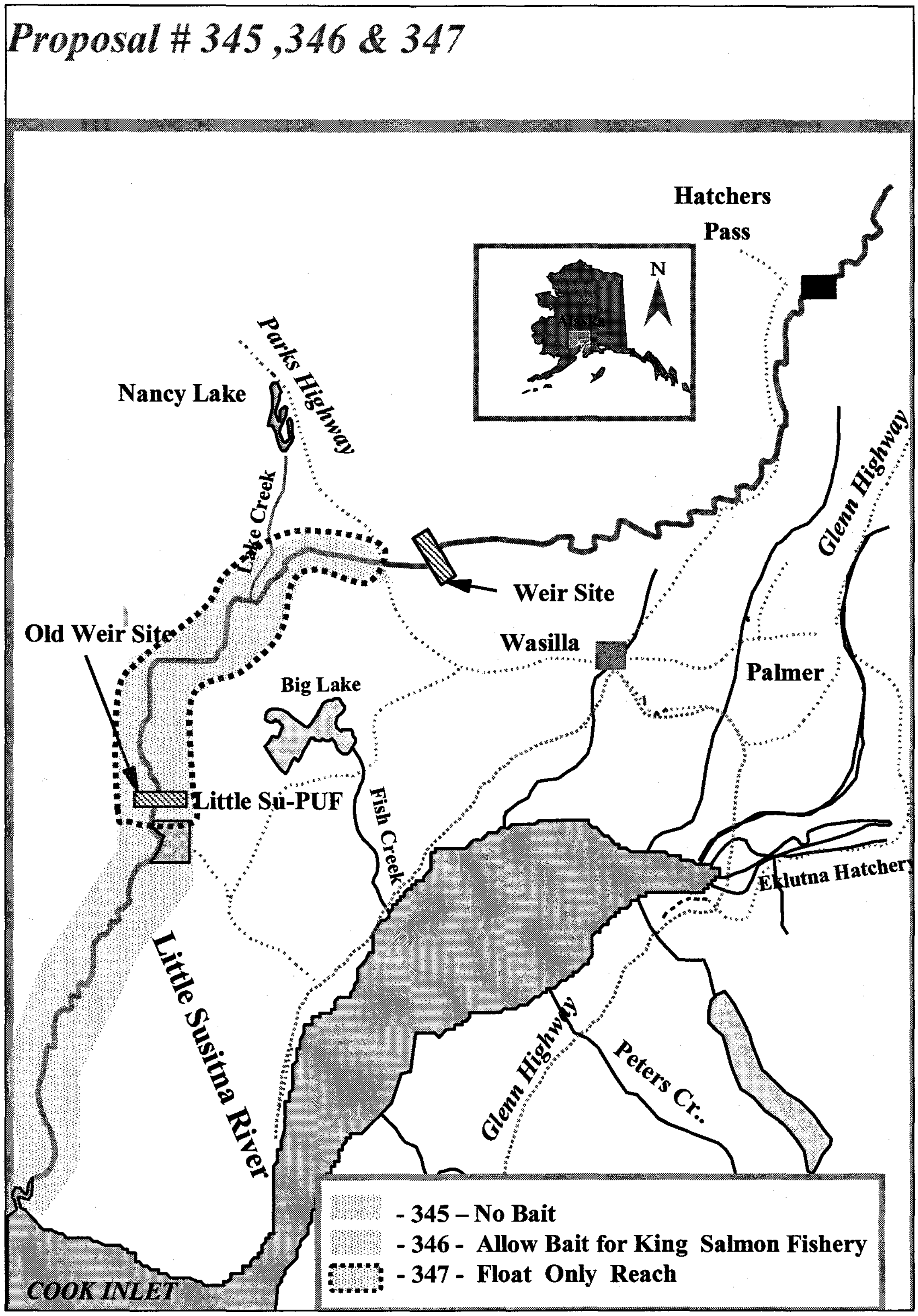


Figure 20.–Little Susitna River.

