Fishery Data Series No. 13-63

Mixed Stock Analysis and Age, Sex, and Length Composition of Chinook Salmon in the Eastside Set Gillnet Fishery in Upper Cook Inlet, Alaska, 2010–2013

by

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December 2013

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)

Mathematics, statistics

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

FISHERY DATA SERIES NO. 13-63

MIXED STOCK ANALYSIS AND AGE, SEX, AND LENGTH COMPOSITION OF CHINOOK SALMON IN THE EASTSIDE SET GILLNET FISHERY IN UPPER COOK INLET, ALASKA, 2010–2013

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ABSTRACT

Chinook salmon were sampled for genetic tissue and age, sex, and length (ASL) composition from the Upper Cook Inlet Eastside set gillnet commercial fishery in the years 2010–2013. Mixed-stock analysis (MSA) was conducted on tissue samples collected in 2010, 2011, and 2013. MSA was not conducted on tissue samples collected in 2012 due to low sample size. Initial MSA results from 2010 and 2011 were reanalyzed using an updated genetic baseline and the same reporting groups used in the 2013 MSA. The four reporting groups representing spawning aggregates used to apportion the Chinook salmon harvest were: "*Kenai River mainstem*," "*Kenai River tributaries*," "*Kasilof River mainstem*," and "*Cook Inlet other*." In 2013, reporting group proportions and ASL compositions were stratified temporally and geographically. In 2010 and 2011, reporting group proportions were not stratified and ASL compositions were stratified temporally but not geographically. *Kenai River mainstem* fish averaged 69% of the total harvest followed by *Kasilof River mainstem* fish, averaging 29% of the total harvest. The remaining reporting groups, *Cook Inlet other* (average 1.4%) and *Kenai River tributaries* (average 0.4%), accounted for a very small percentage of the harvest. The harvest of *Kenai River mainstem* Chinook salmon was 4,536 (SD 263) fish in 2010, 5,135 (SD 309) fish in 2011, and 2,256 (SD 68) fish in 2013. In 2013, within the Kasilof River special harvest area, the harvest of *Kenai River mainstem* Chinook salmon was 84 (SD 31) fish or 24% (SD 9%) of the harvest within the area. Age composition of the Chinook salmon harvest varied from year to year. Predominant age classes were age-1.3 (36%) in 2010, age-1.2 (34%) in 2011, both age-1.3 (36%) and age-1.4 (37%) in 2012, and age-1.2 (44%) in 2013. In 2013, 22% of the harvest was age-1.1 fish (jacks), the highest proportion of jacks ever observed. Sex composition was predominately males. In 2013, the harvest was composed of 88% males, the highest proportion ever observed. Average mid eye to tail fork (METF) length was 743 mm, 794 mm, 818 mm, and 658 mm in 2010–2013, respectively with 2013 the lowest average METF length ever observed.

Key words: Chinook salmon, Upper Cook Inlet, *Oncorhynchus tshawytscha*, Kenai River, Kasilof River, late run, genetic stock identification, GSI, mixed stock analysis, MSA, ASL, ESSN, UCI, commercial fishery.

INTRODUCTION

The commercial fishery in Cook Inlet is one of the largest within the state of Alaska in terms of limited entry salmon permits (Clark et al. 2006). Nearly 10% of all salmon permits issued statewide are in Upper Cook Inlet (UCI) and the harvest typically represents approximately 5% of the statewide catch (Shields and Dupuis 2013). The UCI commercial fisheries management area consists of that portion of Cook Inlet north of the Anchor Point Light (lat 50° 46.15′N) and is divided into the Central and Northern districts (Figure 1). The Central District is approximately 75 miles long, averages 32 miles in width, and is divided into 6 subdistricts (Figure 1). Both set (fixed) and drift gillnets are used in the Central District, while set gillnets are the only gear permitted in the Northern District.

All five species of Pacific salmon are harvested in UCI, but sockeye salmon (*Oncorhynchus nerka*) make up the majority of the harvest (Shields and Dupuis 2013). Harvest statistics are monitored by the Alaska Department of Fish and Game (ADF&G) through the fish ticket system. Harvest data is available and reported by 5-digit statistical areas. Most of the UCI Chinook salmon (*O. tshawytscha*) harvest occurs in the Upper Subdistrict of the Central District, and is commonly referred to as the Eastside set gillnet (ESSN) fishery, located along the eastern shore of Cook Inlet between Ninilchik and Boulder Point (Figure 2). Since 1966, on average the ESSN fishery has accounted for 65% of all Chinook salmon harvested in UCI commercial fisheries (Table 1).

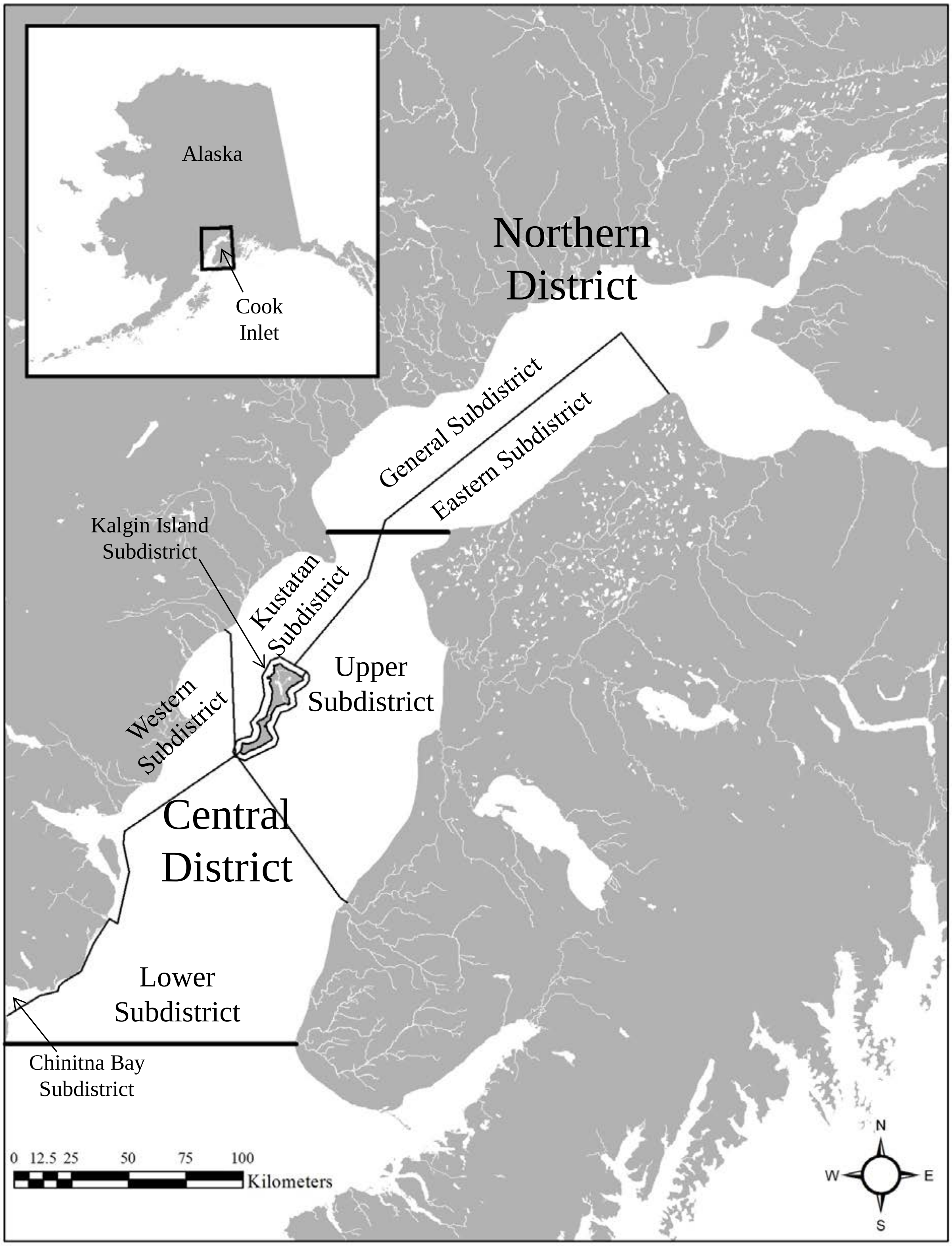

Figure 1.–Map of Upper Cook Inlet commercial fishing districts and subdistricts.

Note: thick lines indicate district borders and thin lines indicate subdistrict borders.

Table 1.–Upper Cook Inlet commercial Chinook salmon harvest by gear type and area, 1966–2013.

	Central District						Northern District		
	Eastside set gillnet		Drift gillnet		Kalgin and Westside set		Set gillnet		
Year	Number	%	Number	%	Number	%	Number	%	Total
1966	7,329	85.8	392	4.6	401	4.7	422	4.9	8,544
1967	6,686	85.1	489	6.2	500	0.1	184	2.3	7,859
1968	3,304	72.8	182	4.0	579	0.1	471	10.4	4,536
1969	5,834	47.1	362	2.9	3,286	0.3	2,904	23.4	12,386
1970	5,368	64.4	356	4.3	1,152	0.1	1,460	17.5	8,336
1971	7,055	35.7	237	1.2	2,875	0.1	9,598	48.6	19,765
1972	8,599	53.5	375	2.3	2,199	0.1	4,913	30.5	16,086
1973	4,411	84.9	244	4.7	369	0.1	170	3.3	5,194
1974	5,571	84.5	422	6.4	434	0.1	169	2.6	6,596
1975	3,675	76.8	250	5.2	733	0.2	129	2.7	4,787
1976	8,249	75.9	690	6.4	1,469	0.1	457	4.2	10,865
1977	9,730	65.8	3,411	23.1	1,084	0.1	565	3.8	14,790
1978	12,468	72.1	2,072	12.0	2,093	0.1	666	3.8	17,299
1979	8,671	63.1	1,089	7.9	2,264	0.2	1,714	12.5	13,738
1980	9,643	69.9	889	6.4	2,273	0.2	993	7.2	13,798
1981	8,358	68.3	2,320	19.0	837	0.1	725	5.9	12,240
1982	13,658	65.4	1,293	6.2	3,203	0.2	2,716	13.0	20,870
1983	15,042	72.9	1,125	5.5	3,534	0.2	933	4.5	20,634
1984	6,165	61.3	1,377	13.7	1,516	0.2	1,004	10.0	10,062
1985	17,723	73.6	2,048	8.5	2,427	0.1	1,890	7.8	24,088
1986	19,826	50.5	1,834	4.7	2,108	0.1	15,488	39.5	39,256
1987	21,159	53.6	4,552	11.5	1,029	0.0	12,700	32.2	39,440
1988	12,859	44.2	2,237	7.7	1,148	0.0	12,836	44.1	29,080
1989	10,914	40.8	0	0.0	3,092	0.1	12,731	47.6	26,737
1990	4,139	25.7	621	3.9	1,763	0.1	9,582	59.5	16,105
1991	4,893	36.1	246	1.8	1,544	0.1	6,859	50.6	13,542
1992	10,718	62.4	615	3.6	1,284	0.1	4,554	26.5	17,171
1993	14,079	74.6	765	4.1	720	0.0	3,307	17.5	18,871
1994	15,575	78.0	464	2.3	730	0.0	3,193	16.0	19,962
1995	12,068	67.4	594	3.3	1,101	0.1	4,130	23.1	17,893
1996	11,564	80.8	389	2.7	395	0.0	1,958	13.7	14,306
1997	11,325	85.2	627	4.7	207	0.0	1,133	8.5	13,292
1998	5,087	62.6	335	4.1	155	0.0	2,547	31.4	8,124
1999	9,463	65.8	575	4.0	1,533	0.1	2,812	19.6	14,383

-continued-

Table 1.–Part 2 of 2.

	Central District						Northern District		
	ESSN		Drift gillnet		Kalgin and West Side set		Set gillnet		
Year	Number	%	Number	%	Number	%	Number	%	Total
2000	3,684	50.1	270	3.7	1,089	0.1	2,307	31.4	7,350
2001	6,009	64.6	619	6.7	856	0.1	1,811	19.5	9,295
2002	9,478	74.5	415	3.3	926	0.1	1,895	14.9	12,714
2003	14,810	80.1	1,240	6.7	770	0.0	1,670	9.0	18,490
2004	21,684	80.5	1,104	4.1	2,208	0.1	1,926	7.2	26,922
2005	21,597	78.1	1,958	7.1	739	0.0	3,373	12.2	27,667
2006	9,956	55.2	2,782	15.4	1,030	0.1	4,261	23.6	18,029
2007	12,292	69.7	912	5.2	603	0.0	3,818	21.7	17,625
2008	7,573	56.8	653	4.9	1,124	0.1	3,983	29.9	13,333
2009	5,588	63.9	859	9.8	672	0.1	1,631	18.6	8,750
2010	7,059	71.3	538	5.4	553	0.1	1,750	17.7	9,900
2011	7,697	68.4	593	5.3	659	0.1	2,299	20.4	11,248
2012	704	27.9	218	8.6	555	0.2	1,049	41.5	2,526
2013	2,988	55.4	493	9.1	590	0.1	1,327	25.7	5,398
Average									
1966–2013[a]	9,605	65.2	982	6.5	1,262	0.2	3,112	19.0	14,961
2004–2013	9,714	62.7	1,011	7.5	873	0.1	2,542	21.7	14,140

Source: 1966–2012 data, Shields and Dupuis (2013: Appendix B1).

[a] Data from 1989 were not used in averages, because the drift fleet did not fish following the Exxon Valdez oil spill, which affected all other fisheries.

Recent low Chinook salmon runs have heightened concerns about stock-specific harvest of Chinook salmon. There are a variety of reasons to obtain stock-specific harvest information about Chinook salmon, including improved understanding of stock productivity, development of brood tables for long-term stock assessment, and setting and attaining escapement goals. Past attempts to estimate the contribution of major Chinook salmon stocks to the ESSN fishery harvest have used data collected on the magnitude and timing of runs with respect to age, sex, and size; however, the accuracy and precision of these estimates were not known. In 1984, the contribution of late-run Kenai River Chinook salmon to the major age components (ocean ages 3 and 4) was estimated to be 75% (McBride et al. 1985). For purposes of stock assessment, all Chinook salmon harvested in the ESSN fishery has been attributed historically as Kenai River late-run fish because it was generally accepted that Kenai River late-run fish made up the majority of the harvest, even though the ESSN fishery harvests other stocks (Eskelin and Miller 2010; McKinley and Fleischman 2010).

Fortunately, recent advancements have occurred in the mixed stock analysis (MSA) of Pacific salmon using genetic analyses that allow for discriminating among discrete stocks in mixed-stock fishery samples (e.g., Habicht et al. 2010). In 2012, a UCI Chinook salmon genetic baseline was developed, which included 30 populations and 40 single nucleotide polymorphism (SNP) loci (Barclay et al. 2012). The baseline showed potential for use in MSA applications; however, additional UCI populations were needed to increase representation of stocks in the baseline to allow for a more comprehensive analysis of fishery mixtures. Since then, the baseline has been augmented with additional collections and previously unrepresented populations (Barclay et al. *In prep*) and it is now available for use for MSA in UCI fisheries.

