Fishery Data Series No. 19-03

Northern Cook Inlet Chinook Salmon Marine Harvest Stock Composition, 2014–2015

by

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February 2019

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

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ABSTRACT

Genetic tissue samples were collected from Chinook salmon harvested in the Northern District commercial set gillnet fishery and the Tyonek subsistence fishery 2014–2015 to determine stock composition of marine harvests in Northern (Upper) Cook Inlet (NCI). Enough samples were collected both spatially and temporally to represent 97% (2014) and 80% (2015) of commercial harvests and 100% (2014–2015) of subsistence harvests. Genetic mixed-stock analysis produced stock composition and stock-specific harvest estimates by reporting group for each fishery. The 4 reporting groups chosen for these analyses were 1) *NCI Northwest*, 2) *Susitna–Matanuska*, 3) *Knik–Turnagain*, and 4) *Kenai Peninsula*. In both years of the study, *NCI Northwest*, *Susitna–Matanuska*, and *Knik–Turnagain* reporting groups composed over 98% of the total harvests in both the Northern District commercial and Tyonek subsistence fisheries. The *NCI Northwest* and *Susitna–Matanuska* reporting groups composed a majority of harvests in the General Subdistrict (south) (88–96%), and the *Knik–Turnagain* reporting group composed the majority of harvests in the General Subdistrict (north) (71–89%) in both years. The *NCI Northwest*, *Susitna–Matanuska*, and *Knik–Turnagain* reporting groups composed over 98% of the Eastern Subdistrict commercial harvest in both years, with similar contributions of the 3 reporting groups in 2014 (28–36%) and higher contributions from the *Knik–Turnagain* reporting group in 2015 (56%). In the Tyonek subsistence fishery, the *NCI Northwest* (56%) and *Susitna–Matanuska* (39%) reporting groups composed the majority of the harvest in 2014, and the *NCI Northwest* reporting group made up most of the harvest in 2015 (79%). These results represent the first mixed-stock analysis using genetic information from Chinook salmon captured in NCI fisheries.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, mixed-stock analysis, Northern District of Upper Cook Inlet, set gillnet, subsistence, Tyonek

INTRODUCTION

All 5 North American species of Pacific salmon are harvested in commercial, subsistence, and sport fisheries in Northern (Upper) Cook Inlet (NCI; Jones and Koster 2018; Oslund et al. 2017; Shields and Frothingham 2018). Sockeye salmon (*Oncorhynchus nerka*) make up the majority of the commercial harvest, but Chinook salmon (*O. tshawytscha*) are also harvested (Shields and Frothingham 2018). Chinook salmon make up the majority of the Tyonek subsistence harvest (Jones and Koster 2018) and are a substantial part of the salmon harvests in NCI sport fisheries behind only coho salmon and sockeye salmon in recent years (Oslund et al. 2017).

Chinook salmon returning to Cook Inlet streams are harvested in NCI mixed-stock marine fisheries, primarily the Tyonek subsistence set gillnet and Northern District commercial set gillnet fisheries (Figure 1). The *Northern District King Salmon Management Plan* (Alaska Administrative Code 5 AAC 21.366) was created by the Alaska Board of Fisheries in 1986 and was most recently modified in 2011. This plan provides direction to the Alaska Department of Fish and Game (ADF&G) regarding management of the Northern District for the directed commercial harvest of Chinook salmon. The directed Chinook salmon commercial fishing season opens on the first Monday on or after May 25 and remains open for all Mondays through June 24. Fishing periods are 12 hours per day from 7:00 AM to 7:00 PM unless altered by emergency order. The commercial fishery is limited to an annual harvest not to exceed 12,500 Chinook salmon. Each permit holder is allowed to fish one 35-fathom, maximum 6-inch mesh set gillnet, with a minimum separation of 1,200 feet between nets.

There are 7 Chinook salmon stocks of concern in Northern Cook Inlet that are susceptible to harvest in NCI marine fisheries (Chuitna, Theodore, and Lewis rivers, and Alexander, Willow, Goose, and Sheep creeks). Under the *Northern District King Salmon Management Plan*, if sport fishing restrictions are imposed on the Theodore, Ivan, Lewis, Chuitna, or Deshka rivers, time and area restrictions will be placed on the commercial fishery. The Northern District set gillnet fishery has been closed from the wood chip dock, adjacent to Tyonek, up to (not including) the

Susitna River due to sport fish closures on the Chuitna River since 2011 (closed area includes the northern half of statistical area 247-20 and all of 247-30; Figure 1) (Shields and Frothingham 2018). Following the directed Chinook salmon fishery, the set gillnet fishery in the Northern District opens by regulation on or after June 25 for regular Monday and Thursday 12-hour periods to target other salmon species. This fishery is managed primarily by the *Northern District Salmon Management Plan* (5 AAC 21.358).

Under the statewide subsistence fishery regulations for Upper Cook Inlet (5 AAC 01.560), the Tyonek subsistence fishery is open for 2 seasons per year. The early season, May 15 through June 15, is open 3 days per week (Tuesday, Thursday, and Friday) for 16 hours per day (4:00 AM to 8:00 PM). The late season, June 16 through October 15, is open for 1 day per week (Saturday) for 12 hours (7:00 AM to 7:00 PM) (5AAC 01.560). Subsistence fishing targeting Chinook salmon occurs from May 15 until approximately June 30. The fishery extends from a point 1 mile south of the southern edge of the Chuitna River to the easternmost tip of Granite Point (Figure 1).

Little information regarding stock-specific harvests of Chinook salmon in these mixed-stock marine fisheries is currently available. This information is potentially useful in managing the marine fisheries of NCI by giving managers and policy makers an understanding of where and when various NCI stocks are harvested and at what rate. Genetic mixed-stock analysis (MSA) has been used in Cook Inlet to estimate the stock composition of sockeye salmon in the commercial fishery since the 1990s (Seeb et al. 2000; Habicht et al. 2007; Barclay et al. 2010a, 2010b, 2013, 2014). With the development of comprehensive genetic baselines for Upper Cook Inlet Chinook salmon (Barclay et al. 2012; Barclay and Habicht 2015), this method has more recently been used to estimate the stock composition of Chinook salmon harvested in the Upper Subdistrict set gillnet fishery (Eskelin 2013; Eskelin and Barclay 2015, 2016) and the Cook Inlet marine sport fishery (Barclay et al. 2016).

Here we report genetic baseline evaluation tests for MSA and MSA results of Chinook salmon harvested in the Tyonek subsistence and Northern District commercial marine fisheries in 2014–2015.

OBJECTIVES

Primary Objectives

1) Estimate the proportion of Chinook salmon harvested in the Tyonek subsistence fishery and NCI Northern District set gillnet commercial fishery by reporting group (*NCI Northwest*, *Susitna–Matanuska*, *Knik–Turnagain*, and *Kenai Peninsula*) for each temporal and geographic stratum such that the estimated proportions are within 22 percentage points of the true values 90% of the time.

2) Estimate the age composition of Chinook salmon harvested by the NCI Northern District set *gillnet* commercial fisheries such that the estimates are within 10 percentage points of the true values 95% of the time.

3) Estimate the age composition of Chinook salmon harvested by the Tyonek subsistence fishery such that the estimates are within 10 percentage points of the true values 95% of the time.

Secondary Objectives

1) Sample 70% of the Chinook salmon harvested in the Northern District commercial set gillnet fishery and 40% in the Tyonek subsistence fishery for tissue, age, sex, and length.
2) Estimate the number of Chinook salmon harvested by the Tyonek subsistence and Northern District set gillnet commercial fisheries by reporting group (*NCI Northwest*, *Susitna–Matanuska*, *Knik–Turnagain*, and *Kenai Peninsula*) for each temporal and geographic stratum.
3) Estimate the sex and length compositions of Chinook salmon harvested in the Tyonek subsistence and NCI Northern District set gillnet commercial fisheries.

METHODS

SAMPLE COLLECTION

Genetic tissue samples and age, sex, and length data were collected from Chinook salmon harvested in the Northern District set gillnet commercial fishery and the Tyonek subsistence fishery in 2014 and 2015 to estimate stock composition of marine harvest in NCI. Samples were collected at ports, processors, buying stations, and set gillnet sites in Anchorage, Tyonek, and the Soldotna area during and after fishery openings. Crews were directed to maximize the number of samples collected to meet sample size requirements. Target sampling rates were 70% of the reported commercial harvest and 40% of the reported subsistence harvest (St. Saviour et al. 2016).

Tissue Sampling

To preserve tissue samples for DNA analysis, tissues were placed in individually labeled 2 mL plastic vials and preserved in 95% ethanol (St. Saviour et al. 2016). Vial numbers were recorded on data sheets. Genetic tissues were sent to the ADF&G Gene Conservation Laboratory for long-term storage and genetic analysis.

Age, Sex, and Length Sampling

Sampled fish were measured from mid eye to tail fork (METF) to the nearest 5 mm. Sex was determined by external physical characteristics, such as kype development (males) or a protruding ovipositor (females). When sex could not be determined by external characteristics, samplers would request permission to make a small incision from the vent forward and sex was determined by inspection of gonads.

During both commercial and subsistence sampling, 4 scales were removed from the preferred area of each fish and placed on an adhesive-coated card (Clutter and Whitesel 1956; Welander 1940). Impressions from scales mounted on gum cards were made in cellulose acetate as described in Clutter and Whitesel (1956) and Scarnecchia (1979). The impressions were magnified 40× and viewed on a microfiche reader, and the ages were determined from growth patterns of the circuli. Ages were recorded in European notation (Jearld Jr. 1983). All data were recorded to standard datasheets and entered into spreadsheets.

LABORATORY ANALYSIS

Assaying Genotypes

Genomic DNA was extracted from tissue samples using a NucleoSpin 96 Tissue Kit by Macherey-Nagel (Düren, Germany). DNA was screened for 39 SNP markers for both years.

DNA from the 2014 and 2015 samples was genotyped using Fluidigm 192.24 Dynamic Array Integrated Fluidic Circuits (IFCs), which systematically combine up to 24 assays and 192 samples into 4,608 parallel reactions. The components were pressurized into the 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 of 95°C for 2 min 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 Dynamic Array 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

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 genotyped.

Quality control (QC) measures were used 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.

STATISTICAL ANALYSIS

Data Retrieval and Quality Control

Genotypes were retrieved from LOKI and imported them into *R*[1] with the *RJDBC* package[2]. All subsequent analyses were performed in *R*, unless otherwise noted.

Prior to statistical analysis, 2 analyses were performed to confirm the quality of the data. First, the 80% rule was used (missing data at 20% or more of loci; Dann et al. 2009) to identify individuals missing substantial genotypic data. These individuals were removed from further

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[1] R Development Core Team. 2016. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/.

[2] Urbanek, S. 2014. RJDBC: Provides access to databases through the JDBC interface. R package version 0.2-5. http://CRAN.R-project.org/package=RJDBC.

analyses. The inclusion of individuals with poor quality DNA might introduce genotyping errors and reduce the accuracy of the MSA.

The final QC analysis identified individuals with duplicate genotypes and removed them from further analyses. Duplicate genotypes, which can occur by sampling or extracting the same individual twice, were defined as pairs of individuals sharing the same alleles in 95% of screened loci. The sample with the most missing genotypic data from each duplicate pair was removed from further analyses. If both samples had the same amount of genotypic data, the first sample was removed from further analyses.

Subsampling for Genetic Mixed-Stock Analysis

Daily commercial harvests were derived from fish tickets (5 AAC 21.355). Daily subsistence harvests were derived from returned permits (5 AAC 01.015; Fall et al. 2017) and Tyonek household surveys as of December 2015 (ADF&G Division of Subsistence, unpublished data). Tissue samples were subsampled in proportion to reported Chinook salmon harvests to form mixtures for MSA. Before selection, we set a minimum sample size requirement of 100 fish per mixture. When an insufficient number of samples was collected for a given day, to select samples in proportion to harvest, excess samples from the next closest day were used to represent the harvest, provided the samples were collected within 7 days of each other.

The commercial fishery was stratified into 3 geographic areas: 1) General Subdistrict (south)[3], including stat areas 247-10 (Trading Bay) and 247-20 (Tyonek); 2) General Subdistrict (north), including stat areas 247-41 (Susitna Flats), 247-42 (Pt. McKenzie), and 247-43 (Fire Island); and 3) Eastern Subdistrict, including stat areas 247-70 (Pt. Possession), 247-80 (Birch Hill), and 247-90 (#3 Bay) (Figure 1). Within each of these geographic areas, the goal was to produce mixtures representing early and late periods: the early stratum includes the first 2 targeted Chinook salmon fishing periods that occurred during May 29 to June 12, and the late stratum includes the last 2 targeted Chinook salmon fishing periods during June 13 to 24 plus incidental Chinook salmon harvest during commercial fishing periods primarily targeting sockeye salmon during June 25–30. When the sample-size requirement could not be met for early and late mixtures, samples were combined to form a single mixture representing the entire season for that geographic area.

The subsistence fishery for Chinook salmon only occurs in 1 geographic area (Tyonek), so only temporal stratification was possible (May 16–31 and June 1–30). The early subsistence fishing temporal stratum was selected to represent early season subsistence harvest that occurs before any commercial fishing in May. The late subsistence fishing temporal stratum was selected to represent subsistence Chinook salmon harvest through the remainder of June. Like the commercial fishery, when the sample size requirement could not be met for early and late mixtures, samples were combined to form a single mixture for the entire season.

Genetic Baseline

The genetic baseline used in this analysis was derived from roughly 7,900 samples collected from Chinook salmon spawning locations throughout Cook Inlet. These collections were analyzed for 42 single nucleotide polymorphism (SNP) markers; there was enough genetic variation at 39 SNPs to characterize 55 Cook Inlet populations, with a minimum sample size of 50 fish per population (Table 1 and Figure 2; Barclay and Habicht 2015). A Cook Inlet–only

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[3] Stat area 247-30 (Beluga) is closed to commercial fishing for Chinook salmon.

baseline was chosen because marine harvests in NCI are believed to contain only fish of Cook Inlet origin.

Baseline Evaluation for Mixed-Stock Analysis

Four reporting groups that were of interest to management and that should perform adequately for MSA were identified at the beginning of the study (Table 1 and Figure 2). These groups are as follows:

1) *NCI Northwest* (Western Cook Inlet, Alexander Creek, and Yentna River populations)
2) *Susitna–Matanuska* (Susitna River and Matanuska River populations)
3) *Knik–Turnagain* (Cook Inlet populations from Turnagain Arm and Knik Arm)
4) *Kenai Peninsula* (Kenai Peninsula populations from the Kenai River south to the Anchor River)

100% Proof Tests

We began our assessment of the identifiability of the reporting groups (see above) in mixtures with "100% proof tests." In these tests, we created mixtures (see Bayes Protocol below) by randomly sampling 200 fish from the baseline for a single reporting group, then we rebuilt the baseline without the sampled fish and analyzed the mixture using the reduced baseline (now with 1 reduced reporting group [less the 200 individuals] and 3 complete reporting groups). These tests provided an indication of the power of the baseline for MSA under the assumption that all populations from a reporting group were represented in the baseline. To assess the precision and accuracy of reporting group assignments, this process was repeated to produce 10 replicate proof tests for each reporting group. The Gene Conservation Laboratory uses the common guideline that correct allocation for these single-reporting group tests should exceed 90% to be considered adequate (Seeb et al. 2000). However, deviation from this guideline is permitted if stakeholders are willing to accept higher levels of MSA uncertainty to include specific reporting groups (Habicht et al. 2012). In this study, the consulted stakeholders were ADF&G management and research staff.

