Fishery Data Series No. 22-33

Russian River Early-Run Sockeye Salmon Run Timing into the Kenai River, 2018–2020

by

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and

Andrew W. Barclay

December 2022

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

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ABSTRACT

Sockeye salmon were sampled for genetic tissue in the lower Kenai River at river mile (RM) 8.6 during the 2018–2020 early runs (prior to 1 July) for genetic mixed stock analysis (MSA) of stock composition for 3 reporting groups (*Russian River Early*, *Russian River Late*, and *Kenai River Other*) and 5 temporal strata (16 May–3 June, 4–10 June, 11–16 June, 17–23 June, and 24–30 June) each year. The MSAs represent the first stock composition estimates for sockeye salmon entering the Kenai River during the early run. Stock compositions were dominated by *Russian River Early* fish each year, especially for strata occurring prior to 24 June. Daily Kenai River RM 13.7 sonar passage estimates of fish between 40 cm and 75 cm (small fish) were used with stock composition estimates by stratum and summed to estimate *Russian River Early* sockeye salmon passage prior to 1 July each year. *Russian River Early* fish represented an estimated 0.91 (2018), 0.92 (2019), and 0.75 (2020) of the estimated small fish passage at RM 13.7 each year and averaged 0.86 for all 3 years (2018–2020). Estimated passage of *Russian River Early* fish was highest for the 4–10 June stratum (35% of each year's early run, on average) and the 11–16 June stratum (28% of each year's early run, on average), with those 2 strata accounting for 62% of estimated *Russian River Early* fish passage on average at RM 13.7. The last stratum (24–30 June) had the lowest estimated passage of *Russian River Early* fish, accounting for 7% of each year's early run, on average. These results will be used to better predict inseason run strengths of Russian River early-run sockeye salmon, thereby increasing management precision to meet the escapement goal.

Keywords: sockeye salmon, *Oncorhynchus nerka*, Kenai River, Russian River, early run, mixed stock analysis, MSA, single nucleotide polymorphism, SNP

INTRODUCTION

The Russian River, approximately 100 miles south of Anchorage on the Kenai Peninsula, is a clearwater tributary of the Kenai River (Figure 1), which supports one of the largest freshwater sport fisheries for sockeye salmon (*Oncorhynchus nerka*) in Alaska (Lipka et al. 2020). The Russian River has 2 genetically distinct runs (Barclay and Habicht 2012) that exhibit a bimodal entry pattern with the modes referred to as the early and late runs (Begich et al. 2017).

Russian River early-run sockeye salmon primarily enter the Kenai River in May and June and migrate 75 river miles (RM) upstream to the Russian River, spawning in the upper reaches of the drainage. Harvest of this stock occurs primarily in the Russian River area sport fishery between RM 73.0 and 73.6 in the Kenai River and in the lower Russian River, although smaller numbers of fish are also harvested in multiple other fisheries: the Kenai River sport fishery downstream of RM 73.0, the Kenaitze Indian Tribe educational fishery, a Federal subsistence dip net fishery at the lower Russian River falls, and the Upper Cook Inlet commercial fishery including the Eastside set gillnet fishery and the Central District drift gillnet fishery (Figure 2).

A weir located at the outlet of lower Russian Lake is used to enumerate the spawning escapement as well as provide a means to trap fish and collect age, sex, and length information (Pawluk 2015). Sockeye salmon passing the weir prior to 15 July are classified as early-run fish and those passing the weir on or after 15 July are classified as late-run fish.

The Russian River sockeye salmon sport fishery is one of the most actively managed sport fisheries in Alaska and has been closed for all or part of the fishery on 27 occasions since 1969 to achieve escapement goals. The most recent fishery restriction was in 2010. In many other years, the fishery has been liberalized by opening the sanctuary area (Figure 2) prior to 15 July and by liberalizing the daily bag limit from the "Russian Fly Fishing Only" area and the mainstem Kenai River downstream to Skilak Lake.

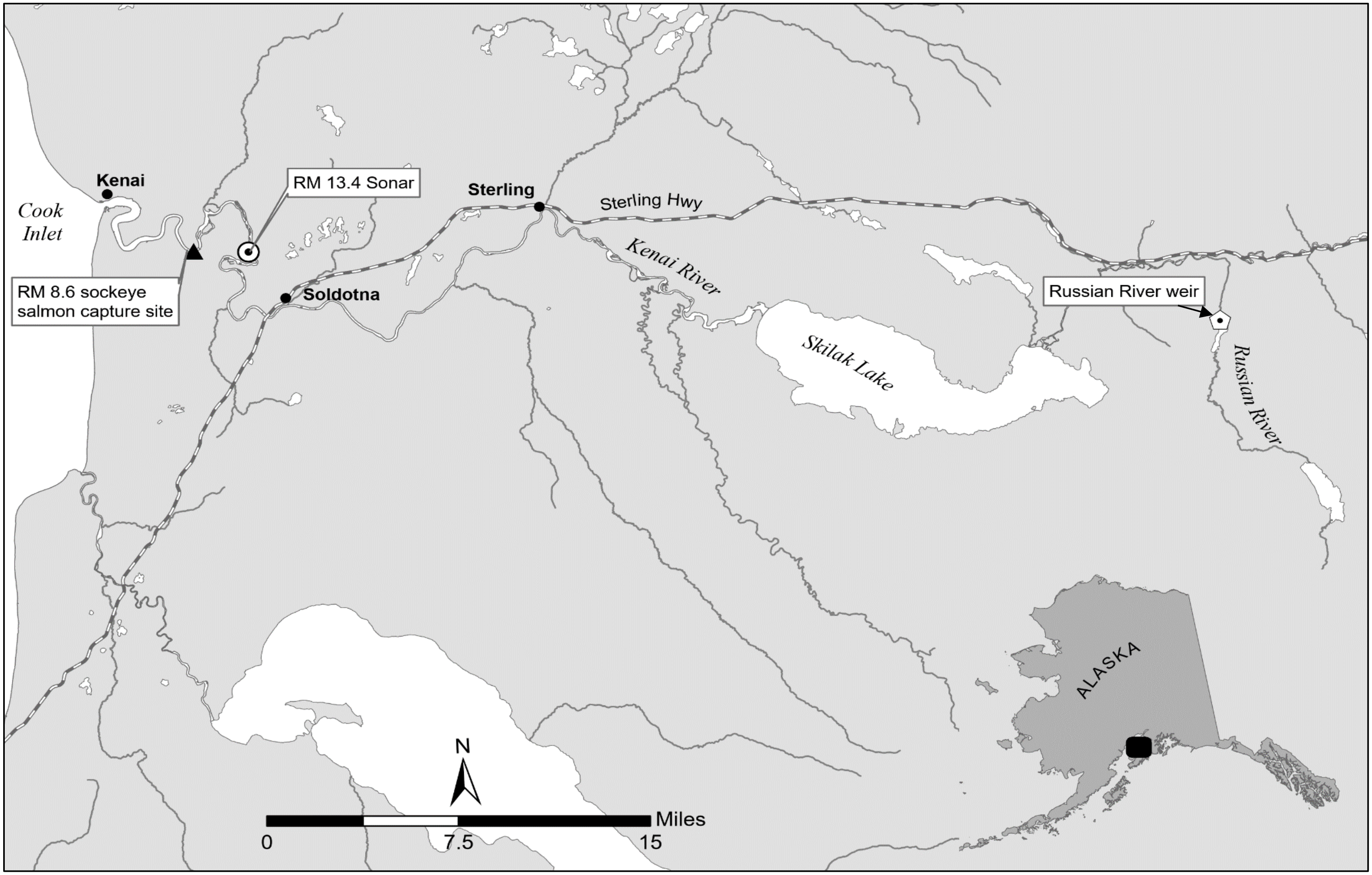

Figure 1.–Map of the Kenai and Russian Rivers.

