Fishery Data Series No. 16-45

Chinook Salmon Escapement in the Chena, Salcha, and Goodpaster Rivers and Coho Salmon Escapement in the Delta Clearwater River, 2015

by

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and

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November 2016

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

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November 2016

Development and publication of this manuscript were partially financed by the Federal Aid in Sport fish Restoration Act(16 U.S.C.777-777K) under Project F-10-31, Job No. S-3-1(b)

ADF&G Fishery Data Series was established in 1987 for the publication of Division of Sport Fish technically oriented results for a single project or group of closely related projects, and in 2004 became a joint divisional series with the Division of Commercial Fisheries. Fishery Data Series reports are intended for fishery and other technical professionals and are available through the Alaska State Library and on the Internet: http://www.adfg.alaska.gov/sf/publications/. This publication has undergone editorial and peer review.

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This document should be cited as follows:
Stuby, L., and M. Tyers. 2016. Chinook salmon escapement in the Chena, Salcha, and Goodpaster rivers and coho salmon escapement in the Delta Clearwater River, 2015. Alaska Department of Fish and Game, Fishery Data Series No. 16-45, Anchorage.

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ABSTRACT

During 2015 the Alaska Department of Fish and Game (ADF&G) conducted salmon enumeration projects on the Chena and Delta Clearwater rivers in the Tanana River drainage. Enumeration projects on the Salcha and Goodpaster rivers were conducted by Bering Sea Fishermen’s Association and Tanana Chiefs Conference, respectively, of which this report serves as an archive. Chinook salmon *Oncorhynchus tshawytscha* escapements for the Salcha and Goodpaster rivers were estimated using tower-counting techniques and similarly for the Chena River with the addition of dual-frequency identification sonar (DIDSON) methodology to account for days missed due to high water. Coho salmon *O. kisutch* escapement in the Delta Clearwater River was estimated by a visual boat survey at peak escapement. Counting towers on the Chena, Salcha, and Goodpaster rivers operated from 30 June until 6 August, 12 July until 9 August, and 9 to 30 July, respectively. High, muddy water due to inclement weather precluded acquiring counts during 3–7, 21–25, and 28 July, and 1–6 August for the Chena River, and 1-11 July for the Salcha River. Estimated Chinook salmon escapement for the Chena River was 6,291 (SE = 169). During the carcass survey, 591 Chinook salmon were collected to estimate the age, sex, and length composition of the escapement. Dominant age classes were age 1.2 (44%) for males and age 1.4 (87%) for females. Estimated proportion of females was 0.55 (SE = 0.02) and the proportion adjusted for gender-bias was 0.39 (SE = 0.07). Mean length of females in the Chena River escapement was 809 mm and mean length of males was 674 mm. Chum salmon escapement for the Chena River was 8,620 (SE = 153), and because counting operations ceased during the chum run, this count is considered incomplete. The peak escapement count of coho salmon escapement in the Delta Clearwater River on 22 October was 19,553. Chinook salmon escapement for the Salcha River was 6,879 (SE = 1,617) and 2,353 (SE = 97) for the Goodpaster River.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, chum salmon, *Oncorhynchus keta*, coho salmon, *Oncorhynchus kisutch*, Chena River, Delta Clearwater River, Salcha River, Goodpaster River, counting tower, escapement, DIDSON

INTRODUCTION

The primary purpose of this report is to present findings from salmon escapement enumeration projects in the Tanana River drainage conducted by the Alaska Department of Fish and Game-Sport Fish Division (ADF&G-SF) during 2015. These projects included an enumeration project on the Chena River that consisted of a counting tower and dual-frequency identification sonar (DIDSON) to estimate total escapement of Chinook salmon *Oncorhynchus tshawytscha* and partial escapement of chum salmon *O. keta*, and a roving boat survey count to estimate escapement of coho salmon *O. kisutch* in the Delta Clearwater River. The main body of this report details methodologies and results from these 2 assessment projects.

Secondarily, this report presents data summaries and estimates of escapement of Chinook salmon from counting tower projects conducted during 2015 by Bering Sea Fishermen’s Association (BSFA) on the Salcha River and by Tanana Chiefs Conference (TCC) on the Goodpaster River. Information from these projects is in this report to archive the count data and escapement estimates in a publication that is easily accessible by stakeholders and other researchers. Information pertinent to the Salcha and Goodpaster rivers enumeration studies are found in Appendix B and Appendix C, respectively.

The Chena and Salcha rivers support the largest spawning populations of Chinook salmon on the Alaskan side of the Yukon River drainage, while the Delta Clearwater River (DCR) supports the largest spawning population of coho salmon *O. kisutch* in the entire Yukon River drainage. The Goodpaster, Chatanika, and Nenana rivers also support important spawning populations of Chinook and coho salmon.

The *Policy for the Management of Sustainable Salmon Fisheries* (SSFP; 5 AAC 39.222, 2001) directs the Alaska Department of Fish and Game (ADF&G) to provide the Alaska Board of Fisheries (BOF) with reports on the status of salmon stocks and identify any salmon stocks that present a concern related to yield, management, or conservation. In 2000, the BOF classified Yukon Chinook salmon as a yield concern. A stock of yield concern is defined as “a concern arising from a chronic inability, despite the use of specific management measures, to maintain expected yields, or harvestable surpluses, above a stock's escapement needs" (5 AAC 39.222(f)(42)).

In response to the BOF designation, a management plan (*Yukon River King Salmon Management Plan* 5AAC 05.360) and biological escapement goals (BEGs) of 2,800–5,700 Chinook salmon for the Chena River and 3,300–6,500 for the Salcha River were established by ADF&G in attempts to provide for maximum sustained yield. In contrast, a sustainable escapement goal (SEG) of 5,200–17,000 coho salmon in the Delta Clearwater River (DCR) was established because the spawner-recruit information required to establish a BEG was not available. There are currently no escapement goals for any salmon stocks in the Chatanika, Goodpaster, or Nenana rivers.

In 2001, the BOF directed ADF&G to manage Chinook and coho salmon harvests so that escapements fall within the BEGs and SEG. Currently the Yukon River Chinook salmon fisheries (commercial, subsistence, personal-use, and sport) are managed under the *Yukon River King Salmon Management Plan* (5 AAC 05.360) and the Chena and Salcha salmon stocks are also managed under the *Chena and Salcha River King Salmon Sport Harvest Management Plan* (5 AAC 74.060). The combined plans manage the commercial, subsistence, personal use, and sport fisheries through fishery gear, bag limit, and timing restrictions to achieve the established escapement goals first and then the amount necessary for subsistence (ANS) throughout the entire Alaskan portion of the Yukon River drainage.

Historically, Chinook salmon along with summer and fall chum salmon were targeted in the commercial fisheries. During the 10-year historical period of high production (1989–1998), commercial harvests of Chinook salmon averaged approximately 100,000 fish (Estensen et al 2015). Due to poor returns, direct commercial gillnet (drift and set) fisheries for Chinook salmon have not taken place since 2007. Incidental harvest of Chinook salmon during summer and fall chum directed fisheries has taken place up through 2011 with an average 5-year harvest of 31,134 during 2009–2013 (Estensen et al. 2015). The commercial sale of Chinook salmon has been prohibited since 2012.

Currently, the commercial harvest of coho salmon takes place during commercial openings on fall chum salmon. Since 2009, ADF&G has allowed late season coho salmon directed commercial fishing when fall chum runs are in excess of 550,000 fish. Such fisheries occurred in 2009–2011 and 2014. The average harvest during these years was 45,816 fish (Estensen et al 2015).

Chinook salmon are an important subsistence species throughout the Yukon River drainage. The current amount ANS of Chinook salmon in the Alaskan Yukon River drainage was designated by the BOF in January 2013 to be 45,500–66,704 Chinook salmon. During 2007–2011, Chinook salmon harvests varied from 55,292 (2007) to 41,069 (2011) with a 5-year average of 44,065 (Fall et al. 2014). Since 2008, Chinook salmon harvests were below the ANS, although earlier harvests had remained relatively stable near 50,000 (Schmidt and Newland 2012). The 2012 harvest fell further to 30,486 and preliminary 2013 and 2014 harvest values average approximately 11,000 and 3,000, respectively (Estensen et al 2015).

Coho salmon are also an important subsistence species in the Yukon River. Since 2003, the average annual coho salmon subsistence harvest was 18,000, the average commercial harvest was 49,000, the average personal-use harvest was 258, and the average sport harvest was 750 (JTC 2015).

The Chena River Chinook salmon sport fishery takes place in the Chena River downstream from all spawning areas. The 5-year (2009–2013) average sport catch of Chinook salmon in the Chena River was 296 fish and the corresponding average harvest was 57 fish (Jennings et al. 2011a, 2011b, 2015, *In press*). A recent 5-year (2009–2013) average sport catch of Chinook salmon in the Salcha River was 713 fish and the corresponding average harvest was 174 fish (Jennings et al. 2011a, 2011b, 2015, *In press*). Sport fishing on the Goodpaster River was opened in 2007 but limited to catch and release only. In 2007–2008, 2010, and 2011–2013, the reported sport catch was zero. In 2009, the sport catch was 104 fish (Jennings et al. 2011a, 2011b, 2015, *In press*). The 5-year (2009–2013) average sport catch of coho salmon in the Delta Clearwater River was 3,070 fish, and the corresponding average harvest was 147 fish (Jennings et al. 2011a, 2011b, 2015, *In press*).

Meaningful biological escapement goals are established with long, unbroken data strings of escapement and composition estimates. Chinook salmon enumeration and escapement composition (age, sex, length) projects have been conducted annually since 1986 in the Chena River and 1987 in the Salcha River, which makes them the longest continuous Chinook salmon escapement data sets in the Yukon River drainage. The monitoring programs provide information on run magnitude and timing, which allows managers to modify fishing regulations to achieve the established escapement goals. In addition, annual Chinook salmon escapement assessments are important when examining the spawner-recruit relationships used to determine the escapement goals. The current BEG is evaluated every 3 years during the BOF with all additional years of acquired data.

OBJECTIVES

The objectives in 2015 were to:

1. estimate the total escapement of Chinook salmon in the Chena River using tower-counting techniques;
2. estimate age, sex, and length compositions of the escapement of Chinook salmon in the Chena River;
3. count coho salmon in the Delta Clearwater River to obtain a count of the minimum escapement; and
4. count chum salmon in the Chena River throughout the duration of the Chinook salmon run.

METHODS

CHENA RIVER CHINOOK SALMON

In 2015 daily escapements of Chinook and chum salmon were estimated by visually counting fish from a scaffolding tower on the north bank of the Chena River just upstream from the Moose Creek dam (Figure 1). Lights were suspended over white fabric panels that were attached to the river bottom to provide illumination during periods of low ambient light. Each year, counting begins on or about 25 June and continues into August until there are 3 continuous days with no net upstream passage of Chinook salmon. Virtually all Chinook salmon spawning occurs upstream of this site and no harvest of salmon is allowed upstream of the dam, so final estimates represent the total escapement.

Five technicians were assigned to enumerate the salmon escapement in the Chena River. Each day was divided into three 8 h shifts. Shift I began at 0000 hour (midnight) and ended at 0759 hours; Shift II began at 0800 hours and ended at 1559 hours; Shift III began at 1600 hours and ended at 2359 hours. The start time for all counts began between the top of the hour and 10 min past.

