Fishery Data Series No. 22-32

Russian River Early-Run Sockeye Salmon Tagging Study, 2017

by

Tony Eskelin

December 2022

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

FISHERY DATA SERIES NO. 22-32

RUSSIAN RIVER EARLY-RUN SOCKEYE SALMON TAGGING STUDY, 2017

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This study investigated the travel times for Russian River early-run sockeye salmon migrating from the Kenai River sonar site at river mile (RM) 13.7 to the Russian River area sport fishery at Kenai RM 73.0 and to the Russian River weir located near lower Russian Lake. A sample of 52 sockeye salmon, captured with inriver gillnets at Kenai RM 8.6, were tagged with esophageal-implant radio transmitters during 23 May to 7 July 2017. Additionally, 218 sockeye salmon were tagged with uniquely numbered spaghetti tags to investigate travel times of fish from Kenai RM 13.7 to the Russian River weir. A total of 22 radiotagged sockeye salmon migrated to the Russian River area sport fishery, taking an average of 9.8 days with a range of 5.2 days to 16.8 days. There were 3 radiotagged fish and 11 spaghetti-tagged fish that migrated past the Russian River weir, taking an average of 17.7 days (range: 13.2 days to 20.1 days) for radiotagged fish and an average of 16.9 days (range: 12.2 days to 19.4 days) for spaghetti-tagged fish. In total, the 14 tagged fish took an average of 17.1 days (range 12.2 days to 19.4 days) to travel from Kenai RM 8.6 to the Russian River weir.

Keywords: Kenai River, Russian River, early run, sockeye salmon, *Oncorhynchus nerka*, radio transmitter, spaghetti tag

INTRODUCTION

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

Russian River early-run sockeye salmon primarily enter the Kenai River in May and June and migrate 75 river miles (RM) upstream to the Russian River, spawning in the upper reaches of the drainage. Harvest of this stock occurs primarily in the Russian River area sport fishery in the mainstem Kenai River between river miles (RM) 73.0 and 73.8 and in the lower Russian River, although smaller numbers of fish are also harvested in multiple other fisheries: the Kenai River sport fishery downstream of RM 73.0, the Kenaitze tribe education fishery near the mouth of the Kenai River, a Federal subsistence fishery at the lower Russian River falls, and the upper Cook Inlet commercial fishery (Figure 2).

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

Although Russian River sockeye salmon have been studied for several decades by ADF&G, the population dynamics of the early and late runs are not fully understood. Considerably more is known about the early run because the annual total early run is estimated by adding estimated local Russian River area sport fishery harvest (the only known source of significant early-run harvest) to counts of sockeye salmon passing the Russian River weir, whereas the late run is harvested by a number of marine and inriver fisheries (commercial set gillnet, commercial drift gillnet, inriver personal use, inriver sport, and inriver subsistence), making harvest estimation and therefore total run estimates much more difficult to obtain for the late run. Using estimates of total run age composition, a brood table has been developed for the early run, and stock–recruit analyses have been conducted periodically (Erickson et al. 2017). A biological escapement goal (BEG) of 22,000–42,000 sockeye salmon past the weir is in place for the early run, whereas a sustainable escapement goal (SEG) of 30,000–110,000 sockeye salmon is established for the late run (Erickson et al. 2017).

