Fishery Manuscript No. 16-06

Stock-specific Abundance and Run Timing of Chinook Salmon in the Kenai River, 2007–2014

by

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and

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December 2016

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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This investigation was partially financed by the Capital Improvement Project entitled Kenai River King Salmon Sonar Assessment Program and by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-22 to 30 Job No. S-2-39.

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This document should be cited as follows:
Reimer, A. M., and S. J. Fleischman. 2016. Stock-specific abundance and run timing of Chinook salmon in the Kenai River, 2007–2014. Alaska Department of Fish and Game, Fishery Manuscript Series No. 16-06, Anchorage.

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ABSTRACT

A stock-specific abundance and run timing model (SSART) was fit to relative and absolute estimates of abundance, genetic stock identification data, radiotelemetry data, and estimates of harvest for Kenai River Chinook salmon (*Oncorhynchus tshawytscha*) from 2007 to 2014. The methods follow a model of the 2007–2012 data except that inference is restricted to Chinook salmon 75 cm mid eye to tail fork (METF) or longer for all results in this report. Bayesian statistical methods were employed to estimate inriver abundance and run timing by stock at river mile 8.6 of the Kenai River. Abundance of early-run Chinook salmon ranged from 1,940 (SE 307) in 2013 to 8,637 (SE 2,215) in 2007. Abundance of late-run Chinook salmon ranged from 9,949 (SE 2,138) in 2010 to 37,180 (SE 10,340) in 2007. Fish from Killey River–Benjamin Creek, Funny River–Slikok Creek, and Quartz–Crescent creeks migrated upstream primarily prior to 30 June; fish from Grant Creek and Russian River migrated upstream primarily between 16 June and 31 July; and fish from Mainstem Kenai River–Juneau Creek migrated upstream primarily after 16 June. Tributary stocks had greater relative abundance within the run before 16 June and the Mainstem–Juneau Creek stock had greater relative abundance after 30 June. Between 16 June and 30 June, tributary stocks had greater relative abundance in 6 of 8 years while Mainstem–Juneau Creek fish had greater relative abundance in the other 2 years.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, Kenai River, abundance, Bayesian statistics, genetic stock identification, OpenBUGS, SSART

INTRODUCTION

The Kenai River watershed encompasses approximately 2,200 square miles of the Kenai Peninsula, including diverse landscapes such as glaciers, large lakes, high mountains, and vast lowlands. The Kenai River mainstem is approximately 82 miles long, including a 15-mile stretch where it flows through Skilak Lake (Figure 1). Tidal influence extends up to river mile (RM) 12. Populations of Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), sockeye salmon (*O. nerka*), pink salmon (*O. gorbuscha*), Dolly Varden (*Salvelinus malma*), and rainbow trout (*O. mykiss*) live in the Kenai River and support valuable commercial and recreational fisheries, including the largest recreational Chinook salmon fishery in Alaska (Jennings et al. 2015). The Kenai River fishery will probably support substantial angler effort into the foreseeable future due to its reputation, easy accessibility, and location near major Alaska population centers.

Kenai River Chinook salmon are separated into tributary and mainstem spawning populations. Tributary spawning Chinook salmon arrive from late April to early July (Burger et al. 1983; Bendock and Alexandersdottir 1992; Reimer 2013). Tributaries of the Kenai River that support populations of Chinook salmon include Slikok Creek, Funny River, Killey River, Benjamin Creek, Russian River, Juneau Creek, Quartz Creek, Crescent Creek, Daves Creek, Ptarmigan Creek, and Grant Creek (Burger et al. 1983; Bendock and Alexandersdottir 1992; Reimer 2013). Funny River, Killey River, and Benjamin Creek support the largest populations of tributary spawning Chinook salmon. Mainstem spawning Chinook salmon arrive from late June to mid-August (Burger et al. 1983; Hammarstrom et al. 1985; Bendock and Alexandersdottir 1992; Reimer 2013). The entire Kenai River mainstem upstream of the intertidal area (RM 12) is suitable spawning habitat for Chinook salmon.

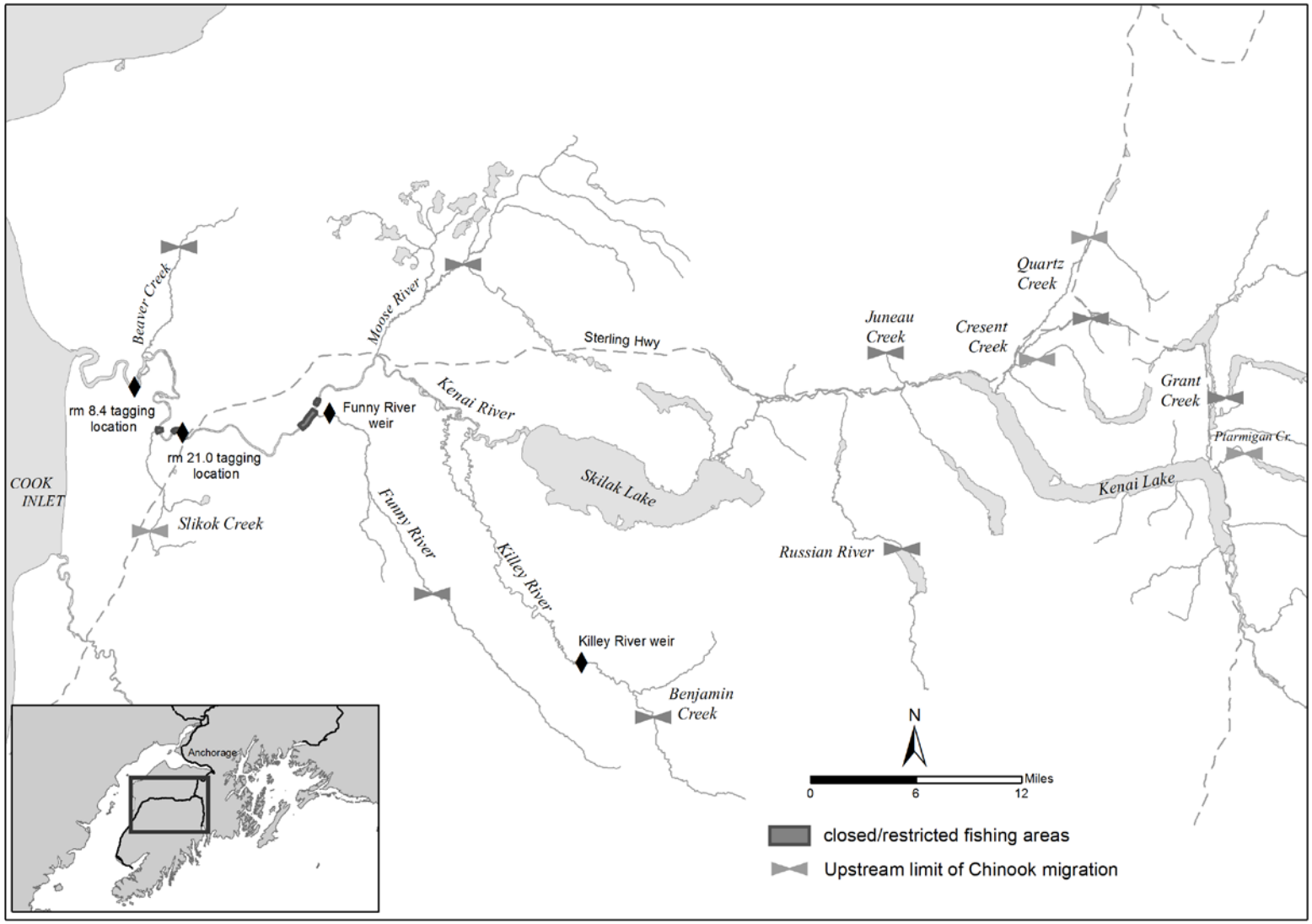

Figure 1.–The Kenai River drainage.

Note: Although not indicated in the figure, the Kenai River upstream of Skilak Lake and all tributaries to the Kenai River are also closed to sport fishing.

Kenai River Chinook salmon are managed using plans first adopted by the Alaska Board of Fisheries in 1988 (McBride et al. 1989). These plans defined the early run as fish entering the Kenai River prior to 1 July and the late run as fish entering after 30 June. Early-run fish are harvested primarily by the inriver sport fishery but also by a marine sport fishery in Cook Inlet and a small subsistence fishery in the estuary. Late-run fish are harvested primarily by an inriver sport fishery and a marine commercial set gillnet fishery in Cook Inlet but also by marine sport, commercial drift gillnet, subsistence, and personal use fisheries. Both runs are actively managed by emergency order to achieve escapement goals.

STOCK ASSESSMENT HISTORY

The size of the inriver run is a key component for estimating spawning escapement and implementing management plans. Daily and seasonal estimates of Kenai River Chinook salmon abundance at RM 8.6 have been generated since 1987 using hydroacoustic (sonar) techniques. Sonar assessment of Chinook salmon abundance in the Kenai River is complicated by the presence of more abundant sockeye salmon, which overlap in size and migrate concurrently with Chinook salmon. Sonar technology and methods have undergone nearly continuous refinement in an effort to improve fish species classification. The most recent technology uses multi-beam imaging sonar technology, which allows technicians to measure the size of targets directly during the counting process. Imaging sonar can produce direct counts of Chinook salmon 75 cm mid eye to tail fork (METF) and longer, whereas measurements from small Chinook salmon (less than 75 cm METF) overlap with measurements of salmon of other species. Abundance of small Chinook salmon has been estimated by fitting an age-structured mixture model to the distributions of fish length measurements from sonar and inriver nets (Key et al. 2016a, 2016b).

Kenai River Chinook salmon are larger at age and older at maturity than most Chinook salmon stocks in North America (Roni and Quinn 1995). Chinook salmon sampled by ADF&G in the Kenai River from 2002 to 2014 ranged in METF length from 27 to 130 cm (Reimer 2004a, 2004b; Reimer 2007; Eskelin 2007, 2009, 2010; Perschbacher 2012a, 2012b, 2012c, 2012d, 2014, 2015; Pershbacher and Eskelin 2016). During this period, on average 70% of the Chinook salmon sampled each year in the early run and 74% of the Chinook salmon sampled each year during the late run were 75 cm METF or longer. Only a negligible number of sockeye salmon were measured longer than 75 cm METF (Miller et al. 2016).

The Kenai River Creel Survey (established in 1974) and Kenai River Inriver Gillnetting Project (established in 1979) are operated annually by the Alaska Department of Fish and Game (ADF&G) on the lower Kenai River (Perschbacher 2014). The creel survey is used to estimate both the magnitude of the harvest and the age, sex, and size composition of the harvest of Chinook salmon from the fishery that occurs in the mainstem Kenai River downstream of the Soldotna Bridge. The inriver gillnetting project occurs near RM 8.6 and provides an index of Chinook salmon abundance through catch per unit effort (CPUE) estimates as well as age, sex, and size composition data from captured Chinook salmon. The gillnetting project also provides a platform to deploy radio tags as part of abundance estimation.

In the 2000s, genetic stock identification (GSI) technology (Adams et al. 1994) was implemented to address important Kenai River Chinook salmon stock assessment issues such as stock-specific run timing and catch allocation. GSI is used to determine the stock composition of a “mixture” of fish of unknown origin by comparing the allele frequency information in the mixture to allele frequencies from fish of known stock origin (the “baseline”) and assigning proportions of the

mixture to the known stocks. Collection of tissue samples for development of a GSI baseline within the Kenai River drainage began in 2005 (Begich et al. 2010). Collection of mixture samples by the Kenai River Inriver Gillnetting Project began in 2003 and by the Kenai River Creel Survey downstream of the Soldotna Bridge (RM 21) in 2006. Beginning in 2007, this was supplemented by mixture samples from the sport fish harvest upstream of the Soldotna Bridge. In 2013, a Kenai River drainage Chinook salmon baseline was developed (Rogers Olive et al. 2013), including 2,205 Chinook salmon from 11 spawning populations.

Several weirs have been operated in Kenai River tributaries to measure salmon escapement. ADF&G operated a weir on Slikok Creek between 2008 and 2012. The United States Fish and Wildlife Service (USFWS) has operated weirs on the Funny River since 2006 (Gates and Palmer 2008; Gates and Boersma 2009a, 2009b, 2011, 2014b; Boersma and Gates 2013, 2014) and on the Killey River near Benjamin Creek since 2012 (Gates and Boersma 2013, 2014a, 2014c). In 2013, a weir was operated on Grant Creek as part of a hydroelectric assessment by Kenai Hydro LLC (Miller and Stevenson 2014).

Here we synthesize data from multiple sources into a stock-specific abundance and run timing model to obtain annual inriver abundance estimates of Chinook salmon 75 cm METF or longer for the years 2007–2014. These data include catch rates and GSI allele counts from the inriver gillnet project, harvest estimates from the creel survey, escapement counts from the Funny and Killey rivers and Slikok Creek, and radiotelemetry data from fish instrumented at RM 8.6 and RM 21. This modelling effort is similar to Reimer et al. (2016) except the inference is restricted to Chinook salmon 75 cm METF and longer, and 2 additional years of data are included. Inference from the model is restricted in order to reduce bias based on the migratory behavior of smaller salmon (Perschbacher 2015; Perschbacher and Eskelin 2016) and to provide estimates to support consideration by ADF&G of Kenai River escapement goals based on Chinook salmon greater than or equal to 75 cm METF.

METHODS

SSART MODEL OVERVIEW

The conceptual framework for the Stock-specific Abundance and Run Timing Model (SSART) was originally developed by the USFWS (Bromaghin et al. 2010)[1]. The model stratifies Chinook salmon abundance by space and time, where genetic reporting groups (Killey River–Benjamin Creek, Funny River–Slikok Creek, Grant Creek, Mainstem Kenai River–Juneau Creek, Quartz Creek–Crescent Creek, and Russian River) represent the spatial stratification and approximately 2-week intervals (16–31 May, 1–15 June, 16–30 June, 1–15 July, 16–31 July, and 1–15 August) represent the time strata. The first 3 time strata compose the early run and the last 3 strata the late run. Information about relative abundance of each stock by spatial stratum is provided by GSI data from inriver gillnetting samples and by final destinations of fish captured and radiotagged in the lower Kenai River. Information about relative abundance of all stocks by temporal stratum is derived from CPUE during the Inriver Gillnetting Project located near RM 8.6. Tributary weir data anchor the analysis by providing known escapements for some stocks. Harvest by stock group is accounted for by collecting genetic samples from harvested fish and weighting estimates of harvest by time strata (Figure 2).

[1] The current methods differ from those of Bromaghin et al. (2010) in the use of GSI allele frequency data, the inclusion of harvest, and in the adoption of a Bayesian, rather than maximum likelihood, framework.

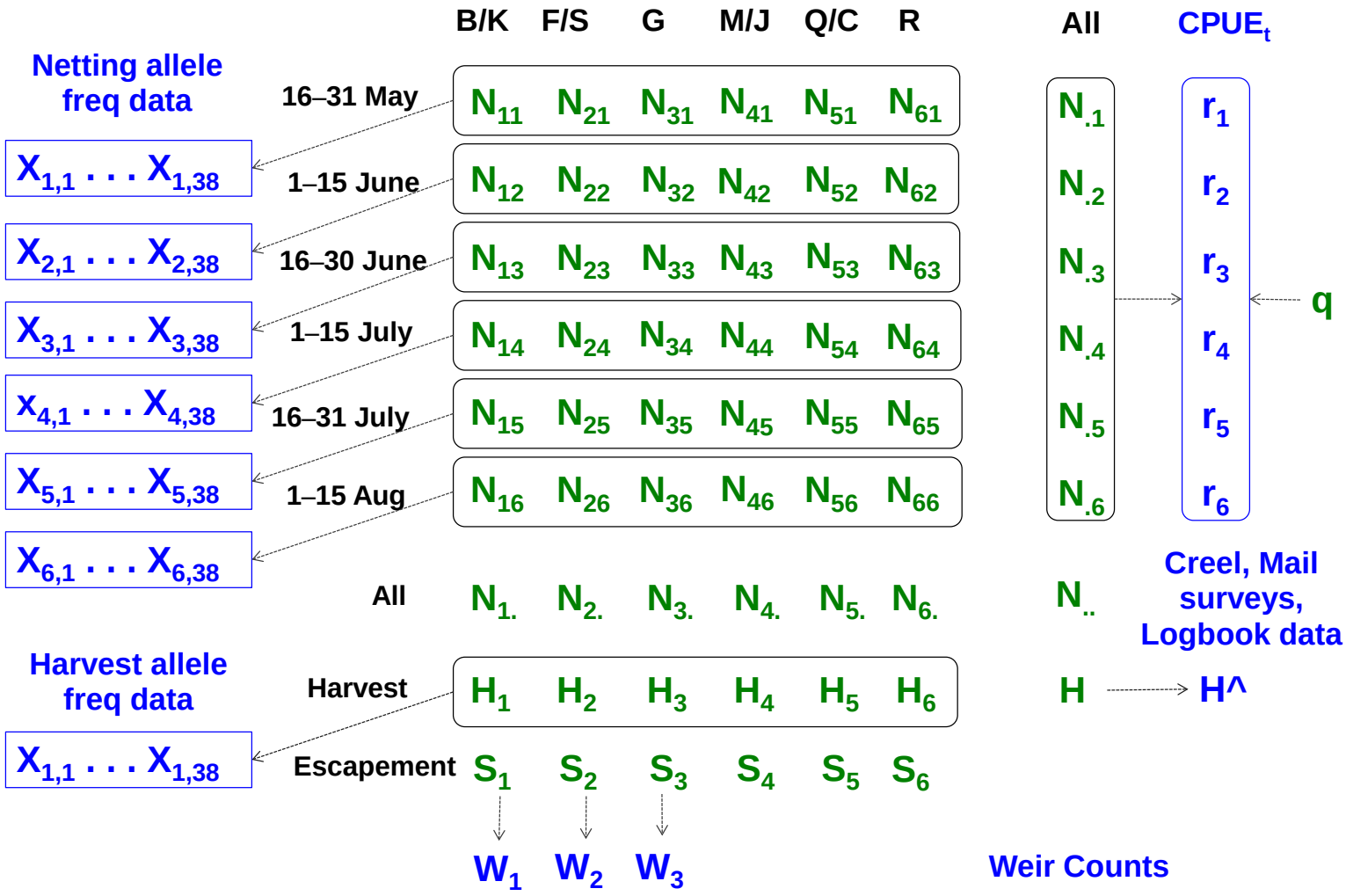

Figure 2.–The SSART model.

Note: Annual quantities of parameters N_{it} (abundance), H_i (harvest), S_i (escapement), and q (catchability) are shown in green; and data $X_{m,h}$, r_t, $\hat{H}$, and W_i are shown in blue. Subscripts index individual fish (m), time (t), stock (i), and allele (h). B/K is Killey River–Benjamin Creek, F/S is Funny River–Slikok Creek, G is Grant Creek, M/J is Mainstem Kenai River–Juneau Creek, Q/C is Quartz Creek–Crescent Creek, and R is Russian River.

It is helpful to think of the SSART analysis in the context of a traditional 2-event closed-population mark–recapture experiment (e.g., Otis et al. 1978; Seber 1982) where M fish are marked in the first "marking" event, and the marked proportion pM is estimated in the second "recapture" event. An estimate of abundance $\widehat{N}$ during the first event is equal to M divided by pM. In genetic mark–recapture experiments like SSART, the events are chronologically reversed. Stock composition is analogous to the marked proportion, and can be estimated from allele frequencies collected during the *first* event. The number of marked fish M is assessed as the count through the weir during the *second* event.

This approach has 3 advantages over traditional mark–recapture experiments. A primary advantage is that stock composition estimates from GSI are produced using tissue samples collected at the time of capture and thus the estimates are unaffected by fish behavior after capture and handling. In contrast, traditional mark–recapture experiments must recapture marked fish and thus handling effect is a large source of potential (and often unknown) bias. Another benefit of the SSART approach is the ability to combine information from multiple data sources. For instance, the precision of stock composition estimates can be improved by supplementing stock identity probabilities produced by GSI with known spawning destinations from radiotagged Chinook salmon[2]. A third feature of the SSART model is that the entire run is reconstructed through space and time, resulting in estimates of stock-specific abundance and harvest by time period and by river reach. Such information is valuable for formulating management strategies.

REQUIRED DATA SOURCES

The SSART model requires input data from several different projects in the Kenai River system. These projects are briefly described in the following sections with reference to their respective comprehensive reports. Data used in the SSART model that are not readily available in published reports are included in Appendices A1–A7.

Indices of Abundance

Three indices of abundance are available for Kenai River Chinook salmon: inriver gillnetting CPUE near RM 8.6, DIDSON sonar counts near RM 8.6, and ARIS sonar counts near RM 13.6. Gillnetting CPUE data are available through the entire study period but are subject to bias associated with incomplete sampling of migrating fish and may be subject to bias associated with net saturation when fish are abundant. DIDSON sonar counts also sample only a portion of the upstream migrants but avoid saturation issues and are only available for the 4 most recent years. ARIS sonar counts avoid both of these known biases but are only available for the 2 most recent years. See Discussion for more on this topic. Herein, we use the best index of abundance available in each year: netting CPUE from 2007 to 2010, DIDSON counts from 2011 to 2012, and ARIS sonar counts from 2013 to 2014. To accommodate differing units, each index was scaled to sum to 1 annually before analysis.

