Fishery Data Series No. 15-19

Mixed Stock Analysis and Age, Sex, and Length Composition of Chinook Salmon in the Eastside Set Gillnet Fishery in Upper Cook Inlet, Alaska, 2014

by

Tony Eskelin

and

Andrew W. Barclay

July 2015

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. 15-19

MIXED STOCK ANALYSIS AND AGE, SEX, AND LENGTH COMPOSITION OF CHINOOK SALMON IN THE EASTSIDE SET GILLNET FISHERY IN UPPER COOK INLET, ALASKA, 2014

by

Tony Eskelin
Alaska Department of Fish and Game, Division of Sport Fish, Soldotna

and

Andrew W. Barclay
Alaska Department of Fish and Game, Division of Commercial Fisheries, Gene Conservation Laboratory, Anchorage

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

July 2015

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Tony Eskelin,
Alaska Department of Fish and Game, Division of Sport Fish,
43961 Kalifornsky Beach Road, Suite B, Soldotna, AK 99669-8276 USA

and

Andrew W. Barclay
Alaska Department of Fish and Game, Division of Commercial Fisheries,
333 Raspberry Rd, Anchorage, AK 99518-1565 USA

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

ABSTRACT

Chinook salmon were sampled for genetic tissue and age, sex, and length (ASL) composition from the Upper Cook Inlet Eastside set gillnet (ESSN) commercial fishery in 2014. Mixed stock analysis (MSA) was conducted on tissue samples that were collected to represent the harvest by date and area. The 4 reporting groups used to apportion the Chinook salmon harvest were *Kenai River mainstem*, *Kenai River tributaries*, *Kasilof River mainstem*, and *Cook Inlet other*. In 2014, the total reported harvest was 2,301 Chinook salmon. Using MSA, the harvest was determined to be composed of 60.9% *Kenai River mainstem* and 38.7% *Kasilof River mainstem* fish, which represented an estimated 1,401 *Kenai River mainstem* and 891 *Kasilof River mainstem* Chinook salmon. *Kenai River tributaries* and *Cook Inlet other* each composed 0.2% of the harvest or an estimated 4 fish each. Reporting group composition in 2014 was similar to 2010, 2011, and 2013. *Kenai River mainstem* fish composed on average 67.1% of the harvest during those years. The remainder of the harvest composition averaged 34.1% *Kasilof River mainstem*, 1.1% *Cook Inlet other*, and 0.4% *Kenai River tributaries*. In 2014, the overall age composition of the sample was 17.6% age-1.1 fish, 32.2% age-1.2 fish, 29.1% age-1.3 fish, 20.9% age-1.4 fish, and 0.1% age-1.5 fish. The sex composition was 61% males and 39% females. Average mid eye to tail fork (METF) length was 712 mm, the third lowest observed since 1987.

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 2013a). 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, whereas set gillnets are the only gear permitted in the Northern District.

All 5 species of Pacific salmon are harvested in UCI, but sockeye salmon (*Oncorhynchus nerka*) make up the majority of the harvest (Shields and Dupuis 2013a). Harvest statistics are monitored by the Alaska Department of Fish and Game (ADF&G) through the fish ticket system. Harvest data are 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, commonly referred to as the Eastside set gillnet (ESSN) fishery, located along the eastern shore of Cook Inlet between Ninilchik and Boulder Point (Figures 1–2). On average since 1966, the ESSN fishery has accounted for 64.8% of all Chinook salmon harvested in UCI commercial fisheries (Table 1).

A recent downturn in Chinook salmon productivity and abundance statewide has created social and economic hardships for many communities in Alaska (ADF&G Chinook Salmon Research Team 2013). Fishery management has been responsive to lower run abundances in an attempt to achieve escapement goals. This downturn has also heightened concerns about stock-specific harvest of Chinook salmon. In July 2012, the Alaska Department of Fish and Game (ADF&G) initiated a comprehensive Chinook Salmon Research Initiative (CSRI) to increase stock assessment capabilities, address knowledge gaps, and elucidate causal mechanisms behind the observed trend in Chinook salmon productivity and abundance (ADF&G Chinook Salmon Research Team 2013). This research plan includes Kenai River Chinook salmon as 1 of 12 statewide indicator stocks and represents an effort to address critical knowledge gaps that limit management capabilities, particularly during times of low abundance.

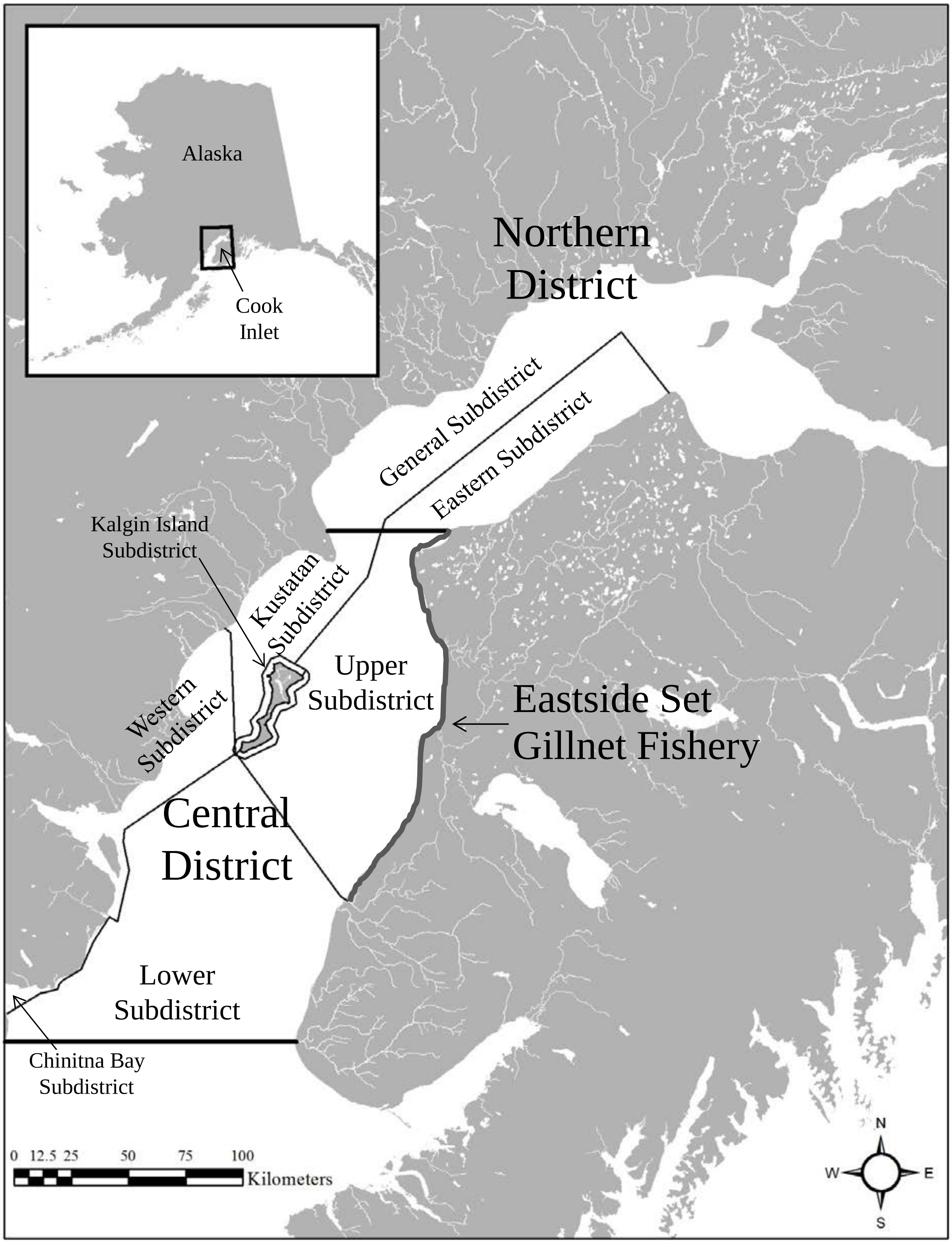

Figure 1.–Map of Upper Cook Inlet commercial fishing districts and subdistricts.

Note: Thick black lines indicate district borders and thin lines indicate subdistrict borders; the thick grey line denotes the ESSN fishery.

