Fishery Data Series No. 16-16

Mixed Stock Analysis and Age, Sex, and Length Composition of Chinook Salmon in the Eastside Set Gillnet Fishery in Upper Cook Inlet, Alaska, 2015

by

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and

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March 2016

Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries

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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. 16-16

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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 (ESSN) commercial fishery in 2015. 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 2015, the total reported harvest was 7,781 Chinook salmon, with an estimated composition of 5,988 (77%) *Kenai River mainstem*, 1,564 (20.1%) *Kasilof River mainstem*, 211 (2.7%) *Cook Inlet other*, and 19 (0.2%) *Kenai River tributaries* stocks. *Kenai River mainstem* fish have composed on average 69.1% of the harvest since 2010. Nearly all the remainder of the harvest was composed of *Kasilof River mainstem* fish. The overall age composition of the sample was 14.2% age-1.1 fish, 37.4% age-1.2 fish, 24.3% age-1.3 fish, 23.8% age-1.4 fish, and 0.3% age-1.5 fish. The sex composition was 69% males and 31% females. Average mid eye to tail fork (METF) length of the sample was 742 mm.

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. 2015). 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. 2015). 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). The Central District is divided into 3 sections (Kenai, Kasilof, and East Foreland) and 7 statistical areas (Figure 2). On average since 1966, the ESSN fishery has accounted for 65.0% 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.

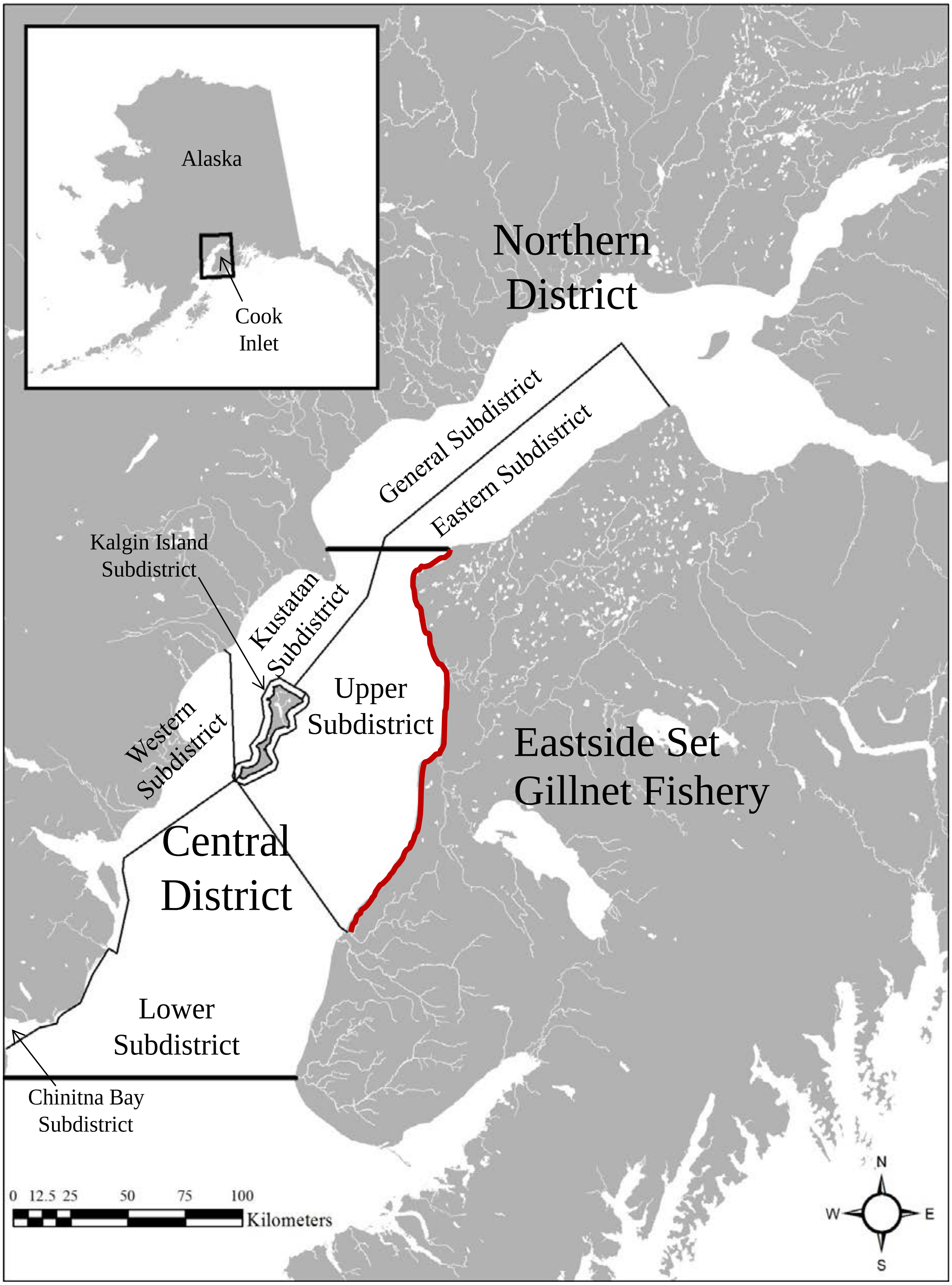

Figure 1.–Map of Upper Cook Inlet commercial fishing districts and subdistricts.

Note: Thick black lines indicate district borders and thin lines indicate subdistrict borders; the thick maroon line near the eastern shore of Cook Inlet denotes the ESSN fishery.

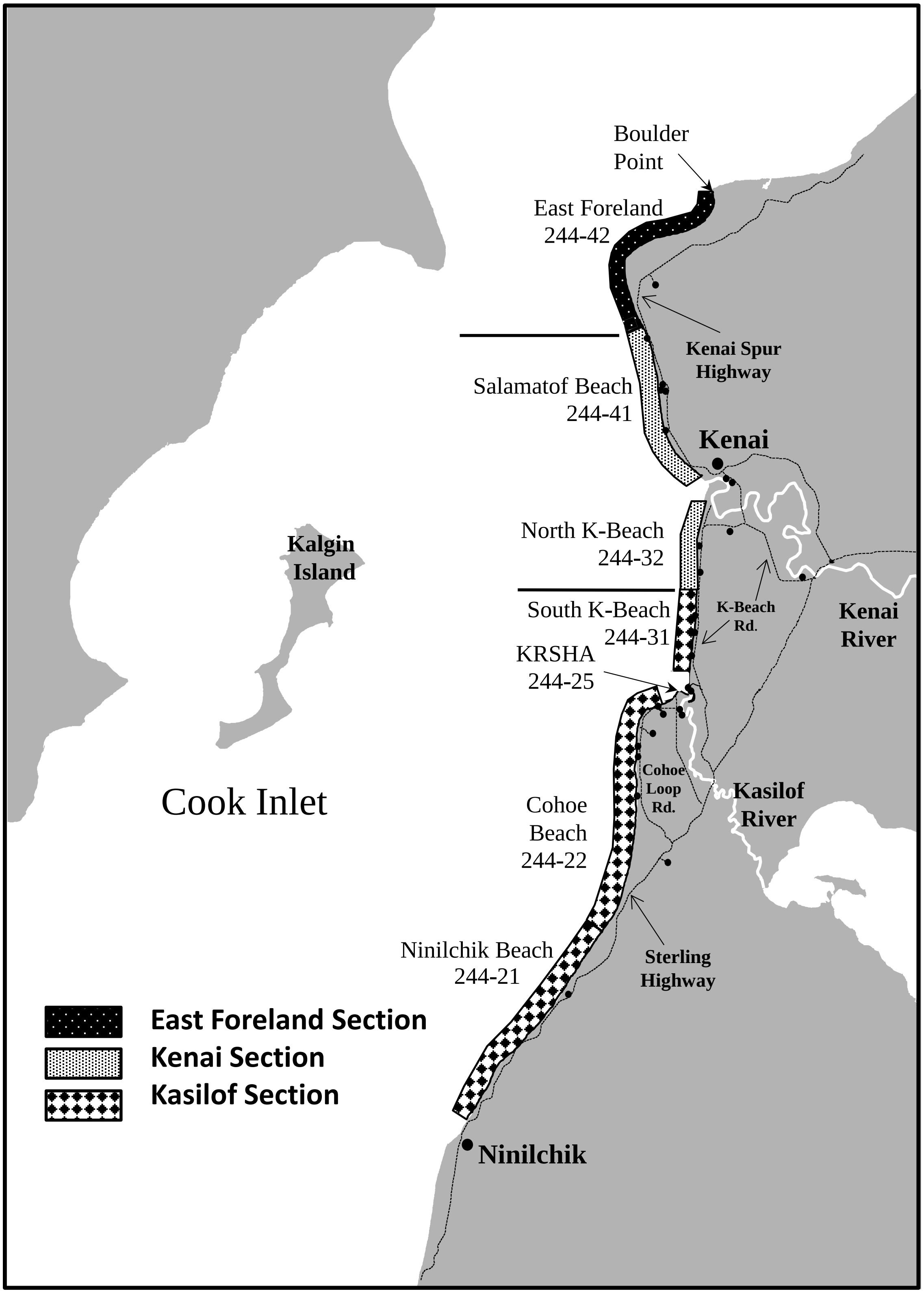

Figure 2.–Map of Upper Cook Inlet Eastside set gillnet commercial fishing statistical areas.

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

Table 1.–Upper Cook Inlet commercial Chinook salmon harvest by gear type and area, 1966–2015.

	Central District						Northern District		
	ESSN		Drift gillnet		Kalgin–Westside setnet		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
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

-continued-

Table 1.–Page 2 of 2.

	Central District						Northern District		
	ESSN		Drift gillnet		Kalgin–Westside setnet		Set gillnet		
Year	Number	%	Number	%	Number	%	Number	%	Total
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
2015	7,781	72.1	556	5.1	538	0.0	1,923	17.8	10,798
Average									
1966–2015[a]	9,418	65.0	961	6.5	1,232	0.2	3,055	19.2	14,665
2006–2015	6,394	59.0	799	7.7	683	0.1	2,351	24.7	10,227

Source: 1966–2012: Shields and Dupuis. (2015: Appendix B1), 2013: Eskelin et al. (2013). 2014: Eskelin and Barclay (2015).