The CPUE of Chinook salmon by the Kenai River Inriver Gillnetting Project near RM 8.6 provides an index of abundance that is assumed to be proportional to Chinook salmon abundance migrating past RM 8.6. Netting CPUE is available for all years included in this study. Gillnet fishing began on 16 May in all years and continued through 10 August in years 2007–2011. In

[2] Use of radiotelemetry information in this way introduces minimal bias related to handing because severely affected fish fail to reach a spawning destination and their stock identities are derived exclusively from GSI data.

2012 and 2014, gillnet fishing continued until 15 August whereas in 2013, gillnet fishing continued until 17 August. These dates were assumed to include the entire run of Kenai River Chinook salmon. Chinook salmon were captured with 2 sizes of gillnet (stretched mesh 5.0 in and 7.5 in) in colors that match Kenai River water. The netting project fished an area approximately 0.3 mi long. Nets were drifted midriver and sets alternated between mesh size and the north and south sides of the thalweg. Gillnetting occurred once per day for 6 consecutive hours beginning 5 hours before low tide, except in 2014 when gillnetting occurred between 7:00 AM and 7:00 PM regardless of tide stage. A full description of methods and daily CPUEs are detailed in Eskelin (2010), Perschbacher (2012a-d, 2014, 2015), and Perschbacher and Eskelin (2016). CPUE data were reduced by summing the daily values within each time stratum and multiplying by the proportion of the catch that was 75 cm METF or longer (Appendix A1).

Sonar based indices of abundance for Chinook salmon 75 cm or longer are available from DIDSON counts conducted at RM 8.6 in 2010–2014 (Miller et al. 2013, 2014, 2015; Key et al. 2016a, 2016b) and ARIS counts conducted at RM 13.6 in 2013–2014 (Miller et al. 2016a, 2016b). Dates of operation match the dates described for the inriver gillnetting project above. The RM 8.6 sonar counts the midriver portion of the Kenai River while the RM 13.6 sonar is designed to count the entire channel. Sonar data were reduced by summing the daily values within each time stratum. Using sonar counts as a temporal index of abundance does not jeopardize the independence of the SSART model and sonar estimates of run size because only the relative magnitude of the counts across time strata, and not the absolute magnitude, is leveraged by the SSART model.

Stock Composition of the Inriver Run

Genetic samples (Appendix A2) used to produce estimates of inriver run stock identification were collected from Chinook salmon captured by the Inriver Gillnetting Project near RM 8.6 (Eskelin 2010; Perschbacher 2012a-d, 2014, 2015; Perschbacher and Eskelin 2016). Tissue samples for genetic analysis were removed from every Chinook salmon that was captured. A half-inch square piece of tissue was removed from the dorsal fin and immediately transferred to a 2 mL cryovial containing reagent grade 95% alcohol buffer solution and stored until DNA extraction. Laboratory analysis followed methods described in McKinley et al. (2013).

For 2013 and 2014, the netting project was expanded into the nearshore areas. Stock composition was estimated separately for fish migrating midriver and fish migrating nearshore, and catches in each area were compared to estimate relative abundance by migration corridor. In 2013, midriver netting was supplemented with nearshore netting on 2 days per week. In 2014, supplemental nearshore netting was completed 7 days per week. Netting and tissue sample procedures follow those described above.

Harvest Estimates

Sport harvest estimates of Chinook salmon in the Lower Kenai River (below the Soldotna Bridge [RM 21]; Figure 1) were available from an onsite creel survey (Eskelin 2010; Perschbacher 2012a-d, 2014, 2015; Perschbacher and Eskelin 2016). Harvest estimates were summed over each of 5 time strata (16–31 May, 1–15 June, 16–30 June, 1–15 July, and 16–31 July) and multiplied by the proportion of the harvest that was 75 cm METF or longer in each time stratum (Appendix A3). Uncertainty of the harvest estimate within each time stratum was summarized by the coefficient of variation (CV).

Sport harvest estimates of Chinook salmon in the Middle Kenai River (Soldotna Bridge to Skilak Lake [RM 21–50]; Figure 1) were available from combined Statewide Harvest Survey estimates (Alaska Sport Fishing Survey database [Internet]. 1996– . Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish. Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey/) and mandatory guide logbook data as described in Reimer et al. (2016). Harvest estimates were multiplied by the proportion of the harvest that was 75 cm METF or longer (Appendix A4) in each stratum (16 May–30 June and 1–31 July). In 2007–2010, length samples from the Middle Kenai River harvest were available to estimate the proportion of the harvest that was 75 cm METF or longer (McKinley et al. 2013). In 2011–2012, length samples from the lower river harvest during the same time periods were used as proxies. Uncertainty of the harvest estimate within each time stratum was summarized by the coefficient of variation (CV).

Total harvest was included by summing estimates of lower and middle river harvests and calculating the associated CVs.

Stock Composition of the Harvest

Genetic samples (Appendix A2) used to produce estimates of the stock identification for the harvests of Chinook salmon in the lower Kenai River were collected from the Kenai River Creel Survey. A full description of the methods are detailed in Eskelin (2010), Perschbacher (2012a-d, 2014, 2015), and Perschbacher and Eskelin (2016). Sampling procedures were similar to those employed by the inriver gillnetting crew except that a half-inch piece of the auxiliary process was collected as the tissue sample. Laboratory analyses were also conducted in the same fashion as for the inriver run.

Tissue samples were also collected by a Middle Kenai River Chinook Salmon Harvest Sampling Study (Appendix A2) to produce estimates of the stock identification for the harvests of Chinook salmon in the middle Kenai River. This survey was conducted by roving crews to sample fish between the Soldotna Bridge (RM 21.0) and the Moose River (RM 36.3). A full description of methods is in McKinley et al. (2013).

Weir Counts

Weir counts provided known escapements for some stocks and anchored abundance estimates for the entire analysis because the contribution of weir-counted substocks to the total run can be determined using GSI. Annual summaries of weir data are tabulated in Appendix A5.

Funny River–Slikok Creek

The USFWS has operated a resistance board weir on the Funny River and collected length samples from passing Chinook salmon since 2006 (Gates and Palmer 2008; Gates and Boersma 2009a, 2009b, 2011, 2014b; Boersma and Gates 2013, 2014). This weir provides an escapement estimate for the Funny River component of the Funny River–Slikok Creek stock group for the SSART model. Upstream migrating fish are allowed to swim freely through the fish pass where they are recorded by a motion-activated digital video recording device. The video footage from the site is reviewed by a technician to determine net upstream passage. The weir is located approximately 0.75 miles upstream from the Funny River confluence with the Kenai River. A minor amount of spawning occurs downstream of the weir (Boersma and Gates 2013; Reimer 2013). Escapement estimates for Chinook salmon were obtained by multiplying the weir passage by the proportion of the passage that was 75 cm METF or longer in each quartile.

The Slikok Creek weir was operated as a double aluminum picket weir by ADF&G between 2008 and 2010. In 2011 and 2012, the weir was operated as a single weir with a motion-activated digital video recording device and underwater camera. Fish passage was recorded as video footage and reviewed to determine net upstream passage. This weir provided escapement estimates for the Slikok Creek component within the Funny River–Slikok Creek stock group. During 2007 and 2013–2014, when no weir counts were available, the average of the 2008–2012 Slikok Creek escapements was used as a proxy[3]. The weir was located approximately 0.31 miles upstream from the Slikok Creek confluence with the Kenai River. Little to no spawning is known to occur downstream of the weir. No length estimates are available from the Slikok Creek escapement although the size distribution is believed similar to the size distribution of Funny River fish. Escapement estimates for Chinook salmon at Slikok Creek were obtained by multiplying the weir passage by the proportion of the Funny River weir count that was 75 cm METF or longer.

Killey River

The USFWS has operated a resistance board weir on the Killey River since 2012 (Gates and Boersma 2013, 2014a, 2014c). This weir provided a partial escapement estimate for the Benjamin Creek–Killey River stock group for the SSART model. Upstream migrating fish swam freely through a fish pass and were recorded by a motion-activated digital video recorder. The video footage from the site was reviewed to determine net upstream passage. Escapement estimates for Chinook salmon were obtained by multiplying the weir passage in each quartile by the proportion of the passage that was 75 cm METF or longer in each quartile. This weir was located approximately 2 miles downstream from the confluence of Benjamin Creek with the Killey River. Significant spawning occurs both upstream and downstream of the weir. Radio tags were used to estimate the fraction of Killey River fish that migrated upstream of the weir.

Grant Creek

In 2013, Kenai Hydro LLC operated a fixed-picked weir on Grant Creek (Miller and Stevenson 2014). All Chinook salmon were manually passed through the weir and measured for length. This weir provided an escapement estimate for the Grant Creek stock group for the SSART model. Little to no spawning occurs downstream of the weir.

SUPPLEMENTARY DATA SOURCES

The projects listed above provided all the necessary data to fit the SSART model for years 2007–2014. The following projects provided additional data that improved the precision of SSART model estimates.

Radiotagging

Esophageal implant radio tags were administered to a subset of the Chinook salmon captured by the Inriver Gillnetting Project beginning in 2010 (Reimer 2013). In 2010 and 2011, every Chinook salmon captured between 16 May and 5 July was radiotagged. In 2012–2014, every Chinook salmon captured in the first part of the season[4] and every third Chinook salmon captured in the second part of the season[5] received a radio tag. Radiotagged Chinook salmon

[3] The SSART model requires the sum of the Funny and Slikok weir counts as an input.

[4] 16 May–5 July in 2012, 16 May–15 July in 2013, and 16 May–30 June in 2014.

[5] 6 July–15 August in 2012, 15 July–17 August in 2013, and 30 June–15 August in 2014.

were actively located by foot, boat, and airplane and were passively located by fixed location radiotelemetry receiving stations.

In order to be considered a migrant and be included in the spawning destination data for the SSART model, the behavior of each fish had to satisfy 5 criteria believed to represent minimum behavior[6] for successfully spawning Chinook salmon. Spawning locations could be determined for 35–57% of the radiotagged Chinook salmon, annually.

Radiotelemetry final destinations were used to improve the precision of stock composition estimates in 2010–2014. GSI provides a vector of (generally nonzero) probabilities of belonging to each stock group, whereas radiotagged fish with known spawning locations could be assigned a probability of 1.0 for the stock group identified by radiotelemetry and 0 for the other stock groups.

Additional radio tags were implanted in Chinook salmon caught in gillnets fished on the Kenai River near RM 21 (Figure 1) in 2011–2013. This project used the same methods and analysis as the RM 8.6 Kenai River Inriver Gillnetting Project except gillnetting occurred 1 day per week from early June to mid-July (Appendix A6). Chinook salmon tagged at this site had a much higher likelihood of being assigned a final spawning destination (79–88% annually) and providing stock composition data about the inriver run for the SSART model (Reimer 2013).

Additional GSI Samples

As part of this project, a harvest sampling program was conducted during 2010–2013 (Appendix A7) to augment the number of tissue samples available from harvested Chinook salmon. Most of the samples collected came from Chinook salmon harvested in the lower Kenai River. Sampling methods follow Perschbacher (2012a-d, 2014, 2015) and Perschbacher and Eskelin (2016).

MODEL DETAILS

In Bayesian modeling, a full probability model is constructed that describes the joint probability distribution of the observed data and the population parameters of interest. Inference is based on the posterior probability distribution of key population parameters given the observed data. Our interest centers on the parameters N_y^{early}, which is the abundance of Chinook salmon 75 cm or longer that entered the Kenai River during the early run in year *y*, and N_y^{late}, which is the abundance of Chinook salmon 75 cm or longer that entered the Kenai River during the late run in year *y*. In this section, we describe the SSART probability model in 2 steps: first, the probability structures of key population parameters are described, and then the sampling distributions for the observed data are described. The complete SSART model is provided in Appendices B1–B4.

Probability Structures of Key Parameters

To determine the early- and late-run abundance parameters, the total number of Chinook salmon of stock group *i* that pass by RM 8.6 during year *y* is described as follows:

$$N_{iy} = N_y \theta_{iy}^0 \tag{1}$$

[6] Fish were censored if they were harvested, failed to migrate upstream of RM 13, died prior to 1 July, failed to display 6 days of site fidelity prior to mortality, or died within 18 days of freshwater entry. Reimer (2013) discusses assignment of radiotag fates at length.

where N_y is total abundance in year y and is lognormally distributed with mean μ_N and standard deviation σ_N. The vector $(\theta_{1y}^0, \theta_{2y}^0, \theta_{3y}^0, \theta_{4y}^0, \theta_{5y}^0, \theta_{6y}^0)$ where θ_{iy}^0 is the proportion of N_y from stock group i in year y, follows a Dirichlet$(\gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5, \gamma_6)$ distribution.

The number of Chinook salmon from stock group i that pass by the netting project at RM 8.6 during year y, time period t is described as follows:

$$N_{iyt} = N_{iy}\pi_{iyt} \tag{2}$$

where π_{iyt}, the run-timing proportion at time t, describes the proportion of N_{iy} that pass by the netting project at RM 8.6 during time period t.

The numbers of Chinook salmon that pass by the netting project at RM 8.6 during the early and late runs in year y are the sums of N_{iyt} across all stocks and appropriate time strata:

$$N_y^{early} = \sum_{t=1}^{3}\sum_{i=1}^{6} N_{iyt} = \sum_{t=1}^{3} N_{yt} \tag{3}$$

and

$$N_y^{late} = \sum_{t=4}^{6}\sum_{i=1}^{6} N_{iyt} = \sum_{t=4}^{6} N_{yt}\,. \tag{4}$$

The run-timing proportions are assumed bell shaped with respect to time strata. That is, the expected abundances passing RM 8.6 at time $t = \{1,2,3,5,6\}$ are proportional to a normal probability density function T_{iyt}:

$$\mathrm{T}_{iyt} = e^{-z_{iyt}^2/2} \tag{5}$$

where

$$z_{iyt} = \left(t - \bar{t}_{iy}\right)/\sigma_{RT1tributary} \tag{6}$$

for tributary stocks $i = \{1,2,3,5,6\}$, and

$$z_{4yt} = \left(t - \bar{t}_{iy}\right)/\sigma_{RT1mainstem\,/\,Juneau} \tag{7}$$

for the mainstem Kenai River–Juneau Creek stock $i = \{4\}$.

Thus the SSART model allows different run timing standard deviations σ_{RT1} for mainstem and tributary stocks. The model also allows different run timing means $\bar{t}_{iy}$ for 3 groups of stocks:

1) Killey River–Benjamin Creek, Funny River–Slikok Creek, and Quartz–Crescent creeks; $i = \{1,2,5\}$
2) Grant Creek and Russian River; $i = \{3,6\}$
3) Mainstem Kenai River–Juneau Creek; $i = \{4\}$

Run timing means $\bar{t}_{iy}$ are assumed to vary among years as a normal distribution with standard deviation σ_{RT2}.

Actual run timing τ_{iyt} is corrupted (i.e., abundance by time period deviates from a perfect bell shape) by lognormal multiplicative errors $e^{\varepsilon_{RT3}}$ with standard deviation σ_{RT3}:

$$\tau_{iyt} = \mathrm{T}_{iyt} e^{\varepsilon_{RT3}} . \tag{8}$$

Run timing proportions are calculated as follows:

$$\pi_{iyt} = \tau_{iyt} / \sum_t \tau_{iyt} . \tag{9}$$

Run timing proportions describe how the number of Chinook salmon that pass by the netting project at RM 8.6 from stock *i* in year *y* are distributed across time strata, whereas stock composition proportions describe how the number of Chinook salmon that pass by the netting project at time *t* in year *y* are distributed across stocks:

$$\theta_{yti} = N_{iyt} / \sum_i N_{iyt} = N_{iyt} / N_{yt} . \tag{10}$$

In 2013 and 2014, stock composition proportions were calculated separately for fish migrating nearshore and midriver using Equation 10 with superscripts indicating geographic location. Fish distribution across geographic location is therefore described by the proportion of fish migrating midriver:

$$p^m_{yt} = N^m_{yt} / \left(N^m_{yt} + N^n_{yt} \right). \tag{11}$$

Another parameter of interest for the SSART model is H_{iy}, the harvest by stock group *i* in year *y*. Fish from stock group *i* were exposed to harvest rate h_{iy} in year *y*, resulting in harvest H_{iy}:

$$H_{iy} = N_{iy} h_{iy} . \tag{12}$$

Stocks assigned similar mean run timing are assumed to have similar harvest rates such that the same harvest rate h_{iy} is used within each run-timing group, though it differs between groups:

1) Killey River–Benjamin Creek, Funny River–Slikok Creek and Quartz–Crescent creeks; $i = \{1,2,5\}$
2) Grant Creek and Russian River; $i = \{3,6\}$
3) Mainstem Kenai River–Juneau Creek; $i = \{4\}$

The proportion of stock group *i* in the harvest of year *y* is

$$\theta_{Hyi} = H_{iy} / H_y \tag{13}$$

where H_y is the total harvest above RM 8.6, across all stocks, in year *y*.

Sampling Distributions of Observed Data

Observed data utilized by the SSART model consist of annual weir counts, annual estimates of harvest, netting CPUE by time period, allele counts from fish sampled by the RM 8.6 netting project, spawning destinations of radiotagged fish by the RM 8.6 netting project, multinomial count pseudo-data constructed as a surrogate for stock composition information from GSI sampling of the harvest, and binomial count pseudo-data constructed as a surrogate for migratory location of fish at RM 8.6.

Annual weir counts for the Funny River–Slikok Creek, Quartz–Crescent creeks, and Russian River stock groups are modeled as follows:

$$\hat{S}_{iy} = S_{iy} e^{\varepsilon_{Siy}} \tag{14}$$

where S_{iy} is the number of fish from stock group *i* that escaped the fishery on year *y* and have the opportunity to spawn:

$$S_{iy} = N_{iy} - H_{iy}\,, \tag{15}$$

and the ε_{Siy} are normal$(0, \sigma^2_{Siy})$. The value of σ^2_{Siy} is calculated from the CV_{Siy}[7], which is set to 0.1 to reflect good precision in the weir-based escapement estimates. Annual weir counts for the portion of the Killey River–Benjamin Creek stock group that migrated upstream of the Killey River weir are modeled as follows:

$$\hat{S}_{By} = S_{By} e^{\varepsilon_{SBy}} \tag{16}$$

where S_{By} is the number of fish from the Benjamin Creek–Killey River stock group that escaped the fishery on year *y* and migrated past the Killey River weir:

$$S_{By} = \rho_y S_{1y}\,, \tag{17}$$

and the ε_{SBy} are normal$(0, \sigma^2_{SBy})$. The values of σ^2_{Siy} are calculated from the CV_{SBy}, which are set to 0.1 to reflect good precision in the weir-based escapement estimates. The number of radio tags observed above the Killey River weir is modeled as having a binomial(ρ_y, bk_y) distribution, where bk_y is the total number of radio tags observed in the Killey River drainage in year *y* and ρ_y is the proportion of radio tags entering the Killey River that migrated upstream of the Killey River weir.

Annual estimates of inriver harvest above RM 8.6, combined from the creel, mail survey, and guide logbook data, are modeled as follows:

$$\hat{H}_y = H_y e^{\varepsilon_{Hy}} \tag{18}$$

where the ε_{Hy} are normal$(0, \sigma^2_{Hy})$, and σ_{Hy} are approximately equal to the coefficient of variation of the harvest estimates.

The index of abundance during time period *t* in year *y* is modeled as linearly related to abundance:

$$INDEX_{yt} = q_y N_{yt} e^{\varepsilon_{Nyt}} \tag{19}$$

where q_y is the constant of proportionality between abundance and standardized index specific to year *y*, and the ε_{Nyt} are normal$(0, \sigma^2_I)$.

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[7] If $x \sim N(0, \sigma^2)$ then $y = e^x \sim LogN(0, \sigma^2)$ and $CV_y = \sqrt{e^{\sigma^2} - 1} \sim \sigma$ when σ is small.

Information about the proportion of fish migrating midriver in 2013 and 2014 were included in the SSART model using surrogate binomial count data from a separate analysis of gillnet catches. Negative binomial regression was used to relate gillnet catches to gillnet drift minutes, time strata, and an interaction between time strata and location (nearshore or midriver). The delta method was used to estimate the expected value and variance of p_{yt}^{m} from the regression coefficients from which the surrogate count data were generated.

Allele counts at multiple (h = 1 to 38) genetic loci were observed for each of the M_{yt}^{8} fish sampled from the run at RM 8.6 during year y and time stratum t. Separately for each year and time stratum, each allele count x for fish m at locus h is modeled as having a binomial($q_{z(m),h}$,2) distribution[8], where q_{ih} is the frequency of allele h in stock group i. The integer quantity $z(m)$, the stock identity index (1 to 6) for fish m, has a categorical prior distribution[9] with stock composition proportions (θ_{yt1}, θ_{yt2}, $\theta_{yt3,}$ θ_{yt4}, θ_{yt5}, θ_{yt6}). For radiotagged fish with known spawning destinations, the stock identity index was directly included as data.

