Regional Information Report 5J17-05

Annual Genetic Stock Composition Estimates for the Upper Cook Inlet Sockeye Salmon Commercial Fishery, 2005–2016

by

Andrew W. Barclay

July 2017

Alaska Department of Fish and Game **Division of Commercial Fisheries**

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

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

REGIONAL INFORMATION REPORT 5J17-05

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by

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The Regional Information Report Series was established in 1987 and was redefined in 2007 to meet the Division of Commercial Fisheries regional need for publishing and archiving information such as area management plans, budgetary information, staff comments and opinions to Alaska Board of Fisheries proposals, interim or preliminary data and grant agency reports, special meeting or minor workshop results and other regional information not generally reported elsewhere. Reports in this series may contain raw data and preliminary results. Reports in this series receive varying degrees of regional, biometric and editorial review; information in this series may be subsequently finalized and published in a different department reporting series or in the formal literature. Please contact the author or the Division of Commercial Fisheries if in doubt of the level of review or preliminary nature of the data reported. Regional Information Reports are available through the Alaska State Library and on the Internet at: http://www.adfg.alaska.gov/sf/publications/.

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INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) has used genetic mixed stock analyses (MSA) to estimate stock-specific harvests of sockeye salmon (*Oncorhynchus nerka*) in the Central and Northern district commercial fisheries of Upper Cook Inlet (UCI) since 2005. The MSA sampling design has remained relatively consistent since the 2005; however, the number of samples and strata analyzed has declined over the years due to budget cuts and the redirecting of project funds to answer other fisheries questions. Regardless, the analyzed samples have represented over 90% of the catch since 2006. The estimates for each fishing season were provided to area managers the spring following each season. However, only estimates from 2005 to 2011 have been published in ADF&G reports and estimates from 2012 and 2013 are submitted to ADFG publications, but not yet published (Barclay et al. 2010a, 2010b, 2013, 2014, *In prep*).

In December of 2016, ADF&G released a report that used genetic MSA to estimate the stock composition and stock-specific harvest of commercial sockeye salmon harvests in the Kodiak Management Area (KMA) from 2014 to 2016 (Shedd et al. 2016). The results were originally presented to the Alaska Board of Fisheries at the KMA meeting in January, 2017, and then again at the UCI meeting in February, 2017. Nonlocal harvest of Cook Inlet sockeye salmon in KMA commercial salmon fisheries from 2014 to 2016 was substantial, but varied in magnitude both spatially and temporally (Shedd et al. 2016). Given the level of nonlocal harvest of Cook Inlet sockeye salmon, the Alaska Board of Fisheries asked ADF&G to further separate genetic estimates of Cook Inlet harvest into 4 subregional reporting groups: *Kenai*, *Kasilof*, *Susitna*, and *Other Cook Inlet*. ADF&G is preparing and will release this analysis as an addendum to the Shedd et al. (2016) report.

In June of 2017, the Kodiak Fisheries Work Group requested from ADF&G overall stock-specific harvest estimates from all UCI sockeye salmon commercial fishery harvests that have been analyzed to date, including unpublished estimates from 2012 to 2016. The request included a table of stock-specific harvest estimates for the total UCI sockeye salmon commercial fishery in each year and a stacked bar plot of the estimates. This report serves 2 purposes: 1) it provides the Kodiak Fisheries Work Group with the data they requested, and 2) it is a medium for making currently unpublished estimates publicly available.

Some reporting groups between this report and the KMA addendum will differ. Reporting groups *Kenai* and *Kasilof* will be identical between this report and the KMA addendum (Figure 1). However, this report's reporting groups *SusYen* and *JCL* will be combined and reported as *Susitna* in the KMA addendum. This report's reporting groups *Crescent*, *West*, *Fish*, and *KTNE* will be combined and reported as *Other Cook Inlet* in the KMA addendum.

METHODS

Overall stock-specific harvest estimates were calculated by combining estimates among strata for each year using a stratified estimator. Sampling, laboratory, and statistical methods for the 2005–2011 harvests are reported in Barclay et al. (2010a, 2010b, 2013, 2014, *In prep*). Methods for the 2014–2016 harvest generally follow those reported in the 2012–2013 report (Barclay et al. *In prep*).