The ESSN Chinook salmon harvest has been sampled for age, sex, and length (ASL) composition annually since the 1980s (Eskelin and Miller 2010). Genetic tissue samples were added to the collection effort beginning in 2010. In 2012, the Kenai River and Susitna River Chinook salmon stocks were selected as 2 of the 12 indicator stocks in the Alaska Statewide Chinook Salmon Research Initiative (CSRI; ADF&G Chinook Salmon Research Team 2013). In fall of 2012, an initial MSA was performed on the ESSN Chinook salmon samples collected in 2010 and 2011. MSA results were disseminated as a memorandum to the directors of the Commercial Fisheries and Sport Fish divisions and were later reported in Appendix B of Fleischman and McKinley (2013). The ADF&G Chinook Salmon Research Team (2013) identified a project to comprehensively estimate stock-specific harvest of Chinook salmon in Cook Inlet fisheries. Through additional funding as part of that project, sampling effort was increased in 2013 to improve temporal and geographic coverage of the fishery and allow for more precise harvest estimates by reporting groups. This report describes the ESSN fishery ASL and genetic tissue sampling effort, analyses, and results from 2010 to 2013.

GOALS AND OBJECTIVES

2010–2012

The sampling goal for each season was to collect ASL samples from 20% of the reported Chinook salmon harvest or 500 samples total. No formal objectives were set for tissue collections because the genetics baseline was incomplete and no tests could be done on MSA performance. Tissue samples were collected in conjunction with ASL samples.

2013

Objectives for 2013 were as follows:

1) Estimate the proportion of Chinook salmon harvested in the UCI ESSN commercial fishery by reporting group for each temporal and geographic stratum for the season such that the estimated proportions are within 13 percentage points of the true values 90% of the time.
2) Estimate the harvest of Chinook salmon in the UCI ESSN commercial fishery by reporting group for each temporal and geographic stratum such that the estimates are within 28% of the true value, 90% of the time.
3) Estimate the age composition of the Chinook salmon harvested by the ESSN fishery such that the estimates are within 10 percentage points of the true values 95% of the time.

METHODS

STUDY DESIGN

Sampling by Year

2010–2012

During 2010–2012, one Alaska Department of Fish and Game (ADF&G) sampler travelled to receiving sites for fish processing plants after each tide and sampled available Chinook salmon for genetic tissue and ASL. The number and location of receiving sites can vary from year to year but is generally between 20 and 25 sites. Approximate locations of the receiving sites and fish processing plants that were sampled are shown in Figure 2 in relation to where the fishery occurs. Generally, only regularly scheduled fishing periods (occurring on Mondays and Thursdays) were sampled, although a few fishery openings that occurred by ADF&G Emergency Order were sampled. Generally, over half of the fishery openings were sampled. During a fishing period, as many sites as possible were sampled; some were sampled more than once. Sampling began after the first round of deliveries to the receiving sites had occurred, starting at the southern-most receiving station near Ninilchik and progressing northward to each major receiving site up to East Forelands. The sampler attempted to collect as many Chinook salmon samples as possible while distributing sampling effort throughout the area. The day following each fishing period, additional Chinook salmon samples were collected at a fish processing plant that paid premium prices, where fish from all areas were delivered.

2013

A similar sampling protocol was used in 2013; however, 3 additional samplers were employed to increase coverage of the fishery. With the additional samplers, the sampling area was divided into 3 areas: 1) Ninilchik and Cohoe beaches, 2) South Kalifornsky Beach (K-Beach) and North K-beach, and 3) Salamatof Beach and East Forelands Section (Figure 2). Sampling was conducted in the same manner as for the years 2010–2012, but instead of 1 sampler assigned to all 3 areas, at least 1 sampler was assigned to each area. When feasible, all receiving sites were sampled after each tide. In addition to sampling the regular fishing periods on Mondays and Thursdays, fishing periods opened by Emergency Order were also sampled.

Age, Sex and Length Sampling

Three scales were removed from the preferred area of each fish and placed on an adhesive-coated card (Clutter and Whitesel 1956; Welander 1940). Acetate impressions were made of each scale card and scales were aged using a microfiche reader. Sex was generally identified from external morphometric characteristics (i.e., protruding ovipositor on females or a developing kype on males). Mid eye to tail fork (METF) length was measured to the nearest half-centimeter. In the years 2010–2012, bellies of Chinook salmon less than 710 mm METF were slit and viscerally examined to verify sex. In 2013, no visceral examinations were performed because in the 2010–2012 samples, nearly all fish less than 710 mm were verified as males. In all years, Chinook salmon were sampled for ASL composition without regard to size, sex, length, or location.

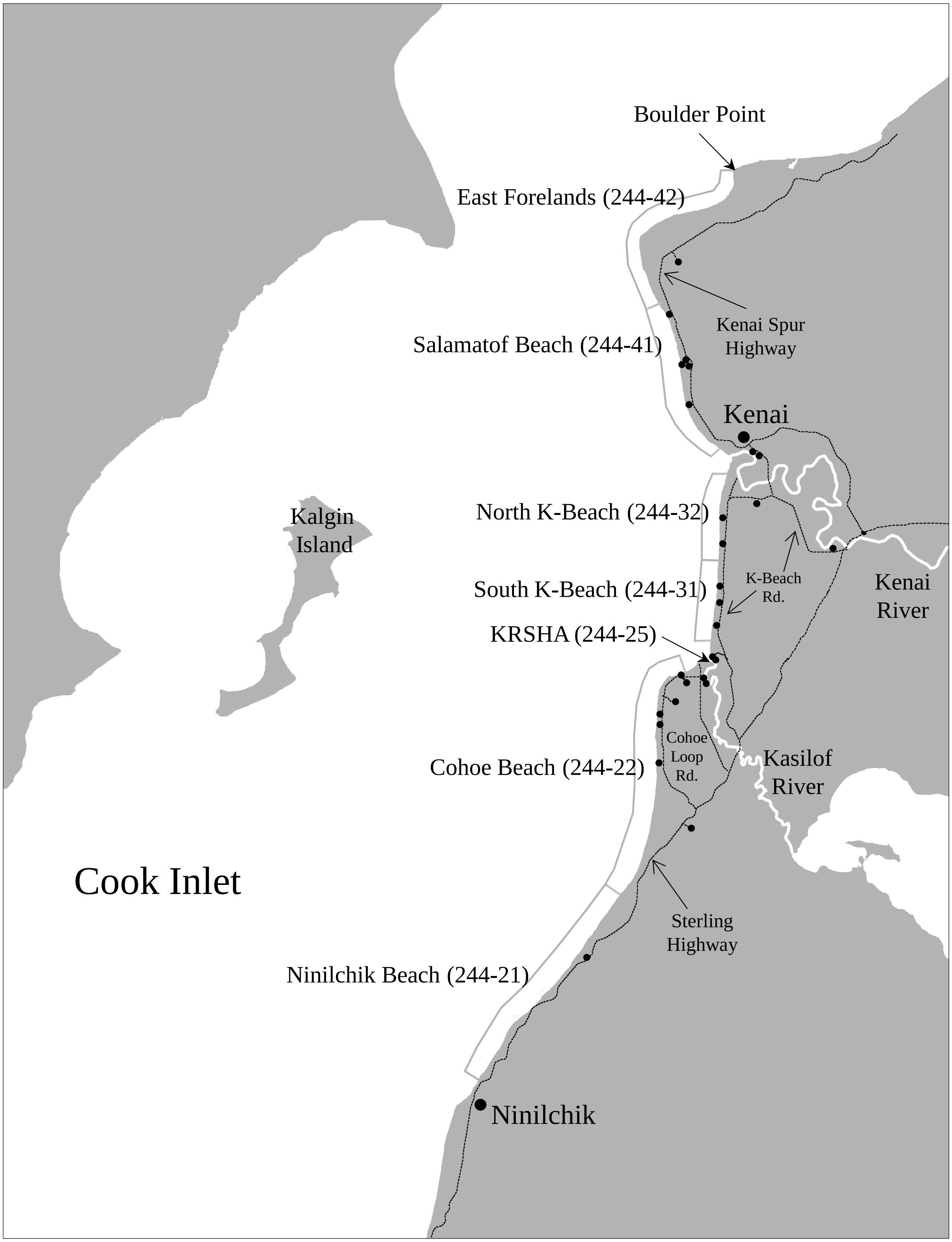

Figure 2.–Map of Upper Cook Inlet Eastside set gillnet commercial fishing statistical areas.

Note: KRSHA (244-25) is Kasilof River special harvest area.

Note: Small circles represent approximate locations of processing plants or receiving sites that were sampled.

Tissue Sampling for MSA

All fish sampled for ASL were also sampled for tissue. A 1⅓-cm (half-inch) piece of axillary process was removed from each fish and placed in a 2-ml plastic vial. Sample vials were then filled until the tissue samples were completely submerged with a Sigma[1] reagent grade 95% alcohol buffer solution such that the liquid-to-tissue ratio was approximately 3:1. Each plastic vial was sequentially numbered and vial numbers were recorded on data sheets.

Geographic and Temporal Stratification

ESSN commercial harvests are reported for 7 statistical areas: Ninilchik Beach (244-22), Cohoe Beach (244-22), South K-Beach (244-31), North K-Beach (244-32), Salamatof Beach (244-41), East Forelands (244-42), and Kasilof River special harvest area (KRSHA) (244-25) (Figure 2). The Kasilof Section is composed of Ninilchik Beach, Cohoe Beach, and South K-Beach. The Kenai Section is composed of North K-Beach and Salamatof Beach. The East Forelands statistical area is its own section, but was grouped with the Kenai Section in this study. KRSHA is not commonly opened for fishing but has been opened at times to concentrate harvest of Kasilof River sockeye salmon while minimizing harvest of other stocks. The Kasilof Section opens the first Monday or Thursday on or after 25 June but can open as early as 20 June if ADF&G estimates that 50,000 sockeye salmon are in the Kasilof River before 25 June (Alaska Administrative Code 5 AAC 21.310 b. 2.C.[i]). The Kenai and East Forelands sections do not open until the first Monday or Thursday on or after 8 July.

Geographic and temporal stratification was done on 2013 data but not for 2010–2012 data, due to low sample sizes; and no MSA was done on 2012 samples. Only seasonal estimates of reporting group proportions and harvest were produced for 2010 and 2011, whereas estimates were divided into the following 4 strata for 2013: 1) prior to 8 July, Kasilof Section; 2) 8–23 July, Kasilof Section; 3) 8–23 July, Kenai and East Forelands sections, and 4) 17 July–2 August, KRSHA.

Baseline and Reporting Groups

The current UCI Chinook salmon genetic baseline used for MSA applications is an update of the baseline reported in Barclay et al. (2012) and includes 35 additional collections and 13 new populations (Table 2). The updated baseline includes the same set of SNP markers except that locus *Ots_FGF6B* was dropped because of its association with locus *Ots_FGF6A*. To minimize misallocation between MSA reporting groups, the Slikok Creek (a Kenai River tributary) population was removed from the baseline because it is very small and is genetically similar to the Crooked Creek (a Kasilof River tributary) population (Barclay et al. 2012). Reporting groups chosen to apportion the harvest were: "*Kenai River mainstem*," "*Kenai River tributaries*," "*Kasilof River mainstem*," and "*Cook Inlet other*." The *Cook Inlet other* reporting group represented all remaining Cook Inlet Chinook salmon baseline populations not included in the three other reporting groups (Table 2 and Figure 3). Juneau Creek, a Kenai River tributary, was grouped with the *Kenai River mainstem* reporting group due to genetic similarity (Barclay et al. 2012). Reporting groups were defined based on one or more of the following criteria: 1) the genetic similarity among populations, 2) the expectation that proportional harvest would be greater than 5%, or 3) the applicability to answer fishery management questions.

[1] Product names used in this publication are included for completeness but do not constitute product endorsement.

Table 2.–Populations of Chinook salmon in the Upper Cook Inlet genetic baseline, including the sampling location, collection years, the number of individuals sampled from each population (N), and the reporting groups used for mixed stock analysis of ESSN harvest.

Map No	Reporting group	Location	Added after baseline[a]	Collection year(s)	N
1	Cook Inlet other	Straight Creek		2010	95
2		Chuitna River		2008, 2009	134
3		Coal Creek		2009, 2010, 2011	118
4		Theodore River	X	2010, 2011	190
5		Lewis River	X	2011, 2012	87
6		Chulitna River		2009, 2010, 2011	182
7		Portage Creek	X	2010, 2011	124
8		Prairie Creek		1995, 2008	160
9		Chunilna Creek		2009, 2012	123
10		Montana Creek		2008, 2009, 2012	213
11		Willow Creek		2005, 2009	170
12		Deshka River		1995, 2005, 2012	303
13		Sucker Creek	X	2011, 2012	143
14		Talachulitna River		1995, 2008, 2010	178
15		Sunflower Creek		2009, 2011	123
16		Peters Creek	X	2009, 2010, 2011, 2012	107
17		Little Susitna River		2009, 2010, 2012	228
18		Moose Creek		1995, 2008, 2009, 2012	149
19		Eagle River	X	2009, 2011, 2012	77
20		Ship Creek		2009	256
21		Campbell Creek	X	2010, 2011, 2012	110
22		Bird Creek	X	2009, 2011, 2012	42
23		Carmen River	X	2011, 2012	50
24		Resurrection Creek	X	2010, 2011, 2012	98
25		Chickaloon River		2008, 2010, 2011	128
26	Kenai R. tributary	Grant Creek	X	2011, 2012	55
27		Quartz Creek		2006, 2007, 2008, 2009, 2010, 2011	131
28		Crescent Creek		2006	164
30		Russian River		2005, 2006, 2007, 2008	213
32		Benjamin Creek		2005, 2006	202
33		Killey River		2005, 2006	254
34		Funny River		2005, 2006	219
29	Kenai R. mainstem	Juneau Creek		2005, 2006, 2007	139
31		Upper Kenai R. mainstem		2009	191
35		Middle Kenai R. mainstem		2003, 2004, 2006	299
36		Lower Kenai R. mainstem	X	2010, 2011	118
37	Kasilof R. mainstem	Kasilof River mainstem		2005	321
38	Cook Inlet other	Crooked Creek		2005	306
39		Ninilchik River		2006, 2010	209
40		Deep Creek		2009, 2010	196
41		Stariski Creek	X	2011, 2012	104
42		Anchor River		2006, 2010	248

Note: Map numbers correspond to sampling sites on Figure 3.

[a] "X" indicates populations that have been added since the Barclay et al. (2012) baseline.