[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 and 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 variant 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. Annual estimates of harvest by reporting group have been produced for 2010, 2011, 2013, and 2014 but not for 2012 due to low sample size. Since 2013, funding provided by CSRI has increased sampling effort, which provided for better coverage of the fishery and allowed MSA estimates to be stratified by time and area. Results for 2010–2013 were published in Eskelin et al. (2013), and 2014 results were published in Eskelin and Barclay (2015). This report describes the ESSN fishery Chinook salmon ASL and genetic tissue sampling effort, analyses, and results from 2015.

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 values 90% of the time.
3) Estimate the age composition of 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, scales, sex, and mid eye to tail fork (METF) length, and check for coded wire tags.
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 Foreland (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 Foreland statistical area is its own section but was fished concurrently with the Kenai Section and grouped with the Kenai Section in this report. The KRSHA was opened separately to concentrate harvest of Kasilof River sockeye salmon while minimizing harvest of Kenai River Chinook salmon. There were also several days of Kasilof Section openings that restricted fishing to within 600 ft of the mean high tide line. These restricted openings were used for the first time in 2015. 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

[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.

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 Foreland sections open by regulation on the first Monday or Thursday on or after 8 July (5 AAC 21.310). In 2015, the ESSN fishery opened on 22 June in the Kasilof Section and on 9 July in the Kenai and East Foreland sections. The Kasilof Section was fished on 28 days during 22 June–10 August including 1 day (18 July) that was restricted to fishing within one-half mile of the mean high tide line; the Kenai and East Foreland sections were fished on 20 days during 9 July–12 August. The KRSHA was fished 20 days during 7 July–2 August. In addition, there were 6 days during 15–31 July when the Kasilof Section was restricted to fishing within 600 ft of the mean high tide line. Nearly all fishery openings were sampled. Estimates were stratified temporally and geographically into 7 strata (Table 2).

Table 2.–Temporal and geographic strata used for analyses in 2015.

Stratum	Dates	Geographic area
1	22 June–6 July	Kasilof Section
2	9–30 July	Kasilof Section
3	9–30 July	Kenai and East Foreland sections
4	7 July–2 August	KRSHA (Kasilof River Special Harvest area)
5	2–10 August	Kasilof Section
6	2–12 August	Kenai and East Foreland sections
7	15–31 July	Kasilof Section 600 ft

Tissue and Age, Sex, and Length Sampling

During and after fishery openings, 3 ADF&G personnel travelled to receiving sites for fish processing plants after each tide and sampled harvested Chinook salmon for genetic tissue and ASL. The number and location of receiving sites can vary from year to year, but there are generally about 18 sampling locations. Approximate locations of the receiving sites and fish processing plants are shown in Figure 2. 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. 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, and if location of harvest by statistical area could be determined.

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 (Koo 1962). Sex was identified from external morphometric characteristics (i.e., protruding ovipositor on females or a developing kype on males). Lengths from mid eye to tail fork (METF) were measured to the nearest half-centimeter.

All fish sampled for ASL were also sampled for tissue. A 1⅓0020cm (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 harvest location.

Baseline and Reporting Groups

The current UCI Chinook salmon genetic baseline used for MSA applications (Barclay and Habicht 2015) 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. To minimize misallocation between MSA reporting groups, the Slikok Creek (Kenai River tributary) population was removed from the baseline because it is very small and genetically similar to the Crooked Creek (Kasilof River tributary) population (Barclay et al. 2012). Therefore, the baseline (Table 3) only includes 54 of the 55 populations reported in Barclay and Habicht (2015).

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*.

Table 3.–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

-continued-

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

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Map no.[a]	Reporting group	Location	Added [b]	Collection year(s)	*n*
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
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

Source: Barclay and Habicht (2015).

[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.

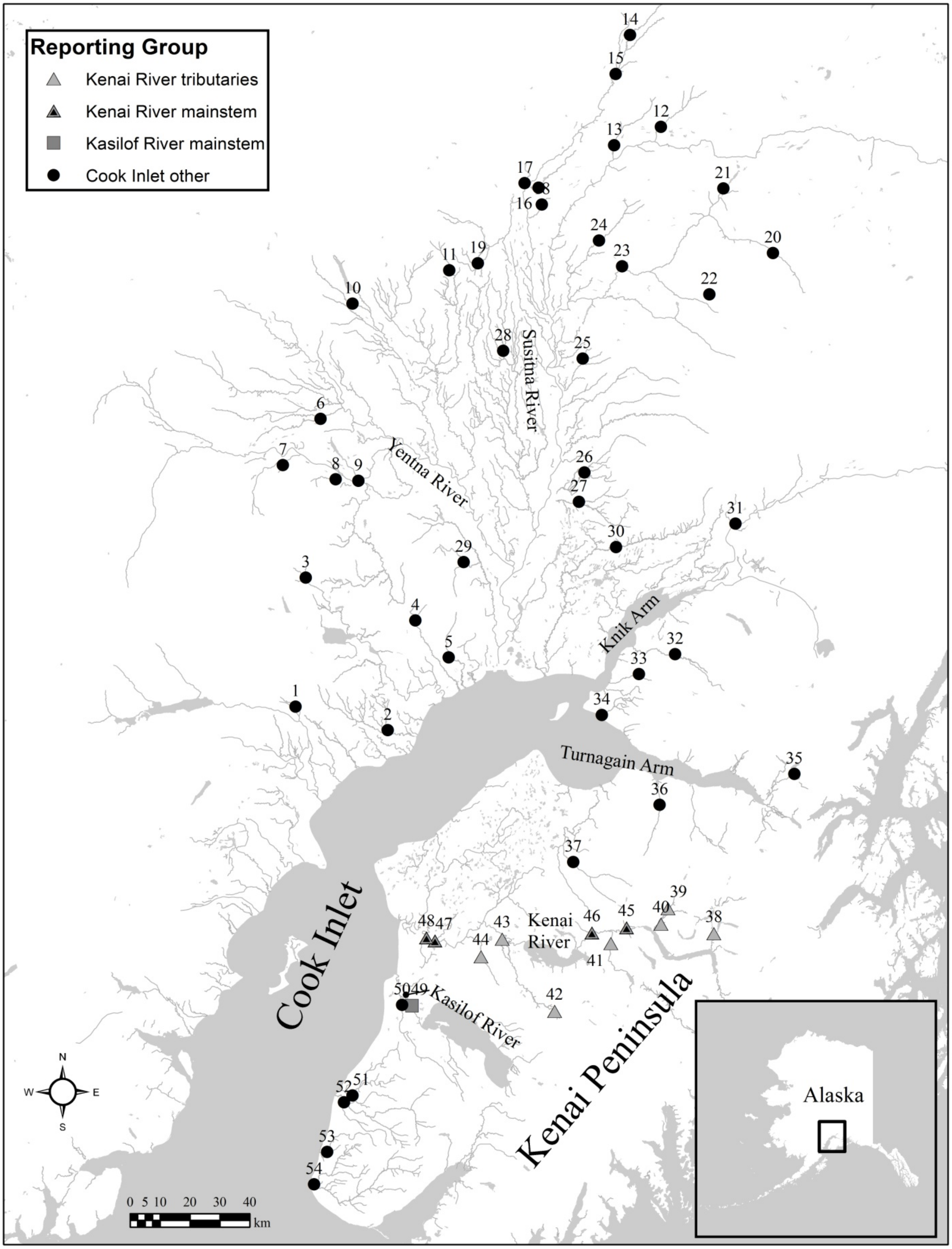

Figure 3.–Sampling locations for Chinook salmon populations included in the genetic baseline.

Note: Numbers correspond to map numbers listed in Table 3.

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 3, Figure 3) (Barclay and Habicht 2015). 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 7 geographic and temporal strata, and samples were selected from each stratum separately. The sample size goal for MSA was 100 fish per stratum when possible unless the reporting group composition was expected to be very high for one group, such as for *Kenai River mainstem* fish within the Kenai Section. 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.

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. For the 2015 ESSN mixtures, the best available information came from the stock proportion estimates from the analysis of the 2014 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 the harvest. The stratified estimates were calculated with the following equation:

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

where H_i is the overall harvest in stratum *i*, $\hat{p}_{g,i}$ is the proportion of reporting group *g* fish in stratum *i*, and $\hat{p}_g$ is the overall proportion of reporting group *g* fish within *S* strata. Symbol "^" denotes an estimated value in Equation 1 and all following equations.

To calculate confidence intervals for H_g (the overall harvest of reporting group *g*), 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:

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

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 the 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 $S = 7$ 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 2015.

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

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

RESULTS

LABORATORY ANALYSIS

A total of 622 fish were genotyped from the 2015 ESSN Chinook salmon tissue samples. The failure rate was 1.43% and the error rate was 0.14%.

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, 12 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 7,781 fish, which was 72.1% of the total UCI Chinook salmon commercial harvest in 2015 (Table 1). A total of 2,241 samples (29% of the harvest) were collected and identified by statistical area, of which 623 (8% of the harvest) were selected for MSA (Table 4). 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 2015.

Table 4.–Reported Chinook salmon harvest, number and proportion of harvest sampled, number and proportion of harvest selected for MSA, and the number analyzed for MSA by temporal and geographic strata in the Upper Cook Inlet eastside set gillnet fishery, 2015.

Dates	Geographic area	Reported harvest	Number sampled	Proportion sampled	Number selected for MSA	Proportion selected for MSA	Number analyzed for MSA
22 Jun–6 Jul	Kasilof Section	813	445	0.55	101	0.12	101
9–30 Jul	Kasilof Section	1,608	536	0.33	100	0.06	98
9–30 Jul	Kenai–EF sections	3,485	655	0.19	82	0.02	78
7 Jul–2 Aug	KRSHA[a]	426	136	0.32	95	0.22	92
15–31 Jul	Kasilof Section 600 ft [b]	209	76	0.36	76	0.36	73
1–10 Aug	Kasilof Section	335	108	0.32	89	0.27	88
1–12 Aug	Kenai–EF sections	905	285	0.31	80	0.09	79
22 Jun–12 Aug	All areas	7,781	2,241	0.29	623	0.08	609

Note: Kenai–EF refers to the Kenai and East Foreland sections.

[a] Kasilof River special harvest area.

[b] Kasilof Section openings restricted to within 600 ft of the mean high tide line.