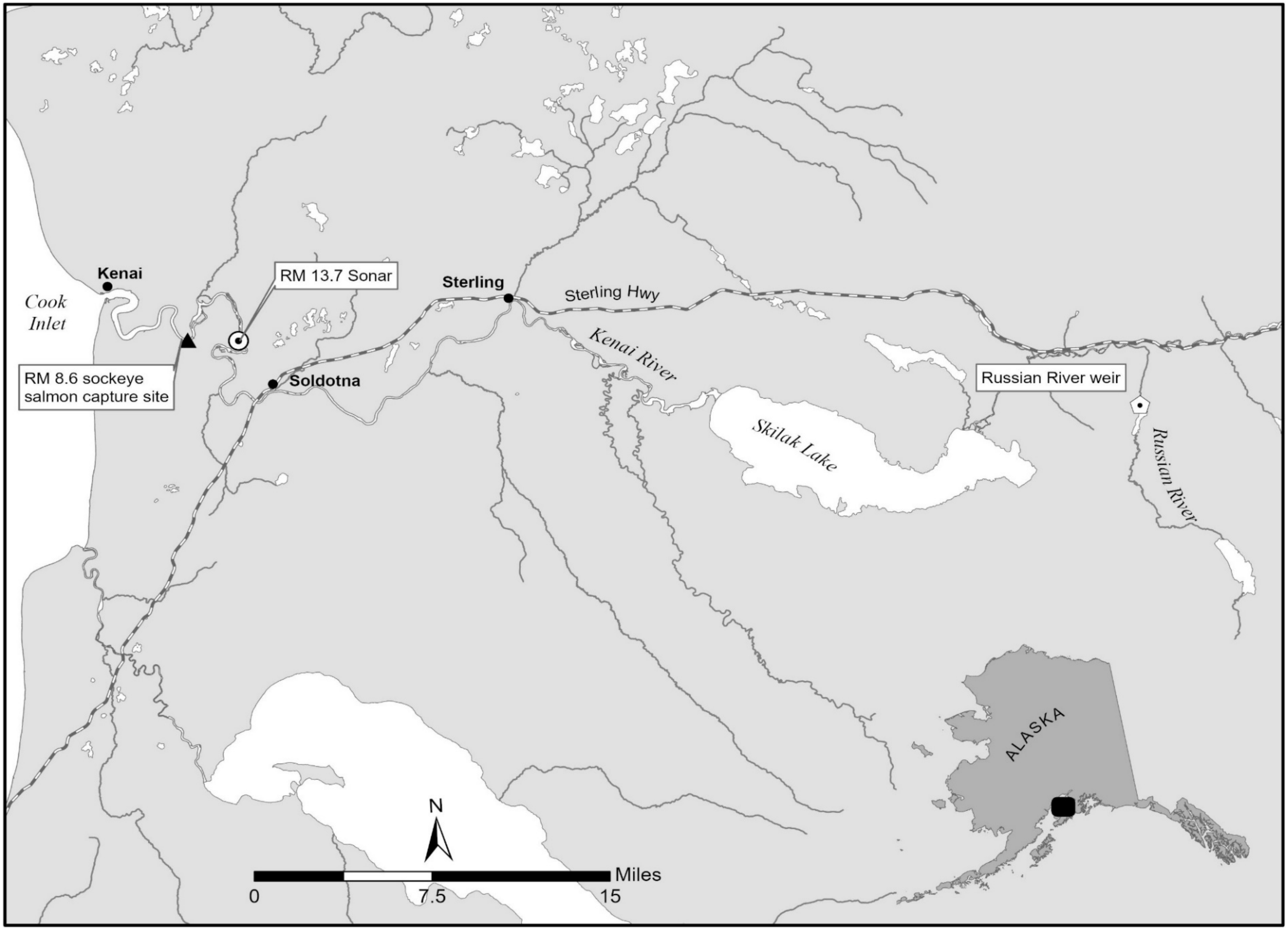

Figure 1.–Map of the Kenai and Russian Rivers.

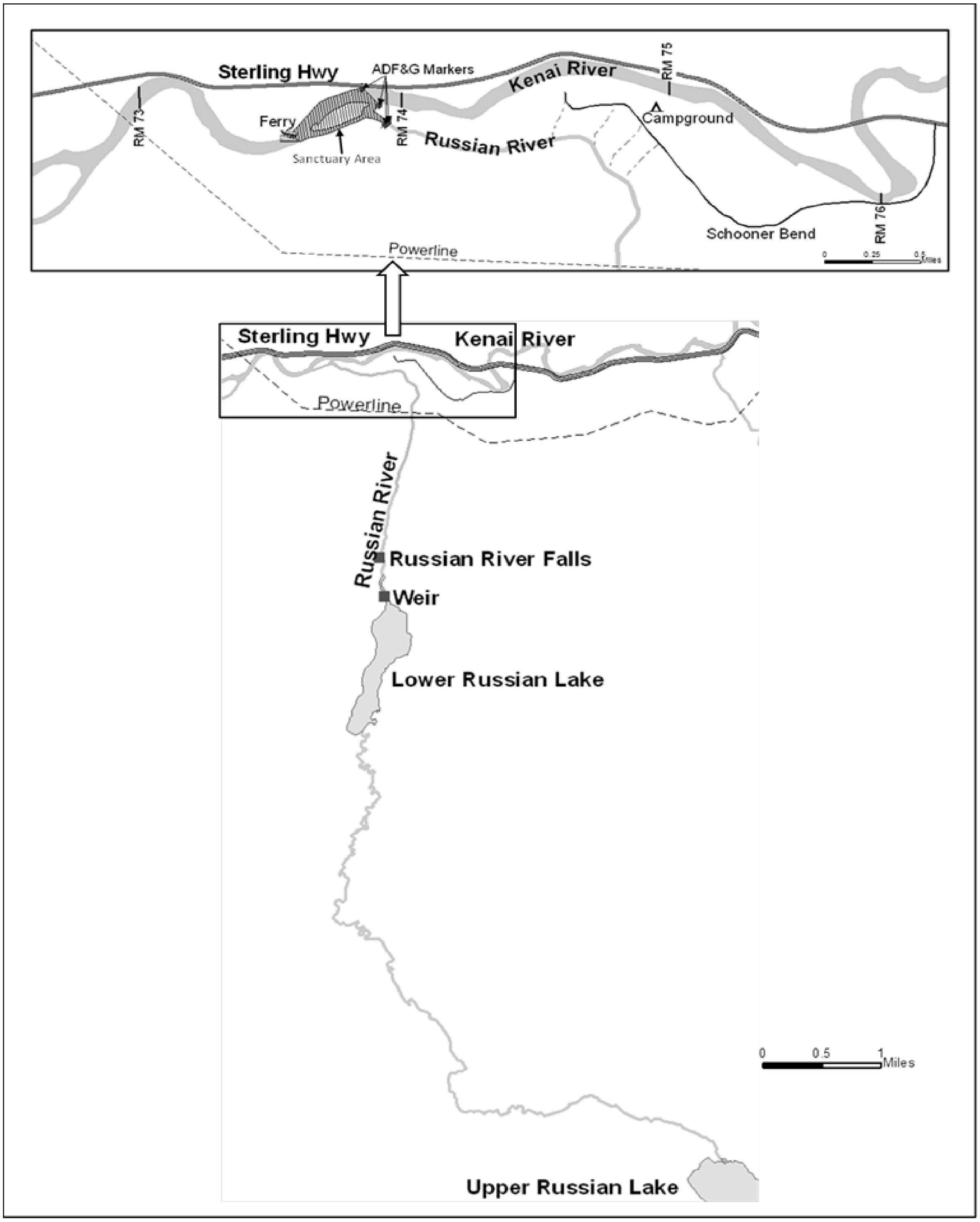

Figure 2.–Map of the Russian River sockeye salmon sport fishing areas and fishing access locations.

Note: The Kenai and Russian River area sport fishery includes the area upstream of the powerline to a marker in the lower Russian River located approximately 600 feet downstream of the falls. The flyfishing-only area includes the sanctuary area (shaded) and in the Russian River to the marker downstream of the falls.

During the early run, sport harvest averaged 30,585 sockeye salmon and ranged from 13,086 to 59,097 fish from 2007 to 2016 (Table 1). A small federal subsistence fishery near the Russian River Falls began in 2007 and harvest averaged 820 fish between 2007 and 2016. Early-run escapement measured through the Russian River weir prior to 15 July has averaged 36,044 fish (range 24,115–52,178) from 2007 to 2016 (Table 1). Estimated annual harvest rates in the early run have averaged 0.46 from 2007 to 2016, ranging from 0.27 in 2016 to 0.58 in 2007 and 2008.

Table 1.–Angler-days (effort), harvest, escapement, and total run for Russian River early-run sockeye salmon, 1985–2017.