Allele counts were also observed for each of the M_{yt}^{21} fish sampled from the run at RM 21 during year y and time stratum t. Fish sampled at RM 21 provided information about the stock composition of the run at RM 8.6 as described above except that the time stratum index when they were present at RM 8.6 is treated as a random variable. The vector of probabilities that fish m was present at RM 8.6 in time stratum t (1 to 6) was given a categorical prior distribution with proportions $\left(tp_{v1}, tp_{v2}, tp_{v3}, tp_{v4}, tp_{v5}, tp_{v6}\right)$ where tp_{vt} is the probability of migrating past RM 8.6 in time stratum t given that it was captured at RM 21 in time stratum v. Fish radiotagged at RM 8 and later observed at RM 21 during time stratum v were modeled as multinomial(tp_{vt},$c21_v$) where $c21_v$ is the number of radiotagged fish detected at RM 21 during time stratum v. A noninformative Dirichlet prior was used for tp_{vt}.

Information on stock composition of the harvest was included in the SSART model in the form of surrogate multinomial count data constructed from a separate analysis of allele frequency data (Appendix B3) sampled from harvested fish[10]. Two geographic strata, upstream and downstream of the Soldotna Bridge, were used to model harvest stock composition. Harvest of fish downstream of the Soldotna Bridge was modeled with harvest timing proportions as described in Equations 2 and 5–10 after replacing abundance parameters (N) with harvest parameters (HL). Allele counts were observed for each of the $M2_{yt}$ fish sampled from the harvest downstream of the Soldotna Bridge. Separately for each year and time period, each allele count $x2$ for fish $m2$ at locus h is modeled as having a binomial($q_{z(m2),h}$,2) distribution, where q_{ih} is the frequency of allele h in stock group i. The integer quantity $z(m2)$, the stock identity index (1 to 6) for fish $m2$, has a categorical prior distribution with stock composition proportions (θ_{HLyt1},$\theta_{HL\ yt2}$,$\theta_{HLyt3,}$ θ_{HLyt4},θ_{HLyt5},θ_{HLyt6}).

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[8] The specified allele is present on either 0, 1, or both of the homologous chromosomes; thus the possible values of x are 0, 1, or 2, respectively.

[9] The categorical distribution is the multivariate analogue of the Bernoulli distribution, or alternatively a multinomial distribution with order 1. If z has a categorical(θ_1,θ_2,θ_3,θ_4,θ_5,θ_6) distribution, it can assume values 1 to 6 with probabilities θ_1, θ_2, θ_3, θ_4, θ_5, and θ_6.

[10] We supplied the harvest stock composition information in simplified multinomial form because it was not computationally feasible to integrate the 2 GSI mixture analyses into a single model.

Allele counts were also observed for each of the $M3_{yt}$ fish sampled from the harvest upstream of the Soldotna Bridge. Separately for each year and time period, each allele count *x3* for fish *m3* at locus *h* is modeled as having a binomial($q_{z(m3),h}$, 2) distribution, where q_{ih} is the frequency of allele *h* in stock group *i*. The integer quantity *z*(*m3)*, the stock identity index (1 to 6) for fish *m3*, has a categorical prior distribution with stock composition proportions (θ_{HMyt1},θ_{HMyt2},$\theta_{HMyt3,}$$\theta_{HMyt4}$,$\theta_{HMyt5}$,$\theta_{HMyt6}$). Harvest timing for fish harvested upstream of the Soldotna Bridge followed directly from the allele frequency data without the harvest timing assumptions described above.

Stock composition of the entire harvest where θ_{Hyi} equals (θ_{Hy1},θ_{Hy2},$\theta_{Hy3,}$$\theta_{Hy4}$,$\theta_{Hy5}$,$\theta_{Hy6}$) was the weighted average of the stratum stock group proportions. This information was transferred to the SSART model using surrogate multinomial "data" that were constructed such that the number of counts (effective sample size) would supply stock composition information with precision equivalent to that contained in harvest allele frequency data.

Auxiliary information about the allele frequencies (q_{ih}) was available from baseline genetic samples collected on the spawning grounds of each stock (Rogers Olive et al. 2013). For each stock group *i*, the baseline allele count *Y* at locus *h* is modeled as having a binomial(q_{ih},n_{ih}) distribution, where n_{ih} is the maximum number of possible instances[11] of allele *h* in fish sampled from the baseline of stock group *i*.

Prior Distributions

Bayesian analyses require that prior probability distributions be specified for all unknown parameters in the model. Annual abundance N_{iy} was hierarchical and lognormally distributed among years and was independent by stock group. An inverse gamma(100,1) prior distribution was given to σ^2_I, which is equivalent to assuming that CPUE is related to true abundance with a CV of 0.1. All other root parameters of the model were assigned noninformative priors, designed to have minimal effects on the posterior.

MODEL FITTING

Markov Chain Monte Carlo (MCMC) methods were employed, and these methods are well-suited for modeling complex population and sampling processes. The MCMC algorithms were implemented in OpenBUGS (Lunn et al. 2009), which is a Bayesian software program. This methodology allows for inclusion of the effects of measurement error and missing data in the analysis, improves the ability to tease out process variation from observation error, and provides a more complete assessment of uncertainty than is generally possible with classical statistical methods.

Sampling from the Posterior Distribution

MCMC samples were drawn from the joint posterior probability distribution of all unknowns in the model. For the results presented here, every sample from 2 Markov chains was written to disk. Of these, the first 25,000 samples of each chain were discarded, and 25,000 additional samples of each chain were used to estimate the marginal posterior medians, standard deviations, and percentiles. The diagnostic tools of OpenBUGS were used to assess mixing and

[11] Two times the number of fish included in genetic baseline for each stock.

convergence, and no major problems were encountered. Interval estimates were constructed from the percentiles of the posterior distribution.

RESULTS

Point estimates reported below are posterior means; standard errors are posterior standard deviations.

INRIVER ABUNDANCE

Early-run and Late-run Inriver Abundance

Estimated inriver abundance of Chinook salmon during the early run, defined as 16 May–30 June, ranged from 8,637 (SE 2,215) in 2007 to 1,940 (307) in 2013 (Table 1). Estimated inriver abundance of Chinook salmon during the late run, defined as 1 July–17 August, ranged from 37,180 (SE 10,340) in 2007 to 9,949 (SE 2,138) in 2010 (Table 1). Abundance estimates are also available for tributary and mainstem spawning fish (Appendix C1).

Table 1.–Early- and late-run abundance estimates of Kenai River Chinook salmon 75 cm or longer passing RM 8.6.

	Early Run			Late Run		
Year	Mean	SD	95% CI	Mean	SD	95% CI
2007	8,637	2,215	5,500–14,290	37,180	10,340	22,680–64,540
2008	6,645	894	5,045–8,557	43,400	6,779	31,070–57,220
2009	6,692	1,598	4,085–10,200	26,650	6,359	15,940–40,490
2010	3,672	696	2,621–5,329	9,949	2,138	6,711–15,000
2011	5,347	1,006	3,703–7,580	17,560	3,508	11,920–25,240
2012	3,718	467	2,865–4,690	25,280	3,686	18,670–33,170
2013	1,940	307	1,426–2,620	13,470	2,348	9,400–18,460
2014	2,507	380	1,915–3,428	11,870	2,113	8,616–17,230

Note: A 95% credibility interval is reported as 2.5 and 97.5 percentiles from the posterior distribution.

Run Timing by Stock and Year

The SSART model structure also provides estimates of inriver abundance by stock and time stratum (Appendix D1). The timing of individual stocks migrating past RM 8.6 exhibited a consistent pattern from year to year. Most stock groups were present in 4 time strata, with over 90% of the total run returning in 3 time strata that encompass a period of approximately 6 weeks (Table 2). For fish from Killey River–Benjamin Creek, Funny River–Slikok Creek, and Quartz–Crescent creeks, more than 89% of upstream passage occurred during the first 3 time strata, from 15 May to 30 June. For fish from Grant Creek and Russian River, more than 93% of the upstream passage occurred during the third through fifth time strata, from 16 June to 31 July. For fish from mainstem Kenai River–Juneau Creek, over 89% of the upstream passage occurred during the last 3 time strata, from 1 July to 17 August.

Table 2.–Run timing proportions $\{\pi_{iyt}\}$ and standard deviations (in parentheses) by stock group, year, and time stratum for Kenai River Chinook salmon 75 cm or longer passing RM 8.6.

Year	Time strata	Killey–Benjamin	Funny–Slikok	Grant	Mainstem–Juneau	Quartz–Crescent	Russian
2007	May 16–31	0.15 (0.03)	0.10 (0.08)	0.00 (0.00)	0.00 (0.00)	0.13 (0.11)	0.00 (0.00)
	Jun 1–15	0.56 (0.06)	0.42 (0.17)	0.02 (0.05)	0.01 (0.00)	0.45 (0.15)	0.01 (0.02)
	Jun 16–30	0.26 (0.06)	0.38 (0.14)	0.19 (0.16)	0.04 (0.01)	0.36 (0.16)	0.17 (0.13)
	Jul 1–15	0.02 (0.02)	0.10 (0.13)	0.45 (0.16)	0.25 (0.02)	0.05 (0.06)	0.48 (0.15)
	Jul 16–31	0.00 (0.00)	0.01 (0.02)	0.30 (0.19)	0.58 (0.03)	0.00 (0.00)	0.29 (0.16)
	Aug 1–10	0.00 (0.00)	0.00 (0.00)	0.05 (0.07)	0.13 (0.01)	0.00 (0.00)	0.04 (0.05)
2008	May 16–31	0.15 (0.03)	0.11 (0.05)	0.00 (0.00)	0.00 (0.00)	0.19 (0.15)	0.00 (0.00)
	Jun 1–15	0.48 (0.06)	0.50 (0.10)	0.01 (0.03)	0.00 (0.00)	0.47 (0.14)	0.01 (0.02)
	Jun 16–30	0.34 (0.06)	0.34 (0.09)	0.18 (0.14)	0.02 (0.01)	0.30 (0.16)	0.15 (0.10)
	Jul 1–15	0.03 (0.02)	0.05 (0.04)	0.48 (0.14)	0.12 (0.01)	0.04 (0.05)	0.55 (0.13)
	Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.28 (0.16)	0.41 (0.03)	0.00 (0.00)	0.26 (0.14)
	Aug 1–10	0.00 (0.00)	0.00 (0.00)	0.03 (0.05)	0.44 (0.03)	0.00 (0.00)	0.03 (0.04)
2009	May 16–31	0.35 (0.05)	0.10 (0.10)	0.00 (0.00)	0.00 (0.00)	0.15 (0.12)	0.00 (0.00)
	Jun 1–15	0.31 (0.05)	0.35 (0.16)	0.01 (0.02)	0.01 (0.00)	0.47 (0.16)	0.02 (0.04)
	Jun 16–30	0.31 (0.07)	0.45 (0.16)	0.17 (0.13)	0.08 (0.01)	0.33 (0.17)	0.22 (0.15)
	Jul 1–15	0.03 (0.03)	0.11 (0.12)	0.47 (0.15)	0.42 (0.03)	0.05 (0.07)	0.49 (0.15)
	Jul 16–31	0.00 (0.00)	0.00 (0.01)	0.30 (0.17)	0.36 (0.03)	0.00 (0.01)	0.25 (0.16)
	Aug 1–10	0.00 (0.00)	0.00 (0.00)	0.04 (0.07)	0.13 (0.01)	0.00 (0.00)	0.03 (0.04)
2010	May 16–31	0.14 (0.02)	0.11 (0.06)	0.00 (0.00)	0.00 (0.00)	0.20 (0.13)	0.00 (0.00)
	Jun 1–15	0.58 (0.05)	0.51 (0.10)	0.02 (0.03)	0.01 (0.00)	0.56 (0.12)	0.01 (0.01)
	Jun 16–30	0.26 (0.05)	0.34 (0.11)	0.24 (0.15)	0.06 (0.01)	0.22 (0.13)	0.14 (0.07)
	Jul 1–15	0.02 (0.01)	0.04 (0.04)	0.47 (0.13)	0.22 (0.02)	0.02 (0.03)	0.67 (0.10)
	Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.25 (0.16)	0.49 (0.03)	0.00 (0.00)	0.16 (0.08)
	Aug 1–10	0.00 (0.00)	0.00 (0.00)	0.02 (0.03)	0.21 (0.02)	0.00 (0.00)	0.02 (0.02)
2011	May 16–31	0.29 (0.04)	0.36 (0.11)	0.00 (0.00)	0.00 (0.00)	0.17 (0.12)	0.00 (0.00)
	Jun 1–15	0.54 (0.05)	0.49 (0.10)	0.02 (0.03)	0.01 (0.00)	0.51 (0.14)	0.01 (0.03)
	Jun 16–30	0.16 (0.04)	0.14 (0.07)	0.20 (0.14)	0.10 (0.01)	0.28 (0.14)	0.15 (0.12)
	Jul 1–15	0.01 (0.01)	0.01 (0.01)	0.52 (0.14)	0.29 (0.03)	0.04 (0.05)	0.48 (0.15)
	Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.24 (0.15)	0.49 (0.03)	0.00 (0.00)	0.31 (0.17)
	Aug 1–10	0.00 (0.00)	0.00 (0.00)	0.03 (0.04)	0.10 (0.01)	0.00 (0.00)	0.04 (0.05)
2012	May 16–31	0.29 (0.04)	0.32 (0.15)	0.00 (0.00)	0.00 (0.00)	0.20 (0.15)	0.00 (0.01)
	Jun 1–15	0.45 (0.04)	0.53 (0.12)	0.02 (0.04)	0.00 (0.00)	0.51 (0.14)	0.01 (0.04)
	Jun 16–30	0.24 (0.04)	0.13 (0.09)	0.23 (0.15)	0.02 (0.00)	0.26 (0.15)	0.15 (0.13)
	Jul 1–15	0.01 (0.01)	0.01 (0.02)	0.47 (0.14)	0.17 (0.02)	0.03 (0.05)	0.47 (0.16)
	Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.25 (0.15)	0.41 (0.03)	0.00 (0.00)	0.31 (0.17)
	Aug 1–15	0.00 (0.00)	0.00 (0.00)	0.03 (0.04)	0.40 (0.03)	0.00 (0.00)	0.05 (0.08)
2013	May 16–31	0.14 (0.03)	0.06 (0.05)	0.00 (0.00)	0.00 (0.00)	0.25 (0.14)	0.00 (0.00)
	Jun 1–15	0.60 (0.07)	0.36 (0.15)	0.01 (0.01)	0.01 (0.00)	0.52 (0.13)	0.01 (0.02)
	Jun 16–30	0.24 (0.07)	0.47 (0.14)	0.15 (0.12)	0.03 (0.01)	0.21 (0.13)	0.18 (0.15)
	Jul 1–15	0.02 (0.02)	0.11 (0.10)	0.45 (0.15)	0.17 (0.02)	0.02 (0.03)	0.45 (0.16)
	Jul 16–31	0.00 (0.00)	0.00 (0.01)	0.34 (0.17)	0.38 (0.03)	0.00 (0.00)	0.30 (0.18)
	Aug 1–17	0.00 (0.00)	0.00 (0.00)	0.05 (0.06)	0.42 (0.03)	0.00 (0.00)	0.06 (0.09)
2014	May 16–31	0.06 (0.01)	0.06 (0.04)	0.00 (0.00)	0.00 (0.00)	0.15 (0.16)	0.00 (0.00)
	Jun 1–15	0.68 (0.05)	0.59 (0.12)	0.02 (0.04)	0.00 (0.00)	0.45 (0.16)	0.03 (0.03)
	Jun 16–30	0.23 (0.05)	0.30 (0.11)	0.26 (0.16)	0.03 (0.01)	0.34 (0.18)	0.28 (0.15)
	Jul 1–15	0.03 (0.02)	0.05 (0.04)	0.46 (0.14)	0.13 (0.01)	0.06 (0.07)	0.49 (0.13)
	Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.23 (0.15)	0.42 (0.03)	0.00 (0.00)	0.19 (0.13)
	Aug 1–15	0.00 (0.00)	0.00 (0.00)	0.02 (0.04)	0.43 (0.03)	0.00 (0.00)	0.02 (0.02)

Stock Composition of the Run by Time Stratum and Year

Stock composition of the run varied annually but also changed in a predictable pattern over the course of the run (Table 3). Between 2007 and 2014, tributary bound Chinook salmon composed most of the inriver run prior to 15 June. During each of the 16–31 May time strata, the Killey River–Benjamin Creek fish were the largest percentage of the run (68–93%), followed by Funny River–Slikok Creek (5–26%), and Quartz Creek (2–9%). Similarly, during the 1–15 June time strata, Killey River–Benjamin Creek fish composed 61–81% of the run, Funny River–Slikok Creek made up 10–31% of the run, and Mainstem Kenai River–Juneau Creek followed with 2–11%. Together, the Killey River–Benjamin Creek and Funny River–Slikok Creek fish contributed over 83% of the inriver run during the first 2 time strata every year.

During the 16–30 June time strata, several stocks made substantial contributions to the inriver run. Mainstem Kenai River–Juneau Creek fish were between 31% and 79% of the inriver run, Killey River–Benjamin Creek fish were between 14% and 50% of the inriver run, and Funny River–Slikok Creek fish were between 3% and 21% of the inriver run (Table 3). In 5 of 8 years, Mainstem Kenai River–Juneau Creek fish contributed the largest percentage of the inriver run during the 16–30 June time stratum.

During the 1–15 July time stratum, Mainstem Kenai River–Juneau Creek fish were at least 85% of the inriver run in every year with minor measurable contributions from most other stock groups (Table 3). After 15 July, Mainstem Kenai River–Juneau Creek fish were the only measurable contributor to the inriver run.

During the study period, a majority of Chinook salmon returning during the early run were tributary stocks (range 58%–86%) (Table 4). The Killey River–Benjamin Creek stock was the largest component of the early run during all 8 years. In one year (2011), the Killey River–Benjamin Creek and Mainstem Kenai River–Juneau Creek stocks were nearly equal primary components of the early run. The second largest component of the early run was the Mainstem Kenai River–Juneau Creek stock (6 years) or the Funny River–Slikok Creek stock (1 year). In one year (2014), the Funny River–Slikok Creek and Mainstem Kenai River–Juneau Creek stocks were equal secondary components of the early run. Chinook salmon returning during the late run were composed almost entirely (95–99%) of Mainstem Kenai River–Juneau Creek fish.

In 2013 and 2014, stock composition was estimated separately for fish migrating midriver and fish migrating nearshore (Table 5). Estimates of nearshore stock composition were imprecise due to small sample sizes, making stock composition differences between nearshore- and midriver-migrating fish difficult to discern.

Table 3.–Stock composition $\{\theta_{yti}\}$ and standard deviations (in parentheses) of the inriver run by stock group, year, and time stratum for Kenai River Chinook salmon 75 cm or longer passing RM 8.6.