The project was designed to count all salmon passing upstream and downstream throughout the whole river for 20 minutes every hour over the course of the run. The numbers of Chinook and chum salmon were recorded on field forms at the end of each 20 min count. In addition, the technician would evaluate and record the water clarity conditions (Table 1), as well as the river height from a staff gauge mounted on the dam. Only counts with an associated water clarity rank of 3 or lower were used in the estimate of escapement. A count with a rank of 4 or 5 was considered as no count. Each day, the data sheets from the previous day were returned to the project leader.

Two DIDSONs (Model 300 Sound Metrics Corp., Lake Forest Park, WA) were deployed upstream of the white fabric panels on both sides of the river to enumerate the number of migrating salmon. The DIDSONs were operated throughout the run with the primary purpose of estimating Chinook and chum salmon passage during periods of high water (>2 consecutive days) when tower counts could not be completed.

Each sonar was positioned so it could record images from each half of the river, 24 hours a day, 7 days a week. Previous tower counts have shown that the majority of the Chinook salmon migrate up the north side of the river at the tower site, which is probably due to a deeper channel located on that side of the river. Both DIDSONs were mounted to portable aluminum tripods that were moved manually to adjust for water depth. Small weir structures were deployed at each site to ensure migrating salmon passed through the sonar beams.

Inseason and during periods of low water clarity, all salmon swimming upstream were recorded on the DIDSONs, and the numbers of salmon for the first 20 min block of each hour were recorded on field forms. These counts were expanded by a factor of 3, providing an estimate of the total number of salmon passing upstream of the sonars. Both the visual and DIDSON counts were reported daily to area managers.

Postseason, a complete set of all sonar targets and their respective length measurements and passage dates were used in an adaptation of a mixture model developed by Huang (2012) and detailed below in the data analysis section. The model uses Bayesian techniques to estimate the proportions of Chinook and chum salmon migrating upstream, providing escapement estimates for periods in which visual counts were compromised by water clarity. During times when visual counts could be conducted, mixture model results were compared to actual tower counts.

In addition to the tower counts, carcasses of spawned-out Chinook salmon were collected during the first 2 weeks of August from the dam upriver to the second bridge (Figure 1) to estimate age, sex, and length composition of the escapement. Each salmon was measured from mid eye to tail fork (METF). Ages were determined from scale patterns as described by Mosher (1969). Three scales were removed from the left side of the fish approximately 2 rows above the lateral line along a diagonal line downward from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (Welander 1940). If no scales were present in the preferred area due to decomposition, scales were removed from the same area on the right side of the fish or, if necessary, from any location other than along the lateral line where there were any scales remaining.

Two riverboats with a minimum of 3 people in each boat (1 operator and 2 people collecting carcasses) were used to collect Chinook salmon carcasses. Chinook salmon carcasses were speared from the boats and collected along banks and gravel bars. All deep pools and eddies that could be safely explored were inspected to find and sample as many Chinook salmon carcasses as possible. After collection, the carcasses were placed in a large tub onboard the boat. Once the tub was full, the boat was landed on a gravel bar and the carcasses were laid out in rows of 10 with their left sides facing up. After sampling, all carcasses were cut in a distinctive manner through the left side of the fish to avoid resampling and returned to the river.

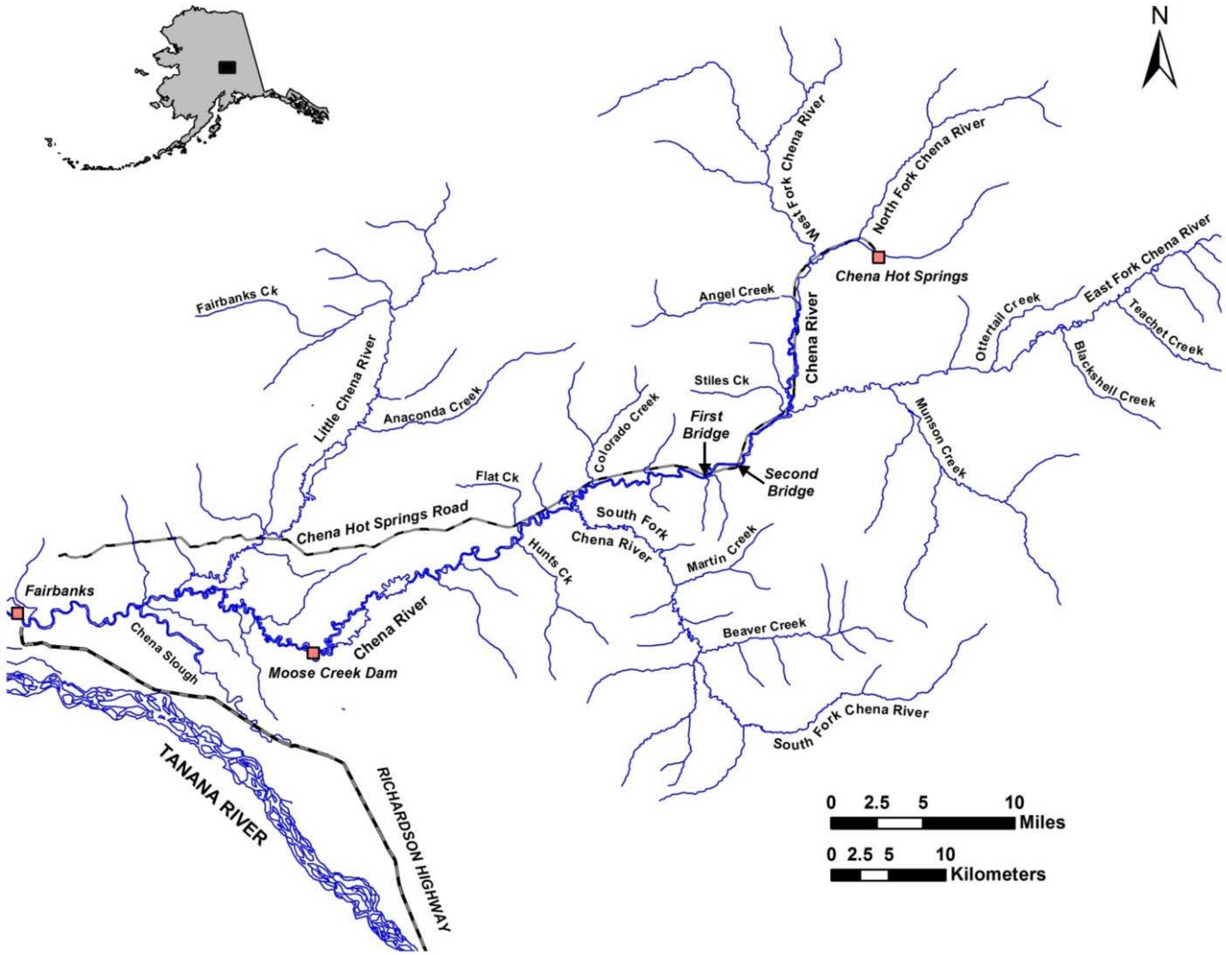

Figure 1.–Map of the Chena River showing the location of Moose Creek Dam where the counting tower was located and the second bridge on Chena Hot Springs Road that was the upstream extent of carcass surveys.

Table 1.–Water clarity classifications.

Rank	Description	Salmon Viewing	Water Condition
1	Excellent	All passing salmon are observable	Virtually no turbidity or glare, "drinking water" clarity; all routes of passage observable
2	Good	All passing salmon are observable	Minimal to moderate levels of turbidity or glare; all routes of passage observable
3	Fair	Possible, but not likely, that some passing salmon may be missed	Moderate to high levels of turbidity or glare; a few likely routes of passage are partially obscured
4	Poor	Likely that some passing salmon may be missed	Moderate to high levels of turbidity or glare; some or many likely routes of passage are obscured
5	Un-observable	Passing fish are not observable	High level of turbidity or glare; ALL routes of passage obscured

Delta Clearwater River Coho Salmon

Previous aerial surveys of the DCR drainage (Figure 2) have shown that an average of 20% of the coho escapement is found in areas inaccessible to a boat survey; therefore, counts of adult coho salmon were conducted to obtain a minimum escapement estimate. This estimate was used to evaluate whether or not the SEG was met. Two persons (a boat operator and a counter) conducted the survey from a drifting river boat equipped with a 5 ft elevated platform. The survey is typically done during peak spawning times over the course of 1 to 2 days. The survey was conducted along the lower 18 miles of the Delta Clearwater River to within 1.0 mile of the Clearwater Lake outlet. The total numbers of coho salmon observed (both dead and alive) were recorded every mile at mile markers posted on the river bank and section counts were summed to estimate escapement.

Data Analysis (Chena River Chinook Salmon)

Counting Tower

Estimates of Chinook salmon escapement were stratified by day. Daily estimates of escapement were considered a two-stage direct expansion where the first stage was 8-hour shifts within a day and the second stage was counting periods within a shift. The second stage was considered systematic sampling because the counting periods were not chosen randomly.

The formulas necessary to calculate escapement from counting tower data were taken directly or modified from those provided in Cochran (1977). The expanded shift escapement on day *d* and shift *i* was calculated by:

$$Y_{di} = \frac{M_{di}}{m_{di}} \sum_{j=1}^{m_{di}} y_{dij} \,. \qquad (1)$$

The average shift escapement for day *d* was:

$$\bar{Y}_d = \frac{\sum_{i=1}^{h_d} Y_{di}}{h_d} \,. \qquad (2)$$

The following criteria were established to determine the methods used to estimate the daily escapement and its variance:

1. when 2 or more shifts were considered complete, escapement and variance were estimated using equations 1-8;
2. when counts were only conducted during 1 shift but all 8 counting periods were sampled, escapement was estimated using equation 1-3 and variance was estimated by back-calculating using equation 11,
3. when no shifts were considered complete for up to 2 consecutive days, interpolation techniques described in equations 12 and 13 were used to estimate escapement and back-calculating using equation 11 was used to estimate variance; and,
4. when no shifts were considered complete for 3 or more consecutive days, the mixture model was used with DIDSON sonar imagery to estimate the daily escapement and associated variance.

A minimum of 4 counting periods per shift was required for a complete shift. Counts were conducted during all scheduled counting periods unless water clarity conditions prohibited counts.