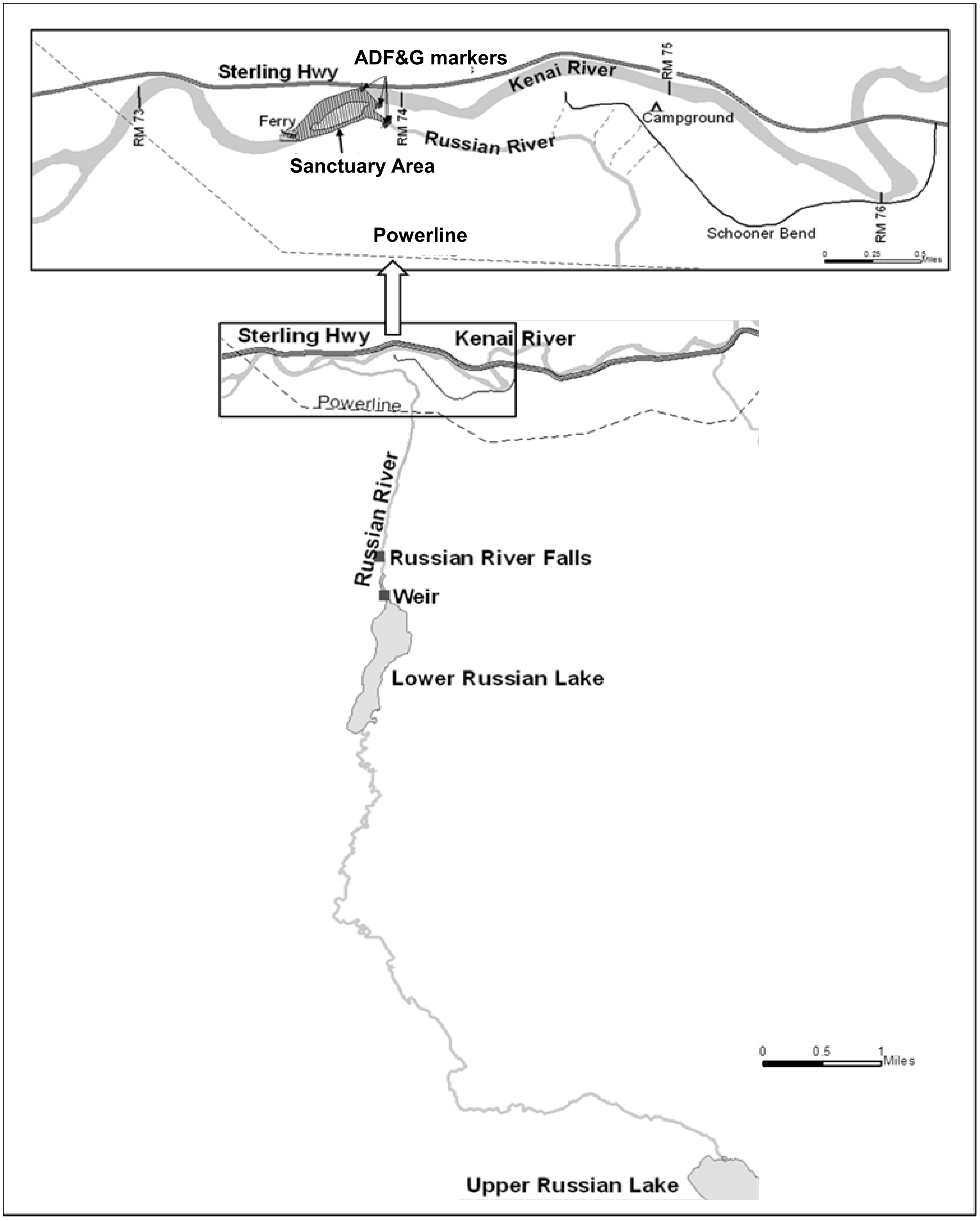

Figure 2.–Map of the Russian River sockeye salmon recreational fishing areas and fishing access locations.

Historically, inseason management actions for early-run Russian River sockeye salmon have been supported by counts of sockeye salmon at a weir located above the fishery at the outlet of lower Russian Lake and foot survey counts of the numbers of sockeye salmon in the Russian River below the weir (Pawluk 2015). Together, the 2 counts provide managers information to estimate run strength and determine if inseason management actions are necessary to achieve the escapement goal.

Recent advancements in sonar technology have provided new opportunities for fish enumeration and assessment on the Kenai River. In 2014, the Kenai River Chinook salmon sonar site was moved from RM 8.6 to RM 13.7 and a new adaptive resolution imaging sonar (ARIS) was deployed (Miller et al. 2016). At this new site, and with the new sonar technology, nearly the entire cross section of river is ensonified, which was not possible at RM 8.6, and fish passage is enumerated by size category. All fish greater than or equal to 75 cm, as measured by ARIS (ARIS length), are counted as "large" Chinook salmon because there is essentially no overlap among fish species of that size, whereas fish greater than or equal to 40 cm and less than 75 cm (hereafter referred to as "small fish") can be composed of multiple fish species with overlapping sizes. The Chinook salmon sonar program does not enumerate fish less than 40 cm because very few fish in that size range are believed to be salmon and even fewer are believed to be Chinook salmon. During the early run, the majority of "small fish" that pass the RM 13.7 sonar are considered to be sockeye salmon based on captures from the inriver gillnetting project at RM 8.6 (Perschbacher 2018a), and a majority of those fish are thought to be bound for the Russian River based on the location of the major sockeye salmon fishery just prior to the confluence. Thus, early-run sonar estimates of "small" fish provide a coarse estimate of Russian River early-run sockeye salmon passage at RM 13.7. Although most "small" fish passing RM 13.7 during the early run are considered to be sockeye salmon bound for the Russian River, the actual stock composition of those fish is not known.

With this new sonar technology providing fish passage estimates by size at RM 13.7, a multi-phase investigation was initiated in 2017 to better understand the migration patterns, run timing, and run size of Russian River sockeye salmon entering the lower Kenai River during the early run. The intent of this multi-phase investigation was to provide information that will assist the use of early run RM 13.7 sonar estimates of "small fish" to better predict run size and increase management precision of the Russian River sockeye salmon early run.

Phase 1 Investigation: Migration Timing of Russian River Early-Run Sockeye Salmon

The first phase of this multi-phase investigation began in 2017 when the Division of Sport Fish initiated a sockeye salmon tagging study at Kenai River RM 8.6 (Eskelin 2022). The goal of the first phase was to estimate the mean migration time (duration) of early-run sockeye salmon from RM 13.7 to the start of the Russian River area sport fishery at RM 73.0 and from RM 13.7 to the lower Russian River weir. Information on the average migration time from RM 13.7 to the Russian River area sport fishery can be used in conjunction with RM 13.7 early-run sonar passage estimates as an inseason tool to better predict Russian River early-run sockeye salmon run strength and more precisely manage the fishery to meet the biological escapement goal and provide for sustained yield (Alaska Administrative Code 5 AAC 57.150).

Fifty-two sockeye salmon were implanted with radio transmitters at RM 8.6 in conjunction with a separate inriver gillnetting study (Perschbacher 2017) and tracked throughout the Kenai River drainage. Based on 22 radiotagged fish that were tracked to the Russian River area sport fishery, the mean migration time from RM 13.7 to RM 73.0 was 9.8 days (SD = 2.7 days), with a range of 5.2–16.8 days (Eskelin 2022).

An additional sample of 218 sockeye salmon was marked with spaghetti tags at the RM 8.6 inriver gillnetting site to better estimate the travel times to the Russian River weir. Travel times were similar between spaghetti-tagged and radiotagged fish. Eleven spaghetti-tagged fish passed the weir with a mean migration time of 16.9 days (range: 12.2–19.4 days), and 3 radiotagged fish passed the weir with a mean migration time of 17.7 days (range: 13.2–20.1 days). Overall, the migration time for the 14 tagged fish (3 radio tag, 11 spaghetti tag) averaged 17.1 days from RM 8.6 to the Russian River weir with a range of 12.2–19.4 days (Eskelin 2022).

Knowledge of the migratory travel times for Russian River sockeye salmon will provide better estimates of when pulses of sockeye salmon observed at the RM 13.7 sonar may arrive at the Russian River area sport fishery, enter the Russian River, and pass the Russian River weir.

Phase 2 Investigation: Stock Composition of Early-Run Sockeye Salmon at Kenai River RM 13.7

The next phase of this investigation, detailed in the remainder of this report, was to estimate the temporal composition of Russian River early-run sockeye salmon relative to other sockeye salmon stocks entering the Kenai River prior to 1 July. Kenai River sockeye salmon genetic baseline data and genetic mixed stock analysis (MSA) techniques, along with RM 13.7 sonar passage estimates, were used to estimate the annual abundance of Russian River early-run sockeye salmon passing RM 13.7 prior to 1 July and the temporal distribution of Russian River sockeye salmon within each season for 3 years (2018–2020).