Year	Time strata	Killey–Benjamin	Funny–Slikok	Grant	Mainstem–Juneau	Quartz–Crescent	Russian
2007	May 16–31	0.78 (0.14)	0.16 (0.13)	0.00 (0.00)	0.01 (0.01)	0.05 (0.05)	0.00 (0.00)
	Jun 1–15	0.71 (0.08)	0.17 (0.07)	0.00 (0.00)	0.06 (0.04)	0.05 (0.03)	0.00 (0.00)
	Jun 16–30	0.36 (0.09)	0.18 (0.08)	0.01 (0.01)	0.40 (0.10)	0.04 (0.03)	0.01 (0.01)
	Jul 1–15	0.01 (0.01)	0.02 (0.03)	0.01 (0.01)	0.95 (0.04)	0.00 (0.00)	0.01 (0.01)
	Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.99 (0.01)	0.00 (0.00)	0.00 (0.00)
	Aug 1–10	0.00 (0.00)	0.00 (0.00)	0.00 (0.01)	1.00 (0.01)	0.00 (0.00)	0.00 (0.00)
2008	May 16–31	0.68 (0.12)	0.25 (0.11)	0.00 (0.00)	0.00 (0.01)	0.06 (0.05)	0.00 (0.00)
	Jun 1–15	0.61 (0.07)	0.31 (0.07)	0.00 (0.00)	0.03 (0.02)	0.04 (0.03)	0.00 (0.00)
	Jun 16–30	0.42 (0.08)	0.21 (0.07)	0.01 (0.01)	0.31 (0.07)	0.03 (0.02)	0.02 (0.02)
	Jul 1–15	0.02 (0.02)	0.02 (0.02)	0.01 (0.01)	0.90 (0.04)	0.00 (0.00)	0.05 (0.03)
	Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.99 (0.01)	0.00 (0.00)	0.01 (0.01)
	Aug 1–10	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00 (0.00)	0.00 (0.00)	0.00 (0.00)
2009	May 16–31	0.93 (0.05)	0.05 (0.05)	0.00 (0.00)	0.01 (0.01)	0.02 (0.02)	0.00 (0.00)
	Jun 1–15	0.69 (0.08)	0.14 (0.06)	0.00 (0.00)	0.11 (0.05)	0.05 (0.03)	0.00 (0.00)
	Jun 16–30	0.28 (0.08)	0.08 (0.04)	0.00 (0.01)	0.62 (0.08)	0.02 (0.02)	0.01 (0.01)
	Jul 1–15	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.98 (0.01)	0.00 (0.00)	0.00 (0.00)
	Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.99 (0.01)	0.00 (0.00)	0.00 (0.00)
	Aug 1–10	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00 (0.00)	0.00 (0.00)	0.00 (0.00)
2010	May 16–31	0.75 (0.10)	0.17 (0.09)	0.00 (0.00)	0.01 (0.01)	0.06 (0.05)	0.00 (0.00)
	Jun 1–15	0.71 (0.05)	0.18 (0.04)	0.00 (0.00)	0.06 (0.03)	0.04 (0.02)	0.00 (0.00)
	Jun 16–30	0.38 (0.08)	0.15 (0.06)	0.02 (0.01)	0.40 (0.08)	0.02 (0.01)	0.04 (0.02)
	Jul 1–15	0.02 (0.01)	0.01 (0.01)	0.02 (0.01)	0.85 (0.05)	0.00 (0.00)	0.10 (0.04)
	Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.01 (0.01)	0.98 (0.01)	0.00 (0.00)	0.01 (0.01)
	Aug 1–10	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00 (0.01)	0.00 (0.00)	0.00 (0.00)
2011	May 16–31	0.71 (0.09)	0.26 (0.09)	0.00 (0.00)	0.01 (0.01)	0.02 (0.02)	0.00 (0.00)
	Jun 1–15	0.68 (0.06)	0.18 (0.05)	0.00 (0.00)	0.10 (0.04)	0.03 (0.02)	0.00 (0.00)
	Jun 16–30	0.14 (0.04)	0.04 (0.02)	0.01 (0.01)	0.79 (0.05)	0.01 (0.01)	0.00 (0.01)
	Jul 1–15	0.00 (0.00)	0.00 (0.00)	0.01 (0.01)	0.97 (0.01)	0.00 (0.00)	0.01 (0.01)
	Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.99 (0.01)	0.00 (0.00)	0.00 (0.00)
	Aug 1–10	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00 (0.01)	0.00 (0.00)	0.00 (0.00)
2012	May 16–31	0.88 (0.05)	0.10 (0.05)	0.00 (0.00)	0.00 (0.00)	0.02 (0.02)	0.00 (0.00)
	Jun 1–15	0.81 (0.05)	0.10 (0.03)	0.00 (0.00)	0.06 (0.03)	0.03 (0.02)	0.00 (0.00)
	Jun 16–30	0.50 (0.09)	0.03 (0.02)	0.02 (0.02)	0.42 (0.09)	0.02 (0.02)	0.01 (0.01)
	Jul 1–15	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)	0.97 (0.02)	0.00 (0.00)	0.01 (0.01)
	Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.99 (0.01)	0.00 (0.00)	0.00 (0.00)
	Aug 1–15	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00 (0.00)	0.00 (0.00)	0.00 (0.00)
2013	May 16–31	0.81 (0.10)	0.09 (0.08)	0.00 (0.00)	0.01 (0.01)	0.09 (0.07)	0.00 (0.00)
	Jun 1–15	0.76 (0.07)	0.12 (0.05)	0.00 (0.00)	0.08 (0.05)	0.04 (0.03)	0.00 (0.00)
	Jun 16–30	0.35 (0.10)	0.17 (0.06)	0.01 (0.01)	0.44 (0.10)	0.02 (0.02)	0.01 (0.02)
	Jul 1–15	0.01 (0.01)	0.02 (0.02)	0.01 (0.00)	0.95 (0.03)	0.00 (0.00)	0.01 (0.01)
	Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.99 (0.00)	0.00 (0.00)	0.00 (0.00)
	Aug 1–17	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00 (0.00)	0.00 (0.00)	0.00 (0.00)
2014	May 16–31	0.80 (0.11)	0.16 (0.10)	0.00 (0.00)	0.01 (0.01)	0.02 (0.03)	0.00 (0.00)
	Jun 1–15	0.81 (0.04)	0.15 (0.04)	0.00 (0.00)	0.02 (0.02)	0.01 (0.01)	0.00 (0.00)
	Jun 16–30	0.44 (0.10)	0.13 (0.05)	0.03 (0.03)	0.34 (0.11)	0.02 (0.02)	0.04 (0.03)
	Jul 1–15	0.03 (0.02)	0.01 (0.01)	0.03 (0.02)	0.90 (0.04)	0.00 (0.00)	0.03 (0.03)
	Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.99 (0.01)	0.00 (0.00)	0.00 (0.00)
	Aug 1–15	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00 (0.00)	0.00 (0.00)	0.00 (0.00)

Table 4.–Stock composition by genetic reporting group, year, and run for Kenai River Chinook salmon 75 cm or longer passing RM 8.6.

Year	Time strata	Killey–Benjamin	Funny–Slikok	Grant	Mainstem–Juneau	Quartz–Crescent	Russian
2007	Early run	0.58 (0.05)	0.17 (0.04)	0.01 (0.01)	0.20 (0.05)	0.05 (0.02)	0.00 (0.01)
	Late run	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)	0.98 (0.01)	0.00 (0.00)	0.00 (0.00)
2008	Early run	0.54 (0.04)	0.26 (0.04)	0.00 (0.01)	0.14 (0.04)	0.04 (0.02)	0.01 (0.01)
	Late run	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.98 (0.01)	0.00 (0.00)	0.01 (0.01)
2009	Early run	0.50 (0.05)	0.08 (0.03)	0.00 (0.00)	0.38 (0.05)	0.02 (0.01)	0.00 (0.01)
	Late run	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)	0.98 (0.01)	0.00 (0.00)	0.00 (0.00)
2010	Early run	0.58 (0.04)	0.17 (0.03)	0.01 (0.01)	0.20 (0.04)	0.03 (0.01)	0.02 (0.01)
	Late run	0.00 (0.00)	0.00 (0.00)	0.01 (0.01)	0.95 (0.02)	0.00 (0.00)	0.03 (0.01)
2011	Early run	0.43 (0.04)	0.13 (0.02)	0.00 (0.01)	0.42 (0.04)	0.02 (0.01)	0.00 (0.00)
	Late run	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)	0.99 (0.01)	0.00 (0.00)	0.00 (0.00)
2012	Early run	0.72 (0.04)	0.07 (0.01)	0.01 (0.01)	0.17 (0.04)	0.02 (0.01)	0.00 (0.00)
	Late run	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.99 (0.00)	0.00 (0.00)	0.00 (0.00)
2013	Early run	0.59 (0.05)	0.14 (0.03)	0.00 (0.00)	0.23 (0.05)	0.04 (0.02)	0.01 (0.01)
	Late run	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.99 (0.01)	0.00 (0.00)	0.00 (0.00)
2014	Early run	0.68 (0.04)	0.14 (0.02)	0.01 (0.01)	0.14 (0.05)	0.01 (0.02)	0.02 (0.01)
	Late run	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)	0.98 (0.01)	0.00 (0.00)	0.01 (0.01)

Note: Standard deviations for each estimate are in parentheses.

Table 5.–Midriver and nearshore stock composition $\{\theta^{m}_{yti}\ and\ \theta^{n}_{yti}\}$ and standard deviations (in parentheses) of the inriver run by stock group, year, and time stratum for Kenai River Chinook salmon 75 cm or longer passing RM 8.6.

Year	Location	Time strata	Killey–Benjamin	Funny–Slikok	Grant	Mainstem–Juneau	Quartz–Crescent	Russian
2013	Midriver	May 16–31	0.86 (0.10)	0.06 (0.07)	0.00 (0.00)	0.01 (0.01)	0.08 (0.07)	0.00 (0.00)
		Jun 1–15	0.75 (0.10)	0.12 (0.08)	0.00 (0.00)	0.08 (0.05)	0.05 (0.04)	0.00 (0.00)
		Jun 16–30	0.19 (0.09)	0.19 (0.09)	0.00 (0.01)	0.60 (0.11)	0.01 (0.02)	0.01 (0.02)
		Jul 1–15	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.98 (0.02)	0.00 (0.00)	0.01 (0.01)
		Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00 (0.00)	0.00 (0.00)	0.00 (0.00)
		Aug 1–17	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Nearshore	May 16–31	0.48 (0.32)	0.29 (0.28)	0.00 (0.00)	0.06 (0.11)	0.17 (0.21)	0.00 (0.00)
		Jun 1–15	0.74 (0.18)	0.13 (0.14)	0.00 (0.00)	0.09 (0.09)	0.03 (0.05)	0.00 (0.00)
		Jun 16–30	0.51 (0.21)	0.16 (0.14)	0.01 (0.01)	0.28 (0.21)	0.03 (0.04)	0.02 (0.03)
		Jul 1–15	0.03 (0.05)	0.04 (0.06)	0.01 (0.02)	0.88 (0.11)	0.00 (0.01)	0.03 (0.06)
		Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.01 (0.01)	0.98 (0.03)	0.00 (0.00)	0.01 (0.03)
		Aug 1–17	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00 (0.01)	0.00 (0.00)	0.00 (0.01)
2014	Midriver	May 16–31	0.81 (0.12)	0.17 (0.11)	0.00 (0.00)	0.00 (0.01)	0.02 (0.03)	0.00 (0.00)
		Jun 1–15	0.82 (0.05)	0.15 (0.05)	0.00 (0.00)	0.02 (0.02)	0.01 (0.01)	0.00 (0.00)
		Jun 16–30	0.55 (0.13)	0.05 (0.05)	0.03 (0.03)	0.32 (0.13)	0.01 (0.02)	0.04 (0.04)
		Jul 1–15	0.02 (0.02)	0.01 (0.01)	0.02 (0.02)	0.93 (0.04)	0.00 (0.00)	0.03 (0.03)
		Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.99 (0.01)	0.00 (0.00)	0.00 (0.00)
		Aug 1–15	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Nearshore	May 16–31	0.33 (0.29)	0.41 (0.31)	0.01 (0.02)	0.09 (0.14)	0.16 (0.21)	0.01 (0.02)
		Jun 1–15	0.74 (0.16)	0.17 (0.15)	0.01 (0.01)	0.04 (0.05)	0.03 (0.05)	0.01 (0.02)
		Jun 16–30	0.09 (0.11)	0.40 (0.17)	0.03 (0.04)	0.43 (0.18)	0.02 (0.04)	0.03 (0.05)
		Jul 1–15	0.08 (0.09)	0.03 (0.05)	0.08 (0.09)	0.74 (0.16)	0.00 (0.02)	0.07 (0.08)
		Jul 16–31	0.00 (0.00)	0.00 (0.00)	0.02 (0.04)	0.96 (0.05)	0.00 (0.00)	0.02 (0.03)
		Aug 1–15	0.00 (0.00)	0.00 (0.00)	0.01 (0.03)	0.98 (0.04)	0.00 (0.00)	0.01 (0.02)

HARVEST BY STOCK

Harvest Timing by Stock and Year

The SSART model structure also provides estimates of harvest by stock and time stratum (Appendices D2–D3). Like run timing, timing of harvest downstream of the Soldotna Bridge varied in a consistent pattern. The largest stock groups were harvested in appreciable numbers in 4 time strata, with over 80% of the total harvest occurring in 2 time strata over a period of 1 month (Table 6). Harvest of fish from Killey River–Benjamin Creek and Funny River–Slikok Creek stock groups occurred primarily during the second and third time strata (1–30 June). Harvest of fish from the Mainstem Kenai River–Juneau Creek stock occurred during the fourth and fifth time strata (1–31 July). For the other stock groups, sample sizes were small, estimates were imprecise, and no strong patterns were evident.

Table 6.–Harvest timing proportions $\{\pi_{iyt}\}$ and standard deviations (in parentheses) by stock group, year, and time stratum for Kenai River Chinook salmon 75 cm or longer harvested downstream of the Soldotna Bridge (RM 21).

Year	Time strata	Killey–Benjamin	Funny–Slikok	Grant	Mainstem–Juneau	Quartz–Crescent	Russian
2007	May 16–31	0.00 (0.00)	0.05 (0.04)	0.02 (0.08)	0.00 (0.00)	0.04 (0.13)	0.04 (0.15)
	Jun 1–15	0.46 (0.11)	0.81 (0.18)	0.03 (0.12)	0.00 (0.00)	0.08 (0.21)	0.09 (0.25)
	Jun 16–30	0.51 (0.11)	0.09 (0.14)	0.56 (0.41)	0.06 (0.02)	0.14 (0.28)	0.14 (0.28)
	Jul 1–15	0.01 (0.03)	0.04 (0.08)	0.25 (0.35)	0.24 (0.03)	0.13 (0.26)	0.48 (0.43)
	Jul 16–31	0.01 (0.03)	0.02 (0.05)	0.14 (0.28)	0.69 (0.04)	0.61 (0.43)	0.25 (0.37)
2008	May 16–31	0.04 (0.02)	0.10 (0.05)	0.16 (0.31)	0.00 (0.00)	0.07 (0.19)	0.01 (0.03)
	Jun 1–15	0.62 (0.08)	0.52 (0.11)	0.07 (0.22)	0.00 (0.00)	0.38 (0.40)	0.02 (0.06)
	Jun 16–30	0.27 (0.06)	0.32 (0.11)	0.13 (0.27)	0.01 (0.01)	0.20 (0.32)	0.30 (0.25)
	Jul 1–15	0.04 (0.05)	0.03 (0.06)	0.35 (0.41)	0.35 (0.04)	0.17 (0.30)	0.28 (0.28)
	Jul 16–31	0.02 (0.04)	0.02 (0.05)	0.29 (0.38)	0.65 (0.04)	0.18 (0.32)	0.40 (0.27)
2009	May 16–31	0.17 (0.05)	0.02 (0.07)	0.04 (0.15)	0.00 (0.00)	0.08 (0.21)	0.02 (0.10)
	Jun 1–15	0.39 (0.10)	0.63 (0.35)	0.06 (0.20)	0.00 (0.00)	0.18 (0.31)	0.08 (0.23)
	Jun 16–30	0.41 (0.10)	0.13 (0.23)	0.19 (0.32)	0.01 (0.01)	0.24 (0.35)	0.07 (0.20)
	Jul 1–15	0.01 (0.02)	0.09 (0.19)	0.45 (0.42)	0.51 (0.04)	0.25 (0.35)	0.71 (0.39)
	Jul 16–31	0.02 (0.05)	0.13 (0.25)	0.27 (0.37)	0.49 (0.04)	0.25 (0.37)	0.12 (0.27)
2010	May 16–31	0.21 (0.07)	0.02 (0.04)	0.01 (0.08)	0.00 (0.00)	0.25 (0.38)	0.00 (0.02)
	Jun 1–15	0.00 (0.00)	0.00 (0.00)	0.01 (0.03)	0.00 (0.00)	0.02 (0.05)	0.00 (0.01)
	Jun 16–30	0.74 (0.08)	0.93 (0.09)	0.71 (0.36)	0.00 (0.00)	0.65 (0.39)	0.45 (0.23)
	Jul 1–15	0.02 (0.03)	0.02 (0.05)	0.17 (0.29)	0.21 (0.04)	0.05 (0.14)	0.43 (0.23)
	Jul 16–31	0.02 (0.05)	0.02 (0.06)	0.10 (0.23)	0.79 (0.04)	0.04 (0.13)	0.12 (0.19)
2011	May 16–31	0.12 (0.05)	0.01 (0.06)	0.05 (0.16)	0.00 (0.00)	0.04 (0.12)	0.01 (0.06)
	Jun 1–15	0.39 (0.12)	0.08 (0.18)	0.10 (0.27)	0.00 (0.00)	0.32 (0.36)	0.02 (0.09)
	Jun 16–30	0.39 (0.13)	0.66 (0.35)	0.16 (0.31)	0.03 (0.02)	0.37 (0.37)	0.08 (0.19)
	Jul 1–15	0.07 (0.09)	0.10 (0.21)	0.45 (0.43)	0.42 (0.04)	0.15 (0.26)	0.82 (0.27)
	Jul 16–31	0.03 (0.07)	0.15 (0.27)	0.24 (0.36)	0.55 (0.04)	0.12 (0.25)	0.07 (0.17)

Note: Harvest timing proportions for 2012–2014 are not presented because of frequent fishery closures during those years.

Timing of harvest upstream of the Soldotna Bridge was estimated for 2 time strata: 16 May–30 June and 1 July–31 July. The majority of harvest of Killey River–Benjamin Creek fish occurred prior to 1 July (Table 7). The majority of harvest of Mainstem Kenai River–Juneau Creek fish occurred after 1 July. No strong patterns were evident for the other stock groups.

Table 7.–Harvest timing proportions $\{\pi_{iyt}^{M}\}$ and standard deviations (in parentheses) by stock group, year, and time stratum for Kenai River Chinook salmon 75 cm or longer harvested between the Soldotna Bridge and Skilak Lake (RM 21–50).

Year [a]	Time strata	Killey–Benjamin	Funny–Slikok	Grant	Mainstem–Juneau	Quartz–Crescent	Russian
2007	May 16–Jun 30	0.86 (0.07)	0.83 (0.15)	0.36 (0.22)	0.17 (0.08)	0.73 (0.19)	0.61 (0.26)
	Jul 1–31	0.14 (0.07)	0.17 (0.15)	0.64 (0.22)	0.83 (0.08)	0.27 (0.19)	0.39 (0.26)
2008	May 16–Jun 30	0.84 (0.05)	0.45 (0.28)	0.36 (0.21)	0.05 (0.03)	0.41 (0.17)	0.22 (0.15)
	Jul 1–31	0.16 (0.05)	0.55 (0.28)	0.64 (0.21)	0.95 (0.03)	0.59 (0.17)	0.78 (0.15)
2009	May 16–Jun 30	0.84 (0.10)	0.62 (0.26)	0.32 (0.24)	0.04 (0.03)	0.62 (0.27)	0.45 (0.28)
	Jul 1–31	0.16 (0.10)	0.38 (0.26)	0.68 (0.24)	0.96 (0.03)	0.38 (0.27)	0.55 (0.28)
2010	May 16–Jun 30	0.89 (0.07)	0.60 (0.28)	0.43 (0.28)	0.07 (0.02)	0.41 (0.28)	0.12 (0.12)
	Jul 1–31	0.11 (0.07)	0.40 (0.28)	0.57 (0.28)	0.93 (0.02)	0.59 (0.28)	0.88 (0.12)

[a] Stock composition data were not collected from the sport fishery upstream of the Soldotna Bridge after 2010 due to small harvests (2011 early run and 2012 both runs) or closed fisheries (2012 early run and 2013–2014 both runs).

Stock Composition of the Harvest by Time Stratum and Year

The stock composition of the harvest downstream of the Soldotna Bridge (RM 21) during each time stratum was similar to, but more variable than, the composition of the inriver run. Much of the variability comes from small GSI sample sizes resulting in imprecise stock composition estimates. Tributary bound Chinook salmon composed the majority of the harvest downstream of the Soldotna Bridge prior to 30 June. During the 16–31 May time stratum, Killey River–Benjamin Creek fish or Funny River–Slikok Creek fish were the largest percentage of the harvest downstream of the Soldotna Bridge, although these estimates were sometimes based on small GSI sample sizes (Table 8). During the 1–15 June and 16–30 June time strata, Killey River–Benjamin Creek fish composed the largest percentage of the harvest downstream of the Soldotna Bridge (greater than 42%), followed by Funny River–Slikok Creek fish. Together, these 2 stock groups composed more than 86% of the harvest downstream of the Soldotna Bridge every year during the first time strata, more than 93% of the harvest downstream of the Soldotna Bridge every year during the second time strata, and more than 54% of the harvest downstream of the Soldotna Bridge every year during the third time strata. During the 16–30 June time strata, Mainstem Kenai River–Juneau Creek fish were a variable component of the harvest, ranging from 1% to 43% (Table 8).

During the 1–15 July time strata, Mainstem Kenai River–Juneau Creek fish composed more than 95% of the harvest downstream of the Soldotna Bridge, except during 2012–2014 when it made up 72–89% of the harvest and when fisheries were often closed and sample sizes were small (Table 8). After 15 July, Mainstem Kenai River–Juneau Creek fish were the only measurable contributor to the harvest downstream of the Soldotna Bridge.

Table 8.–Stock composition $\{\theta_{yti}^{Lk}\}$ and standard deviations (in parentheses) by stock group, year, and time stratum for Kenai River Chinook salmon 75 cm or longer harvested downstream of the Soldotna Bridge (RM 21).

