Fishery Data Series No. 18-16

Abundance, Distribution, and Surveys of Spawning Chinook Salmon 2012–2014 and Spawning Coho Salmon 2013–2014 in the Susitna River

by

Richard J. Yanusz

Peter M. Cleary

Johnathon Campbell

Gayle Horner-Neufeld

Daniel J. Reed

and

Nicholas A. DeCovich

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

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

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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and
Nicholas A. DeCovich

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

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Richard J. Yanusz, Retired,
Alaska Department of Fish and Game, Division of Sport Fish,
1800 Glenn Highway, Palmer, AK, 99645-6736, USA

Peter M. Cleary, Retired,
Alaska Department of Fish and Game, Division of Sport Fish,
1800 Glenn Highway, Palmer, AK, 99645-6736, USA

Johnathon Campbell,
Alaska Department of Fish and Game, Division of Sport Fish,
1800 Glenn Highway, Palmer, AK, 99645-6736, USA

Gayle Horner-Neufeld,
Alaska Department of Fish and Game, Division of Subsistence,
333 Raspberry Rd., Anchorage, AK 99518-1565, USA

Daniel Reed, Retired,
Alaska Department of Fish and Game, Division of Sport Fish,
103 E. Front St. Nome, AK 99762-1148, USA

and

Nicholas A. DeCovich
Alaska Department of Fish and Game, Division of Sport Fish,
1800 Glenn Highway, Palmer, AK, 99645-6736, USA

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ABSTRACT

Between 2012 and 2014, information was collected on the distributions and abundances of adult Chinook (*Oncorhynchus tshawytscha*) and coho (O. *kisutch*) salmon as part of the Susitna–Watana Hydro studies conducted by the Alaska Department of Fish and Game in partnership with LGL Alaska Research Associates Inc. and the Alaska Energy Authority. Spawning distributions were assessed using radiotelemetry for Chinook salmon in the mainstem Susitna River in 2012–2014 and in the Yentna River in 2013 and 2014, and for coho salmon in the mainstem Susitna River in 2013 and 2014 only. Inriver abundances for both species were estimated using mark–recapture techniques in 2013 and 2014 for the mainstem Susitna River and for Chinook salmon in the Yentna River in 2014. For Chinook salmon, these abundance estimates were combined with telemetry data to estimate individual management unit–specific abundances which were then used to calculate the percent contribution of each to total abundance. In both 2013 and 2014, all units but unit 3 (upper Susitna River) contributed nearly equally (21–27%) to the total mainstem Susitna River Chinook salmon inriver run. When the Yentna River estimate was included with estimates for the other management units in 2014, the Yentna River contributed 25% to the drainagewide inriver run; units 1, 2, 5, and 6 contributed 15–19% each; and unit 3 contributed 7%. Sport harvest was subtracted from the mark–recapture inriver abundance to estimate escapement which was then compared to aerial indexes and weir counts. For Chinook salmon, index and weir counts counted 34–39% of the escapement on the mainstem Susitna River and 36% on the Yentna River. For coho salmon, the Deshka River weir counted 19% and 16% of the Sustitna River escapements in 2013 and 2014, respectively. Foot counts of coho salmon escapement for 4 streams on the mainstem Susitna River accounted for an average of 0.9% of the escapement over 2013–2014.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *Oncorhynchus kisutch*, abundance, mark-recapture, Susitna River, Yentna River, spawning distribution, fish wheel, radio telemetry

INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) participated in portions of the Susitna–Watana Hydro studies from 2012 to 2014 to accomplish ADF&G objectives for Chinook salmon research (Yanusz et al. 2013; LGL and ADF&G 2014, 2015) and in 2013 and 2014 to accomplish ADF&G objectives for coho salmon research (LGL and ADF&G 2014, 2015). The results of these studies, and those from all fish and aquatic resource studies for the Federal Energy Regulatory Commission (FERC) permitting requirements, have been reported in the Initial Study Report (LGL and ADF&G 2014) and the Study Completion Report (LGL and ADF&G 2015) prepared for the Alaska Energy Authority, Susitna–Watana Hydroelectric Project. As part of its own assessment program, ADF&G indexes the annual Chinook salmon escapement to the Susitna River drainage with single, annual, aerial surveys of spawning Chinook salmon in tributaries of the Susitna and Yentna rivers and a weir on the Deshka River (Oslund et al. 2017). Coho salmon escapements are counted with a weir on the Deshka River and indexed with foot surveys on 4 Susitna River tributaries. This report relates these indexes and counts to inriver abundance estimates generated from mark–recapture experiments in the Susitna–Watana Hydro studies. In addition, this report provides spawning locations of Chinook and coho salmon observed in the Susitna–Watana Hydro studies. Both abundance estimates and spawning locations add value to the existing Chinook and coho salmon data sets and address ADF&G management interests.

This report's objectives are as follows:

1) Map the probable spawning location of each Chinook salmon radiotagged at the lower Susitna River tagging site from 2012 to 2014.
2) Map the probable spawning location of each Chinook salmon radiotagged at the Yentna River tagging site in 2013 and 2014.
3) Map the probable spawning location of each coho salmon radiotagged at the lower Susitna River tagging site in 2013 and 2014.

4) Estimate the proportion of the escapement (estimated using mark–recapture abundance and harvest information) represented by each index count for Chinook salmon the mainstem Susitna River in 2013 and the mainstem and Yentna rivers in 2014.
5) Estimate the proportion of the mainstem Susitna River inriver run to each management unit (using mark–recapture and radiotag information) for Chinook salmon in the mainstem Susitna river in 2013 and the mainstem and Yentna rivers in 2014.
6) Estimate the proportion of the mainstem Susitna River escapement (estimated using mark–recapture abundance and harvest information) represented by the Deshka River weir-based escapement for coho salmon in 2013 and 2014.

STUDY AREA

The Susitna River watershed, the fourth largest drainage in the state of Alaska, is 49,210 km^2 and originates in the Alaska Range north of Anchorage (Figure 1). The Susitna River flows generally south from the Alaska Range for approximately 400 km before entering Upper Cook Inlet west of Anchorage. Some tributaries that originate in the Alaska or Talkeetna mountain ranges have clear water whereas others are glacially turbid (Sweet et al. 2003). The largest tributaries are the Yentna, Chulitna, and Talkeetna rivers, and numerous small lakes (King and Walker 1997).

METHODS

The general methods are summarized here, with full details for each year (2012, 2013, and 2014) given in Yanusz et al. (2013), the Initial Study Report (LGL and ADF&G 2014), and the Study Completion Report (LGL and ADF&G 2015) prepared for Alaska Energy Authority, Susitna-Watana Hydroelectric Project[1].

The study area consisted of the Susitna River basin upstream from the mouth of the Yentna River. Mark–recapture techniques were used to estimate the inriver abundance of Chinook salmon passing lower river tagging sites at PRM 34[2] of the mainstem Susitna River (2013–2014) and river mile (RM) 6 of the Yentna River (2014). Mark–recapture abundance estimates were also made for coho salmon at PRM 34 of the mainstem Susitna River for 2013–2014. Radio telemetry was used to assess handling effects and estimate the spawning distribution for both species. Chinook salmon spawning distributions for the population passing PRM 34 of the mainstem were estimated for 2012–2014. Chinook salmon spawning distributions for the population passing RM 6 of the Yentna River were estimated for 2013–2014. Coho salmon spawning distributions were estimated for 2013–2014 for the population passing PRM 34 of the mainstem Susitna River.

In the mainstem Sustina River, Chinook salmon were captured using fish wheels operated by ADF&G from late May through the end of August at PRM 34 in 2012–2014 (Table 1). Coho salmon were captured at PRM 34 in 2013 and 2014. Additional Chinook salmon were captured in drift gillnets in areas immediately adjacent to the fish wheels each year. Radiotags, apportioned to fish throughout the run based on historical run timing and current capture rates, were used to determine spawning distribution of Chinook salmon in 2012 for fish ≥400 mm mid

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[1] These documents are available at Alaska Resources Library and Information Services (ARLIS) http://www.arlis.org/resources/susitna-watana/.

[2] River miles for the Susitna River were presented as “project river miles” (PRM) in the Initial Study Report (LGL and ADF&G 2014) and the Study Completion Report (LGL and ADF&G 2015). The difference between “project river miles and “historical river miles” used in Yanusz et al. (2013) is about +3.

eye to tail fork (METF) length. Using the same type of apportionment strategy in 2013 and 2014, Chinook salmon ≥500 mm METF length and coho salmon ≥400 mm METF length were marked with an internal radio tag for tracking to spawning sites, assessing handling effects, and used as the primary mark for mark–recapture inriver abundance estimates.

In the Yentna River, Chinook salmon were captured using fish wheels operated by ADF&G at RM 6 in 2013 and 2014 (but not in 2012; Table 1). Additional Chinook salmon were captured in drift gillnets in areas immediately adjacent to the fish wheels each year. In 2013, radiotags were apportioned to fish throughout the run based on historical run timing and inseason capture rates. Healthy Chinook salmon ≥500 mm METF length were marked with an internal radio tag that was used as the primary mark for the 2013 mark–recapture abundance estimate, assessing handling effects, and for tracking to spawning sites. In 2014, all captured healthy Chinook salmon ≥500 mm METF length were marked with an external, numbered dart tag as the primary mark for the mark–recapture abundance estimate, and a subsample of 300 dart-tagged salmon also received an internal radio tag for tracking to spawning sites and assessing handling and tagging effects. The adipose fin was clipped to provide a secondary mark for assessing dart-tag loss. The spawning distribution of Yentna River coho salmon was not estimated in 2013 and 2014.

Point estimates of abundance for Chinook and coho salmon in the mainstem Susitna River and Chinook salmon in the Yentna river were calculated using a 2-event, mark–recapture design, with testing for size, temporal, and spatial biases used to find the estimator with the least bias (Yanusz et al. 2013; LGL and ADF&G 2014, 2015). In the mainstem during 2013 and 2014, radiotagged Chinook and coho salmon were "recaptured" upstream from the PRM 34 tagging site by stationary radio receiver-loggers that recorded their passage at weirs on the Deshka River and Montana Creek (providing the "number of marked recaptured" variable in the abundance estimate). All Chinook and coho salmon (including radiotagged individuals) were counted by hand as they passed through these weirs and these counts were used as the "number of fish sampled for marks" variable in the abundance estimate. For the Yentna River in 2014, Chinook salmon were captured and examined for dart tags and an adipose finclip in fish wheels and drift gillnets at Yentna River RM 18 to determine number of marked recaptured and number of fish sampled for marks.

To determine spawning locations, stationary radio receiver-logger arrays were placed throughout the mainstem Susitna and Yentna river study area. Aerial surveys were also flown over the major tributaries of the mainstem Susitna and Yentna rivers by ADF&G to track radiotagged fish approximately every 2 weeks, starting in late June and finishing in mid-August for Chinook salmon, and starting mid-August and finishing in late September for coho salmon, making a series of 4 complete surveys for each species each year (Yanusz et al. 2013; LGL and ADF&G 2014, 2015).

Table 1.–Summary of methods used to capture salmon for tagging in the mainstem Susitna River and the Yentna River, 2012–2014.

