Fishery Data Series No. 23-36

Eastside Set Gillnet Chinook Salmon Harvest Composition in Upper Cook Inlet, Alaska, 2022

by

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and

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November 2023

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

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Weights and measures (metric)	
centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm
Weights and measures (English)	
cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd
Time and temperature	
day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s
Physics and chemistry	
all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

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

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

FISHERY DATA SERIES NO. 23-36

EASTSIDE SET GILLNET CHINOOK SALMON HARVEST COMPOSITION IN UPPER COOK INLET, ALASKA, 2022

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November 2023

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 and F-10-37, 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. 2023. Eastside set gillnet Chinook salmon harvest composition in Upper Cook Inlet, Alaska, 2022. Alaska Department of Fish and Game, Fishery Data Series No. 23-36, Anchorage.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

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 2022. Mixed-stock analysis (MSA) was conducted on tissue samples collected to represent harvest by reporting group and size. Reported harvest in the ESSN fishery was 341 Chinook salmon of all sizes (all-fish harvest), with an estimated composition of 219 (64%) *Kenai River mainstem*, 67 (20%) *Kasilof River mainstem*, 53 (15%) *Cook Inlet other*, and 2 (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 2022 was 41 fish (12% of the all-fish harvest and 66% of the large-fish harvest). Large *Kenai River mainstem* fish have composed on average 30% of the all-fish harvests since 2010 ranging from 12% (2022) to 63% (2017). Large *Kenai River mainstem* fish have composed on average 68% of the large-fish harvest ranging from 60% (2010 and 2019) to 79% (2017). Age composition of the all-fish harvest in 2022 was 24% age-1.1 (jacks), 53% age-1.2, 16% age-1.3, and 7% age-1.4 fish. Sex composition of the all-fish harvest was 79% males and 21% females. The average METF length of sampled Chinook salmon was 609 mm in 2022, 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 2022). 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 2022). 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 2022). 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 64% of all Chinook salmon harvested in UCI commercial fisheries (Table 1).