RESULTS AND DISCUSSION

A total of 14 (2005), 23 (2006), 20 (2007), 18 (2008), 20 (2009), 22 (2010), 17 (2011), 12 (2012), 8 (2013), 8 (2014), 7 (2015), and 5 (2016) strata were combined for each year to produce overall stock-specific harvest estimates (Barclay et al. 2010a, 2010b, 2013, 2014, *In prep*; Table 1 for 2014–2016). These estimates represented over 90% of the UCI catch starting in 2006 (Table 2; Figure 1).

UNREPRESENTED STRATA

Unrepresented strata result in underestimates of the total harvest and the distribution of these underestimates across stocks is influenced by which strata are unrepresented. For example, Barclay et al. (2010a, 2010b, 2013, 2014, *In prep*) found that the most common stock captured in the Kasilof Special Harvest Area is the *Kasilof* reporting group. Therefore, if the Kasilof Special Harvest Area stratum is un- or underrepresented in a year, then harvest of *Kasilof* reporting group will be underestimated for the year. These underestimates increase as unrepresented harvest increase. In order to help understand how these unrepresented strata may affect annual stock-specific harvest, we provide information on number of fish and fishing areas that were not represented for years where unrepresented strata comprise more than 5% of the harvest (Table 3). Insights into which stocks are most affected by different unrepresented strata can be gleaned from the stratum-specific stock compositions provided in Barclay et al. (2010a, 2010b, 2013, 2014, *In prep*) for years 2005 to 2013.

Unrepresented strata accounted for over 5% of the harvest in 6 of the 12 years analyzed (2005–2008, 2014, and 2015; Tables 2 and 3). In general, from 2005 to 2007, the Central District drift gillnet fishery accounted for the majority of unrepresented harvest (36.7–75.9%), followed by the Kasilof River Special Harvest Area at the mouth of the Kasilof River (8.4–42%), and the Western and Kalgin Island subdistricts (7.2–16.5%) and Northern District (2.3–5.9%) set gillnet fisheries. In 2008, the Central District drift gillnet fishery accounted for 96.4% of all unrepresented harvest, and the Northern District set gillnet fishery accounted for 3.6% of all unrepresented harvest (Table 3; Figures 2 and 3). In both 2014 and 2015, 94% of the unrepresented harvest occurred in the Kasilof River Special Harvest Area, with the Central District drift gillnet, Western and Kalgin Island subdistricts set gillnet, and Northern District set gillnet fisheries accounting for the remaining unrepresented harvest.

SUMMARY OF ANNUAL STOCK-SPECIFIC HARVESTS

The overall stock-specific harvest estimates for the 2005–2016 UCI commercial sockeye fishery are in Table 2 and a graphical representation of these results is in Figure 4. *Kenai* was the largest contributor to fishery harvest, except 2006 and 2008, when *Kasilof* was the most abundant in the harvest.

Kenai reporting group ranged from a low proportion of the represented harvest in 2006 (28%), to a high in 2016 (83%), and averaged 63% from 2005 to 2016. Harvest numbers for *Kenai* ranged from 577,512 fish in 2006 to 3,901,433 fish in 2011 and averaged 1,861,800 fish.

Kasilof reporting group ranged from a low proportion of the represented harvest in 2012 (5%), to a high in 2006 (65%) and averaged 23% from 2005 to 2016. Harvest numbers for *Kasilof* ranged from 146,512 fish in 2016 to 1,324,611 fish in 2006 and averaged 591,909 fish.

The combination of reporting groups that make up the KMA *Susitna* reporting group ranged from a low proportion of the represented harvest in 2005 (1%), to a high in 2007 and 2015 (8%), and averaged 5% from 2005 to 2016. Harvest numbers for these combined reporting groups ranged from 44,461 fish in 2006 to 238,943 fish in 2007 and averaged 141,682 fish.

The combination of reporting groups that make up the KMA *Other Cook Inlet* reporting group ranged from a low proportion of the represented harvest in 2005 (2%), to a high in 2009 (16%) and averaged 9% from 2005 to 2016. Harvest numbers for these combined reporting groups ranged from 66,676 fish in 2005 to 522,930 fish in 2011 and averaged 246,905 fish.

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TABLES AND FIGURES

Table 1.–Number of samples analyzed (N) and the District, Subdistrict, fishery and harvest dates represented for strata combined to estimate overall stock specific harvests for the Upper Cook Inlet commercial sockeye salmon fishery, 2014–2016.