Stratified Estimates by Time and Area

Kasilof Section, 22 June–6 July Stratum

Reported harvest was 813 Chinook salmon in the Kasilof Section 22 June–6 July stratum (also called "Kasilof Section early" within this report), of which 445 fish (55% of the harvest) were sampled (Table 4). After subsampling representatively by statistical area and date, 101 samples (12% of the harvest) were selected for analysis, of which all 101 were included in the analysis. MSA reporting groups were represented in the following proportions: 0.003 *Kenai River tributaries*, 0.551 *Kenai River mainstem*, 0.200 *Kasilof River mainstem*, and 0.246 *Cook Inlet other* (Figure 4 and Table 5). Estimated Chinook salmon harvest by reporting group was 3 *Kenai River tributaries,*448 *Kenai River mainstem*, 162 *Kasilof River mainstem*, and 200 *Cook Inlet other* (Table 5). Table 5 lists 90% credibility intervals for estimates of reporting group proportions and harvests for all strata.

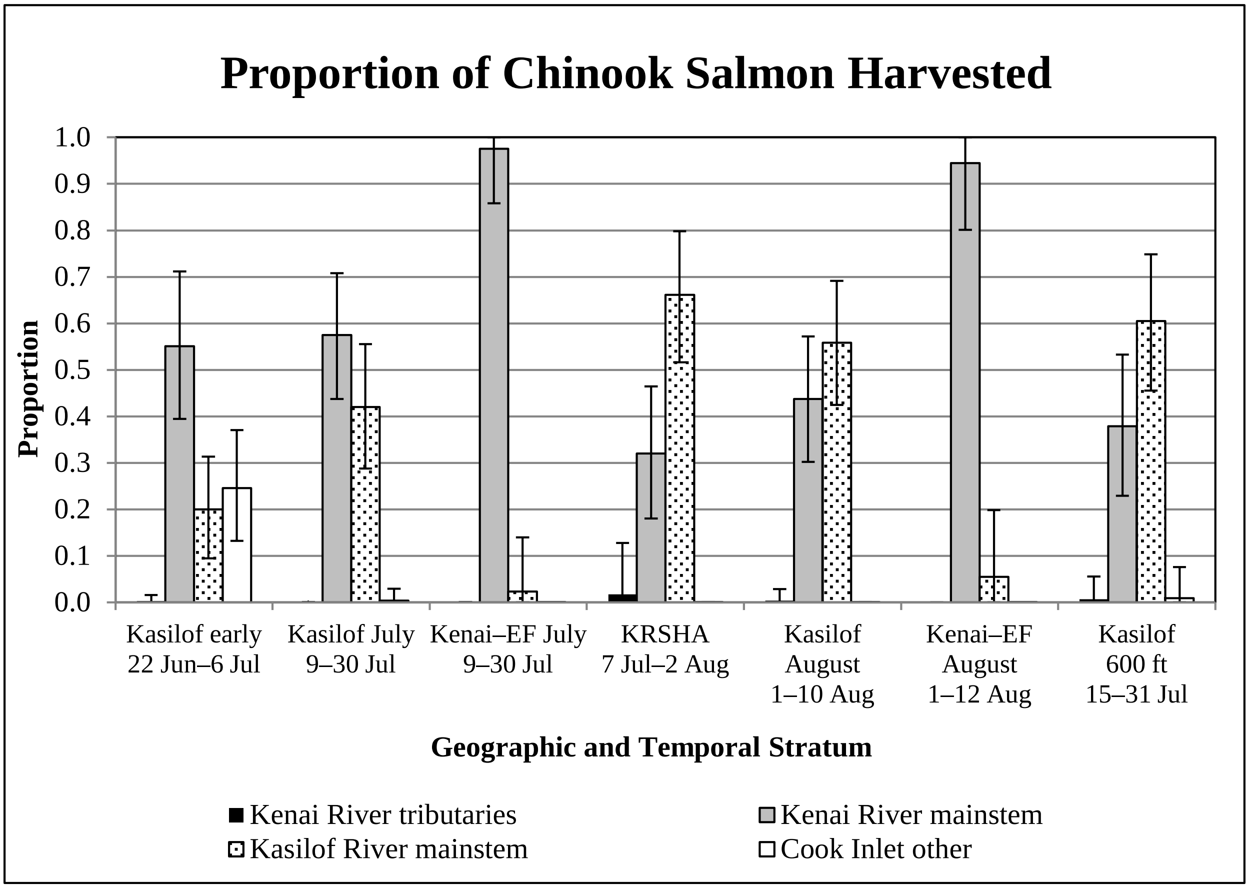

Figure 4.–Proportions and 90% credibility intervals of ESSN Chinook salmon harvested in each stratum by reporting group, 2015.

Note: Kenai-EF means Kenai–East Foreland sections. KRSHA means Kasilof River Special Harvest Area. Kasilof 600 ft indicates the Kasilof Section openings restricted to within 600 ft of the mean high tide line.

Table 5.–Proportion and estimated number of Chinook salmon harvested by reporting group and stratum in the ESSN fishery, Upper Cook Inlet, Alaska, 2015.

Stratum				Credibility interval			Credibility interval	
Area	Date	Reporting group	Proportion	5%	95%	Harvest	5%	95%
Entire 2015 Season (all areas)								
		Kenai River tributaries	0.002	0.000	0.011	19	0	86
		Kenai River mainstem	0.770	0.709	0.814	5,988	5,519	6,330
		Kasilof River mainstem	0.201	0.160	0.260	1,564	1,242	2,025
		Cook Inlet other	0.027	0.014	0.042	211	112	327
Kasilof	22 Jun–6 Jul							
		Kenai River tributaries	0.003	0.000	0.016	3	0	13
		Kenai River mainstem	0.551	0.395	0.712	448	321	579
		Kasilof River mainstem	0.200	0.094	0.313	162	77	255
		Cook Inlet other	0.246	0.132	0.371	200	107	302
Kasilof	9–30 Jul							
		Kenai River tributaries	0.001	0.000	0.001	2	0	1
		Kenai River mainstem	0.575	0.437	0.708	925	703	1,139
		Kasilof River mainstem	0.420	0.288	0.556	675	463	893
		Cook Inlet other	0.004	0.000	0.030	7	0	48
Kenai and East Foreland	9–30 Jul							
		Kenai River tributaries	0.001	0.000	0.001	3	0	3
		Kenai River mainstem	0.975	0.858	1.000	3,398	2,992	3,485
		Kasilof River mainstem	0.023	0.000	0.140	82	0	487
		Cook Inlet other	0.000	0.000	0.000	2	0	1
KRSHA[a]	7 Jul–2 Aug							
		Kenai River tributaries	0.017	0.000	0.128	7	0	54
		Kenai River mainstem	0.320	0.180	0.465	136	77	198
		Kasilof River mainstem	0.661	0.516	0.798	282	220	340
		Cook Inlet other	0.001	0.000	0.001	0	0	0
Kasilof 600 ft[b]	15–31 Jul							
		Kenai River tributaries	0.007	0.000	0.055	1	0	12
		Kenai River mainstem	0.379	0.230	0.533	79	48	111
		Kasilof River mainstem	0.605	0.456	0.748	126	95	156
		Cook Inlet other	0.009	0.000	0.076	2	0	16
Kasilof	1–10 Aug							
		Kenai River tributaries	0.004	0.000	0.029	1	0	10
		Kenai River mainstem	0.437	0.302	0.572	146	101	192
		Kasilof River mainstem	0.558	0.425	0.691	187	142	232
		Cook Inlet other	0.001	0.000	0.001	0	0	0
Kenai and East Foreland	1–12 Aug							
		Kenai River tributaries	0.000	0.000	0.000	0	0	0
		Kenai River mainstem	0.945	0.801	1.000	855	725	905
		Kasilof River mainstem	0.055	0.000	0.198	49	0	180
		Cook Inlet other	0.000	0.000	0.000	0	0	0

Note: Harvest values given by reporting group within each stratum may not sum to overall total for each reporting group due to rounding.

[a] Kasilof River Special Harvest Area.

[b] Kasilof Section openings restricted to within 600 ft of the mean high tide line.

Kasilof Section, 9–30 July Stratum

Reported harvest was 1,608 Chinook salmon, and 536 samples (33% of the harvest) were collected (Table 4). After subsampling representatively by statistical area and date, 100 samples (6% of the harvest) were selected for analysis, of which 98 were included in the analysis (Table 4). Reporting groups were represented in the following proportions: 0.001 *Kenai River tributaries*, 0.575 *Kenai River mainstem*, 0.420 *Kasilof River mainstem*, and 0.004 *Cook Inlet other* (Figure 4 and Table 5). Estimated harvest by reporting group was 2 *Kenai River tributaries*, 925 *Kenai River mainstem*, 675 *Kasilof River mainstem*, and 7 *Cook Inlet other* (Table 5)[3].

Kenai and East Foreland Sections, 9–30 July Stratum

Reported Chinook salmon harvest was 3,485 fish, and 655 samples (19% of the harvest) were collected (Table 4). After subsampling representatively by statistical area and date, 82 samples (2% of the harvest) were selected for analysis, of which 78 were included in the analysis (Table 4). Reporting groups were represented in the following proportions: 0.001 *Kenai River tributaries*, 0.975 *Kenai River mainstem*, 0.023 *Kasilof River mainstem*, and 0.000 *Cook Inlet other* (Figure 4 and Table 5). Estimated harvest by reporting group was 3 *Kenai River tributaries* fish, 3,398 *Kenai River mainstem*, 82 *Kasilof River mainstem*, and 2 *Cook Inlet other* (Table 5).

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

Reported Chinook salmon harvest was 426 fish, and 136 samples (32% of the harvest) were collected (Table 4). After subsampling representatively by date, 95 samples (22% of the harvest) were selected for analysis, of which 92 were included in the analysis. Reporting groups were represented in the following proportions: 0.017 *Kenai River tributaries*, 0.320 *Kenai River mainstem*, 0.661 *Kasilof River mainstem*, and 0.001 *Cook Inlet other* (Figure 4 and Table 5). Estimated harvest by reporting group was 7 *Kenai River tributaries*, 136 *Kenai River mainstem*, 282 *Kasilof River mainstem*, and 0 *Cook Inlet other* (Table 5).