Drainage	Year	Species	Purpose	Capture method	Capture location	Capture dates	Effort (h)	Number radiotagged
Mainstem Susitna	2012	Chinook	Spawning distribution	Fish wheel				
					East bank PRM 34.2	May 25–Aug 26	615	160
					West bank PRM 33.4	May 25–Aug 26	626	178
				Gillnets	PRM 34 mainstem	May 25–Jul 1	135	105
	2013	Chinook	Spawning distribution and abundance	Fish wheel				
					East bank PRM 34.2	Jun 3–Aug 31	1,050	195
					West bank PRM 33.4	Jun 3–Aug 31	1,061	385
				Gillnets	PRM 34 mainstem	May 22–Jun 28	79	118
		Coho	Spawning distribution and abundance	Fish wheel				
					East bank PRM 34.2	Jun 3–Aug 31	1,050	343
					West bank PRM 33.4	Jun 3–Aug 31	1,061	253
	2014	Chinook	Spawning distribution and abundance	Fish wheel				
					East bank PRM 34.2	May 22–Aug 26	1,154	271
					West bank PRM 33.4	May 22–Aug 26	1,153	259
				Gillnets	PRM 34 mainstem	May 22–Jun 28	79	129
		Coho	Spawning distribution and abundance	Fish wheel				
					East bank PRM 34.2	May 22–Aug 26	1,154	303
					West bank PRM 33.4	May 22–Aug 26	1,153	337
Yentna	2013	Chinook	Spawning distribution	Fish wheel				
					North bank RM 6	Jun 2–29	166	145
					South bank RM 6	Jun 3–30	167	278
				Gillnets	RM 6 Yentna River	Jun 3–22	74	267
	2014	Chinook	Spawning distribution and abundance	Fish wheel				
					North bank RM 6	May 22–Jun 25	529	95
					South bank RM 6	May 22–Jun 25	539	95
				Gillnets	RM 6 Yentna River	May 22–Jun 25	282	106

For fixed-station telemetry data, at least 5 detections per minute had to be recorded for the detection records to be considered valid (7/min with slightly noisy receivers, and 100/60 min for very noisy receivers). For aerial survey data, the location with the largest signal strength for each detected radio tag was chosen as the best location for a particular tag on the day it was detected. The time series of detections was plotted on a map of the Susitna River drainage using ArcMap version 10.2 to estimate the most likely spawning location for that radiotagged fish, and the pattern of radiotag detections was categorized according to Table 2. No on-the-ground surveys to verify actual spawning activity were done. The spawning site was inferred from the pattern of fish detections, with the general assumption that the furthest upstream location or the location where a fish spent the most time toward the end of the survey was the most likely spawning location. Data used in these classifications were based on surveys conducted and analyzed only by ADF&G to meet ADF&G objectives, so sample sizes and results presented here may not be identical to the Initial Study Report (LGL and ADF&G 2014) and the Study Completion Report (LGL and ADF&G 2015) prepared for the Alaska Energy Authority, Susitna-Watana Hydroelectric Project.

Table 2.–Assignment and interpretation of spawning codes recorded from radiotagged fish using aerial survey and stationary telemetry data.

Spawning code	Interpretation	Action
1	Fish that are detected and failed to migrate past mark–recapture gateways (mainstem gateway 1 mile upstream of the east bank fishwheel at PRM 34 and Yentna gateway at the Lower Yentna tower at RM 8.6).	Censored from the mark–recapture and spawning distribution analysis. Final location added to the database.
2	Fish that display progressive upstream movement in same drainage as tagged.	Assigned the farthest upstream location. Kept in mark–recapture and spawning distribution analyses.
3	Fish that display progressive upstream movement with the exception of the last 1–2 locations (the last location(s) must be greater than 2 miles from the farthest upstream location) in the same drainage as tagged.	Assigned the farthest upstream location. Kept in mark–recapture and spawning distribution analyses.
4	Fish that initially display upstream movement and then display downstream movement for more than 2 locations (last 3 or more locations must be greater than 2 miles from the farthest upstream location) in the same drainage as tagged.	Assigned the farthest upstream location. Kept in mark–recapture and spawning distribution analyses.
5	Fish that display a cluster of locations (within 20 miles of each other but some in different streams) in the same drainage as tagged.	Assigned a known location in the middle of the cluster. This assignment should not be used when there is a cluster of locations that are in very close proximity (less than 2 miles) to each other, all in the same stream or river. Use codes 2, 3, or 4 instead. Kept in mark–recapture and spawning distribution analyses.

-continued-

Table 2.–Page 2 of 3.

Spawning code	Interpretation	Action
6	Fish that display a cluster of locations with 1 "outlier" in the same drainage as tagged.	Assigned a known location in the middle of the cluster unless the outlier is documented during a late-season survey. In that situation, the assigned location will be to the farthest upstream location (fish was possibly milling prior to migrating to spawning location). Kept in mark–recapture and spawning distribution analyses.
7	Fish migrates up river A then has locations in river B in the same drainage as tagged.	If reasonable signal strengths exist among locations in river B, and fish would have had to back out of river A to get there, then fish are assigned to farthest upstream location in river B. Kept in mark–recapture and spawning distribution analyses.
8	Fish for which only a single location is detected in same drainage as tagged.	Detected location used. Kept in mark–recapture and spawning distribution analyses.
9	Fish caught by angler in the same drainage as tagged.	Dropped from spawning distribution analysis. Kept in mark–recapture analysis; assumes dart tagged and untagged fish are harvested at the same rate.
10	Fish that have tagging data but are never detected by stationary or aerial telemetry.	Assumed to have not made any upstream migration and censored from mark–recapture and spawning distribution analyses.
13	Fish that migrated past the gateway point for the mark–recapture study, but then came back down below the gateway within 48 hours and stayed below in same drainage as tagged.	Stays in the mark-recapture experiment (because it passed the gateway). This behavior biases the abundance estimate upward. Dropped from the distribution analysis.
102	Fish that display progressive upstream movement in a different drainage than tagged for all locations.	Assigned farthest upstream location. Censored from mark–recapture and spawning distribution analyses.
103	Fish that display progressive upstream movement with the exception of the last 1–2 locations (last location(s) must be greater than 2 miles from the farthest upstream location) in a different drainage than tagged.	Assigned farthest upstream location. Censored from mark–recapture and spawning distribution analyses.
104	Fish that initially display upstream movement and then display downstream movement for more than 2 locations (locations must be greater than 2 miles from farthest upstream location) in a different drainage than tagged.	Assigned farthest upstream location. Censored from mark–recapture and spawning distribution analyses.
105	Fish that display a cluster of locations (within 20 miles of each other, but in different streams) in a different drainage than tagged.	Assigned a known location in the middle of the cluster. Should not be used when there is a cluster of locations that are in very close proximity (less than 2 miles) to each other in the same stream or river. Use codes 102, 103, or 104 instead. Censored from mark–recapture and spawning distribution analyses.

-continued-

Table 2.–Page 3 of 3.

Spawning code	Interpretation	Action
106	Fish that display a cluster of locations with 1 "outlier" in a different drainage than tagged.	Assigned a known location in the middle of the cluster unless the outlier is documented during a late-season survey. In that situation, the assigned location will be the farthest upstream location (because the fish was possibly milling prior to migrating to spawning location). Censored from mark–recapture and spawning distribution analyses.
107	Fish migrates up river A then has locations in river B in a different drainage than tagged.	If reasonable signal strengths exist among detections up river B, and fish would have had to back out of river A to get there, then fish are assigned to farthest upstream location in river B. Kept in mark–recapture and spawning distribution analyses.
108	Fish with only a single location detected in a different drainage than tagged.	Detected location used. Censored from mark–recapture and spawning distribution analyses.
109	Fish caught by angler in a different drainage than tagged.	Dropped from spawning distribution analysis. Censored from mark–recapture analysis.
113	Fish that migrated past the gateway point for the mark–recapture study, but then came back down below the gateway within 48 hours and moved to a different drainage than tagged.	Censored from mark–recapture and spawning distribution analysis.

Estimates of the proportion of the mainstem Susitna River Chinook salmon inriver run to each management unit could not be made strictly with mark–recapture point estimates of abundance because recaptures were not management–unit specific, with the exception of the Yentna River drainage (Management Unit 4) in 2014. However, because estimates of Chinook salmon abundance for the mainstem Sustina River were available for both 2013 and 2014, and because spawning locations of tagged fish were determined for these years, estimates of inriver run (abundance) could be made for each of the 5 other management units (Figure 1) and these were determined as follows.

For mark–recapture abundance estimates where size stratification was used, the proportion of all spawning radiotagged salmon in size stratum *z* that spawned in location *l* was calculated as follows:

$$\hat{p}_{lz} = \frac{n_{lz}}{n_z} \tag{1}$$

where n_z is the number of radiotagged salmon from size stratum *z* released at the mainstem tagging site that travelled to a spawning location, and n_{lz} is the number of fish from n_z that travelled to location *l*.

The proportion of radiotagged salmon in size stratum z associated with management unit m is then calculated as follows:

$$\hat{p}_{mz} = \sum_{l=1}^{L_m} \hat{p}_{lz} \tag{2}$$

where L_m is the total number of locations in management unit m

The inriver run of salmon in size stratum z to management unit m was then estimated as follows:

$$\hat{N}_{mz} = \hat{N}_z \hat{p}_{mz} \tag{3}$$

where $\hat{N}_z$ is the mark–recapture estimate of abundance of size-z fish for the mainstem Susitna River.

The total abundance of fish in management unit m was then calculated as follows:

$$\hat{N}_m = \sum_{z=1}^{Z} \hat{N}_{mz} \tag{4}$$

The proportion of salmon spawning in each management unit was estimated as follows:

$$\hat{p}_m = \frac{\hat{N}_m}{\sum_{m=1}^{M} \hat{N}_m}, \tag{5}$$

where M is the total number of management units, including unit 4.

When size stratification is not used, $Z = 1$ in Equation 4 above and subscript z is dropped from all equations.

ADF&G has indexed the annual Chinook salmon escapement to the Susitna River drainage with single, annual aerial surveys of spawning Chinook salmon on 13 clearwater tributaries of the Susitna and Yentna rivers since 1982 and a weir on the Deshka River since 1995 (Oslund et al. 2017). These index and weir counts were continued during this project and were compared to estimates of escapement (mark–recapture abundance minus the sport harvest) for the mainstem Susitna and Yentna rivers in 2013 and 2014.

Each aerial survey of the Chinook salmon escapement took place during the historical peak of spawning, approximately the last week of July through the first week of August each year, when fish were most likely to be in pairs on redds and most visible (Oslund 2013; Oslund et al. 2017). A single observer made 1 pass at low altitude (just above treetop height) in a helicopter following the stream channel, and the observer wore polarized sunglasses to reduce glare (Lafferty 1997).