Year	District	Subdistrict	Fishery	Harvest date(s)	N
2014					
	Central		drift gillnet (excluding corridor-only periods)	6/19–8/14	397
			drift gillnet (corridor-only periods)	7/9–31	386
		Upper	Kasilof Section set gillnet	6/23–8/4	388
			Kenai/East Foreland sections set gillnet	7/9–8/6	389
		Kalgin Island	set gillnet	6/2–8/14	394
		Western	set gillnet	6/11–8/14	385
	Northern	Eastern	set gillnet	6/30–8/18	398
		General	set gillnet	6/26–8/21	395
2015					
	Central		drift gillnet (excluding corridor-only periods)	6/22–8/17	396
			drift gillnet (corridor-only periods)	7/11–8/12	359
		Upper	Kasilof/Kenai/East Forelands sections set gillnet	6/22–7/15	298
				7/16–27	298
				7/28–8/12	299
		Kalgin Island/Western	set gillnet	6/3–8/17	395
	Northern	Eastern/General	set gillnet	6/29–8/20	393
2016					
	Central		drift gillnet (excluding corridor-only periods)	6/20–8/15	399
			drift gillnet (corridor-only periods)	7/9–8/3	393
		Upper	Kasilof/Kenai/East Forelands sections set gillnet	6/23–7/9	389
		Kalgin Island/Western	set gillnet	6/13–8/15	387
	Northern	Eastern/General	set gillnet	6/30–8/18	387

Table 2.–Stock-specific harvest, standard deviation (SD), and 90% credibility intervals (CI) calculated using a stratified estimator for combined spatial and temporal strata in all represented fishing area strata and based on genetic analysis of sockeye salmon harvested in the Upper Cook Inlet, 2005–2016. The numbers of fish that contribute to the unrepresented strata are also provided.

			90% CI		
Year	Reporting Group	Mean	5%	95%	SD
2005	*Crescent*	14,569	64	30,065	8,876
	West	33,352	21,097	48,742	8,588
	JCL	27,178	17,361	38,890	6,600
	SusYen	27,748	15,231	43,673	8,854
	Fish	3,935	108	9,440	2,910
	KTNE	14,820	6,866	26,026	5,975
	Kenai	2,936,487	2,872,816	2,999,501	38,418
	Kasilof	1,019,935	960,699	1,079,433	36,141
	Harvest represented	4,078,024			
	Harvest unrepresented	1,157,465			
	Total harvest	5,235,489			
2006	*Crescent*	27,109	25,279	30,476	1,673
	West	53,574	45,402	62,677	5,264
	JCL	16,230	12,415	20,434	2,445
	SusYen	28,231	21,944	35,250	4,075
	Fish	333	7	1,248	503
	KTNE	17,350	12,645	22,526	3,010
	Kenai	577,512	558,050	597,296	11,902
	Kasilof	1,324,611	1,305,342	1,343,687	11,635
	Harvest represented	2,044,951			
	Harvest unrepresented	143,252			
	Total harvest	2,188,203			
2007	*Crescent*	54,001	46,973	62,559	4,772
	West	153,205	129,922	178,433	14,739
	JCL	134,100	112,161	157,216	13,723
	SusYen	104,842	74,128	137,684	19,335
	Fish	8,199	3,955	14,181	3,192
	KTNE	74,235	55,825	94,015	11,628
	Kenai	1,920,986	1,870,844	1,970,492	30,389
	Kasilof	687,091	645,072	730,015	25,806
	Harvest represented	3,136,660			
	Harvest unrepresented	177,662			
	Total harvest	3,314,322			

-continued-

Table 2.–Page 2 of 4.

Year	Reporting Group	Mean	90% CI 5%	90% CI 95%	SD
2008	*Crescent*	20,145	16,499	24,243	2,359
	West	63,717	54,582	73,860	5,880
	JCL	66,315	55,472	77,926	6,848
	SusYen	47,092	34,396	61,204	8,162
	Fish	3,516	1,471	6,181	1,490
	KTNE	47,826	39,180	57,511	5,582
	Kenai	875,430	842,868	908,403	19,876
	Kasilof	1,111,226	1,079,760	1,142,403	19,076
	Harvest represented	2,235,268			
	Harvest unrepresented	142,378			
	Total harvest	2,377,646			
2009	*Crescent*	59,630	54,305	67,836	4,182
	West	163,460	147,142	181,011	10,286
	JCL	45,224	35,567	55,619	6,127
	SusYen	57,296	42,976	72,923	9,153
	Fish	37,648	29,186	47,195	5,514
	KTNE	54,198	44,734	64,676	6,080
	Kenai	943,784	913,625	974,061	18,379
	Kasilof	670,243	645,021	695,614	15,395
	Harvest represented	2,031,483			
	Harvest unrepresented	9,797			
	Total harvest	2,041,280			
2010	*Crescent*	51,025	46,488	56,471	3,061
	West	204,880	187,225	223,412	10,994
	JCL	55,659	46,040	66,191	6,145
	SusYen	58,425	47,185	70,616	7,162
	Fish	93,905	81,844	106,611	7,564
	KTNE	78,996	67,408	91,554	7,339
	Kenai	1,821,553	1,791,885	1,850,751	17,926
	Kasilof	423,296	404,928	442,293	11,346
	Harvest represented	2,787,738			
	Harvest unrepresented	36,494			
	Total harvest	2,824,232			