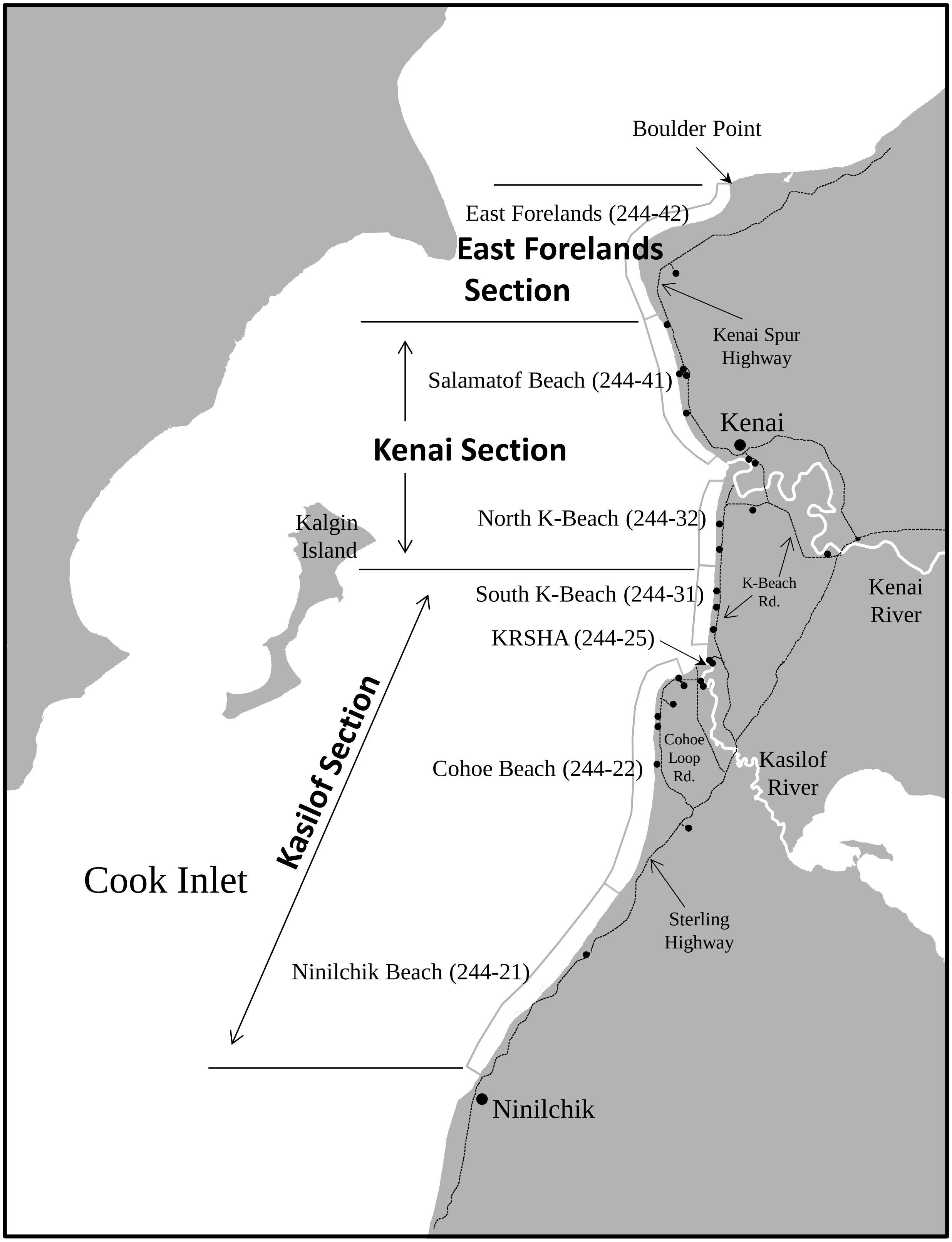

Figure 2.–Map of Upper Cook Inlet Eastside set gillnet commercial fishing statistical areas.

Note: Small circles represent approximate locations of processing plants or receiving sites. KRSHA (244-25) is Kasilof River Special Harvest Area.

Table 1.–Upper Cook Inlet commercial Chinook salmon harvest by gear type and area, 1966–2014.

	Central District						Northern District		
	ESSN		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 Westside 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	24.6	5,398
2014	2,301	49.4	382	8.2	507	0.1	1,470	31.5	4,660
Average									
1966–2014[a]	9,452	64.8	969	6.5	1,246	0.2	3,078	19.3	14,746
2005–2014	7,776	59.6	939	7.9	703	0.1	2,496	24.2	11,914

Source: 1966–2012 data from Shields and Dupuis (2013a: Appendix B1); 2013 data from Eskelin et al. (2013).

[a] Data from 1989 were not used in averages because the Central District drift gillnet fishery did not fish due to the Exxon Valdez oil spill, which affected all other fisheries.

Estimation of adult abundance requires stock-specific information on the escapement or inriver run as well as marine and freshwater harvests. For mixed stock harvests from marine and freshwater fisheries, stock-specific harvest can be estimated by genetic stock identification (GSI) techniques. GSI methods require that a comprehensive genetic baseline is created that includes all populations that may potentially contribute to the harvest. In addition, for available genetic markers, there must be sufficient genetic variation among the populations or population groups (stocks) to allow for mixed stock analysis (MSA) to resolve stock composition with defined levels of accuracy and precision. In 2012, a UCI Chinook salmon genetic baseline was first developed, which included 30 populations and 38 usable single nucleotide polymorphism (SNP) loci (Barclay et al. 2012). Since then, the baseline has been augmented with additional collections and previously unrepresented populations (Barclay and Habicht 2015), and it is now quite comprehensive, including 55 populations and 39 SNPs.

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 for MSA were added to the collection effort beginning in 2010. In 2013, additional funding was secured through the CSRI to increase sampling effort, provide for better coverage of the fishery, and to allow for MSA estimates to be stratified by time and area. In 2013, a report was published describing the results from 2010 to 2013 (Eskelin et al. 2013) where annual MSA estimates were provided for 2010, 2011, and 2013 but not for 2012, due to low sample size. Stratified estimates from 2013 were provided by time and area for the first time.

CSRI funding for the expanded sampling effort of ESSN harvested Chinook salmon was continued in 2014. This report describes the ESSN fishery Chinook salmon ASL and genetic tissue sampling effort, analyses, and results from 2014.

OBJECTIVES

PRIMARY OBJECTIVES

1) Estimate the proportion of Chinook salmon harvested in the UCI ESSN commercial fishery by reporting group (*Kenai River mainstem*, *Kasilof River mainstem*, *Kenai River tributaries*, or *Cook Inlet other*) for each temporal and geographic stratum such that the estimated proportions are within 13 percentage points of the true values 90% of the time.
2) Estimate the harvest of *Kenai River mainstem* and *Kasilof River mainstem* Chinook salmon in the UCI ESSN commercial fishery for each temporal and geographic stratum such that the estimates are within 30% 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.

SECONDARY OBJECTIVES

1) Estimate the harvest of Chinook salmon for the reporting groups *Kenai River tributaries* and *Cook Inlet other* in the UCI ESSN commercial fishery for each temporal and geographic stratum[1].
2) Sample 35% of the Chinook salmon harvested in the UCI ESSN commercial fishery for tissue, coded wire tags, scales, sex, and lengths from mid eye to tail fork (METF).
3) Estimate the sex and length compositions of Chinook salmon harvested in the UCI ESSN commercial fishery, overall and for each temporal and geographic stratum.

