Fishery Data Series No. 22-06

Eastside Set Gillnet Chinook Salmon Harvest Composition in Upper Cook Inlet, Alaska, 2021

by

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and

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February 2022

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

FISHERY DATA SERIES NO. 22-06

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February 2022

This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C.777-777K) under Project F-10-36, Job No. S-2-5c.

ADF&G Fishery Data Series was established in 1987 for the publication of Division of Sport Fish technically oriented results for a single project or group of closely related projects, and in 2004 became a joint divisional series with the Division of Commercial Fisheries. Fishery Data Series reports are intended for fishery and other technical professionals and are available through the Alaska State Library and on the Internet: http://www.adfg.alaska.gov/sf/publications/. This publication has undergone editorial and peer review.

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This document should be cited as follows:
Eskelin, A., and A. W. Barclay. 2022. Eastside set gillnet Chinook salmon harvest composition in Upper Cook Inlet, Alaska, 2021. Alaska Department of Fish and Game, Fishery Data Series No. 22-06, Anchorage.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Chinook salmon were sampled for genetic tissue and age, sex, and length from the Upper Cook Inlet Eastside set gillnet (ESSN) commercial fishery in 2021. Mixed-stock analysis (MSA) was conducted on tissue samples collected to represent harvest by reporting group, date, area, and size. Reported harvest in the ESSN fishery was 1,297 Chinook salmon of all sizes (all-fish harvest), with an estimated composition of 909 (70%) *Kenai River mainstem*, 166 (13%) *Kasilof River mainstem*, 217 (17%) *Cook Inlet other* fish, and 4 (<1%) *Kenai River tributaries* fish. *Kenai River mainstem* fish have composed on average 70% of the all-fish harvest since 2010, ranging from 61% (2014) to 79% (2017). Estimated harvest of large (75 cm mid eye to tail fork [METF] and longer) *Kenai River mainstem C*hinook salmon in 2021 was 217 fish (17% of the all-fish harvest and 66% of the large-fish harvest). Large *Kenai River mainstem* fish have composed on average 32% of the all-fish harvests since 2010 ranging from 17% (2021) to 63% (2017). Large *Kenai River mainstem* fish have composed on average 69% of the large-fish harvest ranging from 60% (2010 and 2019) to 79% (2017). Age composition of the all-fish harvest in 2021 was 32% age-1.1 (jacks), 40% age-1.2, 26% age-1.3, and 2% age-1.4 fish. The percentage of age-1.4 fish (2%) in the all-fish harvest was the lowest observed, and the percentage of jacks (33%) was the 2nd highest observed since sampling began in 1987. Sex composition of the all-fish harvest was 79% males and 21% females. The average METF length of sampled Chinook salmon was 622 mm in 2021, the lowest ever observed.

Keywords: Chinook salmon, *Oncorhynchus tshawytscha*, Upper Cook Inlet, UCI, Kenai River, Kasilof River, late run, mixed-stock analysis, MSA, ASL, ESSN, Eastside set gillnet 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 (Marston and Frothingham 2019). The UCI commercial fisheries management area consists of the 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 allowed in the Central District, whereas only set gillnets are allowed in the Northern District.

Sockeye salmon (*Oncorhynchus nerka*) compose the majority of the commercial harvest in UCI but all other species of North American Pacific salmon, including Chinook salmon (*O. tshawytscha*), are also harvested (Marston and Frothingham 2019). Harvest statistics are monitored by the Alaska Department of Fish and Game (ADF&G) from fish tickets (Alaska Administrative Code 5 AAC 21.355). Harvest data are available and reported by 5-digit statistical areas (Marston and Frothingham 2019). Most of the UCI commercial Chinook salmon harvest occurs in the Upper Subdistrict of the Central District, commonly referred to as the Eastside set gillnet (ESSN) fishery, located along the eastern shore of Cook Inlet between Ninilchik and Boulder Point (Figures 1–2). On average since 1966, the ESSN fishery has accounted for 65% of all Chinook salmon harvested in UCI commercial fisheries (Table 1).

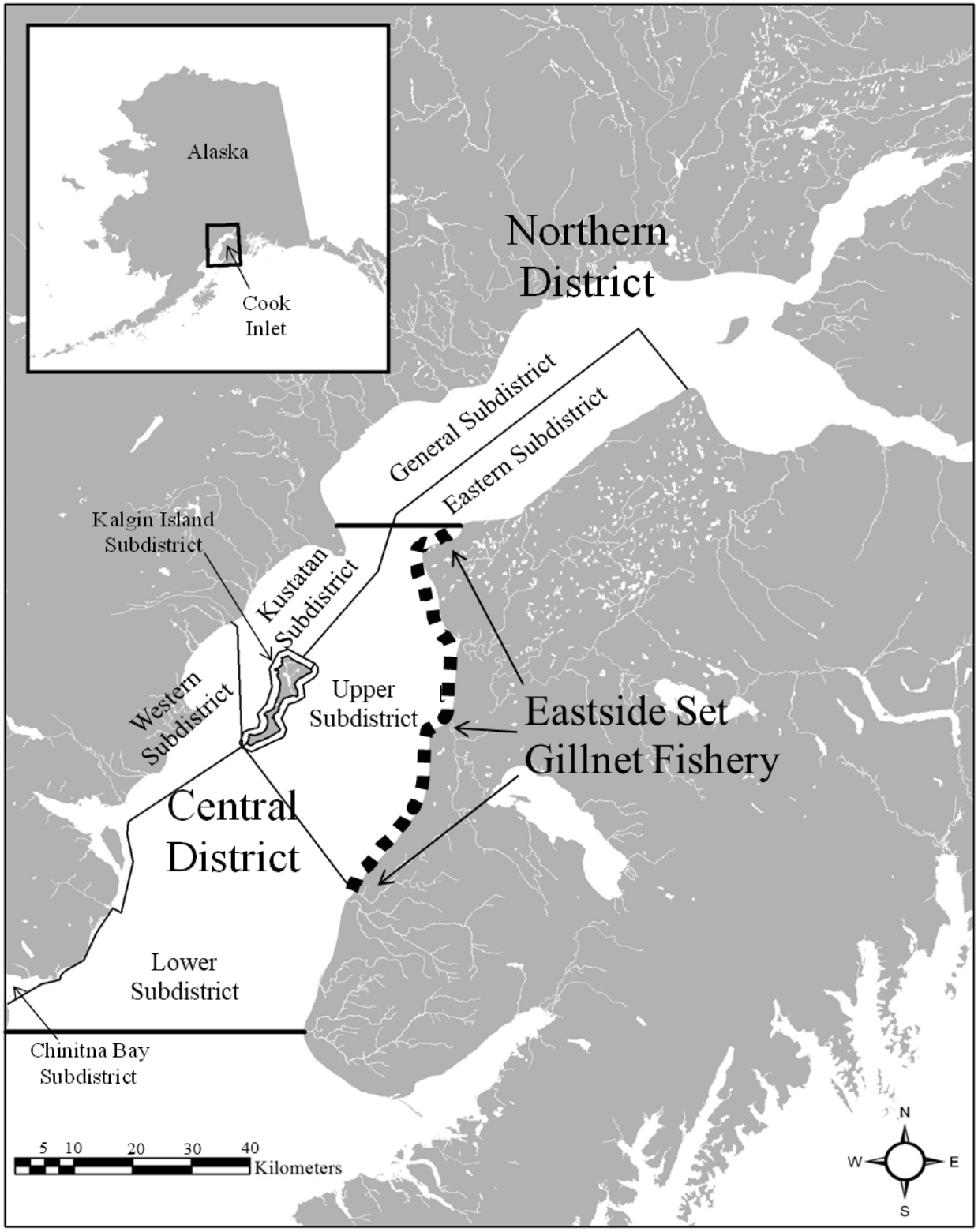

Figure 1.–Map of Upper Cook Inlet commercial fishing districts and subdistricts.

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

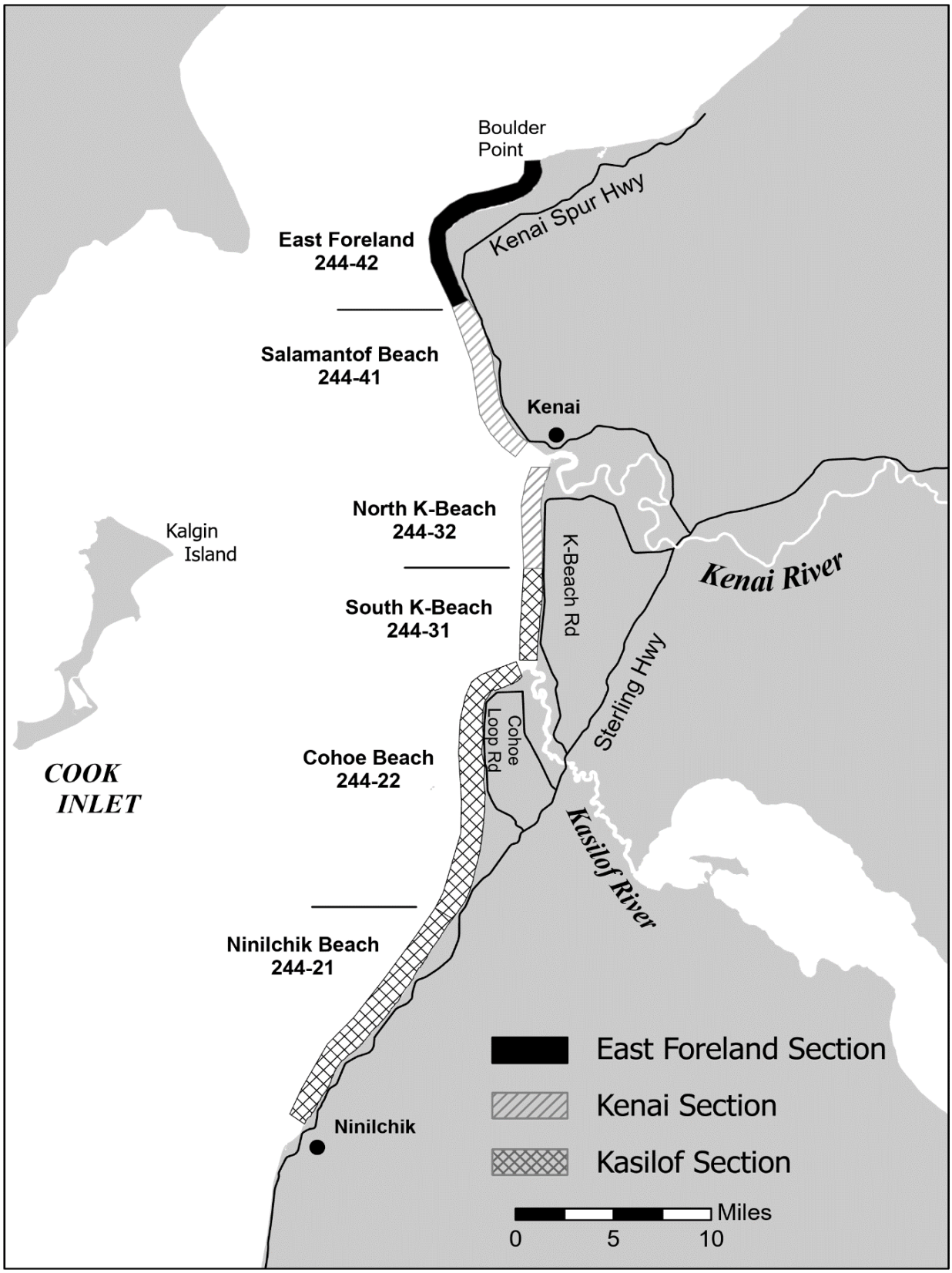

Figure 2.–Map of Upper Cook Inlet Eastside set gillnet commercial fishing statistical areas.

Table 1.–Upper Cook Inlet commercial Chinook salmon gillnet harvest by gear type and area, 1966–2021.

	Central District								
	Eastside set		Drift		Kalgin–Westside set		Northern District set		
Year	Harvest	%	Harvest	%	Harvest	%	Harvest	%	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	6.4	184	2.3	7,859
1968	3,304	72.8	182	4.0	579	12.8	471	10.4	4,536
1969	5,834	47.1	362	2.9	3,286	26.5	2,904	23.4	12,386
1970	5,368	64.4	356	4.3	1,152	13.8	1,460	17.5	8,336
1971	7,055	35.7	237	1.2	2,875	14.5	9,598	48.6	19,765
1972	8,599	53.5	375	2.3	2,199	13.7	4,913	30.5	16,086
1973	4,411	84.9	244	4.7	369	7.1	170	3.3	5,194
1974	5,571	84.5	422	6.4	434	6.6	169	2.6	6,596
1975	3,675	76.8	250	5.2	733	15.3	129	2.7	4,787
1976	8,249	75.9	690	6.4	1,469	13.5	457	4.2	10,865
1977	9,730	65.8	3,411	23.1	1,084	7.3	565	3.8	14,790
1978	12,468	72.1	2,072	12.0	2,093	12.1	666	3.8	17,299
1979	8,671	63.1	1,089	7.9	2,264	16.5	1,714	12.5	13,738
1980	9,643	69.9	889	6.4	2,273	16.5	993	7.2	13,798
1981	8,358	68.3	2,320	19.0	837	6.8	725	5.9	12,240
1982	13,658	65.4	1,293	6.2	3,203	15.3	2,716	13.0	20,870
1983	15,042	72.9	1,125	5.5	3,534	17.1	933	4.5	20,634
1984	6,165	61.3	1,377	13.7	1,516	15.1	1,004	10.0	10,062
1985	17,723	73.6	2,048	8.5	2,427	10.1	1,890	7.8	24,088
1986	19,826	50.5	1,834	4.7	2,108	5.4	15,488	39.5	39,256
1987	21,159	53.6	4,552	11.5	1,029	2.6	12,700	32.2	39,440
1988	12,859	44.2	2,237	7.7	1,148	3.9	12,836	44.1	29,080
1989	10,914	40.8	0	0.0	3,092	11.6	12,731	47.6	26,737
1990	4,139	25.7	621	3.9	1,763	10.9	9,582	59.5	16,105
1991	4,893	36.1	246	1.8	1,544	11.4	6,859	50.6	13,542
1992	10,718	62.4	615	3.6	1,284	7.5	4,554	26.5	17,171
1993	14,079	74.6	765	4.1	720	3.8	3,307	17.5	18,871
1994	15,575	78.0	464	2.3	730	3.7	3,193	16.0	19,962
1995	12,068	67.4	594	3.3	1,101	6.2	4,130	23.1	17,893
1996	11,564	80.8	389	2.7	395	2.8	1,958	13.7	14,306
1997	11,325	85.2	627	4.7	207	1.6	1,133	8.5	13,292
1998	5,087	62.6	335	4.1	155	1.9	2,547	31.4	8,124
1999	9,463	65.8	575	4.0	1,533	10.7	2,812	19.6	14,383
2000	3,684	50.1	270	3.7	1,089	14.8	2,307	31.4	7,350
2001	6,009	64.6	619	6.7	856	9.2	1,811	19.5	9,295
2002	9,478	74.5	415	3.3	926	7.3	1,895	14.9	12,714
2003	14,810	80.1	1,240	6.7	770	4.2	1,670	9.0	18,490
2004	21,684	80.5	1,104	4.1	2,208	8.2	1,926	7.2	26,922
2005	21,597	78.1	1,958	7.1	739	2.7	3,373	12.2	27,667
2006	9,956	55.2	2,782	15.4	1,030	5.7	4,261	23.6	18,029

-continued-

Table 1.–Page 2 of 2.