The expanded daily escapement was estimated as:

$$\hat{N}_d = \bar{Y}_d H_d \,. \qquad (3)$$

The period sampled was systematic, because a period was sampled every hour in a shift. The sample variance associated with periods was approximated using the successive difference approach:

$$s_{2di}^2 = \frac{1}{2(m_{di}-1)} \sum_{j=2}^{m_{di}} \left(y_{dij} - y_{di(j-1)}\right)^2 \,. \qquad (4)$$

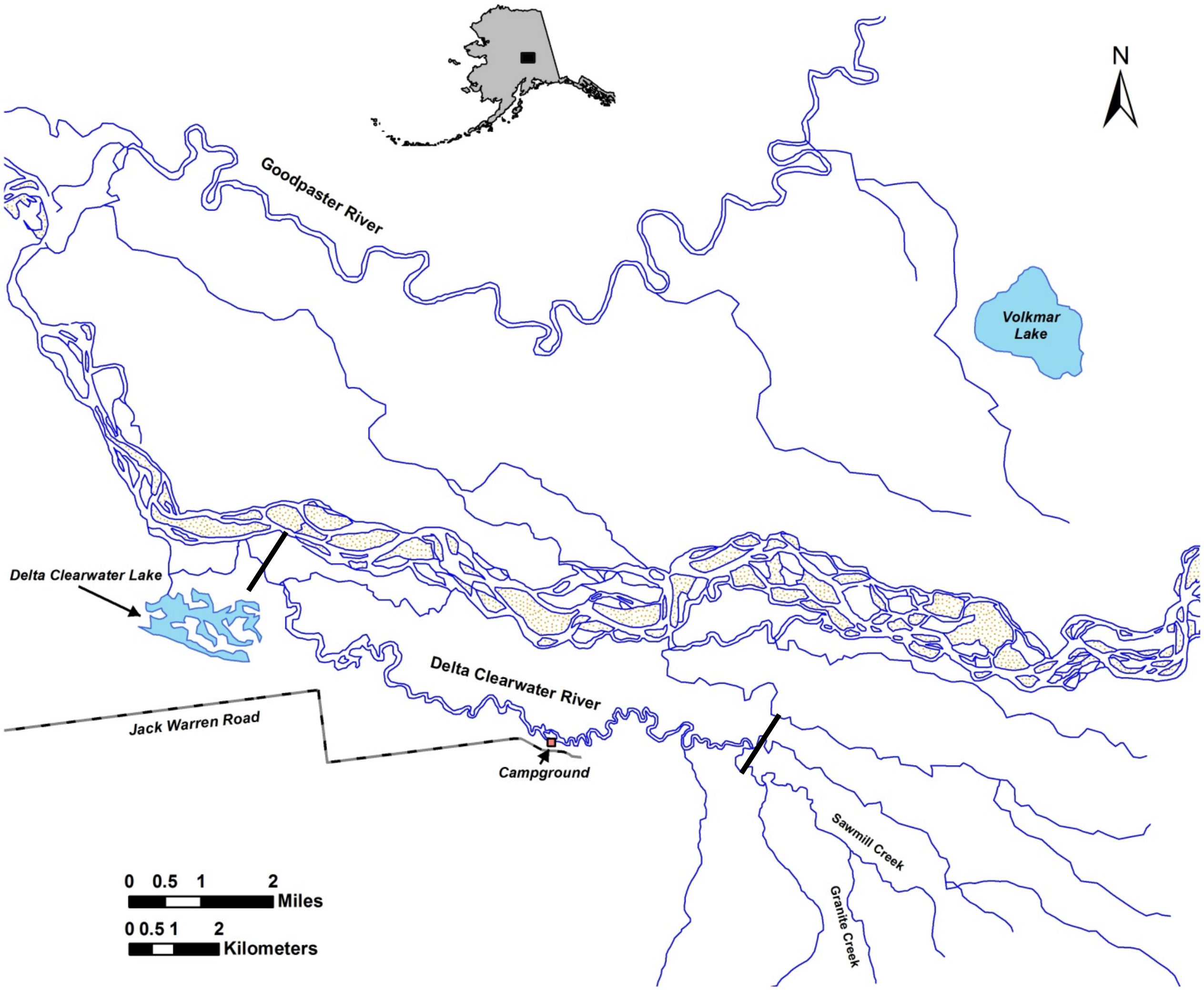

Figure 2.–Map of the Delta Clearwater River demarcating the survey area (bold lines).

Shift sampling was random. The between-shift sample variance was calculated as:

$$s_{1d}^2 = \frac{1}{h_d - 1}\sum_{i=1}^{h_d}\left(Y_{di} - \overline{Y}_d\right)^2 . \quad (5)$$

The variance for the expanded daily escapement was estimated by:

$$\hat{V}\left(\hat{N}_d\right) = \left[\left(1 - f_{1d}\right)H_d^2 \frac{s_{1d}^2}{h_d}\right] + \quad (6)$$

$$\left[\frac{1}{f_{1d}}\sum_{i=1}^{h_d}\left(\left(1 - f_{2di}\right)M_{di}^2 \frac{s_{2di}^2}{m_{di}}\right)\right]$$

where:

$$f_{1d} = \frac{h_d}{H_d}\text{; and} \quad (7)$$

$$f_{2di} = \frac{m_{di}}{M_{di}} \quad (8)$$

Where:

d = day;

i = 8 h shift;

j = 20 min counting period;

y_{dij} = the observed 20 min period count;

Y_{di} = expanded shift escapement;

m_{di} = number of 20 min counting periods sampled within a shift;

M_{di} = total number of possible 20 min counting periods within a day (24 would indicate a full day);

h_d = number of 8 h shifts sampled within a day;

H_d = total number of possible 8 h shifts within a day;

D = total number of possible days;

f_1 = fraction of 8 h shifts sampled; and

f_2 = fraction of 20 min counting periods sampled.

Total escapement and variance were estimated by:

$$\hat{N} = \sum_{d=1}^{D}\hat{N}_d\text{; and} \quad (9)$$

$$\hat{V}\left(\hat{N}\right) = \sum_{d=1}^{D}\hat{V}(\hat{N}_d). \quad (10)$$

Equation 5, the sample variance across shifts, required data from more than 1 shift per day. In the event that water conditions and/or personnel constraints did not permit at least 2 shifts during a day, a coefficient of variation (*CV*) was calculated using all days when more than 1 shift was worked. The average *CV* was used to approximate the daily variation for those days when fewer than 2 shifts were worked. The *CV* was used because it is independent of the magnitude of the estimate and therefore relatively constant throughout the run (Evenson 1995). The daily *CV* was calculated as:

$$CV_d = SE_d \big/ \hat{N}_d . \quad (11)$$

When k ($k \le 2$) consecutive days were not sampled due to adverse viewing conditions, the moving average estimate for the missing day i was calculated as:

$$\hat{N}_i = \frac{\sum_{j=i-k}^{i+k} I(day\, j \text{ } was\, sampled)\hat{N}_j}{\sum_{j=i-k}^{i+k} I(day\, j \text{ } was\, sampled)} \quad (12)$$

where:

$$I(\cdot) = \begin{cases} 1 & when\, the\, condition\, is\, true \\ 0 & otherwise \end{cases} \quad (13)$$

is an indicator function. The moving average procedure was only applied to data gaps that did not exceed 2 days (12 consecutive shifts).

Gender-selective sampling has been noted when comparing sex ratios of Chinook salmon collected during carcass surveys with those collected by electrofishing (Stuby 2001). Correcting the estimated sex composition estimates from a carcass survey to estimates of what we might observe in a completely random sample required analysis of data from previous years when mark–recapture experiments were conducted. The adjustment was based on paired mark–recapture and carcass survey data from the

Chena River (1989–1992, 1995–1997, and 2000). Abundance estimates were generated for each gender and the ratio of the abundance estimate of females to the total abundance was used to generate an unbiased estimate of the proportion of females in the population. A "correction factor" was calculated and applied to the estimated proportion of females in the carcass sample (in years when only carcass samples were collected) based on the average relationship between the proportion estimate from the mark–recapture estimates and the proportion estimates from the carcass samples for all 8 years (unpublished analysis from ADF&G Sport Fish Division, Fairbanks). A similar correction was developed for the Salcha River.

The escapement estimate was apportioned by sex prior to apportioning by age categories within each sex. The estimated proportions of males and females from carcass surveys were calculated using (Cochran 1977):

$$\hat{p}_{sc} = \frac{y_{sc}}{n_c}; \tag{14}$$

with variance:

$$\hat{V}[\hat{p}_{sc}] = \frac{\hat{p}_{sc}(1-\hat{p}_{sc})}{n_c - 1}; \tag{15}$$

where y_{sc} is the number of salmon of sex s observed during carcass surveys and n_c is the total number of salmon of either sex observed during carcass surveys for $s = m$ or f.

The adjustment necessary to compensate for the gender bias associated with carcass sampling is $\hat{R}_p$ = 0.708 with $\hat{V}(\hat{R}_p)$ = 0.018 for the Chena River and $\hat{R}_p$ = 0.867 with $\hat{V}(\hat{R}_p)$ = 0.030 for the Salcha River.

The bias-adjusted estimate and variance (Goodman 1960) of the proportion of females, $\tilde{p}_{fe}$, is:

$\tilde{p}_{fe} = \hat{p}_{fc}\hat{R}_p$ with variance:

$$\hat{V}(\tilde{p}_{fe}) = \hat{p}_{fc}^2\hat{V}(\hat{R}_p) + \hat{R}_p^2\hat{V}(\hat{p}_{fc}) - \hat{V}(\hat{R}_p)\hat{V}(\hat{p}_{fc}). \tag{16}$$

The estimate and variance of the proportion of males observable during past electrofishing events were:

$\tilde{p}_{me} = 1 - \tilde{p}_{fe}$ and $\hat{V}(\tilde{p}_{me}) = \hat{V}(\tilde{p}_{fe})$.

Escapement of each sex was then estimated by:

$$\hat{N}_s = \tilde{p}_{se}\hat{N} \tag{17}$$

The variance for $\hat{N}_s$ in this case was (Goodman 1960):

$$\hat{V}(\hat{N}_s) = \hat{V}(\tilde{p}_{se})\hat{N}^2 + \hat{V}(\hat{N})\tilde{p}_{se}^2 - \hat{V}(\tilde{p}_{se})\hat{V}(\hat{N}). \tag{18}$$

Chinook salmon ages are recorded with the number of freshwater and ocean years of residence. For example, age-1.2 symbolizes 1 year of freshwater residence and 2 years in the ocean. Given these salmon spawn in late summer and hatch the following year, a 1.2 fish will represent a total age of 4.

The proportions of fish at age k by sex s for samples collected solely for age, sex, and length were calculated as:

$$\hat{p}_{sk} = \frac{y_{sk}}{n_s} \tag{19}$$

where: $\hat{p}_{sk}$ = the estimated proportion of Chinook salmon that are age k; y_{sk} = the number of Chinook salmon sampled that are age k; and n_s = the total number of Chinook salmon sampled.