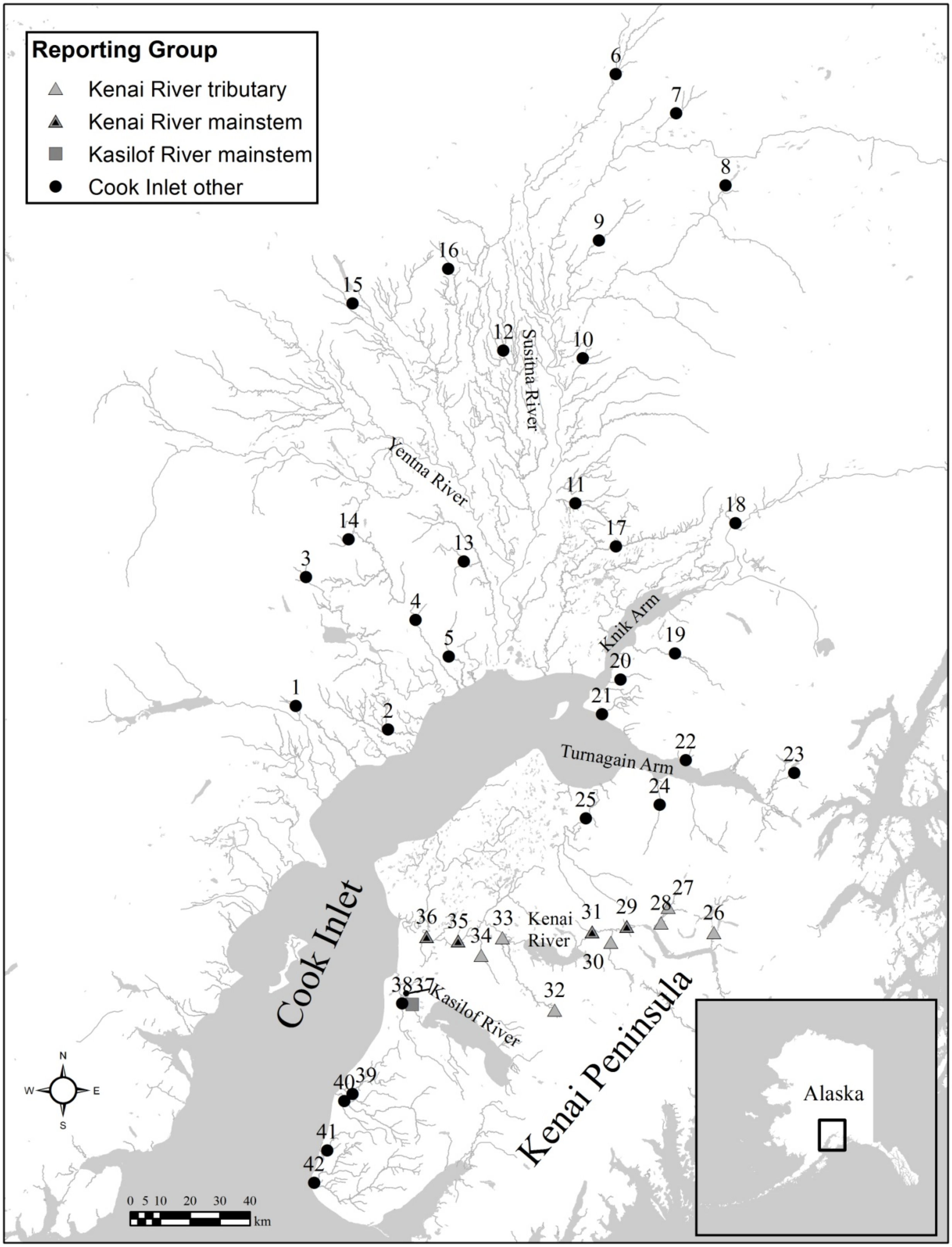

Figure 3.–Sampling locations for Chinook salmon populations included in the genetic baseline.

Note: Numbers correspond to map numbers on Table 2.

Tissue Sample Selection for MSA

Tissue samples used for MSA were selected based on harvest by statistical area and date. For 2010 and 2011, a single sample that was proportional to harvest was selected for MSA. For 2013, harvest was stratified into 4 geographic and temporal strata, and samples were selected from each stratum separately. The minimum sample size goal for MSA was set at 400 fish for 2010 and 2011, and 100 fish for each stratum in 2013. Individual tissue samples were selected based on harvest by statistical area and date. Once the number of samples required from a particular day was determined, samples were selected systematically from all available tissues sampled on that date. However, for 2013, all samples were selected from the 27 June–6 July Kasilof Section and the 17 July–2 August KRSHA strata due to a low number of samples. Length was incorporated into the 2013 sample selection such that the length distribution of sampled fish was equivalent to the length distribution of unsampled fish within each grouping. A grouping was usually 1–2 days of samples within each stratum.

Age- and Length-based Stratification

Separate analyses were done for age-based and length-based stratification. Mixtures were combined for all 3 years of tissue collections with sufficient sample sizes (2010, 2011, and 2013). No KRSHA tissue samples were used in the age- or length-based MSA.

Analyses were stratified by age (jacks [age-1.1 fish] vs. non-jacks [age-1.2 and older fish]) and time (prior to 8 July vs. 8 July to end of season). Sample size was insufficient to stratify by geographic area (e.g., Kasilof Section vs. Kenai and East Forelands sections). In the length-based MSA, length was stratified by small fish (≤750 mm METF) and large fish (>750 mm METF). Fish were stratified at 750 mm METF to be comparable with analyses of passage of large Chinook salmon at the Kenai River sonar site (Miller et al. 2013). Mixtures were stratified both geographically (Kasilof Section vs. Kenai and East Forelands sections) and temporally (prior to 8 July vs. 8 July to end of season).

Laboratory Analysis

Assaying Genotypes

DNA extraction and genotyping generally followed the methods described in detail in Barclay et al. (2012). Briefly, genomic DNA was extracted from tissue samples using a DNeasy 96 Tissue Kit by QIAGEN (Valencia, CA). Fluidigm 192.24 and 96.96 Dynamic Arrays (http://www.fluidigm.com) were used to screen 39 SNP markers; this differs from the methods of Barclay et al. (2012) where they used only the 96.96 Dynamic Arrays. The Dynamic Arrays were read on a Fluidigm EP1 System or BioMark System after amplification and scored using Fluidigm SNP Genotyping Analysis software. Assays that failed to amplify on the Fluidigm system were reanalyzed on the Applied Biosystems platform. The plates were scanned on an Applied Biosystems Prism 7900HT Sequence Detection System after amplification and scored using Applied Biosystems’ Sequence Detection Software version 2.2.

Genotypes produced on both platforms were imported and archived in the Gene Conservation Laboratory (GCL) Oracle database, LOKI.

Laboratory Failure Rates and Quality Control

The overall failure rate was calculated by dividing the number of failed single-locus genotypes by the number of assayed single-locus genotypes. An individual genotype was considered a failure when a locus for a fish could not be satisfactorily scored.

Quality control (QC) measures were instituted to identify laboratory errors and to determine the reproducibility of genotypes. In this process, 8 of every 96 fish (1 row per 96-well plate) were reanalyzed for all markers by staff not involved with the original analysis. Laboratory errors found during the QC process were corrected, and genotypes were corrected in the database. Inconsistencies not attributable to laboratory error were recorded, but original genotype scores were retained in the database.

Assuming that the inconsistencies among analyses (original vs. QC genotyping) were due equally to errors in original genotyping and errors during the QC genotyping and that these analyses are unbiased, error rates in the original genotyping were estimated as one-half the rate of inconsistencies.

DATA ANALYSIS

Baseline Evaluation for MSA

Proof tests were used to evaluate how the baseline performed for MSA. Methods for these tests followed those used by Habicht et al. (2012). Mixtures were created by randomly sampling 100 fish from the baseline for 1 reporting group and then rebuilding the baseline without the sampled fish. The stock composition of the proof test mixtures was estimated using the software package BAYES (Pella and Masuda 2001). BAYES employs a Bayesian algorithm to estimate the most probable contribution of the baseline populations to explain the combination of genotypes in the mixture sample. We followed a BAYES protocol similar to the protocol reported in Barclay and Habicht (2012). However, instead of running 5 independent Markov Chain Monte Carlo (MCMC) chains, we ran 1 MCMC chain with 40,000 iterations and discarded the first 20,000 iterations. The prior parameters for each reporting group were defined to be equal (i.e., a "flat" prior). Within each reporting group, the population prior parameters were divided equally among the populations within that reporting group. Stock proportion estimates and the 90% credibility intervals for each proof test mixture were calculated by taking the mean and 5% and 95% quantiles of the posterior distribution from the single chain output.

Proof tests were repeated 10 times for each reporting group. These tests provided an indication of the power of the baseline for MSA assuming that all populations were represented in the baseline.

Data Retrieval and Quality Control

We retrieved genotypes from LOKI and imported them into *R* (*R* Development Core Team 2011). All subsequent genetic analyses were performed in *R* unless otherwise noted.

Prior to statistical analysis, we performed 2 analyses to confirm the quality of the data. First, we identified individuals that were missing a substantial amount of genotypic data. That is, those individuals missing data at 20% or more of loci (80% rule; Dann et al. 2009). We removed these individuals from further analyses because we suspected samples from these individuals had poor-quality DNA. The inclusion of individuals with poor-quality DNA might introduce genotyping errors into the baseline and reduce the accuracies of mixed stock analyses.

The second quality control analysis identified individuals with duplicate genotypes and removed them from further analyses. Duplicate genotypes can occur as a result of sampling or extracting the same individual twice, and were defined as pairs of individuals sharing the same alleles in 95% or more of loci screened. The individual with the most missing genotypic data from each duplicate pair was removed from further analyses. If both individuals had the same amount of genotypic data, the first individual was removed from further analyses.

Mixed Stock Analysis

The stock composition of the commercial ESSN fishery harvest for each stratum was estimated using the same BAYES protocol described for the proof tests except that the results of 5 separate MCMC chains were used and the definition of the prior parameters differed. Each of the 5 MCMC chains began with different initial values, generated randomly, which summed to 1 over all reporting groups. The prior distribution used in BAYES was based upon the best available information for each mixture analysis. We believed the best available prior information came from the results of the MSA of similar mixtures. For the 2010 ESSN mixtures and the age- and length-based mixtures, we had no similar MSA mixture results, so we used the same flat prior protocol used for the proof test mixtures. For the 2011 and 2013 ESSN mixtures, the best available information came from the stock proportion estimates from the analysis of the 2010 and 2011 ESSN Chinook salmon samples, respectively. We set the sum of the prior parameters equal to 1, thus minimizing the overall influence of the prior distribution. The chains were run until among-chain convergence was reached (shrink factor < 1.2; Pella and Masuda 2001). The first half of each chain was discarded in order to remove the influence of the initial values. Stock proportion estimates and 90% credibility intervals for each stratum were calculated by taking the mean and 5% and 95% quantiles of the combined posterior distribution from the 5 chain outputs (Gelman et al. 2004).

Reporting group proportions and harvest estimates

Group-specific harvest estimates and 90% credibility intervals for each stratum were calculated by multiplying the harvest from that stratum by its unrounded estimate of reporting group proportions and the upper and lower bounds of that estimate. Results were rounded to the nearest fish.

Strata were combined into yearly estimates for each reporting group by weighting them by their respective harvests (stratified estimator). The stratified estimates were calculated with the following equation:

$$\hat{p}_{y,g} = \frac{\sum_{i=1}^{S} H_{y,i}\hat{p}_{y,g,i}}{\sum_{i=1}^{S} H_{y,i}} \tag{1}$$

where $H_{y,i}$ is the harvest in year *y* and stratum *i* (obtained from fish tickets and assumed known without error), $\hat{p}_{y,g,i}$ is the proportion of reporting group *g* fish in year *y* and stratum *i*, and $\hat{p}_{y,g}$ is the overall proportion of reporting group *g* fish in year *y* with *S* strata. Symbol '^' denotes an estimated value in Equation 1 and in all of the following equations.

To calculate confidence intervals for $H_{y,g}$ (the overall harvest of reporting group g in year y), its distribution was estimated via MCMC by resampling 100,000 draws of the posterior output from each of the constituent strata and applying the harvest to the draws according to this slight modification of Equation 1:

$$\hat{H}_{y,g} = \sum_{i=1}^{S} H_{y,i}\,\hat{p}_{y,g,i}\,. \tag{2}$$

This method yielded the same point estimate for number of harvested fish within the fishery each year as would be obtained by simply summing the point estimates from each constituent stratum, but it produced a more appropriate credibility interval than simply summing the lower and upper bounds of credibility intervals together (*cf.* Piston 2008). This method also accommodated non-symmetric credibility intervals.

Age, sex, and length composition of Chinook salmon in ESSN harvest

The age proportions of Chinook salmon harvested in the commercial ESSN fishery by sampling stratum were estimated as follows:

$$\hat{p}^{z}_{y,i} = \frac{n^{z}_{y,i}}{n_{y,i}} \tag{3}$$

where $\hat{p}^{z}_{y,i}$ is the estimated proportion of salmon of age category z from sampling stratum i in year y, $n^{z}_{y,i}$ equals the number of fish sampled from sampling stratum i in year y that were classified as age category z, and $n_{y,i}$ equals the number of Chinook salmon sampled for age determination from sampling stratum i.

The variance of $\hat{p}^{z}_{y,i}$ was calculated as follows:

$$\operatorname{var}\left[\hat{p}^{z}_{y,i}\right] = \left(1 - \frac{n_{y,i}}{H_{y,i}}\right)\frac{\hat{p}^{z}_{y,i}\left(1-\hat{p}^{z}_{y,i}\right)}{n_{y,i}-1} \tag{4}$$

where $H_{y,i}$ is the number of Chinook salmon harvested in sampling stratum i in year y.

The estimates of harvest by age categories in each sampling stratum were calculated as follows:

$$\hat{H}^{z}_{y,i} = H_{y,i}\,\hat{p}^{z}_{y,i} \tag{5}$$

with variance

$$\operatorname{var}\left[\hat{H}^{z}_{y,i}\right] = H^{2}_{y,i}\operatorname{var}\left[\hat{p}^{z}_{y,i}\right]. \tag{6}$$

The total harvest in year y by age category and its variance were estimated by the following summations:

$$\hat{H}_{y}^{\,z} = \sum_{i=1}^{S} \hat{H}^{z}_{y,i} \tag{7}$$

and

$$\operatorname{var}\left[\hat{H}_y^{\,z}\right] = \sum_{i=1}^{S} \operatorname{var}\left[\hat{H}_{y,i}^{z}\right] \tag{8}$$

where S = 4 is the number of sampling strata.

Finally, the total proportion of the ESSN harvest in year y by age category and its variance were estimated by the following:

$$\hat{p}_y^{\,z} = \frac{\hat{H}_y^{\,z}}{H_y} \tag{9}$$

and

$$\operatorname{var}\left[\hat{p}_y^{\,z}\right] = \frac{\operatorname{var}\left[\hat{H}_y^{\,z}\right]}{H_y^{\,2}}. \tag{10}$$

Sex composition was estimated using the same Equations 3–10 used to estimate age composition.