OBJECTIVES

PRIMARY OBJECTIVE

The primary objective of this project is to estimate the proportion of the inriver early-run sockeye salmon at Kenai River RM 13.7 by reporting group (*Russian River Early*, *Russian River Late*, or *Kenai River Other*) for each temporal stratum for each year during 2018–2020 such that the estimated proportions are within 0.10 of the true values 90% of the time.

SECONDARY OBJECTIVES

1) Estimate the number of *Russian River Early* sockeye salmon passing Kenai River RM 13.7 for each temporal stratum during the early run for each year during 2018–2020.
2) Estimate the proportion of small[1] fish passage at RM 13.7 that are *Russian River Early* sockeye salmon at Kenai River RM 13.7 annually during the early run for each year during 2018–2020.

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[1] Small fish enumerated by the RM 13.4 sonar are those fish between 40 cm and 75 cm ARIS length.

METHODS

STUDY DESIGN

Sockeye Salmon Capture

Sockeye salmon were captured as part of a separate inriver netting project at RM 8.6 of the Kenai River (Perschbacher 2018b). The primary goal of that study was to capture a representative biological (age, sex, and length) sample of the Chinook salmon runs; however, numerous sockeye salmon are also captured by the project, which were sampled to satisfy the sampling goals for the tissue collection portion of this study.

Inriver gillnetting was conducted every day beginning on 16 May. The gillnetting crew was composed of 3 fishery technicians, with 2 technicians working each shift (6:00 AM–2:00 PM). Each technician was scheduled to work 5 days per week for 8 hours per day. Nets were fished with equal frequency by location (nearshore and midriver) and mesh size.

Tissue Sampling for MSA

Genetic tissue was sampled from sockeye salmon captured in the first 8 sets of the inriver gillnetting study each day, which represented about the first third of each gillnet sampling day. However, samples were collected from additional sets when insufficient tissue samples were collected during the first 8 sets, such as in May when fish passage and gillnet catches were low.

A 1⅓-cm (½-inch) piece of the axillary process was removed from each fish and placed on a Whatman paper card in its own grid space and then stapled in place. Whatman cards with tissue samples were placed in an airtight case with desiccant beads to preserve the tissue for DNA extraction.

Tissue Selection for MSA

Subsampling of collections was conducted to ensure analyses accurately represented the passage by date. Daily sonar passage estimates of fish less than 75 cm at RM 13.7 were used to weight the number of tissue samples required each day within each temporal stratum. Once the number of samples required from each day was determined, samples were selected randomly from all available tissues sampled on that date.

Stratification

The sample size goal was 100 tissues for each stratum. Dates for each stratum spanned approximately 1 week, except for the earliest stratum, which was longer due to low sample size. The 5 strata each year were 24 May–3 June, 4–10 June, 11–16 June, 17–23 June, and 24–30 June, respectively. However, an additional stratum (stratum 6) was used in 2019 representing 1–10 July.

Assuming the samples were representative of sockeye salmon passing RM 8.6, both sampling error and genetic error were included in the stock composition estimates by reporting group. According to sampling theory (Thompson 1987), under a worst-case scenario of reporting groups at equal proportions, a multinomial proportion can be estimated to within 0.10 of the true values 90% of the time with a sample size of at least 100.

LABORATORY ANALYSIS

Assaying Genotypes

Genomic DNA was extracted from tissue samples using a NucleoSpin 96 Tissue Kit by Macherey-Nagel (Düren, Germany). The DNA was screened for 96 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 96 screened SNP markers. Reactions were conducted in 10 µL volumes 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 a 95°C hold for 15 min followed by 20 cycles of 95°C for 15 s, 60°C for 4 min, and a final extension hold at 4°C.

The preamplified DNA was screened for the 96 SNP markers using Fluidigm 96.96 Dynamic Array Integrated Fluidic Circuits (IFCs), which systematically combined up to 96 assays and 96 samples into 9,216 parallel reactions. The components were pressurized into the IFC using the IFC Controller RX (Fluidigm). Each reaction was conducted in a 7.2 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: a "Thermal-Mix" step of 70°C for 30 min and 25°C for 10 min, an initial "Hot-Start" denaturation of 95°C for 2 min followed by 40 cycles of denaturation at 95°C for 2 s and annealing at 60°C for 20 s, with a final "Cool-Down" at 25ºC for 10 s. The Dynamic Array IFCs were read on a Biomark or EP1 System (Fluidigm) after amplification and scored using Fluidigm SNP Genotyping Analysis software.

Genotypes were imported and archived in Alaska Department of Fish and Game's Gene Conservation Laboratory (GCL) Oracle database, LOKI.

Laboratory Failure Rates and Quality Control

The overall failure rate was calculated by dividing the number of failed single-locus genotypes by the number of assayed single-locus genotypes. An individual genotype was considered a failure when a locus for a fish could not be satisfactorily scored.

Quality control (QC) measures were instituted to identify laboratory errors and to determine the reproducibility of genotypes. In this process, 8 of every 96 fish (1 row per 96-well plate) were reanalyzed for all markers by staff not involved with the original analysis. Laboratory errors found during the QC process were corrected, and genotypes were corrected in the database. Inconsistencies not attributable to laboratory error were recorded, but original genotype scores were retained in the database.

Assuming the inconsistencies among analyses (original vs. QC genotyping) were due equally to errors in original genotyping and errors during the QC genotyping, and that the analyses are unbiased, error rates in the original genotyping were estimated as ½ the rate of inconsistencies.

STATISTICAL ANALYSIS

Baseline and Reporting Groups

The current sockeye salmon genetic baseline for Upper Cook Inlet includes 69 populations analyzed for 96 genetically variant single nucleotide polymorphism (SNP) loci (Barclay and Habicht 2012). For the mixed stock analysis (MSA) of fish captured at the RM 8.6 netting project, the same baseline was used; however, it was reduced to the 14 Kenai River populations in the baseline (Table 1). Previous analyses of sockeye salmon population structure in Cook Inlet (Barclay and Habicht 2012) have shown sufficient variation to produce MSA estimates for the following 3 reporting groups: (1) *Russian River Early* (Upper Russian River early-run spawning populations); (2) *Russian River Late* (Upper Russian River late-run spawning populations), and (3) *Kenai River Other* (the remaining populations within the Kenai River drainage). These reporting groups were chosen to apportion samples of fish captured by the RM 8.6 gillnetting project.

Baseline Evaluation Tests

Baseline evaluation tests were performed to assess the identifiability of reporting groups in mixtures of fish. Test mixtures of 100 individuals were constructed by randomly sampling predetermined mixture compositions from the baseline without replacement. These mixtures were analyzed against the reduced baseline (full baseline minus the 100 individuals removed for the test mixture). To explore a range of stock compositions, 100 test mixtures were constructed for each reporting group composing 1% to 100% (in 1% increments) of that group with the rest of the composition randomly split among the remaining groups.

The stock compositions of the test mixtures were estimated using the *R* package[2] *rubias* (Moran and Anderson 2019). The *rubias* package is a Bayesian approach to the conditional genetic stock identification model based upon computationally efficient C code implemented in *R*. It uses cross validation and simulation to quantify and correct for biases in reporting group estimates. Each mixture was analyzed for 1 Markov Chain Monte Carlo chain with 25,000 iterations, and the first 5,000 iterations were discarded 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 90% credibility intervals for each test mixture were calculated by taking the mean and 5% and 95% quantiles of the posterior distribution from the single chain output.

As a guideline, we consider a reporting group's performance to be adequate for MSA if at least 90% of tests are within 10% of the true test mixture proportion and overall bias does not exceed ±5%. However, deviations from this guideline are permitted if there is a willingness to accept higher levels of MSA uncertainty for specific reporting groups when information about those groups is needed for management. 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.

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[2] *R* Development Core Team. 2021. *R*: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/.

Table 1.–Tissue collections of sockeye salmon in the Kenai River genetic baseline including sample year, the number of individuals (*N*) analyzed from each collection, and their assigned reporting groups for mixed stock analysis.