The variance of this proportion was estimated as:

$$\hat{V}[\hat{p}_{sk}] = \frac{\hat{p}_{sk}(1-\hat{p}_{sk})}{n_s - 1} \tag{20}$$

Mean lengths and associated variances were calculated for each sex and associated age class using:

$$\bar{l}_j = \frac{\sum_{j-1}^{n} l_j}{n_s}; \text{ and} \quad (21)$$

$$V[\bar{l}_j] = \frac{\sum_{j=1}^{n}(l_j - \bar{l}_j)}{n(n-1)} \quad (22)$$

Escapement at age k for each sex was then estimated by:

$$\hat{N}_{sk} = \hat{p}_{sk}\hat{N}_s \quad (23)$$

The variance for $\hat{N}_{sk}$ in this case was (Goodman 1960):

$$\hat{V}(\hat{N}_{sk}) = \hat{V}(\hat{p}_{sk})\hat{N}_s^{\,2} + \hat{V}(\hat{N}_s)\hat{p}_{sk}^2 - \hat{V}(\hat{p}_{sk})\hat{V}(\hat{N}_s). \quad (24)$$

DIDSON Mixture Model

The proportions of Chinook and chum salmon in the total DIDSON counts were estimated using a mixture model with fish length being the discriminating information, informed by run timing. The probability density function (pdf) of the actual length of fish i (y_i) was modeled using a weighted mixture model,

$$f(y_i) = p_{c,i}f_c(y_i) + p_{k,i}f_k(y_i), \quad (25)$$

$$0 \le p_{c,i}, p_{k,i} \le 1, \text{ and } p_{c,i} + p_{k,i} = 1$$

where $f_c(y)$ is the length distribution of chum salmon and $f_k(y)$ is the length distribution of Chinook salmon; weights $p_{c,i}$ and $p_{k,i}$ are the probabilities of fish i being a chum or Chinook salmon, respectively.

There is a moderate difference in lengths between males and females among each species. The length distribution (pdf) of either species can be expressed with a two-component sex mixture model as shown below,

$$f_c(y) = \theta_{c1} f_{c1}(y) + \theta_{c2} f_{c2}(y)$$

$$f_k(y) = \theta_{k1} f_{k1}(y) + \theta_{k2} f_{k2}(y) \quad (26)$$

where θ_{c1} and θ_{c2} are the proportions of male and female chum salmon, respectively; and θ_{k1} and θ_{k2} are the proportions of male and female Chinook salmon, respectively. The proportions of males and females add up to one for each species. Distributions $f_{cs}(y)$ and $f_{ks}(y)$ are assumed to be normal in either sex component s,

$$f_{cs}(y) \sim N(\mu_{cs}, \sigma_{cs}^2)$$

$$f_{ks}(y) \sim N(\mu_{ks}, \sigma_{ks}^2) \quad (27)$$

Prior information about the length means (μ) and variances (σ^2) used in equation (27) were found in other fishery research publications. For this study, prior information for Chinook and chum salmon length distributions were taken from the Arctic-Yukon-Kuskokwim (AYK) Database Management System. In addition, prior information for chum salmon length distribution was provided by Clark (1993).

Actual individual fish length (y) was not measured directly from individual fish and therefore was considered an unobserved variable. Instead, fish length was measured from DIDSON images. A linear relationship was assumed between DIDSON length ($y_{obs,i}$) and the actual fish length (y_i) for fish i. The DIDSON fish length (y_{obs}) was modeled as a normal variable whose mean was a linear function of actual fish length (y_i), or

$$y_{obs,i} = \beta_1 + \beta_2 y_i + \varepsilon_i \quad (28)$$

where y_{obs} refers to observed DIDSON lengths, which are the fish length measurements observed using the DIDSON; y_i refers to the actual fish length; and the intercept β_1 and slope β_2 are unknown parameters of the linear relationship between $y_{obs,i}$ and y_i. Paired data used to inform the relationship between $y_{obs,i}$ and y_i were obtained from the tethered-fish experiment conducted by Burwen and Fleischman (personal communication).

The mixture model (equations 25–29) contains unknown parameters including species probability parameters p_c and p_k, sex proportion parameters θs, intercept parameter β_1, and slope parameter β_2. In order to estimate these unknown parameters, the mixture model was fitted using Markov Chain Monte Carlo (MCMC) as implemented in the statistical software package JAGS (Plummer 2003), called through the statistical software R (R Core Team 2014) using R package R2jags (Su and Yajima 2015).

According to Bayes' Theorem, the posterior distribution of the unknown parameters is proportional to the likelihood of the data multiplied by the prior distribution of the parameters. The likelihood of the data collected follows the mixture model density function (Equation 25). The prior distributions of the sex proportion parameters θs were assigned a Dirichlet(α,γ) distribution. It has been noted since this project's inception that the Chinook salmon run starts earlier and will usually peak before or during the early portion of the chum salmon run and that the proportion of the total run composed of Chinook salmon has followed an approximate logistic trend over the course of the run. Therefore, species probability parameters $p_{c,i}$ and $p_{k,i}$ for each day t_i were assigned diffuse Dirichlet priors (η_t, ζ_t) that were calculated by run date according to:

$$\log\left(\frac{\eta_t}{1-\eta_t}\right) = b_0 + b_1 t$$

$$\zeta_t = 1 - \eta_t; \qquad (29)$$

in which η_t denotes the modeled probability of a given sonar target being a Chinook salmon on day t, and η_t denotes the probability of a given sonar target being a chum salmon on day t. Hyperparameters b_0 and b_1 were estimated using logistic regression to model the relationship between run timing and species in historical data. If visual counts were available for the majority of a given year, that year's estimates of b_0 and b_1 were used; otherwise, the average values of these estimates from the year's tower counts were conducted were used instead. Chinook and chum salmon lengths were assigned normal priors, using data from the AYK Database Management System, as well as Clark (1993). The historic data used for model priors suggests that male and female chum salmon lengths are similar. Female chum salmon mean length was 553.0 mm (SE = 1.1 mm). Male chum salmon had a mean length of 583.6 mm (SE = 1.3 mm). Chinook salmon lengths vary moderately in their sex-length composition. Female Chinook salmon had a mean length of 851.4 mm (SE = 0.8 mm). Male Chinook salmon were smaller in size with a mean length of 703.9 mm (SE = 1.3 mm). The regression parameters β_1 and β_2 were assigned diffuse normal priors. The Bayesian MCMC was conducted using JAGS with 3 chains and 100,000 iterations in each chain. The first 50,000 iterations in each chain were considered as burn-in and discarded.

Species totals were calculated in each iteration of the MCMC procedure, thus giving posterior distributions of the escapement for each species. Escapement estimates and respective standard errors were then obtained by calculating the median and standard deviation of the posterior draws of species totals. JAGS code for model fitting can be found in Appendix A.

RESULTS

CHENA RIVER CHINOOK SALMON

The Chena River counting tower and sonar site operated from 30 June through 6 August. Visual counts could not be conducted during 3–7, 21–25, and 28 July, and 1–6 August due to high, muddy water obscuring visibility on the white flash panels. The estimated escapement of Chinook salmon based on both visual and sonar counts was 6,291 (SE = 169), which was greater than the upper end of the established BEG (Tables 2 and 3, Figure 3). The estimated chum salmon escapement was 8,620 (SE = 153), which was considered a minimum estimate because sonar counts were terminated before the chum salmon run was completed (Table 4).

Paired DIDSON and visual counts were made during the peak of the run during 8–20 July. During this time, the north-side sonar reset its configuration to a default setting that affected the accuracy of the measurement tool. Once this adjustment was realized, fish on these files were carefully re-measured and the estimated proportions of Chinook and chum salmon were similar between the mixture model and visual counts for days of paired estimates during 8–20 July (Figure 4). However, estimated numbers of Chinook and chum salmon for 26 and 27 July were dissimilar with the mixture model results. The counting tower was inoperable before and after these 2 days and this was approximately 2 weeks after the Chinook salmon run peaked and during the time when the chum salmon run was starting to peak.

Run-timing patterns (Figure 5) from the mixture model were described by the day of the run to facilitate comparison among years (i.e., Day 1 equals the first Chinook salmon passing upriver during a scheduled count). The 2015 estimate showed average run timing compared to the average magnitude and span of the run (Figure 5). In comparison, the complete visual tower estimate from 2013 showed a much later start date and proportionately higher numbers of initial fish counted. The later start date for 2014 is likely a result of high-water events throughout the Chinook salmon run that precluded tower counts and delayed the deployment of the DIDSONs until 8 July 2014. Run timing over all of the years that counting tower and/or sonar estimates have been successfully conducted have varied from mid-run (50%) values of 13 and 14 July during 2004 and 2008, respectively, to 24 and 26 July for 1999 and 2012, respectively (Figure 6). Similarly, the first fish were seen earlier during 2004 (25 June) and 2008 (30 June) and later during 2012 (5 July) and 1999 (9 July).

Salmon carcass surveys took place during 3-12 August. A total of 591 Chinook salmon carcasses were sampled for ASL data. The average length for females was 809 mm (SE = 4) and for males was 674 mm (SE = 8). Chum salmon were also sampled for sex and length data to add to the mixture model used to apportion Chinook from chum salmon in the DIDSON files. A total of 257 chum salmon were collected, of which 147 were males and 110 were females. Chum length was an average of 577 mm for males and 537 mm for females.

The sex composition of the escapement was 0.55 (SE = 0.02) females and 0.45 (SE = 0.02) for males (Table 5). The sex composition adjusted for gender bias during carcass surveys was 0.39 (SE = 0.07) for females and 0.61 (SE = 0.07) for males (Table 5, Figure 3).

Of the Chinook salmon sampled, 500 were aged. The dominant age class for females was 1.4 (87%) and for males was 1.2 (44%, Tables 6 and 7). Compared to the previous 5 years, a proportionately larger number of age 6 (1.5, 2.3) fish were collected (Figure 7), the majority being females.

DELTA CLEARWATER RIVER COHO SALMON

For 2015, 2 boat surveys of coho salmon on the Delta Clearwater River were conducted on 22 October and 3 November. The counts were 19,553 and 14,866, respectively (Table 8).

DISCUSSION

DIDSON techniques have proved an appropriate alternative to mark-recapture techniques in estimating large data gaps caused by missing counting tower estimates. Past mark–recapture experiments took place on the spawning grounds. Electroshocking methods can potentially harm salmon eggs within the spawning female during capture and when electrodes skim over redds (Stuby 2001). Mark–recapture experiments were considered a secondary means of acquiring an estimate because the precision of estimates obtained from daily tower-counts were substantially better. Mark–recapture experiments also tended to underestimate total abundance because river channel morphology limited how far upriver an electroshocking and carcassing boat could be driven, so not all of the spawning population could be sampled. Like the tower counts, DIDSON will record the salmon run as it is occurring and, as long as the equipment is operating well, assess the entire run.

Table 2.–Daily estimates of Chena River Chinook salmon escapement, 2015. Shaded cells denote days where counts were estimated from DIDSON due to high-water events precluding visual counts.

Date	Daily Escapement	Daily SE
30 June	12	3
1 July	3	2
2 July	24	2
3 July	10	1
4 July	39	2
5 July	78	3
6 July	116	4
7 July	197	6
8 July	63	3
9 July	159	6
10 Jul	167	7
11 Jul	69	7
12 Jul	393	9
13 Jul	487	10
14 Jul	519	10
15 Jul	465	9
16 Jul	459	9
17 Jul	354	10
18 Jul	336	10
19 Jul	183	6
20 Jul	127	8
21 Jul	89	5
22 Jul	86	7
23 Jul	84	6
24 Jul	148	8
25 Jul	137	9
26 Jul	57	10
27 Jul	185	10
28 Jul	304	11
29 Jul	73	6
30 Jul	158	7
31 Jul	197	7
1 Aug	154	8
2 Aug	112	7
3 Aug	68	6
4 Aug	66	6
5 Aug	95	5
6 Aug	21	4
Total	6,291	169

Table 3.–Estimates of the Chena River Chinook salmon escapement, 1986–2015.