Mean length $\bar{l}_z$ of Chinook salmon at age class z, was estimated as follows:

$$\bar{l}_z = \frac{1}{n_z}\sum_{i=1}^{n_z} l_i \tag{11}$$

where l_i is the length of fish i in a sample n_z and n_z is the number of Chinook salmon of age class z.

The variance $\operatorname{var}(\bar{l}_z)$ of the mean length-at-age class z, was estimated as follows:

$$\operatorname{var}(\bar{l}_z) = \frac{1}{n_z}\frac{\sum_{i=1}^{n_z}(l_i - \bar{l}_z)^2}{n_z - 1}. \tag{12}$$

RESULTS

LABORATORY ANALYSIS

Laboratory Failure Rates and Quality Control

A total of 461, 439, and 807 fish were genotyped from the 2010, 2011, and 2013 ESSN Chinook salmon tissue samples, respectively. Failure rates were 0.92%, 1.34%, and 2.96%, and error rates were 0.07%, 0.07%, and less than 0.01% for 2010–2013, respectively.

DATA ANALYSIS

Baseline Evaluation for MSA

In the analysis of proof test mixtures, all but 2 of the repeated test mixtures assigned to their correct reporting group at greater than 91% correct allocation. Test “repeat 4” for *Kenai River mainstem* (84% correct allocation) and test “repeat 2” for *Cook Inlet other* (86% correct allocation) were the exceptions (Figure 4).

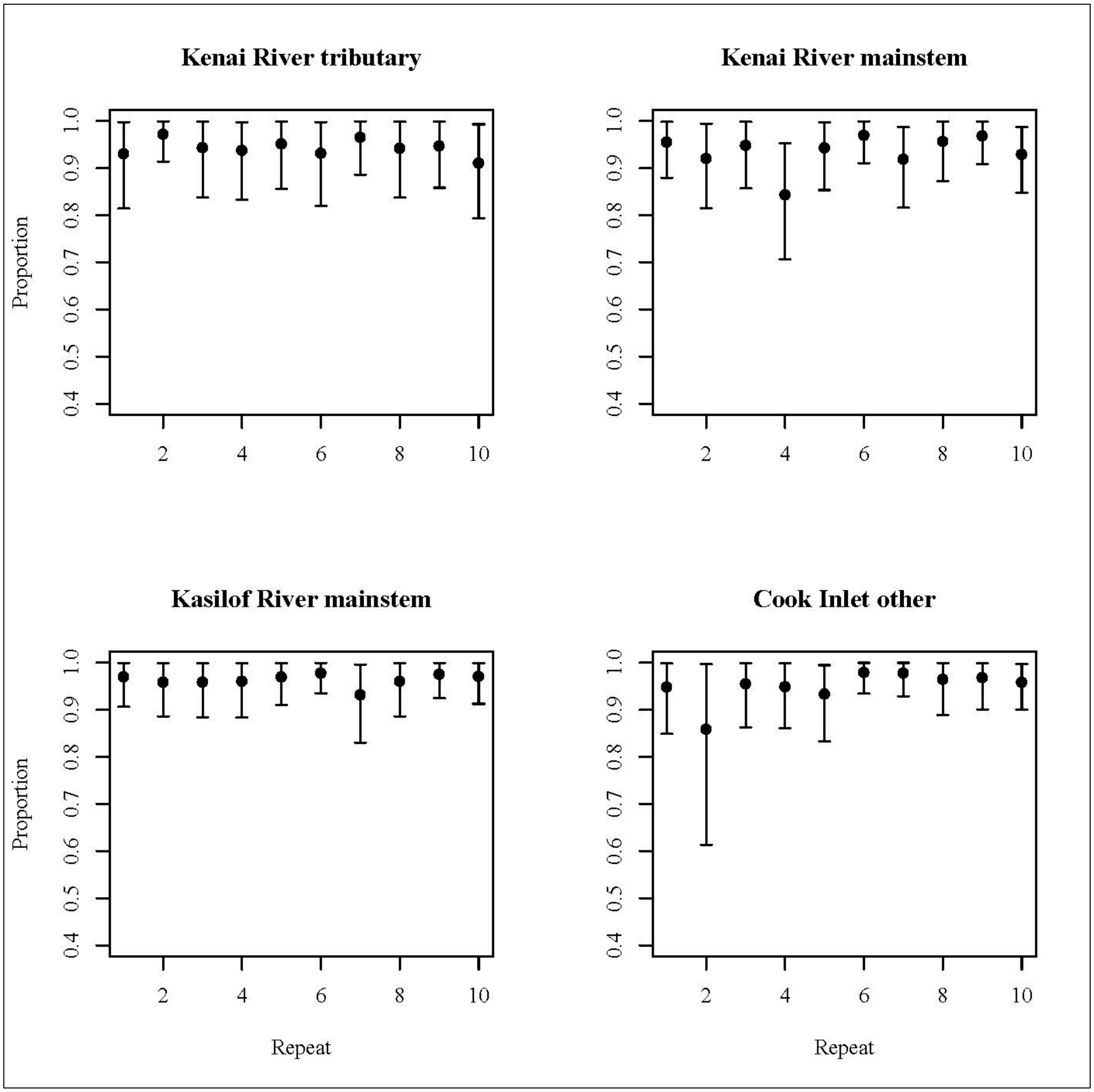

Figure 4.–Mean (dots) and 90% credibility interval (lines) estimates for 10 replicated test mixtures for each reporting group.

Data Retrieval and Quality Control

Based upon the 80% rule, 2.69% of individuals were removed from the ESSN collections during the 3 years of the study. No duplicate individuals were detected in the ESSN collections.

Reporting Group Proportions, Harvest Estimates, and ASL Composition

2010

Reported harvest of Chinook salmon in the ESSN fishery in 2010 was 7,059 fish which was 71% of the total UCI Chinook salmon commercial harvest (Shields 2010). The ESSN fishery opened on 27 June in the Kasilof Section and on 8 July in the Kenai and East Forelands sections. The last fishing period was 12 August (Shields 2010). The Kasilof Section fished on 32 days of which 19 (59%) were sampled. The Kenai and East Forelands sections fished on 20 days of which 13 (65%) were sampled. A total of 886 samples were collected, of which 760 (11% of harvest) were used for ASL composition estimates (Table 3). After subsampling representatively by date and statistical area, 373 (5% of harvest) tissue samples were selected for MSA (Table 4).

Based on the MSA results of harvest tissue, reporting groups were represented in the following proportions (standard deviations and credibility intervals of proportions are listed in Table 4): *Kenai River tributaries* 0.011, *Kenai River mainstem* 0.643, *Kasilof River mainstem* 0.326, and *Cook Inlet other* 0.020 (Table 4 and Figure 5). Estimated harvest by reporting group was 75 (SD 73) fish for *Kenai River tributaries*, 4,536 (SD 263) fish for *Kenai River mainstem*, 2,305 (SD 239) fish for *Kasilof River mainstem*, and 144 (SD 100) fish for *Cook Inlet other* (Table 4).

The ASL composition was divided into 2 temporal strata (28 June–19 July and 21 July–12 August) (Table 3). The overall age composition of both strata combined was 18.3% age-1.1, 24.6% age-1.2, 36.0% age-1.3, 0.1% age-2.2, 20.1% age-1.4, 0.1% age-2.3, and 0.8% age-1.5 fish. Sex composition was 23.1% females and 76.9% males. Average length of all samples was 743 mm (Table 3). Standard errors for ASL composition are listed in Table 3.

2011

Reported harvest in the ESSN fishery in 2011 was 7,697 Chinook salmon (Table 1) which was 68% of the total UCI Chinook salmon commercial harvest (Shields and Dupuis 2012). The ESSN fishery opened on 25 June in the Kasilof Section and on 11 July in the Kenai and East Foreland sections (Shields and Dupuis 2012). The Kasilof Section fished on 28 days of which 15 (54%) were sampled; the Kenai and East Forelands sections fished on 18 days of which 9 (50%) were sampled. A total of 1,280 ASL and tissue samples were collected of which 1,187 (15% of harvest), were used for ASL composition estimates (Table 5). After subsampling representatively by date and statistical area, 342 (4% of harvest) tissue samples were selected for MSA (Table 6).

Reporting groups were represented in the following proportions (standard deviations and credibility intervals of proportions are listed in Table 6): *Kenai River tributaries* 0.001, *Kenai River mainstem* 0.667, *Kasilof River mainstem* 0.330, and *Cook Inlet other* 0.002 (Table 6 and Figure 5). Estimated harvest of Chinook salmon by reporting group was 9 (SD 33) fish for *Kenai River tributaries*, 5,135 (SD 309) fish for *Kenai River mainstem,* 2,538 (SD 306) fish for *Kasilof River mainstem*, and 14 (SD 34) fish for *Cook Inlet other* (Table 6).

The ASL composition was divided into 2 temporal strata (25 June–17 July and 18 July–7 August) (Table 5). The overall age composition of both strata combined was 4.6% age-1.1, 33.7% age-1.2, 25.2% age-1.3, 35.3% age-1.4, 0.1% age-2.3, and 1.2% age-1.5 fish. Sex composition was 30.1% females and 69.9% males. Average length of all samples was 794 mm. Standard errors for ASL composition are listed in Table 5.

Table 3.–Age, sex, and length composition of Chinook salmon harvested in the Upper Cook Inlet Eastside set gillnet fishery, 2010.

			Age class							
Sample period	Sex	Parameter	1.1	1.2	1.3	2.2	1.4	2.3	1.5	All ages
All: 28 Jun–12 Aug										
	Female									
		Sample size		10	91		61	1	2	165
		Age composition		1.2%	12.8%		8.7%	0.1%	0.2%	23.1%
		SE age composition		0.4%	1.2%		1.0%	0.1%	0.2%	1.4%
		Harvest by age		86	906		613	11	16	1,632
		SE harvest by age		26	83		70	10	11	102
		Mean length (mm)		608	873		968	890	1,085	897
		SE mean length (mm)		21	5		7		25	4
	Male									
		Sample size	155	185	169	1	81		4	595
		Age composition	18.3%	23.4%	23.1%	0.1%	11.4%		0.6%	76.9%
		SE age composition	1.1%	1.4%	1.5%	0.1%	1.1%		0.3%	1.4%
		Harvest by age	1,290	1,651	1,633	8	804		42	5,427
		SE harvest by age	81	100	103	8	79		20	102
		Mean length (mm)	430	611	838	725	996		1,108	697
		SE mean length (mm)	4	6	6		5		9	3
	Both									
		Sample size	155	195	260	1	142	1	6	760
		Age composition	18.3%	24.6%	36.0%	0.1%	20.1%	0.1%	0.8%	100.0%
		SE age composition	1.1%	1.4%	1.6%	0.1%	1.4%	0.1%	0.3%	
		Harvest by age	1,290	1,737	2,539	8	1,416	11	58	7,059
		SE harvest by age	81	102	114	8	97	10	23	
		Mean length (mm)	430	611	850	725	984	890	1,102	743
		SE mean length (mm)	4	5	4		4		9	2

-continued-

Table 3.–Part 2 of 3.

Sample period	Sex	Parameter	Age class 1.1	1.2	1.3	2.2	1.4	2.3	1.5	All ages
Period 1: 28 Jun–19 Jul										
	Female									
		Sample size		8	21		12		2	43
		Age composition		2.1%	5.4%		3.1%		0.5%	11.1%
		SE age composition		0.7%	1.1%		0.8%		0.3%	1.5%
		Harvest by age		65	170		97		16	348
		SE harvest by age		21	34		26		11	47
		Mean length (mm)		584	859		971		1,085	849
		SE mean length (mm)		27	14		13		25	9
	Male									
		Sample size	141	122	60	1	20			344
		Age composition	36.4%	31.5%	15.5%	0.3%	5.2%			88.9%
		SE age composition	2.3%	2.2%	1.7%	0.2%	1.1%			1.5%
		Harvest by age	1,143	989	486	8	162			2,788
		SE harvest by age	72	69	54	8	33			47
		Mean length (mm)	429	598	804	725	993			588
		SE mean length (mm)	4	7	12		9			4
	Both									
		Sample size	141	130	81	1	32		2	387
		Age composition	36.4%	33.6%	20.9%	0.3%	8.3%		0.5%	100.0%
		SE age composition	2.3%	2.3%	1.9%	0.2%	1.3%		0.3%	
		Harvest by age	1,143	1,053	656	8	259		16	3,136
		SE harvest by age	72	71	61	8	41		11	
		Mean length (mm)	429	597	819	725	984		1,085	617
		SE mean length (mm)	4	7	10		7		25	3

-continued-

Table 3.–Part 3 of 3.

Sample period	Sex	Parameter	Age class 1.1	1.2	1.3	2.2	1.4	2.3	1.5	All ages
Period 2: 21 Jul–12 Aug										
	Female									
		Sample size		2	70		49	1		122
		Age composition		0.5%	18.8%		13.1%	0.3%		32.7%
		SE age composition		0.4%	1.9%		1.7%	0.3%		2.3%
		Harvest by age		21	736		515	11		1,283
		SE harvest by age		14	76		65	10		91
		Mean length (mm)		685	877		968	890		910
		SE mean length (mm)		5	6		8			5
	Male									
		Sample size	14	63	109		61		4	251
		Age composition	3.8%	16.9%	29.2%		16.4%		1.1%	67.3%
		SE age composition	0.9%	1.8%	2.2%		1.8%		0.5%	2.3%
		Harvest by age	147	663	1,146		642		42	2,640
		SE harvest by age	37	72	88		72		20	91
		Mean length (mm)	439	631	852		997		1,108	813
		SE mean length (mm)	6	9	6		6		9	4
	Both									
		Sample size	14	65	179		110	1	4	373
		Age composition	3.8%	17.4%	48.0%		29.5%	0.3%	1.1%	100.0%
		SE age composition	0.9%	1.9%	2.5%		2.2%	0.3%	0.5%	
		Harvest by age	147	684	1,883		1,157	11	42	3,923
		SE harvest by age	37	73	97		88	10	20	
		Mean length (mm)	439	632	862		984	890	1,108	845
		SE mean length (mm)	6	9	4		5		9	3

Source: Modified from Tobias and Willette (2012).

Note: Values given by age and sex may not sum to totals due to rounding.

Table 4.–Reported Chinook salmon harvest and proportion of harvest by reporting group in the Upper Cook Inlet Eastside set gillnet fishery, 2010.

			Credibility interval				Credibility interval	
Reporting group	Proportion	SD	5%	95%	Harvest	SD	5%	95%
Kenai River tributaries	0.011	0.010	0.001	0.031	75	73	4	220
Kenai River mainstem	0.643	0.037	0.581	0.703	4,536	263	4,100	4,963
Kasilof River mainstem	0.326	0.034	0.271	0.383	2,305	239	1,915	2,701
Cook Inlet other	0.020	0.014	0.003	0.047	144	100	19	334

Note: Sampling dates were 27 June–12 August; 373 tissue samples were used in the MSA.