	Central District								
	Eastside set		Drift		Kalgin–Westside set		Northern District set		
Year	Harvest	%	Harvest	%	Harvest	%	Harvest	%	Total
2007	12,292	69.7	912	5.2	603	3.4	3,818	21.7	17,625
2008	7,573	56.8	653	4.9	1,124	8.4	3,983	29.9	13,333
2009	5,588	63.9	859	9.8	672	7.7	1,631	18.6	8,750
2010	7,059	71.3	538	5.4	553	5.6	1,750	17.7	9,900
2011	7,697	68.4	593	5.3	659	5.9	2,299	20.4	11,248
2012	704	27.9	218	8.6	555	22.0	1,049	41.5	2,526
2013	2,988	55.4	493	9.1	590	10.9	1,327	24.6	5,398
2014	2,301	49.4	382	8.2	507	10.9	1,470	31.5	4,660
2015	7,781	72.1	556	5.1	538	5.0	1,923	17.8	10,798
2016	6,759	67.4	606	6.0	460	4.6	2,202	22.0	10,027
2017	4,779	62.4	264	3.4	387	5.1	2,230	29.1	7,660
2018	2,312	67.8	507	14.9	447	13.1	143	4.2	3,409
2019	2,245	71.1	179	5.7	532	16.8	202	6.4	3,158
2020	852	28.3	181	6.0	317	10.5	1,658	55.1	3,008
Average									
1966–2020 [a]	8,860	64.5	904	6.5	1,158	9.4	2,891	19.6	13,812
2011–2020	3,842	57.0	398	7.2	499	10.5	1,450	25.3	6,189
2021	1,297	32.6	217	5.5	566	14.2	1,893	47.6	3,973

Source: Marston and Frothingham (2019); ADF&G Fish Ticket Database.

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

MANAGEMENT OF THE EASTSIDE SET GILLNET FISHERY

The ESSN fishery is divided into 3 sections (Kenai, Kasilof, and East Foreland) and 7 statistical areas: Ninilchik Beach (244-21), Cohoe Beach (244-22), South K-Beach (244-31), North K-Beach (244-32), Salamatof Beach (244-41), East Foreland Beach (244-42), and the Kasilof River Special Harvest Area (KRSHA, 244-25; Figure 2). Fishery managers generally regulate the ESSN fishery by sections (groups of statistical areas). The Kasilof Section comprises Ninilchik Beach, Cohoe Beach, and South K-Beach. The Kenai Section comprises North K-Beach and Salamatof Beach. The East Foreland Section comprises East Foreland Beach and has historically been fished concurrently with the Kenai Section. Chinook salmon harvest from East Foreland Beach is low; consequently, for this study, harvest from the East Foreland Section is combined with the Kenai Section.

The Kasilof Section opens by regulation on the first Monday or Thursday on or after 25 June; however, if ADF&G estimates that 30,000 sockeye salmon are in the Kasilof River before 25 June but on or after 20 June, the ADF&G Commissioner shall open the fishery by emergency order. The Kenai and East Foreland sections open by regulation on the first Monday or Thursday on or after 8 July (Alaska Administrative Code 5 AAC 21.310). However, the North K-beach statistical area can open as early as 1 July, but the area fished must be restricted to within 600 ft of the mean high tide mark prior to 8 July. Other openings restricted to within 600 ft of the mean high tide mark are also possible but limited to normal opening dates for each section. KRSHA can be opened separately at any time to concentrate harvest of Kasilof River sockeye salmon while minimizing

harvest of other stocks, although all other options and hours in the Kasilof Section must be used prior to opening KRSHA. The ESSN fishery closes by regulation on 15 August.

MIXED-STOCK ANALYSIS

Accurate estimation of adult salmon 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 using genetic information in a mixed-stock analysis (MSA). This analysis requires a comprehensive genetic baseline that includes genetic data from fish representing all potential populations that may contribute to the harvest. In addition, for available genetic markers, there must be enough genetic variation among baseline populations to accurately estimate the contribution of population groups (stocks) in an MSA. These groups of populations are referred to as reporting groups. Stock compositions and stock-specific harvest estimates refer to compositions and harvest by reporting group.

Baseline and Reporting Groups

A Chinook salmon genetic baseline for UCI was first developed in 2012 that included 30 populations and 38 genetically variant single nucleotide polymorphism (SNP) loci (Barclay et al. 2012). Since then, the baseline has been augmented with additional collections and previously unrepresented populations, and is now comprehensive, including 55 populations and 39 variant SNPs (Barclay and Habicht 2015). To minimize misallocation between MSA reporting groups, the Slikok Creek population from the Kenai River drainage was removed from the baseline because it represents a very small number of fish and is genetically similar to the Crooked Creek population from the Kasilof River drainage (Barclay et al. 2012). Therefore, the baseline used for the ESSN harvest sampling project in 2021 only includes 54 of the 55 populations reported in Barclay and Habicht (2015). For more details regarding the UCI Chinook salmon baseline, see Barclay and Habicht (2015) or past reports detailing MSAs for the ESSN Chinook salmon fishery since 2010 (Eskelin et al. 2013; Eskelin and Barclay 2015, 2016, 2017, 2018, 2019, 2020, 2021).

Reporting groups apportioning the harvest were selected 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 for answering fishery management questions. The 4 reporting groups chosen to apportion the ESSN Chinook salmon harvest were as follows: *Kenai River mainstem* (Kenai River mainstem populations and Juneau Creek), *Kenai River tributaries* (Kenai River tributary populations excluding Juneau Creek), *Kasilof River mainstem* (the Kasilof River mainstem population), and *Cook Inlet other* (all remaining UCI baseline populations). Juneau Creek, a Kenai River tributary, was included in the *Kenai River mainstem* reporting group due to its genetic similarity with Kenai River mainstem populations (Barclay et al. 2012).

The results of baseline evaluation tests (proof tests) for the 4 reporting groups 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, AGE, SEX, AND LENGTH SAMPLING AND ANALYSES

Age, sex, and length (ASL) samples have been collected and analyzed for ASL composition from Chinook salmon harvested in the ESSN fishery since 1983 (Tobias and Willette 2010). The age compositions are used for Kenai River Chinook salmon run reconstruction (determining recruitments from brood years), which is then used in escapement goal analysis and forecasting future run size.

Tissue samples for MSA were added to the collection effort beginning in 2010 even though the Upper Cook Inlet Chinook salmon genetic baseline was not fully developed until 2012. Annual stock composition and stock-specific harvest estimates were produced for 2010–2020, except for 2012 due to low sample size. Stock compositions and stock-specific harvest estimates stratified by time and area have also been produced for those same years.

Since 2013, ASL compositions have been stratified temporally and geographically (by area) to match the MSAs. In addition, the same individual fish have been selected for both ASL composition and MSA. Results from these studies can be found in Eskelin et al. (2013) and Eskelin and Barclay (2015–2021).

STOCK COMPOSITIONS AND STOCK-SPECIFIC HARVEST ESTIMATES STRATIFIED BY SIZE

Beginning in 2017, the data used for assessment and management of Kenai River Chinook salmon changed from sonar passage estimates of Chinook salmon of all sizes to those fish that are 75 cm from mid eye to tail fork (METF) and longer (Alaska Administrative Code 5 AAC 57.160). There were many reasons for this change, but the primary reason was that inriver sonar estimates of Kenai River Chinook salmon 75 cm METF and longer (hereafter referred to as "large fish") constitute the most reliable and accurate information available. Large Chinook salmon do not overlap in size with other species, so species apportionment estimation is not necessary because all "large fish" are Chinook salmon. Furthermore, "large" Chinook salmon represent the majority (>95%) of the stock's potential reproductive capacity because "large fish" include nearly all females and nearly all egg production (Appendix E1 in Fleischman and Reimer 2017). In contrast, inriver estimates of Chinook salmon less than 75 cm METF length (hereafter referred to as "small fish") were indirect, imprecise, time consuming, and difficult to obtain for effective inseason management because "small fish" sonar counts are composed of many species of overlapping sizes and are therefore difficult to enumerate accurately with species apportionment methods. Fleischman and Reimer (2017) give more detail for why management of Kenai River Chinook salmon fisheries are based on sonar estimates of large Chinook salmon.

In preparation for the change in assessment and management to large fish, methods to estimate stock composition and stock-specific harvest of ESSN Chinook salmon stratified by size (i.e., large and small fish) were developed in 2016 to analyze the 2016 harvest and to reanalyze the 2015 harvest (Eskelin and Barclay 2017). The 2017 and 2018 harvests were analyzed using the same methods (Eskelin and Barclay 2018, 2019), and a retrospective analysis was done on the 2010, 2011, 2013, and 2014 harvests using reanalyzed tissues to include large fish stock compositions and stock-specific harvests for those years (Eskelin and Barclay 2019). With the inclusion of those years, stock compositions and stock-specific harvests by time, area, and size have been produced for all years of harvest dating back to 2010 (except 2012). The 2021 Chinook salmon harvest for the ESSN fishery is the subject of this report.

OBJECTIVES

PRIMARY OBJECTIVES

1) Estimate the proportion of Chinook salmon harvested in the ESSN fishery by reporting group (*Kenai River mainstem, Kasilof River mainstem, Kenai River tributaries, Cook Inlet other*) and size (large and small) for each temporal and geographic stratum, and for the entire season, 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 ESSN fishery by their respective reporting group and size (large and small) for each temporal and geographic stratum, and for the entire season, such that the estimates are within 30% of the true value 90% of the time.[1]
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 *Kenai River tributaries* and *Cook Inlet other* Chinook salmon in the ESSN fishery by their respective reporting group and size (large and small) for each temporal and geographic stratum, and for the entire season.[2]
2) Estimate the age composition of the Chinook salmon harvest in the ESSN fishery for each temporal and geographic stratum, and for the entire season.
3) Estimate the sex and length compositions of Chinook salmon harvested in the ESSN fishery for each temporal and geographic stratum, and for the entire season.

METHODS

STUDY DESIGN

Chinook Salmon Harvest

ESSN fishery Chinook salmon harvests are required to be recorded on fish tickets whether fish were delivered to the processor or if they were kept for personal use (Alaska Administrative Code 5 AAC 21.355 *Reporting requirements*). In addition to the number of fish harvested, the tickets must include information on the date and location (statistical area) of the harvest. Fish ticket information was entered into the ADF&G fish ticket database and summarized in Marston and Frothingham (*In prep*). Harvest information for the ESSN fishery was retrieved from the database to be used in the analysis and selection of samples.

Tissue and Age, Sex, and Length Sampling

During a fishery opening, fishers generally pick fish from their nets after each tide and at the end of the fishing period when their gear is pulled from the water. Fishers most often deliver their catch

[1] This criterion was for harvest estimates of stocks that account for at least 20% of the total harvest within a stratum. It is not necessary or realistic for harvest estimates that account for less than 20% to meet this criterion.

[2] Based on previous MSA results, it was anticipated that Chinook salmon harvest of reporting groups *Kenai River tributaries* and *Cook Inlet other* would be low (<150 fish), so no precision criteria were set for estimation of these reporting groups. Sample size was driven by Objectives 1 and 2.

after each "pick" and after the end of a fishing period to intermediary receiving sites for fish processing plants that are located at or near their fishing operation. ADF&G personnel travelled to those receiving sites to sample harvested Chinook salmon for genetic tissue, scales, sex, and length. The number and location of receiving sites can vary from year to year, but there are generally about 18 sampling locations (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 began after the first round of deliveries to the receiving sites, generally starting at the southernmost receiving site near Ninilchik and progressing northward. Samplers attempted to collect as many Chinook salmon samples as possible while distributing sampling effort throughout the area. When feasible, additional Chinook salmon samples were collected at fish processing plants the day following each fishing period if the location (statistical area) of harvest could be determined. The sampling rate for each statistical area was monitored by the project biologist after every sampling period and, if necessary, adjustments were made to increase the sampling rate from statistical area(s) with the lowest numbers of samples or the lowest sampling rate.

Three scales were removed from the preferred area of each fish and placed on an adhesive-coated gum 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 generally identified from external morphology (i.e., protruding ovipositor on females or a developing kype on males). If permission was granted by the processor or staff at receiving sites, some small fish that were difficult to identify for sex externally were examined internally by cutting a small slit in the anal opening using a plastic gut hook. A few large fish were also examined internally if the ADF&G sampler was not positive of sex from external morphometric characteristics. All data, including date, sampling location, and statistical area of harvest were recorded on data sheets and then entered onto the project biologist's computer for analysis.

All fish sampled for scales, sex, and length were also sampled for genetic tissue. A 1⅓ cm (half-inch) piece of the axillary process was removed from each fish and placed on a Whatman paper card in its own grid space, then stapled in place. Whatman cards with tissue samples were then placed in an airtight case with desiccant beads to preserve the tissue for DNA extraction. Each Whatman card had a unique barcode and a numbered grid. Card barcodes and grid position numbers were recorded on data sheets for each sample. Tissue samples were archived at the ADF&G Gene Conservation Laboratory and age, sex, and length data were archived at the Soldotna ADF&G office.

Sample Selection

Tissue samples were divided into 3 spatiotemporal strata: (1) Kasilof Section "Early," before the Kenai and East Foreland Sections open in their entirety for the season,[3] (2) Kasilof Section "Late," after the Kenai and East Foreland Sections open in their entirety, and (3) Kenai–East Foreland Sections "Late." The sample size goal for MSA was 100 fish per stratum. Individual samples were selected to represent the harvest by statistical area, length, and date. Once the required number of samples by size category (large and small) for each day was determined, samples were selected randomly from each size category from all available samples in each size category for each day and statistical area. When insufficient samples were collected to represent the harvest for a

[3] The K-Beach North area can open earlier than the rest of the Kenai and East Foreland Sections open, but openings must be restricted to within 600 ft of the mean high tide line mark. The time-period "Late" describes the time after all areas within the Kenai and East Foreland Sections can open.

statistical area on a given day, samples from the next closest day(s) were used to create a "harvest-proportional" sample. Generally, those samples selected to represent the closest day were collected within 3 days of each other and within the same statistical area and temporal stratum. Samples from the same fish were selected for MSA and ASL compositions.