-continued-

Table 2.–Page 3 of 4.

Year	Reporting Group	Mean	90% CI 5%	90% CI 95%	SD
2011	*Crescent*	63,232	58,364	70,028	3,629
	West	295,953	263,201	330,645	20,471
	JCL	92,480	72,759	114,705	12,768
	SusYen	125,039	98,621	154,410	16,997
	Fish	80,172	62,469	100,096	11,490
	KTNE	83,572	64,428	105,570	12,555
	Kenai	3,901,433	3,842,526	3,958,817	35,450
	Kasilof	470,319	437,456	505,024	20,539
	Harvest represented	5,112,200			
	Harvest unrepresented	161,399			
	Total harvest	5,273,599			
2012	*Crescent*	31,142	26,325	37,615	3,517
	West	139,175	117,443	163,628	14,072
	JCL	90,128	69,548	113,076	13,279
	SusYen	88,826	65,832	114,506	14,858
	Fish	20,029	11,630	31,003	5,997
	KTNE	42,393	29,588	58,010	8,711
	Kenai	2,513,544	2,466,204	2,559,099	28,280
	Kasilof	158,968	133,983	186,339	15,951
	Harvest represented	3,084,205			
	Harvest unrepresented	5,874			
	Total harvest	3,090,079			
2013	*Crescent*	24,942	18,225	35,382	5,454
	West	163,040	134,237	194,974	18,557
	JCL	110,754	85,767	138,712	16,135
	SusYen	76,336	55,991	99,733	13,353
	Fish	4,492	1,671	8,693	2,224
	KTNE	54,522	39,589	72,198	9,970
	Kenai	1,816,297	1,759,722	1,871,163	33,862
	Kasilof	335,839	299,715	374,057	22,589
	Harvest represented	2,586,223			
	Harvest unrepresented	21,792			
	Total harvest	2,608,015			

-continued-

Table 2.–Page 4 of 4.

Year	Reporting Group	Mean	90% CI 5%	90% CI 95%	SD
2014	*Crescent*	32,555	30,045	35,226	1,809
	West	164,220	87,101	236,147	45,058
	JCL	56,109	32,826	82,212	15,068
	SusYen	67,659	34,078	124,917	27,974
	Fish	12,424	1,813	30,557	9,728
	KTNE	53,306	25,842	115,557	27,478
	Kenai	1,406,865	1,329,437	1,483,643	46,966
	Kasilof	327,136	277,631	379,368	31,014
	Harvest represented	2,120,276			
	Harvest unrepresented	223,106			
	Total harvest	2,343,382			
2015	*Crescent*	40,192	32,902	52,498	6,100
	West	130,653	100,192	178,200	23,486
	JCL	40,923	27,180	57,050	9,176
	SusYen	159,328	111,308	206,508	28,759
	Fish	17,282	8,014	29,736	6,703
	KTNE	36,957	22,083	55,328	10,285
	Kenai	1,657,183	1,591,903	1,722,145	39,584
	Kasilof	427,733	379,222	476,797	29,672
	Harvest represented	2,510,251			
	Harvest unrepresented	138,826			
	Total harvest	2,649,077			
2016	*Crescent*	32,299	26,298	39,348	4,795
	West	31,835	21,633	48,684	8,762
	JCL	47,807	33,940	63,752	9,113
	SusYen	76,450	42,566	122,620	25,113
	Fish	21,427	11,664	34,007	6,938
	KTNE	53,414	35,491	74,533	11,947
	Kenai	1,970,523	1,908,449	2,027,338	36,260
	Kasilof	146,512	108,130	187,842	24,206
	Harvest represented	2,380,267			
	Harvest unrepresented	16,518			
	Total harvest	2,396,785			

Table 3.–Number of fish within fishery strata contributing to the unrepresented harvest of Upper Cook Inlet commercial sockeye salmon catch by year for years when the total unrepresented harvest was greater than 5% of the total harvest (Table 2). Fishery strata include: Central District drift gillnet, Upper Subdistrict set gillnet, Kasilof River Special Harvest Area (KRSHA) drift and set gillnet, Western and Kalgin Island set gillnet, and Northern District set gillnet fisheries (Figures 2 and 3).