Year	Angler-days	Sport harvest	Subsistence harvest[a]	Escapement	Total run	Harvest rate
1985	50,770	12,300	ND	30,605	42,905	0.29
1986	52,250	35,100	ND	36,338	71,438	0.49
1987	113,010	154,200	ND	61,513	215,713	0.71
1988	72,030	54,780	ND	50,406	105,186	0.52
1989	60,570	11,290	ND	15,278	26,628	0.42
1990	84,710	30,215	ND	25,144	56,931	0.53
1991	85,741	65,390	ND	31,660	97,779	0.67
1992	60,499	30,512	ND	37,117	67,629	0.45
1993	58,093	37,261	ND	39,857	77,118	0.48
1994	64,134	48,923	ND	44,872	93,795	0.52
1995	48,185	23,572	ND	28,603	52,175	0.45
1996	50,122	39,075	ND	52,905	91,980	0.42
1997	46,914	36,788	ND	36,280	73,068	0.50
1998	47,942	42,711	ND	34,143	76,854	0.56
1999	64,536	34,283	ND	36,607	70,890	0.48
2000	69,864	40,732	ND	32,736	73,468	0.55
2001	55,972	35,400	ND	78,255	113,655	0.31
2002	68,263	52,139	ND	85,943	138,082	0.38
2003	50,448	22,986	ND	23,650	46,636	0.49
2004	60,784	32,727	ND	56,582	89,309	0.37
2005	55,801	37,139	ND	52,903	90,042	0.41
2006	70,804	51,167	ND	80,524	131,691	0.39
2007	57,755	36,805	380	27,298	64,483	0.58
2008	55,444	42,492	928	30,989	74,409	0.58
2009	64,518	59,097	605	52,178	111,880	0.53
2010	39,873	23,412	615	27,074	51,101	0.47
2011	47,264	22,697	684	29,129	52,510	0.45
2012	41,152	15,231	867	24,115	40,213	0.40
2013	59,682	27,162	768	35,776	63,706	0.44
2014	57,544	35,870	1,276	44,920	82,066	0.45
2015	55,420	29,997	989	50,226	81,212	0.38
2016	39,957	13,086	1,090	38,739	52,915	0.27
2017	49,455	27,109	1,597	37,123	65,829	0.44
Average						
1985–2016	59,379	38,232	–	41,500	80,100	0.47
2007–2016	51,861	30,585	820	36,044	67,450	0.46

Source: Lipka et al. 2020.

Note: ND means data were not collected. An en dash indicates the number cannot be calculated due to limitations in the data.

[a] The subsistence fishery started in 2007 and data include Russian River Falls and upper Kenai River area.

The Russian River sockeye salmon sport fishery is one of the most actively managed sport fisheries in Alaska. The Division of Sport Fish has closed all or part of the fishery on 27 occasions since 1969 to achieve escapement goals, but the most recent fishery restriction was in 1989. In other years, the fishery has been liberalized by opening the sanctuary area at the Kenai and Russian River confluence (Figure 2) prior to 15 July and by liberalizing the daily bag limit from 3 per day, 6 in possession to 6 per day, 12 in possession from the "Russian Fly Fishing Only" area downstream to Skilak Lake. The sanctuary area has been opened inseason in 16 of the past 20 years and the bag limit has also been increased in 5 of those years.

In 2015, the Kenai River Chinook salmon sonar site was moved from RM 8.6 to RM 13.7 and a new adaptive resolution imaging sonar (ARIS) was deployed (Miller et al. 2016). At this new site and with the new sonar technology, nearly the entire cross section of river is ensonified and fish passage is enumerated by length. Most fish that pass the RM 13.7 sonar during the early run that are less than 75 cm as measured by ARIS (ARIS length) are sockeye salmon, and a majority of those are thought to be bound for the Russian River. Thus, early-run sonar estimates of fish less than 75 cm ARIS length at RM 13.7 provide a coarse maximum estimate of Russian River early-run sockeye salmon passage at this site. However, the amount of time it takes sockeye salmon to migrate from RM 13.7 to the Kenai and Russian River area sport fishery beginning near RM 73.0 is not known.

This sockeye salmon tagging project was the first phase in a planned multi-phase investigation to better understand the migration patterns, run timing, and run size of Russian River sockeye salmon entering the lower Kenai River during the early run. This first phase was designed to assess the migration timing (duration) of Russian River sockeye salmon from RM 13.7 to both RM 73.0 (the Kenai and Russian River area sport fishery) and the Russian River weir so that this information can be coupled with inseason sonar estimates to better gauge inseason run strength for management purposes.

OBJECTIVES

PRIMARY OBJECTIVES

1) Estimate the mean migration time of early-run sockeye salmon from Kenai River RM 13.7 to the inriver sport fishery at Kenai River RM 73.0 such that the estimate is within 0.5 days of the true value 90% of the time.
2) Estimate the mean migration time of sockeye salmon from Kenai River RM 13.7 to the lower Russian River weir such that the estimate is within 0.1 days of the true value 90% of the time.

SECONDARY OBJECTIVE

1) Determine fates (drop-out, censor, regurgitate, migrant) and approximate final destinations (i.e., putative spawning locations) of radiotagged sockeye salmon.

METHODS

SOCKEYE SALMON CAPTURE

All sockeye salmon tagged (radio and spaghetti) in this migration timing study were captured by an existing inriver gillnetting study beginning 16 May and conducted daily during the season from

7:00 AM to 1:00 PM in the lower Kenai River near RM 8.6 (Perschbacher 2017). Gillnetting was conducted each day using 10-fathom-long gillnets drifted with the current. Gillnets consisted of bipanel nets with equal lengths (5 fathoms each) of 5.0-inch or 7.5-inch stretched mesh web in each net. Netting effort was distributed approximately equally with respect to mesh size deployed closest to shore, bank (left or right), and distance offshore (nearshore or midriver) to ensure that fish of all sizes and locations throughout the sampling area had nearly equal probability of capture.