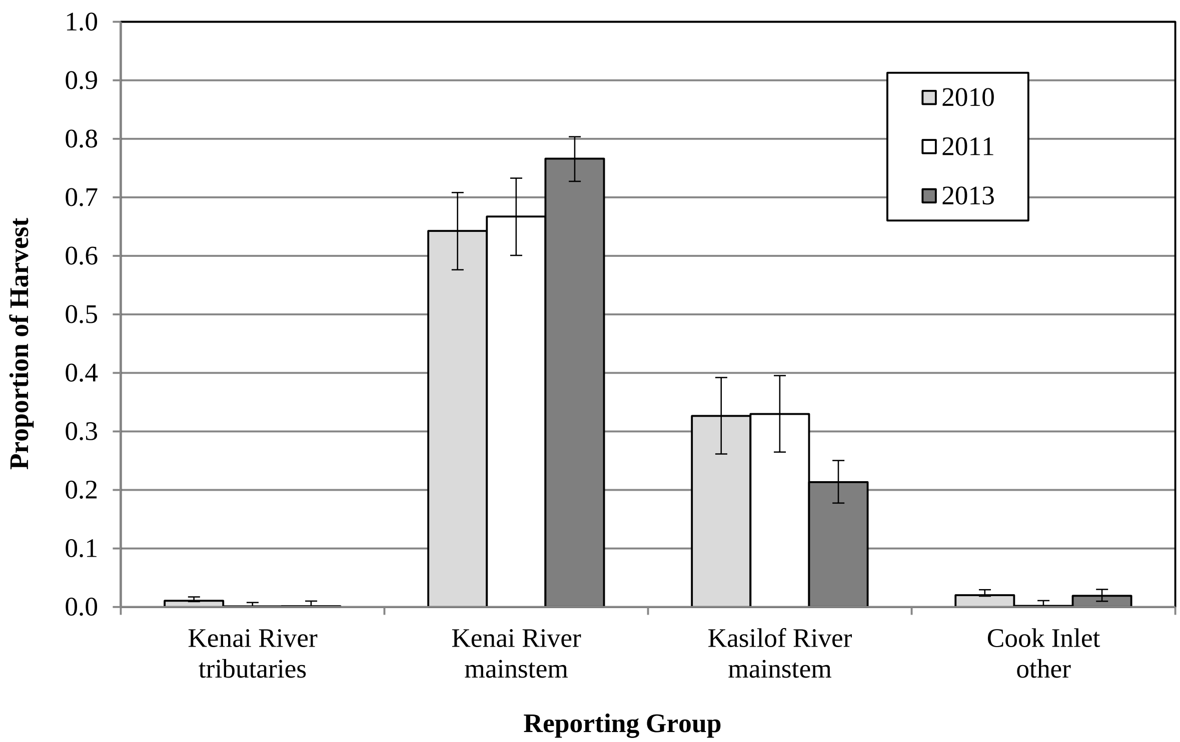

Figure 5.–Proportion and 90% credibility intervals of ESSN Chinook salmon harvested by reporting group and year, 2010, 2011, and 2013.

Table 5.–Age, sex, and length composition of Chinook salmon harvested in the Upper Cook Inlet Eastside set gillnet fishery, 2011.

			Age class						
Sample period	Sex	Parameter	1.1	1.2	1.3	1.4	2.3	1.5	All ages
All: 25 Jun–7 Aug									
	Female								
		Sample size		6	117	217	1	8	349
		Age composition		0.5%	10.2%	18.5%	0.1%	0.7%	30.1%
		SE age composition		0.2%	0.8%	1.1%	0.1%	0.2%	1.2%
		Harvest by age		36	787	1,427	7	57	2,314
		SE harvest by age		14	64	81	7	19	95
		Mean length (mm)		659	880	955	900	1,033	926
		SE mean length (mm)		31	5	3		13	3
	Male								
		Sample size	60	402	175	196		5	838
		Age composition	4.6%	33.2%	14.9%	16.7%		0.5%	69.9%
		SE age composition	0.5%	1.3%	1.0%	1.0%		0.2%	1.2%
		Harvest by age	351	2,559	1,149	1,289		35	5,383
		SE harvest by age	40	96	74	78		14	95
		Mean length (mm)	403	609	842	982		1,088	738
		SE mean length (mm)	3	3	6	4		29	2
	Both								
		Sample size	60	408	292	413	1	13	1,187
		Age composition	4.6%	33.7%	25.2%	35.3%	0.1%	1.2%	100.0%
		SE age composition	0.5%	1.3%	1.2%	1.3%	0.1%	0.3%	
		Harvest by age	351	2,595	1,936	2,715	7	92	7,697
		SE harvest by age	40	97	90	99	7	23	
		Mean length (mm)	403	610	857	968	900	1,054	794
		SE mean length (mm)	3	3	4	3		13	2

-continued-

Table 5.–Part 2 of 3.

Sample period	Sex	Parameter	Age class 1.1	1.2	1.3	1.4	2.3	1.5	All ages
Period 1: 25 Jun–17 Jul									
	Female								
		Sample size		5	43	102		1	151
		Age composition		0.8%	6.8%	16.2%		0.2%	24.0%
		SE age composition		0.3%	0.9%	1.3%		0.1%	1.5%
		Harvest by age		29	249	590		6	873
		SE harvest by age		12	33	49		5	56
		Mean length (mm)		657	867	960		1,130	925
		SE mean length (mm)		31	8	5			4
	Male								
		Sample size	57	245	83	92		1	478
		Age composition	9.1%	39.0%	13.2%	14.6%		0.2%	76.0%
		SE age composition	1.0%	1.8%	1.2%	1.3%		0.1%	1.5%
		Harvest by age	329	1,416	480	532		6	2,763
		SE harvest by age	38	64	45	47		5	56
		Mean length (mm)	402	599	846	984		1,040	694
		SE mean length (mm)	3	5	10	6			3
	Both								
		Sample size	57	250	126	194		2	629
		Age composition	9.1%	39.7%	20.0%	30.8%		0.3%	100.0%
		SE age composition	1.0%	1.8%	1.5%	1.7%		0.2%	
		Harvest by age	329	1,445	728	1,121		12	3,636
		SE harvest by age	38	65	53	61		7	
		Mean length (mm)	402	600	853	972		1,085	749
		SE mean length (mm)	3	4	7	4			3

-continued-

Table 5.–Part 3 of 3.

Sample period	Sex	Parameter	Age class 1.1	1.2	1.3	1.4	2.3	1.5	All ages
Period 2: 18 Jul–7 Aug									
	Female								
		Sample size		1	74	115	1	7	198
		Age composition		0.2%	13.3%	20.6%	0.2%	1.3%	35.5%
		SE age composition		0.2%	1.3%	1.6%	0.2%	0.4%	1.9%
		Harvest by age		7	539	837	7	51	1,441
		SE harvest by age		7	54	65	7	18	76
		Mean length (mm)		665	885	951	900	1,021	927
		SE mean length (mm)			6	5		13	3
	Male								
		Sample size	3	157	92	104		4	360
		Age composition	0.5%	28.1%	16.5%	18.6%		0.7%	64.5%
		SE age composition	0.3%	1.8%	1.5%	1.5%		0.3%	1.9%
		Harvest by age	22	1,143	670	757		29	2,620
		SE harvest by age	12	72	59	62		13	76
		Mean length (mm)	413	621	839	980		1,098	784
		SE mean length (mm)	11	5	7	6		29	3
	Both								
		Sample size	3	158	166	219	1	11	558
		Age composition	0.5%	28.3%	29.7%	39.2%	0.2%	2.0%	100.0%
		SE age composition	0.3%	1.8%	1.8%	1.9%	0.2%	0.5%	
		Harvest by age	22	1,150	1,208	1,594	7	80	4,061
		SE harvest by age	12	72	73	78	7	22	
		Mean length (mm)	413	621	860	966	900	1,049	835
		SE mean length (mm)	11	5	5	4		13	2

Source: Modified from Tobias et al. (2013).

Note: Values given by age and sex may not sum to totals due to rounding.

Table 6.–Reported Chinook salmon harvest and proportion of harvest by reporting group in the Upper Cook Inlet Eastside set gillnet fishery, 2011.

			Credibility interval				Credibility interval	
Reporting group	Proportion	SD	5%	95%	Harvest	SD	5%	95%
Kenai River tributaries	0.001	0.004	0.000	0.008	9	33	0	59
Kenai River mainstem	0.667	0.040	0.601	0.733	5,135	309	4,624	5,641
Kasilof River mainstem	0.330	0.040	0.265	0.395	2,538	306	2,038	3,042
Cook Inlet other	0.002	0.004	0.000	0.011	14	34	0	84

Note: Sampling dates were 25 June–7 August; 342 tissue samples were used in the MSA.

2012

Reported harvest in the ESSN fishery in 2012 was 704 Chinook salmon (Table 1), the smallest harvest recorded and 28% of the total UCI Chinook salmon commercial harvest. The ESSN fishery opened on 3 July in the Kasilof Section and on 16 July in the Kenai and East Foreland sections. The Kasilof Section fished 7 openings and the Kenai and East Forelands sections fished 4 openings (Shields and Dupuis 2013). A total of 185 ASL and tissue samples were collected, of which 167 (24% of harvest) were used for ASL composition estimates (Table 7). MSA was not conducted on tissue samples due to low sample size. The overall composition by age was 9.6% age-1.1, 18.0% age-1.2, 36.5% age-1.3, and 35.9% age-1.4 fish. Sex composition was 30.0% females and 70.0% males. The mean length of all samples was 818 mm (Table 7). Standard errors for ASL composition are listed in Table 7.

2013

Reported harvest of Chinook salmon in the ESSN fishery was 2,988 fish (Tables 1 and 8) which was 55% of the total UCI Chinook salmon commercial harvest in 2013. The ESSN fishery opened on 27 June in the Kasilof Section and on 8 July in the Kenai and East Forelands sections. The Kasilof Section fished on 12 days; the Kenai and East Forelands sections fished on 6 days. In addition, the KRSHA was opened on 17 July and fished on 14 days between 17 July and 2 August. The remainder of the ESSN fishery closed on 23 July. All fishery openings were sampled.

ASL composition estimates and MSA results were stratified temporally and geographically by the following 4 strata: Kasilof Section, 27 June–6 July; Kasilof Section, 8–23 July; Kenai and East Forelands sections, 8–23 July; and KRSHA, 17 July–2 August).

Kasilof Section, 27 June–6 July Stratum

Reported harvest was 404 Chinook salmon and 162 fish (40% of harvest) were sampled (Tables 8 and 9). All 162 ASL and tissue samples collected were used in the analysis; 142 fish were aged successfully. Reporting groups were represented in the following proportions: *Kenai River tributaries* 0.003, *Kenai River mainstem* 0.718, *Kasilof River mainstem* 0.140, and *Cook Inlet other* 0.139 (Figure 6). Standard deviations and credibility intervals of proportions are listed in Table 10. Harvest by reporting group was 1 (SD 6) fish for *Kenai River tributaries*, 290 (SD 26) fish for *Kenai River mainstem*, 57 (SD 20) fish for *Kasilof River mainstem*, and 56 (SD 18) fish for *Cook Inlet other* (Table 10).

The composition by age was 47.9% age-1.1, 30.3% age-1.2, 12.0% age-1.3, and 9.9% age-1.4 fish (Table 9). Sex composition was 2.8% females and 97.2% males. The mean length of all samples was 580 mm (Table 9). Standard errors for ASL composition are listed in Table 9.

Table 7.–Age, sex, and length composition of Chinook salmon harvested in the Upper Cook Inlet Eastside set gillnet fishery, 2012.

		Age class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Female						
	Sample size			25	25	50
	Age composition			15.0%	15.0%	29.9%
	SE age composition			2.3%	2.3%	3.0%
	Harvest by age			87	87	175
	SE harvest by age			14	14	18
	Mean length (mm)			881	983	932
	SE mean length (mm)			11	12	8
Male						
	Sample size	16	30	36	35	117
	Age composition	9.6%	18.0%	21.6%	21.0%	70.1%
	SE age composition	1.9%	2.5%	2.7%	2.7%	3.0%
	Harvest by age	56	105	126	122	409
	SE harvest by age	11	15	16	16	18
	Mean length (mm)	399	560	862	1,022	769
	SE mean length (mm)	6	11	14	11	6
Both						
	Sample size	16	30	61	60	167
	Age composition	9.6%	18.0%	36.5%	35.9%	100.0%
	SE age composition	1.9%	2.5%	3.2%	3.1%	
	Harvest by age	56	105	213	210	584
	SE harvest by age	11	15	18	18	
	Mean length (mm)	399	560	870	1,006	818
	SE mean length (mm)	6	11	9	8	5

Note: Values given by age and sex may not sum to totals due to rounding.

Table 8.–Reported Chinook salmon harvest, number and proportion sampled, and number and proportion of harvest selected for MSA by temporal and geographic strata in the Upper Cook Inlet Eastside set gillnet fishery, 2013.

Dates	Geographic area	Reported harvest	Number sampled	Proportion sampled	Number selected for MSA	Proportion of harvest selected for MSA
27 June–6 July	Kasilof Section	404	162	0.40	162	0.40
8–23 July	Kasilof Section	871	298	0.34	195	0.22
8–23 July	Kenai and East Forelands sections	1,355	525	0.39	293	0.22
17 July–2 August	KRSHA	358	58	0.16	58	0.16
27 June–2 August	All areas	2,988	1,043	0.35	708	0.24

Table 9.–Age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet fishery, Kasilof Section, 27 June–6 July, Upper Cook Inlet, Alaska, 2013.

		Age class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age			9	3	11
	SE (harvest by age)			4	2	5
	Samples by age			3	1	4
	Age composition			2.1%	0.7%	2.8%
	SE (age composition)			1.0%	0.6%	1.1%
	Mean length (mm)			841	970	867
	SE (mean length)			19		30
Males						
	Harvest by age	193	122	40	37	393
	SE (harvest by age)	14	13	8	8	5
	Samples by age	68	43	14	13	138
	Age composition	47.9%	30.3%	9.9%	9.2%	97.2%
	SE (age composition)	3.4%	3.1%	2.0%	2.0%	1.1%
	Mean length (mm)	429	569	850	1,036	567
	SE (mean length)	4	8	20	14	17
Both Sexes						
	Harvest by age	193	122	48	40	404
	SE (harvest by age)	14	13	9	8	
	Samples by age	68	43	17	14	142
	Age composition	47.9%	30.3%	12.0%	9.9%	100.0%
	SE (age composition)	3.4%	3.1%	2.2%	2.0%	
	Mean length (mm)	429	569	848	1,031	580
	SE (mean length)	4	8	16	14	17

Note: Values given by age and sex may not sum to totals due to rounding.