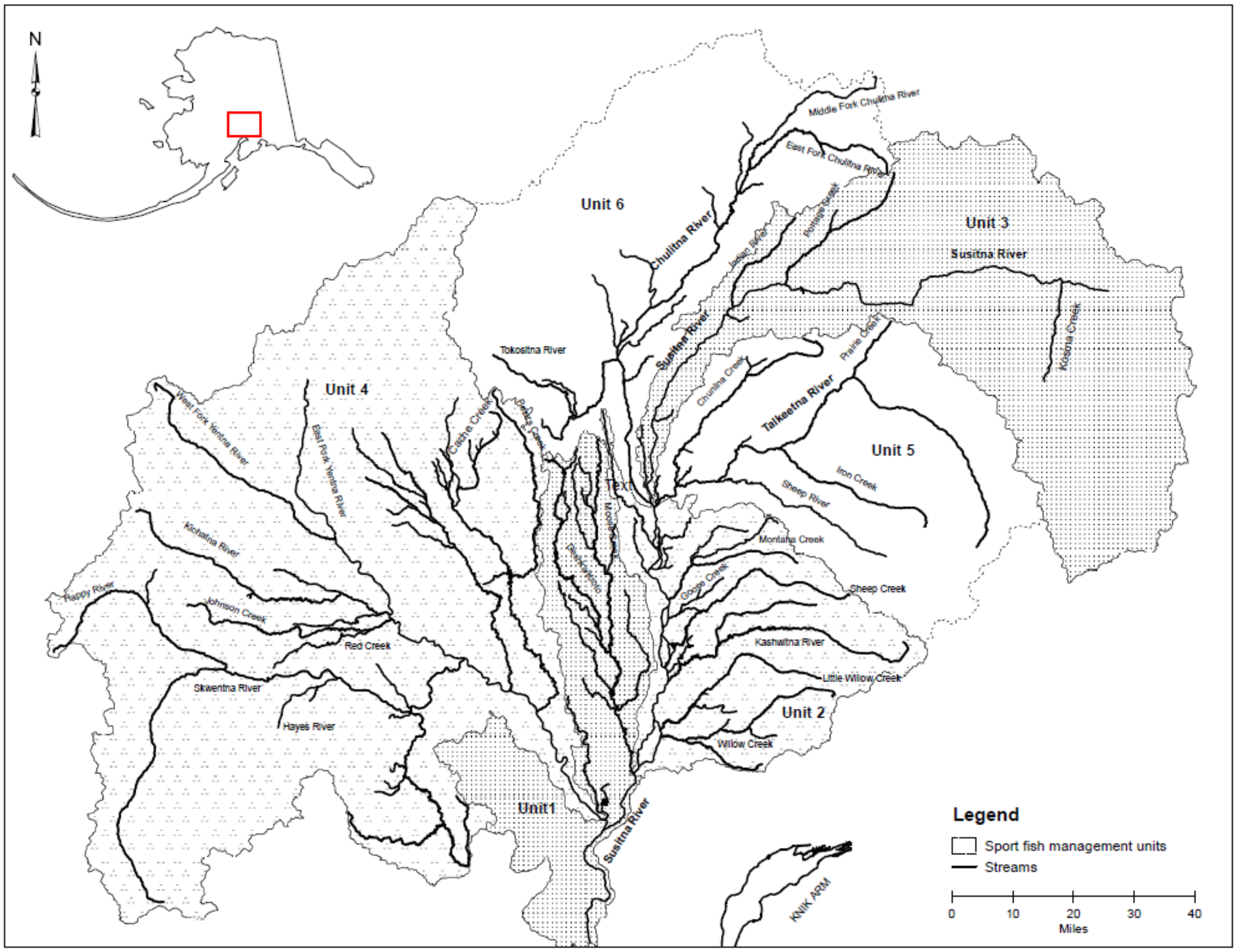

Figure 1.–Sport fishery management units for the Susitna River drainage.

Coho salmon have been counted at the Deshka River weir since 1995, and in single, annual foot surveys on Rabideux, Birch, Question, and Answer Creeks since 1984 (Oslund et al. 2017). These counts were compared to the mark–recapture estimates of escapement for the mainstem Susitna River in 2013 and 2014.

Occasionally, a survey of either Chinook or coho salmon could not be completed on a stream due to persistent high or turbid water that substantially reduced visibility of the fish. Counts for the missing survey were substituted with the average of all actual counts taken since 1982 or 1984 (depending on initial survey year) weighted by the relative deviation from average for the neighboring streams that year. For example, if a stream could not be counted in a given year, and the neighboring streams' counts were 110% of their averages that year, then the missing stream count was filled in with 110% of its average count. Neighboring streams were defined as eastside Susitna River tributaries, westside Susitna River tributaries, or Yentna River tributaries.

RESULTS

CHINOOK SALMON

Susitna River Mainstem

The numbers of Chinook and coho salmon radiotagged in the mainstem Susitna and Yentna rivers in 2012, 2013, and 2014 are given in Table 3. Not all radiotagged fish survived, continued upstream, spawned in the same drainage as tagged, were successfully tracked, or retained their tag, which resulted in losses and gains to the number of fish spawning in each drainage. Typically, fewer fish were categorized as spawning in a river system than were tagged in a river system for both the mainstem Susitna River and the Yentna River. However for 2014 only, more Chinook salmon were categorized as spawning in the Yentna River than were tagged at the Yentna RM 6 tagging site. The mainstem Susitna PRM 34 tagging site is just upstream of the main channels at the mouth of the Yentna River, and one of the seasonal channels of the Yentna River sometimes discharges into the mainstem Susitna River upstream of the PRM 34 fish wheels during high flows in the Yentna River. Chinook salmon tagged at the west bank fish wheel at the mainstem Susitna PRM 34 tagging site are prone to migrating up the Yentna River. It is assumed this is not a tagging-induced behavior, but a consequence of the location of the tagging site so close to the Yentna River mouth.

Table 3.–Radio tags deployed and successfully categorized as reaching a spawning destination for Chinook and coho salmon in the mainstem Susitna River and the Yentna River in 2012, 2013, and 2014.

Species	River	Result	2012	2013	2014
Chinook salmon	Mainstem Susitna River				
		Radiotagged at PRM 34	443	698	659
		Spawned in drainage	326	546	467
Chinook salmon	Yentna River				
		Radiotagged at RM 6	NA	690	296
		Spawned in drainage	NA	667	304
Coho salmon	Mainstem Susitna River				
		Radiotagged at PRM 34	NA	596	640
		Spawned in drainage	NA	405	523

Note: "NA" means not applicable to this study.

It appeared that most of the probable spawning locations (determined from radiotagging) in the mainstem Susitna River coincided with clearwater tributaries that could be surveyed with aerial or weir counts in 2012, 2013, and 2014 (Figures 2, 3, and 4). However, a relatively high density of apparently spawning Chinook salmon occurred in the Chulitna River for several miles upstream of the Tokositna River confluence in 2013 and 2014 in a reach that is too glacially turbid to be visually counted. A relatively moderate density of probable spawning Chinook salmon occurred in Iron Creek in 2012 and 2013. Iron Creek is also too glacially turbid to be visually counted.

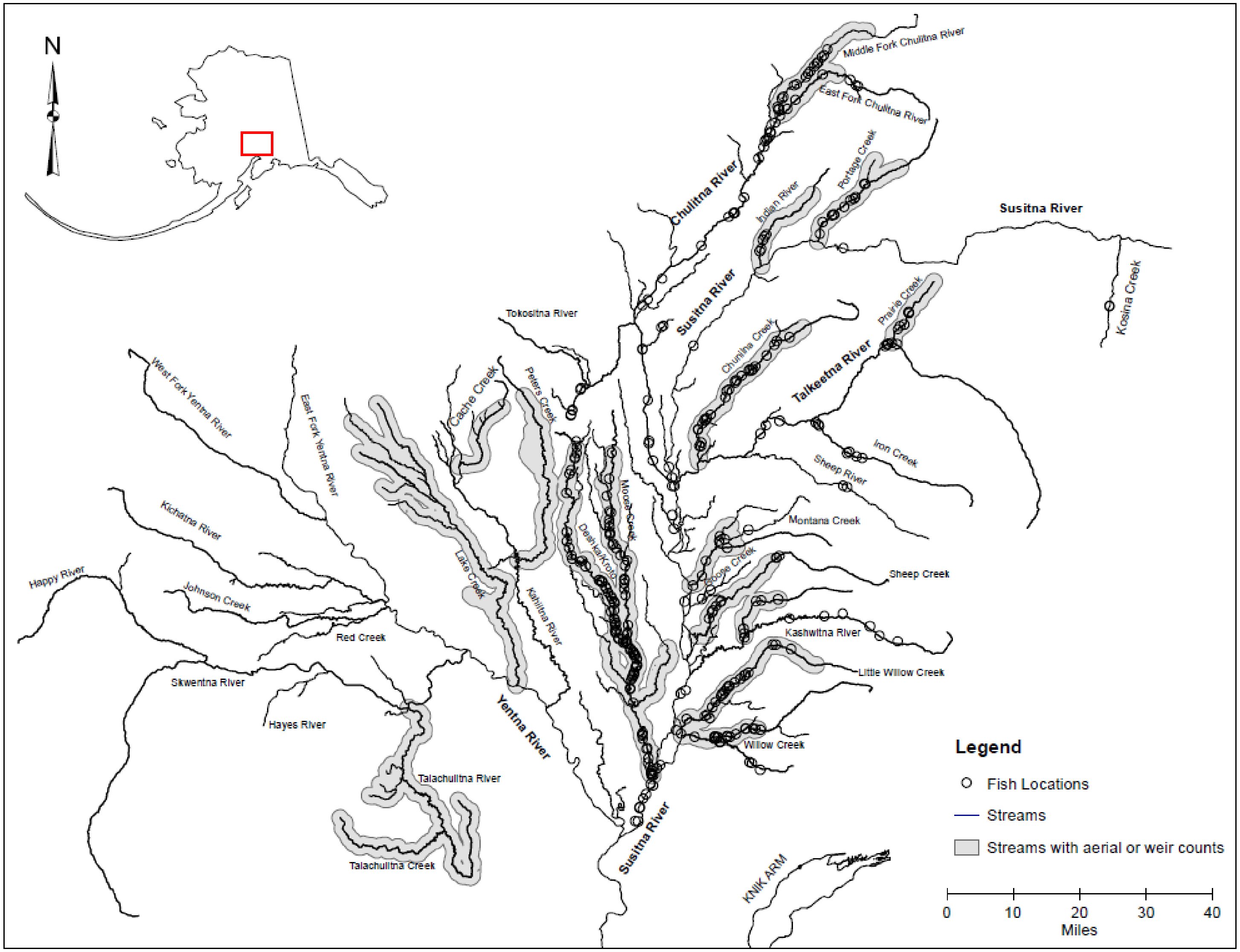

Figure 2.–Probable spawning locations of radiotagged Chinook salmon in the mainstem Susitna River in 2012 compared to streams with aerial or weir counts.

Note: Radiotagging for Chinook salmon was not conducted on the Yentna River during 2012.

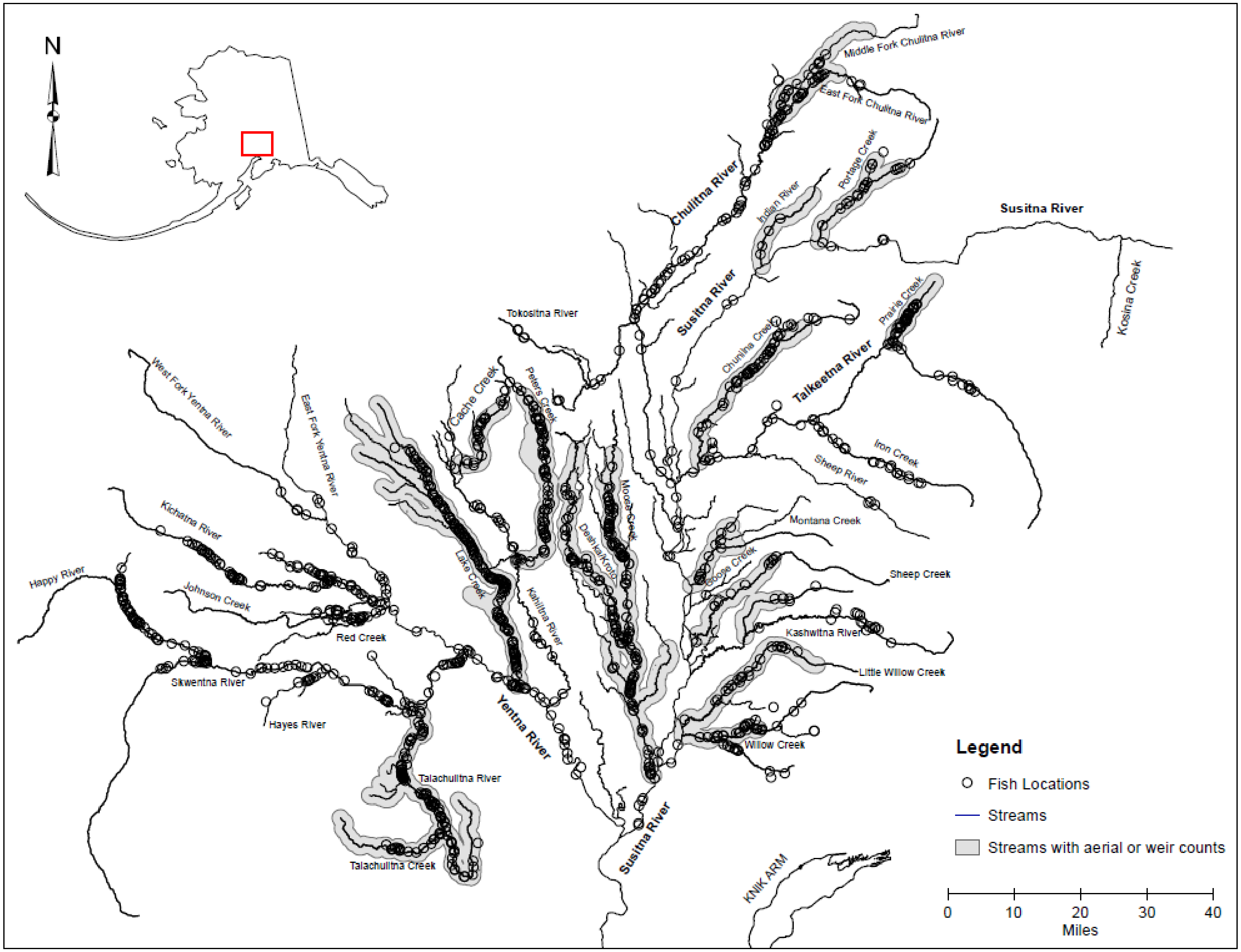

Figure 3.–Probable spawning locations of radiotagged Chinook salmon in the mainstem Susitna and Yentna rivers in 2013 compared to streams with aerial or weir counts.