Proposal # 348, 349 ,350 & 351

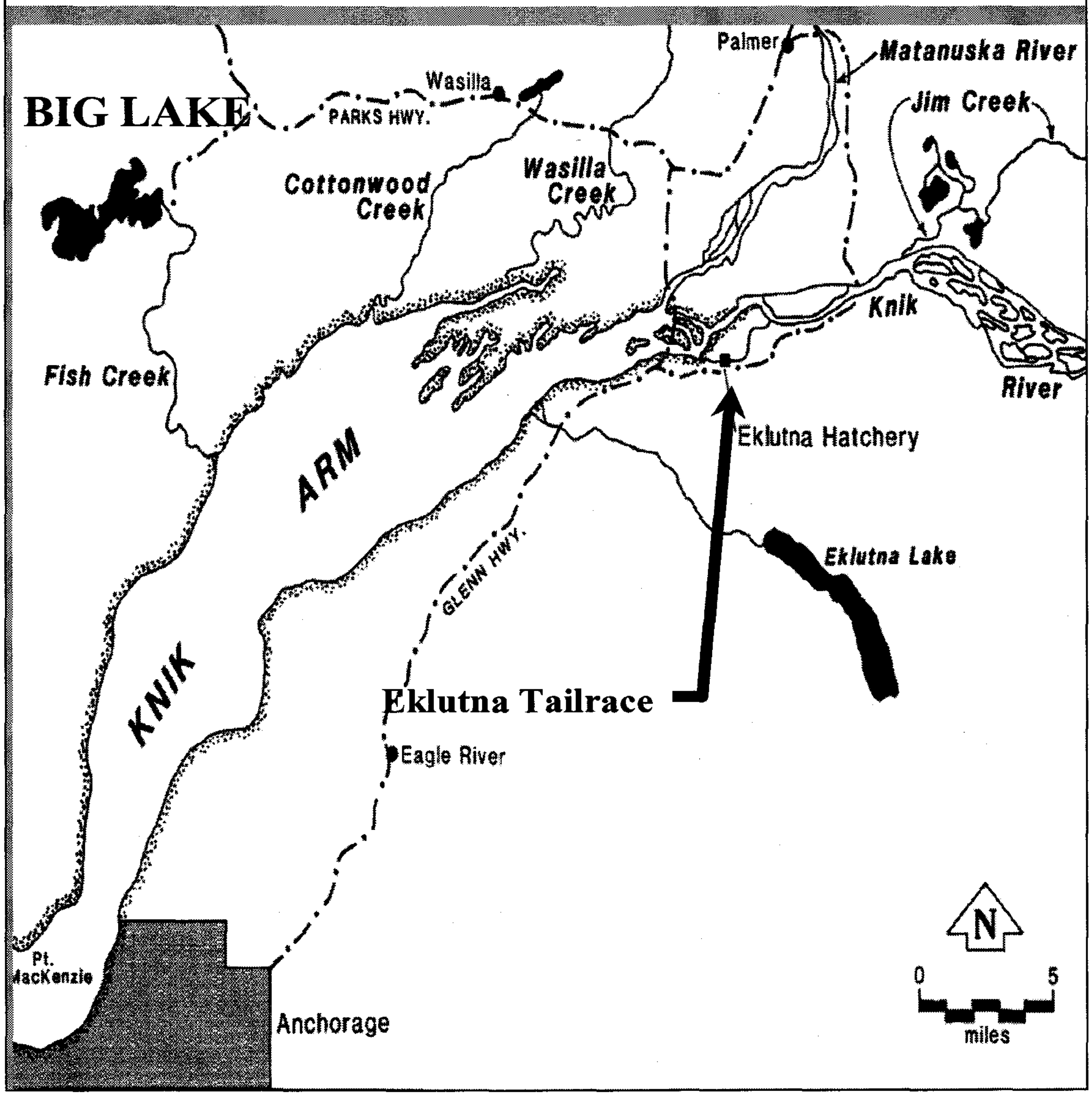