	Escapement		
Year	Estimate	SE	Method
1986	9,065	1,080	Mark–Recapture
1987	6,404	557	Mark–Recapture
1988	3,346	556	Mark–Recapture
1989	2,730	249	Mark–Recapture
1990	5,603	1,164	Mark–Recapture
1991	3,172	282	Mark–Recapture
1992	5,580	478	Mark–Recapture
1993	12,241	387	Counting Tower
1994	11,877	479	Counting Tower
1995	11,394	1,210	Mark–Recapture
1996	7,153	913	Mark–Recapture
1997	13,390	699	Counting Tower
1998	4,745	503	Counting Tower
1999	6,485	427	Counting Tower
2000	4,694	1,184	Mark–Recapture
2001	9,696	565	Counting Tower
2002	6,967	2,466	Mark–Recapture
2003	11,100	653	Counting Tower
2004	9,645	532	Counting Tower
2005	-	-	-
2006	2,936	163	Counting Tower
2007	3,806	226	Counting Tower
2008	3,208	198	Counting Tower
2009	5,253	231	Counting Tower
2010	2,382	152	Counting Tower
2011	-	-	-
2012	2,220	127	Counting Tower
2013	1,859	141	Counting Tower
2014	7,192	73	Sonar
2015	6,291	169	Counting Tower/Sonar

Table 4.–Daily estimates of Chena River chum salmon escapement, 2015. Shaded cells denote days where counts were estimated from DIDSON due to high-water events precluding visual counts.

Date	Daily Escapement	Daily SE
30 June	0	0
1 July	0	2
2 July	0	2
3 July	1	1
4 July	4	2
5 July	9	3
6 July	16	4
7 July	44	6
8 July	0	3
9 July	0	6
10 Jul	0	7
11 Jul	0	7
12 Jul	123	9
13 Jul	257	10
14 Jul	249	10
15 Jul	177	9
16 Jul	276	9
17 Jul	267	10
18 Jul	285	10
19 Jul	92	6
20 Jul	160	8
21 Jul	105	5
22 Jul	188	7
23 Jul	210	6
24 Jul	297	8
25 Jul	406	9
26 Jul	235	10
27 Jul	464	10
28 Jul	726	11
29 Jul	329	6
30 Jul	356	7
31 Jul	412	7
1 Aug	536	8
2 Aug	467	7
3 Aug	481	6
4 Aug	511	6
5 Aug	483	5
6 Aug	454	4
Total	8,620	153

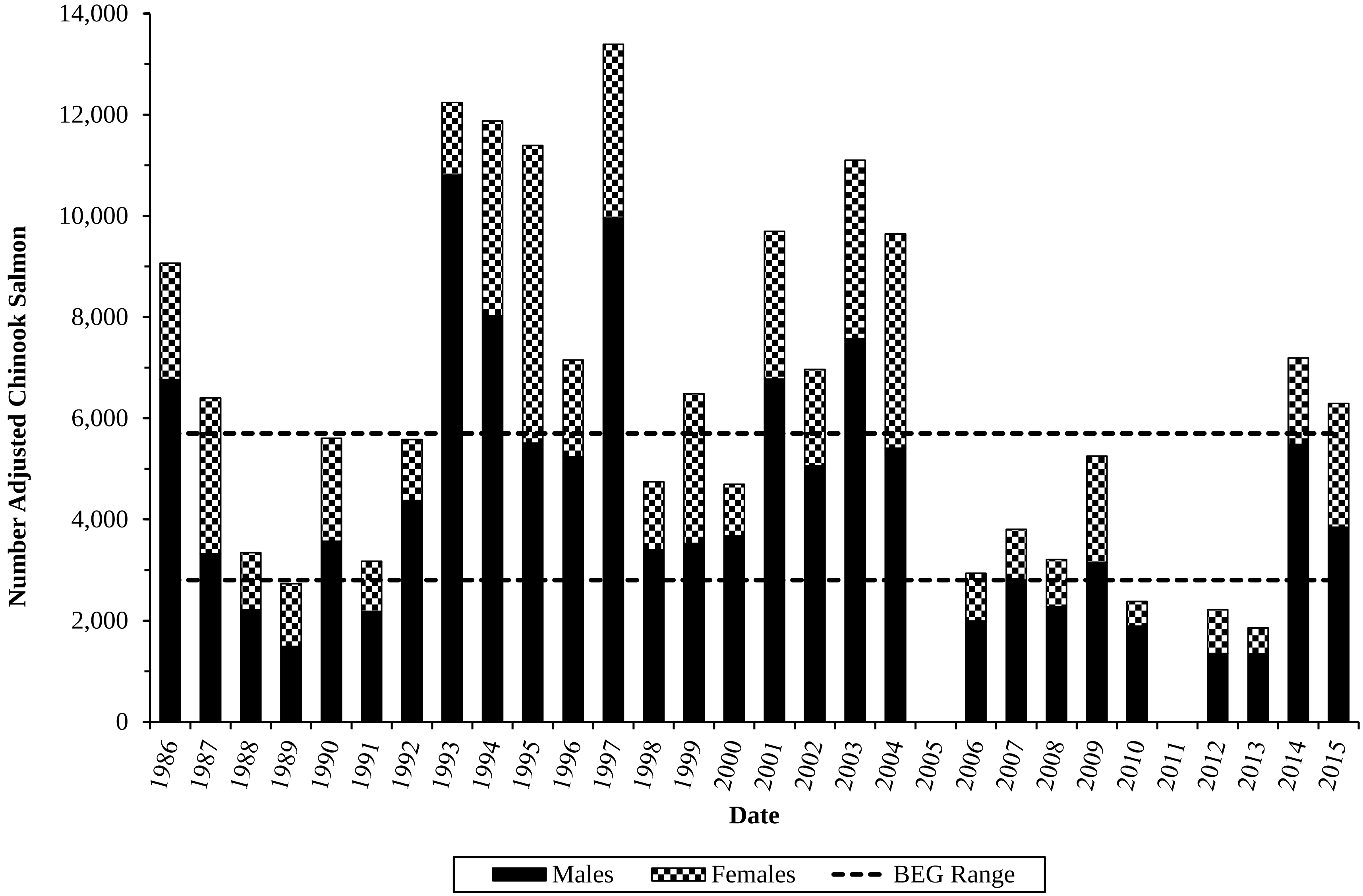

Figure 3.–Estimates of Chinook salmon adjusted sex composition and yearly escapements to the Chena River with the respective BEG range, 1986–2015.

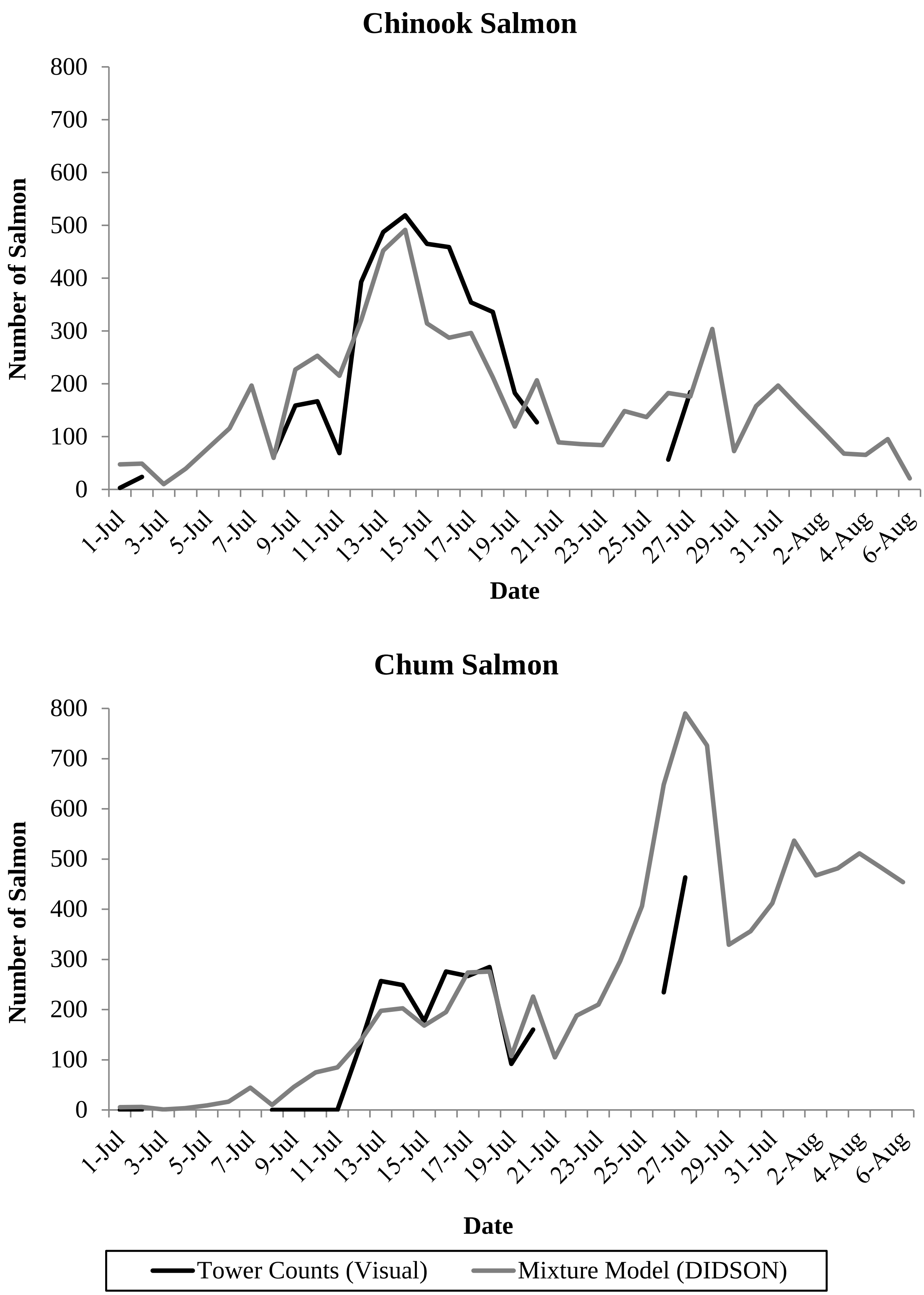

Figure 4.–Comparison of daily estimates of Chinook and chum salmon abundance from visual counting tower and DIDSON estimates.

Although the major drawback of using DIDSON technology is the inability to accurately distinguish Chinook from chum salmon, the 2015 paired counting tower and DIDSON estimate showed good agreement. In 2008, a single DIDSON unit was deployed at this site and a mixture model based on length was used to allocate the total count of salmon passing the sonar into numbers of Chinook and chum salmon (Huang 2012). Results were compared to actual tower counts and suggested this methodology is an appropriate means to estimate passage when conditions prohibit tower counts. According to Miller et al. (2015), modes of salmon lengths measured from DIDSON images lined up well with distributions of METF lengths from salmon measured by a netting project on the Kenai River.

Although fish lengths measured from DIDSON images do not represent actual fish lengths, Burwen et al. (2007) showed from a tethered-fish experiment that DIDSON fish length is a good predictor of actual fish length.