Sample location	Sublocation	Sample year	*N*	Population number[a]	Reporting group
Railroad Creek	–	1997	48	1	*Kenai River Other*
Johnson Creek	–	1997	88	1	*Kenai River Other*
Moose Creek	–	1993	47	2	*Kenai River Other*
Moose Creek	–	1994	95	2	*Kenai River Other*
Ptarmigan Creek	–	1992	47	3	*Kenai River Other*
Ptarmigan Creek	–	1993	95	3	*Kenai River Other*
Tern Lake	–	1992	48	4	*Kenai River Other*
Tern Lake	–	1993	48	4	*Kenai River Other*
Quartz Creek	–	1993	94	5	*Kenai River Other*
Kenai River, between Skilak and Kenai Lakes					
	site 1	1994	47	6	*Kenai River Other*
	site 2	1994	48	6	*Kenai River Other*
	site 3	1994	143	6	*Kenai River Other*
	site 4	1993	95	7	*Kenai River Other*
	site 5	1994	48	7	*Kenai River Other*
	site 6	1994	95	7	*Kenai River Other*
Lower Russian River	–	1993	95	7	*Kenai River Other*
Upper Russian River					
	Goat Creek	1992	96	8	*Russian River Early*
	Goat Creek	1997	95	8	*Russian River Early*
	Goat Creek	2009	95	8	*Russian River Early*
	Goat Creek	2009	95	9	*Russian River Late*
	Bear Creek	2009	95	10	*Russian River Late*
	Upper Lake south shore	1999	95	11	*Russian River Late*
	Upper Lake south shore	2009	95	11	*Russian River Late*
	Upper Lake outlet	1999	95	12	*Russian River Late*
	Upper Lake outlet	2009	95	12	*Russian River Late*
Hidden Lake	–	1993	95	13	*Kenai River Other*
Hidden Lake	–	2008	95	13	*Kenai River Other*
Skilak Lake outlet	–	1992	96	14	*Kenai River Other*
Skilak Lake outlet	–	1994	95	14	*Kenai River Other*
Skilak Lake outlet	–	1995	48	14	*Kenai River Other*

Note: An en dash means not applicable.

[a] Unique population numbers represent collections that contributed to a single population.

Data Retrieval and Quality Control

We retrieved genotypes from LOKI and imported them into *R* with the *RJDBC* package (Urbanek 2014). All subsequent analyses were performed in *R*, unless otherwise noted.

Prior to statistical analysis, we performed 2 analyses to confirm the quality of the data. First, we identified individuals that were missing substantial genotypic data because their sample probably had poor quality DNA. We used the 80% rule (missing data at 20% or more of loci; Dann et al. 2009) to identify individuals missing substantial genotypic data. We removed these individuals from further analyses. The inclusion of individuals with poor quality DNA samples might introduce genotyping errors into the baseline and reduce accuracy of the MSA. The second QC 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 100% of screened loci with genotypic data. 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.

Mixed Stock Analysis

The stock composition of the inriver netting samples for each stratum was estimated for the 3 reporting groups following the *rubias* protocol used in the baseline evaluation tests.

ESTIMATED NUMBER AND PROPORTION OF RUSSIAN RIVER EARLY-RUN SOCKEYE SALMON BY STRATUM

Russian River Early stock composition proportions from RM 8.6 were applied to RM 13.7 sonar small fish passage estimates by stratum to generate an estimated number of *Russian River Early* sockeye salmon passing RM 13.7 by stratum. These estimates were, in turn, used to generate the proportions of the total *Russian River Early* sockeye salmon run passing RM 13.7 by stratum. A summary of stock composition estimates and passage of Russian River early-run sockeye salmon by stratum, by year, and with 3-year averages was produced from this to assist with inseason assessments in the future.

RESULTS

RM 13.7 SONAR SMALL FISH PASSAGE, SOCKEYE SALMON CAPTURE, AND TISSUE SAMPLING FOR MSA AT RM 8.6

In 2018, an estimated 105,610 "small fish" (≥40 cm and <75 cm) passed Kenai River RM 13.7 during 16 May–30 June and 810 sockeye salmon were sampled for tissue at RM 8.6 (Table 2). In 2019, an estimated 224,408 "small fish" passed RM 13.7 during 16 May–30 June and 1,255 sockeye salmon were sampled for tissue during 16 May–10 July at RM 8.6. In 2020, an estimated 103,805 "small fish" passed RM 13.7 during 16 May–30 June and 474 sockeye salmon were sampled for tissue at RM 8.6.

TISSUE SELECTION FOR MSA

In 2018, 481 tissues were selected for MSA of strata 1–5, which was 0.4% of the small fish sonar passage estimate during the early run in 2018 (Table 2). In 2019, 628 tissues were selected for MSA. Of those samples, 502 samples were selected for MSA of strata 1–5, which was 0.2% of the small fish sonar passage estimate during the early run in 2019. The remaining 126 samples from 2019 were selected for an additional stratum (stratum 6; 1–10 July) and were included in the MSA for exploring stock compositions in early July, but the results were not used in the year-to-year comparisons or for estimating stock-specific passage. In 2020, 436 tissues were selected for MSA of strata 1–5, which was 0.4% of the small fish sonar passage estimate in 2020.

Table 2.–Kenai River RM 13.7 early-run sonar passage estimates of small fish, number of sockeye salmon sampled for tissue at RM 8.6, and number of tissues selected and analyzed for MSA by stratum and year at Kenai River RM 8.6, 2018–2020.

			RM 13.7 sonar		RM 8.6 samples		MSA samples		
Year	Dates	Stratum	Estimated passage[a]	Prop.[b]	Collected	Prop. sonar[c]	Selected	Analyzed	Prop. sonar[d]
2018	16 May–3 June	1	10,002	0.09	138	0.014	77	73	0.007
	4–10 June	2	37,808	0.36	151	0.004	123	121	0.003
	11–16 June	3	25,474	0.24	267	0.010	101	98	0.004
	17–23 June	4	20,989	0.20	165	0.008	106	96	0.005
	24–30 June	5	11,337	0.11	89	0.008	74	72	0.006
	Total		105,610	1.00	810	0.008	481	460	0.004
2019	16 May–3 June	1	39,066	0.17	322	0.008	101	100	0.003
	4–10 June	2	63,892	0.28	192	0.003	100	97	0.002
	11–16 June	3	48,212	0.21	171	0.004	101	100	0.002
	17–23 June	4	40,903	0.18	211	0.005	101	100	0.002
	24–30 June	5	32,335	0.14	146	0.005	99	98	0.003
	1–10 July	6[e]	–	–	213	–	126	126	–
	Total		224,408	1.00	1,255	0.006	628	621	0.003
2020	16 May–3 June	1	7,793	0.08	92	0.012	92	91	0.012
	4–10 June	2	29,342	0.28	104	0.004	90	85	0.003
	11–16 June	3	29,546	0.28	87	0.003	87	84	0.003
	17–23 June	4	17,097	0.16	81	0.005	81	80	0.005
	24–30 June	5	20,027	0.19	110	0.005	100	96	0.005
	Total		103,805	1.00	474	0.005	450	436	0.004

Note: An en dash means not applicable.

[a] Standard deviations and confidence intervals of RM 13.7 sonar small fish passage estimates can be found in Appendix A1.

[b] Proportion of total sonar passage by year.

[c] Proportion of total sonar passage by year sampled for MSA.

[d] Proportion of total sonar passage by year analyzed for MSA.

[e] Stratum 6 is not considered part of the early run but was sampled and analyzed to explore stock compositions in early July; therefore, no passage estimates are provided here. Stratum dates and sample sizes are provided for completeness.

LABORATORY ANALYSIS: FAILURE RATES AND QUALITY CONTROL

A total of 481 (2018), 628 (2019), and 450 (2020) fish were genotyped from the tissue samples taken during 2018–2020. Failure rates among collections ranged from 1.55% to 2.89% (data not shown). Discrepancy rates were uniformly low and ranged from 0.00% to 0.06% (data not shown). Assuming equal error rates in the original and the QC analyses, estimated error rates in the samples were half of the discrepancy rate (0.00–0.03%).

STATISTICAL ANALYSIS

Baseline Evaluation Tests

In the baseline evaluation tests, all reporting groups performed adequately for MSA (Table 3 and Figure 3). All test estimates were within 1.28% of the true value for all 3 reporting groups. Overall bias for all reporting groups was low and ranged from –0.47% to −0.15% (mean: −0.26%). All reporting groups exceeded the GCL’s guidelines for reporting group MSA performance.

Table 3.–Baseline evaluation test correct allocation summary results calculated using R package *rubias* for 3 reporting groups.