Year	Time strata	Killey–Benjamin	Funny–Slikok	Grant	Mainstem–Juneau	Quartz–Crescent	Russian
2007	May 16–31	0.11 (0.18)	0.75 (0.26)	0.01 (0.05)	0.08 (0.19)	0.03 (0.08)	0.02 (0.07)
	Jun 1–15	0.59 (0.11)	0.40 (0.11)	0.00 (0.00)	0.01 (0.02)	0.00 (0.01)	0.00 (0.01)
	Jun 16–30	0.49 (0.11)	0.05 (0.08)	0.02 (0.03)	0.43 (0.11)	0.01 (0.02)	0.00 (0.01)
	Jul 1–15	0.01 (0.02)	0.01 (0.03)	0.01 (0.01)	0.97 (0.04)	0.00 (0.01)	0.01 (0.01)
	Jul 16–31	0.00 (0.01)	0.00 (0.01)	0.00 (0.00)	0.99 (0.02)	0.01 (0.02)	0.00 (0.00)
2008	May 16–31	0.44 (0.16)	0.51 (0.17)	0.02 (0.04)	0.02 (0.05)	0.01 (0.02)	0.00 (0.01)
	Jun 1–15	0.69 (0.08)	0.30 (0.08)	0.00 (0.00)	0.00 (0.01)	0.01 (0.01)	0.00 (0.00)
	Jun 16–30	0.55 (0.11)	0.34 (0.12)	0.00 (0.01)	0.06 (0.08)	0.01 (0.03)	0.03 (0.03)
	Jul 1–15	0.02 (0.03)	0.01 (0.02)	0.00 (0.01)	0.95 (0.05)	0.00 (0.01)	0.01 (0.02)
	Jul 16–31	0.01 (0.01)	0.00 (0.01)	0.00 (0.01)	0.98 (0.02)	0.00 (0.00)	0.01 (0.01)
2009	May 16–31	0.96 (0.05)	0.01 (0.03)	0.00 (0.02)	0.01 (0.02)	0.01 (0.02)	0.00 (0.01)
	Jun 1–15	0.77 (0.16)	0.20 (0.16)	0.00 (0.01)	0.01 (0.04)	0.01 (0.02)	0.01 (0.02)
	Jun 16–30	0.79 (0.13)	0.04 (0.09)	0.01 (0.03)	0.14 (0.12)	0.01 (0.03)	0.00 (0.02)
	Jul 1–15	0.00 (0.01)	0.00 (0.01)	0.01 (0.01)	0.97 (0.02)	0.00 (0.01)	0.01 (0.02)
	Jul 16–31	0.01 (0.01)	0.01 (0.02)	0.00 (0.01)	0.98 (0.02)	0.00 (0.00)	0.00 (0.00)
2010	May 16–31	0.91 (0.10)	0.04 (0.08)	0.00 (0.01)	0.01 (0.03)	0.04 (0.06)	0.00 (0.01)
	Jun 1–15	Closed to harvest					
	Jun 16–30	0.53 (0.10)	0.32 (0.11)	0.04 (0.03)	0.01 (0.03)	0.04 (0.05)	0.06 (0.03)
	Jul 1–15	0.01 (0.01)	0.00 (0.01)	0.00 (0.01)	0.95 (0.04)	0.00 (0.00)	0.04 (0.03)
	Jul 16–31	0.00 (0.01)	0.00 (0.00)	0.00 (0.00)	0.99 (0.01)	0.00 (0.00)	0.00 (0.01)
2011	May 16–31	0.95 (0.07)	0.01 (0.04)	0.01 (0.03)	0.01 (0.03)	0.01 (0.03)	0.00 (0.02)
	Jun 1–15	0.90 (0.09)	0.03 (0.06)	0.01 (0.02)	0.01 (0.04)	0.05 (0.06)	0.00 (0.01)
	Jun 16–30	0.42 (0.15)	0.16 (0.13)	0.01 (0.02)	0.37 (0.14)	0.03 (0.05)	0.01 (0.02)
	Jul 1–15	0.02 (0.02)	0.00 (0.01)	0.00 (0.01)	0.96 (0.03)	0.00 (0.01)	0.01 (0.01)
	Jul 16–31	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.99 (0.02)	0.00 (0.00)	0.00 (0.00)
2012	May 16–31	0.93 (0.08)	0.04 (0.07)	0.01 (0.02)	0.00 (0.02)	0.01 (0.03)	0.00 (0.01)
	Jun 1–15	0.86 (0.09)	0.12 (0.09)	0.00 (0.01)	0.00 (0.01)	0.01 (0.01)	0.00 (0.01)
	Jun 16–30	Closed to harvest					
	Jul 1–15	0.01 (0.04)	0.01 (0.04)	0.05 (0.07)	0.84 (0.14)	0.03 (0.06)	0.06 (0.07)
	Jul 16–31	Closed to harvest					
2013	May 16–31	Closed to harvest					
	Jun 1–15	Closed to harvest					
	Jun 16–30	Closed to harvest					
	Jul 1–15	0.01 (0.03)	0.04 (0.07)	0.02 (0.03)	0.89 (0.09)	0.02 (0.03)	0.02 (0.03)
	Jul 16–31	0.07 (0.06)	0.02 (0.03)	0.01 (0.01)	0.89 (0.07)	0.00 (0.01)	0.01 (0.01)
2014	May 16–31	Closed to harvest					
	Jun 1–15	Closed to harvest					
	Jun 16–30	Closed to harvest					
	Jul 1–15	0.12 (0.09)	0.06 (0.06)	0.06 (0.06)	0.72 (0.12)	0.02 (0.03)	0.03 (0.03)
	Jul 16–31	Closed to harvest					

The stock composition of the harvest upstream of the Soldotna Bridge was estimated for 2 time strata: 16 May–30 June and 1 July–31 July. Tributary-bound Chinook salmon were the majority of the harvest upstream of the Soldotna Bridge prior to 1 July. Killey River–Benjamin Creek fish were the largest percentage of the harvest (60–71%) and Mainstem Kenai River–Juneau Creek fish (7–23%) were the second largest contributor to the harvest (Table 9). After 1 July, the harvest upstream of the Soldotna Bridge was predominantly Mainstem Kenai River–Juneau Creek fish (74–90%; Table 9).

Table 9.–Stock composition $\{\theta_{yti}^{Mk}\}$ and standard deviations (in parentheses) by stock group, year, and time stratum for Kenai River Chinook salmon 75 cm or longer harvested between the Soldotna Bridge and Skilak Lake (RM 21–50).

Year [a]	Time strata	Killey–Benjamin	Funny–Slikok	Grant	Mainstem–Juneau	Quartz–Crescent	Russian
2007	May 16–Jun 30	0.60 (0.10)	0.06 (0.06)	0.04 (0.04)	0.15 (0.08)	0.13 (0.08)	0.02 (0.02)
	Jul 1–31	0.10 (0.05)	0.02 (0.02)	0.09 (0.06)	0.74 (0.09)	0.05 (0.04)	0.01 (0.01)
2008	May 16–Jun 30	0.71 (0.06)	0.10 (0.05)	0.02 (0.02)	0.07 (0.04)	0.08 (0.04)	0.02 (0.01)
	Jul 1–31	0.08 (0.03)	0.01 (0.01)	0.03 (0.02)	0.75 (0.06)	0.08 (0.04)	0.04 (0.02)
2009	May 16–Jun 30	0.70 (0.13)	0.05 (0.06)	0.04 (0.04)	0.14 (0.10)	0.06 (0.06)	0.02 (0.03)
	Jul 1–31	0.04 (0.03)	0.02 (0.02)	0.02 (0.02)	0.90 (0.04)	0.01 (0.01)	0.01 (0.01)
2010	May 16–Jun 30	0.69 (0.07)	0.04 (0.04)	0.01 (0.02)	0.23 (0.07)	0.01 (0.01)	0.02 (0.02)
	Jul 1–31	0.03 (0.02)	0.01 (0.01)	0.01 (0.01)	0.90 (0.03)	0.01 (0.01)	0.05 (0.03)

[a] Stock composition data were not collected from the sport fishery upstream of the Soldotna Bridge after 2010 due to small harvests (2011 early run and 2012 both runs) or closed fisheries (2012 early run and 2013–2014 both runs).

DISCUSSION

The SSART model was first developed in 2010 as a way to assess Chinook salmon abundance in the Kenai River that was independent of inriver sonar. Traditional mark–recapture was ruled out as an alternative method to sonar because there were no means to conduct recapture events capable of achieving the desired level of precision in a cost-effective manner. Abundance estimates based on sport fishery exploitation rates (Hammarstrom and Hasbrouck 1998, 1999) were also ruled out because the sport fishery was frequently restricted after 2010. Adapted from the work of Bromaghin et al. (2010), the SSART approach obtains stock identification information from GSI data collected at the time of sampling, thus avoiding bias introduced by tagging and handling effects. GSI data from harvested fish are incorporated as well. Lastly, the SSART model is formulated in a Bayesian hierarchical framework, which extracts maximum information from historical data.

The 2007–2014 Kenai River Chinook salmon abundance estimates for fish 75 cm METF or longer presented herein join several previously published Kenai River Chinook salmon abundance estimates for most of the same years. The abundance estimates presented herein stand apart because they include only fish 75 cm METF or longer, which is the size class that can be directly measured by the current multi-beam sonar technology without inadvertently including other species. Chinook salmon that were 75 cm METF or longer composed an average of 70% of early run and 74% of the late run Chinook salmon caught by midriver netting drifts in 2002–2015. Chinook salmon that were 75 cm METF or longer also may reflect the most important spawning component of the run because female Chinook salmon tend to be larger than males

(90% of early run and 91% of late run female Chinook salmon captured by midriver netting were 75 cm or longer).

Prior to 2013, there are no independent abundance estimates of Chinook salmon 75 cm or longer for comparison to the SSART estimates published herein. Direct estimates of run size for Chinook salmon 75 cm or longer have been produced by ARIS sonar since 2013 at Kenai RM 13.7 and these can be compared to SSART estimates after adjusting for harvest and spawning between RMs 8.6 and 13.7. The 2013 and 2014 SSART estimates of Chinook salmon greater than or equal to 75 cm passing RM 8.6 were within 13% of the direct RM 13.7 sonar estimates in the early run and within 2% of the direct RM 13.7 sonar estimates in the late run (Figure 3). This level of agreement is better than could be expected, given the sampling error associated with the individual estimates.

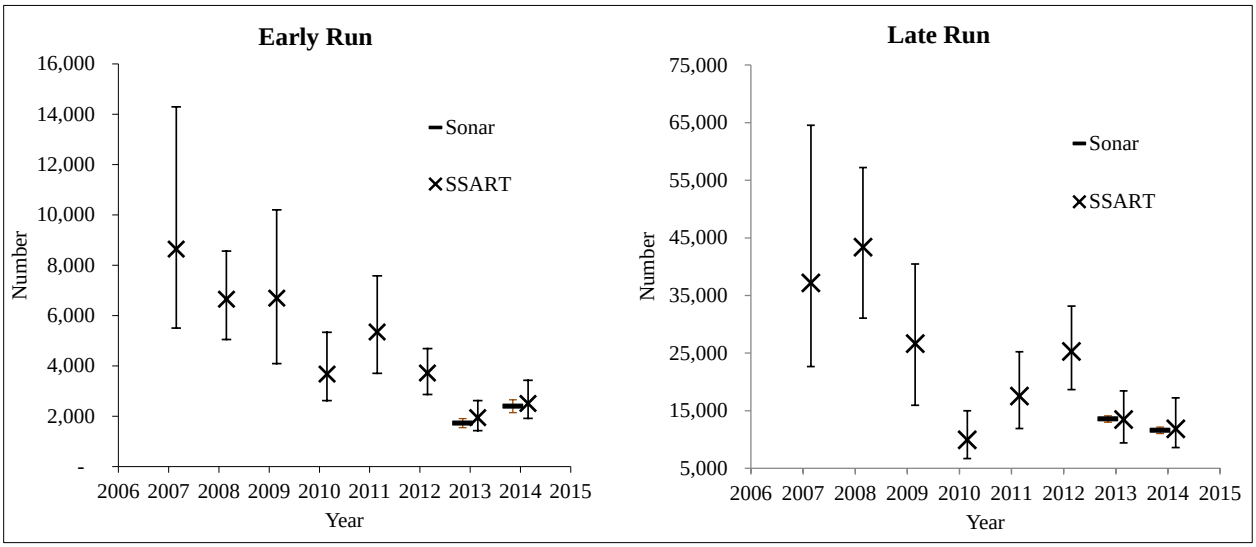

Figure 3.–A comparison of SSART (using RM 13.7 sonar index) and direct RM 13.7 sonar estimates of the number of Kenai River early- (left) and late-run (right) Chinook salmon 75 cm or longer passing RM 8.6 per year.

Note: Scales differ between graphs. "Sonar" indicates multibeam imaging sonar at RM 13.7 plus an estimate of harvest and fish spawning between RM 8.6 and RM 13.7. "SSART" indicates the model described herein.

A run reconstruction and escapement goal analysis similar to Fleischman and McKinley (2013) and McKinley and Fleischman (2013) is planned in the near future for the 75 cm or longer size class. SSART estimates of Chinook salmon 75 cm METF or longer for 2007–2012 ranged from 43% to 81% (early run) and from 46% to 95% (late run) of the SSART estimates that Reimer et al. (2016) produced for all sizes of Chinook salmon between 2007 and 2012. The abundance estimates reported in Reimer (2016) are not directly comparable because they utilize a different abundance index in 2011 and 2012, but the comparison still provides an idea of what fraction of the Kenai River Chinook salmon run would be included in a large fish escapement goal.

Many of the assumptions of traditional mark–recapture experiments apply to SSART. One key assumption is that fish (of all sizes, stocks, etc.) must have equal probabilities of capture in at least 1 event (Seber 1982)[12]. The weir event cannot satisfy this requirement because each weir

[12] In general, failure to achieve equal probability of capture causes bias in mark–recapture estimates (Williams et al. 2002). If both events are selective in the same direction (e.g., they each favor small fish, or large fish) then the estimates will be too low, on average. If the events are selective in different directions (one favors small and the other favors large fish) then the estimates will be too high, on average.

samples a single tributary and the tributaries that have weirs are not likely to be representative of fish from the entire Kenai River drainage in size or age. Therefore, the burden of meeting this assumption rests on obtaining a representative sample from the Kenai River Inriver Netting Project.

Beginning in 2012, it became evident that the traditional inriver netting program, which up to that point sampled exclusively in a midriver corridor, might favor larger fish. In 2013, a pilot program introduced some nearshore sampling to complement the traditional midriver drifts. Perschbacher (2015) found that small Chinook salmon were under-represented in midriver netting samples because smaller Chinook salmon tended to migrate shoreward of the sonar transducers (Miller et al. 2016). In 2014, a full complement of standardized nearshore drifts was added to the netting program (Perschbacher and Eskelin 2016). The current analysis incorporates nearshore netting data for 2013–2014; however, no such data are available for 2007–2012. Because this analysis only includes Chinook salmon 75 cm METF or longer, the impact of undersampling small Chinook salmon in the gillnetting project is further reduced.

A second key assumption of the SSART model is that the temporal index of abundance is directly proportional to abundance by time stratum. This assumption is particularly important for estimates of late-run abundance. Abundance is monitored directly at tributary weirs, providing an anchor for SSART estimates of early arriving fish. Late arriving fish (which are more likely to be of mainstem than tributary origin) are not directly monitored; thus, late-run abundance estimates rely heavily on the assumption that the index is proportional to abundance within a given year. Reimer (2016) used RM 8.6 gillnetting CPUE as an index of abundance, but we now know that CPUE as an index has 2 important shortcomings. First, prior to 2013, the netting project sampled only the midriver corridor corresponding to the zone monitored by sonar. Therefore, fish migrating near shore, outside of this corridor, were not included in the index. If the fraction of fish migrating near shore varies by time stratum, then the proportionality between CPUE and abundance will also vary. Second, inriver gillnets may become saturated in July when sockeye salmon are most abundant. To remedy this, estimates in this report for both runs were based on sonar-derived indices rather than netting CPUE when the sonar indices were available: RM 8.6 sonar in 2011–2012 and RM 13.7 sonar in 2013–2014. Of the 2 sites, estimates from the RM 13.7 sonar produce the better temporal index of abundance because fish are not missed near shore. Neither RM 8.6 nor RM 13.7 sonar is thought to be affected by saturation under high fish density (e.g., see Miller et al. 2013). Note that only the relative magnitudes of the index values are leveraged by the SSART model, not the absolute values and therefore use of sonar as a temporal index in the SSART model does not invalidate comparisons between SSART estimates and direct sonar estimates.

To demonstrate this sensitivity we reran the SSART estimates using different abundance indices in the years they were available to create 2 modified models to contrast with our finalized estimates. In the finalized model, netting CPUE was used as an index for 2007–2010, the RM 8.6 sonar was used as an index for 2011–2012, and the RM 13.7 sonar was used as an index for 2013–2014. In one modified model, we substituted netting CPUE as the abundance index for 2011–2014, and in a second modified model, we substituted RM 8.6 sonar as the abundance index for 2013–2014 (instead of RM 13.7 as in the finalized model). For the early run, SSART abundance estimates of Chinook salmon greater than or equal to 75 cm passing RM 8.6 were not sensitive to the choice of abundance index (within 13% of the finalized SSART estimates presented herein), probably because early run estimates were anchored by tributary weir counts

(Figure 4). SSART estimates for the late run were very sensitive to the choice of abundance index in some of the years where we had more than 1 abundance index available. When the SSART model was rerun using gillnet CPUE as an index for 2011–2014, estimates of late-run abundance were within 11% of the finalized SSART estimates presented herein for 2011 and 2014 but were 36% lower for 2012 and 27% lower for 2013 (Figure 4). When the analysis was rerun using the RM 8.6 sonar as the index for 2013–2014, SSART estimates of late-run abundance were 60% higher in 2013 and 2% lower in 2014 than the estimates presented herein (Figure 4).

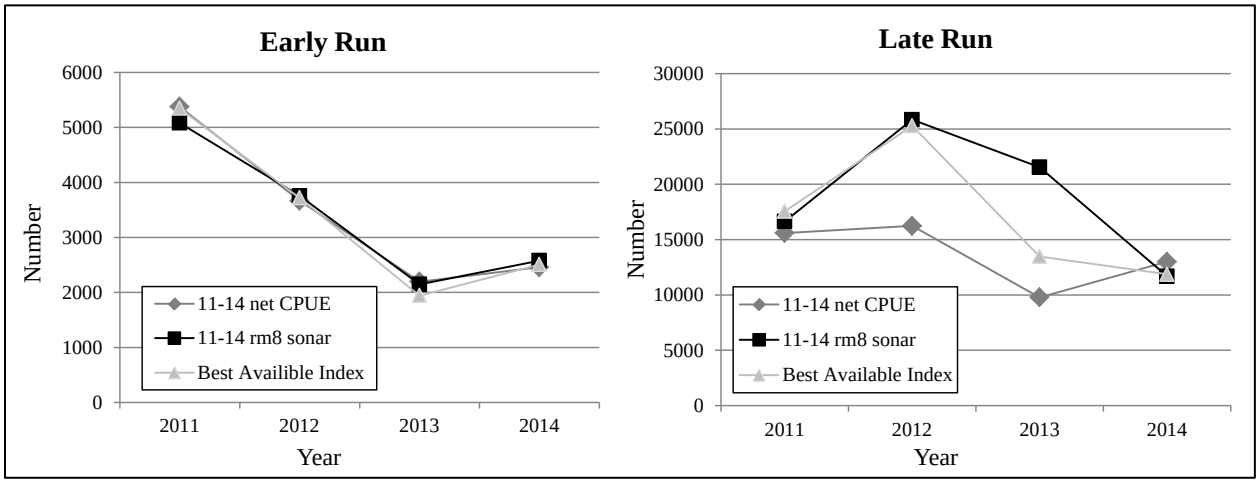

Figure 4.–SSART abundance estimates for 2011–2014 of early- (left) and late-run (right) Chinook salmon 75 cm or longer passing RM 8.6 using 3 different temporal indices: 2011–2014 netting CPUE, 2011–2014 RM 8.6 sonar, or the best available index in each year (RM 8.6 for 2011–2012 and RM 13.7 for 2013–2014; this final estimate is from the SSART model presented herein.).

Note: Results for 2011 and 2012 from the finalized SSART model are indistinguishable from the modified SSART model that used RM 8.6 sonar as an abundance index.

CONCLUSIONS

For 2013 and 2014, SSART estimates of Chinook salmon 75 cm METF and longer were nearly equal to estimates from the ARIS sonar at RM 13.7 adjusted for harvest and spawning between netting and sonar sites, for both the early and late runs.

SSART estimates are the only direct estimates of abundance available for run reconstructions of Chinook salmon 75 cm or longer prior to 2013. The indices of abundance that are available for use in the SSART model for this time period are not optimal and may vary between time strata. Early-run estimates are minimally affected by this problem whereas late-run estimates are sensitive to this problem. However, SSART estimates from both runs are useful for run reconstruction and escapement goal analysis of Chinook salmon 75 cm or longer and will be used in a forthcoming analysis.

ACKNOWLEDGEMENTS

Thanks to all individuals who contributed to the success of this project. Kenai River Inriver Gillnetting Project staff included Jodi Knudsen, Bob Zeyer, Jim Boersma, Sherra Pritchard, Phillip Ischi, Tim Lybrand, Mike Lunde, Art Barboza, Kassie Johnson, Stan Westerman, Jamie McKellar, Samantha Jones, Averee Amend, Evan Atchley, Mike Trujillo, and Sandeep Singh. Ivan Karic, Stacie Mallette, Amanda Alaniz, and Caleb Chase worked on the lower Kenai River Creel Survey. Jeff Perschbacher and Tony Eskelin supervised the inriver gillnetting and creel sampling crews. Harvest samples in the middle Kenai River were collected by Ramona Baker, Julianne Pettey, Will Newberry, and Bristol Whitmore under the supervision of Tim McKinley and Tony Eskelin. ADF&G personnel working on the Slikok Creek weir include Mary King, Jenny Cope, Sandee Simmons, Robert Begich, Jason Pawluk, Kelly Belize, Mike Bonn, Craig Morris, Roy Lusby, and Trisha Trujillo. ADF&G personnel working on the Russian River weir include Patti Berkhahn, Sandee Simons, Tom Rhyner, and Tom Johnson under the supervision of Jason Pawluk. ADF&G personnel responsible for locating radiotagged fish include Kurt Strausbaugh, Jon Essert, Bob Zeyer, Ivan Karic, Jordan Head, and Meg Inokuma. USFWS personnel working the Funny River and Killey River weirs include Ken Gates and Jim Boersma. Many staff from the ADF&G Gene Conservation Lab were involved with this project, including Andy Barclay, who coordinated with the Soldotna ADF&G office; Tara Harrington and Christina Cupp, who oversaw sampling kit assembly and processed incoming samples; Heather Liller, Zac Grauvogel, Serena Olive, Paul Kuriscak, Charles Thompson, and Wei Cheng, who oversaw DNA extractions, screened SNPs, and ensured quality control of laboratory data; Judy Berger for archiving samples; and Eric Lardizabal, for database support.