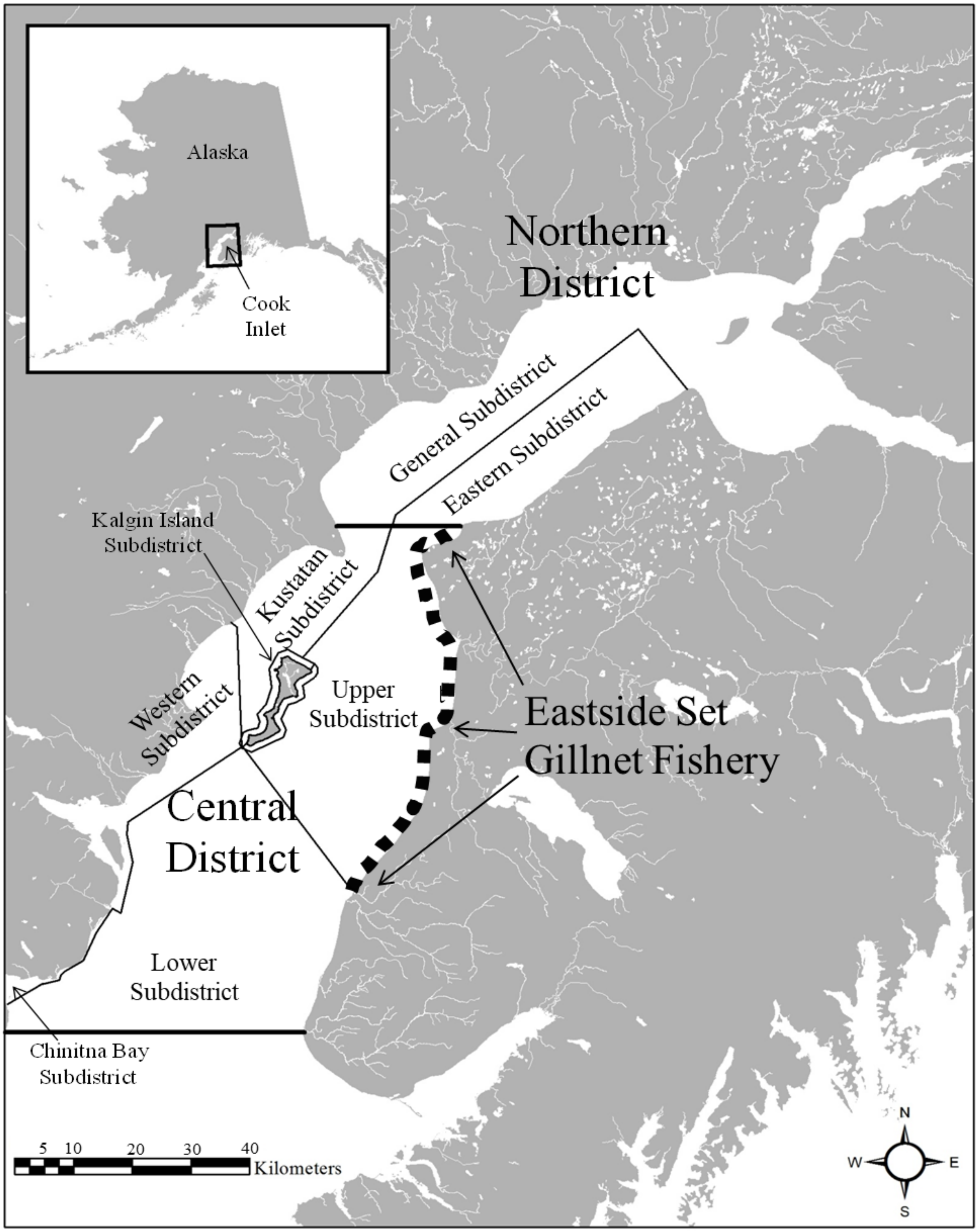

Figure 1.–Map of Upper Cook Inlet commercial fishing districts and subdistricts.

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.