Fishery Scenario Tests

The second, more stringent method used to assess the identifiability of reporting groups in mixtures was the "fishery scenario tests" (Anderson et al. 2008) in which we tested a hypothetical fishery scenario of equal representation for each reporting group. In these tests, we randomly sampled 50 individuals from each of the 4 reporting groups for a total of 200 individuals and analyzed them as a mixture against the (now) reduced baseline. This process was repeated to produce 10 replicates. These tests provided an unbiased indication of the power of the baseline for MSA without the potential issue of overestimation of power seen with 100% proof tests (Anderson et al. 2008). Fishery scenario tests provide information on the accuracy and precision of the baseline for MSA.

Bayes Protocol

The stock composition of the proof test mixtures as well as the MSA (see below) was estimated using the software package *BAYES* (Pella and Masuda 2001). *BAYES* employs a Bayesian algorithm to estimate the most probable contribution of the baseline populations to explain the combination of genotypes in the mixture sample. For the 100% proof tests, we ran 1 Markov

Chain Monte Carlo (MCMC) simulation with 40,000 iterations and discarded the first 20,000 iterations to remove the influence of starting values. The prior parameters for each reporting group were defined to be equal (i.e., a flat prior). Within each reporting group, the population prior parameters were divided equally among the populations within that reporting group. Stock proportion estimates and the 90% credibility intervals for each proof test mixture were calculated by taking the mean and 5% and 95% quantiles of the posterior distribution from the single chain output. Mean bias, root mean square error (RMSE), and mean 90% credibility interval widths were calculated for all proof tests to compare the predictive power of the baseline for each reporting group in terms of precision and accuracy. Mean bias indicates if there is a directional bias in the mean point estimate of the posterior (i.e., accuracy of the mean), RMSE shows the variability in the central tendency of the mean between replicates (i.e., precision of the posterior between replicates), and mean 90% credibility interval widths shows variation within the posterior for each replicate (i.e., precision of posterior within replicates).

Genetic Mixed-Stock Analysis

We estimated the stock composition of the commercial and subsistence fishery samples selected for MSA (mixtures) using the same BAYES protocol as was used for the proof tests, except that we ran 4 MCMC simulations of 40,000 iterations each and used informative Dirichlet priors. Informative Dirichlet priors were defined using a similar step-wise prior protocol as reported in Barclay et al. (2010b) except that for the first time–area stratum within a fishery for each year, the prior parameters were the posterior means from the first time–area of the same fishery from the previous year. For the initial time–area stratum for the 2014 samples, we used the same flat prior as was used in the proof tests. We formed the BAYES posterior distribution for each mixture from the last 20,000 iterations of each chain for a total length of 80,000 iterations. We assessed the among-chain convergence of these estimates in BAYES using the Gelman-Rubin shrink factor, which compares the variation of estimates within a chain to the total variation among chains (Gelman and Rubin 1992). If a shrink factor for any stock group estimate was greater than 1.2, we reanalyzed the mixture with 80,000-iteration chains following the same protocol. Stock proportion estimates and 90% credibility intervals for each mixture were calculated by taking the mean and 5% and 95% quantiles of the posterior distribution.

Stock-specific harvest estimates and 90% credibility intervals for each commercial fishery mixture were calculated by multiplying the reported harvest from that mixture by its unrounded estimates of reporting group proportions (obtained from MSA) and the upper and lower bounds of that estimate. Results were rounded to the nearest fish. We calculated the probability that a harvest estimate for a given reporting group is greater than or equal to 1 fish ($P \geq 1$) as the proportion of iterations in the posterior distribution of harvest estimates where the reporting group harvest was at least 1 fish.

We calculated the stock-specific harvest for subsistence mixtures in the same way as commercial mixtures; however, instead of multiplying the reporting group proportions by the reported harvest, we used the estimated harvest for each mixture (Table 2). The estimated harvest for each mixture was derived by multiplying the annual estimated subsistence Chinook salmon harvest by the proportion of the reported harvest for each mixture within that year.

Stratified Estimates

Estimates from early and late mixtures were combined into yearly harvest estimates for each area and each reporting group by weighting them by their respective harvests (stratified estimator) following the methods of Dann et al. (2009). These harvest estimates, including their upper and lower bounds, were divided by the total harvest from each area to derive the overall proportion and credibility interval of each reporting group in the harvest. This same method was used to combine mixture estimates from each area into annual stock-specific harvest estimates for the entire Northern District and the Tyonek subsistence fishery. The stratified estimates were calculated using the following method.

The harvest of Chinook salmon ($\hat{H}^g$) from reporting group *g* in the Northern District commercial fishery between the first opening as early as late May and the last opening on or before June 24 was estimated as follows:

$$\hat{H}^g = \sum_{i=1}^{T} \sum_{j=1}^{S} H_{i,j} \hat{p}_{i,j}^g \qquad (1)$$

where

$\hat{p}_{i,j}^g$ = estimated proportion of NCI harvest in time stratum *i* and geographic stratum *j* comprising Chinook salmon from reporting group *g* (*NCI Northwest*, *Susitna–Matanuska*, *Knik–Turnagain*, or *Kenai Peninsula*) obtained from Bayesian genetic mixed-stock analysis as described in the previous section.

$H_{i,j}$ = NCI Chinook salmon harvest in time stratum *i* and geographic stratum *j* obtained from commercial fish ticket data (reported harvest) or estimated from subsistence permit return data (estimated harvest; Table 2).

T = number of time strata (2: May 29–June 12 and June 13–30)

S = number of geographic strata (3: General Subdistrict (south) including Trading Bay and Tyonek stat areas, General Subdistrict (north), and Eastern Subdistrict).

The variance of the estimated number of Chinook salmon harvested from reporting group *g*, $\text{var}(\hat{H}^g)$, was estimated as

$$\text{var}(\hat{H}^g) = \sum_{i} \sum_{j} (H_{i,j})^2 \, \text{var}(\hat{p}_{i,j}^g) \qquad (2)$$

where $\text{var}(\hat{p}_{i,j}^g)$ comes from the Bayesian mixed-stock analysis (Pella and Masuda 2001).

Annual harvest of Chinook salmon ($\hat{H}^g$) by reporting group *g* from General Subdistrict (south), General Subdistrict (north), and the Eastern Subdistrict were estimated using Equations 1 and 2 with the appropriate substitutions for each fishing area (where *S* = 1).

Harvest of Chinook salmon ($\hat{H}^g$) by reporting group *g* from the Tyonek subsistence fishery was estimated using Equations 1 and 2 with the appropriate substitutions for the Tyonek fishery (where *S* = 1).

RESULTS

SAMPLE COLLECTION

Tissue Sampling

Sampling rates increased after 2014 as crews learned the best times and locations to intercept fish and built relationships with processors and fisherman. From 2014 through 2015, a total of 1,916 commercial fishery samples and 523 subsistence fishery samples were collected (grand total of 2,439; Table 2). The reported commercial harvest was 1,430 in 2014 and 1,794 in 2015. The proportion of reported commercial harvest sampled across all areas in the commercial fishery though 30 June was 48.6% in 2014 and 65.5% in 2015. Estimated harvest in the Tyonek subsistence fishery was 896 in 2014 and 1,070 in 2015 (Table 2; Jones and Koster 2018). The proportion of estimated subsistence harvest sampled in the Tyonek subsistence fishery was 21.9% in 2014 and 30.6% in 2015.

For the General Subdistrict (south) stratum, separate mixtures for Trading Bay and Tyonek commercial stat areas were produced because sampling rates in Trading Bay were much lower than Tyonek in 2014 and 2015. To produce a single harvest-proportional mixture of samples from both stat areas in these years, samples would have been excluded from the Tyonek stat area to match the sampling rate from Trading Bay, causing the mixture to drop below the minimum sample size requirement. For the General Subdistrict (north) and Eastern Subdistrict strata, samples were combined across stat areas to estimate stock composition for each area.

Age, Sex, and Length Estimates

Commercial

In 2014, the estimated age composition of all Chinook salmon sampled from the entire Northern District commercial set gillnet fishery was 6.0% age 1.1 (SE 0.8%), 27.9% age 1.2 (SE 1.7%), 41.3% age 1.3 (SE 1.8%), 23.1% age 1.4 (SE 1.6%), and 1.7% age 1.5 (SE 0.4%) (Table 3). The average length-at-age for each age group was as follows: 485 mm (SE 0 mm) for age 1.1, 592 mm (SE 4 mm) for age 1.2, 715 mm (SE 7 mm) for age 1.3, 824 mm (SE 7 mm) for age 1.4, and 922 mm (SE 0 mm) for age 1.5. The estimated sex ratio of sampled Chinook salmon was 47.0% female (Table 3).

In 2015, the estimated age composition of all Chinook salmon sampled from the entire Northern District commercial set gillnet fishery was 15.5% age 1.1 (SE 1.1%), 43.1% age 1.2 (SE 1.5%), 32.4% age 1.3 (SE 1.4%), 8.9% age 1.4 (SE 0.9%), and 0.1% age 1.5 (SE 0.1%) (Table 4). The average length-at-age for each age group was as follows: 521 mm (SE 5 mm) for age 1.1, 614 mm (SE 3 mm) for age 1.2, 767 mm (SE 4 mm) for age 1.3, 847 mm (SE 7 mm) for age 1.4, and 935 mm (SE 0 mm) for age 1.5. The estimated sex ratio of sampled Chinook salmon was 41.4% female (Table 4).

Age, sex, and length estimates of the commercial fishery by area can be found in Tables 5–10.

Subsistence

In 2014, the estimated age composition of all Chinook salmon sampled from the Tyonek subsistence set gillnet fishery was 5.9% age 1.1 (SE 1.8%), 18.4% age 1.2 (SE 3.0%), 37.5% age 1.3 (SE 3.7%), 32.4% age 1.4 (SE 3.6%), and 5.9% age 1.5 (SE 1.8%) (Table 11). The average length-at-age for each age group was as follows: 491 mm (SE 23) for age 1.1, 625 mm (SE 13 mm) for age 1.2, 710 mm (SE 13 mm) for age 1.3, 824 mm (SE 9 mm) for age 1.4, and 939 mm (SE 0 mm) for age 1.5. The estimated sex ratio of sampled Chinook salmon was 45.6% female (Table 11).

In 2015, the estimated age composition of all Chinook salmon sampled from the Tyonek subsistence set gillnet fishery was 7.3% age 1.1 (SE 1.2%), 28.3% age 1.2 (SE 2.1%), 52.7% age 1.3 (SE 2.4%), and 11.7% age 1.4 (SE 1.5%) (Table 12). The average length-at-age for each age group was as follows: 574 mm (SE 19 mm) for age 1.1, 660 mm (SE 7 mm) for age 1.2, 788 mm (SE 4 mm) for age 1.3, and 877 mm (SE 10 mm) for age 1.4. The estimated sex ratio of sampled Chinook salmon was 48.0% female (Table 12).

LABORATORY ANALYSIS

Assaying Genotypes

A total of 1,966 fish from the 2014 and 2015 Northern District commercial and Tyonek subsistence fisheries harvest samples were assayed for 39 SNP markers (Table 2).

Laboratory Failure Rates and Quality Control

Genotyping failure rates among the commercial and subsistence collections ranged from 0.30% to 1.41%. Discrepancy rates between original and QC analyses were uniformly low and ranged from 0.00% to 0.50%. Assuming equal error rates in the original and the QC analyses, estimated error rate in the samples is half of the discrepancy rate (0.00–0.25%).

STATISTICAL ANALYSIS

Data Retrieval and Quality Control

Sixteen of the assayed harvest individuals (0.01%) were removed from further analyses based upon the 80% rule. Ten tissue samples were identified as duplicates and were removed from further analyses. After removing fish based on the 80% rule and duplicates, 2,220 fish were available to subsample for MSA.

Subsampling for Mixed-Stock Analysis

Of the 2,220 genotyped fish available for MSA (for 2014 and 2015), 1,966 were subsampled in proportion to harvest to create 13 mixtures for MSA: 10 commercial and 3 subsistence mixtures, composing all temporal and geographic strata (Table 2 and Figure 3). Enough samples were available to represent both early and late commercial fishing periods in all but the following: Trading Bay stat area in both years; and the Tyonek stat area, General Subdistrict (north), and Eastern Subdistrict in 2014. In all of these cases but one (Trading Bay 2015), samples were combined to form mixtures representing the entire season. In 2015, the sample size requirement was not met over the entire season for Trading Bay; therefore, no mixture was created for MSA.

Baseline Evaluation for Mixed-Stock Analysis

100% Proof Tests

The mean percent correctly allocated for all 10 replicate 100% proof tests for each of the 4 reporting groups ranged from 85.0% to 95.5% (Table 13 and Figure 4). The *Knik–Turnagain* and *Kenai Peninsula* reporting groups had the highest mean correct allocations across all repeated tests, averaging 93.7% (RMSE 6.7%; 90% credibility interval width 14.4%) and 95.5% (RMSE

5.8%; 90% credibility interval width 9.8%), respectively. The *NCI Northwest* and *Susitna–Matanuska* allocations had more variation in correct allocations which averaged 89.1% (RMSE 12.7%; 90% credibility interval width 26.6%) and 85.0% (RMSE 16.4%; 90% credibility interval width 33.6%), respectively. *NCI Northwest* and *Susitna–Matanuska* fish misallocated primarily to each other at 8.3% and 11.3%, respectively. *Knik–Turnagain* fish misallocated primarily to *NCI Northwest* (2.7%) and *Susitna–Matanuska* (2.3%), and likewise, *NCI Northwest* and *Susitna–Matanuska* fish misallocated to *Knik–Turnagain* at 2.0% and 2.8%, respectively. *Kenai Peninsula* fish misallocated small percentages to *Susitna–Matanuska* (2.3%), *Knik–Turnagain* (1.5%), and *NCI Northwest* (0.6%), and misallocations of fish from these groups to *Kenai Peninsula* were less than 1.3%.

Fishery Scenario Tests

The average stock compositions by each reporting group for all 10 replicate fishery scenario tests were within 3.1% of their true values (i.e., 25%; Table 14 and Figure 5). Stock composition estimates for *NCI Northwest* and *Knik–Turnagain* were biased higher than their true percentage and averaged 27.4% (RMSE 7.4; 90% credibility interval width 32.5%) and 26.9% (RMSE 7.5; 90% credibility interval width 33.0%), respectively. Stock composition estimates for *Susitna–Matanuska* and *Kenai Peninsula* were biased lower than their true percentage and averaged 21.9% (RMSE 9.8; 90% credibility interval width 34.1%) and 23.8% (RMSE 4.0; 90% credibility interval width 19.3%), respectively.