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APPENDIX A: PREVIOUSLY UNPUBLISHED DATA USED IN THE SSART MODEL

Appendix A1.–Estimates of Chinook salmon CPUE for Kenai River Chinook salmon 75 cm METF or longer passing RM 8.6, 2007–2014.

Year	Time strata	CPUE (all Chinook)	Proportion ≥75 cm METF	CPUE (≥75 cm)
2007	May 16–31	0.244	0.80	0.195
	Jun 1–15	1.238	0.63	0.783
	Jun 16–30	1.095	0.64	0.706
	Jul 1–15	2.884	0.68	1.960
	Jul 16–31	6.382	0.72	4.609
	Aug 1–10	1.147	0.81	0.925
2008	May 16–31	0.214	0.92	0.000
	Jun 1–15	0.873	0.81	0.172
	Jun 16–30	0.899	0.81	0.705
	Jul 1–15	2.037	0.71	0.640
	Jul 16–31	5.042	0.93	1.904
	Aug 1–10	5.094	0.99	4.989
2009	May 16–31	0.192	0.96	4.890
	Jun 1–15	0.280	0.71	0.000
	Jun 16–30	0.693	0.81	0.156
	Jul 1–15	2.894	0.65	0.182
	Jul 16–31	1.888	0.79	0.545
	Aug 1–10	0.598	0.89	2.584
2010	May 16–31	0.113	0.74	1.391
	Jun 1–15	0.660	0.63	0.375
	Jun 16–30	0.549	0.60	0.000
	Jul 1–15	1.208	0.47	0.053
	Jul 16–31	1.348	0.76	0.500
	Aug 1–10	0.469	0.96	0.525
2011	May 16–31	0.191	0.86	1.035
	Jun 1–15	0.730	0.63	0.847
	Jun 16–30	0.779	0.70	0.330
	Jul 1–15	2.228	0.60	0.000
	Jul 16–31	2.522	0.72	0.138
	Aug 1–10	0.391	0.76	0.552
2012	May 16–31	0.180	1.00	0.779
	Jun 1–15	0.278	0.94	2.097
	Jun 16–30	0.295	0.64	1.611
	Jul 1–15	0.587	0.78	0.303
	Jul 16–31	1.519	0.83	0.000
	Aug 1–15	1.138	0.94	0.170
2013	May 16–31	0.026	1.00	0.278
	Jun 1–15	0.178	0.50	0.147
	Jun 16–30	0.165	0.81	0.475
	Jul 1–15	0.663	0.49	0.748
	Jul 16–31	0.743	0.67	0.759
	Aug 1–17	0.367	0.85	0.000
2014	May 16–31	0.124	0.57	0.015
	Jun 1–15	0.402	0.45	0.080
	Jun 16–30	0.311	0.29	0.047
	Jul 1–15	0.819	0.40	0.267
	Jul 16–31	1.398	0.70	0.517
	Aug 1–15	0.136	0.94	0.344

Appendix A2.–Genetic sample sizes by year used to produce the inriver run and harvest estimates of Kenai River Chinook salmon 75 cm METF or longer.

	Year							
Sampling program	2007	2008	2009	2010	2011	2012	2013	2014
Run: RM 8.6 midriver	264	403	391	315	359	296	142	224
Run: RM 8.6 nearshore	–	–	–	–	–	–	13	27
Run: RM 21	–	–	–	–	41	38	23	–
Harvest Lower [a]	312	337	301	358	263	75	54	16
Harvest Middle [b]	117	313	166	287	–	–	–	–

[a] Below Soldotna Bridge, RM 0–21.

[b] Soldotna Bridge to Skilak Lake, RM 21–50.

Appendix A3.–Estimates of harvest of Kenai River Chinook salmon 75 cm METF or longer for the area downstream of the Soldotna Bridge (RM 21).

		Harvest (all Chinook)		Proportion ≥75 cm METF		Harvest (Chinook 75 cm or longer)		
Year	Time strata	Harvest	SE	*p*	SE (*p*)	Harvest	SE	CV
2007	May 16–31	20	9	0.75	0.25	15	8	0.53
	Jun 1–15	959	176	0.77	0.06	735	144	0.20
	Jun 16–30	1,544	419	0.67	0.06	1,038	296	0.29
	Jul 1–15	2,184	311	0.75	0.05	1,644	255	0.15
	Jul 16–31	5,323	513	0.90	0.02	4,791	477	0.10
2008	May 16–31	144	38	0.96	0.04	138	37	0.27
	Jun 1–15	1,530	162	0.88	0.03	1,343	149	0.11
	Jun 16–30	895	140	0.83	0.05	743	124	0.17
	Jul 1–15	3,152	514	0.83	0.04	2,621	445	0.17
	Jul 16–31	5,109	457	0.94	0.02	4,790	440	0.09
2009	May 16–31	112	26	0.84	0.07	94	23	0.25
	Jun 1–15	387	113	0.76	0.10	295	93	0.31
	Jun 16–30	393	84	0.75	0.08	295	71	0.24
	Jul 1–15	3,494	324	0.76	0.03	2,664	271	0.10
	Jul 16–31	2,754	314	0.93	0.02	2,549	298	0.12
2010	May 16–31	79	22	1.00	0.00	79	22	0.28
	Jun 1–15 [a]					1	0.5	0.5
	Jun 16–30	749	91	0.71	0.06	533	80	0.15
	Jul 1–15	1,465	266	0.57	0.07	834	178	0.21
	Jul 16–31	3,465	356	0.91	0.02	3,142	332	0.11
2011	May 16–31	59	18	0.75	0.13	44	15	0.34
	Jun 1–15	226	56	0.75	0.10	169	47	0.28
	Jun 16–30	518	144	0.78	0.08	403	119	0.30
	Jul 1–15	2,826	316	0.75	0.03	2,129	257	0.12
	Jul 16–31	3,174	411	0.87	0.03	2,749	370	0.13
2012	May 16–31	86	74	0.94	0.06	81	69	0.86
	Jun 1–15	241	162	0.96	0.04	218	155	0.71
	Jun 16–30 [a]					1	0.5	0.5
	Jul 1–15	101	93	0.75	0.25	76	71	0.93
	Jul 16–31 [a]					1	0.5	0.5
2013	May 16–31 [a]					1	0.5	0.5
	Jun 1–15 [a]					1	0.5	0.5
	Jun 16–30 [a]					1	0.5	0.5
	Jul 1–15	447	222	0.35	0.09	158	86	0.54
	Jul 16–31	1,094	519	0.76	0.09	832	403	0.49
2014	May 16–31 [a]					1	0.5	0.5
	Jun 1–15 [a]					1	0.5	0.5
	Jun 16–30 [a]					1	0.5	0.5
	Jul 1–15	539	222	0.53	0.09	287	126	0.44
	Jul 16–31 [a]					1	0.5	0.5

Source: Onsite creel surveys in Eskelin (2010)and Perschbacher (2012a-d, 2014)

[a] Because the fishery was closed or restricted downstream of the Soldotna Bridge, estimated harvest $N = 1$ and SE = 0.5 were used to keep the calculation from being undefined.

Appendix A4.–Estimates of harvest of Kenai River Chinook salmon 75 cm METF or longer for the area upstream of the Soldotna Bridge to Skilak Lake (RM 21–50) using guide logbook information and SWHS total harvest for the Kenai River, 2007–2014.

		Harvest (all Chinook) [a]		Proportion ≥75 cm METF [b]		Harvest (Chinook 75 cm or longer)		
Run	Year	Harvest	SE	*p*	SE (p)	Harvest	SE	CV
Early run	2007	778	81	0.73	0.06	571	74	0.13
	2008	467	34	0.88	0.03	411	32	0.08
	2009	202	21	0.86	0.07	175	24	0.14
	2010	476	57	0.82	0.04	389	50	0.13
	2011	114	12	0.79	0.02	91	10	0.11
	2012	67	13	0.93	0.04	63	13	0.20
	2013 [c]					1	0.5	0.50
	2014 [c]					1	0.5	0.50
Late run	2007	640	31	0.84	0.04	537	36	0.07
	2008	763	37	0.88	0.02	668	37	0.06
	2009	720	41	0.88	0.02	634	40	0.06
	2010	1586	96	0.80	0.02	1,274	87	0.07
	2011	40	3	0.79	0.02	32	2	0.08
	2012 [c]					1	0.5	0.50
	2013 [c]					1	0.5	0.50
	2014 [c]					1	0.5	0.50

[a] From Reimer et al. (2016)

[b] 2007–2010 length samples from harvest sampling survey upstream of the Soldotna Bridge, 2011–2012 length samples from creel survey downstream of the Soldotna Bridge.

[c] Because the fishery was closed upstream of the Soldotna Bridge, the estimated harvest N = 1 and SE = 0.5 were used to keep calculations from being undefined.

Appendix A5.–Weir passage estimates for Chinook salmon 75 cm or longer in tributaries to the Kenai River, 2007–2014.

	Funny River [a]		Killey River [b]		Slikok Creek [c]	
Year	N	SE	N	SE	N	SE
2007	1,198	147				
2008	897	126			49	7
2009	480	75			31	5
2010	424	54			10	1
2011	454	62			20	3
2012	204	36	1,204	115	6	1
2013	275	43	459	52		
2014	329	43	747	80		

[a] Boersma and Gates 2013, 2014; Gates and Boersma 2009a, 2009b, 2011, 2014b; Gates and Palmer 2008.

[b] Gates and Boersma 2013, 2014a, 2014c.

[c] Slikok Creek was assumed to have same percentage of passage of 75 cm METF or longer fish as was observed at the Funny River weir.

Appendix A6.–Capture data for inriver gillnetting near Kenai RM 21, 2011–2013.

				Chinook			Chinook	Sockeye			Water data	
Year	Date	Drifts (no.)	Minutes fishing	Capture (no.)	CPUE	SE (CPUE)	≥75 cm METF	Capture (no.)	CPUE	SE (CPUE)	Clarity [a]	Temperature [b]
2011	Jun 2	16	86	7	0.055	0.055	7	11	0.086	0.086	37	0
	Jun 9	15	84	9	0.118	0.030	8	6	0.053	0.053	115	0
	Jun 15	15	56	8	0.145	0.042	6	2	0.037	0.037	150	9.4
	Jun 22	14	38	8	0.209	–	4	8	0.209	–	176	10
	Jun 29	16	57	8	0.241	0.156	5	1	0.011	0.011	60	11
	Jul 7	15	56	7	0.123	0.004	6	9	0.251	0.225	–	–
	Jul 13	9	32	8	0.330	0.131	6	0	0.000	0.000	92	11
2012	Jun 7	18	45	9	0.200	0.034	8	6	0.132	0.008	109	7.5
	Jun 13	15	36	9	0.322	0.236	6	2	0.080	0.080	82	8
	Jun 20	10	25	8	0.271	0.083	8	0	0.000	0.000	54	8.5
	Jun 27	20	74	3	0.048	0.028	3	1	0.010	0.010	44	9
	Jun 28	20	81	4	0.066	0.048	4	2	0.018	0.018	53	10.5
	Jul 4	14	36	11	0.394	0.232	9	0	0.000	0.000	–	–
2013	May 30	15	84	0	0.000	0.000	0	0	0.000	0.000	32	8.5
	Jun 6	21	105	2	0.020	0.005	1	7	0.059	0.034	80	6.5
	Jun 13	33	108	10	0.091	0.006	9	1	0.008	0.008	54	6.5
	Jun 19	22	106	7	0.066	0.011	6	3	0.029	0.029	38	11.5
	Jun 27	34	135	10	0.074	0.014	7	7	0.052	0.038	74	10

[a] Visibility of a 12-inch Secchi disk in centimeters.

[b] Degrees Celsius.

Appendix A7.–Number of genetic samples from Kenai River Chinook salmon 75 cm or longer included in the SSART model from supplementary harvest sampling by harvest area, 2010–2013.

Year	Time strata	Downstream of the Soldotna Bridge	Upstream of the Soldotna Bridge
2010	May 16–31	3	
	Jun 1–15	0	
	Jun 16–30	22	
	Jul 1–15	41	3
	Jul 16–31	60	1
2011	May 16–31	5	
	Jun 1–15	1	
	Jun 16–30	6	
	Jul 1–15	0	
	Jul 16–31	0	
2012	May 16–31	7	
	Jun 1–15	27	
	Jun 16–30	0	
	Jul 1–15	1	
	Jul 16–31	0	
2013	May 16–31	0	
	Jun 1–15	0	
	Jun 16–30	0	
	Jul 1–15	8	
	Jul 16–31	16	

APPENDIX B: OPENBUGS CODE AND DATA

Appendix B1.–OpenBUGS code for Bayesian estimation of inriver abundance[13].

```
model{
  #Prior information for run timing
  RT.mean.trib ~ dnorm(0,1.0E-2)I(-1,6)
  RT.mean.i[4] ~ dnorm(0,1.0E-2)I(-1,6)
  RT.mean.gr ~ dnorm(0,1.0E-2)I(-1,6)
  RT.mean.i[1] <- RT.mean.trib
  RT.mean.i[2] <- RT.mean.trib
  RT.mean.i[3] <- RT.mean.gr
  RT.mean.i[5] <- RT.mean.trib
  RT.mean.i[6] <- RT.mean.gr
  RT.tau1.trib ~ dgamma(0.1,0.1)
  RT.tau1.ms ~ dgamma(0.1,0.1)
  RT.tau2 ~ dgamma(0.1,0.1)
  RT.tau3 ~ dgamma(0.1,0.1)
  log.N.tau ~ dgamma(0.1,0.1)
  index.tau ~ dgamma(100,1)
  RT.sigma1.trib <- 1 / sqrt(RT.tau1.trib)
  RT.sigma1.ms <- 1 / sqrt(RT.tau1.ms)
  RT.sigma2 <- 1 / sqrt(RT.tau2)
  RT.sigma3 <- 1 / sqrt(RT.tau3)

  #Prior information for CPUE
  index.sigma <- 1 / sqrt(index.tau)
  for(y in 1:Y) { q[y] ~ dbeta(1,1)I(0.000001,) }
  N.sigma <- 1 / sqrt(log.N.tau)

  #Hierarchical Niy
  log.N.mean ~ dnorm(0,1.0E-12)
  N.median <- exp(log.N.mean)
  D.scale ~ dunif(0,1)
  D.sum <- 1 / (D.scale * D.scale)
  for (i in 1:5) {theta0p[i] ~ dbeta(0.5,0.5)}
  theta0[1] <- theta0p[1]
  theta0[2] <- theta0p[2] * (1 - theta0[1])
  theta0[3] <- theta0p[3] * (1 - theta0[1] - theta0[2])
  theta0[4] <- theta0p[4] * (1 - theta0[1] - theta0[2] - theta0[3])
  theta0[5] <- theta0p[5] * (1 - theta0[1] - theta0[2] - theta0[3] - theta0[4])
  theta0[6] <- 1 - theta0[1] - theta0[2] - theta0[3] - theta0[4] - theta0[5]
  for (i in 1:C) {
    gamma[i] <- D.sum * theta0[i]
    for (y in 1:Y) {
      g[y,i] ~ dgamma(gamma[i],0.1)
      theta0.y[y,i] <- g[y,i]/sum(g[y,])
    }
  }
  for(y in 1:Y) {
    log.Ny.mean[y] ~ dnorm(log.N.mean,log.N.tau)
    Ny.median[y] <- exp(log.Ny.mean[y])
    for(i in 1:C) {
      N.iy[i,y] <- theta0.y[y,i] * Ny.median[y]                    #Equation 1
      log.Niy[i,y] <- log(N.iy[i,y])
```

-continued-

[13] Prior distributions are specified in green font; sampling distributions of the data (the "likelihood") are specified in blue font.

```
      RT.mean.iy[i,y] ~ dnorm(RT.mean.i[i],RT.tau2)
    }
  }

#Run size calculations
  for(y in 1:Y) {
    N.y[y] <- sum(N.iy[,y])
    Ny.msj[y] <- N.iy[4,y]
    Ny.trib[y] <- N.y[y] - Ny.msj[y]
    Ny.early[y] <- sum(N.yt[y,1:3])                                  #Equation 3
    Ny.late[y] <- sum(N.yt[y,4:6])                                   #Equation 4
    Ny.july[y] <- sum(N.yt[y,4:5])
    Ny.trib.late[y] <- Ny.late[y] - sum(N.iyt[4,y,4:6])
  }

  for(y in 1:Y) {
    for(t in 1:T) {
      z[1,y,t] <- (t - RT.mean.iy[1,y]) / RT.sigma1.trib             #Equations 6-7
      z[2,y,t] <- (t - RT.mean.iy[2,y]) / RT.sigma1.trib
      z[3,y,t] <- (t - RT.mean.iy[3,y]) / RT.sigma1.trib
      z[4,y,t] <- (t - RT.mean.iy[4,y]) / RT.sigma1.ms
      z[5,y,t] <- (t - RT.mean.iy[5,y]) / RT.sigma1.trib
      z[6,y,t] <- (t - RT.mean.iy[6,y]) / RT.sigma1.trib
      N.yt[y,t] <- sum(N.iyt[,y,t])
      log.Nqy[y,t] <- log(N.yt[y,t] * q[y])
      log.index[y,t] ~ dnorm(log.Nqy[y,t], index.tau)                #Equation 18
    }
    for(i in 1:C) {
      RT.sum[i,y] <- sum(RT[i,y,])
      for(t in 1:T) {
        log.RunTiming[i,y,t] <- log(exp(- z[i,y,t]*z[i,y,t])/2)      #Equation 5
        RT[i,y,t] ~ dlnorm(log.RunTiming[i,y,t],RT.tau3)             #Equation 8
        pi[i,y,t] <- RT[i,y,t] / RT.sum[i,y]                         #Equation 9
        N.iyt[i,y,t] <- pi[i,y,t] * N.iy[i,y]                        #Equation 2
        theta[y,t,i] <- N.iyt[i,y,t] / N.yt[y,t]                     #Equation 10
      }
    }
  }

  for(y in 1:6) {
    for(i in 1:C) {
      for(t in 1:T) {
        theta[y,t,i] <- N.iyt[i,y,t] / N.yt[y,t]
        }
      }
    }

  for(y in 1:8) {
    for(i in 1:C) {
        thetaER[y,i] <- N.iyt[i,y,1:3] / N.early[y]
         thetaLR[y,i] <- N.iyt[i,y,4:6] / N.late[y]
    }
  }
```

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```
# Transition probabilities between rm 21 (row) and rm 8 (col) timestrata

  tp[1,1] <- 1; tp[1,2] <- 0; tp[1,3] <- 0; tp[1,4] <- 0; tp[1,5] <- 0; tp[1,6] <- 0;
                              tp[2,3] <- 0; tp[2,4] <- 0; tp[2,5] <- 0; tp[2,6] <- 0;
                                            tp[3,4] <- 0; tp[3,5] <- 0; tp[3,6] <- 0;
                                                          tp[4,5] <- 0; tp[4,6] <- 0;
tp[2,1:2] ~ ddirich(ones[1:2])
tp[3,1:3] ~ ddirich(ones[1:3])
tp[4,1:4] ~ ddirich(ones[1:4])

for (i in 1:4){
    c8[i,1:6] ~ dmulti(tp[i,1:6], c21[i])
    for (r in 1:6) { tpc[i,r] <- cut(tp[i,r]) }
    }