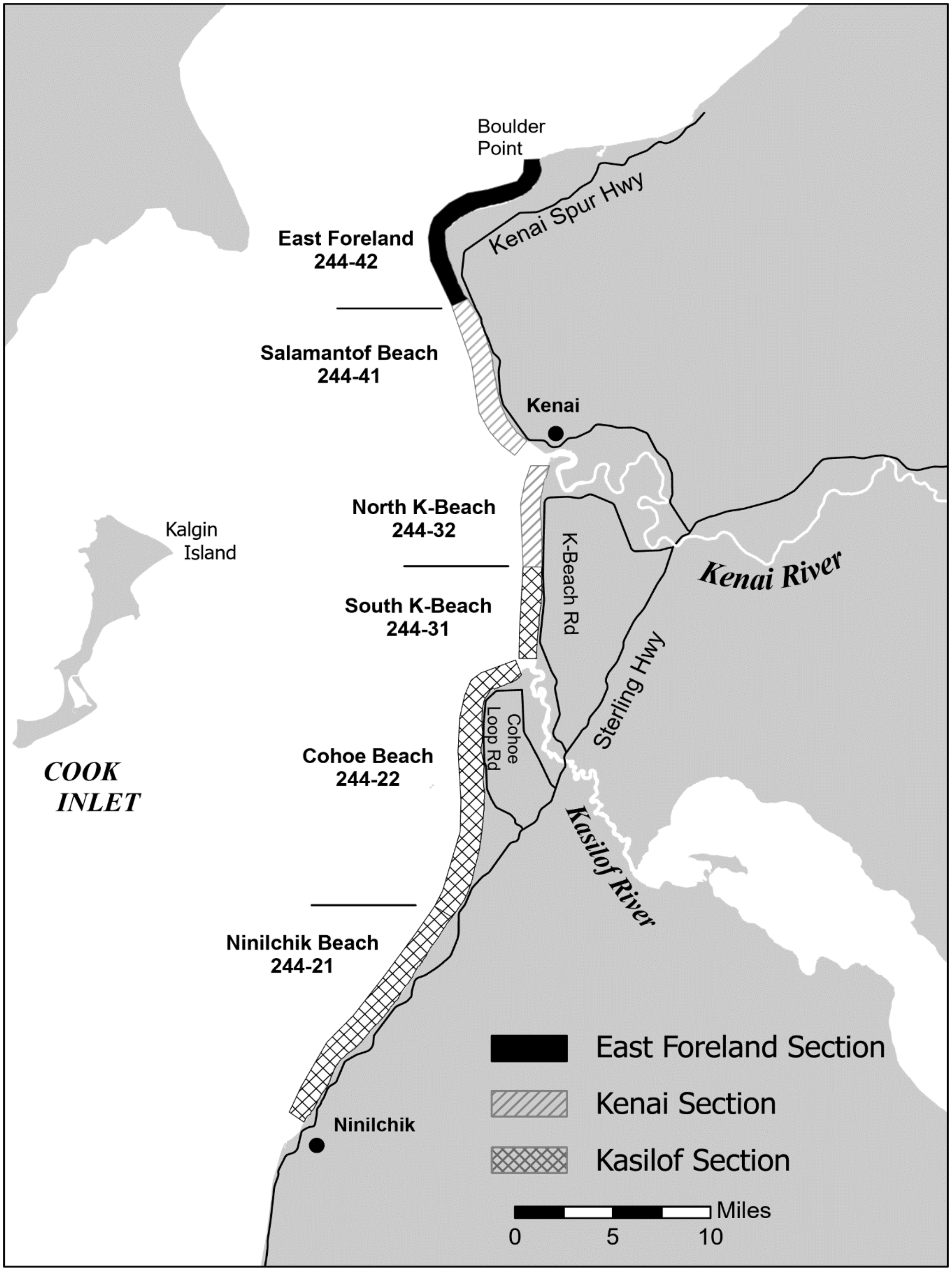

Figure 2.–Map of Upper Cook Inlet Eastside set gillnet commercial fishing statistical areas.

Table 1.–Upper Cook Inlet commercial Chinook salmon gillnet harvest by gear type and area, 1966–2022.

	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						Northern District set		
	Eastside set		Drift		Kalgin–Westside 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
2021	1,297	32.6	217	5.5	566	14.2	1,893	47.6	3,973
Average									
1966–2021[a]	8,723	63.9	891	6.5	1,147	9.5	2,873	20.1	13,633
2012–2021	3,202	53.4	360	7.3	490	11.3	1,410	28.0	5,462
2022	341	15.0	167	7.3	442	19.4	1,328	58.3	2,278

Source: Marston and Frothingham (2022); 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 is composed of Ninilchik Beach, Cohoe Beach, and South K-Beach. The Kenai Section is composed of North K-Beach and Salamatof Beach. The East Foreland Section is 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 2022 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 2015–2022).

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 2010–2021, 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 (2015–2022).

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 (Fleischman and Reimer 2017: Appendix E1). 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 2022 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 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 (C. Lipka, unpublished management report data). Harvest information for the ESSN fishery was retrieved from the database to be used in the analysis and selection of the 2022 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 after each "pick" and after the end of a fishing period to intermediary receiving sites for

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[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.

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. 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). 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

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 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*[3]. 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 file output) and reporting group assignments for each fish at each iteration (.CLS file 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 the mixture analysis. For the 2022 ESSN mixtures, the best available information came from the stock composition estimates of similar strata from the analysis of the 2021 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 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 (CRI) for each stratum were calculated by taking the mean and 5% and 95% quantiles of the posterior distribution from the *.RGN file output (Gelman et al. 2004). Credibility intervals differ from

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[3] 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).

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 "CRI" 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) were calculated by multiplying the reported harvest 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 harvest estimates are included in the tables and figures, but caution should be used in interpretation due to their high uncertainty.

Stock Composition Estimates by Size

The thinned posterior distributions of the *.RGN and *.CLS file 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 Full Season Annual Estimates Across Years

MSA estimates from 2010, 2011, and 2013–2022 were compared across years for full-season estimates of fish of all sizes and for full-season estimates of large fish.

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

The proportions of the total large fish harvest in the entire ESSN fishery by year for the dominant stocks (*Kenai River mainstem* and *Kasilof River mainstem*) were calculated to produce an average and a range of all years (2010, 2011, 2013–2022).

Age, Sex, and Length Composition

Age Composition

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

$$\hat{P}^{(z)} = \frac{n^z}{n} \tag{1}$$

where $\hat{P}^{(z)}$ is the estimated proportion of salmon of age category z, n^z equals the number of sampled fish that were classified in age category z, and n equals the total number of Chinook salmon age determinations.

The variance of $\widehat{P}^{(z)}$ was calculated as follows:

$$\text{var}\left[\widehat{P}^{(z)}\right] = \left(1 - \frac{n}{H}\right)\frac{\widehat{P}^{(z)}\left(1 - \widehat{P}^{(z)}\right)}{n - 1} \tag{2}$$

where H is the reported number of Chinook salmon harvested.