METHODS

STUDY DESIGN

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). Fishery managers generally regulate the ESSN fishery by sections, which are groups of statistical areas. 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 it was always fished concurrently with the Kenai Section and grouped with the Kenai Section in this report. The KRSHA was opened separately to

[1] Chinook salmon harvests of the reporting groups *Kenai River tributaries* and *Cook Inlet other* were anticipated to be low (<150 fish), so no precision criteria were set for estimation of these reporting groups. Sample size goals were driven by Primary Objectives 1 and 2.

concentrate harvest of Kasilof River sockeye salmon while minimizing harvest of Kenai River Chinook and sockeye salmon. The Kasilof Section opens on the first Monday or Thursday on or after 25 June, unless ADF&G estimates that 50,000 sockeye salmon are in the Kasilof River prior to that date, at which time the commissioner may open the fishery by emergency order (EO); however, the fishery may not open earlier than 20 June (Alaska Administrative Code 5 AAC 21.310 b. 2.C.[i]). The Kenai and East Forelands sections open by regulation on the first Monday or Thursday on or after 8 July (5 AAC 21.310). In 2014, the ESSN fishery opened on 23 June in the Kasilof Section and on 9 July in the Kenai and East Forelands sections. The Kasilof Section was fished on 14 days; the Kenai and East Forelands sections were fished on 6 days. In addition, the KRSHA was opened on 16 July and fished for 17 days between 16 July and 2 August. All fishery openings were sampled. Estimates were stratified geographically and temporally into the following 5 strata: 1) 23 June–7 July, Kasilof Section; 2) 9–23 July, Kasilof Section; 3) 9–23 July, Kenai and East Forelands sections; 4) 16 July–2 August, KRSHA; and 5) 2–6 August, Kenai and East Forelands sections.

Tissue and Age, Sex, and Length Sampling

During and after fishery openings, 3 ADF&G staff members traveled to receiving sites for fish processing plants after each tide and sampled Chinook salmon for genetic tissue and ASL. The number and location of these receiving sites can vary from year to year, but there are generally about 20 sites. Approximate locations of the receiving sites and fish processing plants are shown in Figure 2. All commercial fishery openings were sampled. As many sites as possible were sampled during each fishing period, and many sites were sampled more than once if fishing occurred over multiple tides. Sampling was begun after the first round of deliveries to the receiving sites had occurred, starting at the southernmost receiving station near Ninilchik and progressing northward to each major receiving site up to East Forelands. Samplers 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 fish processing plants when feasible.

Three scales were removed from the preferred area of each fish and placed on an adhesive-coated card (Welander 1940; Clutter and Whitesel 1956). Acetate impressions were made of each scale card and scales were aged using a microfiche reader. Sex was 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.

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[2] 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. Chinook salmon were opportunistically sampled without regard to size, sex, length, or location.

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 the same set of SNP markers, 62 additional collections, and 25 new populations (Table 2). To minimize misallocation between

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

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 were chosen based on 1 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. The 4 reporting groups chosen to apportion the harvest were as follows: *Kenai River mainstem*, *Kenai River tributaries*, *Kasilof River mainstem*, and *Cook Inlet other*.

Juneau Creek, a Kenai River tributary, was grouped with the *Kenai River mainstem* reporting group due to genetic similarity (Barclay et al. 2012). The *Cook Inlet other* reporting group represented all remaining Cook Inlet Chinook salmon baseline populations not included in the 3 other reporting groups (Table 2, Figure 3). The results of baseline evaluation tests (proof tests) for reporting groups that were used in the analysis of the 2010, 2011, and 2013 samples are reported in Eskelin et al (2013). Since that report, 12 additional northern Cook Inlet populations have been added to the baseline. Because northern Cook Inlet populations are included in the *Cook Inlet other* reporting group, which represents a very small component of the ESSN Chinook salmon harvest, the previous proof test results are still a good indicator of the performance of the updated baseline for ESSN Chinook salmon reporting groups. Consequently, this report does not contain updated proof test results.

Tissue Sample Selection for MSA

Harvest samples were stratified into 5 geographic and temporal strata, and samples were selected from each stratum separately. Sample size goals for MSA were 100 fish for each stratum when possible. Individual tissue samples were selected to represent the 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. Length was incorporated into the sample selection such that the length distribution of fish selected for MSA was approximately equivalent to the length distribution of all sampled fish within each grouping. A grouping was usually 1–2 days of samples within each stratum. Due to low number of samples collected in August, especially in the Kasilof Section, only samples from the Kenai and East Forelands sections were used in the analysis and all of the samples collected were used from that area.

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.[a]	Reporting group	Location	Added [b]	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, 2012	190
5		Lewis River	X	2011, 2012	87
6		Red Creek	X	2012, 2013	111
7		Hayes River	X	2012, 2013	50
8		Canyon Creek	X	2012, 2013	91
9		Talachulitna River		1995, 2008, 2010	178
10		Sunflower Creek		2009, 2011	123
11		Peters Creek	X	2009, 2010, 2011, 2012	107
12		Portage Creek	X	2009, 2010, 2011, 2013	162
13		Indian River	X	2013	79
14		Middle Fork Chulitna River		2009, 2010	169
15		East Fork Chulitna River	X	2009, 2010, 2011, 2013	77
16		Byers Creek	X	2013	55
17		Spink Creek	X	2013	56
18		Troublesome Creek	X	2013	71
19		Bunco Creek	X	2013	98
20		Upper Talkeetna no name creek	X	2013	69
21		Prairie Creek		1995, 2008	161
22		East Fork Iron Creek	X	2013	57
23		Disappointment Creek	X	2013	64
24		Chunilna Creek		2009, 2012	123
25		Montana Creek		2008, 2009, 2010	213
26		Little Willow Creek	X	2013	54
27		Willow Creek		2005, 2009	170
28		Deshka River		1995, 2005, 2012	303
29		Sucker Creek	X	2011, 2012	143
30		Little Susitna River		2009, 2010	228
31		Moose Creek - Matanuska River		1995, 2008, 2009, 2012	149
32		Eagle River	X	2009, 2011, 2012	77
33		Ship Creek		2009	261
34		Campbell Creek	X	2010	110
35		Carmen River	X	2011, 2012	50
36		Resurrection Creek	X	2010, 2011, 2012	98
37		Chickaloon River		2008, 2010, 2011	128

-continued-

Table 2.–Part 2 of 2.

Map no.[a]	Reporting group	Location	Added [b]	Collection year(s)	*n*
38	Kenai R. tributaries	Grant Creek	X	2011, 2012	55
39		Quartz Creek		2006, 2007, 2008, 2009, 2010, 2011	131
40		Crescent Creek		2006	164
41		Russian River		2005, 2006, 2007, 2008	214
42		Benjamin Creek		2005, 2006	204
43		Killey River		2005, 2006	255
44		Funny River		2005, 2006	219
45	Kenai R. mainstem	Juneau Creek		2005, 2006, 2007	140
46		Upper Kenai R. mainstem		2009	191
47		Middle Kenai R. mainstem		2003, 2004, 2006	299
48		Lower Kenai R. mainstem	X	2010, 2011	118
49	Kasilof R. mainstem	Kasilof River mainstem		2005	321
50	Cook Inlet other	Crooked Creek		2005, 2011	306
51		Ninilchik River weir		2006, 2010	209
52		Deep Creek		2009, 2010	196
53		Stariski Creek	X	2011, 2012	104
54		Anchor River weir		2006, 2010	249

[a] Map numbers correspond to sampling sites on Figure 3.

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

Table 3.–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, 2014.

Dates	Geographic area	Reported harvest	Number sampled	Proportion sampled	Number selected for MSA	Proportion of harvest selected for MSA
23 June–7 July	Kasilof Section	468	233	0.50	97	0.21
9–23 July	Kasilof Section	561	261	0.47	96	0.17
9–23 July	Kenai and East Forelands sections	427	182	0.43	99	0.23
16 July–2 August	KRSHA [a]	625	211	0.34	97	0.16
2–6 August	All areas	220	79	0.36	78	0.35
23 June–6 August	All areas	2,301	966	0.42	467	0.20

[a] Kasilof River special harvest area.