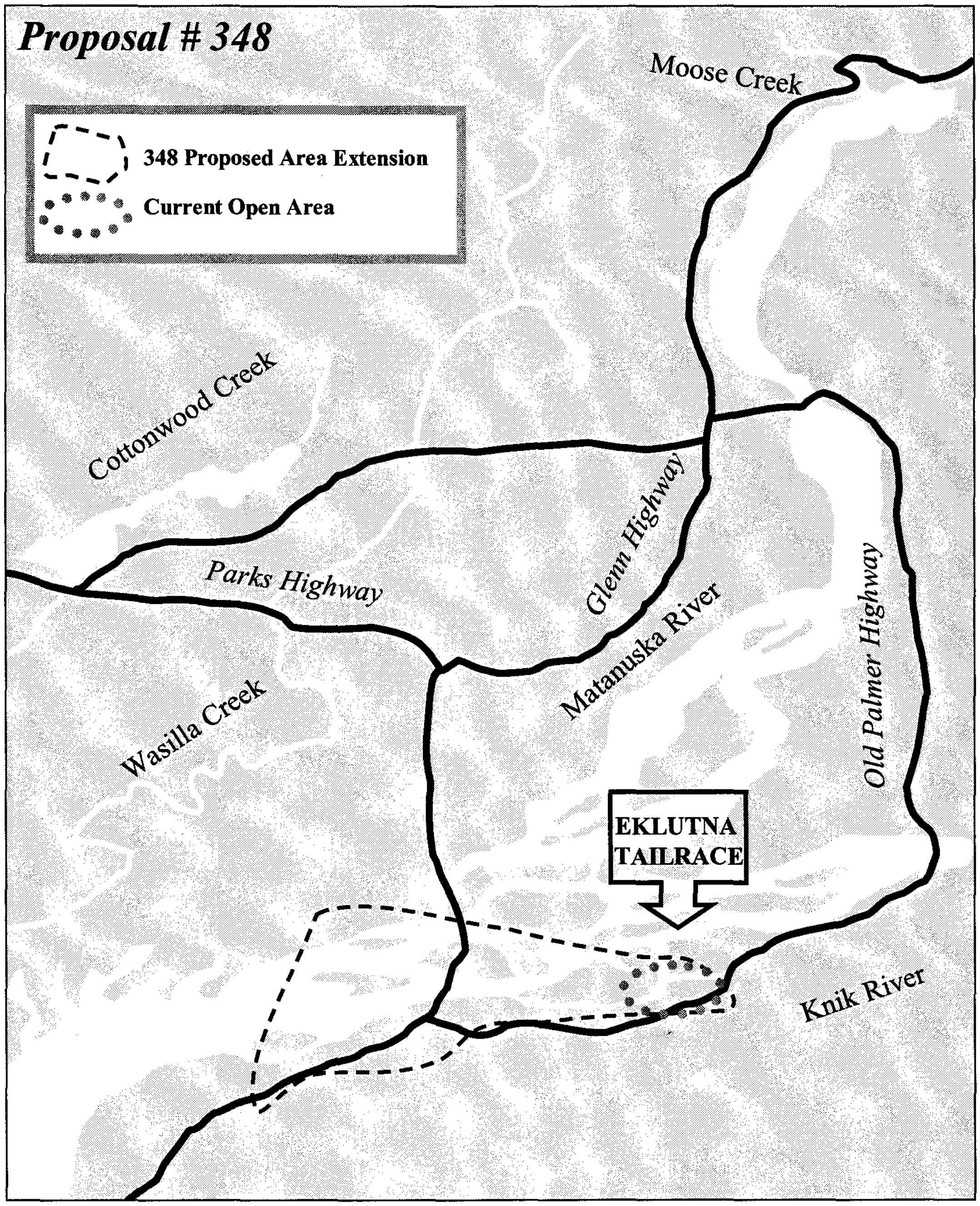