Genetic Mixed-Stock Analysis

MSA was performed on the 13 mixtures created during the subsampling process to produce stock composition and stock-specific harvest estimates (Tables 15–23 and Figures 6–9). Figure 3 illustrates the levels of strata used in the MSA and how the lowest-level strata were combined into higher-level strata using the stratified estimator. This figure also guides the reader to the tables containing results for each level of analysis.

Estimates by Time and Area

In most cases, the temporal stock composition estimates (early and late) within a year and area (that is, estimates at the lowest stratum level) were similar (Tables 16–19). However, in 2015, the dominant reporting group in the Tyonek commercial fishery shifted from *Susitna–Matanuska* in the early period (57.6%) to *NCI Northwest* in the later period (72.2%) (Table 16). A similar shift in dominant reporting group occurred in the 2015 Tyonek subsistence fishery, where the contributions of *Susitna–Matanuska* and *Knik–Turnagain* reporting groups were a substantial proportion of the harvest in the early period (24.0% and 26.1%, respectively) but dropped to 7.2% and 4.4%, respectively, during the late period when *NCI Northwest* was highly dominant (49.8% in the early period vs. 88.3% in the late period) (Table 19).

Annual Estimates

The MSA estimates from the initial MSA mixtures were stratified to produce annual stock composition and stock-specific harvest estimates for the General Subdistrict (south) (2014 and 2015), General Subdistrict (north) (2015), Eastern Subdistrict (2015), the entire Northern District (2014–2015) commercial fishery, and the entire Tyonek subsistence fishery (2015) (Figure 3). The estimates reported in the following sections include these stratified estimates and annual estimates from the initial MSA mixtures.

Annual commercial estimates by area

In 2014 and 2015, annual Chinook salmon harvests in the General Subdistrict (south) area (Trading Bay and Tyonek commercial) were 814 (estimated) and 750, respectively (Tables 2, 15, 16, 20, and 21). Over 2014 and 2015, stock composition estimates were greatest for the *NCI Northwest* (range: 47.7–61.4%) and *Susitna–Matanuska* (range: 35.0–40.5%) reporting groups followed by the *Knik–Turnagain* (range: 3.6–10.1%) and *Kenai Peninsula* (range: 0.0–1.7%) reporting groups (Tables 20 and 21, Figures 6 and 7). In 2014, contributions of *NCI Northwest* (47.7%) and *Susitna–Matanuska* (40.5%) were similar. In 2015, the contribution of *NCI Northwest* (61.4%) was greater than *Susitna–Matanuska* (35.0%); however, only 51% of the harvest was represented by samples in 2015 (Table 21).

In 2014 and 2015, annual Chinook salmon harvests in the General Subdistrict (north) were 398 and 674, respectively (Tables 2, 17, 20, and 21). Harvests were dominated by the *Knik–Turnagain* reporting group (range: 71.2–89.4%; Tables 20 and 21, Figures 6 and 7), particularly in the late fishing period in 2015, when nearly all the harvest was the *Knik–Turnagain* reporting group (97.6%; Table 17). The remaining harvests were represented by smaller contributions of *Susitna–Matanuska* (range: 8.1–18.7%) and *NCI Northwest* (range: 2.5–9.1%) (Tables 20 and 21, Figures 6 and 7).

In 2014 and 2015, annual Chinook salmon harvests in the Eastern Subdistrict were 326 and 360, respectively (Tables 2, 18, 20, and 21). In 2014, the *NCI Northwest*, *Susitna–Matanuska*, and *Knik–Turnagain* reporting groups had similar stock contributions (range: 27.6–36.3%; Table 20). In 2015, the *Knik–Turnagain* reporting group composed the majority of the harvest (56.0%) and most of the remaining contributions to the harvests were from the *NCI Northwest* (26.7%) and *Susitna–Matanusk*a reporting groups (17.1%) (Table 21). The contribution of the *Kenai Peninsula* reporting group was 1.8% in 2014 and less than 1% in 2015 (Tables 20 and 21, Figures 6 and 7).

Annual Northern District commercial estimates

In the overall 2014–2015 Northern District commercial fishery harvests, *NCI Northwest*, *Susitna–Matanuska*, and *Knik–Turnagain* were the dominant reporting groups, with combined contributions of 98.4% and 99.9%, respectively (Table 22, Figure 8). In 2014, contributions of *NCI Northwest*, *Susitna–Matanuska*, and *Knik–Turnagain* reporting groups were similar, ranging from 30.3% to 34.9%. In 2015, the greatest contribution of the harvest was represented by the *Knik–Turnagain* reporting group (58.0%), followed by *NCI Northwest* (24.4%) and *Susitna–Matanuska* (17.6%); however, a large portion of the harvest (368 fish from Trading Bay) was not represented, and this omission probably influenced the overall stock composition estimates.

Annual Tyonek subsistence estimates

In 2014 and 2015, estimated annual Chinook salmon harvests by Tyonek subsistence users were 896 and 1,070 fish respectively (Table 23). In both the 2014 and 2015 Tyonek subsistence harvests, the *NCI Northwest* reporting group was the largest contributor (56.6% and 79.0%, respectively) followed by the *Susitna–Matanuska* (39.2% and 11.2%, respectively) and *Knik–Turnagain* reporting groups (2.5% and 9.6%, respectively; Table 23, Figure 9).

DISCUSSION

This report includes baseline evaluation test results for the Cook Inlet Chinook salmon baseline (Barclay and Habicht 2015) and the MSA of harvest samples collected from the Northern District commercial set gillnet and the Tyonek subsistence fisheries. These results represent the first MSA of Chinook salmon captured in NCI fisheries.

BASELINE EVALUATION TESTS

A key objective of this project was to estimate harvest of NCI Chinook salmon stocks including stocks from the west side of Cook Inlet and the Susitna River drainage. When this project was proposed (Barclay et al. 2012), available data indicated that Kenai Peninsula stocks were genetically distinct enough to represent a reporting group for MSA applications. However, these data also indicated that one of the major tributaries of the Susitna River drainage, the Yentna River, was too similar genetically to western Cook Inlet stocks to be estimated separately in an MSA, leading to the broader reporting group *NCI Northwest*. These initial tests also indicated that misallocation can occur between this broader reporting group and the remaining NCI reporting groups *Susitna–Matanuska* and *Knik–Turnagain*. At the time, all of these reporting groups were missing baseline populations, and we anticipated improved MSA performance once the baseline was augmented. During this project, the baseline for these areas was augmented by other studies (Barclay and Habicht 2015). This new augmented baseline was used for the MSA analyses presented here, but misallocations among NCI reporting groups still persisted. Our standard criterion for defining reporting groups is greater than 90% correct allocation in 100% proof tests. Although *Knik–Turnagain* performance improved and *Kenai Peninsula* continued to perform well, *NCI Northwest* (89.1%) and *Susitna–Matanuska* (85.0%) showed subpar performance (Table 13). We decided to retain all 4 reporting groups because they were close to our standard criteria and because of the value in estimating the contribution of Susitna River fish to the NCI fisheries. The Susitna River including its tributaries above the Yentna River is the largest Chinook salmon producing system in NCI and has some of the highest sport fishing participation rates in the state (Oslund et al. 2017).

Misallocation biases observed in the baseline evaluation tests are informative when interpreting results from this study (Tables 13 and 14). Estimates for *Kenai Peninsula* and *Knik–Turnagain* reporting groups contain low bias, whereas estimates for the *NCI Northwest* and *Susitna–Matanuska* reporting groups suggest they may be trading misallocations with each other. These differences in MSA performance among reporting groups are captured in the large credibility intervals observed for *NCI Northwest* and *Susitna–Matanuska* reporting group estimates compared with *Kenai Peninsula* and *Knik–Turnagain* reporting group estimates (Figure 4).

REPRESENTATION OF HARVESTS

Due to the small relative sizes of the Northern District commercial and Tyonek subsistence Chinook salmon fisheries compared to other commercial fisheries sampled by ADF&G, minimum sample size requirements of 100 representative samples per *a priori* strata (early and late within a year and area) were sometimes difficult to achieve. Therefore, to achieve sample size goals, we allowed the use of surplus samples from one collection day to represent harvest on other days, provided the samples were taken within 7 days and within the same stratum. The general stability in stock composition estimates over entire seasons gave us confidence that this procedure accurately represented harvest.

In most cases, harvests were fully represented for time and area strata, with the following exceptions. In 2014 and 2015, annual stratified stock composition and stock-specific harvest estimates for the General Subdistrict (south) and the whole Northern District do not represent the entire harvest, and caution should be used when interpreting these results (Figure 3). The Trading Bay statistical area (247-10) is the most remote and deliveries from this area proved to be the least predictable. In the Trading Bay statistical area, harvest samples were only available to represent the first half of the season in 2014, and the minimum sample size of 100 harvest samples could not be met to represent the entire season's harvest in 2015. This lack of representative sampling probably influenced the estimates for the General Subdistrict (south) and Northern District stratified stock compositions in these years (Tables 20–22; Figures 6–8). The greatest unrepresented harvest occurred in 2015 when only the Tyonek statistical area harvest samples could be used to represent the General Subdistrict (south) (Table 21, Figure 7). The difference in annual stock composition patterns observed in 2015 compared to 2014 may be attributed to this unrepresented harvest (Tables 20 and 21, Figures 6 and 7).

MAKING INFERENCES OUTSIDE STUDY YEARS

These analyses are derived from samples collected during a specific period with particular environmental and fishery conditions. Nonetheless, this study can be used to inform future scientific and regulatory activities. These results were derived from the most comprehensive data set available to examine stock composition of Chinook salmon captured in the Northern District commercial and Tyonek subsistence fisheries. However, although this 2-year data set provides some measure of interannual variability in stock compositions, caution must be exercised when extrapolating these results to unanalyzed years because changes in relative abundances among reporting groups, prosecution of fisheries, or migratory behavior due to ocean conditions might affect the distribution of stock-specific harvests by time and area.

FUTURE WORK

Additional samples will be collected in 2016 and 2017 under this grant and another from the Pacific States Marine Fishery Commission (PSMFC), adding an additional 2 years to the data set reported here.

Additional analyses are planned in the future that may increase the power of the baseline for detecting finer-scale reporting groups. The inability of the baseline described here to distinguish between some NCI Chinook salmon stocks prompted a new study, funded by PSMFC, which proposed to develop a new baseline dataset with up to 500 new genetic markers for 26 Cook Inlet populations. One of the objectives of the new baseline study was to improve the genetic identifiability of Cook Inlet stocks and to allow for finer resolution of MSA in Cook Inlet.

An extension to this project was also granted by the Alaska Sustainable Salmon Fund (AKSSF) that will add an additional 16 populations to the 26 populations in the PSMFC study being analyzed for the new set of markers. If tests of the new baseline are successful in demonstrating that westside Cook Inlet and Yentna River stocks can be separated for MSA, the Northern District commercial and Tyonek subsistence samples from 2016 and 2017 will be analyzed for the new set of genetic markers, and MSA will be conducted using the finer-scale reporting groups. If baseline tests are unsuccessful, an additional 12 Cook Inlet Chinook salmon populations will be analyzed for the new set of markers to increase baseline representation and MSA of the 2016 and 2017 samples will be conducted using the most informative reporting groups possible. Stock-specific harvests of Chinook salmon determined by this MSA will give managers and policy makers a greater understanding of where and when various NCI stocks are harvested and at what rate.

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TABLES

Table 1.–Populations of Chinook salmon in the Upper Cook Inlet genetic baseline, including the sampling location, collection years, number of individuals sampled from each population, and reporting groups for mixed-stock analysis of the Tyonek subsistence fishery and Northern District commercial fishery harvests.

Pop. no.	Reporting group	Geographic region	Location	Collection Year(s)	*n*
1	*NCI Northwest*	West Side	Straight Creek	2010	95
2		Cook Inlet	Chuitna River	2008, 2009	134
3			Coal Creek	2009, 2010, 2011	118
4			Theodore River	2010, 2011, 2012	191
5			Lewis River	2011, 2012	87
6		Yentna River	Red Creek	2012, 2013	111
7			Hayes River	2012, 2013	50
8			Canyon Creek	2012, 2013	91
9			Talachulitna River	1995, 2008, 2010	178
10			Sunflower Creek	2009, 2011	123
11			Peters Creek	2009, 2010, 2011, 2012	107
12		Susitna River	Sucker Creek (Alexander Cr trib)	2011, 2012	144
13	*Susitna–Matanuska*	Susitna River	Portage Creek	2009, 2010, 2011, 2013	162
14			Indian River	2013	79
15			Chulitna R. middle fork	2009, 2010	169
16			Chulitna R. east fork	2009, 2010, 2011, 2013	77
17			Byers Creek	2013	55
18			Spink Creek	2013	56
19			Troublesome Creek	2013	71
20			Bunco Creek	2013	99
21			Upper Talkeetna trib	2013	69
22			Prairie Creek	1995, 2008	162
23			Iron Creek	2013	57
24			Disappointment Creek	2013	64
25			Chunilna Creek	2009, 2012	80
26			Montana Creek	2008, 2009, 2010	213
27			Little Willow Creek	2013	54
28			Willow Creek	2005, 2009	170
29			Deshka River	1995, 2012, 2005	303
30		Knik Arm	Moose Creek	1995, 2008, 2009, 2012	149
31	*Knik–Turnagain*	Knik Arm	Little Susitna River	2009, 2010	124
32			Eagle River	2009, 2011, 2012	77
33			Ship Creek	2009	268
34		Turnagain Arm	Campbell Creek	2010, 2011, 2012	110
35			Carmen River	2011, 2012	50
36			Resurrection Creek	2010, 2011, 2012	97
37			Chickaloon River	2008, 2010, 2011	128

-continued-

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Pop. no.	Reporting group	Geographic region	Location	Collection Year(s)	*n*
38	*Kenai Peninsula*	Kenai River	Grant Creek	2011, 2012	55
39			Quartz Creek	2006, 2007,2008, 2009, 2010, 2011	131
40			Crescent Creek	2006	163
41			Juneau Creek	2005, 2006, 2007	142
42			Russian River	2005, 2006, 2007, 2008	214
43			Kenai Upper Mainstem	2009	191
44			Benjamin Creek	2005, 2006	204
45			Killey River	2005, 2006	255
46			Funny River	2005, 2006	219
47			Kenai Middle Mainstem	2003, 2004, 2006	299
48			Kenai Lower Mainstem	2010, 2011	126
49			Slikok Creek	2004, 2005, 2008	137
50		Kasilof River	Kasilof River Mainstem	2005	316
51			Crooked Creek	2005, 2011	306
52		Coastal Kenai Peninsula	Ninilchik River	2006, 2010	209
53			Deep Creek	2009, 2010	196
54			Stariski Creek	2011, 2012	99
55			Anchor River	2006, 2010	250

Note: Populations and reporting groups match those in Figure 2.