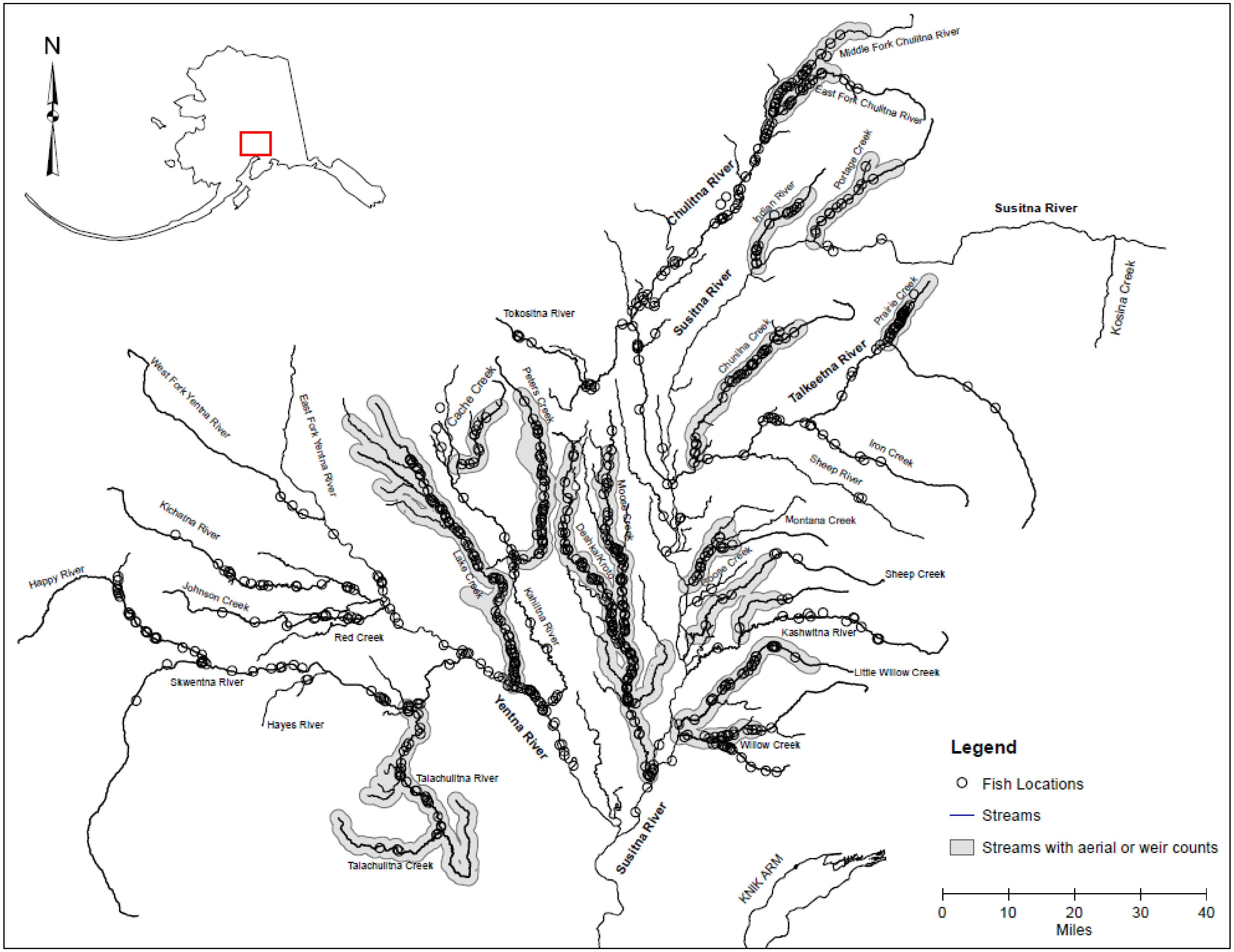

Figure 4.–Probable spawning locations of radiotagged Chinook salmon in the mainstem Susitna and Yentna rivers in 2014 compared to streams with aerial or weir counts.

Point estimates for the Chinook salmon escapement in the mainstem Susitna River were derived by subtracting estimated inriver sport harvest from the mark–recapture estimate of abundance giving 88,358 fish in 2013 and 66,865 fish in 2014 (Table 4). Broad restrictions to the Chinook salmon inriver fisheries in 2013 and 2014 resulted in annual inriver Chinook salmon sport harvests of only 1,105 and 1,360 fish, respectively, for the mainstem Susitna River. On average over 2013 and 2014, the sum of the aerial escapement surveys observed 14.3% of the estimated escapement; there was a 1.7 percentage point difference between years. Adding the Deshka River weir escapement to the aerial surveys, an average of 36.8% of the escapement estimate was observed for 2013 and 2014 with a difference of 5.0 percentage points between years.

The distribution of the estimated inriver run among management units in the mainstem Susitna River varied from 9% to 27% in 2013 and 10% to 25% in 2014 (Table 5). In both 2013 and 2014, Unit 3 (Upper Susitna River) had the lowest percentage of the inriver run: 9% and 10%, respectively. The distribution of the inriver run between the remaining mainstem Susitna River units was relatively uniform, varying between 21% and 27% in 2013 and 21% and 25% in 2014.

Table 4.–Aerial escapement index counts and weir counts compared to the mark–recapture escapement estimates for adult Chinook salmon in the mainstem Susitna River, 2013–2014.

Susitna Management Unit[a]	System	Assessment type	Assessment value 2013	Assessment value 2014	Percent of escapement estimate 2013	Percent of escapement estimate 2014
1	Deshka River	Weir escapement count [b]	18,378	16,099	20.8%	24.1%
2	Willow Creek	Aerial escapement count	1,752	1,335	2.0%	2.0%
2	Little Willow Creek	Aerial escapement count	858	684	1.0%	1.0%
2	Goose Creek	Aerial escapement count	62	232	0.1%	0.3%
2	Montana Creek	Weir count	1,304	953	1.5%	1.4%
2	Kashwitna River	Aerial escapement count	234	88	0.3%	0.1%
2	Sheep Creek	Aerial escapement count	473 [c]	262	0.5%	0.4%
3	Indian River	Aerial escapement count	332	558	0.4%	0.8%
3	Portage Creek	Aerial escapement count	868	826	1.0%	1.2%
5	Clear Creek	Aerial escapement count	1,471	1,390	1.7%	2.1%
5	Prairie Creek	Aerial escapement count	3,304	2,812	3.7%	4.2%
6	Chulitna River	Aerial escapement count	1,262	1,011	1.4%	1.5%
1 [d], 2–3, 5–6	Mainstem Susitna R.	Sum aerial only	11,920	10,151	13.5%	15.2%
		Sum aerial and weir	30,298	26,250	34.3%	39.3%
1 [d], 2–3, 5–6	Mainstem Susitna R.	Mark-recapture abundance (inriver run)	89,463	68,225		
		Lower 95% CI	77,720	53,473		
		Upper 95% CI	114,954	94,240		
		Inriver sport harvest [e]	1,105	1,360		
		Escapement estimate	88,358	66,865		

Note: Mark–recapture estimates are for Chinook salmon ≥500 mm METF length, and aerial and weir counts are of all sizes.

[a] See Figure 1.

[b] In 2013, 153 fish were harvested above weir and subtracted from the weir count to give the escapement count, and in 2014, 236 fish were harvested above the weir and subtracted from the weir count to give the escapement count.

[c] Missing survey, used average of past surveys weighted by the relative deviation from average for the neighboring streams that year.

[d] Does not include Alexander Creek (below experiment).

[e] Statewide Harvest Survey (SWHS) estimate from the Alaska Sport Fishing Survey database [Internet]. 1996–present. Anchorage, AK: ADF&G, Division of Sport Fish. Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey/.

Table 5.–Distribution of Chinook salmon inriver run among the sport fishery management units, 2013 and 2014.

	Mainstem Susitna River										Entire drainage				
	2013					2014					2014				
			Index					Index					Index		
Unit	Inriver run estimate to unit	Unit as % of total inriver run	Count[a]	Method	Index as % of inriver run to unit	Inriver run estimate to unit	Unit as % of total inriver run	Count[a]	Method	Index as % of inriver run to unit	Inriver run estimate to unit	Unit as % of total inriver run	Count [a]	Method	Index as % inriver run to unit
1 [b]	18,469	21%	18,378	weir	99.5%	14,025	21%	16,099	weir	114.8%	14,025	15%	16,099	weir	114.8%
2	19,298	22%	4,683	survey	24.3%	17,171	25%	3,466	survey	20.2%	17,171	19%	3,466	survey	20.2%
3	7,680	9%	1,200	survey	15.6%	6,609	10%	1,384	survey	20.9%	6,609	7%	1,384	survey	20.9%
4											22,267	25%	7,680	survey	34.5%
5	24,408	27%	4,775	survey	19.6%	14,024	21%	4,202	survey	30.0%	14,024	15%	4,202	survey	30.0%
6	19,607	22%	1,262	survey	6.4%	16,397	24%	1,011	survey	6.2%	16,397	18%	1,011	survey	6.2%
Total inriver run	89,463		30,064			68,225		26,162			90,492		33,842		37.4%

[a] Count represents inriver run for Unit 1 and indexes escapement in all other units

[b] Does not include Alexander Creek (below experiment).

The Deshka River was the only major spawning area (as shown by radio telemetry distribution) in Management Unit 1 that was within the study area, and because Chinook salmon were counted at a weir at RM 7 of the Deshka River, this fact resulted in a nearly complete count of the inriver run in the Unit 1 study area. In 2013, 153 Chinook salmon were estimated to have been harvested above the weir, and in 2014, 236 Chinook salmon were estimated to have been harvested above the weir, making the weir escapement count 18,378 in 2013 and 16,099 in 2014 (Table 4). The weir escapement counts were 99.5% and 114.8% of the mark–recapture derived point estimates of the Deshka River inriver runs in 2013 and 2014, respectively (Table 5).

The index for Unit 2 (aerial surveys only) counted 24.3% of the mark–recapture estimated inriver run to Unit 2 in 2013 and 20.2% in 2014 (Table 5). The index for Unit 3 (aerial surveys only) counted 15.6% of the mark–recapture estimated inriver run to Unit 3 in 2013 and 20.9% in 2014. The index for Unit 5 (aerial surveys only) counted 19.6% of the estimated inriver run to Unit 5 in 2013 and 30.0% in 2014. The index for Unit 6 (aerial surveys only) counted the lowest percentage: 6.4% of the estimated inriver run to Unit 6 in 2013 and 6.2% in 2014.