Figure 21.–Big Lake area.



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Proposal # 352 and 353

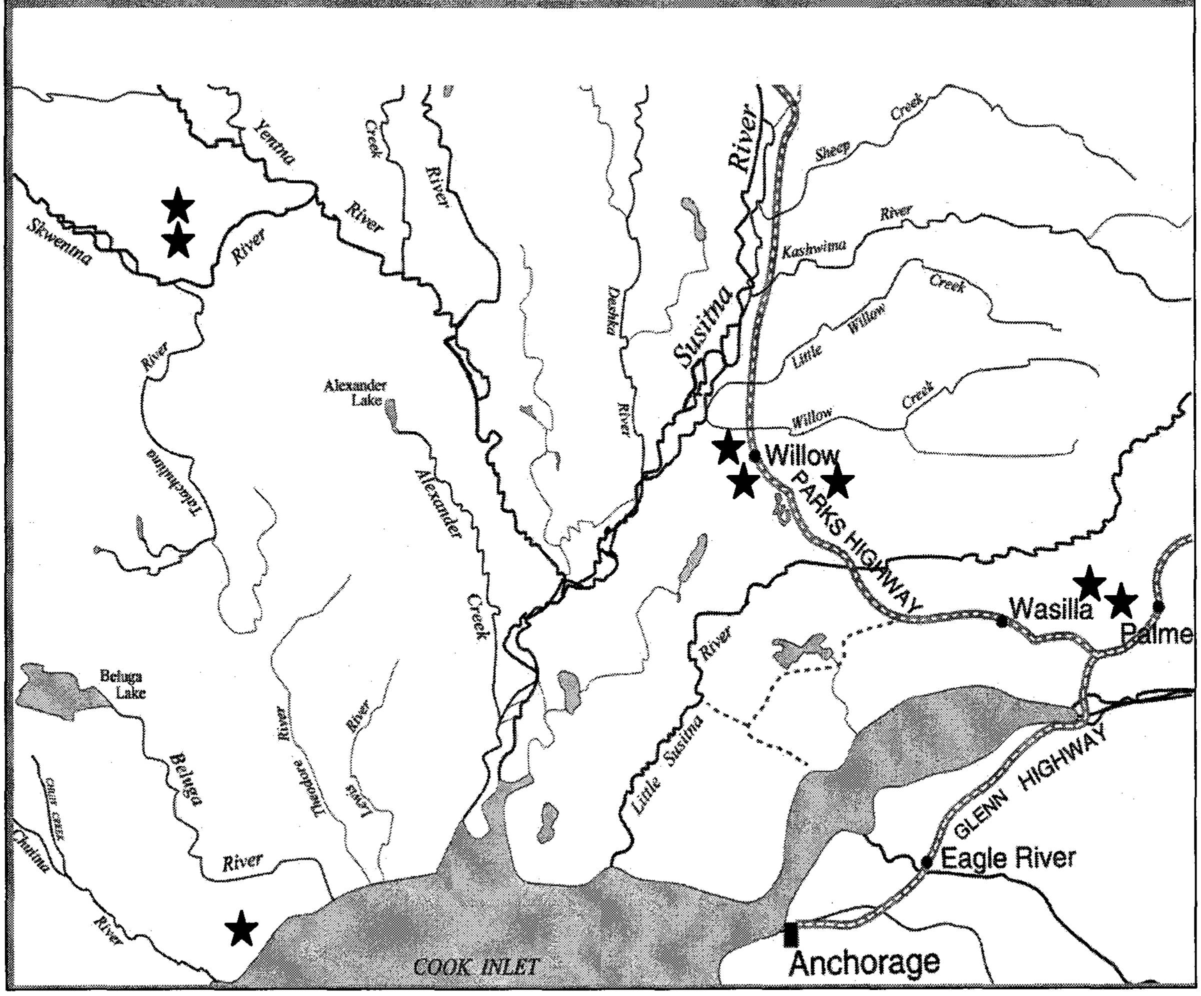

Figure 23.–Selected Northern District lakes.