RADIO TRANSMITTER DEPLOYMENTS

Esophageal implant model 1835B pulse-coded radio transmitters manufactured by Advanced Telemetry Systems were deployed into sockeye salmon captured at Kenai River RM 8.6 during 23 May to 5 July 2017. To determine the tag deployment rate that best represented the entire early run, the catch per unit of effort (CPUE) of sockeye salmon at RM 8.6 was analyzed for the years 2012–2016. During these years sockeye salmon were captured primarily after 24 May. Highest average peak CPUE was observed during 2–7 June with the peak occurring on 4 June (Figure 3). Radio tags were deployed on a schedule that best represented the recent 5-year average sockeye salmon capture rate from 16 May to 30 June (Table 2).

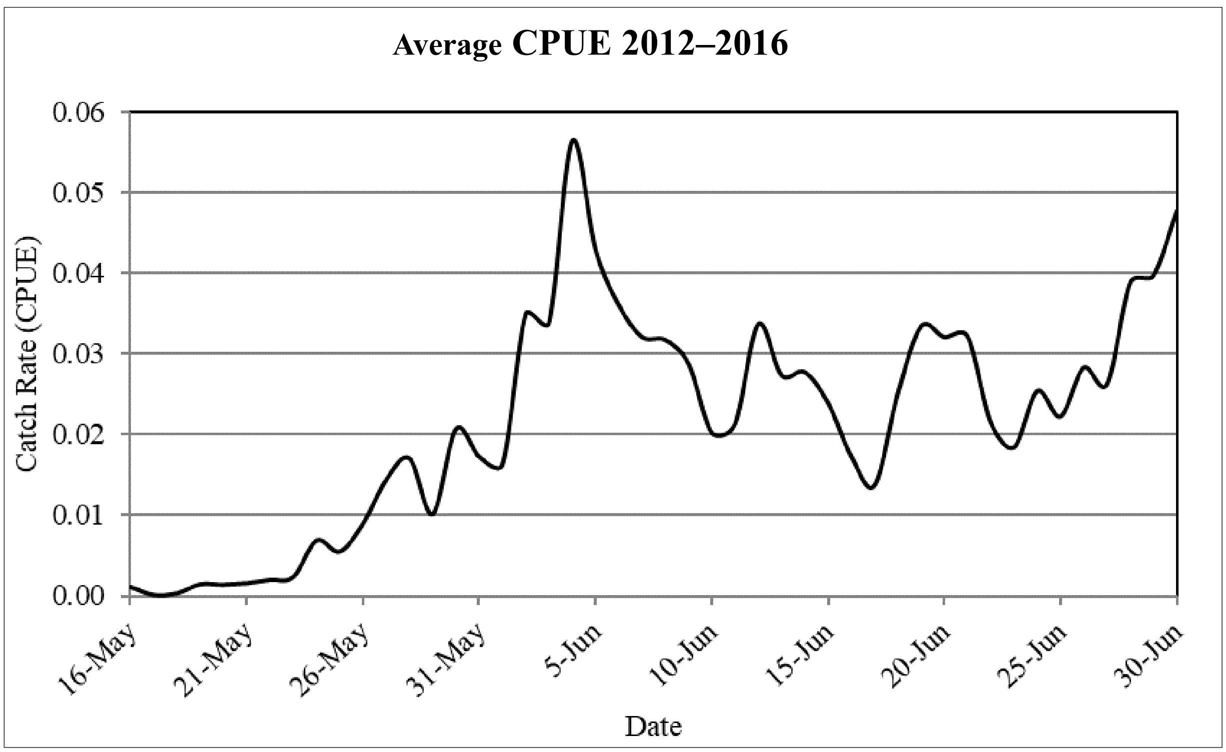

Figure 3.–Average catch per unit effort (CPUE) for sockeye salmon at RM 8.6, 2012–2016.

Source: Perschbacher (2014, 2015, 2018, 2022); Perschbacher and Eskelin (2016).

Table 2.–Sockeye salmon radiotransmitter deployment schedule, 2017.

Date range	Number of radio transmitters
25 May–2 June	7
3–9 June	14
10–16 June	9
17–23 June	9
24–30 June	11
Total	50

Radio transmitters were 48 mm in length, 17 mm in diameter, had a 30.5 cm long antenna and weighed 16 g each. Battery capacity was 96 days with a warranty life of 48 days and each transmitter was programmed to transmit a mortality signal after 24 consecutive hours of no movement. The shortest radiotagged fish was 500 mm mid eye to tail fork (METF). Given that tag weight should not exceed 2% of the fish weight (Winter 1996), fish as small as 0.8 kg (2.75 lb) could be tagged. All radiotagged sockeye salmon should have easily exceeded the recommended transmitter-to-fish weight threshold.

Transmitters were inserted through the esophagus and into the fish's stomach with an applicator made from 2 concentric pipes of polyvinyl chloride. The transmitter fit snugly within the outer tube and could be pushed using the inner tube. Transmitters, lubricated with glycerin, were inserted into fish by gently pressing the tag against the esophageal sphincter until the sphincter relaxed, allowing the tag to pass into the stomach. The transmitter was dislodged from the applicator using the inner pipe as a plunger. Prior to the first deployment, tag placement tests and dissections of sacrificed fish were conducted to practice proper tag placement into the stomach. Every live tag application was followed by a visual inspection of the esophageal sphincter. Successful implantations were confirmed when the transmitter body was completely obscured by the esophageal sphincter and the antenna was directed forward out the mouth. Transmitters from unsuccessful applications were removed and the process repeated.

To aid tag retention, transmitters were fitted with manipulated plastic "hoochie skirts" that have been used in Chinook salmon tagging studies on the Kenai River and were shown to increase tag retention (Eskelin and Reimer 2017). Only captured sockeye salmon deemed healthy were implanted with a transmitter.

RADIO TELEMETRY

Stationary Telemetry Sites

Radiotagged sockeye salmon were located both passively, using a network of stationary radio receiving stations, and actively, by boat. Stationary receiving stations allowed 24-hour monitoring of radiotagged sockeye salmon along their migration routes, whereas active tracking was used to determine specific locations. This system provided redundant locations for each fish with enough resolution to detect noteworthy behavior patterns. In addition, a single aerial survey was conducted to confirm tributary or lake spawning; however, by the time the survey was conducted in August, the batteries in many transmitters had died so the survey was incomplete.