Radiotagged mainstem Susitna River Chinook salmon were separated into 5 stocks based on the management unit in which they spawned: Deshka Unit 1, Montana Unit 2, Susitna Unit 3, Talkeetna Unit 5, and Chulitna Unit 6. In 2012, radiotagged fish from these stocks took between 6.7 to 10.8 days, on average, to travel from the tagging site at PRM 34 to the Deshka River confluence telemetry site ("Deshka mouth;" Figure 5). In 2013, these stocks took between 5.4 to 6.6 days, on average, to travel between the same points (Figure 6). In 2014, these stocks took between 3.6 to 6.8 days, on average, to travel between the same points (Figure 7). The Deshka Unit 1 Chinook salmon stock took an average of 12 days in 2012, 14 days in 2013, and 7.6 days in 2014, to travel from the Susitna PRM 34 tagging site to the Deshka River weir and telemetry site. The Montana Creek Unit 2 Chinook salmon stock took an average of 24 days in 2013 and 34 days in 2014 to travel from the tagging site to the Montana Creek weir site. Stocks bound for Units 3, 5, and 6 took an average of 21.4–22.7 days in 2012, 13.8–14.8 days in 2013, and 13.8–18.2 days in 2014 to travel from the tagging site to the Sunshine telemetry site.

Based on run timing at the PRM 34 tagging site in 2012, Chinook salmon stocks from Chulitna Unit 6 and middle Susitna Unit 3 appeared to have been tagged earlier than the other stocks (Deshka Unit 1 and Talkeetna Unit 5), and especially Montana Creek Unit 2, with a run timing far later than all other stocks (Figure 8a). All of the 5 stocks had nearly identical run timing at Susitna PRM 34 in 2013, and all were very compressed (Figure 8b). All but the Montana Creek Unit 2 stock started much later in 2013 compared to 2012. The Susitna River drainage had a very late ice-out in 2013, which could have influenced the run timing patterns that year. In 2014, like 2012, two of the major Chinook salmon stocks (Chulitna Unit 6 and middle Susitna Unit 3) were tagged at the Susitna River PRM 34 tagging site earlier than the remaining mainstem Susitna River stocks. As in 2012, the Montana Creek stock was tagged latest, but the 2014 run timing started far earlier than in 2012 (Figure 8c).

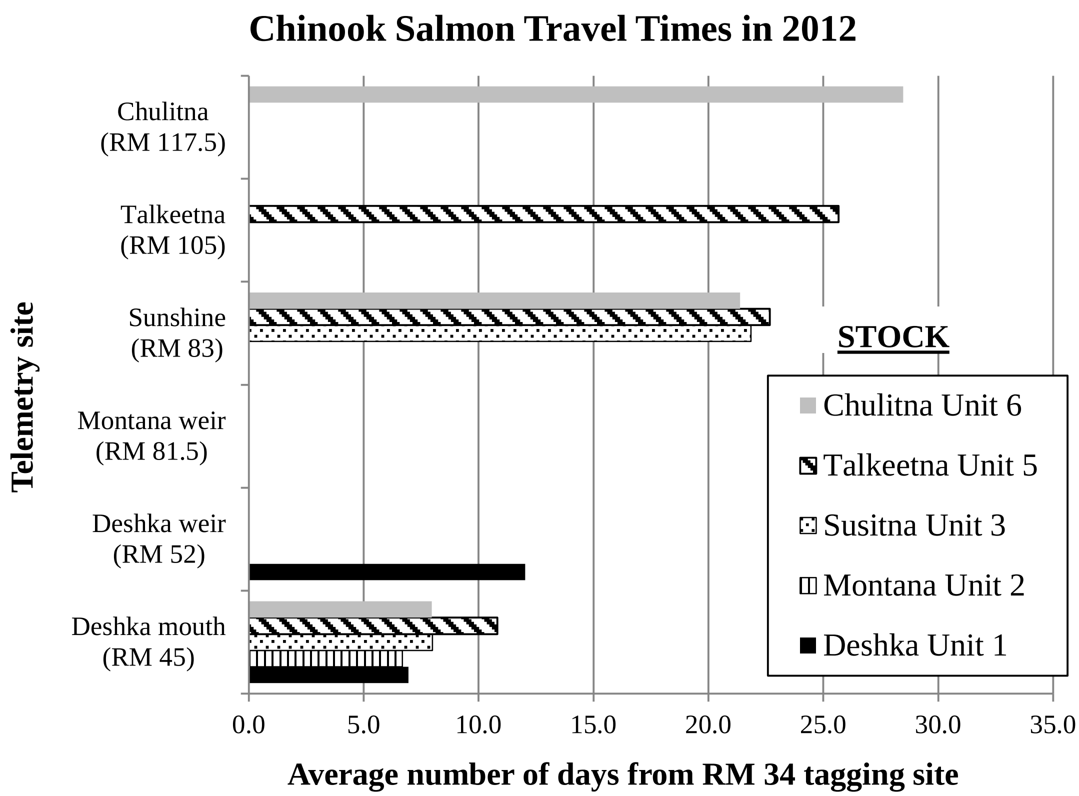

Figure 5.–Average number of days it took for Chinook salmon to travel from the Susitna PRM 34 tagging site to various stationary telemetry sites by stock in 2012.

Note: The average number of days is determined from all fish recorded at a specified telemetry site by stock from the day of release to the first day detected at the specified site.

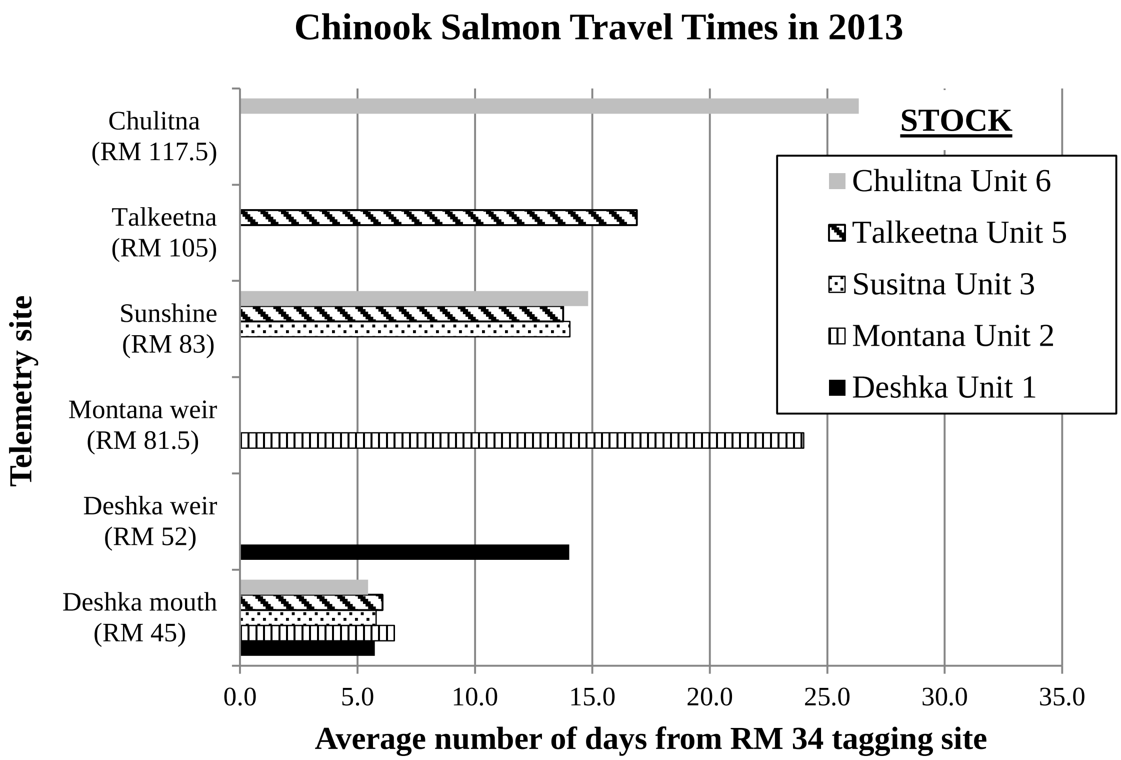

Figure 6.–Average number of days it took for Chinook salmon to travel from the Susitna PRM 34 tagging site to various stationary telemetry sites by stock in 2013.

Note: The average number of days is determined from all fish recorded at a specified telemetry site by stock from the day of release to the first day detected at the specified site.

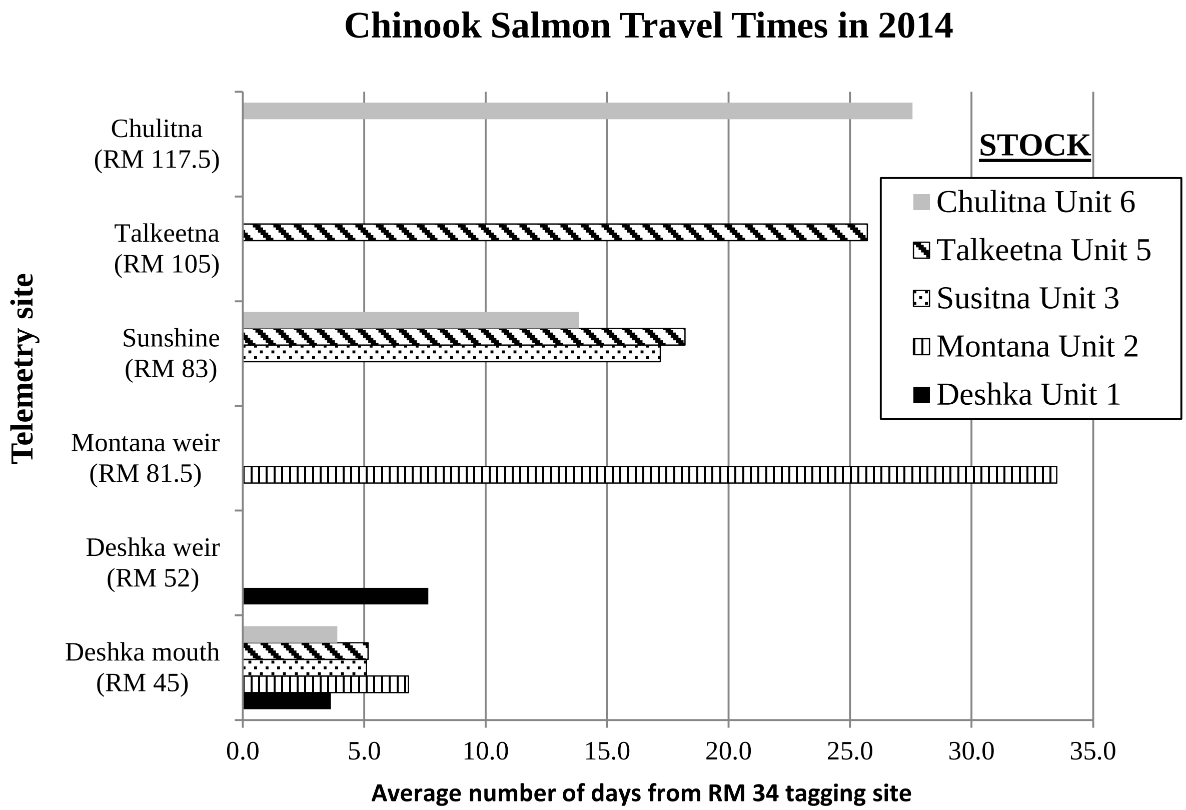

Figure 7.–Average number of days it took for Chinook salmon to travel from the Susitna PRM 34 tagging site to various stationary telemetry sites by stock in 2014.

Note: The average number of days is determined from all fish recorded at a specified telemetry site by stock from the day of release to the first day detected at the specified site.