Reporting group	*N*	Range (%)	RMSE (%)	Within (%)	Bias (%)	PCI (%)
Russian River Early	100	1–100	0.79	1.28	−0.47	99.00
Russian River Late	100	1–100	0.65	1.13	−0.15	99.00
Kenai River Other	100	1–100	0.61	1.04	−0.15	99.00

Note: Test results include the number of test mixtures (*N*), range of compositions tested (Range), root mean square error (RMSE), the maximum percentage points from the true proportion where 90% of point estimates occurred (Within), mean bias (Bias), and the proportion of 90% credibility intervals containing the true proportion (PCI) for each reporting group.

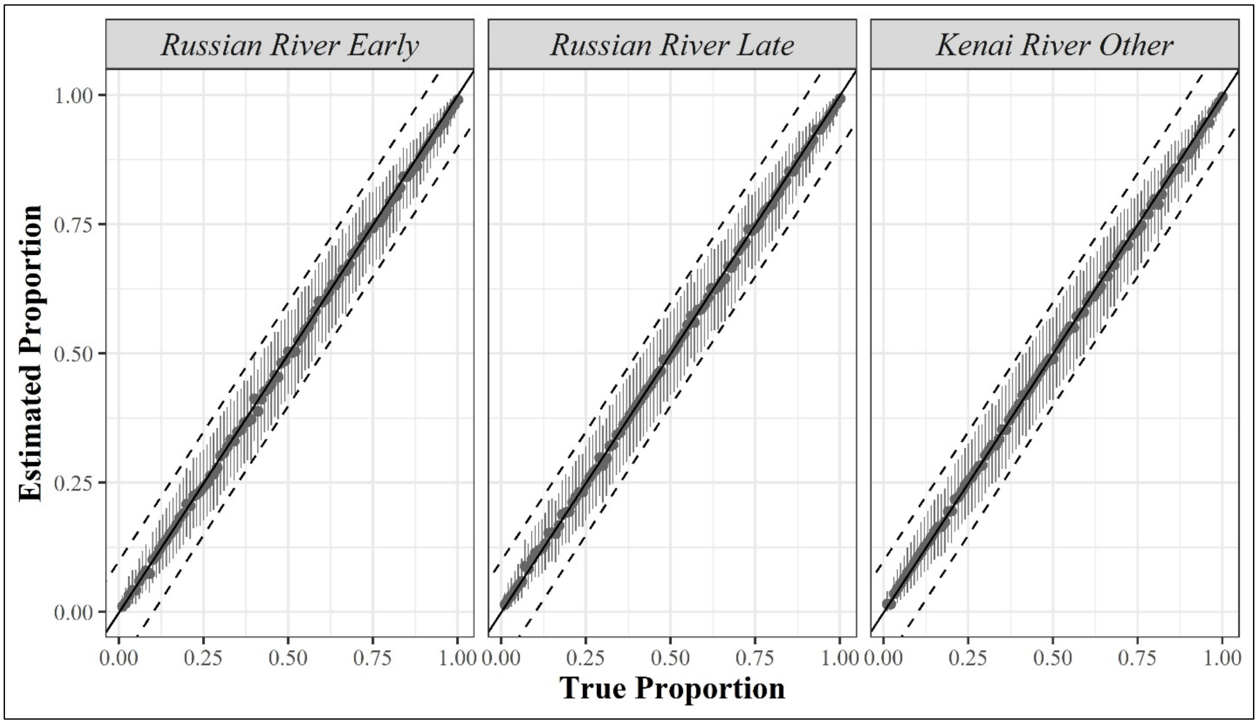

Figure 3.–Results of baseline evaluation test mixtures for the *Russian River Early*, *Russian River Late*, and *Kenai River Other* reporting groups.

Note: Each test mixture contained 380 fish with true proportions ranging from 1% to 100% for the 3 reporting groups (Table 1). The points represent the mean correct allocation (*y*-axis) for each scenario (*x*-axis) with 90% credibility intervals for each point. The solid diagonal line indicates where the estimated proportion equals the true proportion. A reporting group is considered sufficiently identifiable for mixed stock analysis if 90% of point estimates are within ±0.10 of the true proportion (dotted lines). See Table 3 for baseline evaluation summary statistics.

Data Retrieval and Quality Control

Data retrieval and QC results for the baseline collections are reported in Barclay et al. (2012). For the RM 8.6 samples selected for MSA, the 80% scorable marker rule was used to remove 3.15% (2018), 0.80% (2019), and 2.67% (2020) of selected samples before stock composition estimates were calculated. Additionally, 1 (2018), 2 (2019), and 2 (2020) duplicated samples were identified and removed from the selected samples before stock composition estimates were calculated. Stock compositions less than 0.05 are not reported in written summaries due to uncertainty in the estimates.

Mixed Stock Analysis

The estimated proportions of the inriver sockeye salmon early run at Kenai River RM 13.7 by the 3 reporting groups for each temporal stratum within each year were within 0.10 of the true values 90% of the time, thereby satisfying Objective 1 of this project.

In 2018, stock compositions were predominately *Russian River Early*, accounting for 0.92 or greater of the stock composition for every stratum except stratum 5 (24–30 June), during which only 0.55 of the samples were *Russian River Early* (Table 4 and Figure 4). In strata 1–4 (encompassing 16 May–23 June), *Kenai River Other* stocks composed between 0.02 and 0.07 of the samples and no *Russian River Late* fish were detected. In stratum 5 (24–30 June), however, 0.39 of the samples were *Kenai River Other* and 0.06 of the samples were *Russian River Late*.

Table 4.–Stock composition estimates for sockeye salmon sampled at Kenai River RM 8.6, 16 May–30 June 2018.

			Mean	90% CI		
Stratum	Dates	Reporting group	estimate	5%	95%	SD
1	16 May–3 June	*Russian River Early*	0.92	0.83	1.02	0.06
		Russian River Late	0.00	0.00	0.02	0.01
		Kenai River Other	0.07	0.03	0.13	0.03
2	4–10 June	*Russian River Early*	0.97	0.90	1.04	0.04
		Russian River Late	0.00	0.00	0.01	0.00
		Kenai River Other	0.03	0.01	0.06	0.01
3	11–16 June	*Russian River Early*	0.97	0.90	1.05	0.05
		Russian River Late	0.00	0.00	0.02	0.01
		Kenai River Other	0.02	0.01	0.05	0.02
4	17–23 June	*Russian River Early*	0.93	0.87	0.99	0.04
		Russian River Late	0.00	0.00	0.02	0.01
		Kenai River Other	0.07	0.03	0.11	0.03
5	24–30 June	*Russian River Early*	0.55	0.45	0.65	0.06
		Russian River Late	0.06	0.02	0.11	0.03
		Kenai River Other	0.39	0.30	0.48	0.06

Note: Stock compositions by stratum may not sum to 1.00 due to rounding. Due to the integration of uncertainty from the passage estimates, credibility intervals (CI) may exceed 1.00 (see Appendix B1 for stock-specific passage estimates).