Mixture models are widely used to model heterogeneous data. They provide a framework for statistical modeling when the data are categorized in one of *k* classes, whose individual class memberships are unavailable (Gelman et al. 2004). Using a mixture model to estimate species composition based on length information can help avoid many problems that would have been caused by a threshold-based approach (Huang 2012). The methodology developed to estimate the proportion of Chinook and chum salmon based on historic length compositions and run timing was meant to fill any data gaps from the visual counts that were >2 days. The mixture model is constantly being improved by incorporating new information as well as differing approaches to the prior information.

This discrepancy between the mixture model numbers and those from the visual counts during 26 and 27 July could have been a result of difficult viewing conditions because before and after these 2 days the white flash panels were obscured due to high, muddy water. Also, the chum salmon run was peaking during this time. The chum salmon run always peaks after the Chinook salmon run has peaked and is waning in strength. It has been noticed throughout all years of this project that Chinook salmon will typically cross the flash panels singly or in a very small school of 2 or 3 individuals. Chum salmon, however, will cross in much larger schools. It is conceivable that, in between the 20-minute visual counts, one or more large schools of chum salmon may have swum across and caused this measuring fluke with only two consecutive days of visual counts.

For 2014 and 2015, the Chena River Chinook salmon sport fishery was closed early in the season because Lower Yukon River preseason forecasts and early season indicators suggested that the Chinook salmon runs were not projected to meet minimum escapements (JTC 2015). Restrictions had been placed on subsistence, commercial, and sport users in the Yukon River, and closing the Chena River to sport fishing of Chinook salmon seemed prudent based on recent years' production (Brase and Baker 2015, Wuttig and Baker *In press*). It is likely that the escapement goals were met during the past 2 seasons because of all the restrictions placed on Chinook salmon fisheries in the Yukon and Tanana River drainages.

A trend in Chinook salmon composition estimates to greater proportions of large females is important for overall stock health. Typically there are more males than females in Chena River composition estimates. Males vary more in size and maturity than females, and for most populations the average male will be smaller than the average female (Quinn 2005). For 2015, the female population was larger than what has been noted in the past 5 years.

The increase in the number of larger females in 2015 may also be a result of fishing restrictions throughout the Yukon River drainage. Howard and Evenson (2010) noticed that as mesh size increases, the catch will typically contain larger fish with respect to length, weight, and girth; therefore, more larger female Chinook salmon are harvested relative to chum, sockeye, coho, and smaller Chinook salmon. During 2014 and 2015, gillnets in the Lower Yukon River and coastal districts were restricted to 6.0 in or smaller mesh size (Estensen et al. 2015). In addition, subsistence salmon fishing closures were in place throughout the Chinook salmon run. During the lengthy subsistence closures, gillnets with 4.0 in or smaller mesh and less than 60 feet long were allowed to be used to harvest non-salmon species in upriver communities (Estensen et al. 2015). However, for 2014 a relative increase in females was not seen as in 2015, suggesting that other non-anthropogenic reasons are also behind observed trends in gender composition.

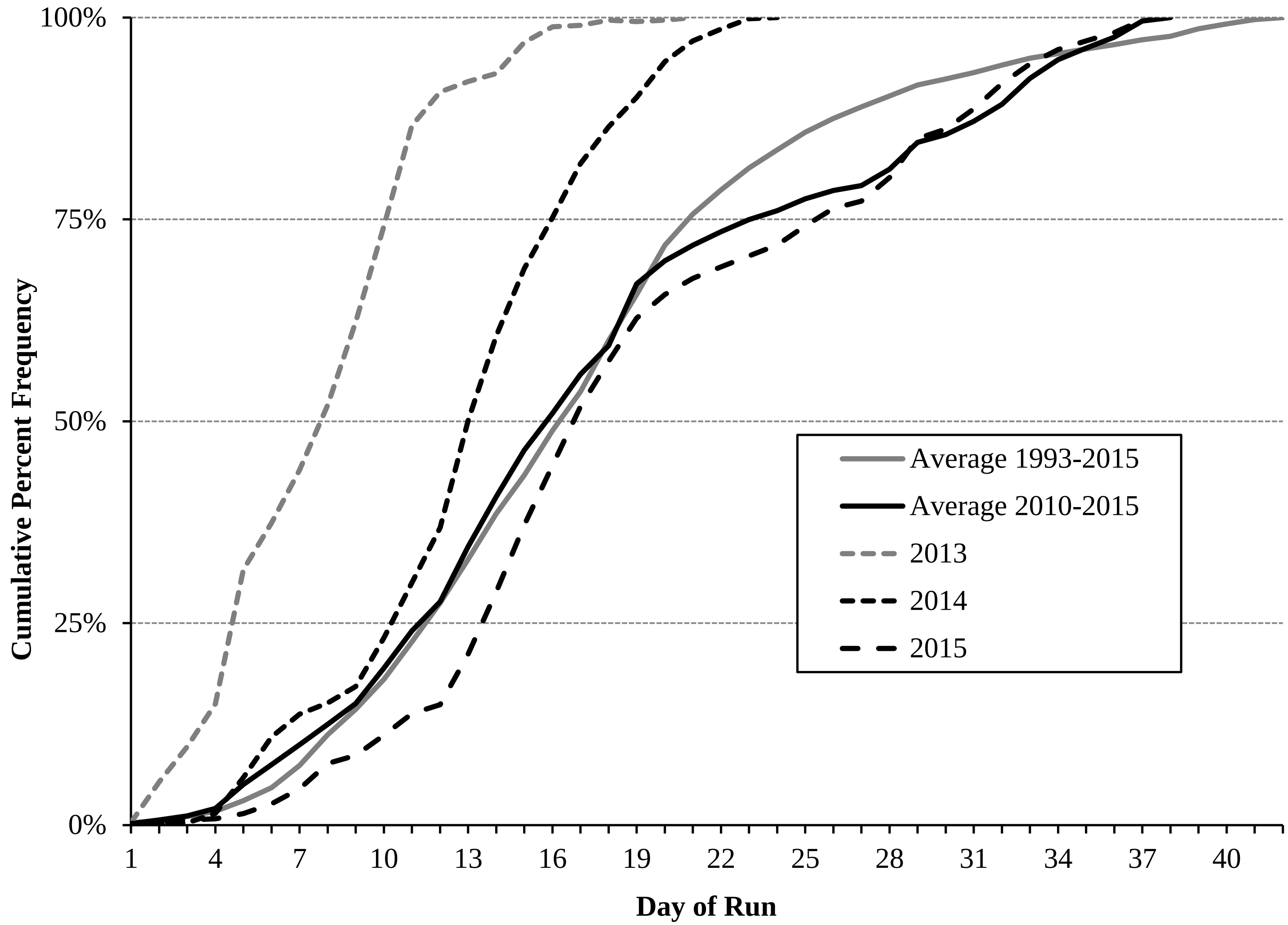

Figure 5.–Average run timing pattern for Chena River Chinook salmon past the counting tower by the first day of run over all years (1993–1994, 1997–1999, 2001, 2004, 2006–2010, and 2012–2015), the last 5 years (2010, 2012–2015), and compared to 2013-2015. Included are years when visual and/or visual and DIDSON combination counts composed a complete estimate of abundance.

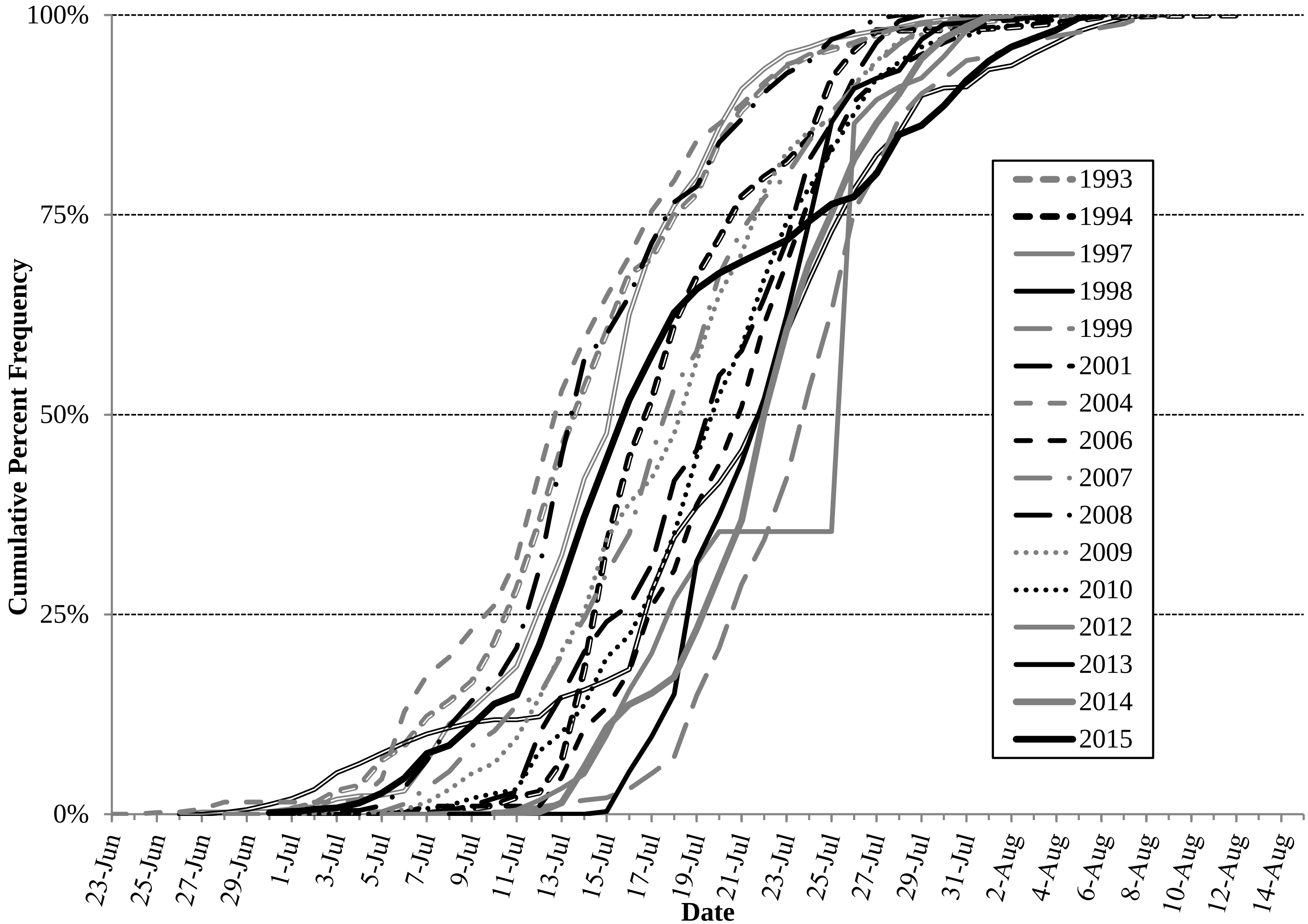

Figure 6.–Cumulative passage of Chinook salmon for the years when visual and/or visual and DIDSON combination counts composed a complete estimate of abundance.

Table 5.–Estimated proportions of male and female Chinook salmon sampled from carcass surveys on the Chena River, 1986–2015.