	Fishery				
Year	Central District drift	Upper Subdistrict set	KRSHA drift & set	Western & Kalgin Island Subdistricts set	Northern District set
2005	878,918	0	97,199	154,933	26,415
2006	52,548	0	60,131	23,647	6,926
2007	134,072	0	20,290	12,799	10,501
2008	137,236	0	0	0	5,142
2014	7,199	0	209,807	2,098	4,002
2015	3,998	0	130,047	578	4,203

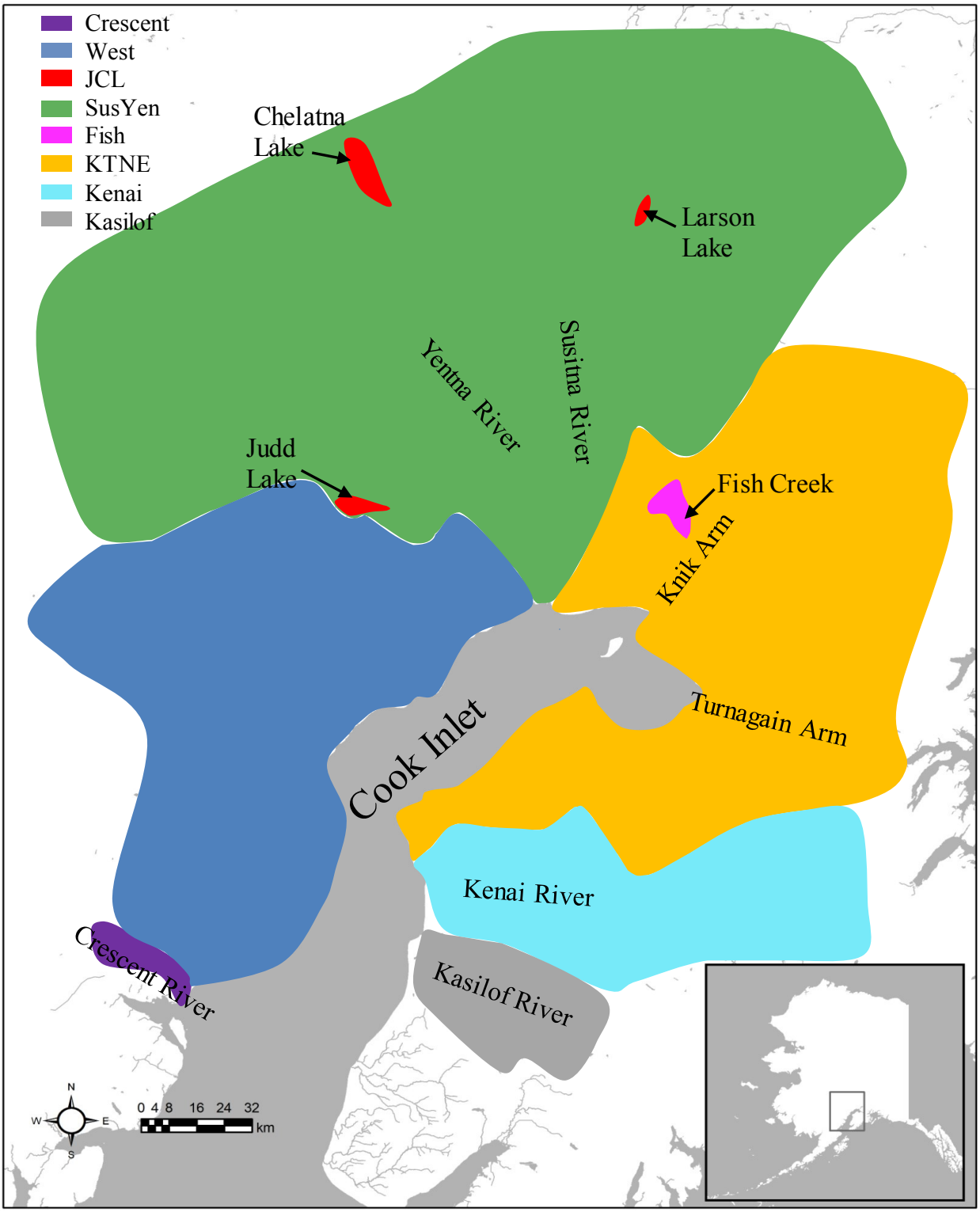

Figure 1.–Map of Cook Inlet showing reporting group areas for genetic mixed stock analysis of sockeye salmon commercial harvest samples.