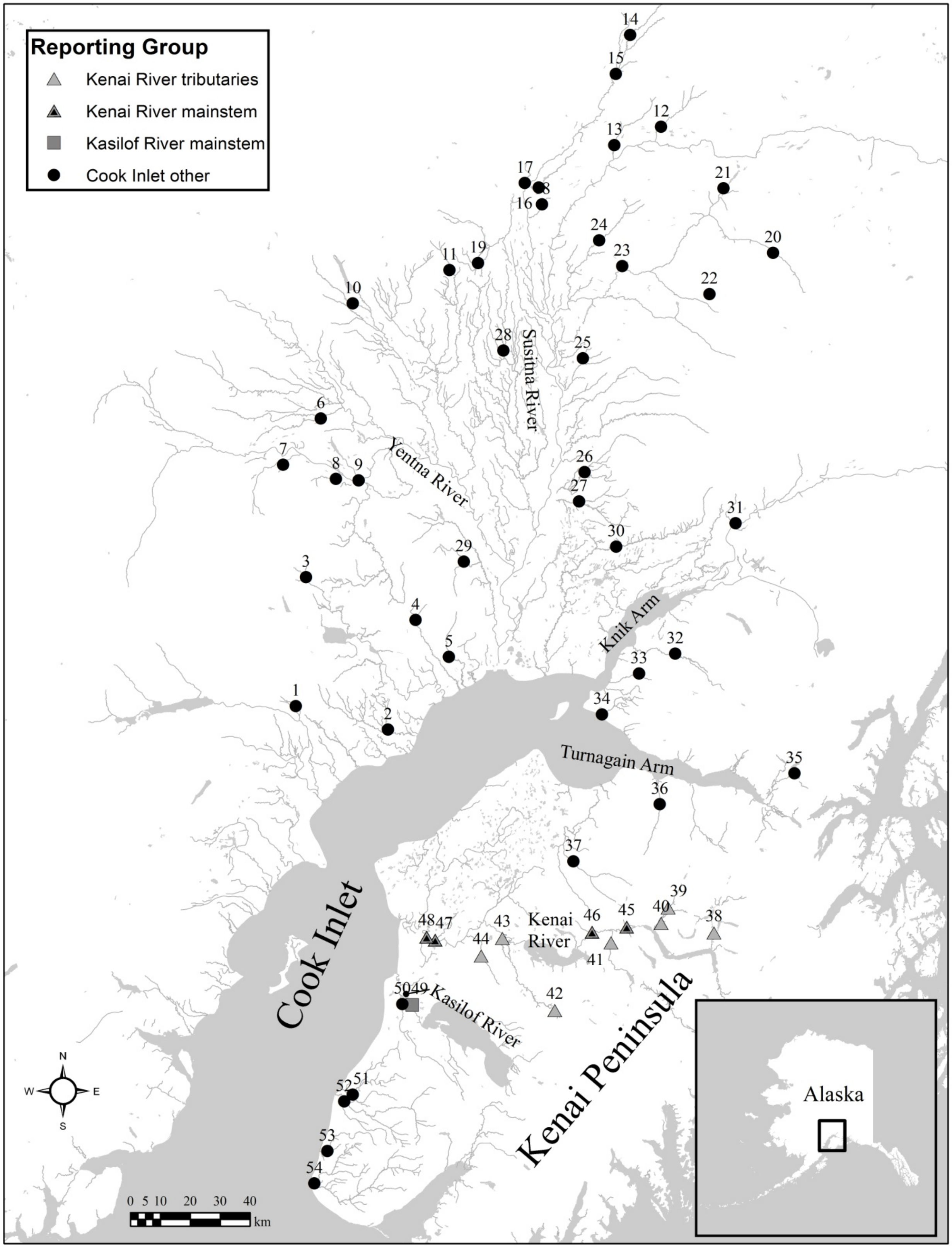

Figure 3.–Sampling locations for Chinook salmon populations included in the genetic baseline.

Note: Numbers correspond to map numbers listed in Table 2.

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), which 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

Methods and results for baseline evaluation tests are reported in Eskelin et al. (2013).

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 software package BAYES (Pella and Masuda 2001). BAYES employs a Bayesian algorithm to estimate the most probable contributions 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). Each of the 5 Markov chain Monte Carlo (MCMC) chains began with different randomly generated initial values, 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 2014 ESSN mixtures, the best available information came from the stock proportion estimates from the analysis of the 2011 and 2013 ESSN Chinook salmon samples. 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 reported harvest from that stratum by its unrounded estimates of reporting group proportions (obtained from MSA) and the upper and lower bounds of that estimate. Results were rounded to the nearest fish.

Strata were combined into yearly harvest estimates for each reporting group by weighting them by their respective harvests (stratified estimator) following the methods of Dann et al. (2009). These harvest estimates, including their upper and lower bounds, were divided by the total ESSN harvest to derive the overall proportion and credibility interval of each reporting group in harvest.

This method yielded the same point estimate for number of harvested fish within the fishery 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 nonsymmetric credibility intervals.

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

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

$$\hat{p}_i^{(z)} = \frac{n_i^{(z)}}{n_i} \tag{3}$$

where $\hat{p}_i^{(z)}$ is the estimated proportion of salmon of age category *z* from sampling stratum *i*, $n_i^{(z)}$ equals the number of fish sampled from sampling stratum *i* that were classified as age category *z*, and n_i equals the number of Chinook salmon sampled for age determination from sampling stratum *i*.

The variance of $\hat{p}_i^{(z)}$ was calculated as follows:

$$\text{var}\left[\hat{p}_i^{(z)}\right] = \left(1 - \frac{n_i}{H_i}\right)\frac{\hat{p}_i^{(z)}\left(1 - \hat{p}_i^{(z)}\right)}{n_i - 1} \tag{4}$$

where H_i is the reported number of Chinook salmon harvested in sampling stratum *i*.

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

$$\hat{H}_i^{(z)} = H_i \hat{p}_i^{(z)} \tag{5}$$

with variance

$$\text{var}\left[\hat{H}_i^{(z)}\right] = H_i^2 \,\text{var}\left[\hat{p}_i^{(z)}\right]. \tag{6}$$

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

$$\hat{H}^{(z)} = \sum_{i=1}^{S} \hat{H}_i^{(z)} \tag{7}$$

and

$$\text{var}\left[\hat{H}^{(z)}\right] = \sum_{i=1}^{S} \text{var}\left[\hat{H}_i^{(z)}\right] \tag{8}$$

where $S = 5$ is the number of sampling strata.

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

$$\hat{p}^{(z)} = \frac{\hat{H}^{(z)}}{H} \tag{9}$$

and

$$\text{var}\left[\hat{p}^{(z)}\right] = \frac{\text{var}\left[\hat{H}^{(z)}\right]}{H^2}. \tag{10}$$

where *H* is the total ESSN reported harvest for 2014.

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

Mean length $\bar{l}_z$ of Chinook salmon in 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 $\mathrm{var}(\bar{l}_z)$ of the mean length-at-age class *z* was estimated as follows:

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

RESULTS

LABORATORY ANALYSIS

A total of 471 fish were genotyped from the 2014 ESSN Chinook salmon tissue samples. The failure rate was 1.19% and the error rate was 0.06%.

DATA ANALYSIS

Baseline Evaluation for MSA

Baseline evaluation tests are reported in Eskelin et al. (2013).

Data Retrieval and Quality Control

Based upon the 80% rule, 3 individuals were removed from the ESSN collection. There was 1 duplicate individual detected in the ESSN collection, which was removed.

REPORTING GROUP PROPORTIONS AND HARVEST ESTIMATES

Reported harvest of Chinook salmon in the ESSN fishery was 2,301 fish, which was 49% of the total UCI Chinook salmon commercial harvest in 2014 (Table 1). A total of 966 samples (42% of the harvest) were collected and identified by statistical area (Table 3), of which 467 (20% of the harvest) were selected for MSA (Table 3). The following 5 temporal and geographic strata were used for estimating reporting group proportions and harvests: 1) 23 June–7 July, Kasilof Section; 2) 9–23 July, Kasilof Section; 3) 9–23 July, Kenai and East Forelands sections; 4) 16 July–2 August, KRSHA; and 5) 2–6 August, Kenai and East Forelands sections. Reporting group proportions by strata were estimated with MSA and applied to total harvest by strata to estimate harvest by reporting group. Harvest estimates were then weighted by stratum to generate overall estimates for each reporting group in 2014.

Stratified Estimates by Time and Area

Kasilof Section, 23 June–7 July Stratum

Reported harvest was 468 Chinook salmon, and 233 fish (50% of the harvest) were sampled in the Kasilof Section, 23 June–7 July stratum (Table 3). After subsampling representatively by statistical area and date, 97 samples (21% of the harvest) were selected for analysis. MSA reporting groups were represented in the following proportions: 0.001 *Kenai River tributaries*, 0.769 *Kenai River mainstem*, 0.224 *Kasilof River mainstem*, and 0.007 *Cook Inlet other* (Figure 4 and Table 4). Estimated Chinook salmon harvest by reporting group was 0 *Kenai River tributaries*, 360 *Kenai River mainstem*, 105 *Kasilof River mainstem*, and 3 *Cook Inlet other* (Table 4). Table 4 lists 90% credibility intervals for estimates of reporting group proportions and harvests for all strata.