Most telemetry data were collected at automated, stationary, data-recording stations (fixed stations). Pulse-coded radio transmitters broadcasting on 5 frequencies between 151.323–151.403 MHz and 10 individually identifiable tags (pulse codes) per frequency were used for this project.

Pulse-coded transmitters allowed the use of fewer frequencies and thus reduced total scan time. During stationary radio tracking, the scan time for each frequency was 3 s with a 15 s timeout. Thus, each frequency was scanned for 3 s; if a transmission was detected, then the receiver paused for 15 seconds on each antenna to decode the pulse code and signal strength. Total scan time ranged from 15 s (5 frequencies × 3 s per frequency), when no signals were detected, up to 225 s (5 frequencies × 15 s per frequency × 3 antennas), when each frequency had at least 1 signal detected.

Each site consisted of a 3–4.5 m (10–15 ft) pole supporting a solar panel and 2 or 3 Yagi directional antennas (Cushcraft Inc. model P154-4) connected via coaxial and communication cables to a 3 dB attenuator (Mini-Circuits, model CAT-3), antenna switch (ATS, model 200 or 300), radio receiver (ATS, model 4100, 4500, or 4520), and data collection computer (ATS, model 5041). The receiver and computer were stored in a weather-resistant box with a 12-volt marine battery. The system continuously scanned the transmitter frequencies and electronically recorded the frequency, pulse code, mortality code, date, time, antenna, and a measure of signal strength whenever a decodable transmission was detected. Sites were visited weekly to download stored data and check the system configuration.

By orienting each site's antennas parallel to the river channel (and tributary when applicable), direction of travel could be discerned by comparing each antenna's signal strength within the chronological data. Individual fish were assigned a date, time, and direction of passage for each migration past each fixed station.

Fixed telemetry stations were placed at the Kenai River Chinook salmon sonar site (RM 13.7), at the Skilak Lake outlet (RM 49.1), near Skilak Lake inlet (RM 66.2), near the major sport fishery at RM 73.0, at the Russian River confluence (Kenai River RM 73.6), and at the Russian River weir near lower Russian Lake (Table 3 and Figure 4).

Table 3.–Location and purpose of fixed telemetry stations in the Kenai and Russian River drainages.

Fixed station location	Kenai River RM	Purpose
Chinook salmon sonar	13.7	Entry site for study, migration past RM 13.7 sonar
Skilak Lake outlet	49.3	Migration into Skilak Lake
Skilak Lake inlet	66.2	Migration through Skilak Lake into upper Kenai River
Russian River area sport fishery	73.0	Migration into Russian River area sport fishery
Russian River confluence	73.6	Migration into Russian River or upstream
Russian River weir	–	Migration past Russian River weir

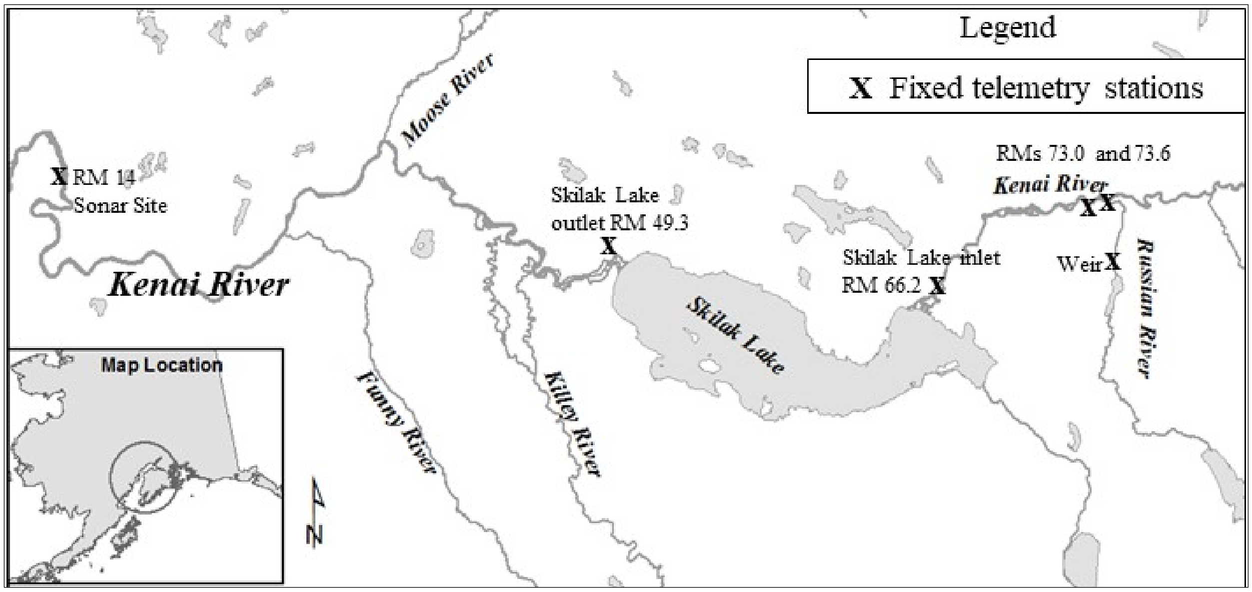

Figure 4.–Map of Kenai and Russian Rivers with location of fixed receiving stations, 2017.

Active Tracking

To complement fixed-station data, radio tags were located by boat using an ATS 4520 receiver and single Yagi-style antenna (Cuschcraft Inc. model P154-4). The area between Cook Inlet and the Russian River confluence was searched 1 time per week. The boat was driven at a moderate speed while scanning active frequencies for 2 seconds each. If a signal was heard, the scan was paused until the tag location could be inferred from the recorded signal strength and the antenna's direction during detection. For each located fish, the date, time, frequency, pulse code, mortality code, river mile, and coordinates (determined by a global positioning system [GPS]) were recorded using an Allegro CX field computer.