Kasilof Section Openings Restricted to Within 600 ft of the Mean High Tide Line, 15–31 July

Reported Chinook salmon harvest was 209 fish. Due to the low number of samples collected during the Kasilof Section openings restricted to within 600 ft of the mean high tide line, all 76 samples (36% of the harvest) were selected for analysis, of which 73 were used in the analysis (Table 4); this number (76) is not necessarily proportional to harvest by day although the sampling rate from each statistical area was similar overall. Reporting groups were represented in the following proportions: 0.007 *Kenai River tributaries*, 0.379 *Kenai River mainstem*, 0.605 *Kasilof River mainstem*, and 0.009 *Cook Inlet other* (Figure 4 and Table 5). Estimated harvest by reporting group was 1 *Kenai River tributaries*, 79 *Kenai River mainstem*, 126 *Kasilof River mainstem*, and 2 *Cook Inlet other* (Table 5).

Kasilof Section, 1–10 August

Reported Chinook salmon harvest was 335 fish and 108 samples (32% of the harvest) were collected (Table 4). After subsampling representatively by date, 89 samples (27% of the harvest)

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[3] Estimates of Chinook salmon harvest by reporting group within each stratum may not sum to exact totals within each stratum due to rounding. The same applies to overall harvest estimates by reporting group; stratum estimates by reporting group may not sum to the overall reporting group totals due to rounding.

were selected for analysis, of which 88 were included in the analysis. Reporting groups were represented in the following proportions: 0.004 *Kenai River tributaries*, 0.437 *Kenai River mainstem*, 0.558 *Kasilof River mainstem*, and 0.001 *Cook Inlet other* (Figure 4 and Table 5). Estimated harvest by reporting group was 1 *Kenai River tributaries*, 146 *Kenai River mainstem*, 187 *Kasilof River mainstem*, and 0 *Cook Inlet other* (Table 5).

Kenai and East Foreland Sections, 1–12 August

Reported Chinook salmon harvest was 905 fish and 285 samples (31% of the harvest) were collected (Table 4). After subsampling representatively by date and statistical area, 80 samples (9% of the harvest) were selected for analysis, of which 79 were included in the analysis. Reporting groups were represented in the following proportions: 0.000 *Kenai River tributaries*, 0.945 *Kenai River mainstem*, 0.055 *Kasilof River mainstem*, and 0.000 *Cook Inlet other* (Figure 4 and Table 5). Estimated harvest by reporting group was 0 *Kenai River tributaries*, 855 *Kenai River mainstem*, 49 *Kasilof River mainstem*, and 0 *Cook Inlet other* (Table 5).

Overall estimates

Overall reporting groups proportions were calculated from Equation 1 as follows: 0.002 *Kenai River tributaries*, 0.770 *Kenai River mainstem*, 0.201 *Kasilof River mainstem*, and 0.027 *Cook Inlet other* (Figure 5 and Table 5). Estimated Chinook salmon harvest by reporting group was as follows: 19 *Kenai River tributaries*, 5,988 *Kenai River mainstem*, 1,564 *Kasilof River mainstem*, and 211 *Cook Inlet other* (Table 5). Table 5 lists 90% credibility intervals for 2015 reporting group proportions and harvest estimates.

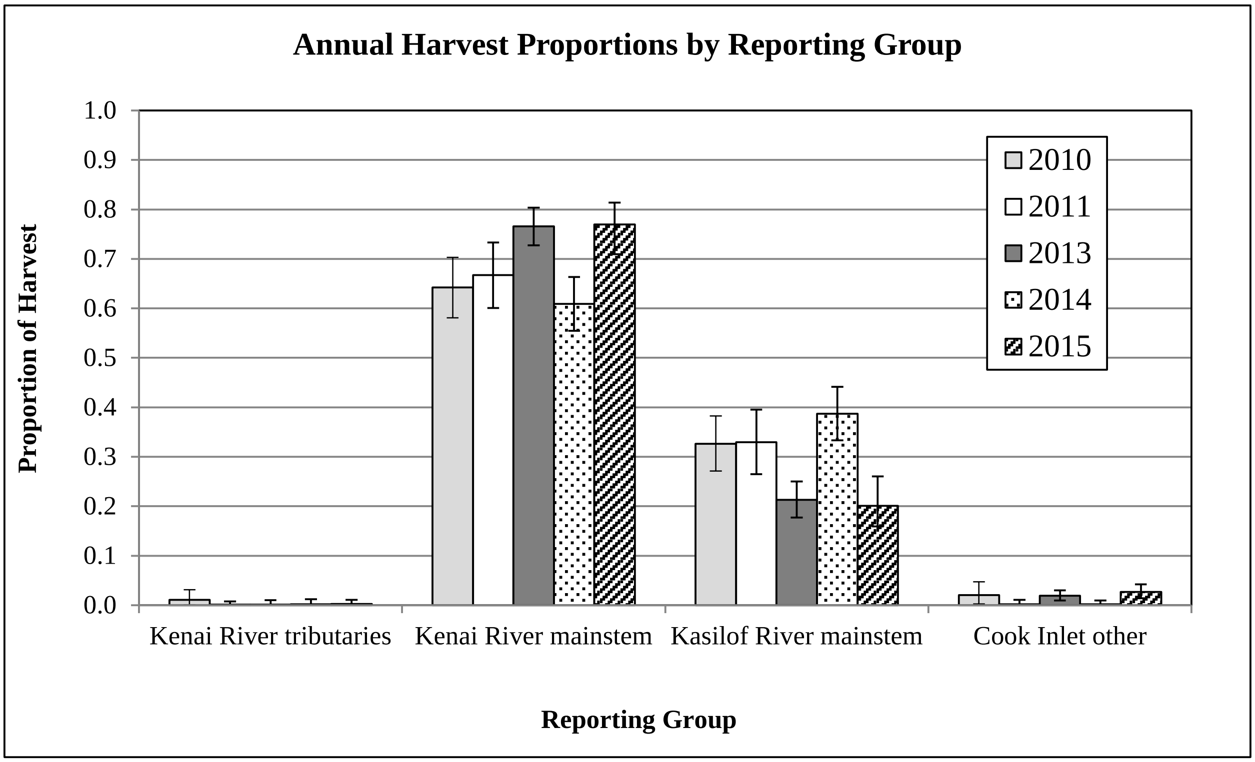

Figure 5.–Proportion and 90% credibility intervals of ESSN Chinook salmon harvested by reporting group and year, 2010, 2011, 2013–2015.

Comparison of Stratified Reporting Group Proportions by Time and Area, 2013–2015

Analyses of reporting group proportions and harvest estimates have been geographically and temporally stratified since 2013. For the Kenai and East Foreland sections in July, Kenai River mainstem fish have composed nearly all the harvest (94%, 98%, and 98%, in 2013, 2014, and 2015, respectively) (Figure 6). Kenai River mainstem fish also composed nearly all the harvest in the Kenai and East Foreland sections in August for 2014 (97%) and 2015 (95%) (Figure 6).

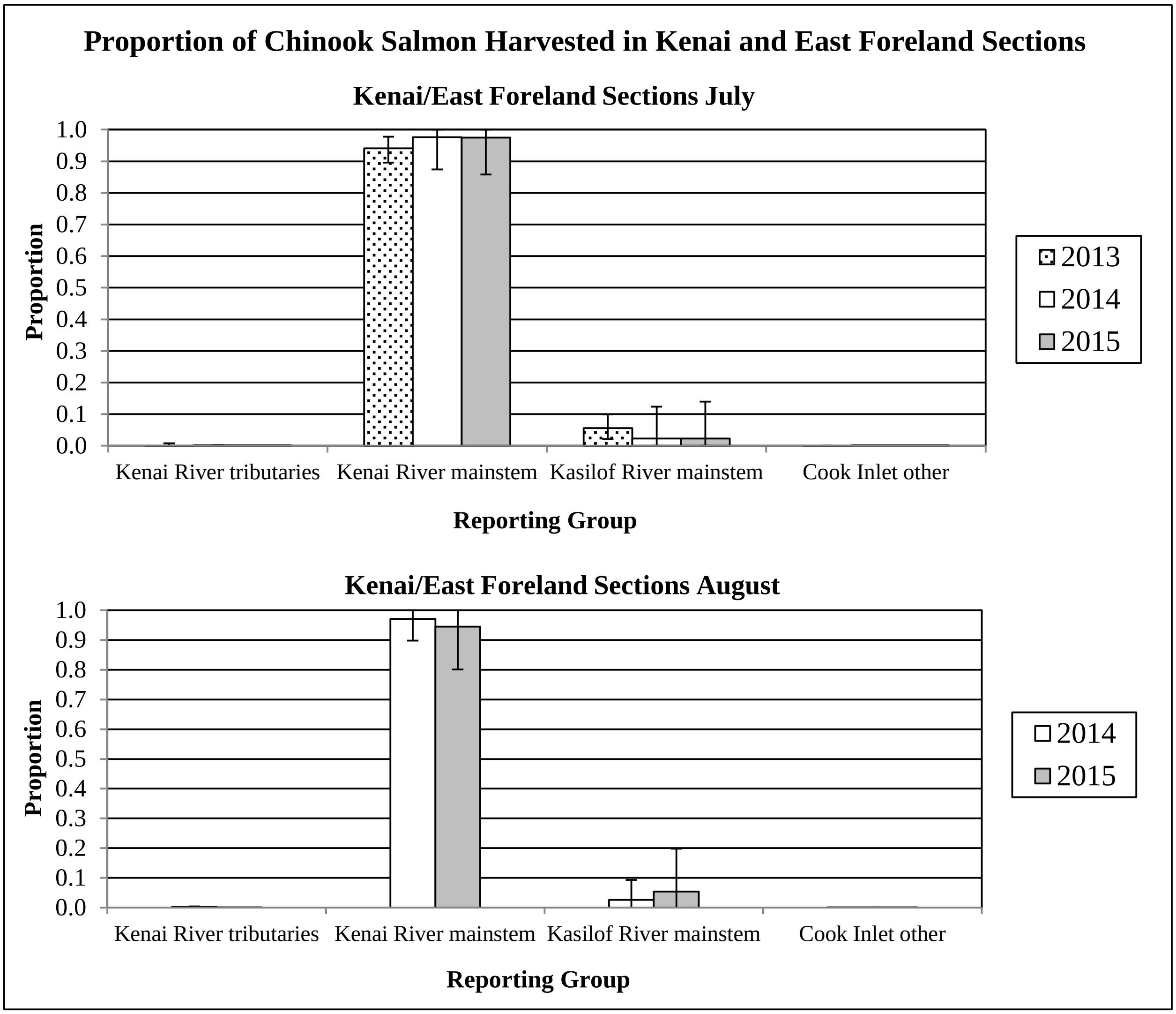

Figure 6.–Proportion and 90% credibility intervals of ESSN Chinook salmon harvested in the Kenai and East Foreland sections, 2013–2015.