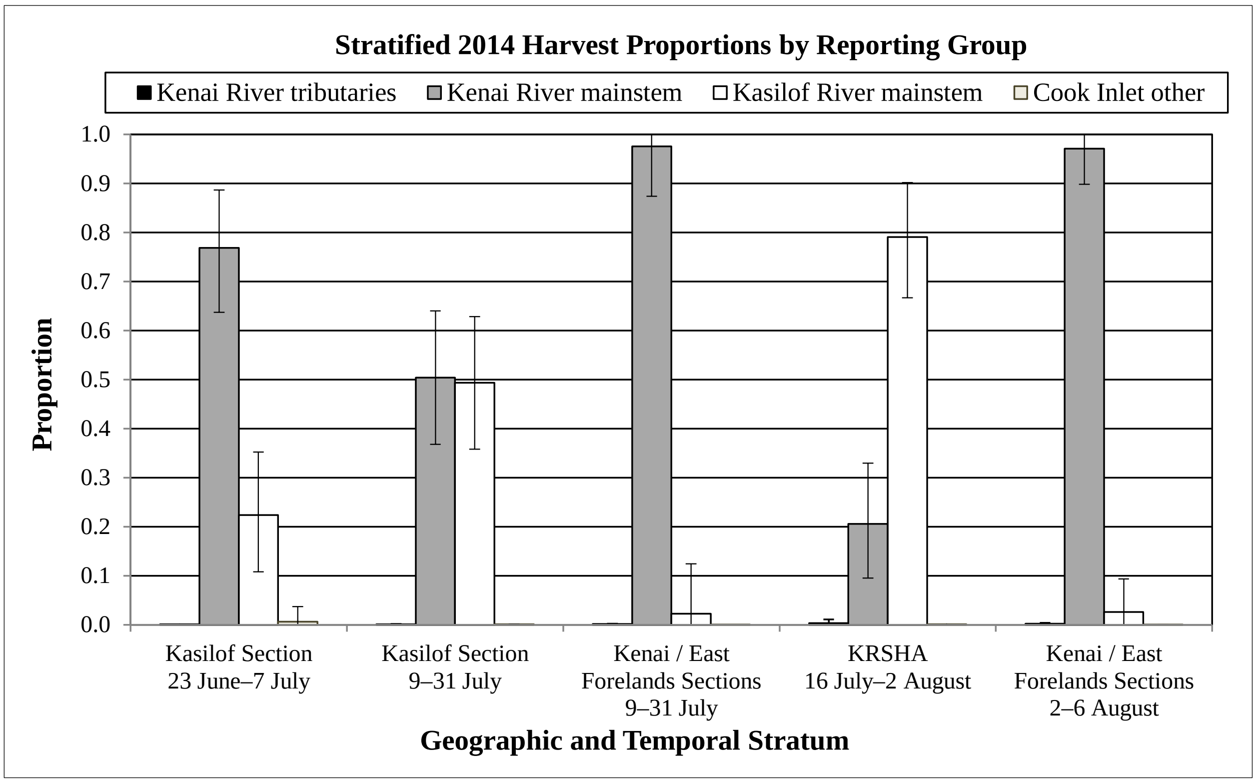

Figure 4.–Proportions and 90% credibility intervals of 2014 ESSN Chinook salmon harvest by reporting group within each geographic and temporal stratum.

Note: KRSHA = Kasilof River Special Harvest Area.

Table 4.–Proportion and estimated number of Chinook salmon harvested by reporting group and stratum in the ESSN fishery, Upper Cook Inlet, Alaska, 2014.

Stratum				Credibility interval			Credibility interval	
Area	Date	Reporting group	Proportion	5%	95%	Harvest	5%	95%
Kasilof	23 Jun–7 Jul							
		Kenai River tributaries	0.001	0.000	0.001	0	0	0
		Kenai River mainstem	0.769	0.637	0.887	360	298	415
		Kasilof River mainstem	0.224	0.108	0.352	105	51	165
		Cook Inlet other	0.007	0.000	0.037	3	0	17
Kasilof	9–23 Jul							
		Kenai River tributaries	0.001	0.000	0.002	1	0	1
		Kenai River mainstem	0.504	0.368	0.640	283	206	359
		Kasilof River mainstem	0.493	0.358	0.629	277	201	353
		Cook Inlet other	0.001	0.000	0.001	1	0	1
Kenai and East Forelands	9–23 Jul							
		Kenai River tributaries	0.001	0.000	0.002	1	0	1
		Kenai River mainstem	0.976	0.874	1.000	417	373	427
		Kasilof River mainstem	0.023	0.000	0.124	10	0	53
		Cook Inlet other	0.000	0.000	0.000	0	0	0
KRSHA[a]	17 Jul–2 Aug 2							
		Kenai River tributaries.	0.003	0.000	0.011	2	0	7
		Kenai River mainstem	0.206	0.095	0.329	129	60	206
		Kasilof River mainstem	0.791	0.667	0.902	494	417	564
		Cook Inlet other	0.000	0.000	0.000	0	0	0
Kenai and East Forelands	2–6 Aug							
		Kenai River tributaries	0.002	0.000	0.004	1	0	1
		Kenai River mainstem	0.971	0.898	1.000	214	198	220
		Kasilof River mainstem	0.026	0.000	0.093	6	0	21
		Cook Inlet other	0.000	0.000	0.000	0	0	0

[a] Kasilof River Special Harvest Area.
Note: KRSHA = Kasilof River Special Harvest Area.

Kasilof Section, 9–23 July Stratum

Reported harvest was 561 Chinook salmon, and 261 samples (47% of the harvest) were collected (Table 3). After subsampling representatively by statistical area and date, 96 samples (17% of the harvest) were selected for analysis (Table 3). Reporting groups were represented in the following proportions: 0.001 *Kenai River tributaries*, 0.504 *Kenai River mainstem*, 0.493 *Kasilof River mainstem*, and 0.001 *Cook Inlet other* (Figure 4 and Table 4). Estimated harvest by reporting group was 1 *Kenai River tributaries*, 283 *Kenai River mainstem*, 277 *Kasilof River mainstem*, and 1 *Cook Inlet other* (Table 4).

Kenai and East Forelands Sections, 9–23 July Stratum

Reported Chinook salmon harvest was 427 fish, and 182 samples (43% of the harvest) were collected (Table 3). After subsampling representatively by statistical area and date, 99 samples (23% of the harvest) were selected for analysis (Table 3). Reporting groups were represented in the following proportions: 0.001 *Kenai River tributaries*, 0.976 *Kenai River mainstem*, 0.023 *Kasilof River mainstem*, and 0.000 *Cook Inlet other* (Figure 4 and Table 4). Estimated harvest by reporting group was 1 *Kenai River tributaries* fish, 417 *Kenai River mainstem*, 10 *Kasilof River mainstem*, and 0 *Cook Inlet other* (Table 4).

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

Reported Chinook salmon harvest was 625 fish, and 211 samples (34% of the harvest) were collected (Table 3). After subsampling representatively by date, 99 samples (16% of the harvest) were selected for analysis. Reporting groups were represented in the following proportions: 0.003 *Kenai River tributaries*, 0.206 *Kenai River mainstem*, 0.791 *Kasilof River mainstem*, and 0.000 *Cook Inlet other* (Figure 4 and Table 4). Estimated harvest by reporting group was 2 *Kenai River tributaries*, 129 *Kenai River mainstem*, 494 *Kasilof River mainstem*, and 0 *Cook Inlet other* (Table 4).

Kenai and East Forelands Sections, 2–6 August Stratum

Reported Chinook salmon harvest was 220 fish, and 79 samples (36% of the harvest) were collected (Table 3). After subsampling representatively by date, 78 samples (35% of the harvest) were selected for analysis (Table 3). Reporting groups were represented in the following proportions: 0.002 *Kenai River tributaries*, 0.971 *Kenai River mainstem*, 0.026 *Kasilof River mainstem*, and 0.000 *Cook Inlet other* (Figure 4 and Table 4). Estimated harvest by reporting group was 1 *Kenai River tributaries*, 214 *Kenai River mainstem*, 6 *Kasilof River mainstem*, and 0 *Cook Inlet other* (Table 4).