LABORATORY ANALYSIS

Assaying Genotypes

Genomic DNA was extracted from tissue samples using a NucleoSpin 96 Tissue Kit (Macherey-Nagel). DNA was screened for 39 SNP markers. To ensure that DNA concentrations were high enough with the dry sampling method used to preserve samples, preamplification was conducted before screening the DNA.

The concentration of template DNA from samples was increased using a multiplexed preamplification PCR of 42 screened SNP markers. Each reaction was conducted within a 10 μL volume consisting of 4 μL of genomic DNA, 5 μL of 2X Multiplex PCR Master Mix (Qiagen), and 1 μL each of 2 μM SNP unlabeled forward and reverse primers. Thermal cycling was performed on a Dual 384-Well GeneAmp PCR system 9700 (Applied Biosystems) at 95°C hold for 15 minutes followed by 20 cycles of 95°C for 15 seconds, 60°C for 4 minutes, and a final extension hold at 4°C.

The preamplified DNA was genotyped using Fluidigm 192.24 Dynamic Array Integrated Fluidic Circuits (IFCs), each of which systematically combines up to 24 assays and 192 samples into 4,608 parallel reactions. The components were pressurized into each IFC using the IFC Controller RX (Fluidigm). Each reaction was conducted in a 9 nL volume chamber consisting of a mixture of 20X Fast GT Sample Loading Reagent (Fluidigm), 2X TaqMan GTXpress Master Mix (Applied Biosystems), Custom TaqMan SNP Genotyping Assay (Applied Biosystems), 2X Assay Loading Reagent (Fluidigm), 50X ROX Reference Dye (Invitrogen), and 60–400 ng/μl DNA. Thermal cycling was performed on a Fluidigm FC1 Cycler using a Fast PCR protocol as follows: an initial "Hot-Start" denaturation at 95°C for 2 minutes followed by 40 cycles of denaturation at 95°C for 2 seconds and annealing at 60°C for 20 seconds, with a final "Cool-Down" at 25°C for 10 seconds. The IFCs were read on a Biomark or EP1 System (Fluidigm) after amplification and genotyped using Fluidigm SNP Genotyping Analysis software.

Genotypes were imported and archived in the Gene Conservation Laboratory's 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 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

Data Retrieval and Quality Control

Genotypes were retrieved from LOKI and imported into *R*[4]. All subsequent genetic analyses were performed in *R* unless otherwise noted.

Prior to statistical analysis, 2 analyses were performed to confirm the quality of the data. First, individuals were identified 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). These individuals were removed from further analyses because their samples were suspected to have poor-quality DNA. The inclusion of individuals with poor-quality DNA might introduce genotyping errors into the mixture samples and reduce the accuracies of MSA.

The second quality control analysis identified individuals with duplicate genotypes and removed them from further analyses. Duplicate genotypes can occur from 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 compositions of the ESSN mixtures were estimated using the software package *BAYES* (Pella and Masuda 2001). *BAYES* employs the Pella-Masuda model via Gibbs sampling algorithm to estimate the most probable contribution of the baseline populations to explain the combination of genotypes in the mixture sample. Within each iterate of the algorithm, each fish is stochastically assigned a hypothetical stock-of-origin based on the statistical likelihood of its genotype in each population. After all assignments are made, they are summarized, deriving the stock composition for that iterate. The process of assigning individuals and deriving stock compositions is repeated many times. *BAYES* outputs a summary of composition estimates by reporting group for each iteration (RGN output) and reporting group assignments for each fish at each iteration (CLS output). A total of 5 Markov chain Monte Carlo chains (MCMC) were run for each mixture with 40,000 iterations for each chain.

The prior distribution used in *BAYES* was based upon the best available information for each mixture analysis. For the 2021 ESSN mixtures, the best available information came from the stock composition estimates of similar strata from the analysis of the 2020 ESSN Chinook salmon samples. The sum of the prior parameters was set 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). To reduce the output file size, the *BAYES* output was thinned to include every 100th iteration, resulting in a final output of 400 iterations for each MCMC chain. The first 200 iterations from each MCMC chain were discarded to reduce the influence of the

[4] R Core Team. 2021. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/ (Accessed April 7, 2021).

starting values and the remaining iterations from each chain were combined to form the posterior distribution (1,000 iterations). Stock composition estimates and 90% credibility intervals (CIs) for each stratum were calculated by taking the mean and 5% and 95% quantiles of the posterior distribution from the RGN output (Gelman et al. 2004). Credibility intervals differ from confidence intervals in that they are a direct statement of probability (e.g., a 90% credibility interval has a 90% chance of containing the true answer); all references to the acronym "CI" in this report refer to the credibility interval.

All-Fish Stock Compositions and Stock-Specific Harvest Estimates

Stock-specific harvest estimates and 90% CIs for Chinook salmon of all sizes (all-fish harvest) in each spatiotemporal 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 90% bounds of that estimate. Results were rounded to the nearest fish. Due to uncertainty in estimates with low stock composition values and low stock-specific harvest estimates, only stock composition values greater than 0.05 and stock-specific harvest estimates with the lower end of the 90% CI at 1 fish or greater are reported in the results section. These low stock composition values and stock-specific estimates are included in the tables and figures, but caution should be used in interpretation due to their high uncertainty.

Stratified stock composition and stock-specific all-fish harvest estimates were obtained using 3 mixtures as follows: (1) Kasilof Section "Early" 22 June–7 July; (2) Kasilof Section "Late" 8–20 July; and (3) Kenai–East Foreland Sections "Late" 8–20 July. Tissues collected from fishing periods restricted to within 600 ft of the mean high tide mark were included in each mixture based on date and area, except 1 sample collected from the North K-Beach statistical area that was included in the Kasilof Section "Early" mixture.

Stock composition (reporting group g) estimates from mixtures 1–3 were also combined to produce stock-specific harvest estimates for the entire 2021 season by weighting the reporting group proportions $\hat{p}_{g,i}$ by their respective stratum i harvests (using a stratified estimator) following the methods of Dann et al. (2009). The sum of the weighted harvest estimates was then divided by the total harvest among combined strata to derive the proportion $\hat{p}_g$ for the entire season's harvest. The estimates $\hat{p}_g$ of the season's total proportion of reporting group g fish within $S = 3$ strata 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 harvest in stratum i and $\hat{p}_{g,i}$ is the estimated proportion of reporting group g fish in stratum i. The caret symbol (^) denotes an estimated value in Equation 1 and all following equations.

To calculate credibility intervals for H_g (the entire season's harvest of reporting group g), its distribution was estimated via MCMC by resampling 1,000 draws of the thinned posterior output

from each of the constituent strata and applying the harvest to the draws according to this slight modification of Equation 1:

$$\hat{H}_g = \sum_{i=1}^{S} H_i \hat{p}_{g,i} \quad (2)$$

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 (Piston 2008). This method also accommodated nonsymmetrical CIs.

Stock Composition Estimates by Size

The thinned posterior distributions of the RGN and CLS outputs were used to estimate the stock composition by size (large fish ≥75 cm vs. small fish <75 cm) for each reporting group. Within each iterate, the number of fish (n_i) that were assigned to reporting group i were summarized first, along with the number of those that were large fish (b_i). The proportion of the stock of interest that was large fish (β_i) was then derived as a draw from a beta distribution with parameters $b_i + ½$ and $n_i - b_i + ½$ before it was multiplied by the reporting group's composition (p_i) in the same iterate. This produced the desired parameter ($s_i = p_i\beta_i$). The proportions (s_i) derived from each iterate were then summarized across iterates to provide estimates ($\hat{s}_i$) for both large and small fish for each reporting group.

MSA Comparisons of Similar Strata and Full Season Annual Estimates Across Years

MSA estimates from 2010, 2011, and 2013–2021 were compared across years for both annual full-season estimates and by similar temporal and geographic strata for fish of all sizes and for large fish. Comparisons were made for Kasilof Section "Early," Kasilof Section "Late," and Kenai–East Foreland Sections "Late" strata for all years. Comparisons were also made for the Kasilof Section "August" (2015 and 2017) and Kenai–East Foreland Sections strata (2014, 2015, 2017).

Large Kenai River Mainstem and Kasilof River Mainstem Fish Harvests Compared to Total Large Fish Harvest

The proportion of the total large fish harvested in the entire ESSN fishery by year for the dominant stocks (*Kenai River mainstem* and *Kasilof River mainstem*) was calculated to produce an average and a range of all years (2010, 2011, 2013–2021) of annual proportions by stock.

Age, Sex, and Length Composition

Age Composition

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

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

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 age determinations from 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 stratum i.

The estimates of harvest by age category in each 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 Chinook salmon harvest for the entire season 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 $S = 3$ is the number of sampling strata.

Finally, the proportion of the ESSN Chinook salmon harvest for the entire season 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 reported Chinook salmon harvest for 2021.

In addition, age composition of the ESSN Chinook salmon harvest was compiled from 1987 to 2020 and combined with 2021 estimates to discern any trends that may have occurred.

Sex Composition

Sex composition was estimated using the same equations (3–10) used to estimate age composition.

Length 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 sample n_z and n_z is the number of Chinook salmon of age class z.

The variance of the mean length-at-age class z was estimated as follows:

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

In addition, average length by age was compiled for ESSN Chinook salmon harvest samples collected during 1987–2020 and compared to 2021 results.

HARVEST KEPT FOR PERSONAL USE

The number of harvested fish kept for personal use was retrieved from the commercial fisheries fish ticket database and tabulated for this project. We monitor harvest kept for personal use for this project because our goal is to collect a representative sample from the harvest, but very few personal-use fish are sampled because many fish kept for personal use are not transferred to receiving stations.

RESULTS

CHINOOK SALMON HARVEST SAMPLING

In 2021, the ESSN fishery opened on 22 June in the Kasilof Section and on 8 July in the Kenai and East Foreland sections. The entire Kasilof Section was opened for 11 days during 22 June–20 July. In addition, the Kasilof section was opened but restricted to within 600 ft of the mean high tide mark for 4 additional days (6 July, 13 July, 14 July, 20 July). The entire Kenai and East Foreland sections were opened for 4 days. The North K-Beach statistical area of the Kenai Section was opened but restricted to within 600 feet of the mean high tide mark for 8 additional days (1 July, 3 July, 5–7 July, 13 July, 14 July, and 20 July). The Salamatof and East Foreland statistical areas were opened but restricted to within 600 feet of the mean high tide mark for 1 additional day (20 July). The entire ESSN fishery closed on 21 July due to low abundance of large late-run Kenai River Chinook salmon.

The ESSN Chinook salmon harvest of 1,297 fish in 2021 was 15% of the historical (1966–2020) average harvest of 8,860 fish, the 3rd lowest ever observed of which only 2020 and 2012 were lower (Table 1). Over the season, more of the harvest occurred in the Kasilof section (715 fish, 55% of total ESSN harvest) than in the Kenai and East Foreland sections (582 fish; 45% of total ESSN harvest; Table 2).

A total of 752 tissue samples were collected and identified by statistical area in 2021, which was 58% of the total reported harvest (Table 2). The sampling rate was highest in the Kenai and East Foreland sections "Late" stratum (68%), and lower in the Kasilof Section "Early" (57%) and Kasilof Section "Late" (41%) strata (Table 2).

Table 2.–Mixture number (Mix), time period, reported Chinook salmon harvest and proportion of fish sampled, number and proportion of harvest selected for MSA and ASL composition, and number of fish analyzed (Used) for each spatiotemporal stratum in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 2021.

			Harvest		Sampled		MSA		
Mix	Period	Geographic area	No.	Prop.[a]	No.	Prop.[b]	Sel.	Prop.[c]	Used
1	22 Jun–20 Jul	Kasilof Section	389	0.30	222	0.57	100	0.26	99
2	8–20 Jul	Kasilof Section	326	0.25	133	0.41	72	0.22	63
3	8–20 Jul	Kenai–EF Sections	582	0.45	397	0.68	100	0.17	98
Total	22 Jun–22 Jul	All areas	1,297	1.00	752	0.58	272	0.21	260

Note: "EF" means East Foreland, "Sel." Means number of fish selected, "Used" means number of fish used in MSA.

[a] Proportion of total harvest.

[b] Proportion of harvest in stratum that was sampled.

[c] Proportion of harvest in stratum that was selected for MSA.

TISSUE SELECTION AND LABORATORY ANALYSIS

A total of 272 samples (21% of the total harvest) was selected and genotyped to represent the 2021 harvest for MSA in mixtures 1–3 (Table 2). The genotyping failure rate was 1.92% and the error rate was 0.17%.

DATA RETRIEVAL AND QUALITY CONTROL

Based on the 80% rule, 12 individuals were removed from the genotyped 2021 samples. After removing these 12 individuals, 260 samples remained and were used in the MSA (Table 2). No individuals were identified as duplicate samples.

ALL-FISH MSA STRATIFIED BY TIME AND AREA FOR 2021

Kasilof Section "Early"

The stock composition (proportion of stratum harvest) and stock-specific harvest estimates for the Kasilof Section "Early" 22 June–7 July stratum were greatest for *Cook Inlet other* (0.56, 217 fish) followed by *Kenai River mainstem* (0.29, 111 fish) and *Kasilof River mainstem* (0.15, 58 fish; Table 3).

Kasilof Section "Late"

The stock composition and stock-specific harvest estimates for the Kasilof Section "Late" 8–20 July stratum were greatest for *Kenai River mainstem* (0.69, 226 fish) followed by *Kasilof River mainstem* (0.31, 100 fish; Table 3).

Kenai–East Foreland Sections "Late"

The stock composition and stock-specific harvest estimates for the Kenai–East Foreland Sections "Late" 8–20 July stratum was nearly all *Kenai River mainstem* fish (0.98, 572 fish; Table 3).

Table 3.–All-fish stock composition and stock-specific harvest estimates of Chinook salmon harvested in the Eastside set gillnet fishery, including mean and 90% credibility intervals (CI), for each temporal and geographic stratum, Upper Cook Inlet, Alaska, 2021.