Proposal # 354 and 355

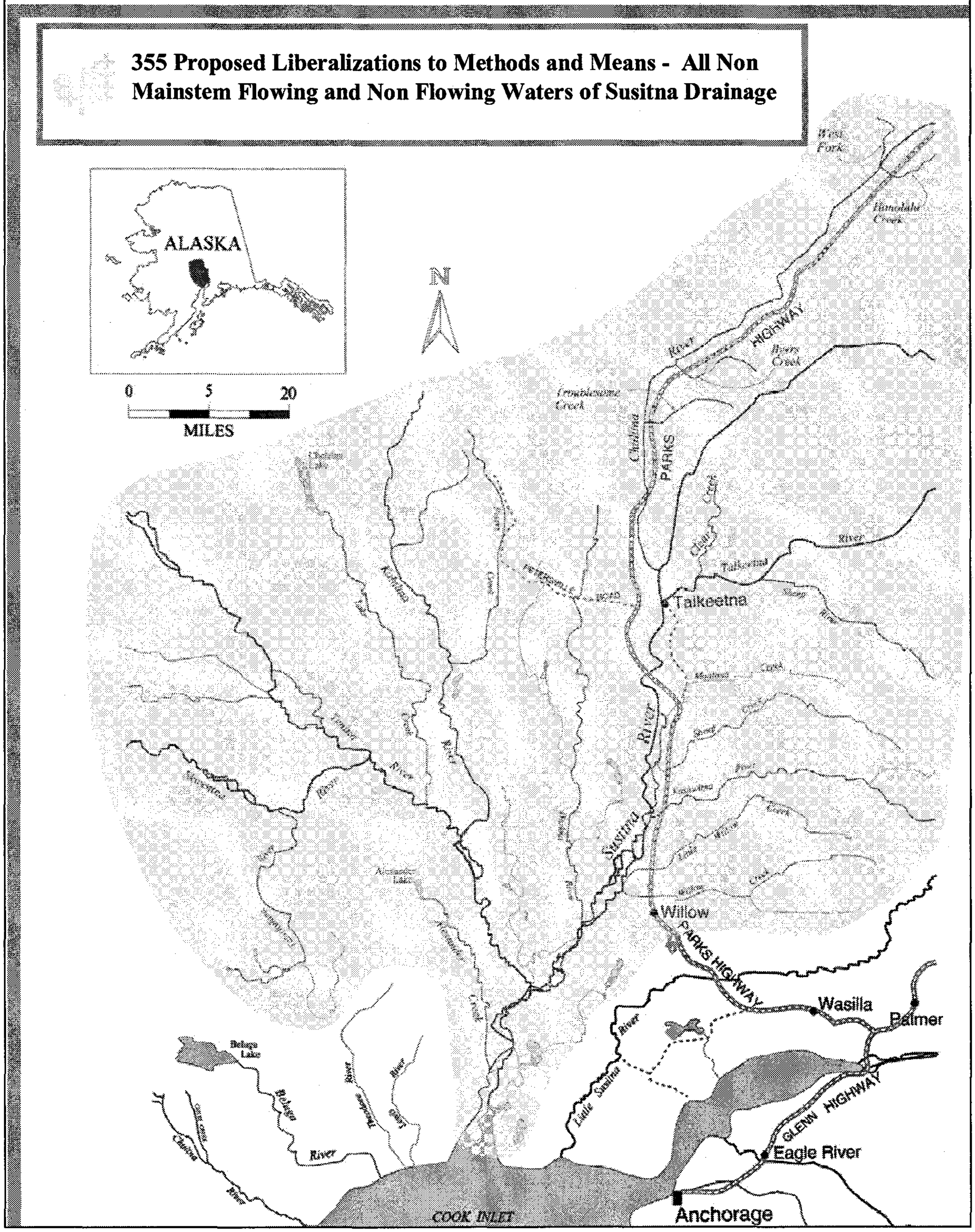

Figure 24.–Susitna River drainage area.