Table 2.–Chinook salmon collection details by time and area used in genetic mixed-stock analysis (MSA) of northern Cook Inlet marine fisheries, 2014 and 2015.

			Harvest		Samples		Analyzed for MSA	
Year	Geographic area [a]	Date range	Reported	Estimated [b]	Number	Percent	Number	Percent
2014								
	Trading Bay	May 29–June 16	491	–	133	27.1%	131	26.7%
	Trading Bay	June 17–30	51	–	0	0.0%	–	–
	Tyonek commercial	May 29–June 30	164	272 [c]	174	64.0%	121	44.5%
	General Subdistrict (north)	May 29–June 30	398	–	302	75.9%	236	59.3%
	Eastern Subdistrict	May 29–June 30	326	–	138	42.3%	130	39.9%
	Tyonek subsistence	May 16–June 30	714	896	196	21.9%	196	21.9%
2015								
	Trading Bay	May 29–June 30	368	–	68 [d]	18.5%	–	–
	Tyonek commercial	May 29–June 12	114	–	118 [e]	103.5% [e]	118	103.5% [e]
	Tyonek commercial	June 13–30	268	–	201	75.0%	173	64.6%
	General Subdistrict (north)	May 29–June 12	343	–	234	68.2%	134	39.1%
	General Subdistrict (north)	June 13–22	331	–	228	68.9%	133	40.2%
	Eastern Subdistrict	May 29–June 12	208	–	213 [e]	102.4% [e]	188	90.4%
	Eastern Subdistrict	June 13–30	152	–	107	70.4%	100	65.8%
	Tyonek subsistence	May 16–31	234 [f]	260	105	40.3%	105	40.3%
	Tyonek subsistence	June 1–20	727 [f]	810	222	27.4%	201	24.8%
Total (number) or average (percent)			4,997		2,439	60.5%	1,966	50.4%

[a] Refers to the Northern District commercial fishery unless subsistence is explicitly stated.

[b] Estimated subsistence harvest numbers for each stratum were obtained by multiplying the seasonal harvest estimates (Jones and Koster 2018) by the proportion of the reported harvest for each stratum.

[c] Includes an additional unreported harvest of 108 fish known to have occurred.

[d] Minimum sample size (100) was not met, so no MSA was conducted.

[e] More fish were sampled than were reported as harvest.

[f] Subsistence harvest numbers for 2015 include 210 fish with unknown harvest dates; these were divided into early and late strata by the proportion of the total known harvest for early (0.24) and late (0.76) fishing periods.

Table 3.–Age, sex, and length composition of Chinook salmon harvested in the Northern District commercial set gillnet fishery, 2014.

		Age class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Sample size by age	8	61	115	82	4	270
	Age composition	1.4%	10.4%	19.9%	14.8%	0.5%	47.0%
	SE (age composition)	0.5%	1.1%	1.5%	1.3%	0.2%	1.8%
	Harvest by age	22	160	306	228	7	723
	SE (harvest by age)	7	18	23	21	2	28
	Mean length (mm METF)	510	600	743	828	900	733
	SE (mean length)	16	6	8	7	0	7
Males							
	Sample size by age	31	100	119	41	7	298
	Age composition	4.6%	17.5%	21.4%	8.3%	1.2%	53.0%
	SE (age composition)	0.6%	1.4%	1.5%	1.1%	0.4%	1.8%
	Harvest by age	70	270	329	127	19	815
	SE (harvest by age)	9	22	23	17	6	28
	Mean length (mm METF)	477	586	688	818	930	662
	SE (mean length)	0	4	10	13	0	8
Both							
	Sample size by age	39	161	234	123	11	568
	Age composition	6.0%	27.9%	41.3%	23.1%	1.7%	100.0%
	SE (age composition)	0.8%	1.7%	1.8%	1.6%	0.4%	0.0%
	Harvest by age	93	429	635	355	26	1,538
	SE (harvest by age)	12	26	27	25	7	0
	Mean length (mm METF)	485	592	715	824	922	695
	SE (mean length)	0	4	7	7	0	6

Table 4.–Age, sex, and length composition of Chinook salmon harvested in the Northern District commercial set gillnet fishery, 2015.

		Age class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Sample size by age	14	96	142	36	0	288
	Age composition	2.0%	13.4%	20.5%	5.4%	0.0%	41.4%
	SE (age composition)	0.5%	1.1%	1.3%	0.7%	0.0%	1.5%
	Harvest by age	36	240	366	96	0	738
	SE (harvest by age)	8	19	23	13	0	27
	Mean length (mm METF)	534	617	771	832	0	717
	SE (mean length)	16	6	5	9	0	6
Males							
	Sample size by age	99	225	86	26	1	437
	Age composition	13.4%	29.6%	11.9%	3.5%	0.1%	58.6%
	SE (age composition)	1.0%	1.4%	0.9%	0.5%	0.1%	1.5%
	Harvest by age	239	529	213	63	3	1,046
	SE (harvest by age)	18	24	17	9	2	27
	Mean length (mm METF)	520	612	759	870	935	637
	SE (mean length)	5	4	7	0	0	5
Both							
	Sample size by age	113	321	228	62	1	725
	Age composition	15.5%	43.1%	32.4%	8.9%	0.1%	100.0%
	SE (age composition)	1.1%	1.5%	1.4%	0.9%	0.1%	0.0%
	Harvest by age	276	769	578	159	3	1,784
	SE (harvest by age)	20	27	25	16	2	0
	Mean length (mm METF)	521	614	767	847	935	670
	SE (mean length)	5	3	4	7	0	4

Table 5.–Age, sex, and length composition of Chinook salmon harvested in the Eastern Subdistrict of the Northern District commercial set gillnet fishery, 2014.

		Age class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Sample size by age	0	5	19	13	0	37
	Age composition	0.0%	4.0%	15.1%	10.3%	0.0%	29.4%
	SE (age composition)	0.0%	1.4%	2.5%	2.1%	0.0%	3.2%
	Harvest by age	0	13	49	34	0	96
	SE (harvest by age)	0	4	8	7	0	10
	Mean length (mm METF)	0	635	737	852	0	764
	SE (mean length)	0	20	18	27	0	18
Males							
	Sample size by age	19	25	35	9	1	89
	Age composition	15.1%	19.8%	27.8%	7.1%	0.8%	70.6%
	SE (age composition)	2.5%	2.8%	3.1%	1.8%	0.6%	3.2%
	Harvest by age	49	65	91	23	3	230
	SE (harvest by age)	8	9	10	6	2	10
	Mean length (mm METF)	472	571	698	906	935	638
	SE (mean length)	10	11	19	31	0	16
Both							
	Sample size by age	19	30	54	22	1	126
	Age composition	15.1%	23.8%	42.9%	17.5%	0.8%	100.0%
	SE (age composition)	2.5%	3.0%	3.5%	2.7%	0.6%	0.0%
	Harvest by age	49	78	140	57	3	326
	SE (harvest by age)	8	10	11	9	2	0
	Mean length (mm METF)	472	582	712	874	935	675
	SE (mean length)	10	10	14	21	0	14

Table 6.–Age, sex, and length composition of Chinook salmon harvested in the General Subdistrict (north) of the Northern District commercial set gillnet fishery, 2014.

		Age class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Sample size by age	6	39	47	34	4	130
	Age composition	2.9%	18.2%	21.3%	16.0%	1.9%	60.3%
	SE (age composition)	0.8%	1.8%	1.9%	1.7%	0.6%	2.1%
	Harvest by age	12	72	85	64	7	240
	SE (harvest by age)	3	7	7	7	2	9
	Mean length (mm METF)	516	598	747	829	900	718
	SE (mean length)	17	7	12	10	14	11
Males							
	Sample size by age	11	39	27	9	4	90
	Age composition	4.6%	17.4%	11.7%	4.1%	1.9%	39.7%
	SE (age composition)	0.8%	1.7%	1.4%	0.9%	0.7%	2.1%
	Harvest by age	18	69	47	16	8	158
	SE (harvest by age)	3	7	6	4	3	9
	Mean length (mm METF)	479	598	751	810	963	667
	SE (mean length)	27	7	21	35	0	15
Both							
	Sample size by age	17	78	74	43	8	220
	Age composition	7.5%	35.6%	33.1%	20.1%	3.8%	100.0%
	SE (age composition)	1.2%	2.2%	2.1%	1.8%	0.9%	0.0%
	Harvest by age	30	142	132	80	15	398
	SE (harvest by age)	5	9	8	7	4	0
	Mean length (mm METF)	492	598	748	825	932	697
	SE (mean length)	19	5	11	11	0	9

Table 7.–Age, sex, and length composition of Chinook salmon harvested in the General Subdistrict (south) of the Northern District commercial set gillnet fishery, 2014.

		Age class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Sample size by age	2	17	49	35	0	103
	Age composition	1.3%	9.1%	21.2%	16.0%	0.0%	47.6%
	SE (age composition)	0.8%	1.9%	2.4%	2.3%	0.0%	3.0%
	Harvest by age	11	74	172	130	0	388
	SE (harvest by age)	7	15	20	18	0	25
	Mean length (mm METF)	504	596	744	820	0	735
	SE (mean length)	28	11	11	10	0	11
Males							
	Sample size by age	1	36	57	23	2	119
	Age composition	0.4%	16.7%	23.5%	10.8%	1.0%	52.4%
	SE (age composition)	0.3%	2.3%	2.4%	1.9%	0.7%	3.0%
	Harvest by age	3	136	192	88	8	426
	SE (harvest by age)	2	19	20	16	5	25
	Mean length (mm METF)	550	589	670	797	899	674
	SE (mean length)	0	5	14	17	0	11
Both							
	Sample size by age	3	53	106	58	2	222
	Age composition	1.7%	25.8%	44.7%	26.8%	1.0%	100.0%
	SE (age composition)	0.9%	2.7%	2.9%	2.7%	0.7%	0.0%
	Harvest by age	14	210	364	218	8	814
	SE (harvest by age)	7	22	24	22	5	0
	Mean length (mm METF)	514	591	705	811	899	703
	SE (mean length)	0	5	9	9	0	8

Table 8.–Age, sex, and length composition of Chinook salmon harvested in the Eastern Subdistrict of the Northern District commercial set gillnet fishery, 2015.

		Age class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Sample size by age	2	17	28	6	0	53
	Age composition	1.1%	8.8%	14.2%	3.1%	0.0%	27.2%
	SE (age composition)	0.5%	1.4%	1.6%	0.8%	0.0%	2.1%
	Harvest by age	4	32	51	11	0	98
	SE (harvest by age)	2	5	6	3	0	8
	Mean length (mm METF)	548	647	764	845	0	727
	SE (mean length)	8	15	9	22	0	12
Males							
	Sample size by age	56	71	10	3	0	140
	Age composition	29.1%	37.0%	5.1%	1.6%	0.0%	72.8%
	SE (age composition)	2.2%	2.4%	1.1%	0.6%	0.0%	2.1%
	Harvest by age	105	133	19	6	0	262
	SE (harvest by age)	8	9	4	2	0	8
	Mean length (mm METF)	506	603	749	870	0	580
	SE (mean length)	9	6	19	18	0	8
Both							
	Sample size by age	58	88	38	9	0	193
	Age composition	30.2%	45.8%	19.4%	4.7%	0.0%	100.0%
	SE (age composition)	2.3%	2.4%	1.9%	1.0%	0.0%	0.0%
	Harvest by age	109	165	70	17	0	360
	SE (harvest by age)	8	9	7	4	0	0
	Mean length (mm METF)	508	612	760	853	0	621
	SE (mean length)	9	6	8	15	0	8

Table 9.–Age, sex, and length composition of Chinook salmon harvested in the General Subdistrict (north) of the Northern District commercial set gillnet fishery, 2015.

		Age class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Sample size by age	6	48	42	15	0	111
	Age composition	2.5%	19.1%	19.3%	7.0%	0.0%	47.9%
	SE (age composition)	0.9%	2.2%	2.4%	1.6%	0.0%	2.9%
	Harvest by age	17	129	130	47	0	323
	SE (harvest by age)	6	15	16	11	0	19
	Mean length (mm METF)	544	615	757	822	0	698
	SE (mean length)	17	6	10	13	0	10
Males							
	Sample size by age	33	76	15	4	0	128
	Age composition	16.2%	29.1%	5.6%	1.2%	0.0%	52.1%
	SE (age composition)	2.3%	2.5%	1.2%	0.4%	0.0%	2.9%
	Harvest by age	109	196	38	8	0	351
	SE (harvest by age)	15	17	8	3	0	19
	Mean length (mm METF)	533	600	718	888	0	598
	SE (mean length)	8	6	18	30	0	8
Both							
	Sample size by age	39	124	57	19	0	239
	Age composition	18.7%	48.2%	24.9%	8.2%	0.0%	100.0%
	SE (age composition)	2.4%	2.8%	2.5%	1.6%	0.0%	0.0%
	Harvest by age	126	325	168	55	0	674
	SE (harvest by age)	16	19	17	11	0	0
	Mean length (mm METF)	534	606	748	832	0	646
	SE (mean length)	7	4	9	12	0	7

Table 10.–Age, sex, and length composition of Chinook salmon harvested in the General Subdistrict (south) of the Northern District commercial set gillnet fishery, 2015.

		Age class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Sample size by age	6	31	72	15	0	124
	Age composition	2.0%	10.6%	24.6%	5.1%	0.0%	42.3%
	SE (age composition)	0.6%	1.4%	2.0%	1.0%	0.0%	2.3%
	Harvest by age	15	79	184	38	0	317
	SE (harvest by age)	5	11	15	8	0	17
	Mean length (mm METF)	518	609	784	839	0	734
	SE (mean length)	34	12	7	13	0	10
Males							
	Sample size by age	10	78	61	19	1	169
	Age composition	3.4%	26.6%	20.8%	6.5%	0.3%	57.7%
	SE (age composition)	0.8%	2.0%	1.9%	1.1%	0.3%	2.3%
	Harvest by age	26	200	156	49	3	433
	SE (harvest by age)	6	15	14	8	2	17
	Mean length (mm METF)	523	630	770	867	935	703
	SE (mean length)	17	7	8	15	0	9
Both							
	Sample size by age	16	109	133	34	1	293
	Age composition	5.5%	37.2%	45.4%	11.6%	0.3%	100.0%
	SE (age composition)	1.0%	2.2%	2.3%	1.5%	0.3%	0.0%
	Harvest by age	41	279	340	87	3	750
	SE (harvest by age)	8	17	17	11	2	0
	Mean length (mm METF)	521	624	777	855	935	716
	SE (mean length)	16	6	5	10	0	7

Table 11.–Age, sex, and length composition of Chinook salmon harvested in the Tyonek subsistence gillnet fishery, 2014.