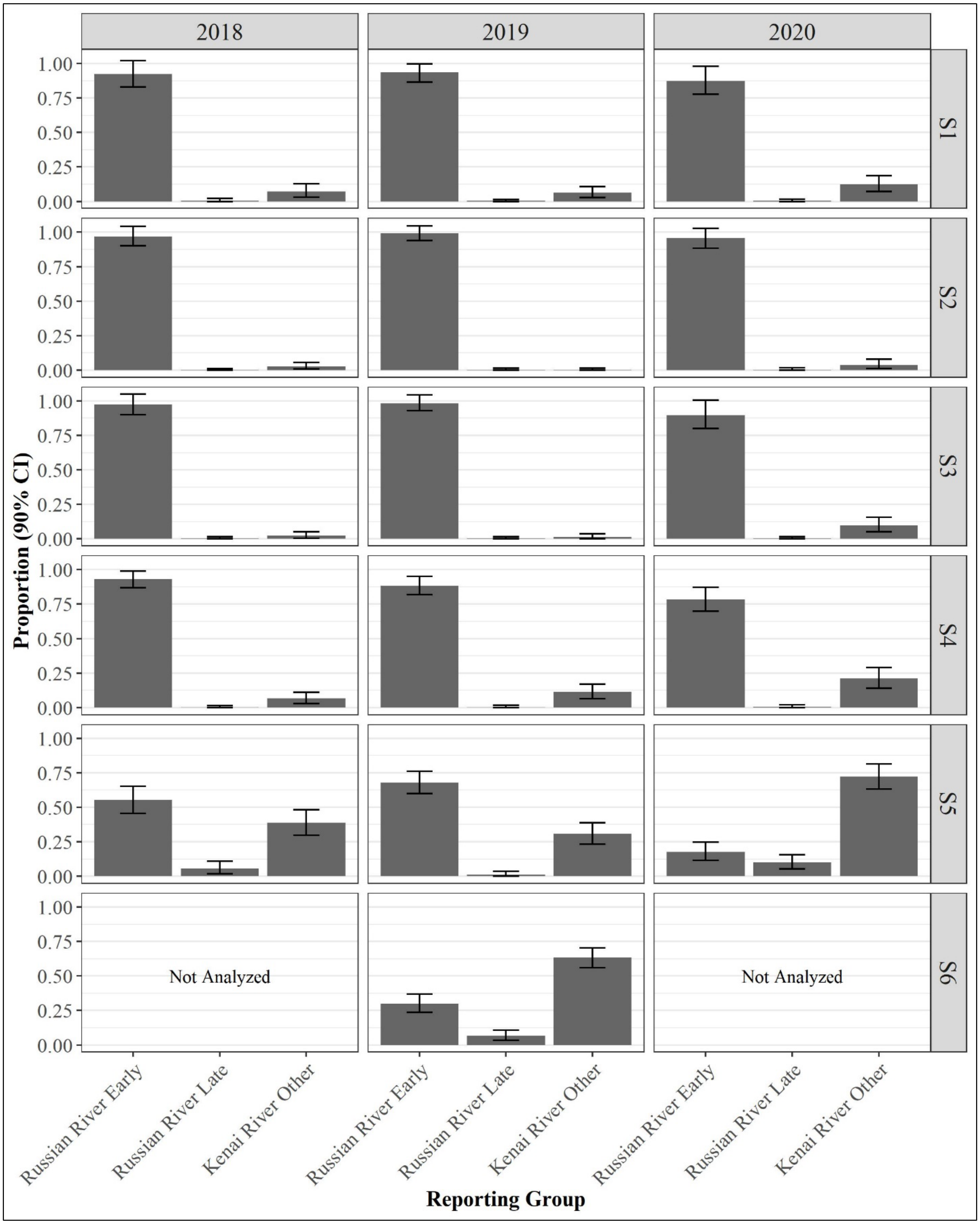

Figure 4.–Stock (reporting group) composition with 90% credibility intervals (CI) for sockeye salmon sampled at Kenai River RM 8.6 by temporal stratum (S1–S6) and year (2018–2020).

Note: S1 = 16 May–3 June; S2 = 4–10 June; S3 = 11–16 June; S4 = 17–23 June; S5 = 24–30 June; S6 = 1–10 July. Due to the integration of uncertainty from the passage estimates, credibility intervals may exceed 1.00.

In 2019, stock compositions were also predominately *Russian River Early*, accounting for 0.88 or greater of the stock composition for every stratum except stratum 5 (24–30 June), during which only 0.68 of the samples were *Russian River Early* (Table 5 and Figure 4). In strata 1–4 (encompassing 16 May–23 June), *Kenai River Other* stocks composed between 0.00 and 0.11 of the samples and no *Russian River Late* fish were detected. In stratum 5 (24–30 June), however, 0.31 of the samples were *Kenai River Other*, although only 0.01 of the samples were *Russian River Late*. In stratum 6 (1–10 July), the predominant stock shifted to *Kenai River Other* (0.63), whereas only 0.30 of the samples were *Russian River Early*, and 0.07 of the samples were *Russian River Late*.

Table 5.–Stock composition estimates for sockeye salmon sampled at Kenai River RM 8.6, 16 May–10 July 2019.

			Mean	90% CI		
Stratum	Dates	Reporting group	estimate	5%	95%	SD
1	16 May–3 June	*Russian River Early*	0.93	0.87	1.00	0.04
		Russian River Late	0.00	0.00	0.01	0.01
		Kenai River Other	0.06	0.03	0.11	0.02
2	4–10 June	*Russian River Early*	0.99	0.94	1.05	0.03
		Russian River Late	0.00	0.00	0.02	0.01
		Kenai River Other	0.00	0.00	0.01	0.01
3	11–16 June	*Russian River Early*	0.98	0.93	1.04	0.03
		Russian River Late	0.00	0.00	0.02	0.01
		Kenai River Other	0.01	0.00	0.04	0.01
4	17–23 June	*Russian River Early*	0.88	0.82	0.95	0.04
		Russian River Late	0.00	0.00	0.02	0.01
		Kenai River Other	0.11	0.06	0.17	0.03
5	24–30 June	*Russian River Early*	0.68	0.60	0.76	0.05
		Russian River Late	0.01	0.00	0.04	0.01
		Kenai River Other	0.31	0.23	0.39	0.05
6	1–10 July	*Russian River Early*	0.30	0.24	0.37	0.04
		Russian River Late	0.07	0.03	0.11	0.02
		Kenai River Other	0.63	0.56	0.70	0.04

Note: Stock compositions by stratum may not sum to 1.00 due to rounding. Due to the integration of uncertainty from the passage estimates, credibility intervals (CI) may exceed 1.00 (see Appendix B2 for stock-specific passage estimates).

In 2020, stock compositions were predominately *Russian River Early*, accounting for 0.78 or greater of the stock composition for every stratum except stratum 5 (24–30 June), when it accounted for 0.18 of the samples (Table 6 and Figure 4). In strata 1–4 (encompassing 16 May–23 June), *Kenai River Other* stocks composed between 0.04 and 0.21 of the samples and no *Russian River Late* fish were detected. In stratum 5 (24–30 June), 0.72 of the samples were *Kenai River Other,* and 0.10 of the samples were *Russian River Late*.

Table 6.–Stock composition estimates for sockeye salmon sampled at Kenai River RM 8.6, 16 May–30 June 2020.

Stratum	Dates	Reporting group	Mean estimate	90% CI 5%	90% CI 95%	SD
1	16 May–3 June	*Russian River Early*	0.87	0.78	0.98	0.06
		Russian River Late	0.00	0.00	0.02	0.01
		Kenai River Other	0.12	0.07	0.19	0.03
2	4–10 June	*Russian River Early*	0.96	0.88	1.03	0.04
		Russian River Late	0.00	0.00	0.02	0.01
		Kenai River Other	0.04	0.01	0.08	0.02
3	11–16 June	*Russian River Early*	0.90	0.80	1.00	0.06
		Russian River Late	0.00	0.00	0.02	0.01
		Kenai River Other	0.10	0.05	0.16	0.03
4	17–23 June	*Russian River Early*	0.78	0.70	0.87	0.05
		Russian River Late	0.00	0.00	0.02	0.01
		Kenai River Other	0.21	0.14	0.29	0.05
5	24–30 June	*Russian River Early*	0.18	0.12	0.25	0.04
		Russian River Late	0.10	0.05	0.16	0.03
		Kenai River Other	0.72	0.63	0.81	0.05

Note: Stock compositions by stratum may not sum to 1.00 due to rounding. Due to the integration of uncertainty from the passage estimates, credibility intervals (CI) may exceed 1.00 (see Appendix B3 for stock-specific passage estimates).

The stock compositions for the first 4 strata each year were similar and composed of nearly all *Russian River Early* fish, whereas in stratum 5, the stock composition was more variable, ranging from 0.68 (2019) to 0.18 of *Russian River Early* fish (2020; Tables 4–6). *Kenai River Other* fish made up the bulk of the rest of the run in stratum 5, and compared to *Russian River Early* fish, ranged from less than half as abundant (0.31 in 2019) to nearly 4 times as abundant (0.72). *Russian River Late* fish were essentially nonexistent in the analysis except in stratum 5 in 2018 (0.06) and 2020 (0.10). The proportion of *Russian River Late* fish in stratum 6 in 2019 was 0.07, but there were no samples collected or analyzed for stratum 6 in 2018 or 2020 for comparison.

ESTIMATED NUMBER AND PROPORTION OF RUSSIAN RIVER EARLY-RUN SOCKEYE SALMON BY STRATUM AND OVERALL

The proportion of the estimated total number of *Russian River Early* fish that migrated past RM 13.7 during the early run rose from stratum 1 (average: 0.12) to a peak during stratum 2 (average: 0.35), followed by declines in stratum 3 (average: 0.28), stratum 4 (average: 0.18), and stratum 5 (average: 0.07; Table 7).

The overall estimated MSA-derived proportions of *Russian River Early* sockeye salmon during the early run were nearly identical in 2018 (0.91) and 2019 (0.92), but much lower in 2020 (0.75; Table 8). The estimated 2018–2020 average MSA-derived proportion of *Russian River Early* fish passing during the early run was 0.86.