Table 10.–Number of Chinook salmon harvested and proportion of harvest by reporting group in the ESSN fishery, Upper Cook Inlet, Alaska, 2013.

Stratum					Credibility interval				Credibility interval	
Area	Date	Reporting group	Proportion	SD	5%	95%	Harvest	SD	5%	95%
				Overall estimates						
All	27 Jun–2 Aug									
		Kenai River tributaries	0.001	0.004	0.000	0.010	4	13	0	30
		Kenai River mainstem	0.766	0.023	0.727	0.804	2,289	69	2,173	2,401
		Kasilof River mainstem	0.213	0.022	0.178	0.250	637	66	530	748
		Cook Inlet other	0.019	0.006	0.010	0.030	57	19	29	89
				Stratified estimates						
Kasilof Section	27 Jun–6 Jul									
		Kenai River tributaries	0.003	0.014	0.000	0.010	1	6	0	4
		Kenai River mainstem	0.718	0.064	0.610	0.820	290	26	246	331
		Kasilof River mainstem	0.140	0.048	0.066	0.225	57	20	27	91
		Cook Inlet other	0.139	0.045	0.072	0.216	56	18	29	87
Kasilof Section	8–23 Jul									
		Kenai River tributaries	0.001	0.004	0.000	0.002	1	4	0	1
		Kenai River mainstem	0.733	0.051	0.648	0.814	639	44	564	709
		Kasilof River mainstem	0.265	0.050	0.185	0.350	231	44	161	305
		Cook Inlet other	0.001	0.004	0.000	0.001	1	4	0	1
Kenai and	8–23 Jul									
East Forelands		Kenai River tributaries	0.002	0.008	0.000	0.008	2	11	0	11
sections		Kenai River mainstem	0.941	0.025	0.896	0.978	1,276	34	1214	1325
		Kasilof River mainstem	0.057	0.024	0.021	0.099	77	33	29	135
		Cook Inlet other	0.000	0.002	0.000	0.000	0	2	0	0
Kasilof River	17 Jul–2 Aug									
Special Harvest		Kenai River tributaries	0.001	0.009	0.000	0.001	0	3	0	0
Area		Kenai River mainstem	0.236	0.088	0.105	0.393	84	31	38	141
		Kasilof River mainstem	0.763	0.087	0.606	0.893	273	31	217	320
		Cook Inlet other	0.000	0.003	0.000	0.000	0	1	0	0

Note: Values given by stratum may not sum to overall estimates due to rounding.

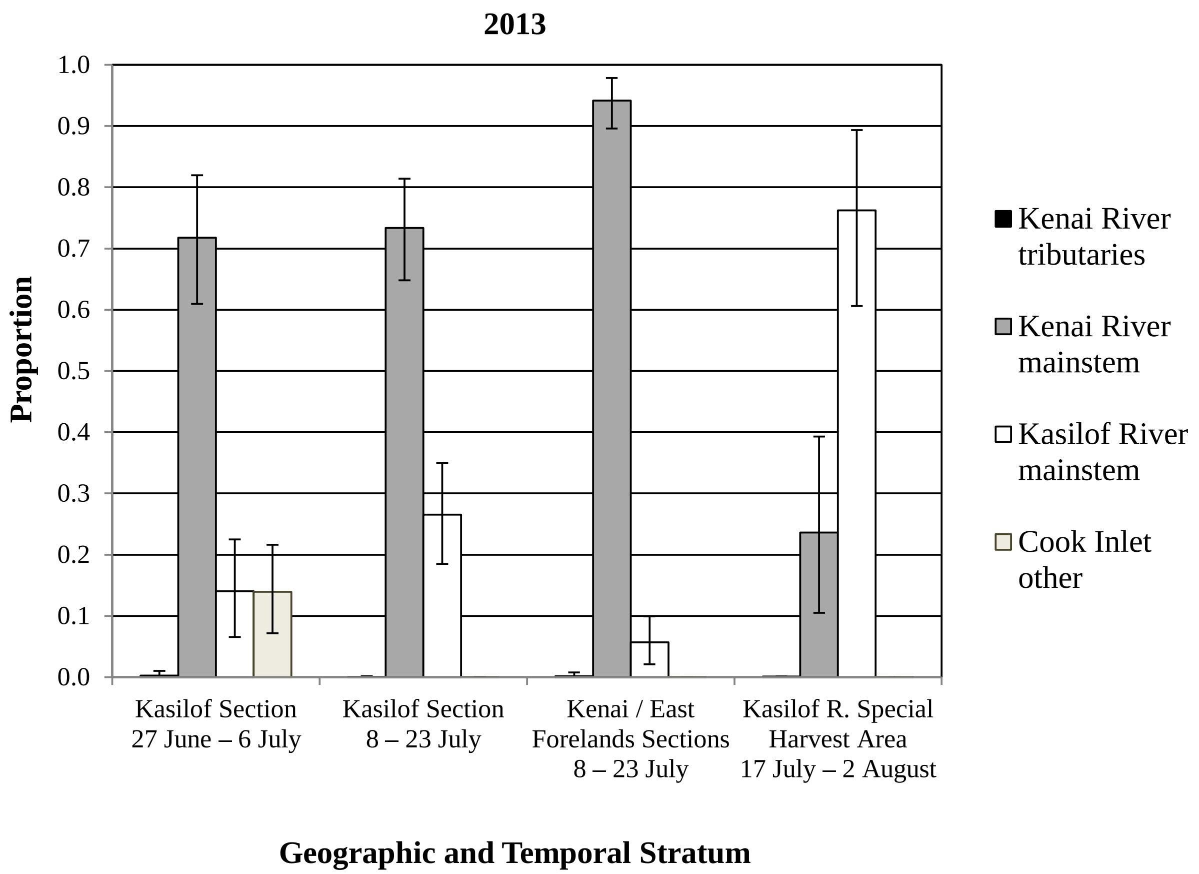

Figure 6.–Proportion and 90% credibility intervals of 2013 ESSN Chinook salmon harvest by reporting group within each geographic and temporal stratum.

Kasilof Section, 8–23 July Stratum

Reported harvest was 871 Chinook salmon and 298 samples (34% of harvest) were collected (Table 8). After subsampling representatively by statistical area, 195 samples (23% of harvest) were used for estimating ASL composition and MSA (Tables 8 and 11); 178 fish were aged successfully.

Reporting groups were represented in the following proportions: *Kenai River tributaries* 0.001, *Kenai River mainstem* 0.733, *Kasilof River mainstem* 0.265, and *Cook Inlet other* 0.001 (Figure 6). Standard deviations and credibility intervals of proportions are listed in Table 10. Harvest by reporting group was 1 (SD 4) fish from *Kenai River tributaries*, 639 (SD 44) fish from *Kenai River mainstem*, 231 (SD 44) fish from *Kasilof River mainstem*, and 1 (SD 4) fish from *Cook Inlet other* (Table 10).

The composition by age was 21.3% age-1.1, 52.2% age-1.2, 12.4% age-1.3, and 14.0% age-1.4 fish. Sex composition was 4.5% females and 95.5% males. The mean length of all samples was 649 mm (Table 11). Standard errors for ASL composition are listed in Table 11.

Kenai and East Forelands Sections, 8–23 July Stratum

Reported Chinook salmon harvest was 1,355 fish and 525 samples (39% of harvest) were collected (Table 8). After subsampling representatively by statistical area, 293 samples (23% of harvest) were used for MSA (Tables 8 and 12).

Based on the MSA results of harvest tissue, reporting groups were represented in the following proportions: *Kenai River tributaries* 0.002, *Kenai River mainstem* 0.941, *Kasilof River mainstem* 0.057, and *Cook Inlet other* 0.000 (Figure 6). Standard deviations and credibility intervals of proportions are listed in Table 10. Harvest by reporting group was 2 (SD 11) fish from *Kenai River tributaries*, 1,276 (SD 34) fish from *Kenai River mainstem*, 77 (SD 33) fish from *Kasilof River mainstem*, and 0 (SD 2) from *Cook Inlet other* (Table 10).

The composition by age was 18.6% age-1.1, 48.3% age-1.2, 12.8% age-1.3, and 20.3% age-1.4 fish. Sex composition was 14.5% females and 85.5% males. The mean length of all samples was 669 mm (Table 12). Standard errors for ASL composition are listed in Table 12.

Kasilof River Special Harvest Area, 17 July–2 August Stratum

Reported Chinook salmon harvest was 358 fish and 58 samples (16% of harvest) were collected (Table 8). All samples were used for estimating ASL composition and MSA (Tables 8 and 13); 54 fish were aged successfully.

Reporting groups were represented in the following proportions: *Kenai River tributaries* 0.001, *Kenai River mainstem* 0.236, *Kasilof River mainstem* 0.763, and *Cook Inlet other* 0.000 (Figure 6). Standard deviations and credibility intervals of proportions are listed in Table 10. Harvest by reporting group was 0 (SD 3) fish from *Kenai River tributaries*, 84 (SD 31) fish from *Kenai River mainstem*, 273 (SD 31) fish from *Kasilof River mainstem*, and 0 (SD 1) fish from *Cook Inlet other* (Table 10).

The composition by age was 13.0% age-1.1, 18.5% age-1.2, 35.2% age-1.3, and 33.3% age-1.4 fish. Sex composition was 35.2% females and 64.8% males. The mean length of all samples was 793 mm (Table 13). Standard errors for ASL composition are listed in Table 13.

Table 11.–Age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet fishery, Kasilof Section, 8–23 July, Upper Cook Inlet, Alaska, 2013.

		Age Class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age			10	29	39
	SE (harvest by age)			6	11	12
	Samples by age			2	6	8
	Age composition			1.1%	3.4%	4.5%
	SE (age composition)			0.7%	1.2%	1.4%
	Mean length (mm)			873	965	942
	SE (mean length)			8	14	18
Males						
	Harvest by age	186	455	98	93	832
	SE (harvest by age)	24	29	18	18	12
	Samples by age	38	93	20	19	170
	Age composition	21.3%	52.2%	11.2%	10.7%	95.5%
	SE (age composition)	2.7%	3.3%	2.1%	2.1%	1.4%
	Mean length (mm)	433	599	805	1,016	632
	SE (mean length)	6	7	19	18	15
Both Sexes						
	Harvest by age	186	455	108	122	871
	SE (harvest by age)	24	29	19	20	
	Samples by age	38	93	22	25	178
	Age composition	21.3%	52.2%	12.4%	14.0%	100.0%
	SE (age composition)	2.7%	3.3%	2.2%	2.3%	
	Mean length (mm)	433	599	811	1,003	649
	SE (mean length)	6	7	18	14	14

Note: Values given by age and sex may not sum to totals due to rounding.

Table 12.–Age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet fishery, Kenai and East Forelands sections, 8–23 July, Upper Cook Inlet, Alaska, 2013.

		Age Class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age			75	121	196
	SE (harvest by age)			16	20	25
	Samples by age			16	26	42
	Age composition			5.5%	9.0%	14.5%
	SE (age composition)			1.2%	1.5%	1.8%
	Mean length (mm)			836	961	913
	SE (mean length)			17	9	13
Males						
	Harvest by age	252	654	98	154	1,159
	SE (harvest by age)	28	35	18	22	25
	Samples by age	54	140	21	33	248
	Age composition	18.6%	48.3%	7.2%	11.4%	85.5%
	SE (age composition)	2.0%	2.6%	1.4%	1.7%	1.8%
	Mean length (mm)	458	584	818	972	628
	SE (mean length)	5	5	13	10	11
Both Sexes						
	Harvest by age	252	654	173	276	1,355
	SE (harvest by age)	28	35	24	28	
	Samples by age	54	140	37	59	290
	Age composition	18.6%	48.3%	12.8%	20.3%	100.0%
	SE (age composition)	2.0%	2.6%	1.7%	2.1%	
	Mean length (mm)	458	584	826	972	669
	SE (mean length)	5	5	10	10	11

Note: Values given by age and sex may not sum to totals due to rounding.

Table 13.–Age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet fishery, Kasilof River Special Harvest Area, 17 July–2 August, Upper Cook Inlet, Alaska, 2013.

		Age Class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age			53	73	126
	SE (harvest by age)			16	18	22
	Samples by age			8	11	19
	Age composition			14.8%	20.4%	35.2%
	SE (age composition)			4.5%	5.1%	6.0%
	Mean length (mm)			835	949	901
	SE (mean length)			17	16	18
Males						
	Harvest by age	46	66	73	46	232
	SE (harvest by age)	15	18	18	15	22
	Samples by age	7	10	11	7	35
	Age composition	13.0%	18.5%	20.4%	13.0%	64.8%
	SE (age composition)	4.3%	4.9%	5.1%	4.3%	6.0%
	Mean length (mm)	713	629	868	1,011	897
	SE (mean length)	24	17	19	18	17
Both Sexes						
	Harvest by age	46	66	126	119	358
	SE (harvest by age)	15	18	22	21	
	Samples by age	7	10	19	18	54
	Age composition	13.0%	18.5%	35.2%	33.3%	100.0%
	SE (age composition)	4.3%	4.9%	6.0%	6.0%	
	Mean length (mm)	713	629	857	973	793
	SE (mean length)	24	17	14	14	27

Note: Values given by age and sex may not sum to totals due to rounding.

2013 Overall

Reported Chinook salmon harvest was 2,988 fish and 1,043 samples (37% of harvest) were collected (Table 8). A total of 708 tissue samples (24% of harvest) were used for MSA (Table 8). Of those same individuals, 664 fish were aged successfully (Table 14). Estimates were summed by stratum to produce overall estimates.

Based on the MSA results over all strata, reporting groups were represented in the following proportions: *Kenai River tributaries* 0.001, *Kenai River mainstem* 0.766, *Kasilof River mainstem* 0.213, and *Cook Inlet other* 0.019 (Figure 6). Standard deviations and credibility intervals of proportions are listed in Table 10. Harvest by reporting group was 4 (SD 13) fish from *Kenai River tributaries*, 2,289 (SD 69) fish from *Kenai River mainstem*, 637 (SD 66) fish from *Kasilof River mainstem*, and 57 (SD 19) fish from *Cook Inlet other* (Table 10).

The composition by age was 22.7% age-1.1, 43.4% age-1.2, 15.2% age-1.3, and 18.6% age-1.4 fish. Sex composition was 12.5% females and 87.5% males. The mean length of all samples was 658 mm (Table 14). Standard errors for ASL composition are listed in Table 14.

Table 14.–Age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet Chinook Salmon fishery, Upper Cook Inlet, Alaska, 2013.