Stratum			Stock composition			Stock-specific harvest		
				90% CI			90% CI	
Area	Period	Reporting group	Mean	5%	95%	Harvest	5%	95%
Kasilof Section	22 Jun–7 Jul	Kenai River tributaries	0.01	0.00	0.05	3	0	18
		Kenai River mainstem	0.29	0.16	0.42	111	63	163
		Kasilof River mainstem	0.15	0.07	0.24	58	28	92
		Cook Inlet other	0.56	0.43	0.68	217	167	266
Kasilof Section	8–20 Jul	Kenai River tributaries	0.00	0.00	0.00	0	0	0
		Kenai River mainstem	0.69	0.53	0.84	226	173	275
		Kasilof River mainstem	0.31	0.15	0.47	100	50	152
		Cook Inlet other	0.00	0.00	0.00	0	0	0
Kenai–E. Foreland Sections	8–20 Jul	Kenai River tributaries	0.00	0.00	0.00	0	0	0
		Kenai River mainstem	0.98	0.92	1.00	572	537	582
		Kasilof River mainstem	0.02	0.00	0.07	9	0	44
		Cook Inlet other	0.00	0.00	0.00	0	0	0

Note: Stock-specific harvest within each stratum may not sum to the total stock-specific harvest for the season due to rounding. Due to uncertainty in estimates with stock composition proportions less than 0.05 and stock-specific harvest estimates with the lower end of the 90% CI less than 1 fish, these estimates are not reported in the text and caution should be used in their interpretation.

ALL-FISH MSA FOR THE ENTIRE 2021 SEASON

The stock composition and stock-specific harvest estimates for the 2021 ESSN season were greatest for *Kenai River mainstem* (0.70, 909 fish) followed by *Cook Inlet other* (0.17, 217 fish) and *Kasilof River mainstem* (0.13, 166 fish; Table 4).

Table 4.–All-fish stock compositions and stock-specific harvest estimates, including mean and 90% credibility intervals (CI) for Chinook salmon harvested in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 2021.

Stratum			Stock composition			Stock-specific harvest		
				90% CI			90% CI	
Area	Period	Reporting group	Mean	5%	95%	Harvest	5%	95%
All areas	22 Jun–20 Jul							
		Kenai River tributaries	0.00	0.00	0.02	4	0	22
		Kenai River mainstem	0.70	0.64	0.76	909	828	989
		Kasilof River mainstem	0.13	0.08	0.18	166	104	233
		Cook Inlet other	0.17	0.13	0.21	217	167	267

LARGE-FISH MSA STRATIFIED BY TIME AND AREA FOR 2021

Large *Kenai River mainstem* fish were harvested (and composed the all-fish harvest) as estimated for each stratum as follows: 41 fish (0.11) from Kasilof Section "Early," 81 fish (0.25) from Kasilof Section "Late," and 95 fish (0.16) from Kenai–East Foreland Sections "Late" (Table 5). Stock compositions by size for the other reporting groups are also reported in Table 5.

Table 5.–Stock composition and stock-specific harvest estimates by size (large and small) of Chinook salmon harvested in the Eastside set gillnet fishery, including mean and 90% credibility intervals (CI), for each temporal and geographic stratum, Upper Cook Inlet, Alaska, 2021.

Stratum				Stock composition [a]			Stock-specific harvest		
					90% CI			90% CI	
Area	Period	Size	Reporting group	Mean	5%	95%	Harvest	5%	95%
Kasilof Section	22 Jun–7 Jul	Large	Kenai R. tributaries	0.00	0.00	0.01	1	0	5
			Kenai R. mainstem	0.11	0.05	0.17	41	18	67
			Kasilof R. mainstem	0.06	0.02	0.11	24	7	43
			Cook Inlet other	0.08	0.03	0.14	31	12	56
		Small	Kenai R. tributaries	0.01	0.00	0.04	2	0	14
			Kenai R. mainstem	0.18	0.09	0.29	71	33	113
			Kasilof R. mainstem	0.09	0.03	0.16	34	13	60
			Cook Inlet other	0.48	0.37	0.59	186	142	229
Kasilof Section	8–20 Jul	Large	Kenai R. tributaries	0.00	0.00	0.00	0	0	0
			Kenai R. mainstem	0.25	0.14	0.36	81	47	119
			Kasilof R. mainstem	0.16	0.07	0.27	53	24	88
			Cook Inlet other	0.00	0.00	0.00	0	0	0
		Small	Kenai R. tributaries	0.00	0.00	0.00	0	0	0
			Kenai R. mainstem	0.44	0.32	0.57	144	104	186
			Kasilof R. mainstem	0.14	0.05	0.26	46	16	84
			Cook Inlet other	0.00	0.00	0.00	0	0	0
Kenai–East Foreland Sections	8–20 Jul	Large	Kenai R. tributaries	0.00	0.00	0.00	0	0	0
			Kenai R. mainstem	0.16	0.11	0.23	95	63	133
			Kasilof R. mainstem	0.00	0.00	0.02	2	0	10
			Cook Inlet other	0.00	0.00	0.00	0	0	0
		Small	Kenai R. tributaries	0.00	0.00	0.00	0	0	0
			Kenai R. mainstem	0.82	0.74	0.89	477	431	515
			Kasilof R. mainstem	0.01	0.00	0.07	8	0	39
			Cook Inlet other	0.00	0.00	0.00	0	0	0

Note: Large fish are 75 cm mid eye to tail fork (METF) and longer; small fish are less than 75 cm METF.

[a] Stock composition is mean proportion of all fish (large and small combined) for each stratum.

LARGE-FISH MSA FOR THE ENTIRE 2021 SEASON

Large *Kenai River mainstem* fish composed 0.17 (estimated 217 fish) and large *Kasilof River mainstem* fish composed 0.06 (estimated 79 fish) of the all-fish ESSN harvest in 2021 (Table 6). Of *Kenai River mainstem* fish, 0.24 (estimated 217 out of 909 fish) were classified as large. Of *Kasilof River mainstem* fish, 0.47 (estimated 79 out of 166 fish) were classified as large. Estimated harvests of large *Cook Inlet other* and *Kenai River tributaries* fish were negligible (0.02 or less).

The proportions of the 2021 ESSN large *Kenai River mainstem* fish harvest (217 fish) by stratum were as follows: 0.44 Kenai–East Foreland Sections "Late," 0.37 Kasilof Section "Late," and 0.19 Kasilof Section "Early" (calculated from Table 5).

Table 6.–Annual stock composition and stock-specific harvest estimates by size (large and small) of Chinook salmon harvested in the Eastside set gillnet fishery, including mean and 90% credibility intervals (CI), Upper Cook Inlet, Alaska, 2021.

Stratum				Stock composition [a]			Stock-specific harvest		
					90% CI			90% CI	
Area	Period	Size	Reporting group	Mean	5%	95%	Harvest	5%	95%
All	22 Jun–20 Jul	Large	Kenai R. tributaries	0.00	0.00	0.01	1	0	7
			Kenai R. mainstem	0.17	0.12	0.21	217	161	273
			Kasilof R. mainstem	0.06	0.03	0.09	79	43	119
			Cook Inlet other	0.02	0.01	0.04	31	12	57
		Small	Kenai R. tributaries	0.00	0.00	0.01	3	0	17
			Kenai R. mainstem	0.53	0.48	0.59	692	622	765
			Kasilof R. mainstem	0.07	0.03	0.11	88	44	139
			Cook Inlet other	0.14	0.11	0.18	186	142	229

Note: Large fish are 75 cm mid eye to tail fork (METF) and longer; small fish are less than 75 METF. Due to uncertainty in estimates with stock composition, proportions less than 0.05 and stock-specific harvest estimates with the lower end of the 90% CI less than 1 fish, caution should be used in the interpretation of these estimates.

[a] Stock composition is mean proportion of all fish (large and small combined) for each stratum.

ALL-FISH MSA COMPARISONS OF SIMILAR STRATA ACROSS YEARS

There are now 11 years of geographically and temporally stratified stock composition and stock-specific harvest estimates with the addition of the 2021 results. Stratification for MSA of the ESSN fishery has differed among years due to dates of commercial fishery openings, limitations due to insufficient number of samples collected by time and area, and budgetary constraints. However, many strata have been similar enough in time and date so that effective summaries and comparisons of results can be made with results across years dating back to 2010.

Kasilof Section "Early"

MSA of the Kasilof Section "Early" stratum harvest has been conducted each year from 2010 to 2021 (excluding 2012). The date of first fishery opening has varied from 22 to 27 June and the ending date for this stratum has varied from 4 to 9 July (Table 7). Since 2010, the all-fish harvest in this stratum has been composed of more *Kenai River mainstem* fish (average 0.61, range: 0.29–0.77) than *Kasilof River mainstem* (average 0.20, range: 0.12–0.30) and *Cook Inlet other* fish (average 0.14, range: 0.00–0.56; Table 7). The estimated stock composition of *Cook Inlet other* fish in this stratum was considerably higher in 2021 (0.56) than in any other year. *Kenai River tributaries* fish have composed very little of the harvest (0.02 or less) in all years prior to 2018 but made up a larger proportion of the harvest during 2018–2020, with 0.11, 0.22, and 0.06 of the harvest for 2018, 2019, and 2020, respectively. Based on these proportions, estimated annual harvests have averaged 447 *Kenai River mainstem* fish (range: 110–1,142), 153 *Kasilof river mainstem* fish (range: 41–392), 74 *Cook Inlet other* fish (range: 1–217), and 16 *Kenai River tributaries* fish (range: 0–72) in the Kasilof Section "Early" stratum since 2010.

Table 7.–All-fish stock compositions and stock-specific harvest estimates for Chinook salmon harvested in the Eastside set gillnet fishery by similar spatiotemporal strata across years, Upper Cook Inlet, Alaska, 2010, 2011, and 2013–2021.

			Reporting group							
			Kenai River tributaries		Kenai River mainstem		Kasilof River mainstem		Cook Inlet other	
Stratum	Period	Year	Stock comp.	Stock-specific harvest	Stock comp.	Stock-specific harvest	Stock comp.	Stock-specific harvest	Stock comp.	Stock-specific harvest
Kasilof Section	27 Jun–7 Jul	2010	0.01	6	0.68	603	0.30	266	0.02	14
"Early" [a]	25 Jun–9 Jul	2011	0.00	1	0.74	1,142	0.26	392	0.00	1
	27 Jun–6 Jul	2013	0.00	1	0.72	290	0.14	57	0.14	56
	23 Jun–7 Jul	2014	0.00	0	0.77	360	0.22	104	0.01	3
	22 Jun–6 Jul	2015	0.00	3	0.55	448	0.20	162	0.25	200
	23 Jun–9 Jul	2016	0.01	8	0.63	714	0.29	332	0.08	87
	24 Jun–8 Jul	2017	0.02	15	0.72	521	0.19	136	0.07	51
	25 Jun–7 Jul	2018	0.11	72	0.67	446	0.12	79	0.10	65
	27 Jul–4 Jul	2019	0.22	47	0.51	110	0.19	41	0.08	17
	23 Jun–8 Jul	2020	0.06	20	0.48	171	0.17	60	0.30	106
	22 Jun–7 Jul	2021	0.01	3	0.29	111	0.15	58	0.56	217
		Average	0.04	16	0.61	447	0.20	153	0.14	74
Kasilof Section	8–31 Jul	2010	0.01	24	0.37	994	0.59	1,576	0.03	69
"Late" [b]	11–31 Jul	2011	0.00	3	0.48	1,477	0.52	1,620	0.00	3
	8–23 Jul	2013	0.00	1	0.73	639	0.26	230	0.00	1
	9–23 Jul	2014	0.00	1	0.50	283	0.49	276	0.00	1
	9–30 Jul	2015	0.00	2	0.58	925	0.42	675	0.00	7
	11–28 Jul	2016	0.00	5	0.47	791	0.52	881	0.00	3
	10–31 Jul	2017	0.02	23	0.63	857	0.34	466	0.01	17
	9–28 Jul	2018	0.00	1	0.60	499	0.40	336	0.00	1
	8 Jul–3 Aug	2019	0.00	1	0.39	378	0.60	577	0.00	1
	9–22 Jul	2020	0.01	1	0.57	111	0.42	82	0.01	1
	8–20 Jul	2021	0.00	0	0.69	226	0.31	100	0.00	0
		Average	0.00	6	0.55	653	0.44	620	0.01	9
Kasilof	1–10 Aug	2015	0.00	1	0.44	146	0.56	187	0.00	0
Section	3–15 Aug	2017	0.00	1	0.37	85	0.62	143	0.00	0
"August"		Average	0.00	1	0.40	116	0.59	165	0.00	0

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Table 7.–Page 2 of 2.

Stratum	Period	Year	Reporting group: Kenai River tributaries — Stock composition	Kenai River tributaries — Stock-specific harvest	Kenai River mainstem — Stock composition	Kenai River mainstem — Stock-specific harvest	Kasilof River mainstem — Stock composition	Kasilof River mainstem — Stock-specific harvest	Cook Inlet other — Stock composition	Cook Inlet other — Stock-specific harvest
Kasilof River	17 Jul–2 Aug	2013	0.00	0	0.24	84	0.76	273	0.00	0
Special	16 Jul–2 Aug	2014	0.00	2	0.21	129	0.79	494	0.00	0
Harvest Area	7 Jul–2 Aug	2015	0.02	7	0.32	136	0.66	282	0.00	0
		Average	0.01	3	0.25	116	0.74	350	0.00	0
Kasilof 600 [c]	15–31 Jul	2015	0.01	1	0.38	79	0.60	126	0.01	2
Kenai–	8–31 Jul	2010	0.01	27	0.95	2,229	0.03	64	0.01	22
East Foreland	11–31 Jul	2011	0.00	1	1.00	2,140	0.00	2	0.00	1
Sections "Late" [b]	8–23 Jul	2013	0.00	2	0.94	1,274	0.06	78	0.00	0
	9–23 Jul	2014	0.00	1	0.97	416	0.02	10	0.00	0
	9–30 Jul	2015	0.00	3	0.98	3,398	0.02	82	0.00	2
	11–28 Jul	2016	0.00	5	0.94	3,061	0.06	195	0.00	1
	10–31 Jul	2017	0.00	5	0.95	1,983	0.05	97	0.00	1
	9–23 Jul	2018	0.00	1	1.00	735	0.00	2	0.00	1
	8 Jul–3 Aug	2019	0.00	1	0.90	970	0.09	95	0.01	6
	9–22 Jul	2020	0.00	1	0.93	279	0.07	21	0.00	0
	8–20 Jul	2021	0.00	0	0.98	572	0.02	9	0.00	0
		Average	0.00	4	0.96	1,551	0.04	60	0.00	3
Kenai–	2–6 Aug	2014	0.00	1	0.97	214	0.03	6	0.00	0
East Foreland	1–12 Aug	2015	0.00	0	0.94	855	0.05	49	0.00	0
Sections "August"	3–14 Aug	2017	0.00	0	0.83	316	0.17	63	0.00	0
		Average	0.00	0	0.92	461	0.08	39	0.00	0

Note: The 90% credibility intervals of stock compositions and stock-specific harvest estimates for prior years can be found in previous reports (Eskelin et al. 2013; Eskelin and Barclay 2015–2021) and Table 3 of this report for 2021.

[a] "Early" describes the portion of 0074he fishery prior to the Kenai and East Foreland Sections opening for the season.

[b] "Late" describes the portion of the fishery in July after the Kenai and East Foreland Sections open for the season except for 2019, which also includes early August.