Based on small fish sonar passage at RM 13.7, the estimated number of *Russian River Early* fish that passed RM 13.7 during the early run was highest in 2019 (205,493) and much lower in 2018 (96,517) and 2020 (78,330; Table 8).

Table 7.–RM 13.7 sonar passage estimates of small fish, estimated proportion of sockeye salmon tissue samples that were *Russian River Early*, estimated number of *Russian River Early* fish passing RM 13.7, and estimated proportion of total *Russian River Early* fish passage by stratum and year, 2018–2020.

Estimate	Stratum	Dates	2018	2019	2020	Average
RM 13.7 sonar small fish passage[a]	1	16 May–3 June	10,002	39,066	7,793	18,954
	2	4–10 June	37,808	63,892	29,342	43,681
	3	11–16 June	25,474	48,212	29,546	34,411
	4	17–23 June	20,989	40,903	17,097	26,330
	5	24–30 June	11,337	32,335	20,027	21,233
		Total	105,610	224,408	103,805	144,608
Proportion *Russian River Early* by stratum from MSA[b]	1	16 May–3 June	0.92	0.93	0.87	0.91
	2	4–10 June	0.97	0.99	0.96	0.97
	3	11–16 June	0.97	0.98	0.90	0.95
	4	17–23 June	0.93	0.88	0.78	0.87
	5	24–30 June	0.55	0.68	0.18	0.47
Number of *Russian River Early* that passed RM 13.7[b]	1	16 May–3 June	9,244	36,514	6,799	17,519
	2	4–10 June	36,666	63,473	28,070	42,736
	3	11–16 June	24,791	47,405	26,519	32,905
	4	17–23 June	19,543	36,140	13,405	23,029
	5	24–30 June	6,274	21,961	3,537	10,591
		Total	96,517	205,493	78,330	126,780
Proportion of total *Russian River Early* sockeye salmon passage at RM 13.7 by stratum	1	16 May–3 June	0.10	0.18	0.09	0.12
	2	4–10 June	0.38	0.31	0.36	0.35
	3	11–16 June	0.26	0.23	0.34	0.28
	4	17–23 June	0.20	0.18	0.17	0.18
	5	24–30 June	0.07	0.11	0.05	0.07

[a] Standard deviations and confidence intervals of stock composition estimates and RM 13.7 sonar small fish passage estimates can be found in Appendix A1.

[b] Standard deviations and credibility intervals of stock composition estimates, and sockeye salmon passage estimates by stock (reporting group) can be found in Appendices B1–B3.

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Table 8.–Kenai River RM 13.7 sonar annual stock composition and stock-specific passage estimates, including mean, 90% credibility interval, and standard deviation (SD), 2018–2020.

		Stock composition				Stock-specific passage			
Year	Reporting group	Mean	SD	5%	95%	Mean	SD	5%	95%
2018	*Russian River Early*	0.91	0.022	0.876	0.950	96,517	2,374	92,534	100,303
	Russian River Late	0.01	0.004	0.004	0.017	961	415	395	1,764
	Kenai River Other	0.08	0.010	0.061	0.095	8,131	1,105	6,389	10,032
2019	*Russian River Early*	0.92	0.016	0.890	0.943	205,493	3,700	199,781	211,807
	Russian River Late	0.00	0.003	0.001	0.010	1,059	710	224	2,357
	Kenai River Other	0.08	0.010	0.063	0.097	17,856	2,323	14,169	21,830
2020	*Russian River Early*	0.75	0.025	0.714	0.796	78,330	2,555	74,103	82,643
	Russian River Late	0.02	0.007	0.013	0.034	2,327	700	1,321	3,538
	Kenai River Other	0.22	0.017	0.195	0.253	23,147	1,808	20,211	26,241
Overall average	*Russian River Early*	0.86	–	–	–	126,780	–	–	–

Note: An en dash means not applicable.

DISCUSSION

This report's mixed stock genetic analysis of early-run sockeye salmon entering the Kenai River during mid-May through June for 2018–2020 is the first ever to document stock composition estimates for this run. It was suspected that the majority of sockeye salmon entering the Kenai River in May and June (early run) were bound for the Russian River, but the actual stock composition and its variation through time were unknown. We found that a very high proportion of fish passing RM 13.7 during the early run was *Russian River Early* sockeye salmon (Table 8). Other sockeye salmon stocks did not enter the Kenai River in substantial numbers until sometime after at least 23 June during each year of this study.

These study results help increase management precision for Russian River early-run sockeye salmon; however, it is important to acknowledge some potential biases in these results. We assumed all small fish were sockeye salmon, although we do not have reliable species composition estimates for fish in that size range. Although it is known that Chinook salmon, Dolly Varden, and rainbow trout are in the Kenai River during the early-run period, sockeye salmon are assumed (based on gillnetting in the lower Kenai River; Perschbacher 2022) to make up a very high proportion the small fish passage at RM 13.7 during this time (e.g., Key et al. 2019), so the positive bias introduced from assuming all small fish are sockeye salmon is probably small. A potential source of negative bias is that small fish counted at the sonar must be 40 cm or longer ARIS length, and it is possible that some *Russian River Early* fish did not meet the length threshold and were not counted. However, nearly all sockeye salmon passing the Russian River weir meet the 40 cm sonar ARIS length threshold for small fish (Lipka et al. 2020), so it is unlikely that many *Russian River Early* fish were not counted because of this. Another potential source of bias is that the timing of fish passage could be different between the tissue sampling location at RM 8.6 and the sonar at RM 13.7; however, a study in 2017 showed tagged sockeye salmon migrated from RM 8.6 to RM 13.7 in less than 1 day, so the potential bias from the difference in timing of fish passing the tissue collection site and those passing the sonar is probably negligible (Eskelin 2022).

The last source of potential bias in these analyses is probably the largest source of bias. The total passage of *Russian River Early* fish at the RM 13.7 sonar was estimated for May and June because that is when the RM 13.7 sonar enumerates small fish, but an unknown proportion of the *Russian River Early* run enters the Kenai River in July. To investigate run timing and passage of *Russian River Early* fish in early July, tissues were collected at RM 8.6 during 1–10 July in 2019 and analyzed for MSA. The stock composition for the 1–10 July stratum in 2019 was 0.30 (SD 0.04) *Russian River Early*, 0.07 (SD 0.02) *Russian River Late*, and 0.63 (SD 0.04) *Kenai River Other* fish (Table 5). However, we were unable to use these MSA estimates to adequately estimate the passage of *Russian River Early* fish during 1–10 July 2019 because small fish passage at RM 13.7 was not recorded during July. We were, however, able to use the Division of Commercial Fisheries late-run sockeye salmon sonar count at RM 19 of the Kenai River, which begins on 1 July annually. This provided an estimated number of 105,332 sockeye salmon that passed RM 19 during 1–10 July in 2019 (W. Glick, ADF&G, Division of Commercial Fisheries, Soldotna, personal communication). Using this estimate and the estimated stock composition at RM 8.6 during the same time equated to about 31,500 *Russian River Early* fish entering the Kenai River during 1–10 July 2019, which would be approximately 0.13 of the total estimated number of *Russian River Early* fish that passed RM 13.7 on or before 10 July. The Russian River early run in 2019 was anomalous compared to other years and was by far the largest run ever observed, with an escapement of 125,942 through the Russian River weir despite very liberalized management of the fishery, including a first-time ever 9-fish daily bag limit (emergency order 2-RS-1-12-19) for part of the run. Although there are several potential biases in the run-size estimates of Russian River early-run sockeye salmon, the biases are probably relatively small, potentially compensatory, or altogether negatively biased, which is a conservative assessment. The assumption that all small-sized fish are sockeye salmon for these analyses introduced a small positive bias in the abundance estimate of *Russian River Early* fish; however, sockeye salmon less than 40 cm ARIS length are not counted at the sonar, which may have introduced a small amount of negative bias, so those biases were compensatory. The negative bias introduced from not accounting for the passage of *Russian River Early* fish in July probably introduced more bias than from any other source, so overall, the annual abundance estimates of *Russian River Early* fish that passed RM 13.7 are considered negatively biased by an unknown amount. In 2019, it was estimated that about 0.13 of the *Russian River Early* run entered the lower Kenai River during 1–10 July. The proportions of the *Russian River Early* run entering the lower Kenai River in July during other years is unknown.