In the Kasilof Section "early" (prior to the Kenai and East Foreland sections opening), the reporting composition has been more variable; however, *Kenai River mainstem* fish have still composed the majority of harvest in that stratum during 2013–2015, ranging from 77% in 2014 to 55% in 2015 (Figure 7). The rest of the harvest has been composed of *Kasilof River mainstem* fish and *Cook Inlet other* fish. *Kasilof River mainstem* fish ranged from 14% of the harvest in 2013 to 22% in 2014, whereas *Cook Inlet other* fish ranged from less than 1% in 2014 to 25% in 2015.

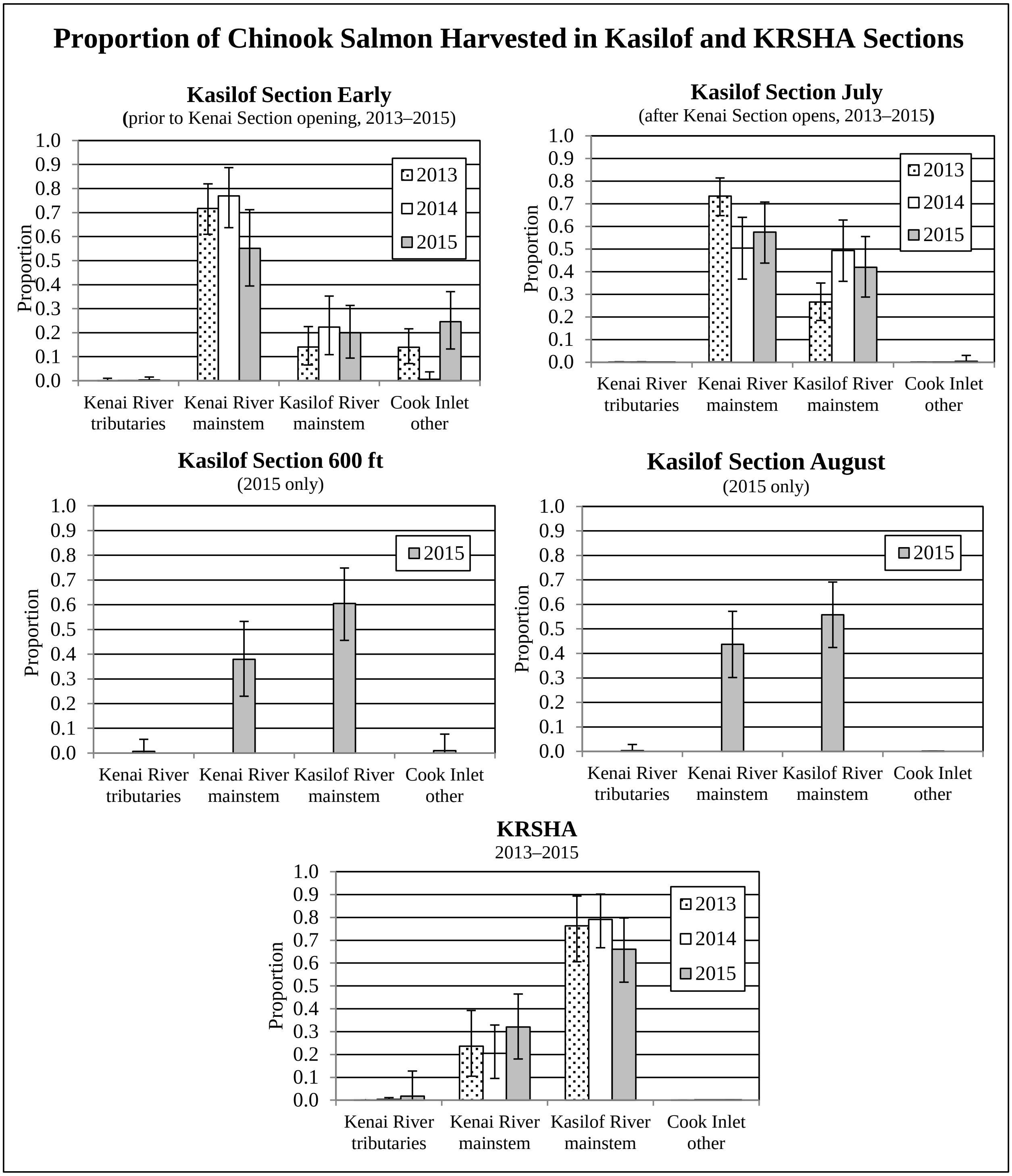

Figure 7.–Proportion and 90% credibility intervals of ESSN Chinook salmon harvested within the Kasilof Section and KRSHA, 2013–2015.

In the Kasilof Section in July, after the Kenai and East Foreland sections opened each year, *Kenai River mainstem* fish composed the majority of the harvest with nearly all the remainder being *Kasilof River mainstem* fish, although the relative reporting group composition for both reporting groups was more variable (Figure 7). In 2013, reporting group composition was 73% *Kenai River mainstem* and 27% *Kasilof River mainstem*, whereas in 2014 the composition was 50% *Kenai River mainstem* and 49% *Kasilof River mainstem* (Figure 7). In 2015, the composition was 58% *Kenai River mainstem* and 42% *Kasilof River mainstem*. In 2013 and 2014, the Kasilof Section was open between 9–23 July, and in 2015, it was open between 9–30 July.

In KRSHA, *Kasilof River mainstem* fish composed the majority of harvest with nearly all the remainder being *Kenai River mainstem* fish (Figure 7). Results from 2013 and 2014 were similar, with *Kasilof River mainstem* fish composing 76% of the harvest in 2013 and 79% in 2014. In 2015, the harvest was composed of 66% *Kasilof River mainstem* fish, 32% *Kenai River mainstem* fish, and about 2% *Kenai River tributaries* fish (Figure 7).

AGE, SEX, AND LENGTH COMPOSITION

The proportions of Chinook salmon in the 2015 ESSN harvest by age were 0.142 age-1.1 fish, 0.374 age-1.2 fish, 0.243 age-1.3 fish, 0.238 age-1.4 fish, and 0.003 age-1.5 fish (Table 6). Mean lengths by age of harvest samples and standard errors for ASL composition are also given in Table 6.

ASL compositions for each temporal and geographic stratum are listed in Tables 7–13. Similar to previous years, a pattern of increasing size and age through the season was observed during 2015 (Figure 8). Age-1.1 fish (jacks) composed 38.6% of the harvest in the Kasilof Section early stratum (22 June–6 July), which was considerably higher than in any other stratum. The Kasilof Section early stratum also had highest percentage of age-1.1 and age-1.2 fish combined (70.3%) of any stratum, but this percentage was not as high as the 83.5% observed for that stratum in 2014 (Eskelin and Barclay 2015). In the Kenai and East Foreland sections July stratum (9–30 July) and the Kasilof Section July stratum (9–30 July), jacks composed 12–13% of the harvest (Tables 9 and 8, respectively). In August, jacks composed less than 4% for both strata and age 1.4-fish composed the majority of the harvest (Tables 12 and 13, Figure 8). In the Kasilof Section in August, the harvest was composed of 49.4% age-1.4 fish (Table 12), and in the Kenai and East Foreland sections in August the harvest was composed of 37.5% age-1.4 fish (Table 13), which were both considerably higher percentages than any other stratum. The highest percentage of age-1.4 fish in all other strata was 23.4% (KRSHA; Figure 8, Table 10).

Age composition estimates of the ESSN Chinook salmon harvest date back to 1987 (Table 14). In 2015, the age composition was similar to recent past years but was composed of a higher percentage of age-1.1 and age-1.2 fish and a lower percentage of age-1.3 and age-1.4 fish than the historical averages.

Overall sex composition was 30.7% females and 69.3% males (Table 6). The earliest stratum (Kasilof Section early) had the largest percentage of males among all strata at 77.2% (Table 7). The largest percentage of females among all strata was in the Kasilof Section in August at 50.6% (Table 12).

The smallest average length over all ages within a stratum (613 mm) was observed in the earliest stratum (Kasilof Section early; Table 7). The largest average length over all ages within a stratum (865 mm) was from the Kasilof Section in August (Table 12). The Kenai–East Foreland sections in August had the second largest average length for all ages (810 mm) among all strata (Table 13). The overall average length in 2015 was 742 mm METF, which was below average compared to historical records (Table 15). Overall, the percentage of jacks (age-1.1 fish) in the harvest was lower in 2015 than in 2013 and 2014 but was still twice as high as the historical average (Table 14). The percentage of age-1.2 fish in the harvest in 2015 was slightly higher than 2014 and well above the historical average. Age-1.3 fish were near the historical average and age-1.4 fish were 36% below the historical average.

Table 6.–Age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet Chinook salmon fishery, Upper Cook Inlet, Alaska, 2015.

		Age class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Harvest by age		415	1,122	842	8	2,387
	SE (harvest by age)		80	137	119	8	164
	Samples by age		39	97	73	1	210
	Age composition		5.3%	14.4%	10.8%	0.1%	30.7%
	SE (age composition)		6.2%	9.3%	8.1%	0.9%	12.0%
	Mean length (mm METF)		664	832	953	1,110	839
	SE (mean length)		7	5	5		8
Males							
	Harvest by age	1,103	2,498	766	1,011	16	5,394
	SE (harvest by age)	130	190	119	134	15	177
	Samples by age	100	170	60	90	1	421
	Age composition	14.2%	32.1%	9.9%	13.0%	0.2%	69.3%
	SE (age composition)	8.5%	11.2%	7.6%	9.1%	1.0%	12.0%
	Mean length (mm METF)	436	624	825	970	1,090	690
	SE (mean length)	3	4	8	4		10
Both sexes							
	Harvest by age	1,103	2,912	1,889	1,853	24	7,781
	SE (harvest by age)	130	195	169	166	17	
	Samples by age	100	209	157	163	2	631
	Age composition	14.2%	37.4%	24.3%	23.8%	0.3%	100.0%
	SE (age composition)	8.5%	11.9%	11.1%	11.0%	1.3%	
	Mean length (mm METF)	436	632	829	962	1,100	742
	SE (mean length)	3	4	5	3	10	8

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

Table 7.–Age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet fishery, Kasilof Section, Upper Cook Inlet, Alaska, 22 June–6 July 2015.