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

Kasilof Section "Late"

MSA of the Kasilof Section "Late" stratum harvest has been conducted each year from 2010 to 2021 (excluding 2012). The date of first fishery opening for this stratum varied 4 days from 8 to 11 July, whereas the stratum ending date was more variable ranging from 20 July to 3 August (Table 7). The all-fish harvest in this stratum has been largely composed of both *Kenai River mainstem* fish (average 0.55, range: 0.37–0.73) and *Kasilof River mainstem* fish (average 0.44, range: 0.26–0.60). Based on these proportions, estimated annual harvests have averaged 653 (range: 111–1,477) *Kenai River mainstem* fish and 620 (range: 82–1,620) *Kasilof River mainstem* fish in the Kasilof Section "Late" stratum since 2010 (Table 7).

Kasilof Section "August"

MSA of the Kasilof section "August" stratum harvest has been conducted for 2 years (2015 and 2017). Dates of fishery openings were 1–10 August in 2015 and 3–15 August in 2017. In both years, the all-fish harvest was mostly composed of *Kenai River mainstem* fish (average 0.40) and *Kasilof River mainstem* fish (average 0.59), with slightly larger proportions of the latter in both years (0.56 *Kasilof River mainstem* vs. 0.44 *Kenai River mainstem* and 0.62 *Kasilof River mainstem* vs. 0.37 *Kenai River mainstem* in 2015 and 2017, respectively; Table 7). The estimated harvests for Kasilof Section "August" were 187 and 143 *Kasilof River mainstem* fish in 2015 and 2017, respectively; and 146 and 85 *Kenai River mainstem* fish in 2015 and 2017, respectively.

Kasilof River Special Harvest Area

MSA of the KRSHA stratum harvest has been conducted for 3 years (2013–2015). Dates of fishery openings were from 17 July to 2 August in 2013, 16 July to 2 August in 2014, and 7 July to 2 August in 2015. The KRSHA all-fish harvest has been mostly composed of *Kasilof River mainstem* fish (average 0.74, range: 0.66–0.79) followed to a lesser extent by *Kenai River mainstem* fish (average 0.25, range 0.21–0.32; Table 7). Based on these proportions, the average estimated KRSHA all-fish harvest was 350 *Kasilof River mainstem* fish (range: 273–494 fish) and 116 *Kenai River mainstem* fish (range: 84–136 fish).

Kasilof Section 600 ft

MSA of the Kasilof Section restricted to within 600 feet of the high tide mark was conducted in 2015 (Table 7). Dates of the fishery openings were from 15 to 31 July. The harvest was composed of 0.60 *Kasilof River mainstem* fish and 0.38 *Kenai River mainstem* fish.

Kenai–East Foreland Sections "Late"

MSA of the Kenai–East Foreland Sections "Late" stratum has been conducted each year from 2010 to 2021 (excluding 2012). The beginning date of fishery openings were within 4 days (8–11 July) every year but the ending date has varied substantially from 20 July (in 2021) to as late as 3 August (in 2019; Table 7). The composition of the all-fish harvest in this stratum has been dominated by *Kenai River mainstem* fish (average 0.96, range: 0.90–1.00; Table 7). Very little of the harvest has been composed of *Kasilof River mainstem* fish, which has never exceeded 0.09 and has averaged 0.04 of the harvest (range: 0.00–0.09; Table 7). Based on these proportions, estimated annual harvests have averaged 1,551 *Kenai River mainstem* fish (range: 279–3,398), and very few *Kasilof River mainstem*, *Kenai River tributaries*, and *Cook Inlet other* fish have been harvested in the Kenai–East Foreland Sections "Late" stratum.

Kenai–East Foreland Sections "August"

MSA of the Kenai–East Foreland Sections "August" stratum harvest has been conducted for 3 years (2014, 2015, and 2017), with dates of fishery openings ranging from 2–6 August in 2014, to 1–12 August in 2015, and 3–14 August in 2017. On average, almost all of the Kenai–East Foreland Sections "August" stratum has been composed of *Kenai River mainstem* fish (average 0.92, range: 0.83–0.97). *Kasilof River mainstem* fish have composed very little of the harvest (average 0.08, range: 0.03–0.17; Table 7). The average estimated harvests were 461 *Kenai River mainstem* fish (range: 214–855 fish) and 39 *Kasilof River mainstem* fish (range: 6–63 fish).

ALL-FISH FULL SEASON ANNUAL MSA COMPARISONS ACROSS YEARS

Kenai River mainstem fish have dominated the ESSN harvest, averaging 0.70 of the harvest and ranging from 0.61 (2014) to 0.79 (2017; Table 8). The average estimated annual harvest of *Kenai River mainstem* fish since 2010 (excluding 2012) is 2,983 fish (range: 561–5,988 fish). *Kasilof River mainstem* fish have averaged 0.25 of the harvest and ranging from 0.13 (2021) to 0.39 (2014). The average estimated annual harvest of *Kasilof River mainstem* fish is 1,080 fish (range: 163–2,448 fish). *Cook Inlet other* have composed a small fraction (0.03 or less) of the harvest every year, except for 2020 (0.13) and 2021 (0.17; Table 8) and the estimated harvest of *Kenai River tributaries* fish has been negligible (0.03 or less). Estimated harvest of *Cook Inlet other* fish has averaged 90 fish and ranged from 4 fish (2014) to 217 fish (2021). Estimated harvest of *Kenai River tributaries* fish has averaged 30 fish (range: 4–78 fish).

Table 8.–All-fish stock compositions and stock-specific harvest estimates for Chinook salmon harvested in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 2010, 2011, and 2013–2021.

	Reporting group							
	Kenai River tributaries		Kenai River mainstem		Kasilof River mainstem		Cook Inlet other	
Year	Stock comp [a]	Stock-specific harvest	Stock comp [a]	Stock-specific harvest	Stock comp [a]	Stock-specific harvest	Stock comp [a]	Stock-specific harvest
2010	0.01	78	0.64	4,534	0.33	2,301	0.02	147
2011	0.00	7	0.68	5,228	0.32	2,448	0.00	14
2013	0.00	4	0.77	2,289	0.21	637	0.02	57
2014	0.00	4	0.61	1,400	0.39	892	0.00	4
2015	0.00	19	0.77	5,988	0.20	1,564	0.03	211
2016	0.00	24	0.74	4,972	0.25	1,667	0.01	96
2017	0.01	43	0.79	3,762	0.19	905	0.01	69
2018 [b]	0.03	77	0.75	1,710	0.19	428	0.03	69
2019	0.02	49	0.65	1,458	0.32	714	0.01	25
2020	0.03	21	0.66	561	0.19	163	0.13	107
2021	0.00	4	0.70	909	0.13	166	0.17	217
Average	0.01	30	0.70	2,983	0.25	1,080	0.04	90
Minimum	0.00	4	0.61	561	0.13	163	0.00	4
Maximum	0.03	78	0.79	5,988	0.39	2,448	0.17	217

Note: The 90% credibility intervals of stock compositions and stock-specific harvest estimates for prior years can be found in previous reports (Eskelin et al. 2013; Eskelin and Barclay 2015–2021) and Table 4 of this report.

[a] "Stock comp" means stock composition relative to the total harvest.

[b] Stock composition and stock-specific harvest estimates for 2018 do not include 28 fish harvested from Kasilof River Special Harvest Area (KRSHA).

LARGE-FISH MSA COMPARISONS OF SIMILAR STRATA ACROSS YEARS

Kasilof Section "Early"

The annual Kasilof section "Early" stratum all-fish harvest comprised a modest proportion of large *Kenai River mainstem* fish (average 0.18, range: 0.08–0.47) but a smaller proportion of large *Kasilof River mainstem* fish (average 0.06, range: 0.01–0.13; Table 9). Based on the proportions, an annual average harvest of 144 (range: 36–463) large *Kenai River mainstem* fish and 52 (range: 7–176) large *Kasilof River mainstem* fish were estimated in the Kasilof Section "Early" stratum.

Kasilof Section "Late"

On average, the annual Kasilof Section "Late" stratum all-fish harvest was composed of 0.25 (range: 0.18–0.49) large *Kenai River mainstem* fish and 0.23 (range: 0.07–0.39) large *Kasilof River mainstem* fish (Table 9). Harvest estimates have averaged 342 large *Kenai River mainstem* fish (range: 36–835 fish) and 357 large *Kasilof River mainstem* fish (range: 29–1,048 fish) across years.

Kasilof Section "August"

There was no commercial fishing in the Kasilof Section during August in 2021; however, there are 2 years (2015 and 2017) when an MSA produced large fish stock compositions for the Kasilof Section "August" stratum. Large *Kasilof River mainstem* fish composed 0.46 (2015) and 0.57 (2017) of the total harvest, averaging 0.52 for both years (Table 9). The remainder of the large fish harvest in the Kasilof Section "August" stratum was composed of 0.34 (2015) and 0.33 (2017) large *Kenai River mainstem* fish, averaging 0.34 for both years. The estimated harvests in the Kasilof Section "August" stratum were 155 (2015) and 130 (2017) large *Kasilof River mainstem* fish, averaging 142 fish for both years, and 115 (2015) and 76 (2017) large *Kenai River mainstem* fish, averaging 96 fish for both years.

Kasilof River Special Harvest Area

There are 3 years (2013–2015) when an MSA produced large fish stock compositions and stock-specific harvests for KRSHA. For these years, the total annual KRSHA harvest averaged 0.43 (range: 0.31–0.49) large *Kasilof River mainstem* fish but only 0.14 (range: 0.12–0.16) large *Kenai River mainstem* fish (Table 9). Estimated harvests averaged 204 (range: 132–305) large *Kasilof River mainstem* fish and 65 (range: 59–77) large *Kenai River mainstem* fish.

Kasilof Section 600 ft

MSA of the Kasilof section restricted to within 600 ft of the mean high tide mark was conducted from 15–31 July in 2015. Large *Kasilof River mainstem* fish composed 0.26 of the total harvest in that stratum and large *Kenai River mainstem* fish composed 0.16 of the harvest (Table 9).

Table 9.–Large-fish (≥75 cm METF) stock compositions relative to all fish harvested and stock-specific large fish harvest estimates by year for Chinook salmon harvested in the ESSN fishery by similar spatiotemporal strata, Upper Cook Inlet, Alaska, 2010, 2011, and 2013–2021.

			Reporting group							
			Kenai River tributaries		Kenai River mainstem		Kasilof River mainstem		Cook Inlet other	
Stratum	Period	Year	Stock comp [a]	Stock-specific large fish harvest	Stock comp [a]	Stock-specific large fish harvest	Stock comp [a]	Stock-specific large fish harvest	Stock comp [a]	Stock-specific large fish harvest
Kasilof Section	27 Jun–7 Jul	2010	0.00	2	0.11	98	0.04	40	0.01	9
"Early" [b]	25 Jun–9 Jul	2011	0.00	0	0.30	463	0.11	176	0.00	0
	27 Jun–6 Jul	2013	0.00	0	0.16	65	0.03	10	0.02	8
	23 Jun–7 Jul	2014	0.00	0	0.08	38	0.03	13	0.00	1
	22 Jun–6 Jul	2015	0.00	1	0.11	90	0.06	49	0.05	44
	23 Jun–9 Jul	2016	0.00	4	0.23	267	0.11	130	0.02	28
	24 Jun–8 Jul	2017	0.01	10	0.47	338	0.13	95	0.04	30
	25 Jun–7 Jul	2018	0.02	16	0.16	107	0.01	7	0.01	10
	27 Jun–4 Jul	2019	0.05	11	0.18	38	0.07	15	0.02	4
	23 Jun–8 Jul	2020	0.02	6	0.10	36	0.04	14	0.07	23
	22 Jun–7 Jul	2021	0.00	1	0.11	41	0.06	24	0.08	31
		Average	0.01	5	0.18	144	0.06	52	0.03	17
		Minimum	0.00	0	0.08	36	0.01	7	0.00	0
		Maximum	0.05	16	0.47	463	0.13	176	0.08	44
Kasilof Section	8–31 Jul	2010	0.01	14	0.22	574	0.39	1,048	0.02	46
"Late" [c]	11–31 Jul	2011	0.00	1	0.27	835	0.30	917	0.00	2
	8–23 Jul	2013	0.00	0	0.20	170	0.07	63	0.00	0
	9–23 Jul	2014	0.00	0	0.21	117	0.18	99	0.00	0
	9–30 Jul	2015	0.00	1	0.25	401	0.20	316	0.00	2
	11–28 Jul	2016	0.00	3	0.28	467	0.34	574	0.00	2
	10–31 Jul	2017	0.01	15	0.49	672	0.27	373	0.01	13
	9–28 Jul	2018	0.00	0	0.26	220	0.16	133	0.00	0
	8 Jul–3 Aug	2019	0.00	0	0.19	184	0.33	318	0.00	0
	9–22 Jul	2020	0.00	0	0.18	36	0.15	29	0.00	0
	8–20 Jul	2021	0.00	0	0.25	81	0.16	53	0.00	0
		Average	0.00	3	0.25	342	0.23	357	0.00	6
		Minimum	0.00	0	0.18	36	0.07	29	0.00	0
		Maximum	0.01	15	0.49	835	0.39	1,048	0.02	46

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Table 9.–Page 2 of 3.

			Reporting group							
			Kenai River tributaries		Kenai River mainstem		Kasilof River mainstem		Cook Inlet other	
Stratum	Period	Year	Stock comp [a]	Stock-specific large fish harvest	Stock comp [a]	Stock-specific large fish harvest	Stock comp [a]	Stock-specific large fish harvest	Stock comp [a]	Stock-specific large fish harvest
Kasilof Section	1–10 Aug	2015	0.00	1	0.34	115	0.46	155	0.00	0
"August"	3–15 Aug	2017	0.00	1	0.33	76	0.57	130	0.00	0
		Average	0.00	1	0.34	96	0.52	142	0.00	0
Kasilof River Special	17 Jul–2 Aug	2013	0.00	0	0.16	59	0.49	174	0.00	0
Harvest Area	16 Jul–2 Aug	2014	0.00	1	0.12	77	0.49	305	0.00	0
	7 Jul–2 Aug	2015	0.01	3	0.14	60	0.31	132	0.00	1
		Average	0.00	2	0.14	65	0.43	204	0.00	0
Kasilof 600 ft [d]	15–31 Jul	2015	0.00	1	0.16	32	0.26	55	0.00	1
Kenai–East Foreland	8–31 Jul	2010	0.00	12	0.46	1,084	0.01	29	0.00	8
Sections "Late" [e]	11–31 Jul	2011	0.00	1	0.41	869	0.00	1	0.00	0
	8–23 Jul	2013	0.00	1	0.28	385	0.02	32	0.00	0
	9–23 Jul	2014	0.00	0	0.38	162	0.01	5	0.00	0
	9–30 Jul	2015	0.00	1	0.44	1,545	0.01	27	0.00	1
	11–28 Jul	2016	0.00	3	0.56	1,836	0.03	112	0.00	1
	10–31 Jul	2017	0.00	3	0.78	1,636	0.04	80	0.00	1
	9–23 Jul	2018	0.00	0	0.31	229	0.00	1	0.00	0
	8 Jul–3 Aug	2019	0.00	0	0.36	391	0.06	60	0.00	2
	9–22 Jul	2020	0.00	0	0.31	94	0.02	6	0.00	0
	8–20 Jul	2021	0.00	0	0.16	95	0.00	2	0.00	0
		Average	0.00	2	0.41	757	0.02	32	0.00	1
		Minimum	0.00	0	0.16	94	0.00	1	0.00	0
		Maximum	0.00	12	0.78	1,836	0.06	112	0.00	8

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Table 9.–Page 3 of 3.