		Age Class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age			146	227	373
	SE (harvest by age)			24	29	35
	Samples by age			29	44	73
	Age composition			4.9%	7.6%	12.5%
	SE (age composition)			0.8%	1.0%	1.2%
	Mean length (mm)			839	959	911
	SE (mean length)			10	17	9
Males						
	Harvest by age	678	1,298	309	331	2,615
	SE (harvest by age)	42	51	33	34	35
	Samples by age	167	286	66	72	591
	Age composition	22.7%	43.4%	10.3%	11.1%	87.5%
	SE (age composition)	1.4%	1.7%	1.1%	1.1%	1.2%
	Mean length (mm)	414	589	867	1012	622
	SE (mean length)	3	3	9	8	8
Both Sexes						
	Harvest by age	678	1,298	455	557	2,988
	SE (harvest by age)	42	51	38	42	
	Samples by age	167	286	95	116	664
	Age composition	22.7%	43.4%	15.2%	18.6%	100.0%
	SE (age composition)	1.4%	1.7%	1.3%	1.4%	
	Mean length (mm)	451	589	832	986	658
	SE (mean length)	3	3	7	6	8

Note: Values given by age and sex may not sum to totals due to rounding.

Harvest by Reporting Group

Proportions of harvest by reporting group were similar between years. *Kenai River mainstem* was the predominate reporting group, averaging 0.692 (range: 0.643 to 0.766) of the harvest each year, followed by *Kasilof River mainstem*, averaging 0.290 (range: 0.213 to 0.330) (Table 15). *Cook Inlet other* averaged 0.014 of the harvest (range: 0.002 to 0.020) and *Kenai River tributaries* averaged 0.004 of the harvest (range: 0.001 to 0.011) (Table 15).

Table 15.–Proportions of ESSN Chinook salmon harvested by reporting group, 2010, 2011, and 2013.

	2010		2011		2013		
Reporting Group	Proportion	SD	Proportion	SD	Proportion	SD	Average
Kenai River tributaries	0.011	0.010	0.001	0.004	0.001	0.004	0.004
Kenai River mainstem	0.643	0.037	0.667	0.040	0.766	0.023	0.692
Kasilof River mainstem	0.326	0.034	0.330	0.040	0.213	0.022	0.290
Cook Inlet other	0.020	0.014	0.002	0.004	0.019	0.006	0.014

Age, Sex, and Length Composition

Overall age composition of the ESSN harvest has varied from year to year. Predominant age classes during this study were age-1.3 (36%) in 2010, age-1.2 (34%) in 2011, age-1.3 (37%) and age-1.4 (36%) in 2012, and age-1.2 (44%) in 2013 (Table 16). During 2010, 2011, and 2013, a higher proportion of the youngest age classes (age-1.1 fish [jacks] and age-1.2 fish) were observed during the earlier temporal stratum. In 2010, jacks (36%) and age-1.2 fish (34%) composed 70% of the harvest prior to 20 July, whereas those age classes composed 21% of the harvest from 20 July on (Table 3). In 2011, jacks (9%) and age-1.2 fish (40%) composed 49% of the harvest prior to 19 July and 29% of the harvest from 19 July on (Table 5). In 2013, the highest proportions of the youngest age classes were seen in the Kasilof Section, prior to 8 July stratum. Jacks (48%), and age-1.2 fish (30%) composed 78% of the harvest in that stratum (Table 9). The KRSHA had the highest proportions of both age-1.3 fish (35%) and age-1.4 fish (35%) of any stratum in 2013 (Table 13). Overall in 2013, 23% of the harvest was jacks, the highest proportion of jacks ever observed (for records since 1987; Table 16). Average METF length was also lowest in 2013 (658 mm SE 8) (Table 17). Sex composition was predominantly males (77% in 2010 [Table 3], 70% in 2011 [Table 5] and 88% in 2013 [Table 14]).

Table 16.–Historical age composition of Chinook salmon harvested in the ESSN fishery, Upper Cook Inlet, Alaska, 1987–2013.

	Age composition (proportion)				
Year	Age 3 (1.1, 0.2)	Age 4 (1.2, 2.1, 0.3)	Age 5 (1.3, 2.2, 0.4)	Age 6 (1.4, 2.3)	Age 7 (1.5, 2.4)
1987	0.02	0.15	0.33	0.49	0.01
1988	0.03	0.11	0.15	0.69	0.03
1989	0.01	0.15	0.21	0.53	0.09
1990	0.01	0.31	0.30	0.33	0.05
1991	0.01	0.25	0.33	0.39	0.02
1992	0.02	0.15	0.28	0.50	0.04
1993	0.03	0.14	0.21	0.57	0.05
1994	0.04	0.12	0.15	0.62	0.07
1995	0.03	0.22	0.34	0.35	0.06
1996	0.03	0.16	0.35	0.44	0.02
1997	0.06	0.14	0.31	0.46	0.02
1998	0.12	0.24	0.23	0.39	0.02
1999	0.02	0.26	0.25	0.44	0.03
2000	0.09	0.13	0.39	0.38	0.01
2001	0.12	0.40	0.15	0.33	0.01
2002	0.11	0.29	0.37	0.23	0.01
2003	0.04	0.52	0.24	0.19	0.02
2004	0.04	0.20	0.48	0.28	0.01
2005	0.03	0.27	0.21	0.48	0.02
2006	0.13	0.35	0.22	0.27	0.03
2007	0.05	0.43	0.23	0.29	0.01
2008	0.10	0.20	0.28	0.41	0.02
2009	0.14	0.51	0.12	0.22	0.01
2010	0.18	0.25	0.36	0.20	0.01
2011	0.05	0.34	0.25	0.35	0.01
2012	0.10	0.18	0.37	0.36	0.00
2013	0.23	0.43	0.15	0.19	0.00
Average	0.07	0.26	0.27	0.38	0.02

Source: 1987–2012, Shields and Dupuis (2013).

Table 17.–Historical length composition of Chinook salmon harvested in the ESSN fishery, Upper Cook Inlet, Alaska, 1987–2013.

	Average length by age class (mm METF)					
Year	Age 3 (1.1, 0.2)	Age 4 (1.2, 2.1, 0.3)	Age 5 (1.3, 2.2, 0.4)	Age 6 (1.4, 2.3)	Age 7 (1.5, 2.4)	Overall Average
1987	408	614	873	1,008	1,067	893
1988	399	647	820	992	957	909
1989	451	673	825	992	1,037	898
1990	560	611	773	979	979	798
1991	461	626	822	976	1,054	835
1992	442	613	784	974	1,052	855
1993	419	632	826	990	1,047	887
1994	420	662	866	898	1,088	934
1995	422	646	895	1,026	1,107	883
1996	410	625	871	1,018	1,098	883
1997	426	632	858	1,003	1,055	868
1998	443	644	838	994	1,045	806
1999	414	626	808	968	1,055	827
2000	413	631	846	989	1,064	832
2001	422	614	820	985	1,054	748
2002	422	640	871	989	1,057	784
2003	434	640	859	1,017	1,102	763
2004	428	645	866	1,010	1,093	848
2005	408	594	814	985	1,090	828
2006	440	581	806	978	1,102	733
2007	430	600	800	954	1,046	743
2008	424	593	825	982	1,097	806
2009	409	577	865	1,003	1,051	686
2010	430	611	850	984	1,102	743
2011	403	610	857	968	1,054	794
2012[a]	399	560	870	1,006	[a]	818
2013[a]	451	589	832	986	[a]	658
Average	429	620	839	987	1,062	817

Source: 1987–2012, Shields and Dupuis (2013).

[a] No age-1.5 fish were sampled in 2012 and 2013.

Reporting Group Proportions: Jacks vs. Non-jacks.

A separate age-based MSA was conducted on jacks and non-jacks (age-1.2 and older fish). All 3 years of tissue collections that were analyzed (2010, 2011, and 2013) were combined to meet the required minimum sample size. As stated in the methods, no KRSHA samples were included in the age-based MSA. Estimates were temporally stratified (prior to 8 July vs. 8 July to the end of season) for each year. For the “prior to 8 July” stratum, when only the Kasilof Section was allowed to fish, reporting group proportions for jacks and non-jacks were nearly identical, and all reporting groups had overlapping 90% credibility intervals (Table 18 and Figure 7). All sections were combined for the “8 July to end of season” temporal period to meet required minimum sample sizes. The *Kenai River mainstem* and *Kasilof River mainstem* reporting groups differed; the *Kenai River mainstem* component had a higher ratio of jacks to non-jacks than the *Kasilof River mainstem* component (Table 18 and Figure 7).

Reporting Group Proportions: Small vs. Large Fish

Mixtures were separated into groups of small fish (<u><</u>750 mm METF) and large fish (>750 mm METF). Like the age-based MSA, all 3 years of tissue collections that were analyzed (2010, 2011, and 2013) were combined to meet required minimum sample sizes for the length-based MSA. As stated in the methods, no KRSHA samples were included in the length-based MSA. Estimates were stratified temporally (prior to 8 July vs. 8 July to the end of season). There were enough sample sizes to allow for the “8 July to end of season” estimates to be geographically stratified by the Kasilof Section and the Kenai and East Forelands sections.

For the “prior to 8 July” stratum, reporting group proportions were nearly identical between small and large fish, with individual reporting groups having overlapping 90% credibility intervals (Table 19 and Figure 8). For the Kasilof Section, 8 July to end of season stratum, the *Kenai River mainstem* reporting group had a higher ratio of small fish to large fish than the other reporting groups. That pattern was seen in the Kenai and East Forelands sections, 8 July to end of season stratum as well, although to a lesser degree, at least partly because *Kenai River mainstem* fish made up such a large proportion (0.96) of the harvest in that stratum.

Table 18.–Age-based MSA for ESSN Chinook salmon harvested jacks (age-1.1 fish) and non-jacks (age-1.2+ fish) using mixtures combined by temporal and geographic strata for all 3 years (2010, 2011, and 2013).

		Jacks (age-1.1 fish)				Non-jacks (age 1.2+ fish)			
				Credibility interval				Credibility interval	
Stratum	Reporting group	Proportion	SD	5%	95%	Proportion	SD	5%	95%
Kasilof Section, prior to 8 July									
	Kenai River tributaries	0.022	0.033	0.000	0.093	0.024	0.034	0.000	0.097
	Kenai River mainstem	0.714	0.078	0.580	0.837	0.711	0.075	0.584	0.828
	Kasilof River mainstem	0.208	0.062	0.112	0.315	0.173	0.054	0.089	0.267
	Cook Inlet other	0.056	0.048	0.000	0.144	0.092	0.046	0.025	0.176
All sections combined, 8 July to end of season									
	Kenai River tributaries	0.010	0.017	0.000	0.045	0.003	0.005	0.000	0.013
	Kenai River mainstem	0.892	0.053	0.797	0.969	0.757	0.028	0.710	0.802
	Kasilof River mainstem	0.088	0.046	0.019	0.171	0.236	0.027	0.193	0.282
	Cook Inlet other	0.010	0.019	0.000	0.050	0.004	0.005	0.000	0.015

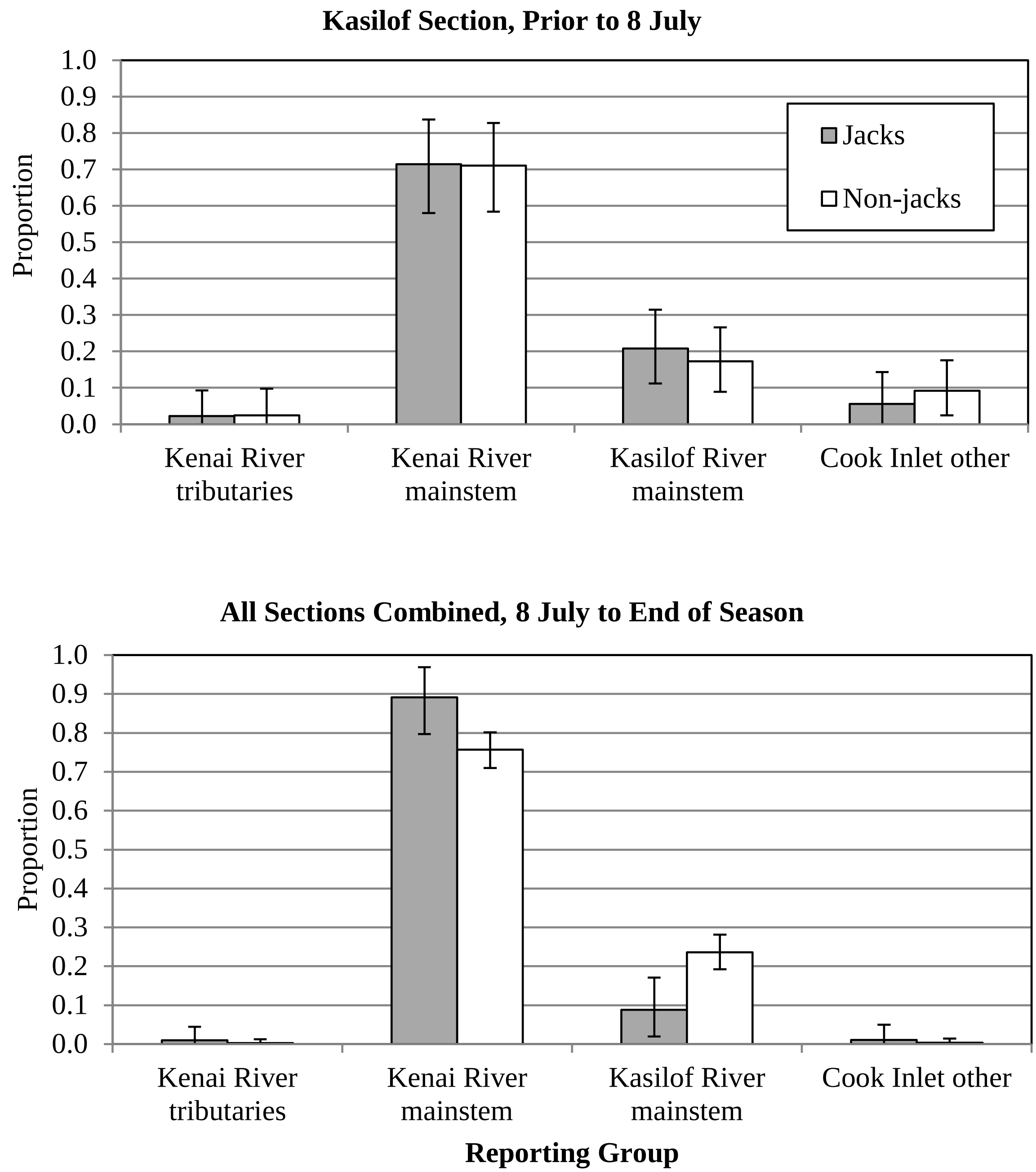

Figure 7.–Age-based (jacks vs. non-jacks) MSA with all 3 years of tissue collections (2010, 2011, and 2013) combined for Kasilof Section, prior to 8 July (top), and all sections combined, 8 July to end of season (bottom).

Note: Error bars represent 90% credibility intervals.

Table 19.–Length-based MSA (≤750 mm vs. >750 mm) for ESSN harvested Chinook salmon using mixtures combined by geographic and temporal strata for all 3 years (2010, 2011, and 2013).