		Age Class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Harvest by age		40	89	48	8	185
	SE (harvest by age)		17	24	18	8	32
	Samples by age		5	11	6	1	23
	Age composition		5.0%	10.9%	5.9%	1.0%	22.8%
	SE (age composition)		2.0%	2.9%	2.2%	0.9%	3.9%
	Mean length (mm METF)		667	763	952	1,110	807
	SE (mean length)		15	11	9		27
Males							
	Harvest by age	314	217	64	32		628
	SE (harvest by age)	37	34	21	15		32
	Samples by age	39	27	8	4		78
	Age composition	38.6%	26.7%	7.9%	4.0%		77.2%
	SE (age composition)	4.6%	4.1%	2.5%	1.8%		3.9%
	Mean length (mm METF)	434	608	778	945		556
	SE (mean length)	6	11	23	23		17
Both sexes							
	Harvest by age	314	258	153	80	8	813
	SE (harvest by age)	37	35	30	23	8	
	Samples by age	39	32	19	10	1	101
	Age composition	38.6%	31.7%	18.8%	9.9%	1.0%	100.0%
	SE (age composition)	4.6%	4.4%	3.7%	2.8%	0.9%	
	Mean length (mm METF)	434	617	769	949	1,110	613
	SE (mean length)	6	10	12	10		18

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

Table 8.–Age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet fishery, Kasilof Section, Upper Cook Inlet, Alaska, 9–30 July 2015.

		Age Class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Harvest by age		175	287	207		669
	SE (harvest by age)		48	60	52		39
	Samples by age		11	18	13		42
	Age composition		10.9%	17.8%	12.9%		41.6%
	SE (age composition)		3.0%	3.7%	3.2%		4.8%
	Mean length (mm METF)		665	840	956		830
	SE (mean length)		9	10	19		19
Males							
	Harvest by age	207	430	159	127	16	939
	SE (harvest by age)	52	69	46	42	15	77
	Samples by age	13	27	10	8	1	59
	Age composition	12.9%	26.7%	9.9%	7.9%	1.0%	58.4%
	SE (age composition)	3.2%	4.3%	2.9%	2.6%	1.0%	4.8%
	Mean length (mm METF)	447	624	796	968	1,090	669
	SE (mean length)	8	12	25	13	0	24
Both sexes							
	Harvest by age	207	605	446	334	16	1,608
	SE (harvest by age)	52	75	70	63	15	
	Samples by age	13	38	28	21	1	101
	Age composition	12.9%	37.6%	27.7%	20.8%	1.0%	100.0%
	SE (age composition)	3.2%	4.7%	4.3%	3.9%	1.0%	
	Mean length (mm METF)	448	638	823	961	1,090	741
	SE (mean length)	8	9	11	13		18

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

Table 9.–Age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet fishery, Kenai and East Foreland sections, Upper Cook Inlet, Alaska, 9–30 July 2015.

		Age Class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age		103	444	308	854
	SE (harvest by age)		58	114	97	147
	Samples by age		3	13	9	25
	Age composition		2.9%	12.7%	8.8%	24.5%
	SE (age composition)		1.7%	3.3%	2.8%	4.2%
	Mean length (mm METF)		695	805	954	850
	SE (mean length)		5	17	11	21
Males						
	Harvest by age	410	1,401	342	478	2,631
	SE (harvest by age)	110	168	102	118	147
	Samples by age	12	41	10	14	77
	Age composition	11.8%	40.2%	9.8%	13.7%	75.5%
	SE (age composition)	3.2%	4.8%	2.9%	3.4%	4.2%
	Mean length (mm METF)	431	627	770	991	681
	SE (mean length)	13	7	28	10	21
Both sexes						
	Harvest by age	410	1,503	786	786	3,485
	SE (harvest by age)	110	169	143	143	
	Samples by age	12	44	23	23	102
	Age composition	11.8%	43.1%	22.5%	22.5%	100.0%
	SE (age composition)	3.2%	4.9%	4.1%	4.1%	
	Mean length (mm METF)	431	631	790	977	723
	SE (mean length)	13	7	16	8	18

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

Table 10.–Age, sex, and length composition of Chinook salmon harvested in the Kasilof River Special Harvest Area, Upper Cook Inlet, Alaska, 7 July–2 August 2015.

		Age Class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age		23	59	45	127
	SE (harvest by age)		9	13	12	18
	Samples by age		5	13	10	28
	Age composition		5.3%	13.8%	10.6%	29.8%
	SE (age composition)		2.1%	3.2%	2.8%	4.2%
	Mean length (mm METF)		677	852	956	858
	SE (mean length)		16	13	13	20
Males						
	Harvest by age	113	100	32	54	299
	SE (harvest by age)	17	17	10	13	18
	Samples by age	25	22	7	12	66
	Age composition	26.6%	23.4%	7.4%	12.8%	70.2%
	SE (age composition)	4.0%	3.9%	2.4%	3.1%	4.2%
	Mean length (mm METF)	434	627	853	972	641
	SE (mean length)	7	13	13	8	26
Both sexes						
	Harvest by age	113	122	91	100	426
	SE (harvest by age)	17	18	16	17	
	Samples by age	25	27	20	22	94
	Age composition	26.6%	28.7%	21.3%	23.4%	100.0%
	SE (age composition)	4.0%	4.1%	3.7%	3.9%	
	Mean length (mm METF)	434	636	852	965	705
	SE (mean length)	7	12	10	7	22

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 openings restricted to within 600 ft of mean high tide line, Upper Cook Inlet, Alaska, 15–31 July 2015.

		Age Class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age		24	36	6	66
	SE (harvest by age)		7	8	3	10
	Samples by age		8	12	2	22
	Age composition		11.4%	17.1%	2.9%	31.4%
	SE (age composition)		3.1%	3.7%	1.6%	4.6%
	Mean length (mm METF)		668	828	928	779
	SE (mean length)		10	13	23	21
Males						
	Harvest by age	21	69	12	42	143
	SE (harvest by age)	6	10	5	8	10
	Samples by age	7	23	4	14	48
	Age composition	10.0%	32.9%	5.7%	20.0%	68.6%
	SE (age composition)	2.9%	4.6%	2.3%	3.9%	4.6%
	Mean length (mm METF)	427	627	836	960	712
	SE (mean length)	14	11	30	14	28
Both sexes						
	Harvest by age	21	93	48	48	209
	SE (harvest by age)	6	10	9	9	
	Samples by age	7	31	16	16	70
	Age composition	10.0%	44.3%	22.9%	22.9%	100.0%
	SE (age composition)	2.9%	4.9%	4.1%	4.1%	
	Mean length (mm METF)	427	637	830	956	733
	SE (mean length)	14	9	12	12	21

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, Kasilof Section, Upper Cook Inlet, Alaska, 1–10 August 2015.

		Age Class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age		16	73	81	170
	SE (harvest by age)		7	13	14	16
	Samples by age		4	18	20	42
	Age composition		4.8%	21.7%	24.1%	50.6%
	SE (age composition)		2.1%	3.9%	4.1%	4.8%
	Mean length (mm METF)		620	854	953	879
	SE (mean length)		80	39	43	107
Males						
	Harvest by age	4	32	44	85	165
	SE (harvest by age)	4	9	11	14	16
	Samples by age	1	8	11	21	41
	Age composition	1.2%	9.6%	13.3%	25.3%	49.4%
	SE (age composition)	1.0%	2.8%	3.2%	4.2%	4.8%
	Mean length (mm METF)	390	629	842	962	851
	SE (mean length)		15	16	9	24
Both sexes						
	Harvest by age	4	48	117	165	335
	SE (harvest by age)	4	11	15	16	
	Samples by age	1	12	29	41	83
	Age composition	1.2%	14.5%	34.9%	49.4%	100.0%
	SE (age composition)	1.0%	3.4%	4.6%	4.8%	
	Mean length (mm METF)	390	626	850	957	865
	SE (mean length)		16	8	6	14

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, Kenai and East Foreland sections, Upper Cook Inlet, Alaska, 1–12 August 2015.

		Age Class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age		34	136	147	317
	SE (harvest by age)		18	35	36	46
	Samples by age		3	12	13	28
	Age composition		3.8%	15.0%	16.3%	35.0%
	SE (age composition)		2.0%	3.8%	4.0%	5.1%
	Mean length (mm METF)		652	857	952	879
	SE (mean length)		58	13	11	20
Males						
	Harvest by age	34	249	113	192	588
	SE (harvest by age)	18	43	32	40	46
	Samples by age	3	22	10	17	52
	Age composition	3.8%	27.5%	12.5%	21.3%	65.0%
	SE (age composition)	2.0%	4.8%	3.6%	4.4%	5.1%
	Mean length (mm METF)	442	622	860	976	773
	SE (mean length)	32	9	16	9	25
Both sexes						
	Harvest by age	34	283	249	339	905
	SE (harvest by age)	18	45	43	47	
	Samples by age	3	25	22	30	80
	Age composition	3.8%	31.3%	27.5%	37.5%	100.0%
	SE (age composition)	2.0%	5.0%	4.8%	5.2%	
	Mean length (mm METF)	442	625	858	966	810
	SE (mean length)	32	10	10	7	19