Tagged sockeye salmon were also located by airplane (single aerial survey) using an ATS 4520 receiver and 2 H-style antennas (Telonics Inc. model RA-2AK) attached to the strut for each wing. When the plane flew level to the ground, the antennas were pointed approximately 45 degrees to the ground surface. Signals could be monitored from each individual antenna or both antennas together using an ATS Inc. manual antenna switch box. Both antennas were monitored while flying except when attempting to discern direction. The plane typically flew 600–1000 ft above the ground surface at approximately 80 mph. If a signal was heard, the scan was paused briefly while the receiver decoded the tag and recorded the signal strength, date, time, frequency, pulse code, mortality code, and GPS coordinates. This process was repeated each time a transmission was heard. The record with the largest signal strength was assumed to best describe the tag location. A secondary paper matrix was used to back up the electronic record and verify adequate detection.

ASSESSMENT OF RADIOTAGGED SOCKEYE SALMON FATES

Radiotagged fish were assigned 1 of 4 fates based on their behavior after tagging: dropout, regurgitation, censor, or migrant. All telemetry data were consolidated into 1 graphic per fish before deciding on a fate. Dropouts, regurgitations, and censors are similar in their failure to provide useful spawning destination or migratory timing information. The following list defines these behaviors:

1) Dropouts: Fish categorized as dropouts probably entered salt water almost immediately after tagging. These fish were either never observed again in the study or were only observed downstream of the tagging location. Because radio tags cannot transmit a signal through salt water, dropouts are rarely located after being deployed and are most likely direct handling mortalities.
2) Regurgitation: Tags that were permanently stationary immediately after deployment and were close to the tagging site were categorized as regurgitations. Regurgitated tags were presumed ejected from the esophagus and were mostly distinguishable from mortalities because dead radiotagged fish often have rapid downstream movement. Because radio tags were deployed in the tidally influenced zone, some fish classified as regurgitations may have been dropouts (mortalities) that were not flushed out to salt water due to a lack of current. This error had little influence on the primary results because neither fate was used in the spawning destination analysis nor the migratory timing analysis.
3) Censor: Fish that displayed upstream migration of insufficient length, distance, or duration after tagging and could not be placed in a likely spawning area were censored from the analysis. Tagged fish were censored if they did not enter a tributary, did not show significant upstream movement, or were classified as mortalities prior to 15 July.
4) Migrant: Fish that migrated upstream of the tagging site and past the fixed station at Skilak Lake outlet (RM 49.3) were considered migrants. Tributary use was verified by both station (Russian River station only) and aerial tracking data.

Final destinations were determined for radiotagged sockeye salmon as the most upstream location observed. Determining final destinations and fates was not a primary objective of this study, but knowing the final destinations could assist in development of future studies of early-run sockeye salmon.

SPAGHETTI TAG DEPLOYMENTS

To increase the sample size needed to estimate migration time to the Russian River weir, sockeye salmon were also tagged with spaghetti tags at Kenai River RM 8.6. Spaghetti tags were deployed systematically through time. The goal was to spaghetti-tag a minimum of 200 sockeye salmon from mid-May to early July. Sockeye salmon were spaghetti-tagged after radio transmitter deployments were done for the day. Spaghetti tag deployment in the existing inriver gillnetting study was determined by catch rates of all species and how much time it took to tag sockeye salmon such that it did not interfere with the netting crew's primary objectives for the Chinook salmon sampling part of the project. Usually, 5 to 10 spaghetti tags were deployed each day. The uniquely numbered 30 cm (12 inch) Floy FT-4 plastic spaghetti tags were inserted into each fish below the posterior insertion of the dorsal fin with a standard spaghetti-tagging needle (hollow barrel, solid point) and secured with a tightly cinched overhand knot. The number of spaghetti tag deployments in the existing inriver gillnetting study was determined by the number of fish captured and how much time it took to tag fish without interfering with the inriver gillnetting study design for capturing Chinook salmon.

RUSSIAN RIVER WEIR

A weir at the outlet of Lower Russian Lake was used to census the spawning escapement of sockeye salmon in the Russian River drainage upstream of lower Russian River. Due to water clarity and low water depth in the Russian River, salmonid species are easily counted and differentiated by the weir attendants. Spaghetti-tagged sockeye salmon were observed and trapped by weir attendants and the tag number and date of capture were recorded. Biological samples (age, sex, and mid eye to tail fork [METF] length) of sockeye salmon were also collected at the weir. In addition, weir personnel collected climatological and river discharge data, and operated the Russian River fish pass when necessary.

The weir was installed on 5 June and operated daily through 5 September during 2017 (Lipka et al. 2020).

RESULTS

RADIOTAG DEPLOYMENTS AND FATES

Sockeye salmon were captured and radiotagged from 23 May to 7 July 2017. Tags were deployed in 52 sockeye salmon at RM 8.6. All 50 available transmitters were deployed into sockeye salmon, but 2 of those transmitters were recovered early in the project and redeployed into newly captured fish. One of the transmitters that was redeployed was recovered and returned to ADF&G from a sport harvested fish near the Russian River confluence on 12 June, and the other transmitter was recovered on the riverbank on 22 June where a bear had harvested the tagged fish.

Of the 52 radio tag deployments, 32 (61.5%) were classified as migrants and used to describe spawning destinations and migratory timing (Table 4). Four fish (7.7%) regurgitated tags. Of the 5 fish (9.6%) classified as dropouts, 4 fish had no records after tagging, making it likely they were dropouts, and 1 fish was a verified dropout. Eleven fish (21.2%) were censored; 2 fish either died shortly after tagging (mortality signal) or had little movement after tagging, and the remaining 8 censored fish were never verified to have migrated upstream of approximately RM 19.0. Dropouts and censored fish were not used in this study.

Table 4.–Fates of radiotagged sockeye salmon tagged at RM 8.6 Kenai River, 23 May–7 July 2017.