#GSI stock composition
  for(i in 1:C) {
    for(h in 1:38) {
      qd[i,h] ~ dbeta(0.5,0.5)
      Yd[i,h] ~ dbin(qd[i,h],nd[i,h])                    #Baseline Allele Frequencies
    }
  }

  for(t in 1:T) { for(i in 1:C) {theta1[t,i] <- theta[1,t,i]} }    #Year 2007 (i.e. y=1)
  for(m in 1:M[1]) {
    z1[m] ~ dcat(theta1[tstrat1[m],1:C])                 #Stock Identification
    for(h in 1:38) {
      Xd1[m,h] ~ dbin(qd[z1[m],h],2)                     #Allele Counts
    }
  }

  for(t in 1:T) { for(i in 1:C) {theta2[t,i] <- theta[2,t,i]} }    #Year 2008 (i.e. y=2)
  for(m in 1:M[2]) {
    z2[m] ~ dcat(theta2[tstrat2[m],1:C])
    for(h in 1:38) {
      Xd2[m,h] ~ dbin(qd[z2[m],h],2)
    }
  }

  for(t in 1:T) { for(i in 1:C) {theta3[t,i] <- theta[3,t,i]} }    #Year 2009 (i.e. y=3)
  for(m in 1:M[3]) {
    z3[m] ~ dcat(theta3[tstrat3[m],1:C])
    for(h in 1:38) {
      Xd3[m,h] ~ dbin(qd[z3[m],h],2)
    }
  }

  for(t in 1:T) { for(i in 1:C) {theta4[t,i] <- theta[4,t,i]} }    #Year 2010 (i.e. y=4)
  for(m in 1:M[4]) {
    z4[m] ~ dcat(theta4[tstrat4[m],1:C])
    for(h in 1:38) {
      Xd4[m,h] ~ dbin(qd[z4[m],h],2)
    }
```

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```
  }

for(t in 1:T) { for(i in 1:C) {theta5[t,i] <- theta[5,t,i]} }                #Year 2011 (i.e. y=5)
  for(m in 1:359) {
    z5[m] ~ dcat(theta5[tstrat5[m],1:C])
    for(h in 1:38) {
      Xd5[m,h] ~ dbin(qd[z5[m],h],2)
    }
  }
  for(m in 360:400) {
    tstrat5[m]~dcat(tpc[tstrat5_21[m],1:6])
    tstrat5_21[m]~dcat(quarters[])
    z5[m] ~ dcat(theta5[tstrat5[m],1:C])
    for(h in 1:38) {
      Xd5[m,h] ~ dbin(qd[z5[m],h],2)
    }
  }

for(t in 1:T) { for(i in 1:C) {theta6[t,i] <- theta[6,t,i]} }                #Year 2012 (i.e. y=6)
  for(m in 1:296) {
    z6[m] ~ dcat(theta6[tstrat6[m],1:C])
    for(h in 1:38) {
      Xd6[m,h] ~ dbin(qd[z6[m],h],2)
      }
    }
  for(m in 297:334) {
    tstrat6[m]~dcat(tpc[tstrat6_21[m],1:6])
    tstrat6_21[m]~dcat(quarters[])
    z6[m] ~ dcat(theta6[tstrat6[m],1:C])
    for(h in 1:38) {
      Xd6[m,h] ~ dbin(qd[z6[m],h],2)
      }
    }

  for(i in 1:C) {                                                           #Year 2013 (i.e. y=7)
    for(t in 1:T) {
    p.m7.it[i,t] ~ dbeta(0.5,0.5)
    N7m.it[i,t] <- p.m7.it[i,t] * N.iyt[i,7,t]
    N7n.it[i,t] <- (1-p.m7.it[i,t]) * N.iyt[i,7,t]
    theta7[t,i] <- N.iyt[i,7,t] / N.yt[7,t]
    theta7m[t,i] <- N7m.it[i,t] / N7m.t[t]
    theta7n[t,i] <- N7n.it[i,t] / N7n.t[t]
    }
  }

  for(t in 1:T) {
    N7m.t[t] <- sum(N7m.it[,t])
    N7n.t[t] <- sum(N7n.it[,t])
    p.m7.t[t] <- N7m.t[t] / (N7m.t[t] + N7n.t[t])
    xm7.t[t] ~ dbin(p.m7.t[t],xmn7.t[t])            #Pseudodata from negative binomial regression
  }
  for(m in 1:142) {
    z7[m]    ~ dcat(theta7m[tstrat7[m],1:C])                                #Stock Identification, midriver
    for(h in 1:38) {        Xd7[m,h] ~ dbin(qd[z7[m],h],2)   }
```

-continued-

```
    }
  for(m in 143:155) {
    z7[m]    ~ dcat(theta7n[tstrat7[m],1:C])                    #Stock Identification, nearshore
    for(h in 1:38) { Xd7[m,h] ~ dbin(qd[z7[m],h],2) }
    }
  for(m in 156:178) {
    tstrat7[m]~dcat(tpc[tstrat7_21[m],1:6])
    tstrat7_21[m]~dcat(quarters[])
    z7[m]    ~ dcat(theta7[tstrat7[m],1:C])                     #Stock Identification, overall
    for(h in 1:38) { Xd7[m,h] ~ dbin(qd[z7[m],h],2) }
  }


  for(i in 1:C) {                                               #Year 2014 (i.e. y=8)
    for(t in 1:T) {
      p.m8.it[i,t] ~ dbeta(0.5,0.5)
      N8m.it[i,t] <- p.m8.it[i,t] * N.iyt[i,8,t]
      N8n.it[i,t] <- (1-p.m8.it[i,t]) * N.iyt[i,8,t]
      theta8[t,i] <- N.iyt[i,8,t] / N.yt[8,t]
      theta8m[t,i] <- N8m.it[i,t] / N8m.t[t]
      theta8n[t,i] <- N8n.it[i,t] / N8n.t[t]
    }
  }
  for(t in 1:T) {
    N8m.t[t] <- sum(N8m.it[,t])
    N8n.t[t] <- sum(N8n.it[,t])
    p.m8.t[t] <- N8m.t[t] / (N8m.t[t] + N8n.t[t])                                   #Equation 11
    xm8.t[t] ~ dbin(p.m8.t[t],xmn8.t[t])          #Pseudodata from negative binomial regression
  }
  for(m in 1:224) {
    z8[m]    ~ dcat(theta8m[tstrat8[m],1:C])                    #Stock Identification, midriver
    for(h in 1:38) { Xd8[m,h] ~ dbin(qd[z8[m],h],2) }
  }
  for(m in 225:251) {
    z8[m]    ~ dcat(theta8n[tstrat8[m],1:C])                    #Stock Identification, nearshore
    for(h in 1:38) { Xd8[m,h] ~ dbin(qd[z8[m],h],2) }
  }

#Harvest and escapement
  for(y in 1:Y) {
    HRm.y[y] ~ dbeta(0.5,0.5)
    HRgr.y[y] ~ dbeta(0.5,0.5)
    HRt.y[y] ~ dbeta(0.5,0.5)
    HR.iy[1,y] <- HRt.y[y]
    HR.iy[2,y] <- HRt.y[y]
    HR.iy[3,y] <- HRgr.y[y]
    HR.iy[4,y] <- HRm.y[y]
    HR.iy[5,y] <- HRt.y[y]
    HR.iy[6,y] <- HRgr.y[y]
    for(i in 1:C) {
      H.iy[i,y] <- N.iy[i,y] * HR.iy[i,y]                                           #Equation 12
      theta.H[y,i] <- H.iy[i,y] / H.y[y]                                            #Equation 13
      S.iy[i,y] <- N.iy[i,y] - H.iy[i,y]                                            #Equation 15
      log.Siy[i,y] <- log(S.iy[i,y])
```

-continued-

```
      log.Syi.hat[y,i] ~ dnorm(log.Siy[i,y],tau.logSiy[i,y])                    #Equation 14
      tau.logSiy[i,y] <- 1 / log(cv.Syi[y,i] * cv.Syi[y,i] + 1)
    }
  }

  for(y in 1:Y) {
    log.H.hat[y] ~ dnorm(log.H[y],tau.logH[y])                                 #Equation 18
    tau.logH[y] <- 1 / log(cv.H[y] * cv.H[y] + 1)
    x[y,1:C] ~ dmulti(theta.H[y,1:C],n.H[y])                  #Multinomial harvest pseudodata

    H.y[y] <- sum(H.iy[,y])
    n.H[y] <- sum(x[y,])
    log.H[y] <- log(H.y[y])
  }

  rho.Benj ~ dbeta(0.5,0.5)
  B.scale ~ dunif(0,1)
  B <- 1 / (B.scale * B.scale)
  B1 <- rho.Benj * B
  B2 <- B - B1
  for(y in 1:Y) {
    tau.logSBy[y] <- 1 / log(cv.SBy[y] * cv.SBy[y] + 1)
    rho.y[y] ~ dbeta(B1,B2)
    b[y] ~ dbin(rho.y[y],bk[y])
    S.Benj[y] <- rho.y[y] * S.iy[1,y]                                          #Equation 17
    log.SB[y] <- log(S.Benj[y])
    log.SB.hat[y] ~ dnorm(log.SB[y],tau.logSBy[y])                             #Equation 16
  }
}
```

Appendix B2.–Abbreviated input dataset for Bayesian estimation of inriver abundance.

```
list(
C=6, Y=8, T=6, ones=c(1,1,1,1,1,1), quarters=c(0.25,0.25,0.25,0.25),
M=c(264,403,391,315,400,334,178,251),

# pseudo data from negative binomial regression
xm7.t=c(4,12,8,29,24,16),
xmn7.t=c(4,20,17,37,28,20),
xm8.t=c(42,80,51,75,141,89),
xmn8.t=c(43,91,64,91,158,92),

log.SB.hat=c(NA, NA, NA, NA, NA, 7.09, 6.13, 6.62),
cv.SBy=c(0.1, 0.1, 0.1, 0.1, 0.1, 0.10, 0.12, 0.11),
bk=c(0,0,0,37,45,52,25,29),
b=c(0,0,0,18,21,21,10,12),

log.H.hat=c(9.14, 9.28, 8.81, 8.74, 8.63, 6.09, 6.90, 5.68),
cv.H=c(0.07, 0.06, 0.06, 0.06, 0.08, 0.42, 0.41, 0.43),

# pseudo data from Harvest GSi theta v2.6e report
x=structure(.Data=c(22,7,2,119,2,1,…),.Dim=c(8,6)),

c8=structure(.Data=c(13,0,0,0,0,0,26,39,0,0,0,0,…),.Dim=c(4,6)),
c21=c(13,65,167,62),

log.Syi.hat=structure(.Data=c(NA, 7.11, NA, NA, NA, NA,…),.Dim=c(8,6)),
cv.Syi=structure(.Data=c(0.1,0.12,0.1,0.1,0.1,0.1,…),.Dim=c(8,6)),

#CPUE 2007-2010, rm8 didson 2011-2012 and rm 14 aris 2013-2014
log.index=structure(.Data=c(-3.85, -2.46, -2.56, -1.54, -0.69, -2.29,…),.Dim=c(8,6)),

z4=c(NA,NA,NA,1,1,NA,NA,…),
…
z8=c(1,1,1,NA,4,NA,1,1,1,NA,1,…),

Yd=structure(.Data=c(668,240,735,685,589,105,…),.Dim=c(6,38)),
nd=structure(.Data=c(914,908,902,906,906,906,…),.Dim=c(6,38)),

tstrat1=c(1,...,2,…,3,…,4,…,5,...,6,…),
Xd1=structure(.Data=c(2,1,2,2,2,0,0,2,0,2,… ),.Dim=c(264,38)),
…
tstrat8=c(1,...,2,…,3,…,4,…,5,...,6,…),
Xd8=structure(.Data=c(2,2,2,2,2,0,0,2,0,2,2,2,1,0,0,…),.Dim=c(251,38))
)
```

Appendix B3.–OpenBUGS code for harvest stock composition [14].

```
model{
#Prior information for run timing
  RT.mean.trib ~ dnorm(0,1.0E-2)I(0,5)
  RT.mean.i[4] ~ dnorm(0,1.0E-2)I(0,5)
  RT.mean.gr ~ dnorm(0,1.0E-2)I(0,5)
  RT.mean.i[1] <- RT.mean.trib
  RT.mean.i[2] <- RT.mean.trib
  RT.mean.i[3] <- RT.mean.gr
  RT.mean.i[5] <- RT.mean.trib
  RT.mean.i[6] <- RT.mean.gr
  RT.tau1.trib ~ dgamma(0.1,0.1)
  RT.tau1.mjgr ~ dgamma(0.1,0.1)
  RT.tau2 ~ dgamma(0.1,0.1)
  RT.tau3 ~ dgamma(0.1,0.1)
  log.HL.tau ~ dgamma(0.1,0.1)
  log.HM.tau ~ dgamma(0.1,0.1)
  RT.sigma1.trib <- 1 / sqrt(RT.tau1.trib)
  RT.sigma1.mjgr <- 1 / sqrt(RT.tau1.mjgr)
  RT.sigma2 <- 1 / sqrt(RT.tau2)
  RT.sigma3 <- 1 / sqrt(RT.tau3)
  HL.sigma <- 1 / sqrt(log.HL.tau)
  HM.sigma <- 1 / sqrt(log.HM.tau)

  for(i in 1:C) {
    log.HLi.mean[i] ~ dnorm(0,1.0E-12)I(0,)
    log.HMi.mean[i] ~ dnorm(0,1.0E-12)I(0,)
    for(y in 1:Y) {
        log.HLiy[i,y] ~ dnorm(log.HLi.mean[i],log.HL.tau)I(1,)
        RT.mean.iy[i,y] ~ dnorm(RT.mean.i[i],RT.tau2)
        log.HMiy[i,y] ~ dnorm(log.HMi.mean[i],log.HM.tau)I(1,)
      }
    }

 for(y in 1:Y) {
     for(t in 1:T.L) {
        z[1,y,t] <- (t - RT.mean.iy[1,y]) / RT.sigma1.trib                    #Equations 6-7
        z[2,y,t] <- (t - RT.mean.iy[2,y]) / RT.sigma1.trib
        z[3,y,t] <- (t - RT.mean.iy[3,y]) / RT.sigma1.mjgr
        z[4,y,t] <- (t - RT.mean.iy[4,y]) / RT.sigma1.mjgr
        z[5,y,t] <- (t - RT.mean.iy[5,y]) / RT.sigma1.trib
        z[6,y,t] <- (t - RT.mean.iy[6,y]) / RT.sigma1.mjgr
      }
}

for(y in 1:Y) {
   for(i in 1:C) {
      HL.iy[i,y] <- exp(log.HLiy[i,y])
      RT.sum[i,y] <- sum(RT[i,y,])
      HM.iy[i,y] <- exp(log.HMiy[i,y])
      D.sum[i,y] <- sum(D[i,y,])
   for(t in 1:T.L) {
```

-continued-

[14] Prior distributions are specified in green font; sampling distributions of the data (the "likelihood") are specified in blue font.

```
        log.RunTiming[i,y,t] <- log(exp(- z[i,y,t]*z[i,y,t])/2)          #Equation 5
        RT[i,y,t] ~ dlnorm(log.RunTiming[i,y,t],RT.tau3)                 #Equation 8
        pi[i,y,t] <- RT[i,y,t] / RT.sum[i,y]                             #Equation 9
        HL.iyt[i,y,t] <- pi[i,y,t] * HL.iy[i,y]                          #Equation 2
        theta.Lk[y,t,i] <- HL.iyt[i,y,t] / HL.yt[y,t]                    #Equation 10
      }
    for(t in 1:T.M) {
        D[i,y,t] ~ dgamma(1,0.1)
        piM[i,y,t] <- D[i,y,t] / D.sum[i,y]
        HM.iyt[i,y,t] <- piM[i,y,t] * HM.iy[i,y]                         #Equation 2
        theta.Mk[y,t,i] <- HM.iyt[i,y,t] / HM.yt[y,t]                    #Equation 10
      }
    }
    for(t in 1:T.L) {
      HL.yt[y,t] <- sum(HL.iyt[,y,t])
    }
    for(t in 1:T.M) {
      HM.yt[y,t] <- sum(HM.iyt[,y,t])
    }
}

  for(y in 1:Y) {
    for(t in 1:T.L) {
      log.HLyt[y,t] <- log(HL.yt[y,t])
      tau.HLyt[y,t] <- 1 / cv.HLyt[y,t] / cv.HLyt[y,t]
      log.HLyt.hat[y,t] ~ dnorm(log.HLyt[y,t], tau.HLyt[y,t])
    }
    for(t in 1:T.M) {
      log.HMyt[y,t] <- log(HM.yt[y,t])
      tau.HMyt[y,t] <- 1 / cv.HMyt[y,t] / cv.HMyt[y,t]
      log.HMyt.hat[y,t] ~ dnorm(log.HMyt[y,t], tau.HMyt[y,t])
    }
    for(i in 1:C) {
      H.iy[i,y] <- HL.iy[i,y] + HM.iy[i,y]
      theta.H[i,y] <- H.iy[i,y] / H.y[y]
      theta.L[i,y] <- HL.iy[i,y] / HL.y[y]
      theta.M[i,y] <- HM.iy[i,y] / HM.y[y]
    }
  }

   for(y in 1:Y) {
     HL.y[y] <- sum(HL.yt[y,])
     HM.y[y] <- sum(HM.yt[y,])
     H.y[y] <- HL.y[y] + HM.y[y]
   }

#GSI stock composition

for(i in 1:C) {
    for(h in 1:A) {
        qd[i,h] ~ dbeta(0.5,0.5)
        Yd[i,h] ~ dbin(qd[i,h],nd[i,h])                    #Baseline Allele Frequencies
    }
}
```

-continued-

```
for(i in 1:C) {                                          # YEAR 2007 (i.e. y=1)
    for(t in 1:T.L) {
        theta.Lk.1[t,i] <- theta.Lk[1,t,i]
    }
    for(t in 1:T.M) {
        theta.Mk.1[t,i] <- theta.Mk[1,t,i]
    }
}
for(m2 in 1:M2[1]) {
    z2.1[m2] ~ dcat(theta.Lk.1[tstrat.L.1[m2],1:C])      #Stock Identification
    for(h in 1:A) {
        Xd2.1[m2,h] ~ dbin(qd[z2.1[m2],h],2)             #Allele Counts
    }
}
for(m3 in 1:M3[1]) {
    z3.1[m3] ~ dcat(theta.Mk.1[tstrat.M.1[m3],1:C])
    for(h in 1:A) {
        Xd3.1[m3,h] ~ dbin(qd[z3.1[m3],h],2)
    }
}

for(i in 1:C) {                                          # YEAR 2008 (i.e. y=2)
    for(t in 1:T.L) {
        theta.Lk.2[t,i] <- theta.Lk[2,t,i]
    }
    for(t in 1:T.M) {
        theta.Mk.2[t,i] <- theta.Mk[2,t,i]
    }
}
for(m2 in 1:M2[2]) {
    z2.2[m2] ~ dcat(theta.Lk.2[tstrat.L.2[m2],1:C])
    for(h in 1:A) {
        Xd2.2[m2,h] ~ dbin(qd[z2.2[m2],h],2)
    }
}
for(m3 in 1:M3[2]) {
    z3.2[m3] ~ dcat(theta.Mk.2[tstrat.M.2[m3],1:C])
    for(h in 1:A) {
        Xd3.2[m3,h] ~ dbin(qd[z3.2[m3],h],2)
    }
}

for(i in 1:C) {                                          # YEAR 2009 (i.e. y=3)
    for(t in 1:T.L) {
        theta.Lk.3[t,i] <- theta.Lk[3,t,i]
    }
    for(t in 1:T.M) {
        theta.Mk.3[t,i] <- theta.Mk[3,t,i]
    }
}
for(m2 in 1:M2[3]) {
    z2.3[m2] ~ dcat(theta.Lk.3[tstrat.L.3[m2],1:C])
    for(h in 1:A) {
```

-continued-

```
        Xd2.3[m2,h] ~ dbin(qd[z2.3[m2],h],2)
    }
}
for(m3 in 1:M3[3]) {
    z3.3[m3] ~ dcat(theta.Mk.3[tstrat.M.3[m3],1:C])
    for(h in 1:A) {
        Xd3.3[m3,h] ~ dbin(qd[z3.3[m3],h],2)
    }
}

for(i in 1:C) {                                          # YEAR 2010 (i.e. y=4)
    for(t in 1:T.L) {
        theta.Lk.4[t,i] <- theta.Lk[4,t,i]
    }
    for(t in 1:T.M) {
        theta.Mk.4[t,i] <- theta.Mk[4,t,i]
    }
}
for(m2 in 1:M2[4]) {
    z2.4[m2] ~ dcat(theta.Lk.4[tstrat.L.4[m2],1:C])
    for(h in 1:A) {
        Xd2.4[m2,h] ~ dbin(qd[z2.4[m2],h],2)
    }
}
for(m3 in 1:M3[4]) {
   z3.4[m3] ~ dcat(theta.Mk.4[tstrat.M.4[m3],1:C])
   for(h in 1:A) {
       Xd3.4[m3,h] ~ dbin(qd[z3.4[m3],h],2)
   }
 }

for(i in 1:C) {                                          # YEAR 2011 (i.e. y=5)
    for(t in 1:T.L) {
       theta.Lk.5[t,i] <- theta.Lk[5,t,i]
    }
}
for(m2 in 1:M2[5]) {
    z2.5[m2] ~ dcat(theta.Lk.5[tstrat.L.5[m2],1:C])
    for(h in 1:A) {
        Xd2.5[m2,h] ~ dbin(qd[z2.5[m2],h],2)
    }
}

for(i in 1:C) {                                          # YEAR 2012 (i.e. y=6)
    for(t in 1:T.L) {
       theta.Lk.6[t,i] <- theta.Lk[6,t,i]
    }
}
for(m2 in 1:M2[6]) {
    z2.6[m2] ~ dcat(theta.Lk.6[tstrat.L.6[m2],1:C])
    for(h in 1:A) {
       Xd2.6[m2,h] ~ dbin(qd[z2.6[m2],h],2)
    }
```

-continued-

```
}

for(i in 1:C) {                                          # YEAR 2013 (i.e. y=7)
    for(t in 1:T.L) {
        theta.Lk.7[t,i] <- theta.Lk[7,t,i]
    }
}
for(m2 in 1:M2[7]) {
   z2.7[m2] ~ dcat(theta.Lk.7[tstrat.L.7[m2],1:C])
   for(h in 1:A) {
      Xd2.7[m2,h] ~ dbin(qd[z2.7[m2],h],2)
   }
}

for(i in 1:C) {                                          # YEAR 2014 (i.e. y=8)
    for(t in 1:T.L) {
        theta.Lk.8[t,i] <- theta.Lk[8,t,i]
    }
}
for(m2 in 1:M2[8]) {
    z2.8[m2] ~ dcat(theta.Lk.8[tstrat.L.8[m2],1:C])
    for(h in 1:A) {
        Xd2.8[m2,h] ~ dbin(qd[z2.8[m2],h],2)
    }
}
}
```

Appendix B4.–Abbreviated input dataset for Bayesian estimation of harvest stock composition.

```
list(
C=6, Y=8, T.L=5, T.M=2, A=38,
M2=c(312,337,301,358,263,75,54,16),
M3=c(117,313,166,287,0,0,0,0),

log.HLyt.hat=structure(.Data=c(2.71, 6.60, 6.94, 7.41, 8.47,…),.Dim=c(8,5)),

cv.HLyt=structure(.Data=c(0.53, 0.20, 0.29, 0.15, 0.10,…),.Dim=c(8,5)),

log.HMyt.hat=structure(.Data=c(6.35, 6.29, 6.02, 6.50,…),.Dim=c(8,2)),

cv.HMyt=structure(.Data=c(0.13, 0.07, 0.08, 0.06,…),.Dim=c(8,2)),

Yd=structure(.Data=c(668,240,735,685,589,…),.Dim=c(6,38)),
nd=structure(.Data=c(914,908,902,906,906,…),.Dim=c(6,38)),

tstrat.L.1=c(1,…,2,…,3,…,4,…,5,…),
Xd2.1=structure(.Data=c(1,1,1,2,0,1,1,2,0,2,2,2,2,0,0,0,0,0,1,0,NA,…),.Dim=c(312,38)),

tstrat.M.1=c(1,…,2,…,3,…,4,…,5,…),
Xd3.1=structure(.Data=c(2,0,2,1,1,0,0,2,0,2,2,2,2,0,0,0,1,0,0,2,0,0,1,2,…),.Dim=c(117,38)),

…

tstrat.L.8=c(1,…,2,…,3,…,4,…,5,…),
Xd2.8=structure(.Data=c(1,1,2,2,1,0,0,NA,1,2,2,2,1,0,0,2,0,0,2,0,0,…),.Dim=c(16,38))
)
```

APPENDIX C: ABUNDANCE ESTIMATES FOR CHINOOK SALMON FROM TRIBUTARY AND MAINSTEM SPAWNING DESTINATIONS

Appendix C1.–Abundance estimates for Kenai River Chinook salmon 75 cm or longer from tributary and mainstem spawning destinations passing RM 8.6.