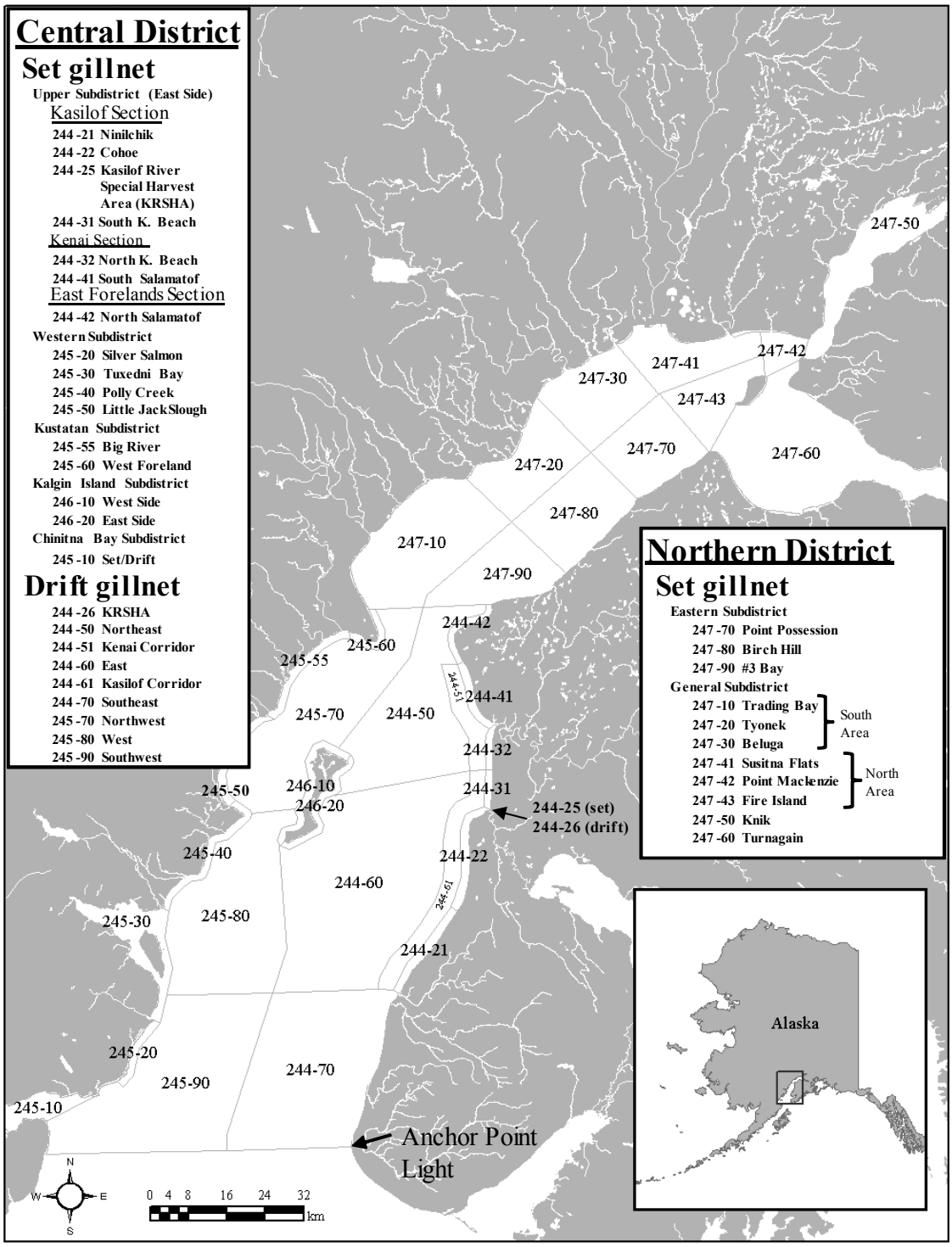

Figure 2.–Map of Upper Cook Inlet showing commercial fishing boundaries (statistical areas) for subdistricts and selected sections and subsections within the Northern and Central districts for both set and drift gillnet fisheries.