Fate	Number of fish	Percent of total
Censor	11	21.2%
Regurgitate	4	7.7%
Dropout	5	9.6%
Migrant	32	61.5%
Total	52	100.0%

TRAVEL TIMES AND MIGRATORY BEHAVIORS OF RADIOTAGGED SOCKEYE SALMON

There were 33 radiotagged sockeye salmon that passed the fixed telemetry station at RM 13.7 and 32 fish that passed the fixed station near Skilak Lake outlet (RM 49.3), satisfying the “migrant” criterion (Table 5). The 1 fish that passed the RM 13.7 fixed station but did not migrate past Skilak Lake outlet was dead near RM 26.0, and it is unknown whether it was a harvested fish or not.

Table 5.–Number of fish and travel time (number of days) of radiotagged sockeye salmon from the Kenai River RM 13.7 fixed telemetry station to each upstream fixed telemetry station, 2017.

	Fixed telemetry site location				
Information	Skilak Lake outlet (RM 49.3)	Skilak Lake inlet (RM 65.7)	Kenai–Russian River area sport fishery (RM 73.0)	Kenai–Russian River confluence (RM 73.7)	Russian River weir
Number of tagged fish	32	26	22	18	3
Travel time from RM 13.7					
Average	5.2	7.7	9.8	11.2	16.6
SD (average)	0.4	0.4	0.6	0.8	3.6
Minimum	2.3	4.4	5.2	6.0	12.4
Maximum	13.7	13.2	16.8	17.2	19.2
Range	11.3	8.8	11.6	11.2	6.7
Averages					
Miles/day from RM 13.7	6.8	6.8	5.3	5.4	3.8
Days between stations	5.2	2.5	2.1	1.4	5.4
Miles/day between stations	6.8	6.8	3.5	0.5	0.4

Note: All travel times are given in number of days. Tagging location was Kenai River RM 8.6. Average duration for 36 fish from the RM 8.6 tagging site to RM 13.7 station was 1.2 days, SD 0.1 days (range: 0.3 days to 4.2 days).

Of the 32 fish that passed the Skilak Lake outlet station, 6 fish did not make it to the Skilak Lake inlet station at RM 65.7. Of those 6 fish, 1 was tracked back down to the RM 13.7 sonar station and likely died, although no mortality signal was detected. Another was never located again and probably died in Skilak Lake, 1 fish did not make it to the Skilak Lake inlet station but migrated within Skilak Lake, and the other 3 fish were recorded at the Skilak Lake inlet station, but they did not pass the station and either died or fell back into Skilak Lake.

Of the remaining 26 fish that passed the Skilak Lake inlet station, 4 fish were not recorded on the next upstream station at the downstream boundary of the Kenai and Russian River area sport fishery at RM 73.0. Of those 4 fish, 1 was harvested by a bear in the Kenai River canyon and the transmitter was recovered on 22 June and redeployed into a new fish at RM 8.6. One fish stayed near Skilak Lake inlet then died, 1 fish died between the stations due to unknown cause, and 1 fish was briefly recorded on the station at the Russian River area sport fishery but did not enter or pass the area and fell back down to Skilak Lake.

There were 22 fish that migrated into the Russian River area sport fishery at RM 73.0 (Table 6). Of those 22 fish, 11 went downstream back to Skilak Lake, but it is not known whether dead or alive because mortality signals are not transmitted if a dead fish moves (downstream) in the water column. Two of the 22 fish were harvested by sport anglers, who returned 1 of the transmitters to ADF&G, which was redeployed into a new fish at RM 8.6. Of the remaining 9 fish, 3 migrated into the Russian River but died downstream of the Russian River falls due to unknown causes, 3 fish migrated upstream and passed through the Russian River weir, and 3 fish migrated in the Kenai River upstream of the Russian River confluence. Of the 3 fish that migrated in the Kenai River upstream of the Russian River confluence, the approximate highest upstream locations were RMs 65.0, 67.0, and 79.0 for each fish, respectively, although radiotracking was rarely done in that area so it is possible the most-upstream locations could have been higher.

Table 6.–Fates of radiotagged sockeye salmon tagged at Kenai River RM 8.6 that migrated to the Russian River area sport fishery, 2017.

Fate upon entering Russian River area sport fishery	Number of radiotagged fish
Passed Russian River weir	3
Tag recovery from sport fishery harvest	2
Died in Russian River downstream of weir	3
Migrated downstream to Skilak Lake (dead or alive)	11
Migrated in Kenai River upstream of Russian River confluence	3
Total	22

TRAVEL TIMES TO FIXED TELEMETRY SITES

Travel times for the 32 radiotagged sockeye salmon migrating from RM 13.7 to the Skilak Lake outlet station at RM 49.3 averaged 5.2 days, travelling at an average speed of 6.8 miles/day (Table 5).

For the 26 fish that passed the Skilak Lake inlet station at RM 65.7, it took an average of 7.7 days to migrate from RM 13.7 to Skilak Lake inlet (Table 5), still averaging 6.8 miles per day. Thus, it took fish an additional 2.5 days on average to transit Skilak Lake and migrate past the Skilak Lake inlet station.

The 22 fish that migrated to the Kenai and Russian River area sport fishery at RM 73.0 took an average of 9.8 days from RM 13.7, travelling an average of 5.3 miles per day (Table 5). It took an average of 2.1 days to go between the Skilak Lake inlet and the sport fishery area.

For the 18 fish that migrated to the Russian River confluence, it took those fish an average of 11.2 days from RM 13.7 to RM 73.7, travelling an average of 5.4 miles per day (Table 5). These fish took an average of 1.4 days to travel between RM 73.0 and RM 73.7.

The 3 fish that migrated past the Russian River weir took an average of 16.6 days from RM 13.7 to the weir, travelling an average of 3.8 miles/day (Table 5). It took those 3 tagged fish an average of 5.4 days to ascend the lower Russian River and pass the weir at lower Russian lake outlet.