			Reporting group							
			Kenai River tributaries		Kenai River mainstem		Kasilof River mainstem		Cook Inlet other	
Stratum	Period	Year	Stock comp [a]	Stock-specific large fish harvest	Stock comp [a]	Stock-specific large fish harvest	Stock comp [a]	Stock-specific large fish harvest	Stock comp [a]	Stock-specific large fish harvest
Kenai–East Foreland	2–6 Aug	2014	0.00	0	0.66	145	0.02	3	0.00	0
Sections "August"	1–12 Aug	2015	0.00	0	0.62	562	0.03	31	0.00	0
	3–14 Aug	2017	0.00	0	0.73	276	0.14	53	0.00	0
		Average	0.00	0	0.67	328	0.06	29	0.00	0

Note: The 90% credibility intervals of stock compositions and stock-specific harvest estimates for prior years can be found in previous reports (Eskelin et al. 2013; Eskelin and Barclay 2015–2021) and Table 5 of this report for 2021.

[a] "Stock comp" means stock composition of large fish relative to the total harvest of all fish (large and small combined).

[b] "Early" describes the portion of the fishery prior to the Kenai–East Foreland Sections opening for the season.

[c] "Late" describes the portion of the fishery in July after the Kenai–East Foreland Sections open for the season, except in 2019 which also includes early August.

[d] Kasilof Section openings restricted to within 600 feet of the mean high tide mark.

[e] "Late" describes the portion of the fishery in July, except in 2019 which also includes early August.

Kenai–East Foreland Sections "Late"

In the Kenai–East Foreland Sections "Late" stratum, large *Kenai River mainstem* fish have composed on average 0.41 of the total harvest in that stratum, but the composition has ranged considerably among years from 0.16 (2021) to 0.78 (2017; Table 9). Harvest estimates for the Kenai–East Foreland Sections "Late" stratum have averaged 757 large *Kenai River mainstem* fish (range: 94–1,836 fish) and 32 large *Kasilof River mainstem* fish (range: 1–112 fish).

Kenai–East Foreland Sections "August"

There were 3 years (2014, 2015, and 2017) when an MSA produced large fish stock compositions relative to the total harvest for the Kenai–East Foreland Sections "August" stratum. The majority of harvest for this stratum was composed of large *Kenai River mainstem* fish (average 0.67, range: 0.62–0.73; Table 9). The remainder of the Kenai–East Foreland Sections "August" stratum harvest included 0.06 (range: 0.02–0.14) *Kasilof River mainstem* fish on average. Estimated harvests of large *Kenai River mainstem* fish have averaged 328 fish (range: 145–562 fish) and harvests of large *Kasilof River mainstem* fish have averaged 29 fish (range: 3–53 fish) in the Kenai–East Foreland Sections "August" stratum.

LARGE-FISH FULL SEASON ANNUAL MSA COMPARISONS ACROSS YEARS

There are 11 years of annual stock composition and stock-specific harvest estimates for large Chinook salmon relative to all-fish harvest in the ESSN fishery dating back to 2010 (Table 10). Overall, *Kenai River mainstem* fish have composed the greatest proportion of the large fish harvest every year, averaging 0.32 of the annual harvest of all fish sizes, ranging from 0.17 (2021) to 0.63 (2017). *Kasilof River mainstem* fish have averaged 0.13 of the annual all-fish harvest ranging from 0.06 (2018, 2020, and 2021) to 0.21 (2010). The average harvest of large *Kenai River mainstem* was an estimated 1,503 fish (range: 166–2,998 fish) with the two lowest harvests by far occurring in 2020 and 2021. The average harvest of large *Kasilof River mainstem* was an estimated 620 fish (range: 49–1,466 fish), with the 2 lowest harvests by far occurring in 2020 and 2021.

KENAI RIVER MAINSTEM LARGE FISH HARVEST RELATIVE TO TOTAL LARGE FISH HARVEST BY STRATUM AND YEAR

Large *Kenai River mainstem* fish have composed much of the large fish harvest for both the Kasilof Section "Early" stratum (average 0.63, range: 0.42–0.78) and the Kasilof Section "Late" stratum (average 0.53, range: 0.34–0.73; Table 11). Large *Kenai River mainstem* fish have composed an overwhelming majority of the large fish harvests for the Kenai–East Foreland Section "Late" stratum (average 0.95, range: 0.86–1.00; Table 11).

Table 10.–Large fish (≥75 cm mid eye to tail fork [METF]) stock compositions relative to all fish harvested and stock-specific large fish harvest estimates by year for Chinook salmon harvested in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 2010, 2011, and 2013–2021.

	Reporting group							
	Kenai River tributaries		Kenai River mainstem		Kasilof River mainstem		Cook Inlet other	
Year	Stock comp. relative to all fish [a]	Stock-specific large fish harvest	Stock comp. relative to all fish [a]	Stock-specific large fish harvest	Stock comp. relative to all fish [a]	Stock-specific large fish harvest	Stock comp. relative to all fish [a]	Stock-specific large fish harvest
2010	0.01	44	0.34	2,384	0.21	1,466	0.01	96
2011	0.00	3	0.32	2,499	0.19	1,445	0.00	10
2013	0.00	1	0.23	679	0.09	279	0.00	8
2014	0.00	2	0.31	706	0.19	439	0.00	2
2015	0.00	8	0.36	2,808	0.10	764	0.01	48
2016	0.00	14	0.43	2,906	0.15	1,039	0.01	34
2017	0.01	29	0.63	2,998	0.15	730	0.01	44
2018 [b]	0.01	16	0.24	555	0.06	141	0.00	10
2019	0.01	12	0.27	613	0.18	393	0.00	6
2020	0.01	6	0.19	166	0.06	49	0.03	24
2021	0.00	1	0.17	217	0.06	79	0.02	31
Average	0.00	13	0.32	1,503	0.13	620	0.01	28
Minimum	0.00	1	0.17	166	0.06	49	0.00	2
Maximum	0.01	44	0.63	2,998	0.21	1,466	0.03	96

Note: The 90% credibility intervals of stock compositions and stock-specific harvest estimates for prior years can be found in previous reports (Eskelin et al. 2013; Eskelin and Barclay 2015–2021) and Table 6 of this report for 2021.

[a] "Stock comp" means stock composition of large fish relative to the total harvest of all fish (large and small combined).

[b] Stock compositions and stock-specific harvest estimates for 2018 do not include large Chinook salmon harvested in the Kasilof River Special Harvest Area.

Table 11.–Total large (≥75 cm mid eye to tail fork [METF]) fish harvests, large *Kenai River mainstem* fish harvests, and proportion *Kenai River mainstem* in the large fish harvests by spatiotemporal stratum and year in the ESSN, Upper Cook Inlet, Alaska, 2010, 2011, and 2013–2021.

	Kasilof Section "Early"			Kasilof Section "Late"			Kenai–EF Sections "Late"		
Year	Total large fish harvest	Kenai River mainstem large fish harvest	Proportion Kenai River mainstem in large fish harvest	Total large fish harvest	Kenai River mainstem large fish harvest	Proportion Kenai River mainstem in large fish harvest	Total large fish harvest	Kenai River mainstem large fish harvest	Proportion Kenai River mainstem in large fish harvest
2010	149	98	0.66	1,683	574	0.34	1,133	1,084	0.96
2011	640	463	0.72	1,755	835	0.48	871	869	1.00
2013	83	65	0.78	233	170	0.73	418	385	0.92
2014	51	38	0.73	217	117	0.54	167	162	0.97
2015	184	90	0.49	720	401	0.56	1,575	1,545	0.98
2016	429	267	0.62	1,046	467	0.45	1,952	1,836	0.94
2017	473	338	0.71	1,072	672	0.63	1,719	1,636	0.95
2018 [a]	139	107	0.77	353	220	0.62	230	229	0.99
2019	68	38	0.56	503	184	0.37	453	391	0.86
2020	79	36	0.46	66	36	0.54	100	94	0.94
2021	96	41	0.42	135	81	0.60	97	95	0.98
Average	218	144	0.63	708	342	0.53	792	757	0.95
Minimum	51	36	0.42	66	36	0.34	97	94	0.86
Maximum	640	463	0.78	1,755	835	0.73	1,952	1,836	1.00

Note: Stock-specific harvest estimates for prior years can be found in previous reports (Eskelin et al. 2013; Eskelin and Barclay 2015–2021) and Table 5 of this report for 2021.

[a] Harvests and proportions for 2018 do not include large Chinook salmon harvested in the Kasilof River Special Harvest Area.

KENAI RIVER MAINSTEM LARGE FISH HARVEST RELATIVE TO TOTAL LARGE FISH HARVEST BY YEAR

Large *Kenai River mainstem* fish have composed on average 0.69 of the total large fish harvest by year, ranging from 0.60 (2010 and 2019) to 0.79 (2017; Table 12). By contrast, large *Kasilof River mainstem* fish have composed on average 0.28 of the total large fish harvest by year, ranging from 0.19 (2017 and 2018) to 0.38 (2014 and 2019).

Table 12.–Season total large (≥75 cm METF) fish harvests, large Kenai River mainstem and Kasilof River mainstem fish harvests, and proportions of total large fish harvests by year in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 2010, 2011, and 2013–2021.

		Reporting group			
		Kenai River mainstem		Kasilof River mainstem	
Year	Total large fish harvest	Stock-specific large fish harvest	Proportion of total large fish harvest	Stock-specific large fish harvest	Proportion of total large fish harvest
2010	3,990	2,384	0.60	1,466	0.37
2011	3,957	2,499	0.63	1,445	0.37
2013	967	679	0.70	279	0.29
2014	1,149	706	0.61	439	0.38
2015	3,628	2,808	0.77	764	0.21
2016	3,993	2,906	0.73	1,039	0.26
2017	3,801	2,998	0.79	730	0.19
2018 [a]	723	555	0.77	141	0.19
2019	1,025	613	0.60	393	0.38
2020	246	166	0.68	49	0.20
2021	328	217	0.66	79	0.24
Average	2,164	1,503	0.69	620	0.28
Minimum	246	166	0.60	49	0.19
Maximum	3,993	2,998	0.79	1,466	0.38

Note: Stock-specific harvest estimates for prior years can be found in previous reports (Eskelin et al. 2013; Eskelin and Barclay 2015–2021) and Table 5 of this report for 2021.

[a] Harvests and proportions for 2018 do not include large Chinook salmon harvested in the Kasilof River special harvest area.

AGE, SEX, AND LENGTH COMPOSITION

All-Fish Age Composition

In 2021, the Kenai–East Foreland Sections "Late" stratum harvest had the highest percentage of age-1.1 fish (39%) of all strata (Figure 3; Appendices A1–A3). The stratum with the highest percentage of age-1.2 fish (45%) was the Kasilof Section "Early" stratum, although a high percentage of age-1.2 fish was also observed in the Kenai–East Foreland Sections "Late" stratum (41%) followed by the Kasilof Section "Late" stratum (32%). Very low percentages of age-1.4 fish were harvested overall (2%), with the Kasilof Section "Late" stratum having the highest percentage of age-1.4 fish (4%).

The age composition of the entire 2021 ESSN Chinook salmon harvest was estimated as 32% age-1.1, 40% age-1.2, 26% age-1.3, and 2% age-1.4 fish, with no age-1.5 fish observed (Table 13). The percentage of age-6 (age-1.4) fish (2%) was by far the lowest observed since 1987 and significantly below the historical average of 34% (Appendix B1). The last 3 years have had the lowest percentages of age-6 fish observed: 11%, 9%, and 2% in 2019–2021, respectively

(Appendices B1 and B2). The percentage of age-3 fish (age-1.1 jacks) in the 2021 harvest of 32% was the 2nd highest observed after 33% in 2020, and these 2 years have had by far the highest percentages of jacks observed in the harvest since 1987 when sampling began. The percentage of age-4 (age-1.2) fish in the harvest in 2021 (40%) was above the historical average of 28% and the percentage of age-5 (age-1.3) fish in the harvest (26%) was near the historical average of 27%.

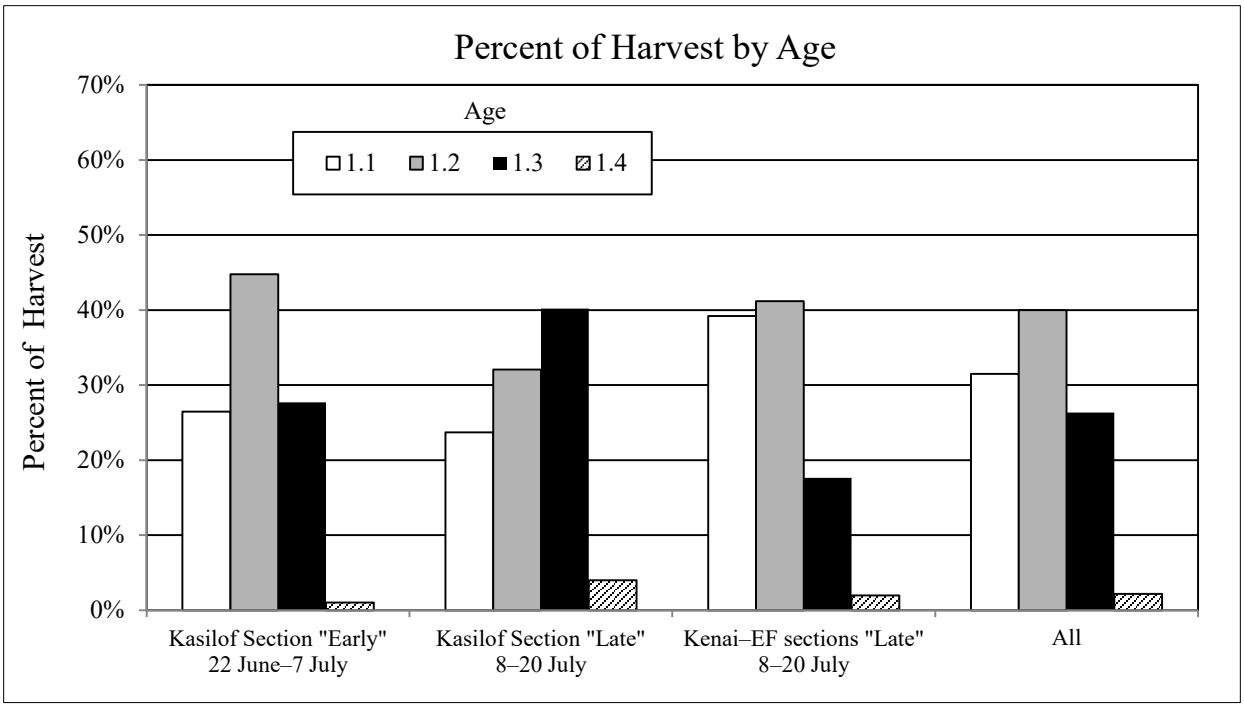

Figure 3.–Age composition estimates of Chinook salmon harvested in the Eastside set gillnet fishery by temporal and geographic stratum, Upper Cook Inlet, Alaska, 2021.