The estimates of harvest by age category were calculated as follows:

$$\widehat{H}^{(z)} = H\widehat{P}^{(z)} \tag{3}$$

with variance

$$\text{var}\left[\widehat{H}^{(z)}\right] = H^2 \,\text{var}\left[\widehat{P}^{(z)}\right] \tag{4}$$

In addition, age composition of the ESSN Chinook salmon harvest was compiled from 1987 to 2021 and combined with 2022 estimates to discern any trends that may have occurred.

Sex Composition

Sex composition was estimated using the same equations (1–4) used to estimate age composition.

Length Composition

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

$$\bar{l}_z = \frac{1}{n_z}\sum_{i=1}^{n_z} l_i \tag{5}$$

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:

$$\text{var}\left(\bar{l}_z\right) = \frac{1}{n_z}\frac{\sum_{i=1}^{n_z}\left(l_i - \bar{l}_z\right)^2}{n_z - 1} \tag{6}$$

In addition, average length by age was compiled for ESSN Chinook salmon harvest samples collected during 1987–2021 and compared to 2022 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 2022, the ESSN fishery opened on 23 June in the Kasilof Section and on 11 July in the Kenai and East Foreland sections. The Kasilof Section was opened for 7 days (23 June, 27 June, 30 June, 4 July, 7 July, 11 July, and 14 July). The Kenai and East Foreland sections were opened for 2 days (11 July, 14 July). The entire ESSN fishery closed on 14 July due to low abundance of large late-run Kenai River Chinook salmon.

The 2022 ESSN Chinook salmon harvest of 341 fish was 4% of the historical (1966–2021) average harvest of 8,723 fish and the lowest ever observed (Table 1). Over the season, more of the harvest occurred in the Kasilof section (254 fish, 74% of total ESSN harvest) than in the Kenai and East Foreland sections (87 fish; 26% of total ESSN harvest).

A total of 153 tissue samples were collected and identified by statistical area in 2022, which was 45% of the total reported harvest.

Tissue Selection and Laboratory Analysis

From the 153 tissue samples collected, a total of 96 samples (28% of the total harvest) were selected to represent the 2022 harvest for MSA and ASL compositions. These samples were genotyped. The genotyping failure rate was 0.01% and the error rate was 0.16%. Based on the 80% rule, 4 individuals were removed from the genotyped 2022 samples. After removing these four individuals, 92 samples remained and were used in the MSA, although the ASL data from the four individuals were used for ASL compositions. No individuals were identified as duplicate samples.

ALL-FISH MSA

The all-fish stock composition and stock-specific harvest estimates for the 2022 ESSN season were greatest for *Kenai River mainstem* (0.64, 219 fish), followed by *Kasilof River mainstem* (0.20, 67 fish) and *Cook Inlet other* (0.15, 53 fish; Table 2).

Table 2.–All-fish stock compositions and stock-specific harvest estimates, including mean and 90% credibility intervals (CRI) for Chinook salmon harvested in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 2022.

Stratum			Stock composition			Stock-specific harvest		
				90% CRI			90% CRI	
Area	Period	Reporting group	Mean	5%	95%	Harvest	5%	95%
All areas	23 Jun–14 Jul							
		Kenai River tributaries	0.01	0.00	0.03	2	0	10
		Kenai River mainstem	0.64	0.50	0.76	219	170	260
		Kasilof River mainstem	0.20	0.11	0.30	67	37	101
		Cook Inlet other	0.15	0.07	0.26	53	25	87

Note: Due to uncertainty in estimates with stock composition, caution should be used in the interpretation of estimated proportions less than 0.05 and stock-specific harvest estimates with the lower end of the 90% CI less than 1 fish.

LARGE-FISH MSA

Large *Kenai River mainstem* fish composed 0.12 (estimated 41 fish) and large *Kasilof River mainstem* fish composed 0.05 (estimated 18 fish) of the all-fish harvest in 2022 (Table 3). Of *Kenai River mainstem* fish, 0.19 (estimated 41 out of 219 fish) were classified as large. Of *Kasilof River mainstem* fish, 0.26 (estimated 18 out of 68 fish) were classified as large. Estimated harvests of large *Cook Inlet other* and *Kenai River tributaries* fish were negligible (0.01 or less).

Table 3.–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 (CRI), Upper Cook Inlet, Alaska, 2022.