Note: Districts, subdistricts, and sections are defined in Alaska Administrative Code (5 AAC 21.200). For the purposes of this report the statistical areas in Upper Subdistrict (Central District) are referred to as subsections.

Map Point	Latitude	Longitude
A	60.3765	-151.3389
B	60.3844	-151.3422
C	60.4022	-151.314
D	60.4025	-151.2953

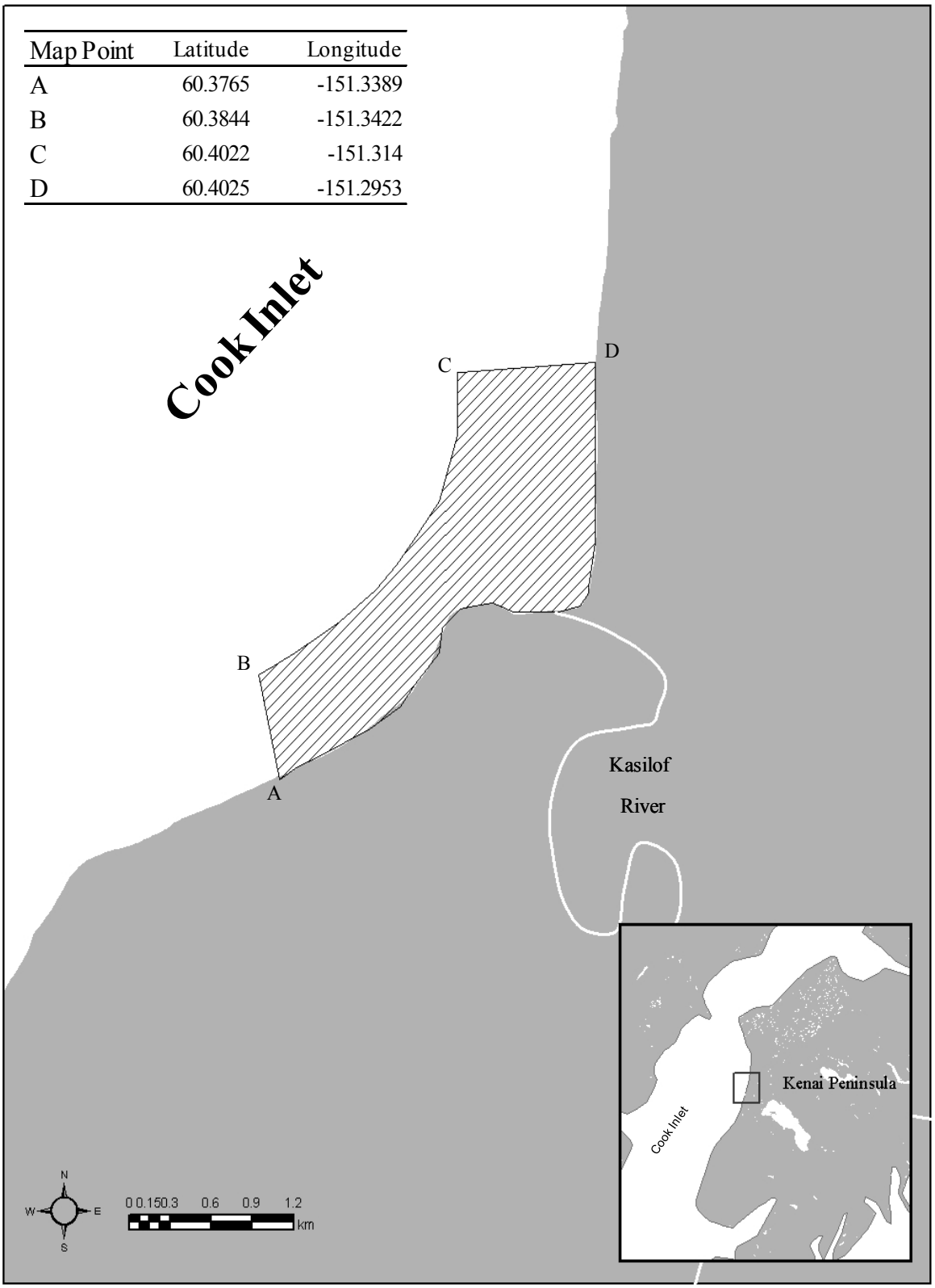

Figure 3.–Map of the mouth of the Kasilof River showing management fishing boundaries for the Kasilof River Special Harvest Area (Central District, Upper Subdistrict).