Overall estimates

Overall reporting groups proportions were calculated from Equation 1 as follows: 0.002 *Kenai River tributaries*, 0.609 *Kenai River mainstem*, 0.387 *Kasilof River mainstem*, and 0.002 *Cook Inlet other* (Figure 5 and Table 5). Estimated Chinook salmon harvest by reporting group was as follows: 4 *Kenai River tributaries*, 1,409 *Kenai River mainstem*, 891 *Kasilof River mainstem*, and 4 *Cook Inlet other* (Table 4). Table 5 lists 90% credibility intervals for 2014 reporting group proportions and harvest estimates.

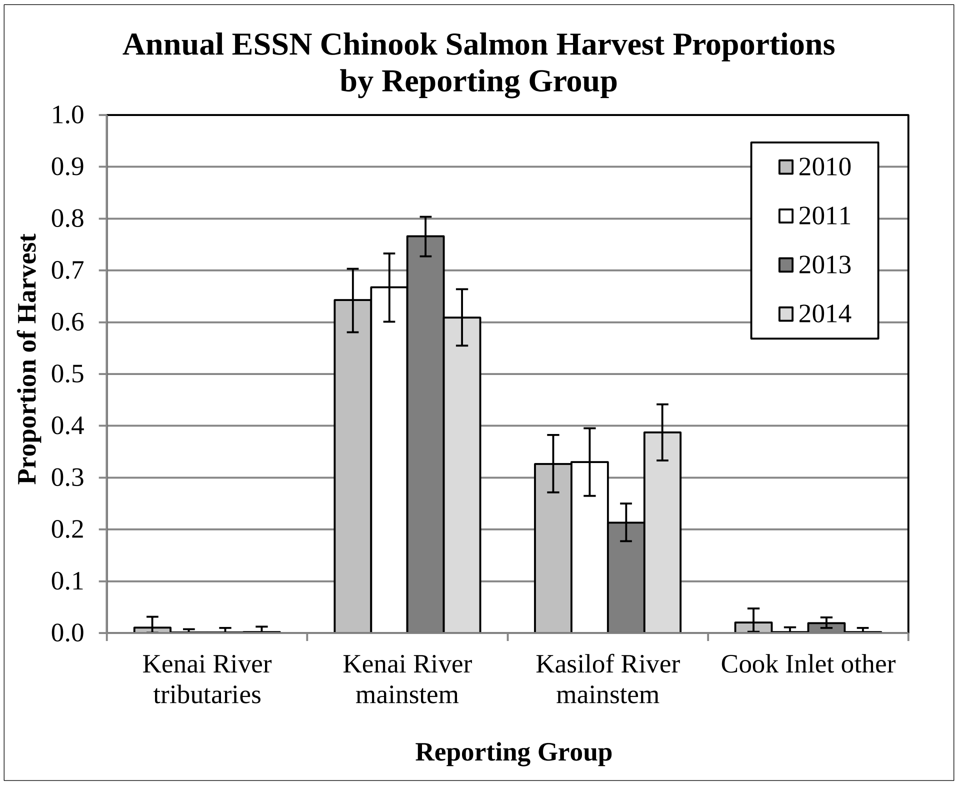

Figure 5.–Proportions and 90% credibility intervals of ESSN Chinook salmon harvested by reporting group and year, 2010, 2011, 2013, and 2014.

Table 5.–Proportion and estimated number of Chinook salmon harvested by reporting group in the ESSN fishery, Upper Cook Inlet, Alaska, 2014.

		Credibility interval			Credibility interval	
Reporting group	Proportion	5%	95%	Harvest	5%	95%
Kenai River tributaries	0.002	0.000	0.012	4	0	28
Kenai River mainstem	0.609	0.555	0.664	1,401	1,276	1,527
Kasilof River mainstem	0.387	0.333	0.441	891	766	1,015
Cook Inlet other	0.002	0.000	0.010	4	0	22

Table 6.–Proportions of ESSN Chinook salmon harvest by reporting group and year.

			Credibility interval			Credibility interval	
Reporting group	Year	Proportion	5%	95%	Harvest	5%	95%
Kenai River tributaries	2010	0.011	0.001	0.031	75	4	220
	2011	0.001	0.000	0.008	9	0	59
	2013	0.001	0.000	0.010	4	0	30
	2014	0.002	0.000	0.012	4	0	28
	Average	0.004			23		
Kenai River mainstem	2010	0.643	0.581	0.703	4,536	4,100	4,963
	2011	0.667	0.601	0.733	5,135	4,624	5,641
	2013	0.766	0.727	0.804	2,289	2,173	2,401
	2014	0.609	0.555	0.664	1,401	1,276	1,527
	Average	0.671			3,340		
Kasilof River mainstem	2010	0.326	0.271	0.383	2,305	1,915	2,701
	2011	0.330	0.265	0.395	2,538	2,038	3,042
	2013	0.213	0.178	0.250	637	530	748
	2014	0.387	0.333	0.441	891	766	1,015
	Average	0.314			1,593		
Cook Inlet other	2010	0.020	0.003	0.047	144	19	334
	2011	0.002	0.000	0.011	14	0	84
	2013	0.019	0.010	0.030	57	29	89
	2014	0.002	0.000	0.010	4	0	22
	Average	0.011			55		

AGE, SEX, AND LENGTH COMPOSITION

In 2014, the proportions of Chinook salmon in the ESSN harvest by age were 0.18 age-1.1 fish, 0.32 age-1.2 fish, 0.29 age-1.3 fish, 0.21 age-1.4 fish, and 0.00 age-1.5 fish (Table 7). Mean length by age of harvest samples are given in Tables 8 and 9. Standard errors for ASL composition are listed in Table 9.

ASL compositions for each temporal and geographic stratum are depicted in Figure 6 and listed in Tables 10–14. Similar to previous years, a pattern of increasing size and age through time was observed during the 2014 season (Figure 6, Tables 10–14; Eskelin et al. 2013). A higher percentage of smaller, younger fish was observed in the earliest stratum (Kasilof section, 23 June–7 July) than in any other strata. In that stratum, 46.4% of the harvest was composed of jacks (age-1.1 fish), whereas the average percentage of jacks for all other strata was less than 10%. Jacks and age-1.2 fish combined composed 83.5% of the earliest stratum, whereas for all other strata, the percentage of age-1.1 and -1.2 fish combined ranged from 19.4% to 51.5%. There was 1 age-1.5 fish sampled in 2014, harvested from the Kenai section in August.

The smallest average length within any stratum (564 mm) was observed in the earliest stratum (Table 10). The largest average length within any stratum (894 mm) was from the stratum for 2–6 August, Kenai and East Forelands sections (Table 14). The KRSHA had the second-largest average length for all ages (770 mm) of any stratum (Table 13).

Overall sex composition was 38.6% females and 61.4% males (Table 9). The earliest stratum had the largest percentage of males of any strata at 83.5% (Table 10). The percentage of males from all other strata ranged from 41.7% to 68.0%.

Table 7.–Historical age composition of Chinook salmon harvest samples in the ESSN fishery, Upper Cook Inlet, Alaska, 1987–2014.

	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
2014	0.18	0.32	0.29	0.21	0.00 [a]
Average	0.07	0.26	0.27	0.38	0.02

Source: 1987–2012: Shields and Dupuis 2013a; 2013: Eskelin et al. 2013.

[a] One age-1.5 fish was sampled in 2014.

Table 8.–Historical mean length by age of Chinook salmon harvest samples in the ESSN fishery, Upper Cook Inlet, Alaska, 1987–2014.

Year	Average length by age class (mm)					Overall average length of harvest samples
	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	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
2014[b]	431	626	795	954	1,240	712
Average	429	620	837	986	1,069	813

Source: 1987–2012: Shields and Dupuis 2013a; 2013: Eskelin et al. 2013.

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

[b] One age-1.5 fish was sampled in 2014.

Table 9.–Age, sex, and length composition of Chinook salmon harvest samples in the Eastside set gillnet Chinook salmon fishery, Upper Cook Inlet, Alaska, 2014.