Stratum				Stock composition [a]			Stock-specific harvest		
					90% CRI			90% CRI	
Area	Period	Size	Reporting group	Mean	5%	95%	Harvest	5%	95%
All	23 Jun–14 Jul	Large	Kenai R. tributaries	0.00	0.00	0.00	0	0	1
			Kenai R. mainstem	0.12	0.07	0.19	41	23	64
			Kasilof R. mainstem	0.05	0.02	0.10	18	6	34
			Cook Inlet other	0.01	0.00	0.04	4	0	12
		Small	Kenai R. tributaries	0.00	0.00	0.02	2	0	8
			Kenai R. mainstem	0.52	0.40	0.63	178	135	216
			Kasilof R. mainstem	0.15	0.07	0.24	50	25	80
			Cook Inlet other	0.14	0.07	0.24	49	22	83

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, caution should be used in the interpretation of estimated proportions less than 0.05 and stock-specific harvest estimates with the lower end of the 90% CI less than 1 fish.

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

ALL-FISH MSA COMPARISONS ACROSS YEARS

There are now 12 years of stock compositions and stock-specific harvest estimates dating back to 2010. *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 4). The average estimated annual harvest of *Kenai River mainstem* fish since 2010 (excluding 2012) is 2,752 fish (range: 219–5,988 fish). *Kasilof River mainstem* fish have averaged 0.24 of the harvest, ranging from 0.13 (2021) to 0.39 (2014). The average estimated annual harvest of *Kasilof River mainstem* fish is 996 fish (range: 67–2,448 fish). *Cook Inlet other* have composed a small fraction (0.03 or less) of the harvest every year, except for the last 3 years (2020, 0.13; 2021, 0.17; 2022, 15; Table 4). The estimated harvest of *Cook Inlet other* fish has averaged 89 fish. *Kenai River tributaries* fish have been a negligible portion of the harvest (0.03 or less), averaging an estimated 28 fish, but estimates for 2021 and 2022 were less than 5 fish in each year.

Table 4.–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 2013–2022.

	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
2022	0.01	2	0.64	219	0.20	67	0.15	53
Average	0.01	28	0.70	2,752	0.24	996	0.05	89
Minimum	0.00	2	0.61	219	0.13	67	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 2015–2022) and Table 2 of this report for 2022.

[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 ACROSS YEARS

There are also 12 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 5). Overall, *Kenai River mainstem* fish have composed the greatest proportion of the large fish harvest every year, averaging 0.30 of the annual harvest of all fish sizes, ranging from 0.12 (2022) to 0.63 (2017). Large *Kasilof River mainstem* fish have averaged 0.12 of the annual all-fish harvest ranging from 0.05 (2022) to 0.21 (2010). The average harvest of large *Kenai River mainstem* fish is 1,381 fish (range: 41–2,998 fish) with by far the 5 lowest harvests occurring since 2018. The average harvest of large *Kasilof River mainstem* fish is 570 fish (range: 18–1,466 fish).

Table 5.– 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 Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 2010, 2011, and 2013–2022.

	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	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
2022	0.00	0	0.12	41	0.05	18	0.01	4
Average	0.00	12	0.30	1,381	0.12	570	0.01	26
Minimum	0.00	0	0.12	41	0.05	18	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, 2022) and Table 3 of this report for 2022.

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

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

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

Large *Kenai River mainstem* fish have composed on average 0.68 of the total large fish harvest by year, ranging from 0.60 (2010 and 2019) to 0.79 (2017; Table 6). 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 6.–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 2013–2022.

		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
2022	63	41	0.66	18	0.28
Average	1,989	1,381	0.68	570	0.28
Minimum	63	41	0.60	18	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 2015–2022) and Table 4 of this report for 2022.

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

AGE, SEX, AND LENGTH COMPOSITION

All-Fish Age Composition

The estimated age composition of the 2022 ESSN Chinook salmon harvest was 24% age-1.1, 53% age-1.2, 16% age-1.3, and 7% age-1.4 fish, with no age-1.5 fish observed (Table 7). The percentage of age-6 (age-1.4) fish (7%) was the second lowest observed since 1987 and significantly below the historical average of 33% (Appendix A1). The last 4 years have had the lowest percentages of age-6 fish observed (11%, 9%, 2%, and 7% in 2019–2022; Appendices A1 and A2). The percentage of age-3 fish (age-1.1 jacks) in the 2022 harvest (28%) was the 3rd highest observed, only below 33% in 2020 and 32% in 2021, and these 3 years had by far the highest percentages of jacks observed in the harvest since 1987. The percentage of age-4 (age-1.2) fish in the harvest in 2022 (49%) was well above the historical average of 28%, and the percentage of age-5 (age-1.3) fish in the harvest (16%) was below the historical average of 27%.