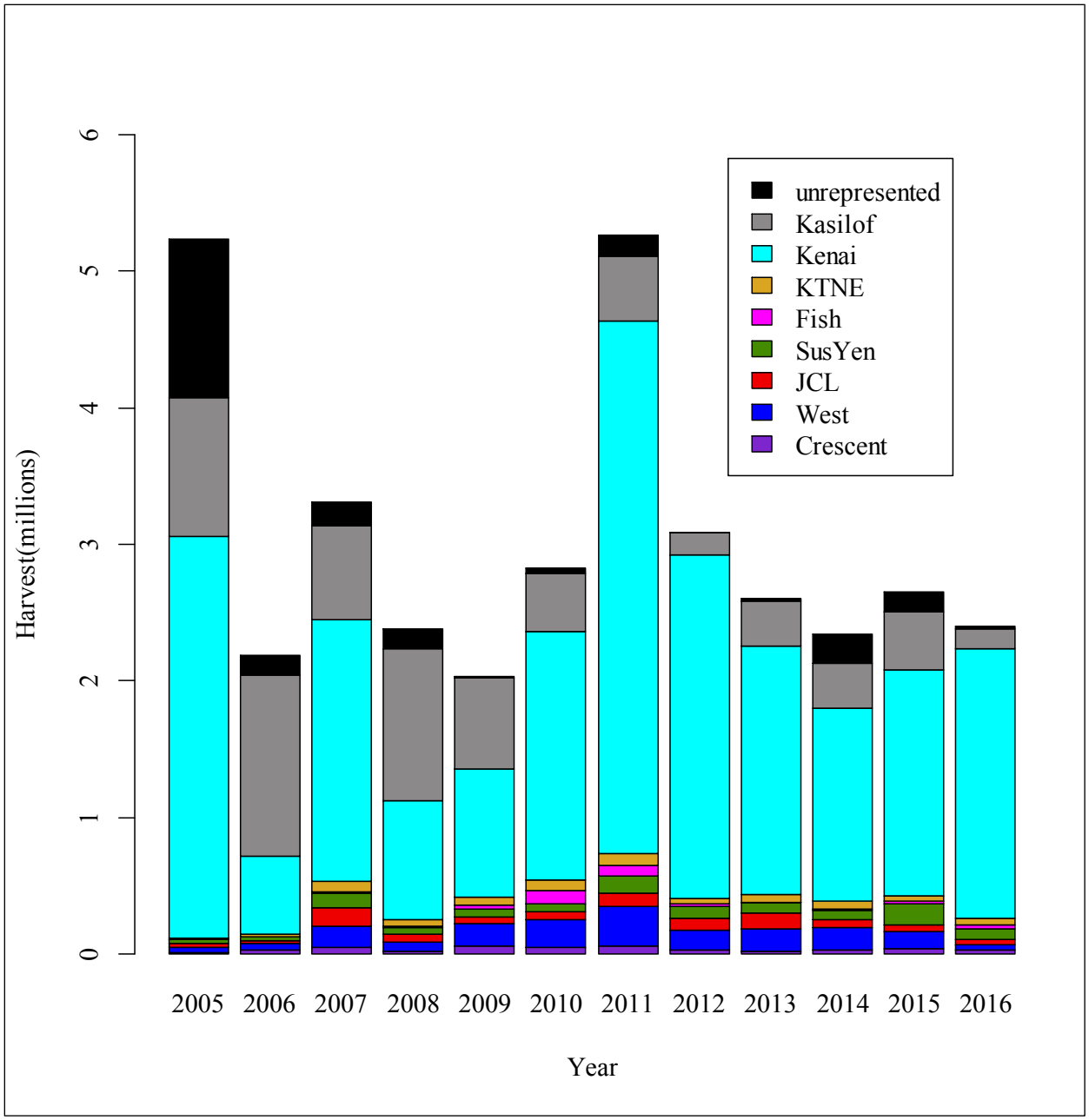

Figure 4.–Estimates of commercial harvest by stock in the Upper Cook Inlet sockeye salmon fishery calculated using a stratified estimator for all strata, 2005–2016.