Proposal # 356 & 358

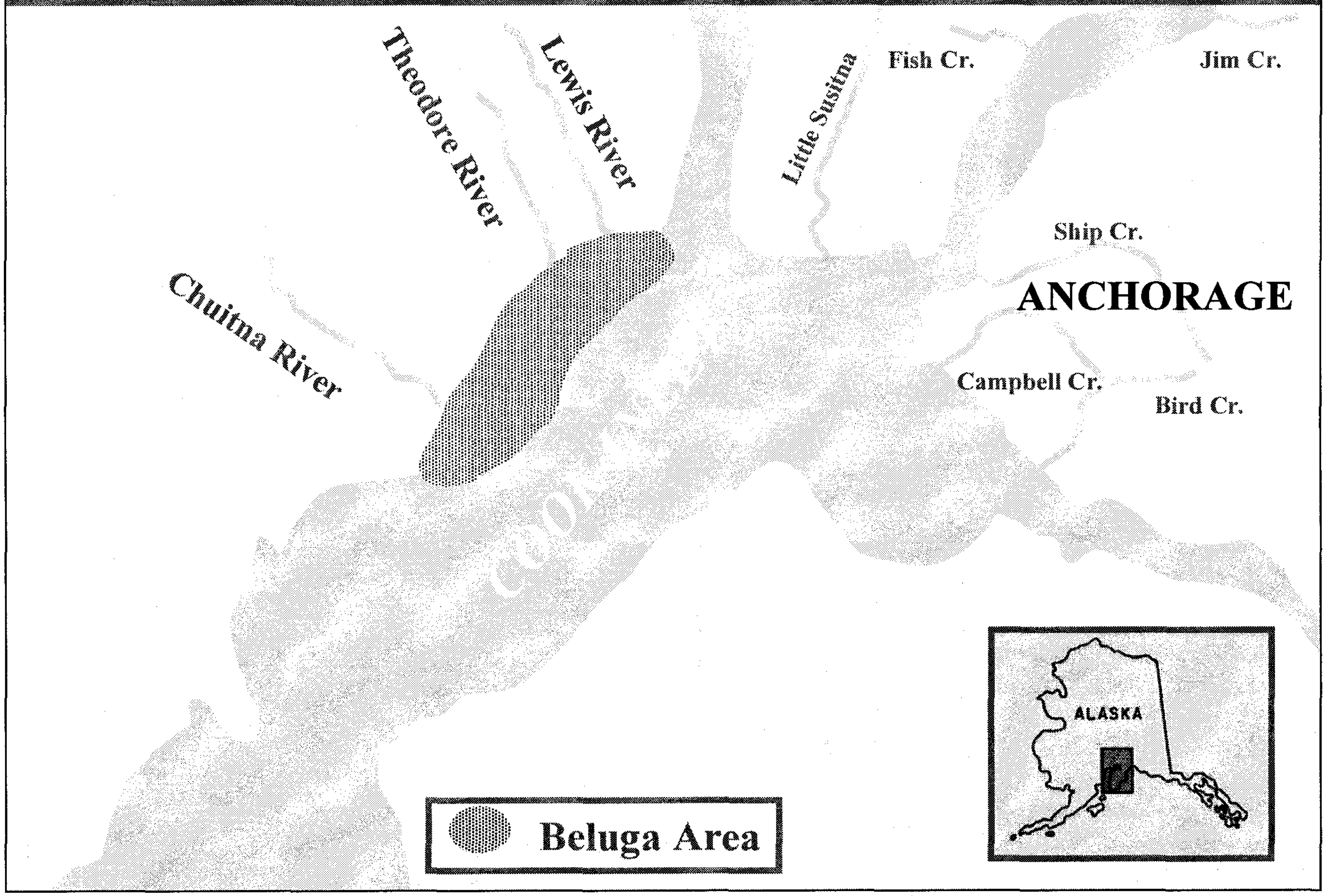

Figure 25.–Western Cook Inlet area.