Fish slowed as they approached the Russian River. Initial speeds clocked an average of 6.8 miles/day from RM 13.7 to the Skilak Lake inlet station at RM 65.7, then slowed to an average of only 3.5 miles/day from RM 65.7 to the Russian River area sport fishery at RM 73.0, then slowed further to an average of only 0.5 miles/day from RM 73.0 to the Russian River confluence at RM 73.7, and finally the slowest speed averaged 0.4 miles/day when migrating up the Russian River to the weir.

SPAGHETTI TAG DEPLOYMENTS

A total of 218 spaghetti tags were deployed during 16 May–6 July, averaging approximately 4 deployments per day. Of the 218 spaghetti tag deployments, only 11 tagged fish were observed, trapped, and recorded when they passed the Russian River weir. The average time for spaghetti-tagged sockeye salmon to travel from RM 8.6 to the Russian River weir was 16.9 days (range: 12.2 days–19.4 days), which was near the 17.7-day average for the 3 radiotagged fish that passed the Russian River weir (range: 13.2 days–20.1 days; Table 7). The average migration time from RM 8.6 to the Russian River weir for all 14 tagged fish (3 radiotagged, 11 spaghetti-tagged) was 17.1 days (SD 0.6 days; Table 7).

Of the 218 spaghetti-tagged fish, 20 were harvested and reported to ADF&G from sport anglers, and 1 was reported from the Kenaitze tribe subsistence net fished near RM 28.0. Of the sport-caught fish, 3 tag numbers were reported from fish harvested at Bings Landing (RM 39.5), 1 at Kenai River RM 27, 1 in the Kenai River canyon at RM 69.2, and 2 near Jim's Landing (RM 69.6), and the rest of the 13 known harvests were either in the Russian River (3) or the Kenai and Russian River area sport fishery (10).

Table 7.–Travel time (number of days) for radiotagged and spaghetti-tagged sockeye salmon from Kenai River RM 8.6 to the Russian River weir, 2017.

	Tag type		
Parameter	Spaghetti	Radio	All
Number of fish	11	3	14
Travel time from RM 8.6			
Average	16.9	17.7	17.1
SD	0.7	2.3	0.6
Mininum	12.2	13.2	12.2
Maximum	19.4	20.1	20.1
Range	7.2	6.9	7.9

DISCUSSION

This study was designed to provide information regarding the time it takes sockeye salmon to migrate the Kenai River upstream from the Chinook salmon sonar at RM 13.7 to the Kenai and Russian River area sport fishery beginning near RM 73.0 as well as the Russian River weir at the lower Russian Lake outlet. Only 22 out of 52 radiotagged fish (42%) reached RM 73.0, although a low survival rate was expected because fish were tagged in the tidally influenced area of RM 8.6, which previous tagging studies on other salmon species have shown can result in low survival rates near 50% (Eskelin and Reimer 2017). The tagged fish that reached RM 73.0 provided valuable migration speed and timing information. With this new information, we will be better able to anticipate when pulses of fish observed at the RM 13.7 sonar will arrive at the Russian River area sport fishery. Based on the results of this study (Table 5), pulses seen at the sonar site should arrive at the sport fishery approximately 10 days later and then pass the Russian River weir approximately a week after that (slightly less than 17 days in total from RM 13.7). Both spaghetti-tagged and radiotagged sockeye salmon had very similar travel times from Kenai RM 13.7 to the Russian River weir (Table 7), indicating correspondence in results from the 2 types of tagging.

It is remarkable that of the 22 radiotagged fish that entered the Kenai and Russian River area sport fishery, only 3 passed the Russian River weir, and only 3 migrated in the Kenai River upstream of the Russian River confluence. Two radiotagged fish were harvested, and their tags were recovered from the sport fishery, but it is likely many more tagged fish were either harvested, died from hooking injuries or stress, or were predated. There were 3 mortalities of radiotagged fish observed in the Russian River downstream of the weir and 11 radiotagged fish that entered the Kenai and Russian River area sport fishery upstream of the powerline crossing but fell back down to Skilak Lake; it is suspected that most of those 11 fish were dead, dying, or harvested and in a boat. Most of the harvest occurs near or in the Russian River so it is not surprising that a proportion of tagged fish did not pass the Russian River weir after entering the intense sport fishery area. The recent 10-year (2007–2016) average estimated harvest rate for Russian River early-run sockeye salmon is 0.46. However, the high proportion of radiotagged fish (11/22 = 0.50) that entered the Russian

River area sport fishery and went back downstream to Skilak Lake, dead or alive, suggests that the sport fishery may potentially be responsible for an even greater overall mortality rate than estimated.

A very small fraction (0.05) of the 218 spaghetti-tagged fish passed the Russian River weir. Sockeye salmon were deployed with bright pink- and orange-colored spaghetti tags to make it easier for weir personnel to observe and trap the tagged fish in the fish box as they passed the weir, thereby recovering the tag number. Unfortunately, anglers were also able to easily spot the tags (and tagged fish), especially in the clear waters of the Russian River but also to some extent in the more turbid Kenai River. Anglers were observed targeting those tagged fish and so consequently, the spaghetti-tagged fish were more likely to have been harvested at a much higher rate than fish that did not have a spaghetti tag. A more muted, darker, or camouflaged tag color such as grey is recommended if a similar study is planned in the future. Using a grey-colored tag would make it harder for weir personnel to spot tagged fish and be ready to trap them as they pass into the fish box, but this may be less of a concern than ensuring anglers are less apt to see the tag and target the tagged fish.

In summary, this study was successful in providing timing information for sockeye salmon migrating upstream from the Kenai River RM 13.7 sonar site to the Russian River and ascending the Russian River to spawn. These data will be useful for predicting when pulses of sockeye salmon observed at the RM 13.7 sonar will arrive at the Russian River. A follow-up study to determine the genetic stock composition of early-run sockeye salmon that pass RM 13.7 at various times throughout the run should provide additional information that will benefit management of early-run Russian River sockeye salmon. Knowledge of the stock composition through time coupled with the general migration rates determined from this study will improve projected inseason escapement estimates and thereby increase management precision of the sport fishery to meet escapement goals. This study also provided some information of migratory behaviors and other areas where early-run sockeye salmon might spawn.

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