		Age class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Sample size by age	2	9	22	23	6	62
	Age composition	1.5%	6.6%	16.2%	16.9%	4.4%	45.6%
	SE (age composition)	0.9%	1.9%	2.9%	2.9%	1.6%	3.9%
	Harvest by age	10	47	115	120	31	325
	SE (harvest by age)	7	14	20	21	11	27
	Mean length (mm METF)	535	610	683	819	928	742
	SE (mean length)	25	13	19	9	10	15
Males							
	Sample size by age	6	16	29	21	2	74
	Age composition	4.4%	11.8%	21.3%	15.4%	1.5%	54.4%
	SE (age composition)	1.6%	2.5%	3.2%	2.8%	0.9%	3.9%
	Harvest by age	31	84	152	110	10	387
	SE (harvest by age)	11	18	23	20	7	27
	Mean length (mm METF)	477	634	731	829	970	724
	SE (mean length)	28	18	17	15	0	15
Both							
	Sample size by age	8	25	51	44	8	136
	Age composition	5.9%	18.4%	37.5%	32.4%	5.9%	100.0%
	SE (age composition)	1.8%	3.0%	3.7%	3.6%	1.8%	0.0%
	Harvest by age	42	131	267	230	42	712
	SE (harvest by age)	13	21	27	26	13	0
	Mean length (mm METF)	491	625	710	824	939	732
	SE (mean length)	23	13	13	9	0	11

Table 12.–Age, sex, and length composition of Chinook salmon harvested in the Tyonek subsistence set gillnet fishery, 2015.

		Age class					
Sex	Parameter	1.1	1.2	1.3	1.4	1.5	All ages
Females							
	Sample size by age	9	37	79	19	0	144
	Age composition	3.0%	12.3%	26.3%	6.3%	0.0%	48.0%
	SE (age composition)	0.8%	1.6%	2.1%	1.2%	0.0%	2.4%
	Harvest by age	28	115	245	59	0	446
	SE (harvest by age)	8	15	19	11	0	22
	Mean length (mm METF)	563	670	786	875	0	754
	SE (mean length)	36	13	4	12	0	8
Males							
	Sample size by age	13	48	79	16	0	156
	Age composition	4.3%	16.0%	26.3%	5.3%	0.0%	52.0%
	SE (age composition)	1.0%	1.7%	2.1%	1.1%	0.0%	2.4%
	Harvest by age	40	149	245	50	0	483
	SE (harvest by age)	9	16	19	10	0	22
	Mean length (mm METF)	582	652	791	878	0	740
	SE (mean length)	21	8	7	16	0	9
Both							
	Sample size by age	22	85	158	35	0	300
	Age composition	7.3%	28.3%	52.7%	11.7%	0.0%	100.0%
	SE (age composition)	1.2%	2.1%	2.4%	1.5%	0.0%	0.0%
	Harvest by age	68	263	489	108	0	929
	SE (harvest by age)	12	20	22	14	0	0
	Mean length (mm METF)	574	660	788	877	0	747
	SE (mean length)	19	7	4	10	0	6

Table 13.–Results from 10 replicates of 100% proof tests of the Cook Inlet Chinook salmon genetic baseline using 39 loci for each reporting group.

	Reporting group mixture [a]															
	NCI Northwest				*Susitna–Matanuska*				*Knik–Turnagain*				*Kenai Peninsula*			
Reporting group	Mean [b]	Bias	RMSE [c]	CI width	Mean [b]	Bias	RMSE [c]	CI width	Mean [b]	Bias	RMSE [c]	CI width	Mean [b]	Bias	RMSE [c]	CI width
NCI Northwest	**89.1**	−10.9	12.7	26.6	11.3	11.3	12.8	30.1	2.7	2.7	3.2	9.7	0.6	0.6	0.7	2.9
Susitna–Matanuska	8.3	8.3	10.4	24.1	**85.0**	−15	16.4	33.6	2.3	2.3	2.5	8.5	2.3	2.3	3.7	7
Knik–Turnagain	2.0	2.0	2.3	7.4	2.8	2.8	3.3	10.1	**93.7**	−6.3	6.7	14.4	1.5	1.5	1.8	5.8
Kenai Peninsula	0.6	0.6	0.7	2.9	0.9	0.9	0.9	3.9	1.3	1.3	1.6	4.8	**95.5**	−4.5	5.8	9.8

Note: Bold shaded values indicate correct allocations. Stock composition estimates (mean percentage contributions) may not sum to 100 due to rounding error.

[a] Each replicate comprised 200 individuals sampled from 1 of 4 reporting groups in the genetic baseline. There were 10 replicates for each reporting group.

[b] Mean contribution.

[c] Root mean square error.

Table 14.–Estimates of average stock composition (percent by stock), bias, root mean square error (RMSE), and 90% credibility interval (CI) width for 10 replicates of fishery scenario proof tests of the Cook Inlet Chinook salmon genetic baseline with 39 loci.

Reporting group	True percentage	Average	Bias	RMSE	CI Width
NCI Northwest	25.0	27.4	2.4	7.4	32.5
Susitna–Matanuska	25.0	21.9	−3.1	9.8	34.1
Knik–Turnagain	25.0	26.9	1.9	7.5	33.0
Kenai Peninsula	25.0	23.8	−1.2	4.0	19.3

Note: Each replicate was a sample of 50 individuals from each reporting group (total of 200 individuals) removed from the genetic baseline.

Table 15.–Stock composition (%) and stock-specific harvest estimates based on genetic data for Chinook salmon harvested in the Trading Bay and Tyonek statistical areas of the Northern District commercial set gillnet fishery of Cook Inlet, Alaska, 2014.

	Trading Bay [a]								Tyonek [b]							
	Stock composition (%)				Stock-specific harvest				Stock composition (%)				Stock-specific harvest			
		90% CI				90% CI				90% CI				90% CI		
Reporting group	Mean	5%	95%	SD	Mean	5%	95%	$P \geq 1$	Mean	5%	95%	SD	Mean	5%	95%	$P \geq 1$
NCI Northwest	48.9	19.9	73.8	16.6	240	98	362	1.00	45.5	23.4	70.0	14.3	124	64	190	1.00
Susitna–Matanuska	37.3	11.7	68.3	17.5	183	57	335	1.00	46.3	22.0	69.0	14.4	126	60	188	1.00
Knik–Turnagain	11.6	0.1	26.0	8.1	57	0	128	0.93	7.3	0.4	18.5	5.7	20	1	50	0.95
Kenai Peninsula	2.2	0.0	8.4	2.9	11	0	41	0.68	0.9	0.0	3.9	1.5	2	0	11	0.41
Harvest represented					491								272			
Harvest not represented					51 [c]								0			
Total harvest					542								272			

Note: Standard deviation (SD) is of the proportion and *P* is the probability that the stock-specific harvest estimate is greater than or equal to 1 fish. Stock-specific harvest estimates may not sum to the total harvest due to rounding error, and 90% credibility intervals may not include the point estimate for very low stock-specific harvest numbers because fewer than 5% of the iterations had values above zero.

[a] Sample size is 141; dates are May 29–June 16.

[b] Sample size is 121; dates are May 29–June 30.

[c] Trading Bay is not represented by harvest samples after June 16.

Table 16.–Stock composition (%) and stock-specific harvest estimates based on genetic data for Chinook salmon harvested in the Trading Bay and Tyonek statistical areas of the Northern District commercial set gillnet fishery of Cook Inlet, Alaska, 2015.

		Stock composition (%)				Stock-specific harvest			
			90% CI				90% CI		
Stat area	Reporting group	Mean	5%	95%	SD	Mean	5%	95%	$P \geq 1$
Trading Bay [a]	*NCI Northwest*	–	–	–	–	–	–	–	–
	Susitna–Matanuska	–	–	–	–	–	–	–	–
	Knik–Turnagain	–	–	–	–	–	–	–	–
	Kenai Peninsula	–	–	–	–	–	–	–	–
	Harvest represented					0			
	Harvest not represented					368			
	Total harvest					368			
Tyonek (early) [b]									
	NCI Northwest	36.0	11.2	62.6	15.6	41	13	71	0.99
	Susitna–Matanuska	57.6	29.9	83.5	16.2	66	34	95	1.00
	Knik–Turnagain	6.3	0.0	17.0	5.6	7	0	19	0.79
	Kenai Peninsula	0.1	0.0	0.0	0.5	0	0	0	0.02
	Harvest represented					114			
	Harvest not represented					0			
	Total harvest					114			
Tyonek (late) [c]									
	NCI Northwest	72.2	54.2	87.0	10.1	194	145	233	1.00
	Susitna–Matanuska	25.4	11.2	43.5	9.9	68	30	117	1.00
	Knik–Turnagain	2.4	0.0	11.4	4.1	6	0	30	0.43
	Kenai Peninsula	0.0	0.0	0.0	0.4	0	0	0	0.02
	Harvest represented					268			
	Harvest not represented					0			
	Total harvest					268			

Note: Standard deviation (SD) is of the percentage, and *P* is the probability that the stock-specific harvest estimate is greater than or equal to 1 fish. Stock-specific harvest estimates may not sum to the total harvest due to rounding error, and 90% credibility intervals may not include the point estimate for very low stock-specific harvest numbers because fewer than 5% of the iterations had values above zero.

[a] Sample size is 61 but the minimum sample size of 100 fish was not available to perform MSA, and therefore there are no stock composition estimates; dates are May 29–June 30.

[b] Sample size is 118; dates are May 29–June 12 (early).

[c] Sample size is 173; dates are June 13–30 (late).

Table 17.–Stock composition (%) and stock-specific harvest estimates based on genetic data for Chinook salmon harvested in the General Subdistrict (north) of the Northern District commercial set gillnet fishery of Cook Inlet, Alaska, 2015.

	General Subdistrict north (early) [a]								General Subdistrict north (late) [b]							
	Stock composition (%)				Stock-specific harvest				Stock composition (%)				Stock-specific harvest			
		90% CI				90% CI				90% CI				90% CI		
Reporting group	Mean	5%	95%	SD	Mean	5%	95%	$P \geq 1$	Mean	5%	95%	SD	Mean	5%	95%	$P \geq 1$
NCI Northwest	4.3	0.0	18.2	6.4	15	0	63	0.52	0.7	0.0	4.7	2.6	2	0	16	0.16
Susitna–Matanuska	14.4	0.9	29.0	8.2	49	3	100	0.96	1.7	0.0	9.8	4.1	6	0	34	0.37
Knik–Turnagain	81.3	67.2	93.4	8.0	279	231	320	1.00	97.6	87.3	100	4.8	333	298	341	1.00
Kenai Peninsula	0.0	0.0	0.0	0.3	0	0	0	0.02	0	0.0	0	0.3	0	0	0	0.02
Harvest represented					343								341			
Harvest not represented					0								0			
Total harvest					343								341			

Note: Standard deviation (SD) is of the percentage, and *P* is the probability that the stock-specific harvest estimate is greater than or equal to 1 fish. Stock-specific harvest estimates may not sum to the total harvest due to rounding error, and 90% credibility intervals (CI) may not include the point estimate for very low stock-specific harvest numbers because fewer than 5% of the iterations had values above zero.

[a] Sample size is 134; dates are May 29–June 12 (early).

[b] Sample size is 133; dates are June 13–22 (late).

Table 18.–Stock composition (%) and stock-specific harvest estimates based on genetic data for Chinook salmon harvested in the Eastern Subdistrict of the Northern District commercial set gillnet fishery of Cook Inlet, Alaska, 2015.

	Eastern Subdistrict (early) [a]								Eastern Subdistrict (late) [b]							
	Stock composition (%)				Stock-specific harvest				Stock composition (%)				Stock-specific harvest			
		90% CI				90% CI				90% CI				90% CI		
Reporting group	Mean	5%	95%	SD	Mean	5%	95%	$P \geq 1$	Mean	5%	95%	SD	Mean	5%	95%	$P \geq 1$
NCI Northwest	35.2	12.7	55.5	12.9	73	26	115	1.00	15.1	0.0	39.1	13.0	23	0	59	0.86
Susitna–Matanuska	12.5	0.0	34.9	11.4	26	0	73	0.88	23.4	0.0	49.9	15.9	36	0	76	0.88
Knik–Turnagain	52.2	37.3	67.1	9.0	109	78	139	1.00	61.2	42.3	79.2	11.2	93	64	120	1.00
Kenai Peninsula	0.1	0.0	0.1	0.4	0	0	0	0.03	0.3	0.0	1.7	1.1	0	0	3	0.08
Harvest represented					208								152			
Harvest not represented					0								0			
Total harvest					208								152			

Note: Standard deviation (SD) is of the percentage, and *P* is the probability that the stock-specific harvest estimate is greater than or equal to 1 fish. Stock-specific harvest estimates may not sum to the total harvest due to rounding error, and 90% credibility intervals (CI) may not include the point estimate for very low stock-specific harvest numbers because fewer than 5% of the iterations had values above zero.

[a] Sample size is 188; dates are May 29–June 12 (early).

[b] Sample size is 100; dates are June 13–30 (late).

Table 19.–Stock composition (%) and stock-specific harvest estimates based on genetic data for Chinook salmon harvested in the Tyonek subsistence set gillnet fishery of Cook Inlet, Alaska, 2015.

	Tyonek subsistence (early) [a]								Tyonek subsistence (late) [b]							
	Stock composition (%)				Stock-specific harvest				Stock composition (%)				Stock-specific harvest			
		90% CI				90% CI				90% CI				90% CI		
Reporting group	Mean	5%	95%	SD	Mean	5%	95%	$P \geq 1$	Mean	5%	95%	SD	Mean	5%	95%	$P \geq 1$
NCI Northwest	49.8	26.3	74.9	14.7	129	68	195	1.00	88.3	73.1	98.1	7.8	715	592	794	1.00
Susitna–Matanuska	24.0	6.6	48.9	13.3	62	17	127	1.00	7.2	0.0	23.4	8.0	58	0	189	0.82
Knik–Turnagain	26.1	0.0	47.3	14.2	68	0	123	0.89	4.4	0.0	11.7	3.9	36	0	95	0.88
Kenai Peninsula	0.1	0.0	0.2	0.7	0	0	1	0.04	0.1	0.0	0.6	0.8	1	0	5	0.07
Harvest represented					260								810			
Harvest not represented					0								0			
Total harvest					260								810			

Note: Standard deviation (SD) is of the percentage, and *P* is the probability that the stock-specific harvest estimate is greater than or equal to 1 fish. Stock-specific harvest estimates may not sum to the total harvest due to rounding error, and 90% credibility intervals (CI) may not include the point estimate for very low stock-specific harvest numbers because fewer than 5% of the iterations had values above zero.

[a] Sample size is 105; dates are May 16–31 (early).

[b] Sample size is 201; dates are June 1–20 (late).

Table 20.–Stock composition (%) and stock-specific harvest estimates based on genetic data for Chinook salmon harvested in the General Subdistrict (south), General Subdistrict (north), and Eastern Subdistrict of the Northern District commercial set gillnet fishery of Cook Inlet, Alaska, 2014.