	Tributaries			Mainstem–Juneau Creek		
Year	Mean	SD	95% CI	Mean	SD	95% CI
2007	7,511	1,659	5,177–11,650	38,310	10,970	23,020–67,370
2008	6,405	853	4,926–8,254	43,640	6,897	31,090–57,700
2009	4,431	985	2,859–6,601	28,910	7,017	17,150–44,310
2010	3,442	623	2,495–4,941	10,180	2,248	6,771–15,510
2011	3,334	603	2,359–4,676	19,570	3,911	13,300–28,120
2012	3,271	412	2,534–4,149	25,720	3,768	18,960–33,790
2013	1,608	224	1,230–2,101	13,800	2,459	9,559–19,040
2014	2,381	351	1,836–3,194	11,990	2,170	8,647–17,520

APPENDIX D: ESTIMATES BY STOCK GROUP, TIME STRATUM, AND YEAR

Appendix D1.–Inriver run estimates (and standard deviations) by stock group, year, and time stratum for Kenai River Chinook salmon 75 cm or longer passing RM 8.6.

Year	Time strata	Killey–Benjamin	Funny–Slikok	Grant	Mainstem–Juneau	Quartz–Crescent	Russian	Total by time stratum
2007	May 16–31	773 (253)	158 (127)	0 (1)	12 (15)	54 (54)	0 (0)	997 (281)
	Jun 1–15	2,855 (872)	667 (274)	5 (13)	260 (192)	187 (128)	2 (5)	3,976 (1,049)
	Jun 16–30	1,330 (521)	604 (234)	39 (46)	1,510 (683)	152 (123)	29 (37)	3,664 (981)
	Jul 1–15	114 (109)	162 (219)	105 (92)	9,393 (2,862)	23 (34)	86 (84)	9,883 (2,856)
	Jul 16–31	2 (4)	11 (34)	79 (99)	22,310 (6,469)	1 (2)	53 (61)	22,450 (6,476)
	Aug 1–10	0 (0)	0 (1)	14 (31)	4,823 (1,388)	0 (0)	7 (14)	4,844 (1,386)
	Total by stock	5,073 (1,480)	1,602 (186)	241 (199)	38,310 (10,970)	417 (248)	178 (156)	45,820 (12,450)
2008	May 16–31	544 (137)	198 (93)	0 (0)	3 (4)	48 (43)	0 (0)	793 (135)
	Jun 1–15	1,784 (370)	893 (197)	2 (5)	88 (67)	129 (78)	5 (7)	2,901 (425)
	Jun 16–30	1,255 (310)	597 (183)	26 (31)	921 (299)	83 (66)	69 (47)	2,951 (463)
	Jul 1–15	112 (86)	85 (78)	73 (67)	5,189 (984)	10 (18)	274 (158)	5,743 (1,016)
	Jul 16–31	2 (3)	2 (3)	46 (59)	18,050 (3,143)	0 (1)	144 (137)	18,240 (3,168)
	Aug 1–10	0 (0)	0 (0)	6 (14)	19,390 (3,364)	0 (0)	18 (31)	19,410 (3,368)
	Total by stock	3,697 (630)	1,775 (210)	153 (134)	43,640 (6,897)	270 (138)	510 (286)	50,040 (7,543)
2009	May 16–31	1,184 (311)	57 (61)	0 (0)	13 (14)	22 (24)	0 (0)	1,276 (324)
	Jun 1–15	1,057 (304)	210 (97)	1 (3)	175 (96)	72 (54)	2 (5)	1,518 (382)
	Jun 16–30	1,090 (407)	276 (114)	18 (25)	2,430 (760)	59 (62)	26 (33)	3,898 (972)
	Jul 1–15	97 (119)	68 (79)	49 (49)	12,210 (3,111)	11 (23)	59 (57)	12,490 (3,122)
	Jul 16–31	1 (3)	3 (6)	31 (35)	10,270 (2,584)	0 (2)	29 (36)	10,330 (2,593)
	Aug 1–10	0 (0)	0 (0)	5 (11)	3,810 (976)	0 (0)	3 (7)	3,818 (978)
	Total by stock	3,429 (906)	613 (90)	104 (92)	28,910 (7,017)	164 (119)	120 (105)	33,340 (7,870)
2010	May 16–31	294 (79)	67 (38)	0 (0)	5 (5)	23 (19)	0 (0)	389 (85)
	Jun 1–15	1,267 (286)	315 (71)	2 (4)	114 (58)	67 (36)	4 (5)	1,769 (342)
	Jun 16–30	571 (179)	213 (73)	26 (23)	618 (215)	27 (22)	59 (38)	1,514 (318)
	Jul 1–15	40 (31)	25 (23)	53 (37)	2,285 (561)	3 (5)	278 (117)	2,684 (610)
	Jul 16–31	1 (1)	1 (1)	30 (30)	4,982 (1,158)	0 (0)	66 (45)	5,079 (1,171)
	Aug 1–10	0 (0)	0 (0)	3 (5)	2,175 (500)	0 (0)	7 (10)	2,185 (501)
	Total by stock	2,173 (477)	621 (72)	114 (70)	10,180 (2,248)	119 (58)	415 (161)	13,620 (2,784)

-continued-

Appendix D1.–Page 2 of 2.

Year	Time strata	Killey–Benjamin	Funny–Slikok	Grant	Mainstem–Juneau	Quartz–Crescent	Russian	Total by time stratum
2011	May 16–31	674 (182)	243 (77)	0 (0)	12 (10)	18 (18)	0 (0)	947 (190)
	Jun 1–15	1,261 (299)	330 (75)	2 (4)	189 (87)	56 (38)	1 (2)	1,838 (353)
	Jun 16–30	370 (132)	92 (47)	24 (26)	2,033 (468)	31 (27)	12 (13)	2,561 (543)
	Jul 1–15	23 (23)	6 (8)	69 (62)	5,708 (1,236)	4 (9)	46 (40)	5,855 (1,254)
	Jul 16–31	0 (1)	0 (0)	31 (35)	9,644 (2,058)	0 (1)	33 (38)	9,708 (2,065)
	Aug 1–10	0 (0)	0 (0)	4 (6)	1,983 (432)	0 (0)	4 (8)	1,991 (432)
	Total by stock	2,327 (518)	671 (77)	130 (105)	19,570 (3,911)	110 (67)	96 (80)	22,900 (4,434)
2012	May 16–31	798 (138)	88 (43)	0 (0)	3 (3)	16 (17)	0 (0)	904 (139)
	Jun 1–15	1,235 (196)	144 (41)	2 (5)	93 (52)	43 (32)	1 (2)	1,518 (215)
	Jun 16–30	651 (140)	35 (25)	25 (25)	554 (159)	23 (24)	8 (12)	1,296 (201)
	Jul 1–15	39 (35)	3 (5)	62 (58)	4,468 (762)	3 (7)	30 (36)	4,604 (773)
	Jul 16–31	0 (1)	0 (0)	36 (46)	10,430 (1,725)	0 (1)	22 (32)	10,490 (1,732)
	Aug 1–15	0 (0)	0 (0)	4 (9)	10,180 (1,681)	0 (0)	4 (11)	10,190 (1,682)
	Total by stock	2,723 (343)	270 (46)	130 (111)	25,720 (3,768)	84 (59)	65 (73)	29,000 (4,081)
2013	May 16–31	155 (35)	18 (16)	0 (0)	2 (2)	17 (14)	0 (0)	192 (37)
	Jun 1–15	682 (126)	109 (49)	0 (0)	74 (49)	37 (27)	1 (2)	903 (152)
	Jun 16–30	281 (94)	144 (49)	4 (4)	391 (138)	16 (17)	10 (15)	845 (151)
	Jul 1–15	26 (26)	33 (33)	13 (13)	2,324 (471)	2 (4)	26 (32)	2,423 (471)
	Jul 16–31	0 (1)	2 (3)	11 (15)	5,235 (1,006)	0 (0)	18 (26)	5,266 (1,007)
	Aug 1–17	0 (0)	0 (0)	2 (3)	5,778 (1,099)	0 (0)	4 (9)	5,783 (1,099)
	Total by stock	1,144 (181)	304 (48)	30 (29)	13,800 (2,459)	72 (47)	58 (65)	15,410 (2,620)
2014	May 16–31	108 (27)	24 (15)	0 (0)	1 (1)	3 (5)	0 (0)	137 (26)
	Jun 1–15	1,184 (211)	223 (54)	2 (4)	34 (27)	14 (18)	3 (5)	1,459 (227)
	Jun 16–30	399 (105)	113 (43)	26 (25)	325 (131)	13 (20)	35 (30)	911 (164)
	Jul 1–15	44 (32)	17 (17)	49 (39)	1,500 (315)	2 (6)	64 (46)	1,676 (329)
	Jul 16–31	1 (2)	0 (1)	27 (31)	4,986 (972)	0 (0)	25 (26)	5,039 (981)
	Aug 1–15	0 (0)	0 (0)	3 (6)	5,146 (999)	0 (0)	2 (4)	5,151 (1,000)
	Total by stock	1,735 (278)	377 (47)	107 (76)	11,990 (2,170)	32 (40)	129 (83)	14,370 (2,450)

Note: Individual estimates and totals may differ slightly due to rounding.

Appendix D2.–Harvest estimates (and standard deviations) by stock group, year, and time stratum from the lower Kenai River (below Soldotna Bridge [RM 21]) for Chinook salmon 75 cm or longer.

Year	Time strata	Killey–Benjamin	Funny–Slikok	Grant	Mainstem–Juneau	Quartz–Crescent	Russian	Total by year
2007	May 16–31	2 (4)	15 (10)	0 (1)	2 (5)	0 (2)	0 (2)	20 (11)
	Jun 1–15	419 (117)	285 (98)	1 (3)	5 (13)	2 (5)	1 (5)	712 (142)
	Jun 16–30	483 (182)	45 (83)	22 (28)	419 (171)	5 (15)	2 (7)	975 (280)
	Jul 1–15	14 (30)	17 (43)	9 (19)	1,629 (253)	4 (11)	12 (20)	1,684 (252)
	Jul 16–31	10 (27)	7 (25)	6 (21)	4,681 (480)	42 (71)	6 (13)	4,752 (475)
	Total by stock	928 (221)	369 (150)	38 (39)	6,735 (569)	52 (74)	22 (23)	8,144 (624)
2008	May 16–31	64 (30)	75 (32)	2 (5)	3 (7)	1 (3)	0 (1)	145 (40)
	Jun 1–15	914 (149)	390 (119)	1 (6)	3 (9)	12 (19)	1 (4)	1,321 (144)
	Jun 16–30	400 (108)	243 (100)	2 (7)	46 (61)	8 (20)	24 (22)	723 (122)
	Jul 1–15	66 (89)	28 (55)	9 (20)	2,497 (445)	5 (16)	36 (52)	2,641 (449)
	Jul 16–31	29 (65)	21 (54)	12 (30)	4,637 (432)	6 (22)	39 (43)	4,745 (426)
	Total by stock	1,472 (227)	757 (187)	28 (37)	7,186 (629)	33 (40)	100 (77)	9,575 (650)
2009	May 16–31	96 (25)	1 (3)	0 (2)	1 (2)	1 (2)	0 (1)	100 (25)
	Jun 1–15	234 (90)	61 (52)	1 (4)	4 (14)	3 (7)	2 (6)	304 (94)
	Jun 16–30	237 (70)	13 (26)	4 (10)	42 (39)	4 (9)	1 (5)	301 (73)
	Jul 1–15	6 (14)	8 (22)	16 (30)	2,601 (270)	5 (14)	38 (43)	2,675 (267)
	Jul 16–31	14 (36)	17 (43)	8 (18)	2,503 (309)	4 (11)	4 (11)	2,550 (306)
	Total by stock	587 (124)	100 (73)	30 (35)	5,150 (414)	17 (20)	45 (44)	5,930 (424)
2010	May 16–31	76 (24)	3 (7)	0 (1)	1 (2)	3 (5)	0 (1)	84 (24)
	Jun 1–15	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
	Jun 16–30	272 (69)	164 (60)	19 (18)	7 (15)	22 (24)	28 (17)	512 (76)
	Jul 1–15	6 (12)	4 (11)	4 (9)	808 (174)	1 (4)	31 (24)	854 (181)
	Jul 16–31	10 (21)	4 (13)	3 (10)	3,108 (346)	1 (6)	12 (26)	3,138 (346)
	Total by stock	364 (77)	176 (63)	26 (21)	3,923 (388)	28 (25)	72 (42)	4,589 (398)
2011	May 16–31	47 (17)	1 (2)	0 (2)	1 (2)	1 (2)	0 (1)	50 (17)
	Jun 1–15	159 (49)	5 (12)	1 (4)	2 (7)	8 (11)	0 (2)	176 (50)
	Jun 16–30	167 (80)	65 (57)	2 (7)	147 (77)	13 (20)	3 (8)	397 (119)
	Jul 1–15	33 (47)	9 (23)	8 (13)	2,056 (256)	5 (15)	26 (23)	2,137 (258)
	Jul 16–31	16 (34)	14 (34)	5 (12)	2,731 (359)	4 (13)	2 (7)	2,772 (359)
	Total by stock	423 (114)	94 (67)	16 (17)	4,937 (449)	31 (31)	32 (26)	5,533 (461)
2012	May 16–31	145 (144)	7 (17)	1 (4)	1 (6)	2 (5)	1 (3)	157 (155)
	Jun 1–15	270 (193)	36 (38)	1 (4)	1 (7)	2 (4)	1 (3)	311 (215)
	Jun 16–30	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
	Jul 1–15	5 (18)	4 (17)	14 (23)	357 (319)	10 (20)	18 (26)	408 (331)
	Jul 16–31	0 (0)	0 (0)	0 (1)	0 (1)	0 (1)	0 (0)	1 (1)
	Total by stock	420 (244)	47 (41)	17 (23)	360 (319)	14 (20)	20 (25)	878 (423)

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Year	Time strata	Killey–Benjamin	Funny–Slikok	Grant	Mainstem–Juneau	Quartz–Crescent	Russian	Total by year
2013	May 16–31	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	2 (1)
	Jun 1–15	0 (0)	0 (1)	0 (0)	0 (0)	1 (1)	0 (0)	2 (1)
	Jun 16–30	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	1 (1)
	Jul 1–15	4 (11)	12 (20)	5 (8)	242 (145)	4 (8)	6 (9)	272 (158)
	Jul 16–31	85 (88)	28 (45)	9 (15)	1,136 (563)	3 (10)	9 (15)	1,269 (611)
	Total by stock	90 (86)	40 (44)	14 (16)	1,378 (572)	9 (12)	14 (15)	1,546 (616)
2014	May 16–31	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (1)	1 (1)
	Jun 1–15	0 (0)	0 (1)	0 (0)	0 (0)	0 (1)	0 (1)	1 (1)
	Jun 16–30	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (1)	1 (1)
	Jul 1–15	63 (56)	30 (33)	27 (30)	387 (191)	9 (13)	15 (17)	532 (226)
	Jul 16–31	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
	Total by stock	64 (56)	31 (33)	28 (30)	388 (191)	11 (13)	16 (17)	538 (226)

Note: Individual estimates and totals may differ slightly due to rounding. Totals by year differ from creel survey harvest estimates (Appendix A3) because posterior distributions from the SSART model are affected by the other components of the probability model. Differences are minor unless harvests were estimated imprecisely outside of the model (for example, all time strata in 2012–2014).

Appendix D3.–Harvest estimates (and standard deviations) from the middle Kenai River (Soldotna Bridge to the outlet of Skilak Lake [RM 21–50]) by stock group, year, and time stratum for Chinook salmon 75 cm or longer.

Year	Time strata	Killey–Benjamin	Funny–Slikok	Grant	Mainstem–Juneau	Quartz–Crescent	Russian	Total by year
2007	May 16–Jun 30	334 (72)	32 (35)	23 (20)	83 (48)	70 (46)	11 (12)	554 (71)
	Jul 1–31	53 (28)	10 (12)	47 (35)	398 (58)	25 (23)	7 (8)	540 (38)
	Total by stock	387 (78)	43 (40)	70 (45)	481 (78)	95 (56)	18 (15)	1,093 (81)
2008	May 16–Jun 30	293 (34)	40 (21)	10 (7)	28 (16)	32 (16)	7 (6)	410 (33)
	Jul 1–31	56 (21)	8 (8)	21 (16)	496 (49)	52 (27)	28 (15)	661 (40)
	Total by stock	349 (41)	48 (24)	31 (20)	524 (53)	84 (34)	35 (17)	1,071 (51)
2009	May 16–Jun 30	124 (29)	9 (11)	7 (8)	24 (19)	10 (11)	4 (5)	178 (25)
	Jul 1–31	24 (17)	10 (12)	15 (13)	572 (43)	5 (6)	5 (5)	632 (38)
	Total by stock	148 (35)	19 (18)	22 (16)	596 (47)	16 (14)	9 (7)	810 (45)
2010	May 16–Jun 30	274 (45)	15 (14)	6 (6)	89 (30)	4 (5)	7 (7)	395 (51)
	Jul 1–31	36 (24)	8 (10)	9 (11)	1,143 (92)	8 (11)	61 (32)	1,265 (88)
	Total by stock	310 (52)	23 (20)	15 (13)	1,232 (98)	12 (12)	68 (34)	1,659 (102)
2011	May 16–Jun 30	18 (18)	11 (13)	12 (15)	23 (21)	12 (14)	12 (14)	87 (11)
	Jul 1–31	6 (5)	5 (5)	5 (5)	7 (6)	5 (5)	5 (4)	33 (3)
	Total by stock	24 (20)	16 (15)	17 (17)	30 (23)	17 (16)	17 (16)	120 (11)
2012	May 16–Jun 30	13 (12)	9 (9)	9 (10)	16 (13)	9 (10)	9 (9)	65 (13)
	Jul 1–31	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	5 (2)
	Total by stock	14 (12)	10 (9)	10 (10)	17 (13)	10 (10)	10 (9)	70 (13)
2013	May 16–Jun 30	2 (1)	2 (1)	2 (1)	2 (1)	2 (1)	2 (1)	11 (5)
	Jul 1–31	2 (1)	2 (1)	2 (1)	2 (1)	2 (1)	2 (1)	12 (5)
	Total by stock	4 (1)	4 (1)	4 (1)	4 (1)	4 (1)	4 (1)	23 (3)
2014	May 16–Jun 30	2 (1)	2 (1)	2 (1)	2 (1)	2 (1)	2 (1)	11 (5)
	Jul 1–31	2 (1)	2 (1)	2 (1)	2 (1)	2 (1)	2 (1)	11 (5)
	Total by stock	4 (1)	4 (1)	4 (1)	4 (1)	4 (1)	4 (1)	23 (3)

Note: Individual estimates and totals may differ slightly due to rounding. Totals by year differ from Statewide Harvest Survey–Guide Logbook harvest estimates (Appendix A4) because posterior distributions from the SSART model are affected by the other components of the probability model. Differences are minor unless harvests were estimated imprecisely outside of the model.