All-Fish Sex Composition

Sex composition in the 2021 ESSN harvest was estimated as 79% males (1,028 fish) and 21% females (269 fish; Table 13). The sex ratio was similar for the Kasilof Section "Early" stratum (29% females: 71% males) and the Kasilof Section "Late" stratum (31% females: 69% males) but was skewed even more toward males in the Kenai and East Foreland sections "Late" stratum (10% females: 90% males; Appendices A1–A3). This pattern of male-dominated sex composition has occurred every year since 2010, except 2017 when 52% of the harvest was composed of females (Table 14).

All-Fish Length Composition

Average METF length by age in 2021 was 497 mm for age-1.1, 590 mm for age-1.2, 820 mm for age-1.3, and 943 mm for age-1.4 fish (Table 13). Average METF length was 622 mm for all fish sampled, which was the shortest average fish length observed since sampling began in 1987 (Appendix B3).

Large-Fish Age and Sex Composition

The estimated age composition of the large fish harvest was 3% age-1.2, 88% age-1.3, and 9% age-1.4 fish (Table 15). The estimated sex composition of the large fish harvest was 46% males (151 fish) and 54% females (177 fish).

Table 13.–All-fish age, sex, and mean mid eye to tail fork (METF) length composition of Chinook salmon harvested in the Eastside set gillnet fishery, 22 June–20 July, Upper Cook Inlet, Alaska, 2021.

		Age class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age	0	70	180	19	269
	SE (harvest by age)	–	16	24	8	28
	Samples by age	0	16	41	4	61
	Age composition	–	5.4%	13.9%	1.4%	20.8%
	SE (age composition)	–	1.2%	1.9%	0.6%	2.2%
Males						
	Harvest by age	408	448	161	10	1,028
	SE (harvest by age)	32	33	23	6	28
	Samples by age	83	93	34	2	212
	Age composition	31.5%	34.6%	12.4%	0.7%	79.2%
	SE (age composition)	2.5%	2.6%	1.8%	0.5%	2.2%
Both sexes						
	Harvest by age	408	518	342	28	1,297
	SE (harvest by age)	32	34	31	10	0
	Samples by age	83	109	75	6	273
	Age composition	31.5%	40.0%	26.3%	2.2%	100.0%
	SE (age composition)	2.5%	2.6%	2.4%	0.8%	0.0%
	Mean length (mm METF)	497	590	820	943	622

Note: Values given by age and sex may not sum to totals due to rounding. An en dash indicates value not estimated.

Table 14.–Chinook salmon harvest and percent of harvest by sex in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 2010–2021.

	Total Chinook salmon harvest		Percent of total Chinook salmon harvest	
Year	Females	Males	Females	Males
2010	1,632	5,427	23%	77%
2011	2,314	5,383	30%	70%
2012	175	409	30%	70%
2013	11	393	3%	97%
2014	889	1,412	39%	61%
2015	2,387	5,394	31%	69%
2016	2,243	4,516	33%	67%
2017	2,496	2,283	52%	48%
2018	408	1,904	18%	82%
2019	581	1,664	26%	74%
2020	103	749	12%	88%
2021	269	1,028	21%	79%

Note: Harvest by age and percent of harvest by sex for prior years can be found in previous reports (Eskelin et al. 2013; Eskelin and Barclay 2015–2021) and Table 13 of this report for 2021.

Table 15.–Age and sex composition of large (≥75 cm METF) Chinook salmon harvested in the Eastside set gillnet fishery, 22 June–20 July, Upper Cook Inlet, Alaska, 2021.

		Age class			
Sex	Parameter	1.2	1.3	1.4	All ages
Females					
	Harvest by age	0	159	19	177
	SE (harvest by age)	–	17	8	17
	Samples by age	0	36	4	40
	Age composition	–	48.3%	5.7%	54.1%
	SE (age composition)	–	5.2%	2.4%	5.2%
Males					
	Harvest by age	10	131	10	151
	SE (harvest by age)	6	17	6	17
	Samples by age	2	28	2	32
	Age composition	3.0%	40.0%	3.0%	45.9%
	SE (age composition)	1.8%	5.1%	1.8%	5.2%
Both sexes					
	Harvest by age	10	290	28	328
	SE (harvest by age)	6	11	10	0
	Samples by age	2	64	6	72
	Age composition	3.0%	88.4%	8.7%	100.0%
	SE (age composition)	1.8%	3.4%	3.0%	0.0%

Note: Values given by age and sex may not sum to totals due to rounding. An en dash indicates value not estimated.

DISCUSSION

2021 MIXED-STOCK ANALYSIS

In 2021, 58% of the harvest was sampled, which was the highest sampling rate since genetic sampling began in 2010. The high sampling rate easily met the primary objectives and established precision criteria goals for estimating stock compositions, stock-specific harvests, and age composition.

Despite the low harvest of 1,297 Chinook salmon (third lowest since 1987), a low number of fishery openings, and an early closure to the fishery, enough samples were collected to conduct MSAs by size for the entire fishery (annual estimates) and for the 3 major spatiotemporal strata (Kasilof Section "Early," Kasilof Section "Late," and Kenai–East Foreland Sections "Late") that have been used in all previous years' MSAs dating back to 2010 (Eskelin et al. 2013; Eskelin and Barclay 2015, 2016, 2017, 2018, 2019, 2020, 2021). These results provide good comparative information to assess variability of stock compositions and harvest by size through time each season and between seasons, and these results provide the necessary information for Kenai River Chinook salmon stock assessment.

KENAI RIVER CHINOOK SALMON HARVEST

An important objective of this project has been to provide annual estimates of large Kenai River Chinook salmon harvest for run reconstruction, brood table development, and escapement goal analyses. Whereas *Kenai River mainstem* fish of all sizes have composed on average 0.70 of the all-fish harvest since 2010 with low variation among years (range: 0.61–0.79), large *Kenai River mainstem* fish have composed 0.32 of the all-fish harvests and the proportion by year has been

more variable (range: 0.17–0.63; Table 16). Since 2010, there have been 6 years (2013, 2014, 2018–2021) of low harvests of *large Kenai River mainstem* fish, averaging 490 fish annually over those years and 5 years (2010, 2011, 2015–2017) of higher harvests of large *Kenai River mainstem* fish averaging 2,719 fish annually over those years (calculated from Table 16). Harvests of large *Kenai River mainstem* fish were by far the lowest in 2020 and 2021 (excluding 2012 with no MSA), resulting from weak runs with high proportions of younger smaller fish, limited fishing openings, and gear restrictions.

Table 16.–Summary of annual all-fish and large-fish Kenai River mainstem Chinook salmon harvests in the ESSN fishery, Upper Cook Inlet, Alaska, 2010, 2011, and 2013–2021.

Year	Entire ESSN all-fish harvest	Kenai River mainstem all-fish harvest	Proportion Kenai River mainstem of total all-fish harvest	Kenai River mainstem large-fish harvest	Proportion large Kenai River mainstem of total all-fish harvest
2010	7,059	4,534	0.64	2,384	0.34
2011	7,697	5,228	0.68	2,499	0.32
2013	2,988	2,289	0.77	679	0.23
2014	2,301	1,400	0.61	706	0.31
2015	7,781	5,988	0.77	2,808	0.36
2016	6,759	4,972	0.74	2,906	0.43
2017	4,779	3,762	0.79	2,998	0.63
2018	2,284	1,710	0.75	555	0.24
2019	2,245	1,458	0.65	613	0.27
2020	852	561	0.66	166	0.19
2021	1,297	909	0.70	217	0.17
Average	4,186	2,983	0.70	1,503	0.32
Minimum	852	561	0.61	166	0.17
Maximum	7,781	5,988	0.79	2,998	0.63

The MSA estimates stratified by time, area, and size within each year and among years have provided valuable information for assessing the harvest patterns for large *Kenai River mainstem* fish. Nearly all the large fish harvests in the Kenai–East Foreland Sections "Late" stratum have been composed of *Kenai River mainstem* fish (Table 11). For this stratum, large *Kenai River mainstem* fish composed an average of 0.41 (range: 0.16–0.78) of the all-fish harvests in that stratum since 2010 (Table 9). A greater number of large *Kenai River mainstem* fish have been harvested in the Kenai–East Foreland Sections "Late" stratum (annual average of 757 fish; Table 11) than in the Kasilof Section "Early" and "Late" strata combined (combined annual average of 485 fish; Table 11) despite considerably fewer openings during most years in the Kenai–East Foreland sections compared to the Kasilof Section. Relative to their total large fish harvests, the Kasilof Section "Late" stratum has had much higher variation in the proportion of large *Kenai River mainstem* fish among years (range: 0.34–0.73) compared to Kenai–East Foreland Sections "Late" stratum (range: 0.86–1.00; Table 11).

Since 2010, the proportion of large fish in the harvest, including large *Kenai River mainstem* fish, has generally increased through time each season, with the lowest proportion of large fish in the harvest during the Kasilof Section "Early" time stratum and highest proportions during both the Kasilof section and Kenai–East Foreland sections "Late" time strata (Table 5). MSA estimates for August strata have been produced for 3 years (2014, 2015, 2017) for Kenai–East Foreland

sections and only 2 years (2015, 2017) for the Kasilof section, and the proportion of large fish harvested in those strata was much higher than earlier strata in those years.

STOCK COMPOSITION WITHIN 600 FT OF MEAN HIGH TIDE MARK

MSAs of the ESSN Chinook salmon harvest have generally been conducted to the highest resolution possible with respect to time and area each year. Since 2010, MSAs have been conducted for nearly all areas of the ESSN fishery, although not for every area in every year. The area opened between the mean high tide mark and 600 feet offshore (i.e., 600 ft openers) has garnered attention recently as a potential tool to minimize large Kenai River Chinook salmon harvest in times of low abundance while still allowing sockeye salmon harvest.

Unfortunately, the number of samples collected during openers restricted to fishing within 600 ft offshore has not met the sample size requirement to conduct MSA except in the Kasilof Section during 2015 (Tables 7 and 9). Consequently, the stock compositions and stock-specific harvests during 600 ft openers for all other years and areas are unknown. However, considering that nearly all Chinook salmon harvests from both the Salamatof Beach and East Foreland sections have consistently been composed of *Kenai River mainstem* fish, it is highly likely that nearly all the large-fish harvest within 600 ft of the mean high tide mark in that area of the fishery would be large *Kenai River mainstem* fish. That area of the fishery has only been fished for 1 period on 20 July 2020 with a reported harvest of 45 Chinook salmon, and 10 out of 34 (42%) samples collected were of large-sized fish.

Several years of MSAs of the harvest in the nearshore area within 600 ft from the high tide mark would be necessary to adequately characterize the variation in the harvest stock composition, and it is outside of the scope of this project to speculate on the stock composition of those restricted openers in any given year, especially for harvests south of Salamatof Beach.

AGE, SEX, AND LENGTH COMPOSITION

In the 2021 ESSN fishery Chinook salmon harvest, the percentage of age-6 (1.4) fish in the harvest (2%) was 6 percentage points lower than the previously lowest observed in 2020 (9%) and is the lowest observed since sampling began in 1987 (Appendix B1). The estimated percentage of age-6 fish in the harvest has been in decline since 2019 and was 11%, 9%, and 2% in 2019–2021, respectively (Appendix B1). In 2021, the percentage of age-1.4 fish was also consistently low among the 3 major strata (Figure 3). The extremely low percentage of age-1.4 fish in the harvest in 2021 appears to be an anomaly and was likely a result of several factors not indicative of the age composition of the total runs of fish returning to the Kenai and Kasilof Rivers, and which might be due to fishers intentionally releasing large fish, the time and areas open to fishing, and the early end to the fishery on July 20.

The ESSN harvest in 2021 was composed primarily of males (79%; Table 14), which has been a consistent pattern since 2010, except for 2017. All jacks and nearly all age-1.2 fish in the harvest samples have been classified as males, so it is likely that future harvests will have a high percentage of males if the age composition continues to be skewed towards jacks and age-1.2 fish.

The average METF length (622 mm) of all samples collected in 2021 was the lowest ever observed since sampling began in 1987 and similar to the average METF length of samples collected in 2020 (628 mm; Appendix B3).

HARVEST KEPT FOR PERSONAL USE

By regulation, all salmon harvested in the ESSN fishery must be recorded on fish tickets, including those not sold but kept for personal use. However, most fish kept for personal use are not transferred to receiving stations, making it more logistically challenging to collect samples from those fish. In most years dating back to 1993, fewer than 100 Chinook salmon in the ESSN harvest were reported as kept for personal use. The reported harvest kept for personal use has been as high as 867 fish (2005); however, that year had the second highest total harvest (21,597 fish) of any year, so the reported harvest kept for personal use was only 4% of the total harvest that year (Table 17).

The percentage of the Chinook salmon harvest reported as retained for personal use has trended upwards recently, but the overall harvest of those fish kept for personal use has not. For example, in 2021, the reported harvest kept for personal use was 11.5%, which was the highest percentage of the total reported harvest ever observed, but it was only 149 fish, which is just under the average annual harvest for years 2010–2020. The harvest reported as kept for personal use has ranged from 3.4% to 11.5% since 2012; however, during 1993–2011, harvest reported as kept for personal use was much lower and only exceeded 2% of the total harvest in 2005, when personal use fish accounted for 4% of the harvest.

An important aspect of this study is to collect unbiased length samples of the harvest. It is not known if the size (lengths) of fish kept for personal use is similar to, larger than, or smaller than those fish sold and sampled or how that relationship varies. It is doubtful there are major differences in the size of fish kept for personal use relative to those harvested and sold, but if there are major differences between the two samples then that could introduce bias into MSA and age, sex, and length composition estimates. However, because most harvested Chinook salmon are sold and transferred to receiving stations where they can be easily sampled, any bias resulting from the difference between lengths of those sampled and those kept for personal use and not sampled is probably small. This facet of the fishery will be monitored, and adjustments will be made to the sampling protocol in future years if necessary.