This new information about early-run sockeye salmon stock composition and passage of *Russian River Early* fish at RM 13.7 combined with estimates of sockeye salmon migratory travel times from the lower Kenai River to the Russian River will improve inseason assessment and management of this valuable sport fisheries resource by providing additional knowledge to assess the strength of the *Russian River Early* sockeye salmon run before fish arrive at the Russian River sport fishery area or pass the Russian River weir. Overall, based on the run timing and assessment information collected during this multi-phase investigation, the small fish enumerated by the RM 13.7 sonar, those fish between 40 cm and 75 cm ARIS length, will provide a useful index of early-run Russian River sockeye run strength, especially in broad categories of high, medium, or low abundance, so more timely inseason management actions for the sport fishery can be taken to achieve the escapement goal.

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APPENDIX A: KENAI RIVER RM 13.7 SONAR SMALL FISH PASSAGE ESTIMATES, 2018–2020

Appendix A1.–Kenai River RM 13.7 sonar small fish passage by stratum including passage dates, point estimate, standard deviation (SD), 90% confidence interval, and coefficient of variation (CV), 2018–2020.

Year	Stratum	Dates	Estimate[a]	SD	5%	95%	CV
2018	1	16 May–3 June	10,002	518	9,150	10,854	0.052
	2	4–10 June	37,808	1,573	35,221	40,395	0.042
	3	11–16 June	25,474	1,181	23,531	27,417	0.046
	4	17–23 June	20,989	523	20,129	21,849	0.025
	5	24–30 June	11,337	366	10,734	11,940	0.032
2019	1	16 May–3 June	39,066	1,298	36,930	41,202	0.033
	2	4–10 June	63,892	2,038	60,540	67,244	0.032
	3	11–16 June	48,212	1,552	45,659	50,765	0.032
	4	17–23 June	40,903	1,169	38,980	42,826	0.029
	5	24–30 June	32,335	741	31,115	33,555	0.023
2020	1	16 May–3 June	7,793	473	7,014	8,572	0.061
	2	4–10 June	29,342	1,163	27,430	31,254	0.040
	3	11–16 June	29,546	1,746	26,674	32,418	0.059
	4	17–23 June	17,097	591	16,124	18,070	0.035
	5	24–30 June	20,027	823	18,674	21,380	0.041

[a] *Source*: Brandon Key, Fisheries Biologist, ADF&G, Soldotna, unpublished data associated with Key et al. (*In prep*).

APPENDIX B: STOCK (REPORTING GROUP) COMPOSITION AND STOCK-SPECIFIC PASSAGE ESTIMATES OF SOCKEYE SALMON BY STRATUM AT THE KENAI RIVER RM 13.7 SONAR

Appendix B1.–Kenai River RM 13.7 sonar temporal strata stock composition and stock-specific passage estimates, including mean, 90% credibility interval, and standard deviation (SD), 2018.

			Stock composition				Stock-specific passage			
Stratum	Dates	Reporting group	Mean	SD	5%	95%	Mean	SD	5%	95%
1	16 May–3 June	*Russian River Early*[a]	0.924	0.058	0.828	1.022	9,244	575	8,285	10,220
		Russian River Late	0.005	0.008	0.000	0.021	46	80	0	213
		Kenai River Other	0.071	0.030	0.030	0.128	712	302	298	1,277
2	4–10 June	*Russian River Early*[a]	0.970	0.043	0.901	1.041	36,666	1,637	34,075	39,352
		Russian River Late	0.003	0.005	0.000	0.012	99	174	0	455
		Kenai River Other	0.028	0.015	0.008	0.056	1,043	558	307	2,120
3	11–16 June	*Russian River Early*[a]	0.973	0.047	0.898	1.051	24,791	1,194	22,887	26,764
		Russian River Late	0.004	0.006	0.000	0.015	92	150	0	392
		Kenai River Other	0.023	0.015	0.005	0.052	591	388	129	1,320
4	17–23 June	*Russian River Early*	0.931	0.035	0.870	0.988	19,543	737	18,257	20,746
		Russian River Late	0.003	0.006	0.000	0.015	71	123	0	323
		Kenai River Other	0.065	0.025	0.029	0.112	1,374	531	617	2,359
5	24–30 June	*Russian River Early*	0.553	0.060	0.455	0.654	6,274	682	5,156	7,409
		Russian River Late	0.058	0.028	0.019	0.110	652	313	220	1,247
		Kenai River Other	0.389	0.057	0.297	0.482	4,411	646	3,368	5,459

[a] Due to the integration of uncertainty from the passage estimates, the credibility intervals for these estimates exceeded the passage point estimate.

Appendix B2.–Kenai River RM 13.7 sonar temporal strata stock composition and stock-specific passage estimates, including mean, 90% credibility interval, and standard deviation (SD), 2019.

			Stock composition				Stock-specific passage			
Stratum	Dates	Reporting group	Mean	SD	5%	95%	Mean	SD	5%	95%
1	16 May–3 June	*Russian River Early*	0.935	0.039	0.866	0.996	36,514	1,507	33,839	38,925
		Russian River Late	0.003	0.005	0.000	0.014	123	209	0	542
		Kenai River Other	0.062	0.024	0.028	0.106	2,429	938	1,100	4,156
2	4–10 June	*Russian River Early*[a]	0.993	0.032	0.941	1.046	63,473	2,057	60,120	66,802
		Russian River Late	0.003	0.006	0.000	0.015	210	376	0	966
		Kenai River Other	0.003	0.005	0.000	0.015	209	350	0	927
3	11–16 June	*Russian River Early*[a]	0.983	0.034	0.929	1.042	47,405	1,658	44,785	50,251
		Russian River Late	0.003	0.006	0.000	0.015	165	279	0	734
		Kenai River Other	0.013	0.012	0.001	0.036	642	562	66	1,745
4	17–23 June	*Russian River Early*	0.884	0.041	0.818	0.951	36,140	1,670	33,464	38,898
		Russian River Late	0.004	0.006	0.000	0.017	154	264	0	693
		Kenai River Other	0.113	0.032	0.065	0.169	4,609	1,302	2,656	6,919
5	24–30 June	*Russian River Early*	0.679	0.050	0.599	0.762	21,961	1,609	19,359	24,639
		Russian River Late	0.013	0.012	0.001	0.036	407	383	17	1,172
		Kenai River Other	0.308	0.047	0.233	0.389	9,967	1,530	7,526	12,565

[a] Due to the integration of uncertainty from the passage estimates, the credibility intervals for these estimates exceeded the passage point estimate.

Appendix B3.–Kenai River RM 13.7 sonar temporal strata stock composition and stock-specific passage estimates, including mean, 90% credibility interval, and standard deviation (SD), 2020.

			Stock composition				Stock-specific passage			
Stratum	Dates	Reporting group	mean	SD	5%	95%	mean	SD	5%	95%
1	16 May–3 June	*Russian River Early*	0.872	0.062	0.776	0.979	6,799	479	6,048	7,628
		Russian River Late	0.004	0.006	0.000	0.016	28	49	0	122
		Kenai River Other	0.124	0.034	0.072	0.186	966	265	560	1,447
2	4–10 June	*Russian River Early*[a]	0.957	0.045	0.885	1.029	28,070	1,307	25,965	30,179
		Russian River Late	0.004	0.007	0.000	0.018	118	215	0	521
		Kenai River Other	0.039	0.021	0.012	0.078	1,153	604	343	2,287
3	11–16 June	*Russian River Early*[a]	0.898	0.062	0.799	1.005	26,519	1,831	23,615	29,692
		Russian River Late	0.004	0.007	0.000	0.017	114	199	0	509
		Kenai River Other	0.099	0.034	0.051	0.158	2,913	998	1,495	4,654
4	17–23 June	*Russian River Early*	0.784	0.054	0.698	0.872	13,405	919	11,931	14,912
		Russian River Late	0.004	0.007	0.000	0.019	74	124	0	321
		Kenai River Other	0.212	0.046	0.141	0.289	3,618	782	2,413	4,948
5	24–30 June	*Russian River Early*	0.177	0.040	0.115	0.248	3,537	804	2,306	4,957
		Russian River Late	0.099	0.031	0.053	0.155	1,992	624	1,063	3,111
		Kenai River Other	0.724	0.055	0.632	0.814	14,498	1,098	12,653	16,311

[a] Due to the integration of uncertainty from the passage estimates, the credibility intervals for these estimates exceeded the passage point estimate.