		Age class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Harvest		73	473	342		889
	SE (harvest)		17	40	35		46
	Samples		15	95	67		177
	Age composition		3.2%	20.6%	14.9%		38.6%
	SE (age composition)		0.7%	1.7%	1.5%		2.0%
	Mean length (mm)		695	796	944		845
	SE (mean length)		50	68	55		103
Males							
	Harvest by age	404	669	197	139	3	1,412
	SE (harvest)	35	45	27	23	3	46
	Samples	79	132	41	29	1	282
	Age composition	17.6%	29.1%	8.6%	6.1%	0.1%	61.4%
	SE (age composition)	1.5%	1.9%	1.2%	1.0%	0.1%	2.0%
	Mean length (mm)	431	619	793	978	1,240	630
	SE (mean length)	45	52	82	61		178
Both Sexes							
	Harvest	404	742	670	482	3	2,301
	SE (harvest)	35	46	44	40	3	
	Samples	79	147	136	96	1	459
	Age composition	17.6%	32.2%	29.1%	20.9%	0.1%	100.0%
	SE (age composition)	1.5%	2.0%	1.9%	1.7%	0.1%	
	Mean length (mm)	431	626	795	954	1,240	712
	SE (mean length)	45	56	72	59		186

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

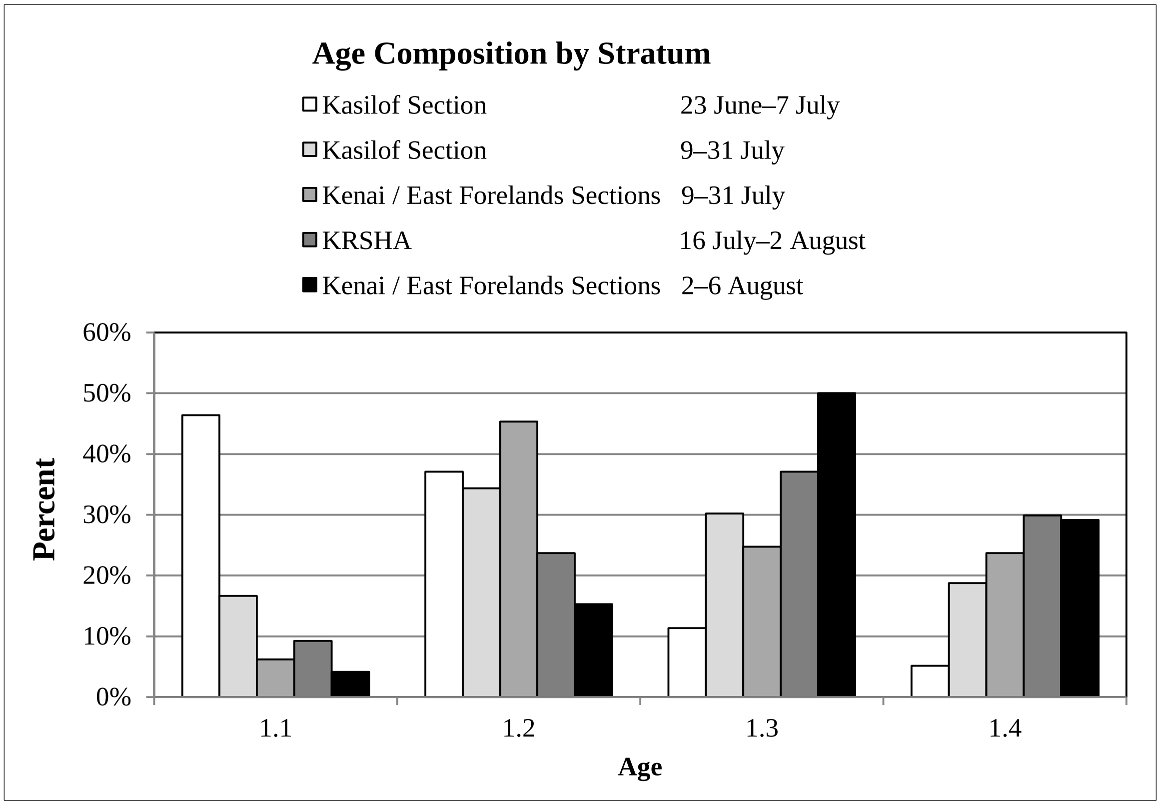

Figure 6.–Age composition by temporal and geographic stratum, 2014.

Note: KRSHA = Kasilof River Special Harvest Area.

Table 10.–Age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet fishery, Kasilof Section, 23 June–7 July, Upper Cook Inlet, Alaska, 2014.

		Age class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest		10	48	19	77
	SE (harvest)		6	13	8	16
	Samples		2	10	4	16
	Age composition		2.1%	10.3%	4.1%	16.5%
	SE (age composition)		1.3%	2.8%	1.8%	3.4%
	Mean length (mm)		688	753	955	795
	SE (mean length)		11	73	58	116
Males						
	Harvest	217	164	5	5	391
	SE (harvest)	21	20	4	4	16
	Samples	45	34	1	1	81
	Age composition	46.4%	35.1%	1.0%	1.0%	83.5%
	SE (age composition)	4.5%	4.3%	0.9%	0.9%	3.4%
	Mean length (mm)	429	604	780	915	512
	SE (mean length)	39	52			112
Both Sexes						
	Harvest	217	174	53	24	468
	SE (harvest)	21	21	13	9	
	Samples	45	36	11	5	97
	Age composition	46.4%	37.1%	11.3%	5.2%	100.0%
	SE (age composition)	4.5%	4.4%	2.9%	2.0%	
	Mean length (mm)	430	608	750	953	564
	SE (mean length)	39	54	69	50	158

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

Table 11.–Age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet fishery, Kasilof section, 9–23 July, Upper Cook Inlet, Alaska, 2014.

		Age Class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest		18	105	76	199
	SE (harvest)		9	20	18	25
	Samples		3	18	13	34
	Age composition		3.1%	18.8%	13.5%	35.4%
	SE (age composition)		1.6%	3.6%	3.2%	4.5%
	Mean length (mm)		707	781	939	835
	SE (mean length)		6	66	54	103
Males						
	Harvest	94	175	64	29	362
	SE (harvest)	20	24	17	12	25
	Samples	16	30	11	5	62
	Age composition	16.7%	31.3%	11.5%	5.2%	64.6%
	SE (age composition)	3.5%	4.3%	3.0%	2.1%	4.5%
	Mean length (mm)	447	633	758	940	632
	SE (mean length)	49	49	76	39	150
Both Sexes						
	Harvest	94	193	169	105	561
	SE (harvest)	20	25	24	20	
	Samples	16	33	29	18	96
	Age composition	16.7%	34.4%	30.2%	18.8%	100.0%
	SE (age composition)	3.5%	4.4%	4.3%	3.6%	
	Mean length (mm)	447	640	772	939	704
	SE (mean length)	49	51	69	49	166

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, 9–23 July, Upper Cook Inlet, Alaska, 2014.

		Age Class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest		40	44	53	136
	SE (harvest)		11	12	13	18
	Samples		9	10	12	31
	Age composition		9.3%	10.3%	12.4%	32.0%
	SE (age composition)		2.6%	2.7%	3.0%	4.2%
	Mean length (mm)		713	806	959	838
	SE (mean length)		20	79	32	115
Males						
	Harvest	26	154	62	48	291
	SE (harvest)	9	18	13	12	18
	Samples	6	35	14	11	66
	Age composition	6.2%	36.1%	14.4%	11.3%	68.0%
	SE (age composition)	2.2%	4.3%	3.2%	2.8%	4.2%
	Mean length (mm)	455	609	781	1,009	698
	SE (mean length)	44	53	77	64	176
Both Sexes						
	Harvest	26	194	106	101	427
	SE (harvest)	9	19	17	16	
	Samples	6	44	24	23	97
	Age composition	6.2%	45.4%	24.7%	23.7%	100.0%
	SE (age composition)	2.2%	4.5%	3.9%	3.8%	
	Mean length (mm)	455	630	791	983	743
	SE (mean length)	44	64	77	55	172

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, 16 July–2 August, Upper Cook Inlet, Alaska, 2014.