RECOMMENDATIONS AND FUTURE STUDIES

An important goal of this study was to accurately assess harvest of large Chinook salmon by stock now that Kenai River Chinook salmon are managed for escapement of "large" fish (≥75 cm METF). Results from this study will be used for Kenai River Chinook salmon run reconstruction, evaluation of escapement goals, management decisions, and further advancements in Chinook salmon stock assessment. In 2022, we will be assessing the ESSN Chinook salmon harvest in a similar manner, collecting as many representative samples as possible, and if funding for MSA becomes available, we will conduct analyses within budget to the finest resolution possible.

Table 17.–Number of Chinook salmon harvested and reported as kept for personal use in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 1993–2021.

Year	Chinook salmon harvest reported as kept for personal use (*n*)	Total reported Chinook salmon harvest (*N*)	Percent of 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%
2016	237	6,759	3.5%
2017	164	4,779	3.4%
2018	130	2,312	5.6%
2019	157	2,245	7.0%
2020	92	852	10.8%
2021	149	1,297	11.5%

Source: ADF&G fish ticket database.

ACKNOWLEDGEMENTS

We would like to thank all individuals who contributed to the success of this project. Harvest samples were collected by Jenna Helminski, Capra Edwards-Smith, and Parker Lockwood. Staff members from the Gene Conservation Lab who worked on this project were Zach Pechacek, Erica Chenoweth, Jodi Estrada, Tela Barkley, Tanya Johnson, Heather Hoyt, Eric Lardizabal, and Judy Berger. Jiaqi Huang provided valuable biometric assistance and selected tissue samples for analyses.

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APPENDIX A: AGE, SEX, AND LENGTH COMPOSITIONS OF CHINOOK SALMON HARVESTED IN THE EASTSIDE SET GILLNET FISHERY BY SPATIOTEMPORAL STRATUM, 2021

Appendix A1.–All-fish age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet fishery, Kasilof Section "Early" stratum, 22 June–7 July, Upper Cook Inlet, Alaska, 2021.

		Age class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age	0	40	72	0	111
	SE (harvest by age)	–	3	3	–	4
	Samples by age	0	10	18	0	28
	Age composition	–	10.2%	18.5%	–	28.6%
	SE (age composition)	–	2.7%	3.4%	–	4.0%
Males						
	Harvest by age	103	135	36	4	278
	SE (harvest by age)	4	4	2	1	4
	Samples by age	26	34	9	1	70
	Age composition	26.5%	34.6%	9.2%	1.0%	71.4%
	SE (age composition)	3.9%	4.2%	2.5%	0.9%	4.0%
Both sexes						
	Harvest by age	103	174	108	4	389
	SE (harvest by age)	4	4	4	1	0
	Samples by age	26	44	27	1	98
	Age composition	26.5%	44.8%	27.7%	1.0%	100.0%
	SE (age composition)	3.9%	4.4%	3.9%	0.9%	0.0%

Note: Values given by age and sex may not sum to totals due to rounding. An en dash indicates value not estimated.

Appendix A2.–All-fish age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet fishery, Kasilof Section "Late" stratum, 8–20 July, Upper Cook Inlet, Alaska, 2021.

		Age class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age	0	14	74	13	101
	SE (harvest by age)	–	7	14	7	16
	Samples by age	0	3	17	3	23
	Age composition	–	4.2%	22.7%	4.0%	30.9%
	SE (age composition)	–	2.1%	4.3%	2.0%	4.8%
Males						
	Harvest by age	77	91	57	0	225
	SE (harvest by age)	14	15	13	–	16
	Samples by age	17	20	13	0	50
	Age composition	23.7%	27.9%	17.5%	–	69.1%
	SE (age composition)	4.4%	4.7%	3.9%	–	4.8%
Both sexes						
	Harvest by age	77	105	131	13	326
	SE (harvest by age)	14	16	17	7	0
	Samples by age	17	23	30	3	73
	Age composition	23.7%	32.1%	40.2%	4.0%	100.0%
	SE (age composition)	4.4%	4.8%	5.1%	2.0%	0.0%

Note: Values given by age and sex may not sum to totals due to rounding. An en dash indicates value not estimated.

Appendix A3.–All-fish age, sex, and length composition of Chinook salmon harvested in the Eastside set gillnet fishery, Kenai–East Foreland Sections "Late" stratum, 8–20 July, Upper Cook Inlet, Alaska, 2021.

		Age class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age	0	17	34	6	57
	SE (harvest by age)	–	9	12	5	16
	Samples by age	0	3	6	1	10
	Age composition	–	2.9%	5.9%	1.0%	9.8%
	SE (age composition)	–	1.5%	2.1%	0.9%	2.7%
Males						
	Harvest by age	228	223	68	6	525
	SE (harvest by age)	26	26	17	5	16
	Samples by age	40	39	12	1	92
	Age composition	39.2%	38.2%	11.8%	1.0%	90.2%
	SE (age composition)	4.4%	4.4%	2.9%	0.9%	2.7%
Both sexes						
	Harvest by age	228	240	103	11	582
	SE (harvest by age)	26	26	20	7	0
	Samples by age	40	42	18	2	102
	Age composition	39.2%	41.2%	17.6%	2.0%	100.0%
	SE (age composition)	4.4%	4.4%	3.4%	1.3%	0.0%

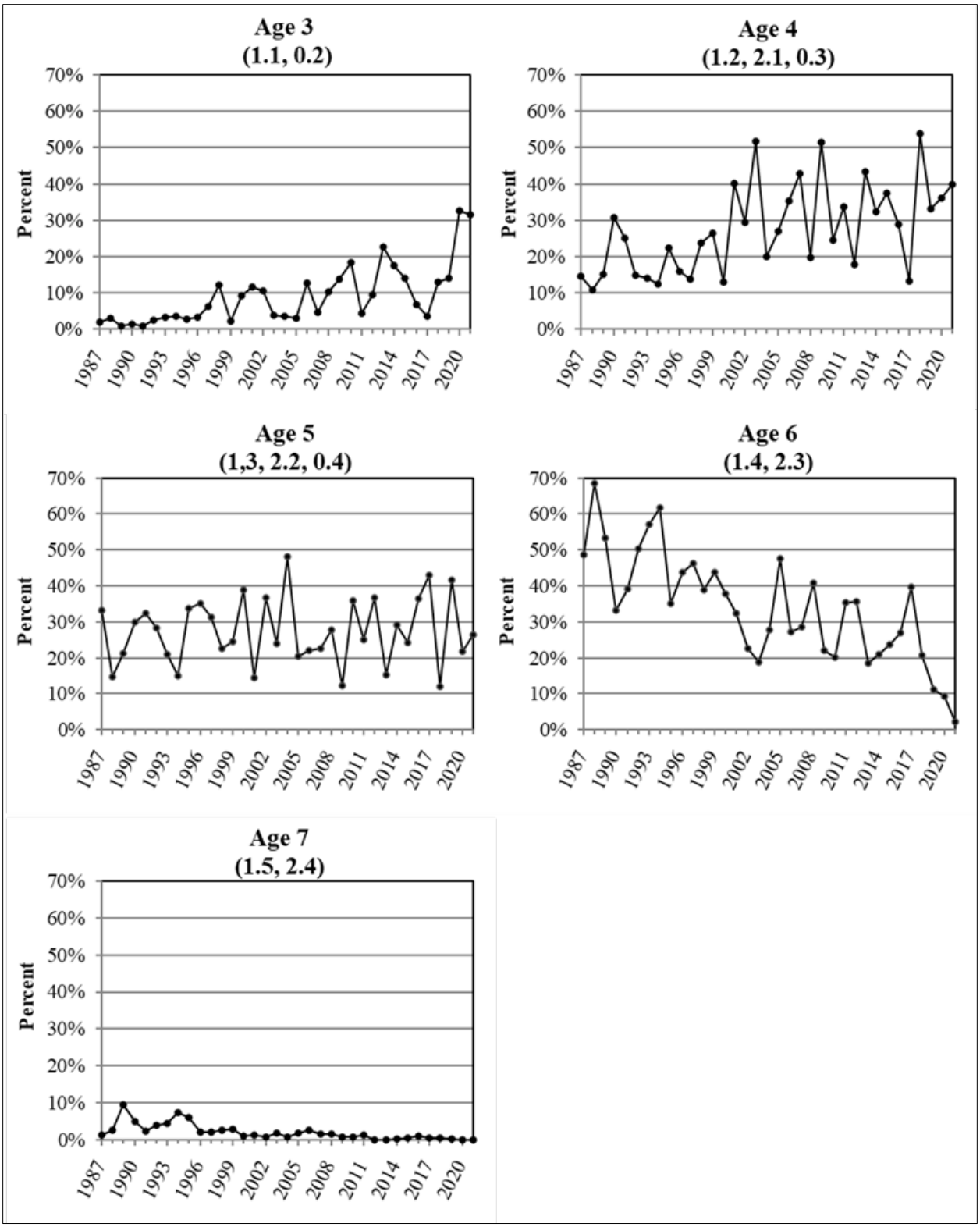
Note: Values given by age and sex may not sum to totals due to rounding. An en dash indicates value not estimated.

APPENDIX B: HISTORICAL AGE AND LENGTH COMPOSITIONS OF HARVESTED CHINOOK SALMON IN THE EASTSIDE SET GILLNET FISHERY, UPPER COOK INLET, ALASKA, 1987–2021

Appendix B1.–Age composition of Chinook salmon harvested in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 1987–2021.

		Percent composition by age class (%)				
Year	Sample size	Age 3 (1.1, 0.2)	Age 4 (1.2, 2.1, 0.3)	Age 5 (1.3, 2.2, 0.4)	Age 6 (1.4, 2.3)	Age 7 (1.5, 2.4)
1987	1,212	2.1	14.8	33.2	48.8	1.2
1988	870	3.2	10.8	14.8	68.6	2.5
1989	854	0.9	15.1	21.3	53.3	9.4
1990	437	1.4	30.6	29.9	33.1	5.0
1991	446	0.9	25.1	32.5	39.2	2.2
1992	688	2.5	15.0	28.2	50.4	3.9
1993	992	3.3	14.0	20.9	57.3	4.5
1994	1,502	3.5	12.4	14.9	61.7	7.4
1995	1,508	2.7	22.4	33.6	35.1	6.1
1996	2,186	3.3	15.9	35.0	43.9	2.0
1997	1,691	6.4	13.8	31.4	46.4	2.1
1998	911	12.2	23.7	22.7	38.9	2.4
1999	1,818	2.4	26.5	24.5	43.9	2.8
2000	991	9.2	13.2	39.0	37.9	0.9
2001	989	11.7	40.0	14.5	32.5	1.2
2002	1,224	10.6	29.3	36.7	22.6	0.8
2003	678	3.8	51.8	23.9	18.7	1.8
2004	1,409	3.5	19.9	48.2	27.7	0.7
2005	482	3.1	27.0	20.6	47.5	1.9
2006	560	12.9	35.4	22.1	27.1	2.5
2007	789	4.8	42.7	22.6	28.5	1.4
2008	380	10.3	19.7	27.6	40.8	1.6
2009	487	13.8	51.3	12.3	22.0	0.6
2010	743	18.3	24.6	36.1	20.2	0.8
2011	1,187	4.6	33.7	25.2	35.4	1.2
2012	167	9.6	18.0	36.6	35.8	0.0
2013	668	22.7	43.4	15.2	18.6	0.0
2014	459	17.6	32.2	29.1	20.9	0.1
2015	610	14.2	37.4	24.3	23.8	0.3
2016	807	6.8	28.8	36.5	26.9	1.0
2017	881	3.6	13.3	43.0	39.7	0.4
2018	300	12.9	53.9	12.1	20.7	0.4
2019	600	14.1	33.1	41.5	11.1	0.1
2020	296	32.7	36.1	21.8	9.4	0.0
2021	273	31.5	40.0	26.3	2.2	0.0
Average 1987–2021	860	9.1	27.6	27.4	34.0	2.0

Source for prior years: 1987–2009, Shields and Dupuis (2013, Appendix A15); 2010–2013, Eskelin et al. (2013); 2014–2020 Eskelin and Barclay (2015–2021).



Appendix B2.–Age composition estimates of Chinook salmon harvested in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 1987–2021.

Source for prior years: 1987–2009, Shields and Dupuis (2013, Appendix A15); 2010–2013, Eskelin et al. (2013); and 2014–2020, Eskelin and Barclay (2015–2021).

Appendix B3.–Average mid eye to tail fork (METF) length in millimeters by age for Chinook salmon sampled in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 1987–2021.

	Average METF length (mm) by age class					
Year	Age 3 (1.1, 0.2)	Age 4 (1.2, 2.1, 0.3)	Age 5 (1.3, 2.2, 0.4)	Age 6 (1.4, 2.3)	Age 7 (1.5, 2.4)	Overall average
1987	408	614	873	1,008	1,067	893
1988	399	647	820	992	957	909
1989	451	673	825	992	1,037	898
1990	560	611	773	979	979	798
1991	461	626	822	976	1,054	835
1992	442	613	784	974	1,052	855
1993	419	632	826	990	1,047	887
1994	420	662	866	898	1,088	934
1995	422	646	895	1,026	1,107	883
1996	410	625	871	1,018	1,098	883
1997	426	632	858	1,003	1,055	868
1998	443	644	838	994	1,045	806
1999	414	626	808	968	1,055	827
2000	413	631	846	989	1,064	832
2001	422	614	820	985	1,054	748
2002	422	640	871	989	1,057	784
2003	434	640	859	1,017	1,102	763
2004	428	645	866	1,010	1,093	848
2005	408	594	814	985	1,090	828
2006	440	581	806	978	1,102	733
2007	430	600	800	954	1,046	743
2008	424	593	825	982	1,097	806
2009	409	577	865	1,003	1,051	686
2010	430	611	850	984	1,102	743
2011	403	610	857	968	1,054	794
2012	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
2016	446	625	800	903	1,078	759
2017	420	617	859	983	1,105	851
2018	448	574	846	1,020	1,115	685
2019	440	601	827	981	1,085	715
2020	444	606	839	968	[a]	628
2021	497	590	820	943	[a]	622
Average 1987–2021	433	617	836	982	1,073	794

Source for prior years: 1987–2008, Tobias and Willette (2010, Table 54); 2009, Tobias and Willette (2012); 2010–2013, Eskelin et al. (2013); and 2014–2020, Eskelin and Barclay (2015–2021).

[a] No age-7 fish were sampled in 2012, 2013, 2020, and 2021.