All-Fish Sex Composition

Sex composition in the 2022 ESSN harvest was estimated as 79% males (270 fish) and 21% females (71 fish; Tables 7 and 8). This was the same sex composition as in 2021. This pattern of male-dominated sex composition in the harvest has occurred every other year since 2010, except 2017 when 52% of the harvest was composed of females (Table 8).

All-Fish Length Composition

Average METF length by age in 2022 was 452 mm for age-1.1, 596 mm for age-1.2, 794 mm for age-1.3, and 906 mm for age-1.4 fish (Table 7 and Appendix A3). Average METF length was 609 mm for all fish sampled, which was the shortest average METF length observed since sampling began in 1987 (Appendix A3).

Large-Fish Age and Sex Composition

The estimated age composition of the large fish harvest was 63% age-1.3 and 37.5% age-1.4 fish (Table 9). The estimated sex composition of the large fish harvest was 75% males (47 fish) and 25% females (16 fish).

Table 7.–All-fish age, sex, and mean mid eye to tail fork (METF) length composition of Chinook salmon harvested in the Eastside set gillnet fishery, 23 June–14 July, Upper Cook Inlet, Alaska, 2022.

		Age class				
Sex	Parameter	1.1	1.2	1.3	1.4	All ages
Females						
	Harvest by age	0	7	43	21	71
	SE (harvest by age)	–	4	10	7	12
	Samples by age	0	2	12	6	20
	Age composition	–	2.1%	12.5%	6.3%	20.8%
	SE (age composition)	–	1.2%	2.9%	2.1%	3.5%
Males						
	Harvest by age	82	174	11	4	270
	SE (harvest by age)	13	15	5	3	12
	Samples by age	23	49	3	1	76
	Age composition	24.0%	51.0%	3.1%	1.0%	79.2%
	SE (age composition)	3.7%	4.3%	1.5%	0.9%	3.5%
Both sexes						
	Harvest by age	82	181	53	25	341
	SE (harvest by age)	13	15	11	8	0
	Samples by age	23	51	15	7	96
	Age composition	24.0%	53.1%	15.6%	7.3%	100.0%
	SE (age composition)	3.7%	4.3%	3.2%	2.3%	0.0%
	Mean length (mm METF)	452	590	794	906	622

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

Table 8.–Chinook salmon harvest and percent of harvest by sex in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 2010–2022.

	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%
2022	71	270	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 2015–2022) and Table 8 of this report for 2022.

Table 9.–Age and sex composition of large (≥75 cm METF) Chinook salmon harvested in the Eastside set gillnet fishery, 23 June–14 July, Upper Cook Inlet, Alaska, 2022.

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

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

DISCUSSION

MIXED-STOCK ANALYSIS

In 2022, 45% of the harvest was sampled, which was the highest sampling rate since genetic sampling began in 2010. This sampling rate easily met the primary objectives and precision criteria goals for estimating stock compositions, stock-specific harvests, and age composition.

Despite the lowest-ever reported harvest of 341 Chinook salmon, there were enough samples to conduct an overall MSA and MSA by size for the entire fishery (annual estimates). Due to the low harvest, there were not enough samples to conduct representative MSAs by time and area for the first time in any year except 2012. However, the annual MSA estimates overall and by size are valuable for assessing between-season variability of stock compositions and harvest, overall and by size, providing necessary information for Kenai River Chinook salmon stock assessment.

KENAI RIVER CHINOOK SALMON HARVEST

An important objective of this project has been to provide 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; Table 10), large *Kenai River mainstem* fish have composed on average 0.30 of the all-fish harvests with more variable proportions by year (range: 0.12–0.63; Table 10). Since 2010, there have been 7 years (2013, 2014, 2018–2022) of low harvests of large *Kenai River mainstem* fish, averaging 425 fish over those years and 5 years (2010, 2011, 2015–2017) of higher harvests of large *Kenai River mainstem* fish averaging 2,719 fish over those years (calculated from Table 10). Harvests of large *Kenai River mainstem* fish have been by far the lowest in 2020–2022 (excluding 2012 with no MSA), resulting from weak runs with high proportions of younger and smaller fish, limited fishing openings, and gear restrictions.