		Age Class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest		6	193	148	348
	SE (harvest)		6	27	25	29
	Samples		1	30	23	54
	Age composition		1.0%	30.9%	23.7%	55.7%
	SE (age composition)		0.9%	4.3%	4.0%	4.7%
	Mean length (mm)		705	828	939	873
	SE (mean length)			50	62	
Males						
	Harvest	58	142	39	39	277
	SE (harvest)	17	25	14	14	29
	Samples	9	22	6	6	43
	Age composition	9.3%	22.7%	6.2%	6.2%	44.3%
	SE (age composition)	2.7%	3.9%	2.3%	2.3%	4.7%
	Mean length (mm)	408	611	831	988	649
	SE (mean length)	51	42	85	78	187
Both Sexes						
	Harvest	58	148	232	187	625
	SE (harvest)	17	25	28	27	
	Samples	9	23	36	29	97
	Age composition	9.3%	23.7%	37.1%	29.9%	100.0%
	SE (age composition)	2.7%	4.0%	4.5%	4.3%	
	Mean length (mm)	408	615	828	949	770
	SE (mean length)	51	46	56	67	179

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

Table 14.–Age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet fishery, Kenai and East Forelands sections, 2–6 August, Upper Cook Inlet, Alaska, 2014.

		Age Class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Harvest			83	46		128
	SE (harvest)			10	9		11
	Samples			27	15		42
	Age composition			37.5%	20.8%		58.3%
	SE (age composition)			4.7%	4.0%		4.8%
	Mean length (mm)			787	937		879
	SE (mean length)			66	62		92
Males							
	Harvest	9	34	28	18	3	92
	SE (harvest)	4	8	7	6	3	11
	Samples	3	11	9	6	1	30
	Age composition	4.2%	15.3%	12.5%	8.3%	1.4%	41.7%
	SE (age composition)	1.9%	3.5%	3.2%	2.7%	1.1%	4.8%
	Mean length (mm)	393	649	825	955	1,240	980
	SE (mean length)	45	51	96	23		199
Both Sexes							
	Harvest	9	34	110	64	3	220
	SE (harvest)	4	8	11	10	3	
	Samples	3	11	36	21	1	72
	Age composition	4.2%	15.3%	50.0%	29.2%	1.4%	100.0%
	SE (age composition)	1.9%	3.5%	4.9%	4.4%	1.1%	
	Mean length (mm)	393	649	797	942	1,240	894
	SE (mean length)	45	51	75	53		148

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

DISCUSSION

REPORTING GROUP PROPORTIONS AND HARVEST ESTIMATES

The reporting group *Kenai River mainstem* made up the highest proportion of the harvest in every year (2010, 2011, 2013, and 2014), averaging 0.671 (range: 0.609 to 0.766) of the harvest, followed by *Kasilof River mainstem*, averaging 0.314 (range: 0.213 to 0.387) (Table 6). *Cook Inlet other* averaged 0.011 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). On average, the *Kenai River mainstem* and *Kasilof River mainstem* reporting groups have accounted for 98.5% of the sampled ESSN harvest each year. The lowest proportion *Kenai River mainstem* fish (0.61) and the highest proportion *Kasilof River mainstem* fish (0.39) were observed in 2014 (Table 6). However, reporting group proportions from MSA in 2014 are reasonably similar to results from 2010, 2011, and 2013 (Figure 5). The smaller *Kenai River mainstem* proportion was probably due to the way the ESSN fishery was prosecuted in 2014, which was to maximize Kasilof River and Kenai River sockeye salmon harvest while minimizing Kenai River Chinook salmon harvest. The fishery in the combined Kenai and East Forelands sections, which has had a Chinook salmon harvest composed almost entirely of *Kenai River mainstem* fish (94% in 2013 and 98% in 2014), was only opened for 3 periods in July 2014, whereas it was opened for 12, 13, and 6 periods in July in 2010, 2011, and 2013, respectively. The KRSHA was fished heavily in 2014, with 27% of ESSN Chinook salmon harvested from that area, and was composed primarily of *Kasilof River mainstem* fish (79%) (Table 4).

A greater proportion of *Kasilof River mainstem* fish was observed in the Kasilof section, 9–23 July stratum in 2014 (49%; Table 4) than in the Kasilof section, 8–23 July stratum in 2013 (26%; Eskelin et al. 2013:Table 10) despite the area being fished on similar dates each year. This was likely due to differences in run timing, run strengths, or migration patterns of each stock between years.

Of the 4 years of MSA sampling, 2014 was the first year samples from August were given a separate temporal stratum. Unfortunately, samplers were unable to collect enough samples in August that were representative of the Kasilof section to be included in the analysis, so reporting group proportions and harvest estimates only represent samples from the Kenai and East Forelands sections in the 2–6 August stratum. The bias from not including the Kasilof section harvest in the analysis is probably very small because only 47 Chinook salmon (1.8% of total harvest) were reported in the harvest from the Kasilof section during August.

ESSN Chinook salmon harvest has been composed of very few fish from the *Kenai River tributaries* or *Cook Inlet other* reporting groups for any year, which has been due to the early run timing of those stocks prior to fishery openings compared to *Kenai River mainstem* and *Kasilof River mainstem* fish. *Kenai River tributaries* has composed on average less than 1% of the total ESSN Chinook salmon harvest since 2010 (Table 6). In 2013 and 2014, the harvest estimates of *Kenai River tributary* Chinook salmon were each 4 fish with 90% credibility intervals between zero and 30 fish. Greater numbers of harvested *Cook Inlet other* fish were present in the early Kasilof section stratum in 2013 (56 of 404 harvested fish; Eskelin et al. 2013: Table 10), than in 2014 (3 of 468 harvested fish). Earlier run timing of *Cook Inlet other* stocks relative to the fishery openings in 2014 is a likely explanation for the difference.

The KRSHA was opened and fished on 17 days in 2014 to concentrate harvest of sockeye salmon bound for the Kasilof River while minimizing harvest of *Kenai River mainstem* Chinook salmon. There are now 2 years of MSA estimates for KRSHA. As expected, Chinook salmon harvest in KRSHA has been predominately *Kasilof River mainstem* fish (0.76 in 2013 [Eskelin et al. 2013: Table 10] and 0.79 in 2014 [Table 4]). Harvest and proportional estimates of *Kenai River mainstem* in KRSHA were 84 fish (0.24; Eskelin et al. 2013: Table 10) in 2013 and 129 fish (0.21; Table 4) in 2014. Although the number of *Kenai River mainstem* fish harvested in KRSHA has been very low compared to other sections, results show that these fish are present in the KRSHA as they migrate to the Kenai River terminus.

AGE, SEX, AND LENGTH COMPOSITIONS

The pattern of younger, smaller, and predominately male fish arriving early in the season was observed again in 2014 with the harvest in the 23 July–7 July sample composed of 83.5% males (Table 10; see also Eskelin et al. [2013]). There was a slight decline in the proportion of jacks (age-1.1 fish) in 2014 (17.6%; Table 9) compared to 2013 (22.7%; Eskelin et al. 2013: Table 14), which had the highest proportion of jacks since 1987 (Shields and Dupuis 2013b: Appendix A15; Eskelin et al. 2013: Table 14) and the highest proportion of age-1.1 and -1.2 fish combined (66%) of any year since 1987 (Table 7). However, 2014 still had the third-highest proportion of jacks (Shields and Dupuis 2013b: Appendix A15; Eskelin et al. 2013: Table 14) and fifth-highest proportion of jacks and age-1.2 fish combined since 1987 (Table 7). It is unknown if this long-term trend towards smaller, younger fish will continue. For the first time since 2011, an age-1.5 fish was sampled from the harvest. This sample was collected from the Kenai Section in August.

FUTURE SAMPLING

We sampled 42% of the harvest in 2014, the highest sampling rate of any year since 2010 (see Eskelin et al. 2013). An experienced sampling crew with knowledge of the intricacies of each buying station and the timing of when to arrive at each station helped maximize the number of samples collected. Also, the samplers were diligent in determining the statistical area of harvest, which is information generally required for each sample in the MSA.

This project continues to provide useful information about the ASL and stock composition of the ESSN Chinook salmon harvest. The information provided by this study will be useful for Kenai River Chinook salmon run reconstruction, for properly setting and managing for escapement goals, and for determining stock composition by time and area, information that was unknown historically.

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