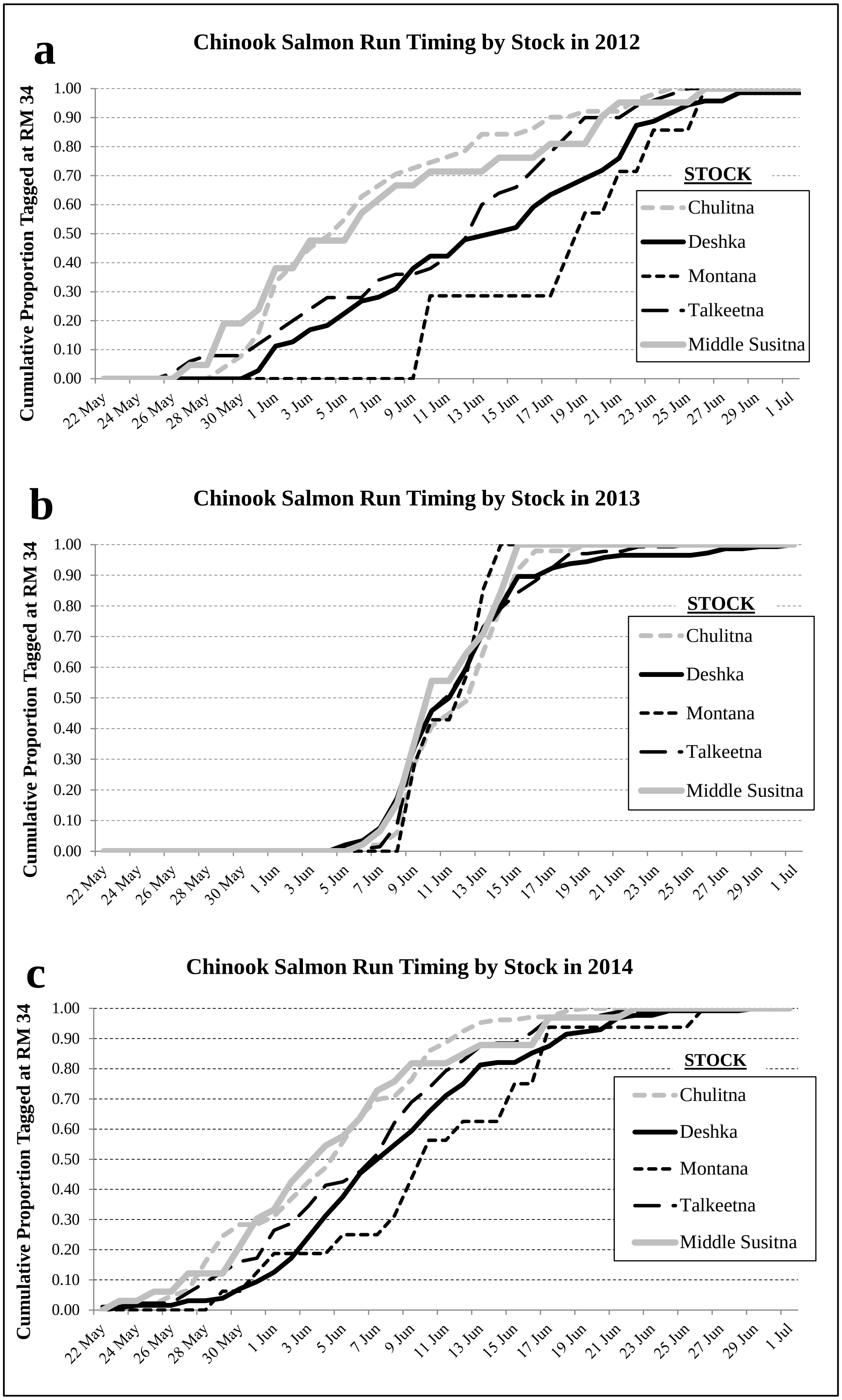

Figure 8.–Run timing of Chinook salmon stocks tagged at the Susitna PRM 34 tagging site in 2012 (a), 2013 (b), and 2014 (c).

Yentna River

In 2013 and 2014, radiotelemetry results revealed relatively high densities of apparently spawning Chinook salmon occurring in several tributaries of the Yentna River that do not get annual aerial counts (Figures 3 and 4). Of those tributaries, the Happy River appears to be the most utilized by spawning Chinook salmon.

In 2014, the sum of the aerial escapement surveys for Chinook salmon in the Yentna River drainage (Unit 4) observed 35.6% of the estimated escapement (based on mark–recapture results and estimated harvest) of 21,578 fish (Table 6). Broad restrictions to the inriver Chinook salmon fisheries in the Yentna River in 2014 probably contributed to a sport harvest estimate of only 689 fish. The aerial counts in each of the surveyed stream systems in the Yentna River varied from 2.2% to 16.2% of the mark–recapture escapement estimate in 2014.

Radiotagged Yentna River Chinook salmon were separated into 5 stocks based on the streams in which they spawned: Skwentna River, Talachulitna River, Lake Creek, Peters Creek, and the remainder. Telemetry tower locations were not conducive to monitoring these stocks from the RM 6 marking site to common points upstream. However, based on the available data, the major Yentna River Chinook salmon stocks appeared to have similar run timing past the Yentna RM 6 tagging site in 2013, possibly due to the late ice-out (Figure 9a). In 2014, the Talachulitna River and Skwentna River stocks appeared to pass the RM 6 tagging site earlier than the other Yentna River stocks (Figure 9b).

Table 6.–Aerial escapement index counts compared to the mark–recapture escapement estimate for adult Chinook salmon in the Yentna River drainage.

		2014	
System	Assessment	Assessment value	Percent of escapement estimate
Cache Creek	Aerial survey	475	2.2%
Lake Creek	Aerial survey	3,506	16.2%
Peters Creek	Aerial survey	1,443	6.7%
Talachulitna River	Aerial survey	2,256	10.5%
	Total	7,680	35.6%
Yentna River drainage			
	Mark–recapture abundance	22,267	
	Lower 95% CI	17,466	
	Upper 95% CI	28,701	
	Inriver sport harvest	689	
	Escapement estimate	21,578	

Note: Mark–recapture estimates are for Chinook salmon ≥500 mm METF length, and aerial counts are of all sizes.

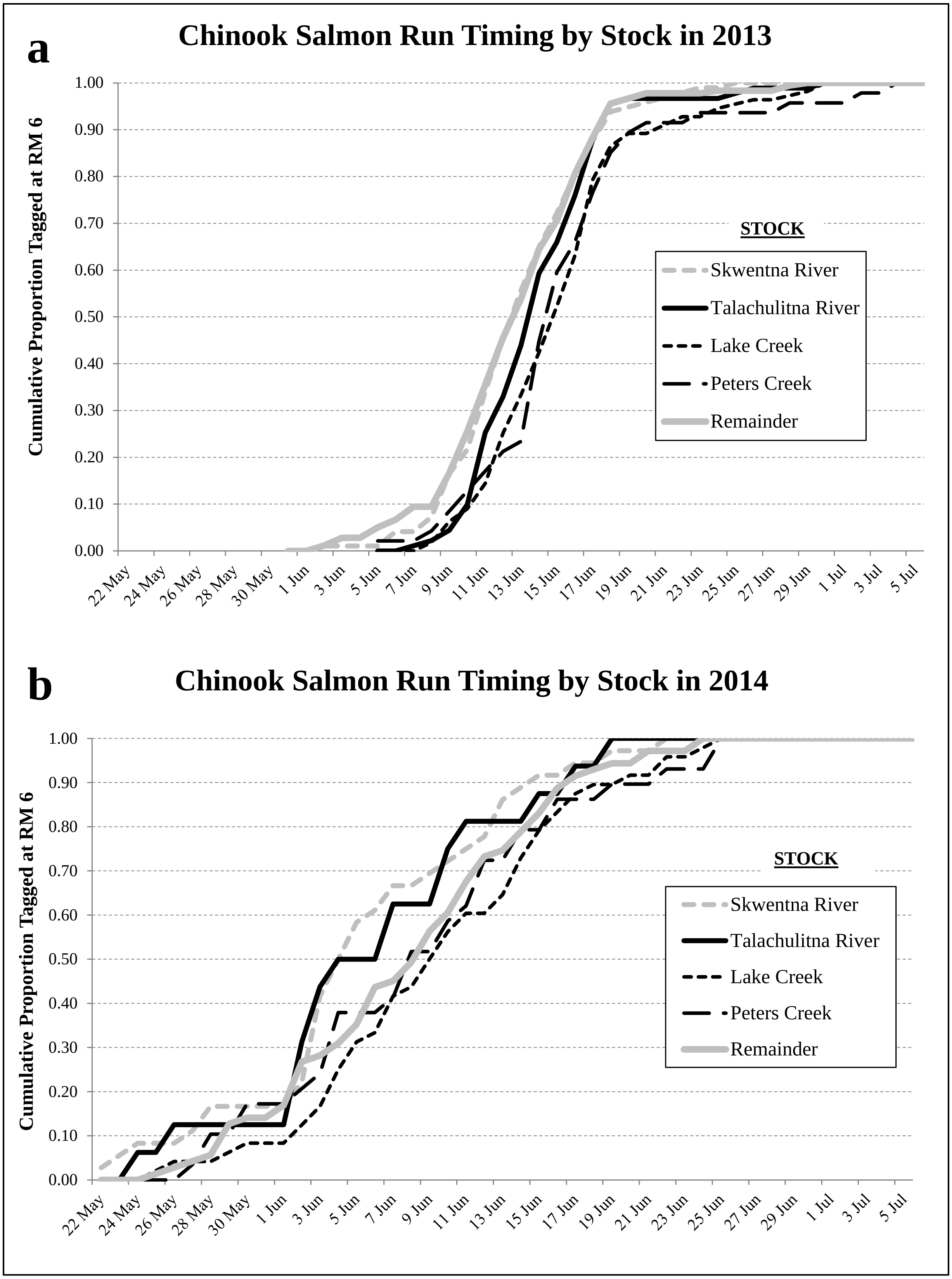

Figure 9.–Timing of Chinook salmon stocks tagged at the Yentna River RM 6 tagging site in 2013 (a) and 2014 (b).

Entire Susitna River Drainage

For the entire Sustina River drainage (mainstem Susitna River plus the Yentna River), Management Unit 3 (upper Susitna River) had the smallest percentage of spawners in the mark–recapture estimated Susitna River Chinook salmon inriver run in 2014 (7%), whereas Management Unit 4 (Yentna River drainage) had the largest percentage (25%) (Table 5). The remaining 4 units varied only slightly, from 15% to 19% of the estimated inriver run.

COHO SALMON

Mainstem Susitna River

Based on radiotagging results from 2013 and 2014, the probable spawning locations of coho salmon in the mainstem Susitna River appeared well distributed among clearwater and turbid water reaches (Figures 10 and 11).

The Deshka River weir provides the largest index of coho salmon abundance for the mainstem Susitna River. In 2013, the coho salmon escapement at the Deshka River weir was 19% of the estimated mainstem Susitna River escapement of 114,379 fish based on the mark–recapture abundance estimate minus the SWHS harvest estimate. In 2014, escapement at the weir was 16% of an estimated mainstem Susitna River escapement of 69,819 fish based on the mark–recapture abundance estimate minus the SWHS harvest estimate. The average over both years was 17% (Table 7).

Table 7.–The Deshka River coho escapements compared to the mainstem Susitna River coho salmon escapements in 2013 and 2014.

Year	Deshka weir count	Sport harvest above weir	Deshka escapement	Mainstem Susitna inriver abundance	Mainstem Susitna sport harvest	Mainstem Susitna escapement	Deshka % Mainstem Susitna escapement
2013	22,141	616	21,525	130,026	15,647	114,379	19%
2014	11,578	664	10,914	84,879	15,060	69,819	16%
Average							17%

Single, annual foot counts of coho salmon have been conducted in Rabideux, Birch, Question, and Answer creeks since 1984 (Oslund et al. 2017). In 2013, the count for all 4 streams combined was 570 fish or 0.5% of the mark–recapture estimated mainstem Susitna River escapement (570/114,379). In 2014, the count for all 4 streams combined was 828 fish or 1.2% of the mark–recapture estimated mainstem Susitna River escapement (828/69,819).