Table 10.–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 2013–2022.

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
2022	341	63	0.64	41	0.12
Average	3,865	1,989	0.70	1,381	0.30
Min.	341	63	0.61	41	0.12
Max.	7,781	3,993	0.79	2,998	0.63

Source: Eskelin and Barclay (2016–2022) for 2010–2021; Table 5 in this report for 2022.

Note: Large fish are 75 cm or greater METF; small fish are less than 75 cm METF.

AGE, SEX, AND LENGTH COMPOSITION

The percentage of age-6 (1.4) fish in the last 4 years (2019–2022; average 8%) has been much lower than the historical average (33%) and in 2022, the percentage of age-6 (1.4) fish was 7%, the 2nd lowest observed since sampling began in 1987 (Appendix A1). This recent decline is mainly due to the decline in size and age of returning Chinook salmon but also partly because some fishers have voluntarily released large Chinook salmon to help meet escapement goals.

The average METF length (609 mm) of all samples collected in 2022 was the lowest observed since sampling began in 1987 and close to the average METF length of samples collected since 2020 (628 mm and 622 mm in 2020 and 2021, respectively; Appendix A3). The low average length in the past several years can be directly tied to younger age-at-return for Chinook salmon as well as the voluntary release of larger Chinook salmon by some fishers.

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.

The percentage of the Chinook salmon harvest reported as retained for personal use has trended upwards recently, but the total harvest of those fish kept for personal use has not. For example, in 2022, the reported harvest kept for personal use was 20.8%, which was by far the highest percentage of the total reported harvest ever observed, but the reported number was only 71 fish, which is about half the average annual harvest kept for personal use during 2010–2021. A large proportion of fish kept for personal use can affect the ability of the sampling crew to collect representative samples of the harvest by statistical area and date. For instance, in 2022, the reported harvest in the North K-Beach statistical area (244-32) was 10 Chinook salmon, but 8 of those 10 fish were reported as kept for personal use. Fortunately, the ratio of Chinook salmon kept for personal use to the total harvest was much lower in the other statistical areas.

To accurately estimate stock compositions and stock-specific harvests by size, the length samples collected of the harvest must be relatively unbiased and represent the actual harvest. It is not known how the size (lengths) of fish kept for personal use compare to fish sold and sampled or how that relationship varies. If there are major differences between the 2 samples (sold or kept for personal use), then results from MSA and age, sex, and length composition estimates could be biased. Fortunately, most harvested Chinook salmon have been historically transferred to receiving stations where they are sold and can be easily sampled, so any bias resulting from the difference between lengths of those sampled and those kept for personal use and not sampled is probably small. These important facets of the ability to representatively sample the fishery will be monitored, and adjustments may need to be made to the sampling protocol in future years if necessary.

Table 11.–Number of Chinook salmon harvested and reported as kept for personal use in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 1993–2022.

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%
2022	71	341	20.8%

Source: ADF&G fish ticket database.

ACKNOWLEDGMENTS

We would like to thank all individuals who contributed to the success of this project. Harvest samples were collected by Isaac Pontius, Benjamin Niedbalski, and Trent Powell. Staff members from the Gene Conservation Lab who worked on this project were Zach Pechacek, 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. 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 and F-10-37, Job No. S-2-5c.