		Chinook salmon ≤750 mm				Chinook salmon >750 mm			
				Credibility interval				Credibility interval	
Stratum	Reporting group	Proportion	SD	5%	95%	Proportion	SD	5%	95%
Kasilof Section, prior to 8 July									
	Kenai River tributaries	0.022	0.027	0.000	0.078	0.020	0.032	0.000	0.088
	Kenai River mainstem	0.728	0.055	0.634	0.814	0.740	0.089	0.585	0.877
	Kasilof River mainstem	0.189	0.043	0.122	0.262	0.213	0.080	0.090	0.354
	Cook Inlet other	0.060	0.032	0.017	0.119	0.027	0.032	0.000	0.093
Kasilof Section, 8 July to end of season									
	Kenai River tributaries	0.013	0.015	0.000	0.042	0.005	0.008	0.000	0.023
	Kenai River mainstem	0.660	0.049	0.578	0.739	0.411	0.055	0.321	0.501
	Kasilof River mainstem	0.313	0.045	0.240	0.388	0.581	0.054	0.492	0.669
	Cook Inlet other	0.015	0.015	0.000	0.046	0.003	0.006	0.000	0.016
Kenai & East Forelands sections, 8 July to end of season									
	Kenai River tributaries	0.010	0.015	0.000	0.040	0.007	0.012	0.000	0.031
	Kenai River mainstem	0.963	0.023	0.920	0.994	0.874	0.042	0.800	0.938
	Kasilof River mainstem	0.022	0.016	0.001	0.053	0.113	0.040	0.052	0.182
	Cook Inlet other	0.005	0.009	0.000	0.024	0.007	0.012	0.000	0.032

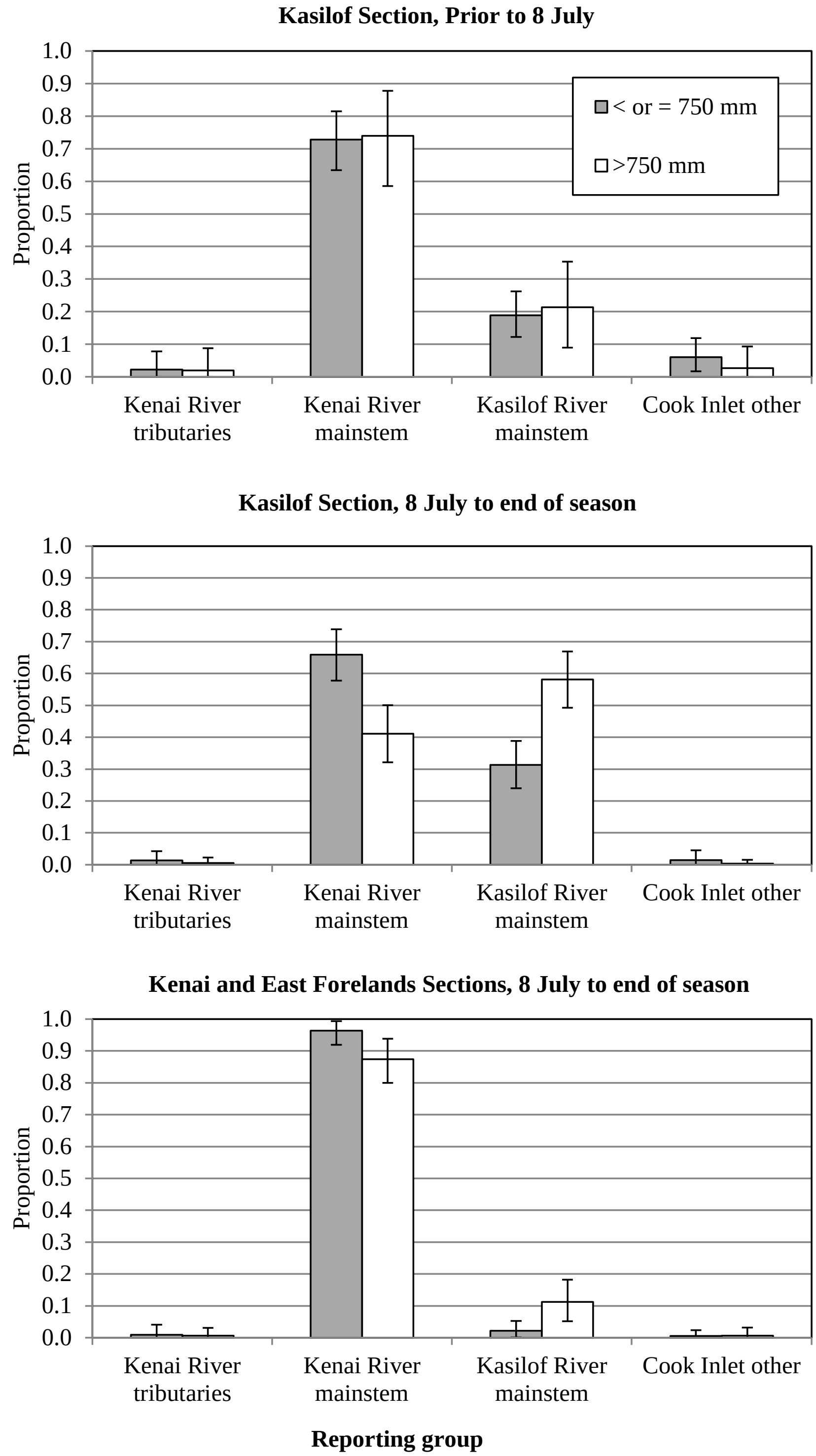

Figure 8.–Length-based (≤750 mm vs. >750 mm) MSA with all 3 years of tissue collections (2010, 2011, and 2013) combined for the following strata: Kasilof Section, prior to 8 July (top), Kasilof Section, 8 July to end of season (middle), and for Kenai and East Forelands sections, 8 July to end of season (bottom).

Note: Error bars represent 90% credibility intervals.

DISCUSSION

Baseline Performance

Baseline performance is assessed by the correct allocation of fish during proof tests. Results from the proof tests (Figure 4) demonstrated that the variation among reporting groups in the baseline is adequate to produce highly accurate estimates of stock compositions; however, test "repeat 4" for the *Kenai River mainstem* (correct allocation: 84%) and test "repeat 2" for *Cook Inlet other* (correct allocation: 86%) indicate that the composition of a mixture sample can affect the resulting MSA estimates. The genetic relationships among baseline populations in Barclay et al. (2012) revealed that some populations are genetically similar to populations in other drainages: the *Kenai River mainstem* population is genetically similar to both the *Kasilof River mainstem* population and to tributaries within the Kenai River, and Crooked Creek (Kasilof River drainage) is similar to tributaries in the Kenai River and southern Kenai Peninsula streams. Because of these genetic similarities between populations, some misallocation between reporting groups with genetically similar populations is expected. When the fish were randomly selected for the proof test mixtures, 2 of the mixtures happened to contain fish that were more genetically similar to populations outside of their reporting group, which caused misallocation to other reporting groups.

Laboratory Failure Rates and Quality Control

Failure rates were low (range: 0.92%–2.96%). Failure rates can occur from a variety of reasons; however, the higher failure rate in 2013 (2.96%) was likely due to the high proportion of jacks (48%) in the first stratum and an inexperienced sampler misclassifying and sampling several female pink salmon of same size intermixed with much more numerous Chinook salmon jacks. Those samples did not affect the MSA because they were missing data at 20% or more of loci (80% rule) and removed. Discrepancy rates between the original laboratory analysis and the quality control analysis were also low during this study (range: 0.01–0.07%).

Reporting Group Proportions and Harvest Estimates

The MSA of tissue collections in 2010, 2011, and 2013 represent the first genetic application to apportion Chinook salmon harvest by reporting group in a UCI commercial fishery. Results from these analyses will be used for Kenai River Chinook salmon run reconstruction, assessing production, and refining brood tables and escapement goals. Prior to the initial MSA of the 2010 and 2011 collections, detailed in a memorandum and reported in Appendix B of Fleischman and McKinley (2013), all Chinook salmon harvested in the ESSN fishery were classified as Kenai River late-run fish because there was a lack of stock composition information. Not surprisingly, the majority of the harvest was composed of the *Kenai River mainstem* population, averaging 69% of the estimated total for 3 years (2010, 2011, and 2013). Nearly all the remainder of the harvest was of *Kasilof River mainstem* fish. The harvest consisted of very few Kenai River tributary fish or other Cook Inlet stocks, which was not surprising, due to the earlier run timing of those stocks.

There are slight differences in *Kenai River mainstem* and *Kasilof River mainstem* reporting group proportions in the initial MSA compared to the results in this report. The initial MSA results from 2010 are nearly identical to results in this report; however, in 2011 there is a 4% difference in the *Kenai River mainstem* and *Kasilof River mainstem* proportions between each analysis. Reasons for the difference include: 1) the initial analysis used an older UCI baseline with fewer populations and individuals, and 2) the overall stock proportions for each year in this study were calculated using a stratified estimator instead of grouping all samples from each year into single mixtures. The method used to estimate the overall stock proportion probably had the greatest effect because it is important to select samples in proportion to the harvest by stratum. However, the individual mixtures in the original analysis did not account for the differences in harvests for each stratum. In this analysis, the stratified estimator used the estimates for each stratum and weighted them by their respective harvest to calculate the overall stock-specific harvest for a given year. For this reason, the estimated harvest proportions provided in this report for 2010 and 2011 are considered more reliable than previously reported results.

Annual proportion of harvest from each reporting group varied among years, but not to a large degree. Different fishing patterns among years, specifically late in the year, are likely mostly responsible for the variation. In 2010, the ESSN fishery was open for 8 periods in August, for 5 periods in August in 2011, and the fishery closed on 23 July (except for the KRSHA that was opened until 2 August) in 2013. Of the two major reporting groups, proportion of total harvest was nearly the same in 2010 and 2011 (64% to 67% *Kenai River mainstem*, 33% *Kasilof River mainstem*), whereas a larger proportion of *Kenai River mainstem* fish (77%) and smaller proportion for of *Kasilof River mainstem* fish (21%) were harvested in 2013. *Kasilof River mainstem* spawning Chinook salmon have a later run-timing on average than other Cook Inlet stocks (Reimer and Fleischman 2012), a pattern that was also seen in this study. The early ending of the fishery in 2013 was likely responsible for differences in proportions among the two major reporting groups in 2013 compared to 2010 and 2011.

Harvest estimates were temporally and geographically stratified in 2013. The Kenai and East Forelands sections harvested a greater proportion of *Kenai River mainstem* fish compared to the Kasilof Section, whereas a greater proportion of *Kasilof River mainstem* fish were harvested in the Kasilof Section. Higher stock proportions with closer proximity to their natal streams is common and has also been observed for Cook Inlet sockeye salmon stocks (Eskelin et al. 2013; Barclay et al. 2010). For the same temporal period (8–23 July), the Kenai and East Forelands sections harvest of *Kenai River mainstem* Chinook salmon (1,276 fish, SE 34) was about double the harvest of *Kenai River mainstem* Chinook salmon in the Kasilof Section (639 fish, SE 44).

So that the entire harvest of Chinook salmon in the ESSN fishery was represented, MSA was performed on the 58-fish sample collected from the KRSHA in 2013. Caution should be taken when interpreting these results. The sampling rate (16%) for the KRSHA harvest was the lowest of any stratum and the 58-fish sample was also the lowest. Assuming perfect genetic identification, a sample size of 58 would meet the precision criteria for objective 1, but given the results of the 100% proof tests (best-case scenario) there is not perfect genetic identification. Because of this, the large credibility intervals around these estimates should be taken into account when interpreting the results. The 90% credibility interval range for KRSHA harvest of *Kenai River mainstem* fish was 38–141 fish; the 90% credibility range for proportions was 0.105–0.393. We know that *Kenai River mainstem* fish were present in the KRSHA harvest, but we are less confident in the estimated contribution to the harvest due to the low sample size.

ASL Compositions

The pattern of younger and smaller fish arriving early in the season was seen in each year of this study. The ASL composition in 2013 was atypical. The average length of sampled fish in 2013 was the smallest ever measured and 2013 had the highest proportion of jacks ever sampled. Jacks and age-1.2 fish accounted for 2 out of every 3 fish in the harvest and no age-1.5 fish were sampled in 2013. Further, 88% of the harvest in 2013 was composed of males. The pattern of small average size, a higher percentage of jacks, and a higher percentage of males was also observed in the Kenai River for both tributary and mainstem spawning fish measured in the ADF&G inriver gillnetting program and United States Fish and Wildlife Service (USFWS) weirs on tributaries streams (J. Perschbacher, Fisheries Biologist, ADF&G, and K. Gates, USFWS, Soldotna, personal communication). Interestingly, the KRSHA had the highest percentage of both age-1.3 fish and age-1.4 fish and the largest average length of any stratum, a result that could be influenced by the late timing of that portion of the fishery, the relative stock composition compared to other strata, or even physical characteristics of the fishery itself, such as shallow depth.

For 2010, 2011, and 2013, *Kenai River mainstem* fish had a higher likelihood of being classified as jacks and a lower likelihood of being classified as large fish (>750 mm) compared to *Kasilof River mainstem* fish. Caution should be used when interpreting these results because timing effects, like those observed in the KRSHA, could potentially influence results. For instance, in 2013, there was a greater proportion of smaller and younger fish in the harvest but the season ended about the 23 July; whereas in 2010 and 2011, the season went into August and there were smaller proportions of these fish in 2013. There were slight differences in run timing among mainstem fish from the Kenai and Kasilof rivers, and that difference could confound the results of the age- and length-based MSA.

FUTURE SAMPLING

The additional samplers employed in 2013 were valuable. We sampled 35% of the harvest in 2013, a higher fraction of the overall harvest than previous years. The higher fraction and more representative sample of the harvest allowed for stratification of harvest estimates and stock proportions, both geographically and temporally, for the first time. We were also able to sample the KRSHA harvest. If the KRSHA is fished in the future, it should be sampled to determine the variability in reporting group proportions between years, especially because of the low sample size used in the analysis in 2013.

Beginning in 2010, a local processor started offering premium prices for Chinook salmon, so many gillnetters held their Chinook salmon, waiting to deliver them to that processor after each fishing period. Because of this, a large portion of the harvest was delivered to that processor and fish deliveries from different areas became mixed, making it difficult to determine which statistical area fish were harvested. So in 2013, with additional samplers available, we were able to station a sampler on-site at that processor for long periods of time in order to sample fish as deliveries arrived and prior to fish being mixed with other deliveries from different statistical areas. If this occurs in the future, it is recommended that a sampler be stationed on-site at that processor the day after fishery openings.

In summary, this project successfully conducted a MSA that provided useful information about the stock composition of the ESSN Chinook salmon harvest and also the ASL composition. The MSA portion of this project should be continued until ADF&G can confidently assess the variation in stock proportions with respect to geographic and temporal characteristics of the harvest, and the ASL sampling should be continued due to the cost-effectiveness of sampling for ASL composition.

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