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

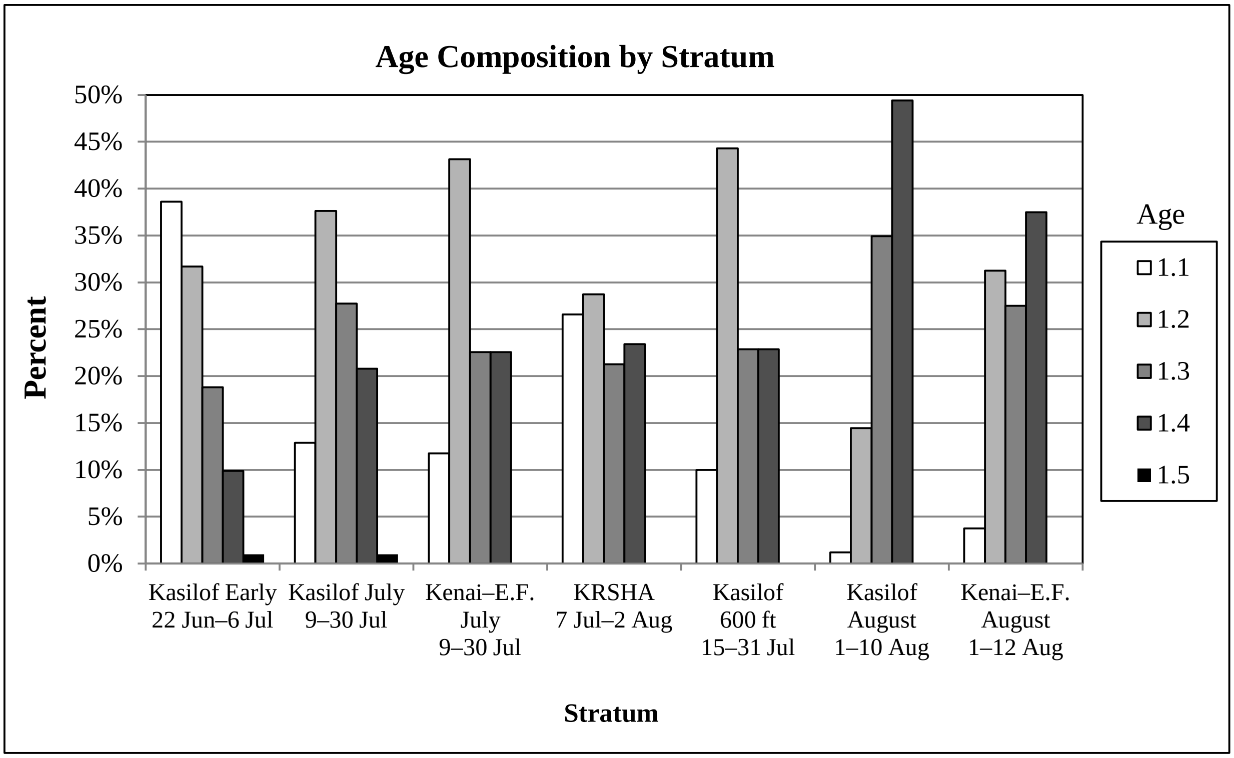

Figure 8.–ESSN Chinook salmon age composition by temporal and geographic stratum, 2015.

Note: KRSHA means Kasilof River Special Harvest Area. Kenai–E.F. means Kenai and East Foreland sections.

Table 14.–Historical age composition of Chinook salmon harvest samples in the ESSN fishery, Upper Cook Inlet, Alaska, 1987–2015.

	Age composition (proportion)				
	Age 3	Age 4	Age 5	Age 6	Age 7
Year	(1.1, 0.2)	(1.2, 2.1, 0.3)	(1.3, 2.2, 0.4)	(1.4, 2.3)	(1.5, 2.4)
1987	0.021	0.148	0.332	0.488	0.012
1988	0.032	0.108	0.148	0.686	0.025
1989	0.009	0.151	0.213	0.533	0.094
1990	0.014	0.306	0.299	0.331	0.050
1991	0.009	0.251	0.325	0.392	0.022
1992	0.025	0.150	0.282	0.504	0.039
1993	0.033	0.140	0.209	0.573	0.045
1994	0.035	0.124	0.149	0.617	0.074
1995	0.027	0.224	0.336	0.351	0.061
1996	0.033	0.159	0.350	0.439	0.020
1997	0.064	0.138	0.314	0.464	0.021
1998	0.122	0.237	0.227	0.389	0.024
1999	0.024	0.265	0.245	0.439	0.028
2000	0.092	0.132	0.390	0.379	0.009
2001	0.117	0.400	0.145	0.325	0.012
2002	0.106	0.293	0.367	0.226	0.008
2003	0.038	0.518	0.239	0.187	0.018
2004	0.035	0.199	0.482	0.277	0.007
2005	0.031	0.270	0.206	0.475	0.019
2006	0.129	0.354	0.221	0.271	0.025
2007	0.048	0.427	0.226	0.285	0.014
2008	0.103	0.197	0.276	0.408	0.016
2009	0.138	0.513	0.123	0.220	0.006
2010	0.183	0.246	0.361	0.202	0.008
2011	0.046	0.337	0.252	0.354	0.012
2012	0.096	0.180	0.366	0.358	0.000
2013	0.227	0.434	0.152	0.186	0.000
2014	0.176	0.322	0.291	0.209	0.001
2015	0.142	0.374	0.243	0.238	0.003
Average	0.074	0.262	0.278	0.373	0.023

Source: 1987–2012: Shields and Dupuis 2015; 2010–2013: Eskelin et al. 2013; 2014: Eskelin and Barclay 2015.

Table 15.–Historical mean length by age of Chinook salmon harvest samples from the ESSN fishery, Upper Cook Inlet, Alaska, 1987–2015.

	Average length by age class (mm METF)					
	Age 3	Age 4	Age 5	Age 6	Age 7	Overall
Year	(1.1, 0.2)	(1.2, 2.1, 0.3)	(1.3, 2.2, 0.4)	(1.4, 2.3)	(1.5, 2.4)	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	399	560	870	1,006	[a]	818
2013	451	589	832	986	[a]	658
2014	431	626	795	954	1,240	712
2015	436	632	829	962	1,100	742
Average	429	620	837	985	1,070	813

Source: 1987–2012: Shields and Dupuis 2015; 2013: Eskelin et al. 2013; 2014: Eskelin and Barclay 2015.

[a] No fish were in the sample selection.

DISCUSSION

REPORTING GROUP PROPORTIONS AND HARVEST ESTIMATES

There are now 5 years (2010, 2011, 2013–2015) of genetic-based estimates of ESSN Chinook salmon harvest by reporting group. *Kenai River mainstem* fish have composed the majority of the ESSN Chinook salmon harvest in every year, averaging 69.1% of the harvest and ranging from 77.0% in 2015 to 60.9% in 2014 (Table 16). *Kasilof River mainstem* fish have composed nearly all of the remainder of the harvest, averaging 29.2% of the harvest and ranging from

20.1% in 2015 to 38.7% in 2014. *Cook Inlet other* and *Kenai River tributaries* have composed a very small fraction of the harvest. The greatest combined total of *Cook Inlet other* and *Kenai River tributaries* has composed only 3.1% (219/7,059) of the harvest (in 2010). *Cook Inlet other* has averaged 1.4% (86/5,565) of the harvest with a maximum of 2.7% (211/7,781) in 2015. *Kenai River tributaries* have composed on average 0.8% (22/5,565) of the harvest with a maximum of 2.7% (19/7,781) in 2015.

Table 16.–Proportions of ESSN Chinook salmon harvest by reporting group and year.

				Credibility interval				Credibility interval	
Reporting group	Year	Proportion	SD	5%	95%	Harvest	SD	5%	95%
Kenai River tributaries	2010	0.011	0.010	0.001	0.031	75	73	4	220
	2011	0.001	0.004	0.000	0.008	9	33	0	59
	2013	0.001	0.004	0.000	0.010	4	13	0	30
	2014	0.002	0.005	0.000	0.012	4	12	0	28
	2015	0.027	0.005	0.000	0.011	19	38	0	86
	Average	0.008				22			
	Range	0.001–0.027				4–75			
Kenai River mainstem	2010	0.643	0.037	0.581	0.703	4,536	263	4,100	4,963
	2011	0.667	0.040	0.601	0.733	5,135	309	4,624	5,641
	2013	0.766	0.023	0.727	0.804	2,289	69	2,173	2,401
	2014	0.609	0.033	0.555	0.664	1,401	76	1,276	1,527
	2015	0.770	0.032	0.709	0.814	5,988	248	5,519	6,330
	Average	0.691				3,870			
	Range	0.609–0.770				1,401–5,988			
Kasilof River mainstem	2010	0.326	0.034	0.271	0.383	2,305	239	1,915	2,701
	2011	0.330	0.040	0.265	0.395	2,538	306	2,038	3,042
	2013	0.213	0.022	0.178	0.250	637	66	530	748
	2014	0.387	0.033	0.333	0.441	891	76	766	1,015
	2015	0.201	0.031	0.160	0.260	1,564	239	1,242	2,025
	Average	0.292				1,587			
	Range	0.201–0.387				637–2,538			
Cook Inlet other	2010	0.020	0.014	0.003	0.047	144	100	19	334
	2011	0.002	0.004	0.000	0.011	14	34	0	84
	2013	0.019	0.006	0.010	0.030	57	19	29	89
	2014	0.002	0.004	0.000	0.010	4	9	0	22
	2015	0.027	0.009	0.014	0.042	211	67	112	327
	Average	0.014				86			
	Range	0.002–0.027				4–211			

There are also 3 years (2013–2015) of geographically and temporally stratified estimates of the ESSN Chinook salmon harvest. *Kenai River mainstem* fish have composed nearly all of the harvest in the Kenai and East Foreland sections in July (average 96.4% for 2013–2015; Figure 6). Results from the Kenai and East Foreland sections in August in 2014 and 2015 are nearly identical to estimates from July. MSA results from the Kenai and East Foreland sections have been the least variable of any strata or geographic area.

The Kasilof Section early stratum has been more variable but still composed of predominately *Kenai River mainstem* fish and also has been the only stratum composed of more than 10% *Cook Inlet other* fish in any year. The proportion of *Kenai River mainstem* fish in the harvest has ranged from 0.769 in 2014 to 0.551 in 2015 and the proportion of *Kasilof River mainstem* fish has ranged from 0.140 in 2013 to 0.224 in 2014 (Figure 7). *Kenai River tributaries* fish have not been harvested in appreciable numbers in the Kasilof Section early stratum; however, those stocks are currently depressed and it is possible that if run sizes of *Kenai River tributaries* fish improve, more would be harvested in the earliest Kasilof Section openings. *Cook Inlet other* fish represented 0.139 of the Kasilof Section early stratum harvest in 2013 and 0.246 in 2015 (Figure 7, Table 5). Although the proportion *Cook Inlet other* is relatively high, this represents low numbers of fish because the stratum occurs before most of the *Kenai River mainstem* and *Kasilof River mainstem* fish arrive. For instance, by the end of the season, the weighted average of the *Cook Inlet other* reporting group in 2015 was 2.7% with an estimated total of 211 harvested fish (90% CI: 112–327 fish; Table 5).