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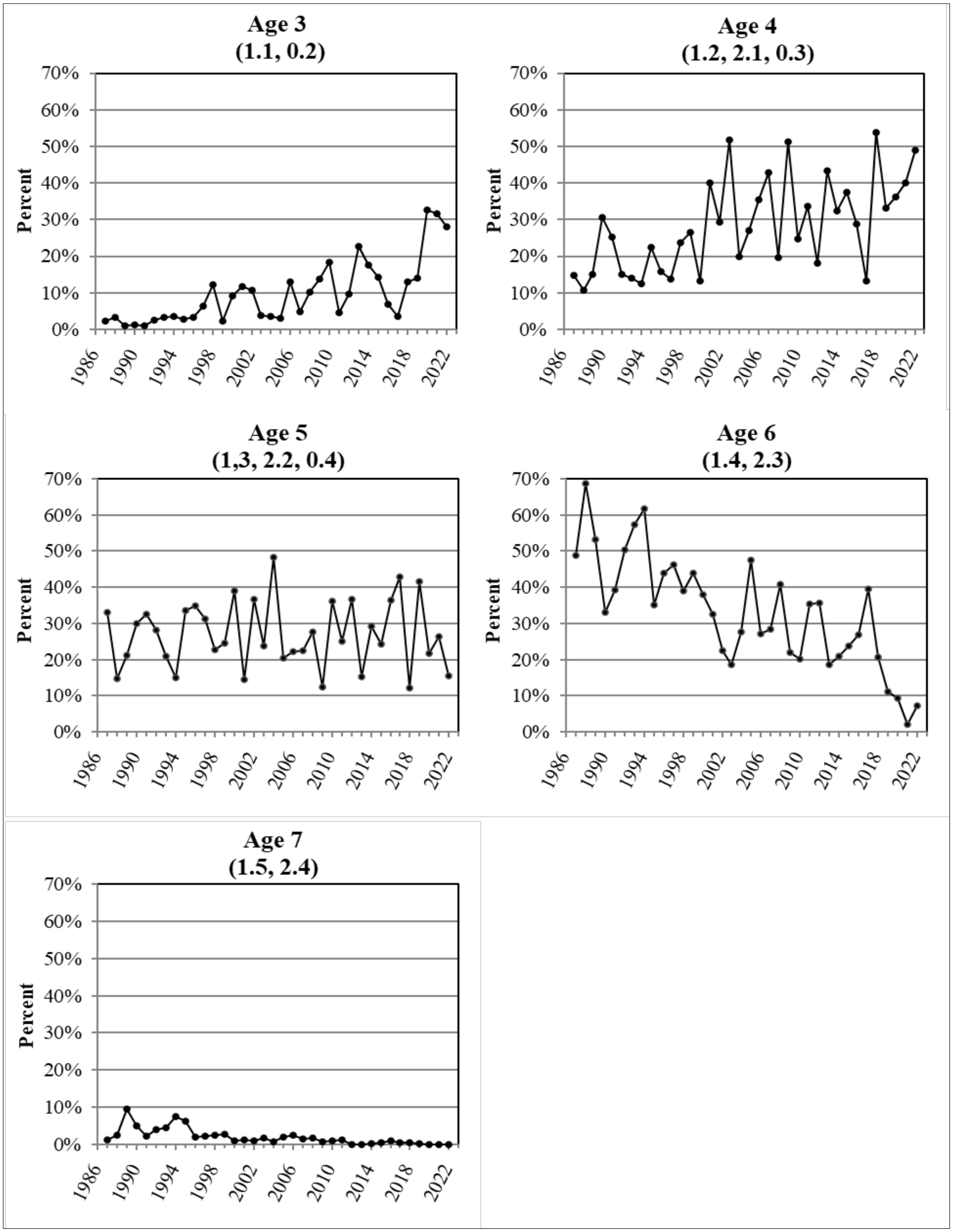
APPENDIX A: HISTORICAL AGE AND LENGTH COMPOSITIONS OF HARVESTED CHINOOK SALMON IN THE EASTSIDE SET GILLNET FISHERY, UPPER COOK INLET, ALASKA, 1987–2022

Appendix A1.–Age composition of Chinook salmon harvested in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 1987–2022.

		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
2022	96	28.1	49.0	15.6	7.3	0.0
Average 1987–2022	839	9.6	28.2	27.1	33.3	1.9

Source for prior years: 1987–2009, Shields and Dupuis (2013: Appendix A15); 2010–2013, Eskelin et al. (2013); 2014–2020, Eskelin and Barclay (2015–2022).

Appendix A2.–Age composition estimates of Chinook salmon harvested in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 1987–2022.



Source for prior years: 1987–2009, Shields and Dupuis (2013, Appendix A15); 2010–2013, Eskelin et al. (2013); and 2014–2020, Eskelin and Barclay (2015–2022).

Appendix A3.–Average length in millimeters from mid eye to tail fork (METF) by age for Chinook salmon sampled in the Eastside set gillnet fishery, Upper Cook Inlet, Alaska, 1987–2022.

	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
2022	452	596	794	906	[a]	609
Average 1987–2022	433	617	835	980	1,073	788

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 (2015–2022).

[a] No age-7 fish were sampled in 2012, 2013, or 2020–2022.