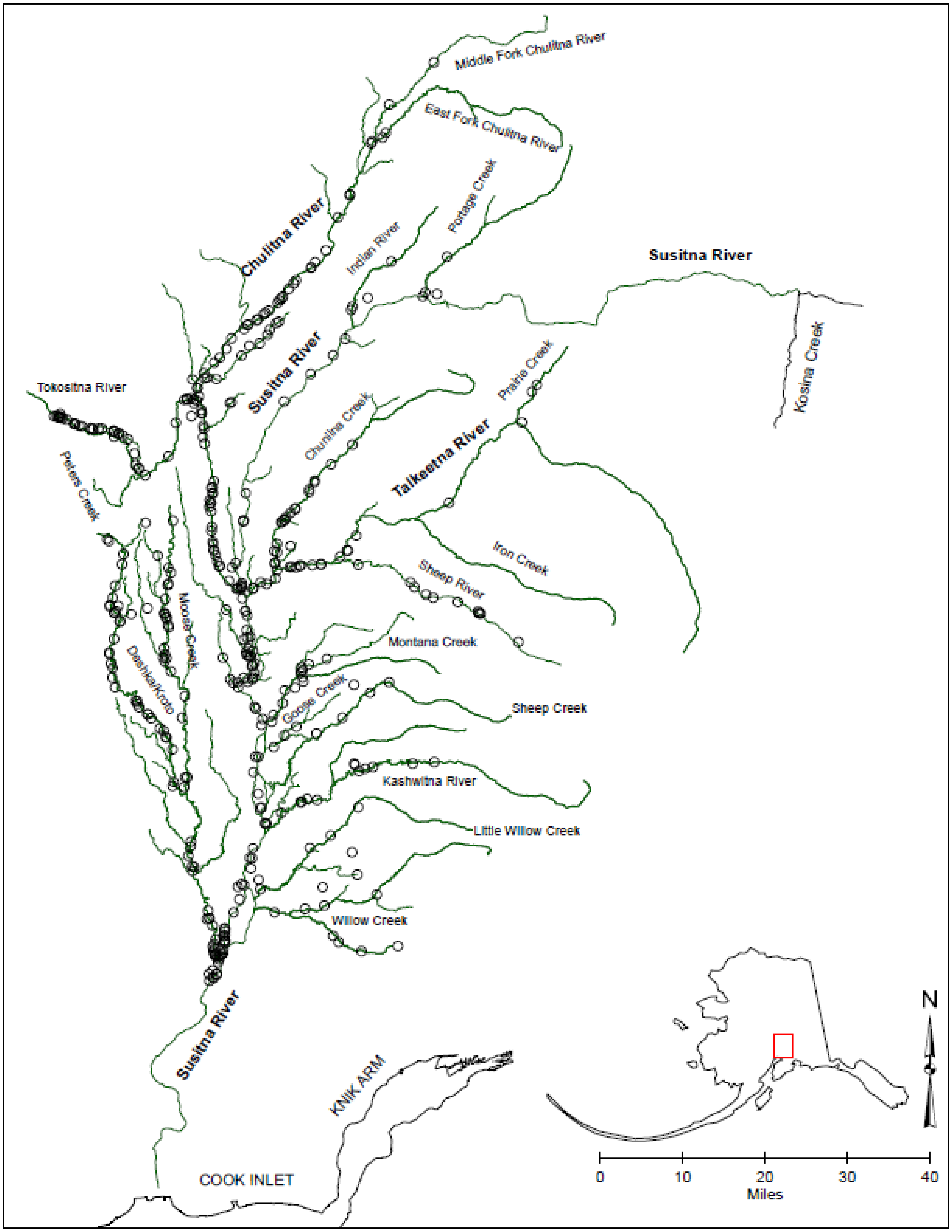

Figure 10.–Probable spawning locations of radiotagged coho salmon in the mainstem Susitna River in 2013.

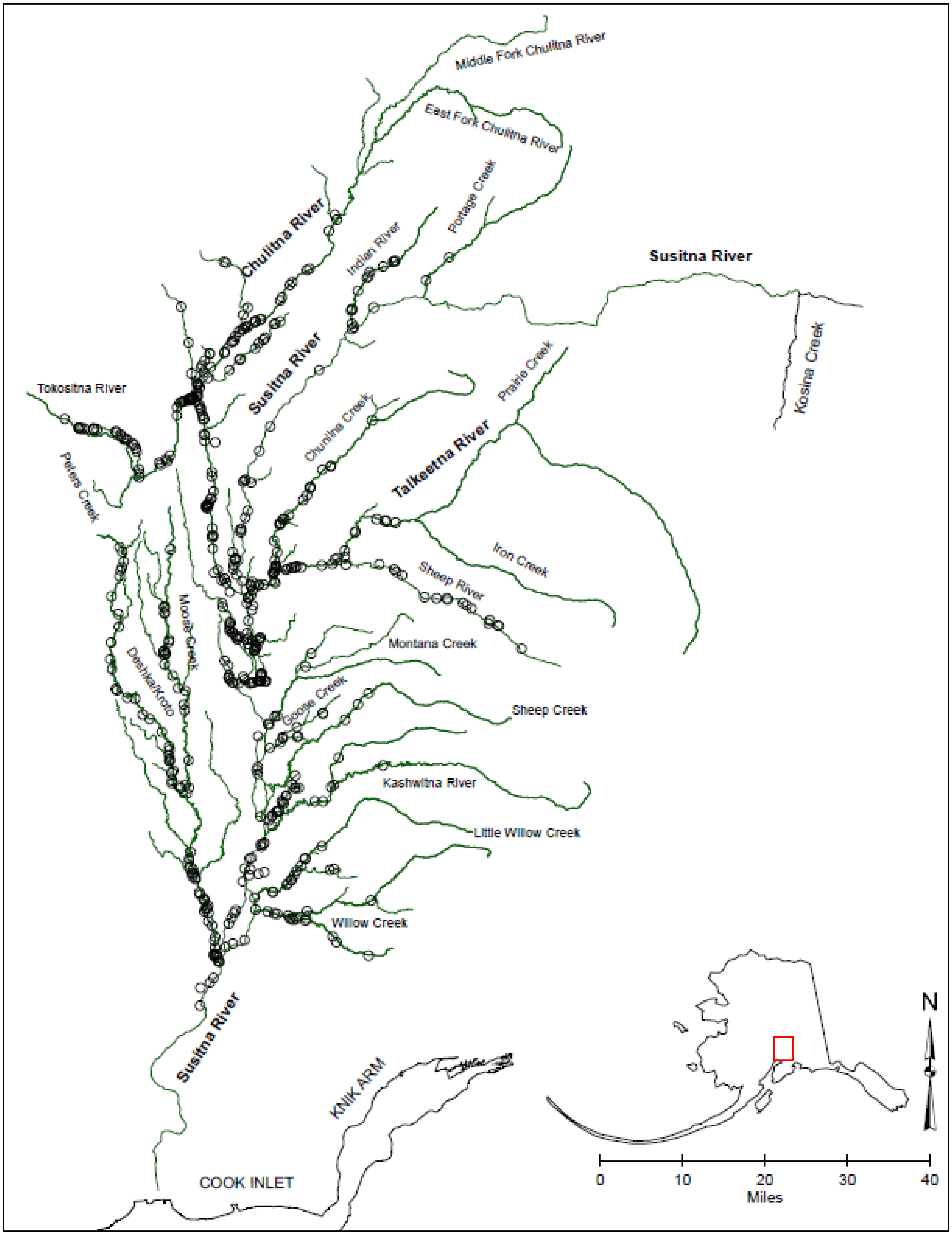

Figure 11.–Probable spawning locations of radiotagged coho salmon in the mainstem Susitna River in 2014.

Radiotagged mainstem Susitna River coho salmon were separated into 5 stocks based on the management unit in which they spawned: Deshka Unit 1, Montana Unit 2, Susitna Unit 3, Talkeetna Unit 5, and Chulitna Unit 6. In 2013, fish from these stocks took 3.8–5.9 days on average to travel from the tagging site at PRM 34 to the Deshka River confluence telemetry site ("Deshka mouth;" Figure 12). In 2014, fish from these stocks took 2.5–4.0 days, on average, to travel between the same points (Figure 13). The Deshka River coho salmon stock (Deshka Unit 1) took an average of 18 days in 2013 and 13.4 days in 2014 to travel from the tagging site to the Deshka River weir site. The Montana Creek coho salmon stock (Montana Unit 2) took an average of 20.9 days in 2013 to travel from the tagging site to the Montana Creek weir site. No travel times were calculated for Montana Creek coho salmon in 2014 because only 2 radiotagged fish were probable Montana Creek spawners, which is not enough for analysis. Coho salmon from stocks bound for Units 3, 5, and 6 took an average of 17.7–21.9 days in 2013 and 17.7–19.3 days in 2014 to travel from the tagging site to the Sunshine telemetry site.

The mainstem Susitna River coho salmon stocks appeared to have similar run timing past the Susitna RM 34 tagging site in both 2013 and 2014 (Figure 15).

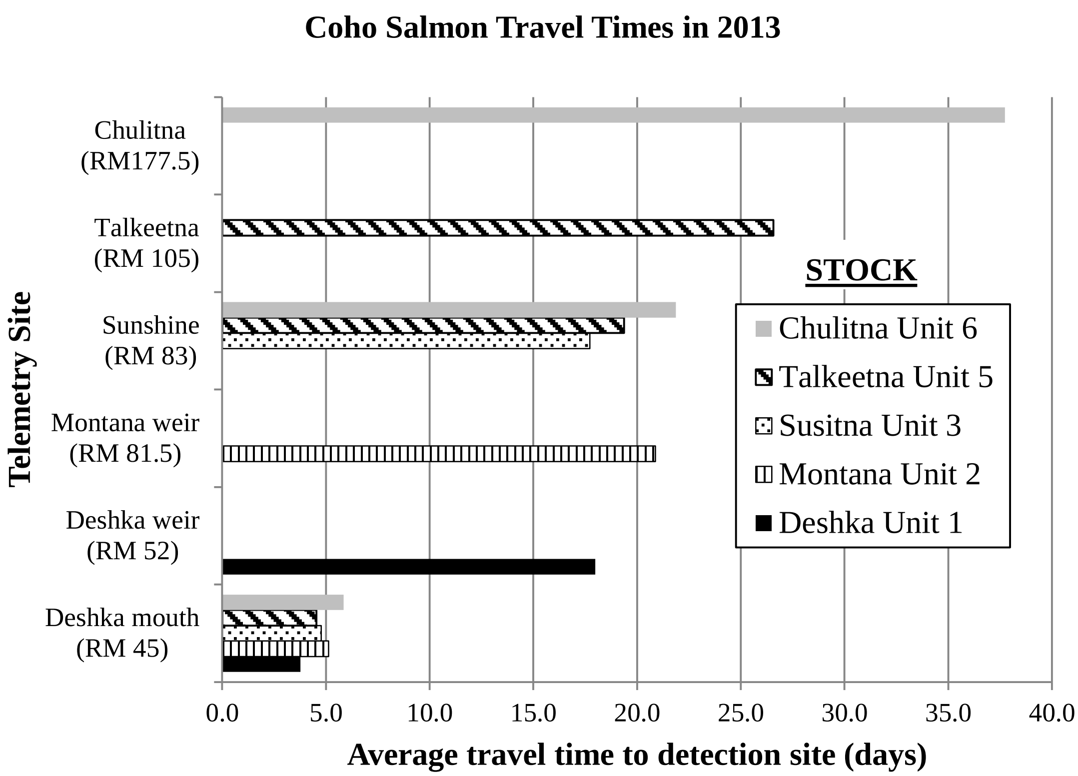

Figure 12.–Average number of days it took for coho salmon to travel from the Susitna PRM 34 tagging site to various stationary telemetry sites by stock (determined from spawning location) in 2013.