	Sexed Sample Size		Sexed Sample Proportion		Sexed and Aged Sample Size		Sexed and Aged Sample Proportion		Adjusted Sample Proportion[a]		Total	
Year	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Escapement	Method[b]
1986	987	365	0.73	0.27	538	183	0.75	0.25	0.75	0.25	9,065	MR
1987	438	592	0.43	0.57	235	325	0.42	0.58	0.52	0.48	6,404	MR
1988	347	543	0.39	0.61	183	285	0.39	0.61	0.66	0.34	3,346	MR
1989	119	218	0.35	0.65	101	187	0.35	0.65	0.55	0.45	2,730	MR
1990	291	258	0.53	0.47	291	258	0.53	0.47	0.64	0.36	5,603	MR
1991	231	108	0.68	0.32	231	108	0.68	0.32	0.68	0.32	3,172	MR
1992	289	176	0.62	0.38	289	176	0.62	0.38	0.78	0.22	5,580	MR
1993	205	38	0.84	0.16	156	31	0.83	0.17	0.88	0.12	12,241	CT
1994	326	275	0.54	0.46	281	231	0.55	0.45	0.68	0.32	11,877	CT
1995	305	593	0.34	0.66	267	520	0.34	0.66	0.48	0.52	11,394	MR
1996	286	229	0.56	0.44	286	229	0.56	0.44	0.73	0.27	7,153	MR
1997	424	278	0.60	0.40	424	278	0.60	0.40	0.74	0.26	10,810	MR
1998	160	107	0.60	0.40	134	94	0.59	0.41	0.72	0.28	4,745	CT
1999	75	133	0.36	0.64	61	116	0.34	0.66	0.55	0.45	6,485	CT
2000	113	56	0.67	0.33	99	50	0.66	0.34	0.78	0.22	4,694	MR
2001	342	253	0.57	0.43	292	229	0.56	0.44	0.70	0.30	9,696	CT
2002	277	216	0.56	0.44	207	167	0.55	0.45	0.73	0.27	6,967	MR
2003	253	206	0.55	0.45	204	166	0.55	0.45	0.68	0.32	11,100[c]	CT
2004	98	160	0.38	0.62	88	151	0.37	0.63	0.56	0.44	9,645	CT
2005	352	268	0.57	0.43	319	234	0.58	0.42	0.69	0.31	-	CT
2006	221	183	0.55	0.45	196	166	0.54	0.46	0.68	0.32	2,936	CT
2007	51	32	0.61	0.39	36	26	0.58	0.42	0.74	0.26	3,806	CT
2008	26	18	0.59	0.41	20	16	0.56	0.44	0.71	0.29	3,208	CT
2009	209	272	0.43	0.57	198	244	0.45	0.55	0.60	0.40	5,253	CT
2010	132	54	0.71	0.29	56	25	0.69	0.31	0.79	0.21	2,382	CT
2011	331	156	0.68	0.32	292	135	0.68	0.32	0.77	0.23	-	-
2012	107	132	0.44	0.56	88	110	0.44	0.56	0.61	0.39	2,220	CT/S
2013	127	81	0.61	0.39	105	71	0.60	0.40	0.72	0.28	1,859	CT
2014	244	123	0.66	0.34	190	94	0.67	0.33	0.76	0.24	7,192	S
2015	267	324	0.45	0.55	223	277	0.45	0.55	0.61	0.39	6,291	S/CT
Average	282	231	0.56	0.44	203	173	0.55	0.45	0.68	0.32	6,273	

[a] In years when mark–recapture experiments (MR) were conducted (1986–1992, 1995–1997, 2000, and 2002), males were more likely to be sampled during the first event (electroshocking) and overall less bias in estimating size and sex was noted from electroshocking than sampling carcasses (second event). As a result, an adjustment factor has been applied to the carcass samples, which have been the primary means of obtaining age, sex, and length since 2003.

[b] Escapement estimates were obtained from either a counting tower (CT) assessment, sonar images (S), or a mark–recapture (MR) experiment.

[c] Estimate includes an expansion for missed counting days. Minimum documented abundance with large gaps in counts due to flooding, was 8,739 (SE = 653) fish.

Table 6.–Estimated proportions and mean length by age and sex of Chinook salmon sampled during the Chena River carcass survey, 2015.

Age[a]	Sample Size	Sample Proportion	Length (mm)			
			Mean	SE	Min	Max
Males						
1.1	3	0.01	363	10	345	380
1.2	99	0.20	555	4	460	665
1.3	46	0.09	716	7	580	805
1.4	75	0.15	801	8	540	950
Total Males Aged	223	0.45				
Total Males[b]	267	0.45	674	8	345	1,050
Adjusted Total[c]		0.61				
Females						
1.3	34	0.07	771	8	690	855
1.4	240	0.48	815	3	560	940
1.5	3	0.01	830	49	750	920
Total Females Aged	277	0.55				
Total Females[b]	324	0.55	809	4	560	940
Adjusted Total[c]		0.39				
Total						
Total Aged	500		746	5	345	950
Total Collected	591		748	5	345	1,050

[a] Age is represented by the number of annuli formed during river residence and ocean residence (i.e., an age of 1.4 represents one annulus formed during river residence and four annuli formed during ocean residence for a total age of 6 years).

[b] Totals include those Chinook salmon that could not be aged.

[c] Estimated proportion of females was adjusted by a factor of 0.708.

Table 7.–Age composition and escapement estimates by gender and by all fish combined (unadjusted and adjusted) of Chena River Chinook salmon, 1986–2015. Escapement estimates were obtained from either a counting tower (CT) assessment, sonar (S), or mark-recapture (MR) project.

Males	Total Age (years)/European Age (freshwater years/ocean years)										Male	Male
	3	4	5		6		7		8		Unadjusted[a]	Adjusted[b]
Year	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5	Escapement	Escapement
1986	0.002	0.126	0.636	0.000	0.197	0.019	0.020	0.000	0.000	0.000	6,618	6,764
1987	0.000	0.064	0.281	0.000	0.613	0.009	0.034	0.000	0.000	0.000	2,723	3,320
1988	0.016	0.268	0.355	0.000	0.279	0.000	0.082	0.000	0.000	0.000	1,305	2,212
1989	0.010	0.109	0.495	0.020	0.347	0.010	0.010	0.000	0.000	0.000	964	1,492
1990	0.000	0.423	0.309	0.003	0.254	0.000	0.010	0.000	0.000	0.000	2,970	3,569
1991	0.000	0.126	0.489	0.000	0.312	0.000	0.074	0.000	0.000	0.000	2,161	2,172
1992	0.031	0.682	0.208	0.000	0.080	0.000	0.000	0.000	0.000	0.000	3,468	4,373
1993	0.006	0.355	0.445	0.000	0.187	0.000	0.006	0.000	0.000	0.000	10,327	10,804
1994	0.000	0.053	0.644	0.000	0.292	0.004	0.007	0.000	0.000	0.000	6,442	8,029
1995	0.000	0.131	0.360	0.000	0.491	0.000	0.015	0.004	0.000	0.000	3,870	5,509
1996	0.038	0.108	0.629	0.000	0.136	0.000	0.087	0.000	0.000	0.000	3,972	5,239
1997	0.005	0.611	0.184	0.000	0.196	0.000	0.002	0.002	0.000	0.000	6,529	8,038
1998	0.000	0.075	0.858	0.000	0.045	0.000	0.022	0.000	0.000	0.000	2,843	3,399
1999	0.000	0.115	0.377	0.000	0.508	0.000	0.000	0.000	0.000	0.000	2,338	3,527
2000	0.000	0.303	0.444	0.000	0.222	0.000	0.030	0.000	0.000	0.000	3,139	3,675
2001	0.010	0.154	0.462	0.000	0.353	0.000	0.021	0.000	0.000	0.000	5,573	6,777
2002	0.000	0.001	0.004	0.000	0.001	0.000	0.001	0.000	0.000	0.000	3,915	5,063
2003	0.000	0.088	0.623	0.000	0.240	0.000	0.049	0.000	0.000	0.000	6,120[c]	7,573[c]
2004	0.000	0.295	0.318	0.000	0.364	0.000	0.023	0.000	0.000	0.000	3,664	5,410
2005	0.000	0.110	0.571	0.000	0.292	0.000	0.016	0.013	0.000	0.000	-	-
2006	0.000	0.235	0.592	0.005	0.148	0.005	0.015	0.000	0.000	0.000	1,606	1,994
2007	0.194	0.222	0.306	0.000	0.278	0.000	0.000	0.000	0.000	0.000	2,339	2,767
2008	0.000	0.150	0.750	0.000	0.100	0.000	0.000	0.000	0.000	0.000	1,896	2,279
2009	0.000	0.313	0.293	0.000	0.394	0.000	0.000	0.000	0.000	0.000	2,282	3,150
2010	0.000	0.196	0.518	0.018	0.250	0.000	0.018	0.000	0.000	0.000	1,690	1,892
2011	0.003	0.331	0.555	0.003	0.103	0.000	0.000	0.003	0.000	0.000	-	-
2012	0.011	0.114	0.636	0.000	0.239	0.000	0.000	0.000	0.000	0.000	994	1,352
2013	0.019	0.486	0.257	0.000	0.229	0.000	0.010	0.000	0.000	0.000	1,135	1,346
2014	0.021	0.053	0.900	0.000	0.021	0.000	0.000	0.005	0.000	0.000	4,782	5.485
2015	0.013	0.444	0.206	0.000	0.336	0.000	0.000	0.000	0.000	0.000	2,842	3,849
Average	0.008	0.246	0.469	0.002	0.255	0.002	0.018	0.001	0.000	0.000	3,520	4,325

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Table 7.–Page 2 of 4.