		Stock composition (%)				Stock-specific harvest			
			90% CI				90% CI		
Area	Reporting group	Mean	5%	95%	SD	Mean	5%	95%	$P \geq 1$
General Subdistrict (south) [a]									
	NCI Northwest	47.7	27.9	65.4	11.5	364	213	499	1
	Susitna–Matanuska	40.5	22.0	61.8	12.1	309	168	471	1
	Knik–Turnagain	10.1	1.8	19.8	5.5	77	14	151	1
	Kenai Peninsula	1.7	0.0	5.8	2.0	13	0	44	0.83
	Harvest represented					763			
	Harvest not represented					51 [b]			
	Total harvest					814			
General Subdistrict (north) [c]									
	NCI Northwest	9.1	0.0	23.2	7.9	36	0	92	0.84
	Susitna–Matanuska	18.7	6.0	34.6	9.0	74	24	138	1
	Knik–Turnagain	71.2	58.7	82.9	7.3	283	234	330	1
	Kenai Peninsula	1.1	0.0	4.2	1.5	4	0	17	0.56
	Harvest represented					398			
	Harvest not represented					0			
	Total harvest					398			
Eastern Subdistrict [d]									
	NCI Northwest	36.3	16.6	57.6	12.5	118	54	188	1
	Susitna–Matanuska	34.3	15.5	54.8	12.1	112	50	179	1
	Knik–Turnagain	27.6	12.5	45.1	9.9	90	41	147	1
	Kenai Peninsula	1.8	0.0	6.8	2.4	6	0	22	0.63
	Harvest represented					326			
	Harvest not represented					0			
	Total harvest					326			

Note: Standard deviation (SD) is of the percentage, and *P* is the probability that the stock-specific harvest estimate is greater than or equal to 1 fish. Stock-specific harvest estimates may not sum to the total harvest due to rounding error, and 90% credibility intervals (CI) may not include the point estimate for very low stock-specific harvest numbers because fewer than 5% of the iterations had values above zero.

[a] Estimates for General Subdistrict (south) were calculated using a stratified estimator for combined area strata (see Figure 3). Sample size is 196.

[b] Trading Bay is not represented by harvest samples after June 16.

[c] Sample size is 196.

[d] Sample size is 130.

Table 21.–Stock composition (%) and stock-specific harvest estimates based on genetic data for Chinook salmon harvested in the General Subdistrict (south), General Subdistrict (north), and Eastern Subdistrict of the Northern District commercial set gillnet fishery of Cook Inlet, Alaska, 2015.

		Stock composition (%)				Stock-specific harvest			
			90% CI				90% CI		
Area	Reporting group	Mean	5%	95%	SD	Mean	5%	95%	$P \geq 1$
General Subdistrict (south) [a]									
	NCI Northwest	61.4	47.0	74.3	8.3	235	180	284	1
	Susitna–Matanuska	35.0	22.1	49.5	8.3	134	84	189	1
	Knik–Turnagain	3.6	0.0	10.4	3.3	14	0	40	0.88
	Kenai Peninsula	0.0	0.0	0.1	0.3	0	0	1	0.04
	Harvest represented					382			
	Harvest not represented					368 [b]			
	Total harvest					750			
General Subdistrict (north) [c]									
	NCI Northwest	2.5	0.0	9.9	3.5	17	0	68	0.6
	Susitna–Matanuska	8.1	0.9	16.3	4.6	55	6	112	0.98
	Knik–Turnagain	89.4	81.0	96.2	4.7	603	554	658	1
	Kenai Peninsula	0.0	0.0	0.1	0.2	0	0	0	0.04
	Harvest represented					674			
	Harvest not represented					0			
	Total harvest					674			
Eastern Subdistrict [d]									
	NCI Northwest	26.7	11.4	41.8	9.2	96	41	150	1
	Susitna–Matanuska	17.1	2.9	33.7	9.3	62	10	121	0.99
	Knik–Turnagain	56.0	44.3	67.6	7.1	202	159	243	1
	Kenai Peninsula	0.1	0.0	1.0	0.5	1	0	4	0.1
	Harvest represented					360			
	Harvest not represented					0			
	Total harvest					360			

Note: Estimates were calculated using a stratified estimator for combined temporal and area strata (see Figure 3). Standard deviation (SD) is of the percentage, and P is the probability that the stock-specific harvest estimate is greater than or equal to 1 fish. Stock-specific harvest estimates may not sum to the total harvest due to rounding error, and 90% credibility intervals (CI) may not include the point estimate for very low stock-specific harvest numbers because fewer than 5% of the iterations had values above zero.

[a] Sample size is 291.

[b] Insufficient samples to analyze Trading Bay.

[c] Sample size is 267.

[d] Sample size is 288.

Table 22.–Annual stock composition (%) and stock-specific harvest estimates based on genetic data for Chinook salmon harvested in the Northern District commercial set gillnet fishery of Cook Inlet, Alaska, 2014 and 2015.

		Stock composition (%)				Stock-specific harvest			
			90% CI				90% CI		
Year	Reporting group	Mean	5%	95%	SD	Mean	5%	95%	$P \geq 1$
2014 [a]									
	NCI Northwest	34.9	23.0	45.9	6.9	518	342	682	1
	Susitna-Matanuska	33.3	22.0	45.9	7.3	495	327	682	1
	Knik-Turnagain	30.3	23.8	37.1	4.0	450	354	551	1
	Kenai Peninsula	1.6	0.2	3.9	1.2	23	2	59	0.98
	Harvest represented					1,487			
	Harvest not represented					51 [b]			
	Total harvest					1,538			
2015 [c]									
	NCI Northwest	24.4	18.4	30.5	3.7	348	262	434	1
	Susitna-Matanuska	17.6	11.4	24.4	4.0	250	162	349	1
	Knik-Turnagain	58.0	52.9	62.6	3.0	827	755	893	1
	Kenai Peninsula	0.1	0.0	0.4	0.2	1	0	6	0.17
	Harvest represented					1,426			
	Harvest not represented					368 [d]			
	Total harvest					1,794			

Note: Estimates were calculated using a stratified estimator for combined temporal and area strata (see Figure 3). Standard deviation (SD) is of the percentage, and P is the probability that the stock-specific harvest estimate is greater than or equal to 1 fish. Stock-specific harvest estimates may not sum to the total harvest due to rounding error, and 90% credibility intervals (CI) may not include the point estimate for very low stock-specific harvest numbers because fewer than 5% of the iterations had values above zero.

[a] Sample size is 618.

[b] Trading Bay is not represented by harvest samples after June 16.

[c] Sample size is 846.

[d] Insufficient samples to analyze Trading Bay.

Table 23.–Annual stock composition (%) and stock-specific harvest estimates based on genetic data for Chinook salmon harvested in the Tyonek subsistence set gillnet fishery of Cook Inlet, Alaska, 2014 and 2015.

		Stock composition (%)				Stock-specific harvest			
			90% CI				90% CI		
Year	Reporting group	Mean	5%	95%	SD	Mean	5%	95%	$P \geq 1$
2014 [a]									
	NCI Northwest	56.6	25.2	86.3	18.9	507	226	774	1
	Susitna–Matanuska	39.2	9.9	70.8	18.7	351	89	634	1
	Knik–Turnagain	2.5	0.0	11.9	4.5	22	0	107	0.66
	Kenai Peninsula	1.8	0.0	6.7	2.3	16	0	60	0.71
	Harvest represented					896			
	Harvest not represented					0			
	Total harvest					896			
2015 [b]									
	NCI Northwest	79.0	66.2	88.9	7.0	845	707	951	1
	Susitna–Matanuska	11.2	2.7	24.6	6.9	120	29	264	1
	Knik–Turnagain	9.6	2.0	17.1	4.5	104	22	184	0.99
	Kenai Peninsula	0.1	0.0	0.8	0.6	1	0	8	0.11
	Harvest represented					1,070			
	Harvest not represented					0			
	Total harvest					1,070			

Note: Estimates were calculated using a stratified estimator for combined temporal and area strata (see Figure 3). Standard deviation (SD) is of the percentage, and *P* is the probability that the stock-specific harvest estimate is greater than or equal to 1 fish. Stock-specific harvest estimates may not sum to the total harvest due to rounding error, and 90% credibility intervals (CI) may not include the point estimate for very low stock-specific harvest numbers because fewer than 5% of the iterations had values above zero.

[a] Sample size is 196.

[b] Sample size is 306.

FIGURES

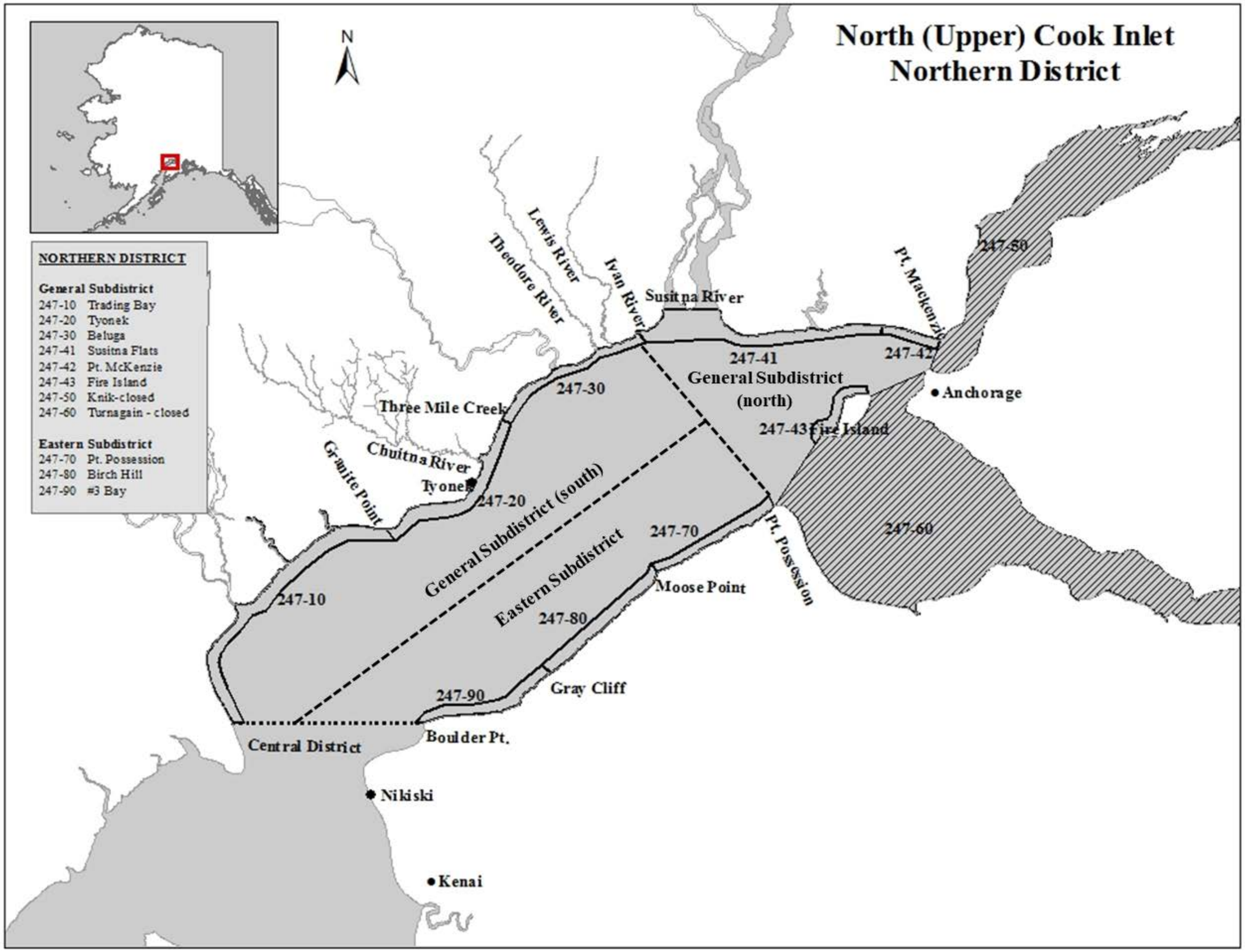

Figure 1.–Map of statistical areas for set gillnet commercial fishing in the Northern District of Upper Cook Inlet.

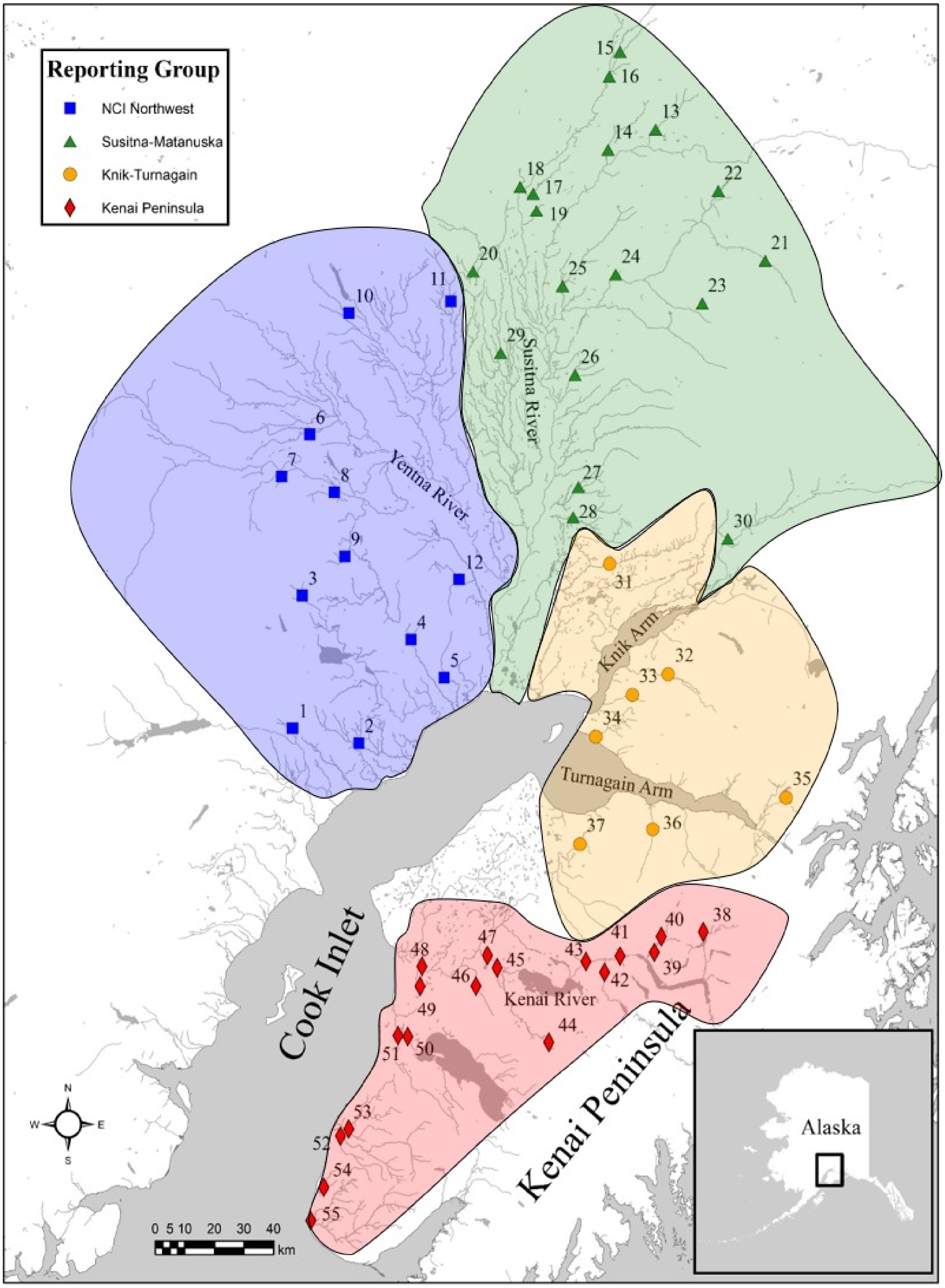

Figure 2.–Sampling locations for Chinook salmon populations from Cook Inlet included in the Cook Inlet genetic baseline.