Reporting group composition from the Kasilof Section has been even more variable in July after the Kenai and East Foreland sections first open. For that stratum, *Kenai River mainstem* fish have ranged from 0.733 of the harvest in 2013 to 0.504 of the harvest in 2014 (Figure 7). In 2015, the proportion of *Kenai River mainstem* fish in the harvest was 0.575. This stratum has had the most variability in proportional reporting group estimates among strata during the past 3 years. This variability is probably due to differences in run timing and run size of *Kenai River mainstem* and *Kasilof River mainstem* fish, as well as timing of fishery openings. For instance, in 2013 and 2014, the last Kasilof Section fishing period was on 23 July, whereas in 2015, the last Kasilof Section fishing period was on 30 July.

In 2015, enough samples were collected from Kasilof Section openings in August to estimate stock composition for that stratum. This represents the first MSA for Kasilof Section samples collected in August. Nearly all samples collected during this time and area were used in this MSA analysis in order to meet sample size requirements. Fortunately, samples were collected such that they closely represented the harvest by statistical area and date. More *Kasilof River mainstem* fish (0.558 of harvest) than *Kenai River mainstem* fish (0.437 of harvest) were harvested. Even though these results make sense in terms of the location and timing of the samples, more years of data are needed to accurately characterize the variability in this portion of the fishery.

The KRSHA has been fished consistently since 2013 to target harvest of Kasilof River sockeye salmon yet minimize harvest of *Kenai River mainstem* Chinook salmon and to also reduce Kenai River sockeye salmon harvest. In 2015, we were able to sample more fishing days within KRSHA than any other year, which enabled the selection of a more representative sample of the harvest by date than previous years. MSA results from 2015 were similar to 2013 and 2014 with more *Kasilof River mainstem* fish harvested (0.661 of harvest) than *Kenai River mainstem* fish (0.320). The proportion *Kenai River mainstem* in the KRSHA stratum was highest in 2015 (0.320) and lowest in 2014 (0.206) (Figure 7). The KRSHA was fished earlier and for a longer duration in 2015 compared to 2013 and 2014, which could explain why the proportion of *Kenai River mainstem* fish was higher in 2015 than in other years. Although the proportion of *Kenai River mainstem* fish in KRSHA has been as high as 0.320, harvest of K*enai River mainstem* fish is low and supports the intent of the emergency order used to open the restricted area. Only 136, 129, and 84 *Kenai River mainstem* fish were harvested in KRSHA during 2013, 2014, and 2015, respectively. Harvest of *Kasilof River mainstem* fish in KRSHA has also been relatively low with 273, 494, and 282 fish harvested in 2013, 2014, and 2015, respectively. KRSHA remains an effective tool to maximize harvest of Kasilof River sockeye salmon yet minimize harvest of other stocks.

Fishery managers opened the Kasilof Section but restricted fishing to within the first 600 ft from the mean high tide line for the first time in 2015; this restriction occurred for 6 openings during 15–31 July 2015. These restricted openings had the same justification as for opening KRSHA—to concentrate harvest of Kasilof River sockeye salmon while minimizing harvest of *Kenai River mainstem* Chinook salmon and possibly Kenai River sockeye salmon. Compared to unrestricted Kasilof Section openings, the proportion of *Kenai River mainstem* fish was lower in the Kasilof Section 600 ft openings (0.37) than in unrestricted Kasilof Section openings during July (0.575), which also (similar to KRSHA) supports the intent of the emergency order used to restrict fishing in the Kasilof Section within 600 ft of the mean high tide line.

Overall, relatively similar stock proportions were observed for KRSHA, Kasilof section in August, and Kasilof Section openings restricted to within 600 ft of mean high tide line (Figure 7). Because we have only 1 year of results from Kasilof Section August and Kasilof Section openings restricted to within 600 ft of mean high tide line, more years of MSA are needed to better characterize the stock composition variability within those areas and dates.

By regulation, all salmon harvested in the ESSN fishery must be recorded on fish tickets, including those not sold but kept for personal use (Alaska Administrative Code 5 AAC 21.355 *Reporting requirements*). In most years dating back to 1993, fewer than 100 Chinook salmon in the ESSN harvest were reported as kept for personal use, but in some years, the reported harvest has been as high as 867 (2005; Table 17). In 2015, 507 fish were kept from the harvest for personal use. Although this part of the harvest in 2015 represented only 6.5% of the total reported Chinook salmon harvest, there was a sharp increase in 2015 compared to any recent years and this recorded harvest was the 2nd highest since 1993. We are unable to sample fish kept for personal use and the ASL and reporting group composition of these fish are unknown, but because the harvest is relatively small, it is doubtful that the reporting group and ASL composition estimates reported herein are biased due to this unsampled portion of the fishery. Even if there were a dramatic difference in the reporting group and ASL composition of the sampled and unsampled harvest of fish kept for personal use, the overall compositions would be biased only to a very small degree.

We have sampled all portions of the commercial ESSN fishery harvest and have MSA estimates for many different strata. The only portion of the harvest that we have not analyzed for MSA are the Kasilof Section openings restricted to one-half mile from the mean high tide line due to limited fishing periods, resulting in insufficient sample size. Obtaining MSA results from Kasilof Section one-half mile restricted openings would allow an interesting comparison with adjacent unrestricted Kasilof Section openings as well as Kasilof Section openings restricted to within 600 ft of the mean high tide line. Because Kasilof Section openings restricted to within 600 ft of the mean high tide line comprised a much higher proportion of *Kasilof River mainstem* fish compared to unrestricted Kasilof Section periods, it is possible a lower proportion of *Kenai River mainstem* fish would be observed in Kasilof Section one-half mile restricted periods compared to unrestricted Kasilof Section periods.

Table 17.–ESSN Chinook salmon harvest reported as personal use, 1993–2015.

Year	Harvest reported as kept for personal use (N)	Total reported harvest (N)	Percent of total harvest reported as kept for personal use (%)
1993	110	14,079	0.8
1994	13	15,575	0.1
1995	36	12,068	0.3
1996	43	11,564	0.4
1997	44	11,325	0.4
1998	48	5,087	0.9
1999	73	9,463	0.8
2000	33	3,684	0.9
2001	105	6,009	1.7
2002	14	9,478	0.1
2003	48	14,810	0.3
2004	255	21,684	1.2
2005	867	21,597	4.0
2006	38	9,956	0.4
2007	38	12,292	0.3
2008	26	7,573	0.3
2009	56	5,588	1.0
2010	40	7,059	0.6
2011	97	7,697	1.3
2012	39	705	5.5
2013	122	2,988	4.1
2014	177	2,301	7.7
2015	507	7,781	6.5

Source: Pat Shields, Commercial Fisheries manager, ADF&G, Soldotna, personal communication.

AGE, SEX, AND LENGTH COMPOSITIONS

Similar to recent years, the earliest stratum in 2015 was composed of primarily jacks and age-1.2 fish, and as the season progressed, the age composition shifted to older fish, with August samples being primarily age-1.4 fish. The exception is KRSHA which, since 2013, has had a consistently different age composition than other strata, probably due to location (near the Kasilof River terminus), timing, and physical characteristics of the fishery itself, such as shallow depth.

In 2015, the proportion of jacks (age-1.1 fish) in the ESSN fishery was lower than in 2013 and 2014 but was the 4th highest since 1987, and 3 of the 4 years with the highest proportion of jacks have been in the past 4 years (Table 14). When considering jacks and age-1.2 fish combined, 2015 had the 5th highest proportion observed, and 11 of the 15 highest proportions have been observed since 2001. The average length of the 2015 samples was the 4th lowest observed, and also an artifact of earlier average age at maturity (Table 3). Overall, ASL compositions with nearly half the population made up of smaller, younger fish have been common for many years since the early 2000s. Younger, smaller fish are predominately males so more males than females have been harvested in the ESSN fishery, which probably reflects the composition of the runs as well.

The mechanism driving the shift towards runs with smaller, younger fish over recent years is not entirely understood. Size and age at maturity are important life-history traits for Pacific salmon, reflecting an assortment of evolutionary and ecological influences affecting growth and survival including competition, food availability, predation, disease, temperature, harvest intensity, and selectivity (Lewis et al. 2015); however, the relative importance of these factors in shaping life-history traits is largely unknown. The recently observed earlier age at maturity compared to historical records in the ESSN fishery has also been observed for many other Chinook salmon stocks in Alaska (Lewis et al. 2015). Although there was an increase in age at maturity of harvested Chinook salmon in the ESSN fishery in 2015 compared to 2014, the average age at maturity was still well below historical averages. Because the cause is unknown, it is unknown if the trend of decreasing age at maturity will continue.

FUTURE SAMPLING

Having an experienced sampling crew with knowledge of the intricacies of each buying station and the timing of when to arrive at each station helped to maximize the number of samples collected in 2015. Statistical area of harvest is generally required for each sample used in the MSA, and samplers were diligent in determining the statistical area of harvest; however, this can be difficult when stations have fish from more than 1 statistical area. In 2015, we sampled 29% of the harvest, which was the lowest sampling rate in the 3 years (2013–2015) of expanded sampling, yet we collected the most samples (n = 2,241) of any year since sampling began in 1987. The harvest of 7,781 Chinook salmon in 2015 was the highest since 2007, but very similar to 2008, 2010, and 2011. Results for 2015 were analyzed for 7 strata, which is the most strata analyzed for MSA of any year. Due to the increased number of openings and budgetary constraints, we did not sample every fishing period. Unsampled periods included 2 periods in July in the Kenai and East Foreland sections, 1 period that was unrestricted in the Kasilof Section, and 4 KRSHA periods. If a similar number of fishing periods occur in 2016, we will probably not sample as many periods in the Kenai and East Foreland sections because results have consistently shown that these sections are composed of almost entirely *Kenai River mainstem* fish. Depending on available funding, sampling rates, and possible strata that meet minimum sample size requirements, we may not conduct MSA on that portion of the harvest from the Kenai and East Foreland sections, but we will still collect representative genetic tissue samples for future analysis in addition to collecting and analyzing ASL samples. Sampling effort will be even more directed to the Kasilof Section fishing periods due to the higher variability of stock compositions in this area.

This project continues to provide useful information regarding the genetic reporting groups and ASL composition of the ESSN Chinook salmon harvest. Results will be used for Kenai River Chinook salmon run reconstruction, modification of escapement goals if necessary, and management of the fishery. Fortunately, there is funding to conduct this sampling project in 2016 and 2017. CSRI will provide funding for the 2016 season, and ADF&G was awarded funding from the Pacific States Marine Fisheries Commission to conduct the project in 2017.

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