Note: The average number of days is determined from all fish recorded at a specified telemetry site by stock from the day of release to the first day detected at the specified site.

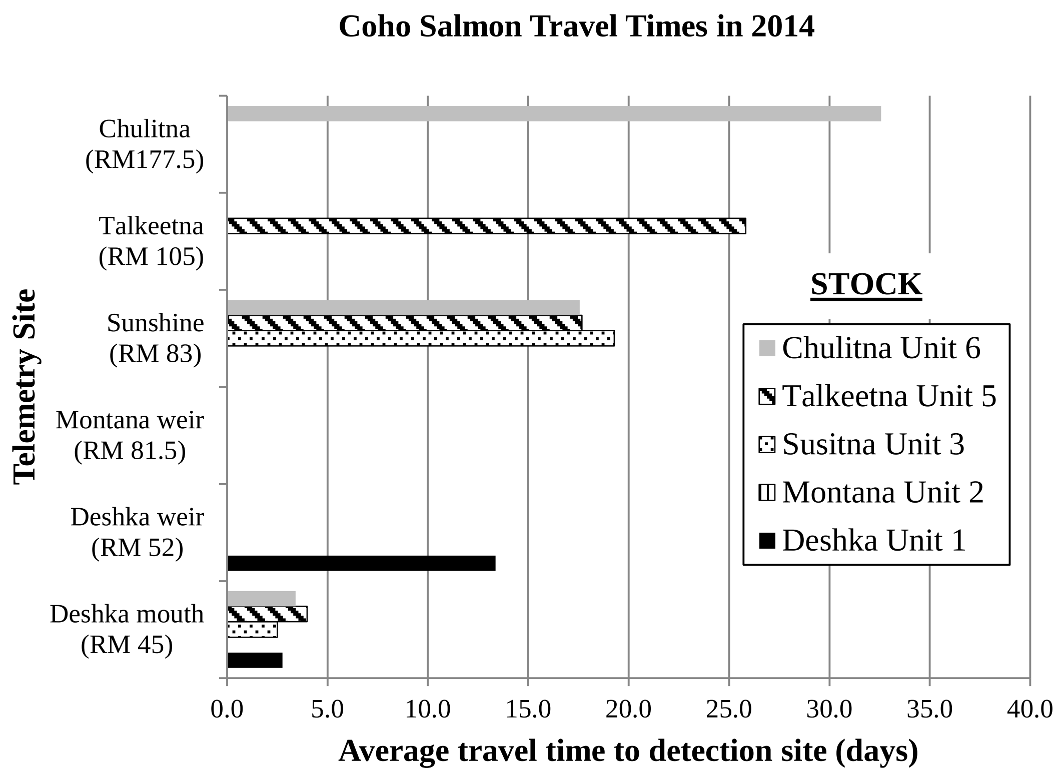

Figure 13.–Average number of days it took for coho salmon to travel from the Susitna PRM 34 tagging site to various stationary telemetry sites by stock (determined from spawning location) in 2014.

Note: The average number of days is determined from all fish recorded at a specified telemetry site by stock from the day of release to the first day detected at the specified site.

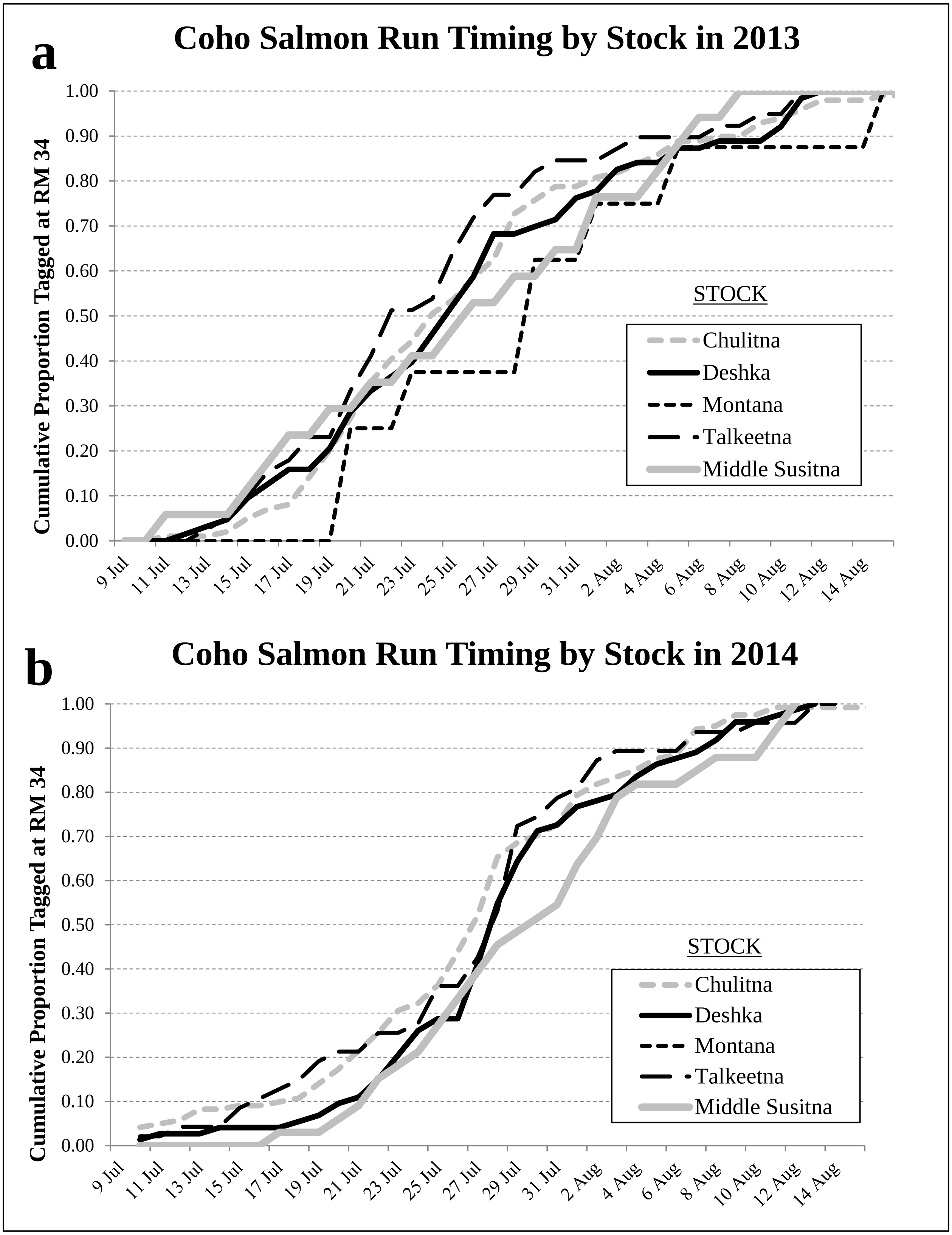

Figure 14.–Run timing of coho salmon stocks tagged at the Susitna PRM 34 tagging site in 2013 (a) and 2014 (b).

DISCUSSION

The Susitna River inriver sport fishery is managed by geographical areas called "Units" (Figure 1). From radiotag distribution and mark–recapture estimates of the Chinook salmon inriver run, we estimated the inriver run to each unit and the proportional contribution of each unit to the overall abundance (Table 5). We did not estimate escapement to each unit because the sport harvest estimates are not unit-specific. Radiotagged Chinook salmon were assigned to a "stock" based on the management unit they were assumed to have spawned in. Overall, stocks from most management units (except upper Susitna River Unit 3) contributed equally to the mainstem Susitna River inriver run. However, when the Yentna River stock was included in 2014, the Yentna River stock contributed 25% to the run; stocks from units 1, 2, 5, and 6 contributed 15–19%; and the Susitna Unit 3 stock contributed 7%.

The escapement index as a percentage of the inriver run to a unit (e.g., for 2014, the escapement index for Unit 2 was 20% of the inriver run estimate to Unit 2; Table 5) has some potential for bias and inferences should be made with care because the inriver run estimates do not account for harvest and therefore the percent of the inriver run represented by the escapement index underrepresents escapement if any harvest occurred. Furthermore, the percentages for each unit may not be comparable to each other because harvest may vary between units. However, the total mainstem Susitna River Chinook salmon inriver harvests in 2013 and 2014 were extremely low by historical standards so this bias should be minimal and not meaningfully alter the resulting proportions given here for each management unit.

Based on telemetry and mark–recapture abundance estimates, the Unit 6 (Chulitna River drainage) aerial survey indexed the smallest percentage of the estimated Chinook salmon run within a unit, counting 6.4% and 6.2% of the inriver runs to Unit 6 in 2013 and 2014, respectively (Table 5). This low percentage appears due to the large concentrations of probable spawning sites located outside the surveyed area but within the unit (Figures 2, 3, and 4). Only the Chulitna River upstream of the West Fork Chulitna River has major clearwater tributaries that are most practical for visual surveys (personal observation).

The Unit 1 (Deshka River) weir count indexed the greatest percentage of the estimated Chinook salmon run within a unit in both 2013 and 2014 (Table 5). Greater than 100% of the inriver run estimate to Unit 1 was counted at the weir on the Deshka River in 2014. However, the Deshka River is the only portion of Unit 1 within the mark–recapture abundance experiment boundary, so the estimate and the weir count should be nearly identical. However, the point estimate of the inriver run to the Deshka River in 2014 was less than the Deshka River weir count, and this is probably due to random error inherent with the sampling used in the mark–recapture abundance estimate.

The percentage of the estimated Chinook salmon inriver run that was observed by aerial indexes of Units 2, 3, and 5 varied from 15.6% (Unit 3 in 2013) to 30.0% (Unit 5 in 2014) in 2013 and 2014 (Table 5). In Unit 4 (Yentna River), 34% of the estimated Chinook salmon inriver run to that unit was observed by the aerial index count in 2014. Overall, these results suggest that the aerial and weir indexes in all units except Unit 6 and Unit 3 observe at least one fifth of the inriver run to each unit.

For Chinook salmon index counts in the mainstem Susitna and Yentna rivers to be useful for fishery management, they must be related to the escapement. Although escapement cannot be estimated by unit because unit-specific harvest information is not available, direct comparisons between the sum of aerial and weir escapement indexes and the mark–recapture estimate of escapement (mark–recapture abundance minus inriver sport harvest) were made for Chinook salmon in the mainstem Susitna River (Table 4) and the Yentna River (Table 6), and for coho salmon in the mainstem Susitna River (Table 7). The percentage of the mark–recapture escapement estimate observed in the sum of aerial index counts was fairly consistent between 2013 and 2014 for Chinook salmon in the mainstem Susitna River (13.5% and 15.2%, respectively); aerial surveys observed 35.6% of the Yentna River Chinook salmon escapement in 2014; and for coho salmon, the Deshka weir counts were fairly consistent between 2013 and 2014 as well (19% and 16%, respectively).

ADF&G has a 30-year time series of escapement index counts for Chinook salmon on the mainstem Susitna and Yentna rivers. Trends in escapement over the 30-year period can be examined using an expansion factor based on the average percentage of the escapement that an index counts. For example, on average 14% of the estimated Chinook salmon escapement was observed in aerial surveys in the mainstem Susitna River, which translates into an expansion factor of 7.0 (1/0.143) for converting aerial surveys to the full escapement in the mainstem Susitna River (Table 4). However, including the Deshka River weir escapement counts in addition to the aerial surveys gives an expansion factor of 2.72 (1/0.368) for Chinook salmon in the mainstem Susitna River, which is much less subject to error. Aerial surveys observed 36% of the escapement estimate for Chinook salmon in the Yentna River (Table 6), which translates into an expansion factor of 2.8 (1/0.356) for converting aerial surveys to the full escapement. Finally, the expansion factor to estimate the mainstem Susitna River coho salmon escapement from the Deshka River escapement is 5.8 (1/0.172; Table 7).

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