Note: Numbers correspond to map numbers on Table 1. Location dot shape and color matches reporting group assignment.

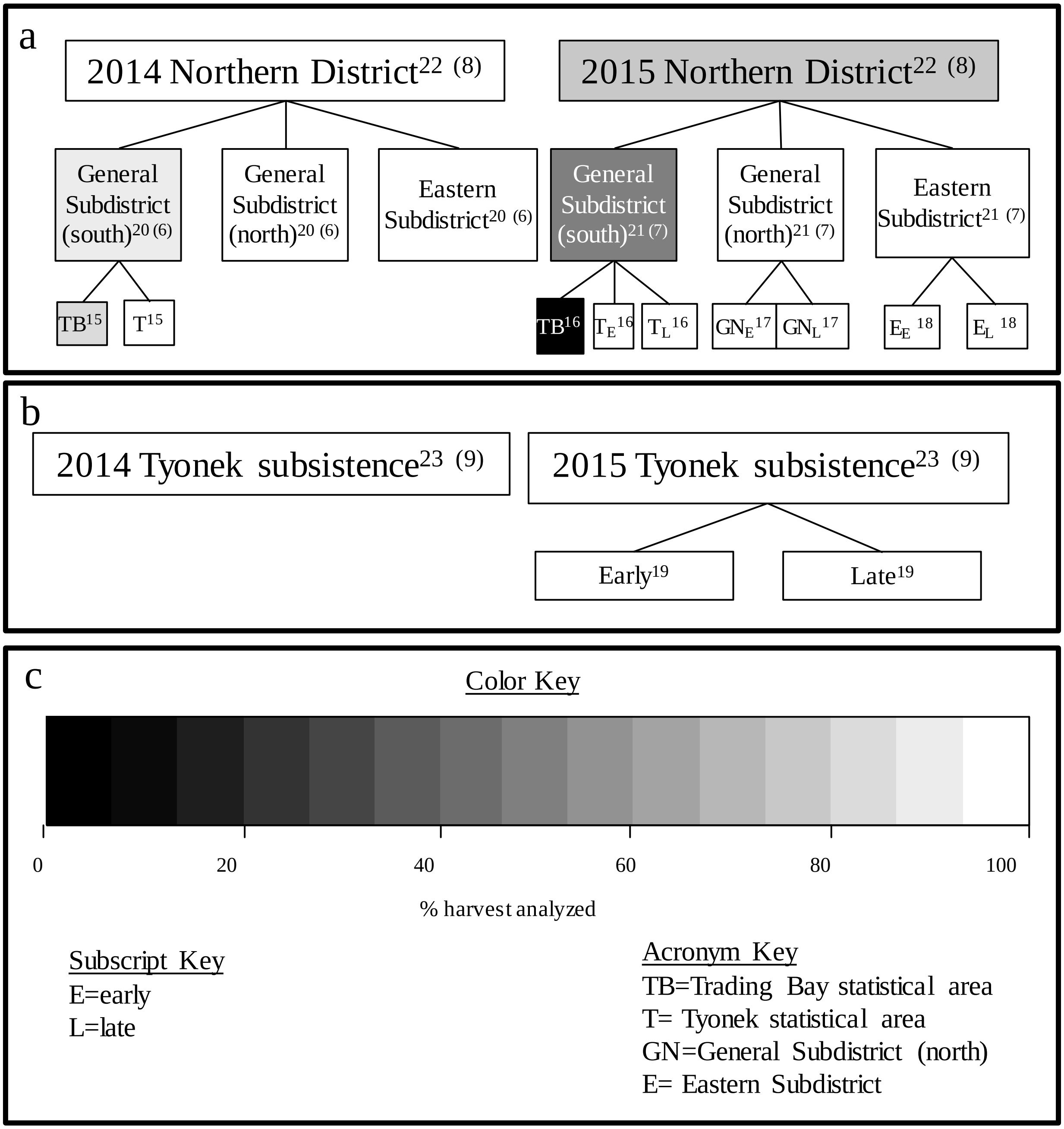

Figure 3.–Graphical depictions of temporal and geographic strata (boxes) for which stock composition and stock-specific harvest was estimated for the Northern District set gillnet fishery (a) and the Tyonek subsistence set gillnet fishery (b), and keys for the colors indicating percentage of the harvest used in each analysis, acronyms of each area stratum, and subscripts used to indicate temporal strata (c).

Note: Lines connecting smaller strata to larger strata indicate which estimates were stratified to calculate larger strata. Superscript numbers next to the name or acronym of each temporal and area stratum indicate the table number and figure number (parentheses) where the estimates can be found.

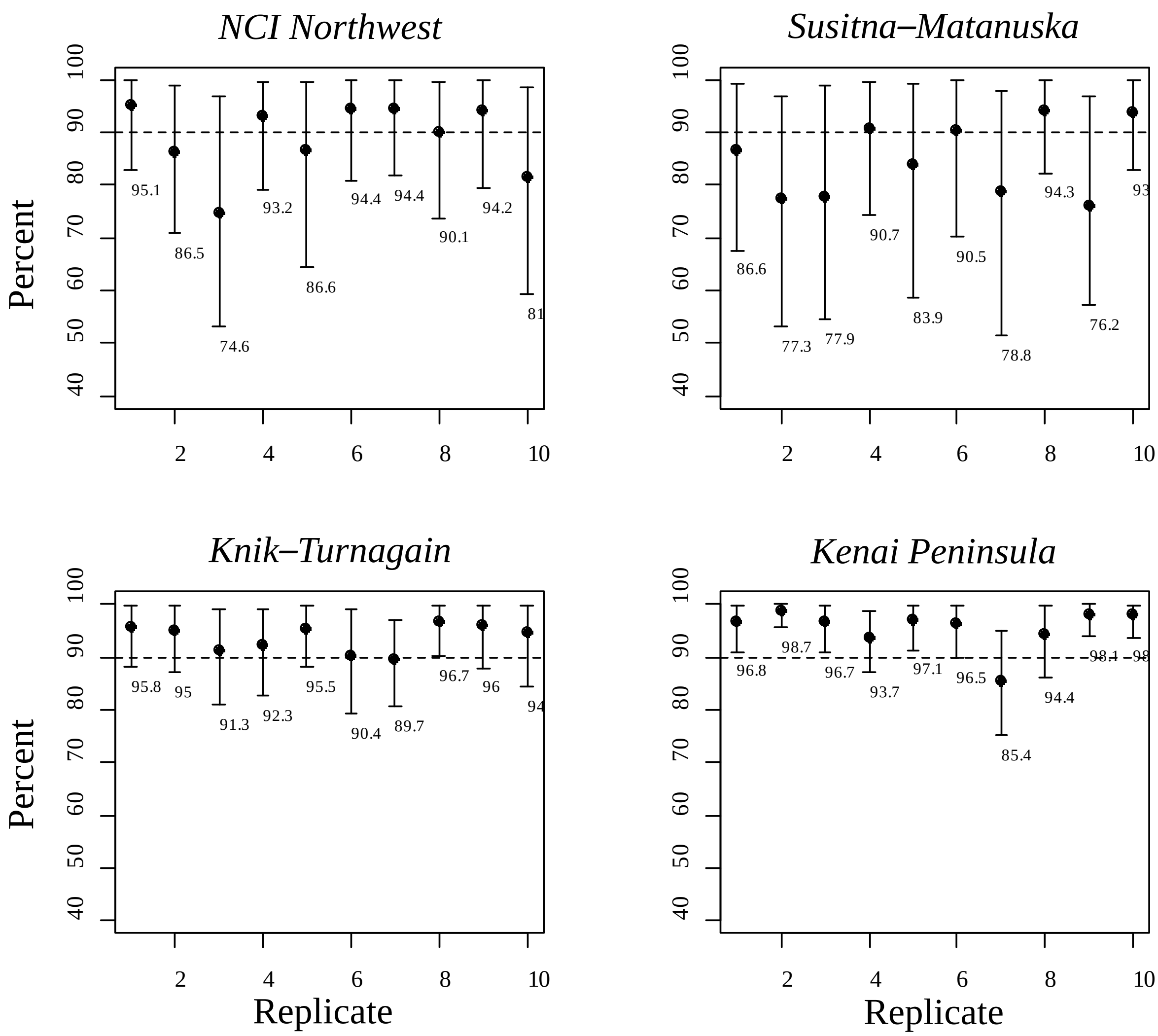

Figure 4.–Results of 100% proof tests for 10 replicates each of 4 reporting groups.

Note: The points represent the mean correct allocation from each replicate with 90% credibility intervals for each point, and the dotted line indicates 90% correct allocation. Point estimates for each replicate are included below the lower credibility interval.

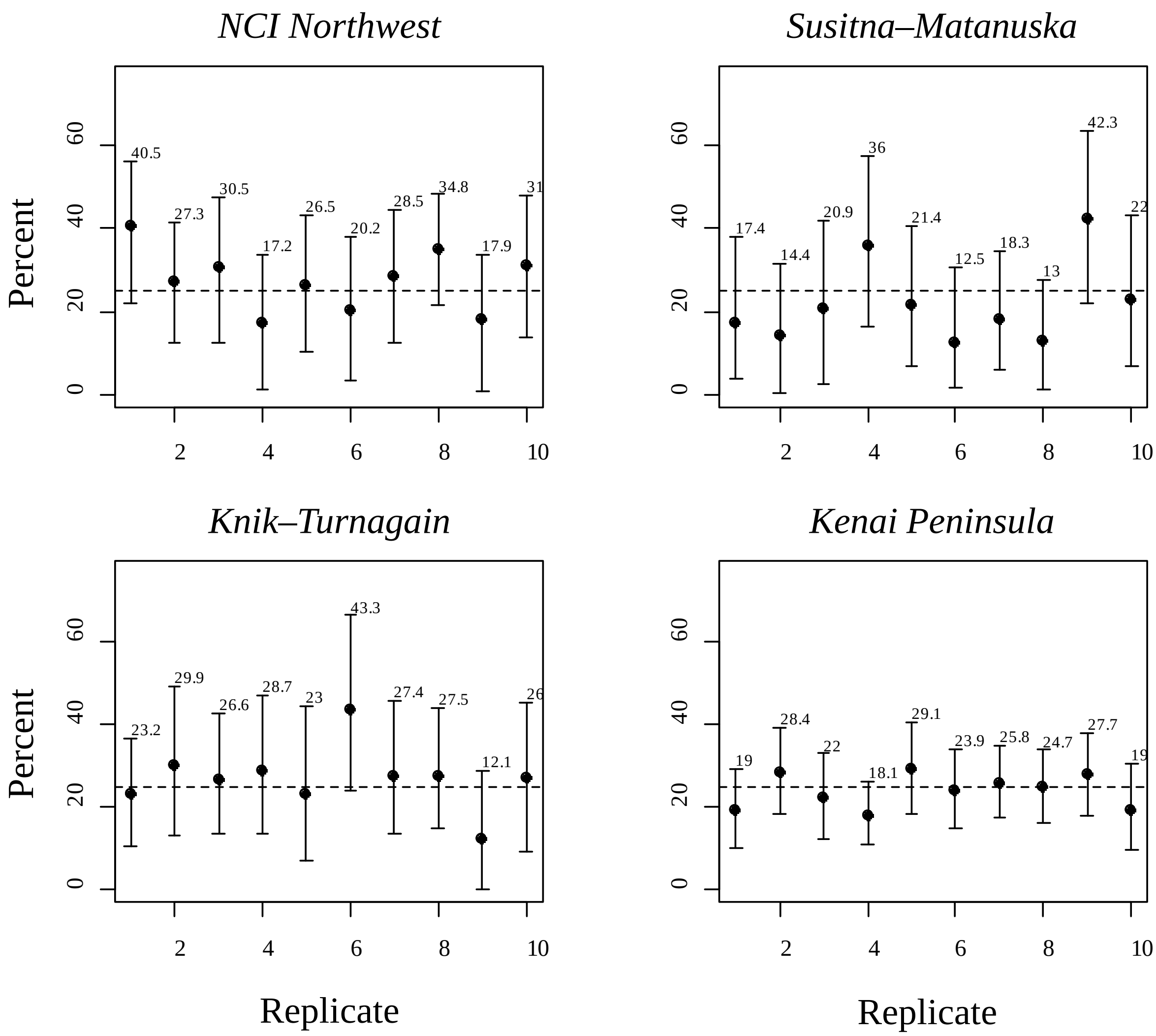

Figure 5.–Results of 10 replicate fishery scenario tests for each of 4 reporting groups.

Note: The points represent the mean stock composition estimate from each replicate with 90% credibility intervals for each point, and the dotted line indicates the actual percentage (25%). Point estimates for each replicate are included above the upper credibility interval.

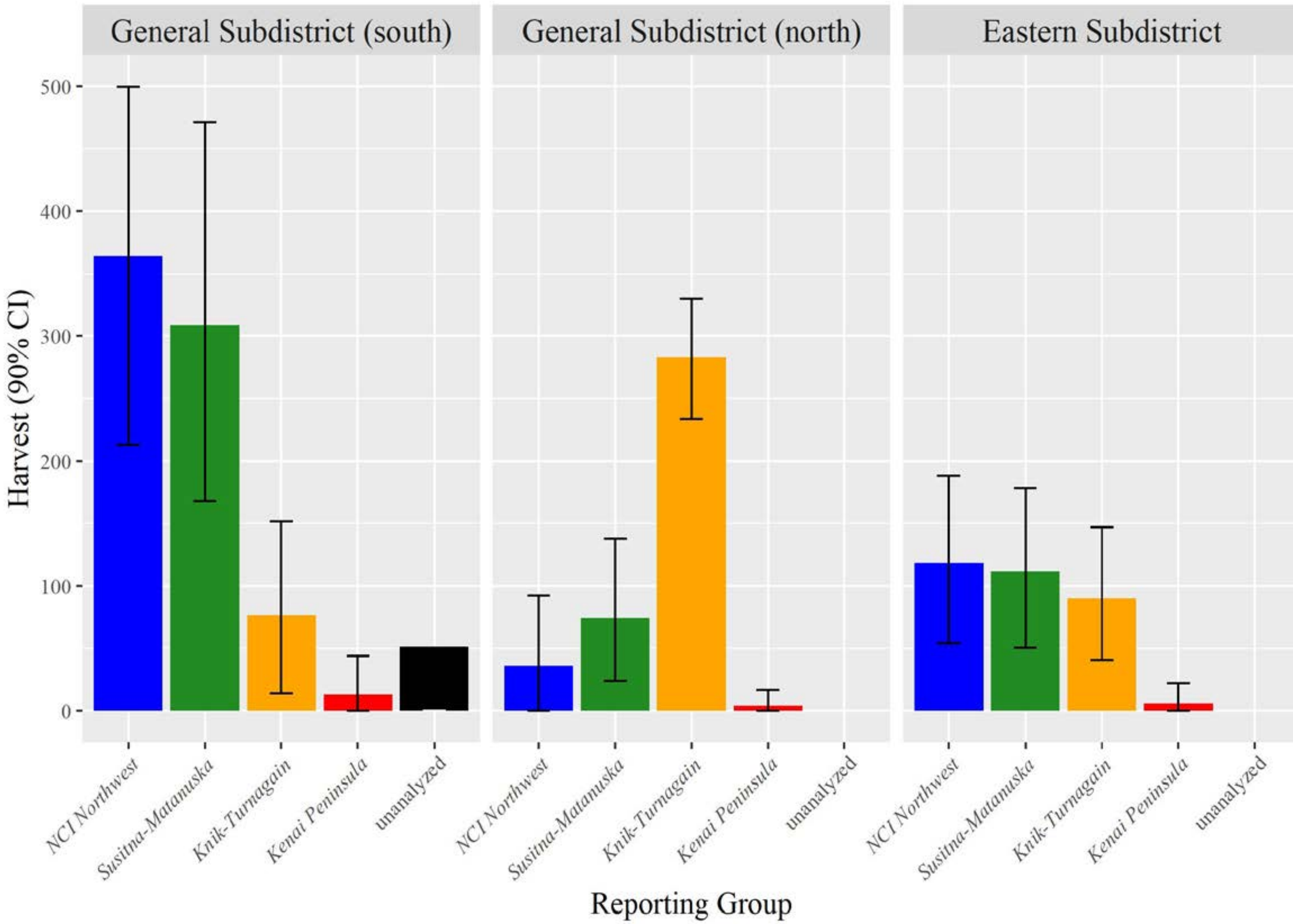

Figure 6.–Annual stock-specific harvest estimates and 90% credibility intervals based on genetic data for Chinook salmon harvested in the General Subdistrict (south), General Subdistrict (north), and Eastern Subdistrict of the Northern District set gillnet fishery of Cook Inlet, Alaska, 2014.

Note: Estimates for General Subdistrict (south) were calculated using a stratified estimator for combined area strata (see Figure 3).

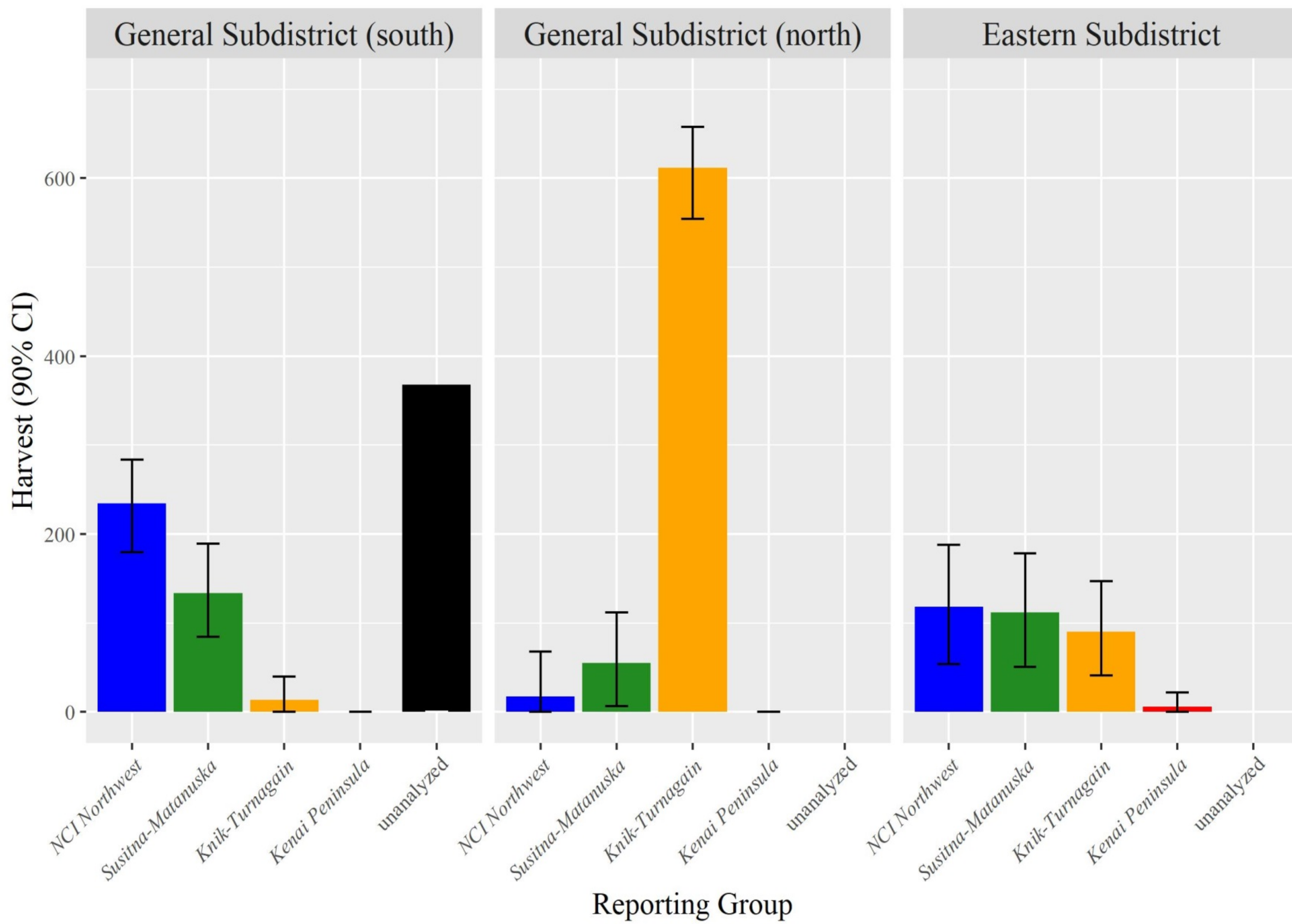

Figure 7.–Annual stock-specific harvest estimates and 90% credibility intervals based on genetic data for Chinook salmon harvested in the General Subdistrict (south), General Subdistrict (north), and Eastern Subdistrict of the Northern District set gillnet fishery of Cook Inlet, Alaska, 2015.

Note: Estimates were calculated using a stratified estimator for combined area strata (see Figure 3).

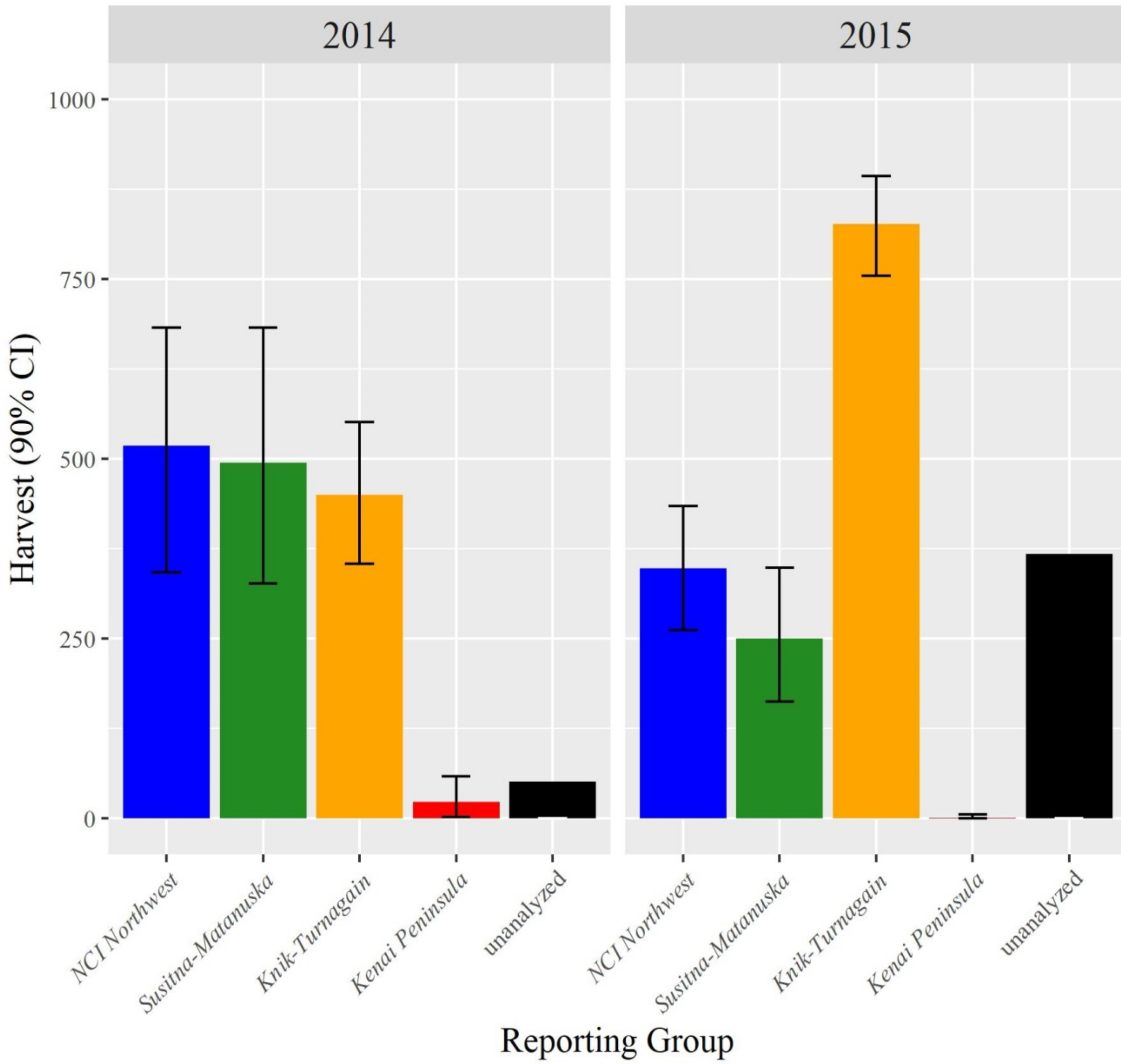

Figure 8.–Annual stock-specific harvest estimates and 90% credibility intervals based on genetic data for Chinook salmon harvested in the Northern District commercial set gillnet fishery of Cook Inlet, Alaska in 2014 and 2015.

Note: Estimates were calculated using a stratified estimator for combined area strata (see Figure 3).

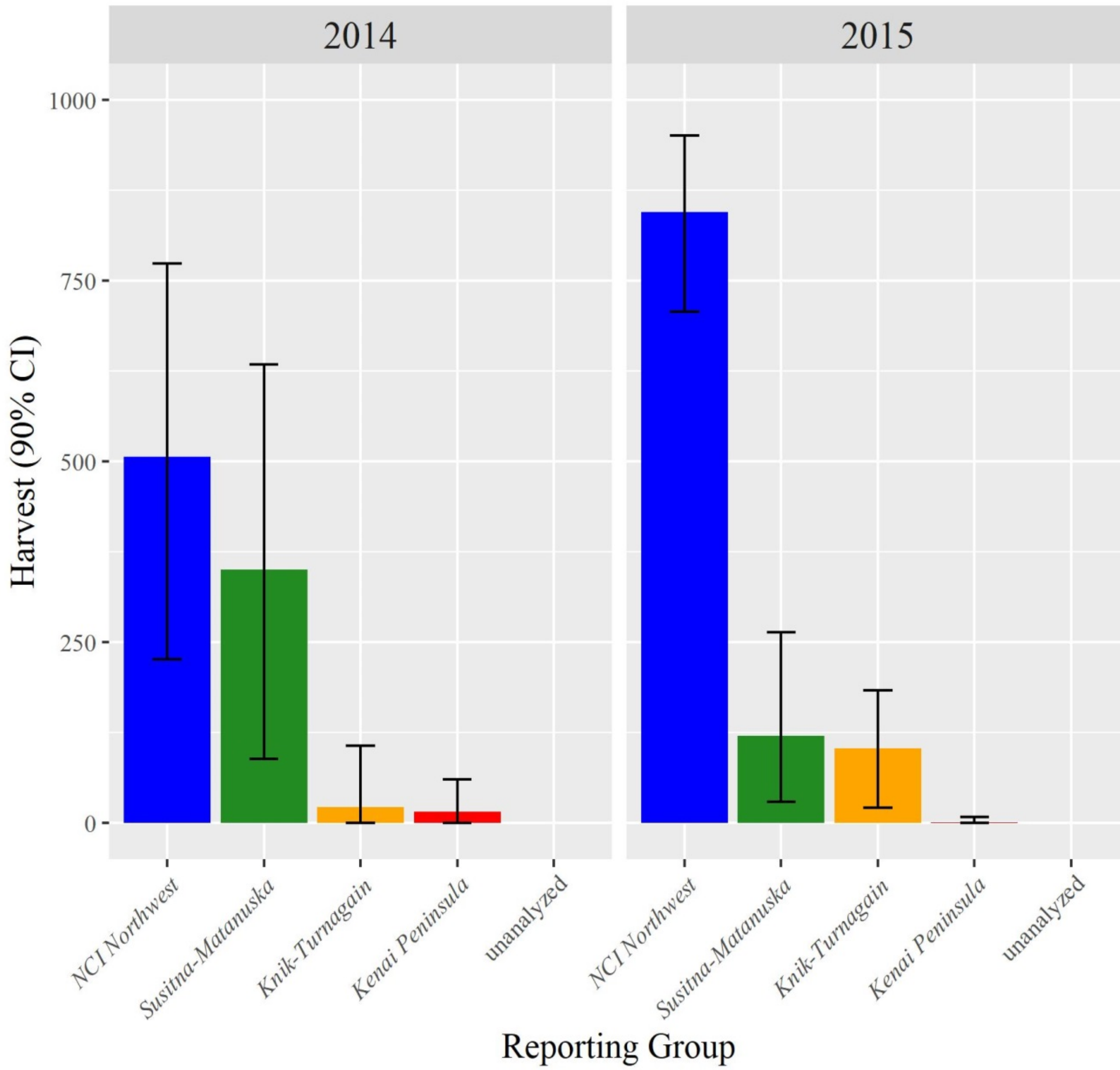

Figure 9.–Annual stock-specific harvest estimates and 90% credibility intervals based on genetic data for Chinook salmon harvested in the Tyonek subsistence set gillnet fishery of Cook Inlet, Alaska in 2014 and 2015.

Note: Estimates were calculated using a stratified estimator for combined area strata (see Figure 3).