Females	Total Age (years)/European Age (freshwater years/ocean years)										Female	Female
	3	4	5		6		7		8		Unadjusted[a]	Adjusted[b]
Year	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5	Escapement	Escapement
1986	0.000	0.000	0.131	0.000	0.552	0.000	0.306	0.005	0.000	0.005	2,447	2,301
1987	0.000	0.003	0.022	0.000	0.855	0.000	0.114	0.006	0.000	0.000	3,681	3,084
1988	0.000	0.000	0.060	0.000	0.582	0.000	0.351	0.000	0.000	0.007	2,041	1,134
1989	0.000	0.005	0.187	0.000	0.652	0.000	0.155	0.000	0.000	0.000	1,766	1,238
1990	0.000	0.008	0.194	0.000	0.733	0.000	0.066	0.000	0.000	0.000	2,633	2,034
1991	0.000	0.000	0.120	0.000	0.620	0.000	0.231	0.009	0.009	0.009	1,011	1,000
1992	0.000	0.000	0.284	0.000	0.710	0.000	0.006	0.000	0.000	0.000	2,112	1,207
1993	0.000	0.000	0.258	0.000	0.710	0.000	0.032	0.000	0.000	0.000	1,914	1,437
1994	0.000	0.000	0.182	0.000	0.771	0.004	0.043	0.000	0.000	0.000	5,435	3,848
1995	0.000	0.000	0.131	0.000	0.821	0.000	0.044	0.004	0.000	0.000	7,524	5,885
1996	0.000	0.004	0.210	0.000	0.358	0.000	0.428	0.000	0.000	0.000	3,181	1,914
1997	0.000	0.007	0.058	0.000	0.914	0.000	0.022	0.000	0.000	0.000	4,281	2,772
1998	0.000	0.000	0.532	0.000	0.383	0.000	0.085	0.000	0.000	0.000	1,902	1,346
1999	0.000	0.009	0.181	0.000	0.810	0.000	0.000	0.000	0.000	0.000	4,147	2,958
2000	0.000	0.000	0.180	0.000	0.620	0.000	0.200	0.000	0.000	0.000	1,555	1,019
2001	0.000	0.022	0.175	0.000	0.716	0.000	0.087	0.000	0.000	0.000	4,123	2,919
2002	0.000	0.000	0.003	0.000	0.005	0.000	0.006	0.000	0.000	0.000	3,052	1,904
2003	0.000	0.006	0.271	0.000	0.633	0.000	0.090	0.000	0.000	0.000	4,980[c]	3,527[c]
2004	0.000	0.000	0.086	0.000	0.881	0.000	0.033	0.000	0.000	0.000	5,981	4,235
2005	0.000	0.004	0.402	0.000	0.530	0.004	0.043	0.017	0.000	0.000	1,761	1,247
2006	0.000	0.000	0.289	0.000	0.705	0.000	0.006	0.000	0.000	0.000	1,330	942
2007	0.038	0.154	0.423	0.000	0.385	0.000	0.000	0.000	0.000	0.000	1,467	1,039
2008	0.000	0.000	0.438	0.000	0.438	0.000	0.125	0.000	0.000	0.000	1,312	929
2009	0.000	0.008	0.070	0.000	0.910	0.000	0.012	0.000	0.000	0.000	2,971	2,103
2010	0.000	0.000	0.480	0.000	0.480	0.000	0.040	0.000	0.000	0.000	692	490
2011	0.000	0.000	0.274	0.000	0.681	0.000	0.030	0.015	0.000	0.000	-	-
2012	0.000	0.000	0.309	0.000	0.691	0.000	0.000	0.000	0.000	0.000	1,226	868
2013	0.000	0.000	0.169	0.000	0.817	0.014	0.000	0.000	0.000	0.000	724	513
2014	0.000	0.000	0.691	0.000	0.287	0.021	0.000	0.000	0.000	0.000	2,410	1,707
2015	0.000	0.000	0.123	0.000	0.866	0.000	0.011	0.000	0.000	0.000	3,449	2,442
Average	0.000	0.008	0.235	0.000	0.669	0.001	0.084	0.002	0.000	0.001	2,832	2,027

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Unadjusted[a] **All Fish**	Total Age (years)/European Age (freshwater years/ocean years)											
	3	4	5		6		7		8		Total	
Year	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5	Escapement	Method
1986	0.001	0.094	0.508	0.000	0.287	0.014	0.093	0.001	0.000	0.001	9,065	MR
1987	0.000	0.029	0.130	0.000	0.754	0.004	0.080	0.004	0.000	0.000	6,404	MR
1988	0.006	0.105	0.175	0.000	0.464	0.000	0.246	0.000	0.000	0.004	3,346	MR
1989	0.003	0.042	0.295	0.007	0.545	0.003	0.104	0.000	0.000	0.000	2,730	MR
1990	0.000	0.228	0.255	0.002	0.479	0.000	0.036	0.000	0.000	0.000	5,603	MR
1991	0.000	0.086	0.372	0.000	0.410	0.000	0.124	0.003	0.003	0.003	3,172	MR
1992	0.019	0.424	0.234	0.002	0.316	0.002	0.002	0.000	0.000	0.000	5,580	MR
1993	0.005	0.294	0.412	0.000	0.278	0.000	0.011	0.000	0.000	0.000	12,241	CT
1994	0.000	0.029	0.436	0.000	0.508	0.004	0.023	0.000	0.000	0.000	11,877	CT
1995	0.000	0.044	0.208	0.000	0.709	0.000	0.034	0.004	0.000	0.000	11,394	MR
1996	0.021	0.062	0.443	0.000	0.235	0.000	0.239	0.000	0.000	0.000	7,153	MR
1997	0.003	0.372	0.134	0.000	0.480	0.000	0.010	0.001	0.000	0.000	10,810	MR
1998	0.000	0.044	0.724	0.000	0.184	0.000	0.048	0.000	0.000	0.000	4,745	CT
1999	0.000	0.045	0.249	0.000	0.706	0.000	0.000	0.000	0.000	0.000	6,485	CT
2000	0.003	0.302	0.390	0.000	0.283	0.000	0.022	0.000	0.000	0.000	4,694	MR
2001	0.006	0.096	0.336	0.000	0.512	0.000	0.050	0.000	0.000	0.000	9,696	CT
2002	0.000	0.238	0.278	0.000	0.444	0.000	0.040	0.000	0.000	0.000	6,967	MR
2003	0.000	0.051	0.465	0.000	0.416	0.000	0.068	0.000	0.000	0.000	11,100[c]	CT
2004	0.000	0.109	0.172	0.000	0.690	0.000	0.029	0.000	0.000	0.000	9,645	CT
2005	0.000	0.065	0.499	0.000	0.392	0.002	0.027	0.014	0.000	0.000	4,075	CT
2006	0.000	0.127	0.453	0.003	0.403	0.003	0.011	0.000	0.000	0.000	2,936	CT
2007	0.129	0.194	0.355	0.000	0.323	0.000	0.000	0.000	0.000	0.000	3,806	CT
2008	0.000	0.083	0.611	0.000	0.250	0.000	0.056	0.000	0.000	0.000	3,208	CT
2009	0.000	0.145	0.170	0.000	0.679	0.000	0.007	0.000	0.000	0.000	5,253	CT
2010	0.000	0.136	0.506	0.012	0.321	0.000	0.025	0.000	0.000	0.000	2,382	CT
2011	0.002	0.226	0.466	0.002	0.287	0.000	0.009	0.007	0.000	0.000	-	-
2012	0.005	0.051	0.455	0.000	0.490	0.000	0.000	0.000	0.000	0.000	2,220	CT/S
2013	0.011	0.290	0.222	0.000	0.466	0.006	0.006	0.000	0.000	0.000	1,859	CT
2014	0.014	0.035	0.831	0.000	0.109	0.007	0.000	0.004	0.000	0.000	7,192	S
2015	0.006	0.198	0.160	0.000	0.630	0.000	0.006	0.000	0.000	0.000	6,291	S/CT
Average	0.005	0.141	0.364	0.001	0.438	0.001	0.049	0.001	0.000	0.000	6,352	

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Table 7.–Page 4 of 4.

Adjusted[b]	Total Age (years)/European Age (freshwater years/ocean years)											
All Fish	3	4	5		6		7		8		Total	
Year	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5	Escapement	Method
1986	0.001	0.094	0.508	0.000	0.287	0.014	0.093	0.001	0.000	0.001	9,065	MR
1987	0.000	0.035	0.156	0.000	0.730	0.004	0.072	0.003	0.000	0.000	6,404	MR
1988	0.011	0.177	0.255	0.000	0.382	0.000	0.173	0.000	0.000	0.002	3,346	MR
1989	0.005	0.062	0.355	0.011	0.485	0.005	0.076	0.000	0.000	0.000	2,730	MR
1990	0.000	0.272	0.267	0.002	0.428	0.000	0.030	0.000	0.000	0.000	5,603	MR
1991	0.000	0.086	0.373	0.000	0.409	0.000	0.123	0.003	0.003	0.003	3,172	MR
1992	0.027	0.574	0.194	0.000	0.204	0.000	0.001	0.000	0.000	0.000	5,580	MR
1993	0.006	0.311	0.421	0.000	0.253	0.000	0.009	0.000	0.000	0.000	12,241	CT
1994	0.000	0.036	0.494	0.000	0.447	0.004	0.019	0.000	0.000	0.000	11,877	CT
1995	0.000	0.063	0.241	0.000	0.661	0.000	0.030	0.004	0.000	0.000	11,394	MR
1996	0.028	0.081	0.517	0.000	0.196	0.000	0.179	0.000	0.000	0.000	7,153	MR
1997	0.004	0.456	0.152	0.000	0.380	0.000	0.007	0.002	0.000	0.000	10,810	MR
1998	0.000	0.053	0.766	0.000	0.141	0.000	0.040	0.000	0.000	0.000	4,745	CT
1999	0.000	0.066	0.288	0.000	0.646	0.000	0.000	0.000	0.000	0.000	6,485	CT
2000	0.003	0.302	0.390	0.000	0.283	0.000	0.022	0.000	0.000	0.000	4,694	MR
2001	0.007	0.114	0.376	0.000	0.462	0.000	0.041	0.000	0.000	0.000	9,696	CT
2002	0.002	0.307	0.302	0.000	0.369	0.000	0.020	0.000	0.000	0.000	6,967	MR
2003	0.000	0.062	0.511	0.000	0.365	0.000	0.062	0.000	0.000	0.000	11,100[c]	CT
2004	0.000	0.166	0.216	0.000	0.591	0.000	0.027	0.000	0.000	0.000	9,645	CT
2005	0.000	0.077	0.519	0.000	0.364	0.001	0.024	0.014	0.000	0.000	-	-
2006	0.000	0.159	0.495	0.003	0.327	0.003	0.012	0.000	0.000	0.000	2,936	CT
2007	0.152	0.204	0.338	0.000	0.307	0.000	0.000	0.000	0.000	0.000	3,806	CT
2008	0.000	0.107	0.659	0.000	0.198	0.000	0.036	0.000	0.000	0.000	3,208	CT
2009	0.000	0.191	0.204	0.000	0.600	0.000	0.005	0.000	0.000	0.000	5,253	CT
2010	0.000	0.156	0.510	0.014	0.297	0.000	0.022	0.000	0.000	0.000	2,382	CT
2011	0.003	0.256	0.491	0.003	0.235	0.000	0.007	0.006	0.000	0.000	-	-
2012	0.007	0.069	0.508	0.000	0.415	0.000	0.000	0.000	0.000	0.000	2,220	CT/S
2013	0.014	0.352	0.233	0.000	0.391	0.004	0.007	0.000	0.000	0.000	1,859	CT
2014	0.016	0.040	0.851	0.000	0.084	0.005	0.000	0.004	0.000	0.000	7,192	S
2015	0.008	0.272	0.174	0.000	0.542	0.000	0.004	0.000	0.000	0.000	6,291	CT/S
Average	0.006	0.177	0.392	0.001	0.383	0.001	0.038	0.001	0.000	0.000	6,273	

[a] Unadjusted escapement and composition estimates were derived from the observed sample proportions of males and females from carcass surveys.

[b] In years when mark–recapture experiments (MR) were conducted, males were more likely to be sampled during the first event (electroshocking) and overall less bias in estimating size and sex was noted from electroshocking than sampling carcasses (second event). As a result, an adjustment factor has been applied to the carcass samples, which have been the primary means of obtaining age, sex, and length since 2003.

[c] Estimate includes an expansion for missed counting days. Minimum documented abundance with large gaps in counts due to flooding was 8,739 (SE = 653) fish.

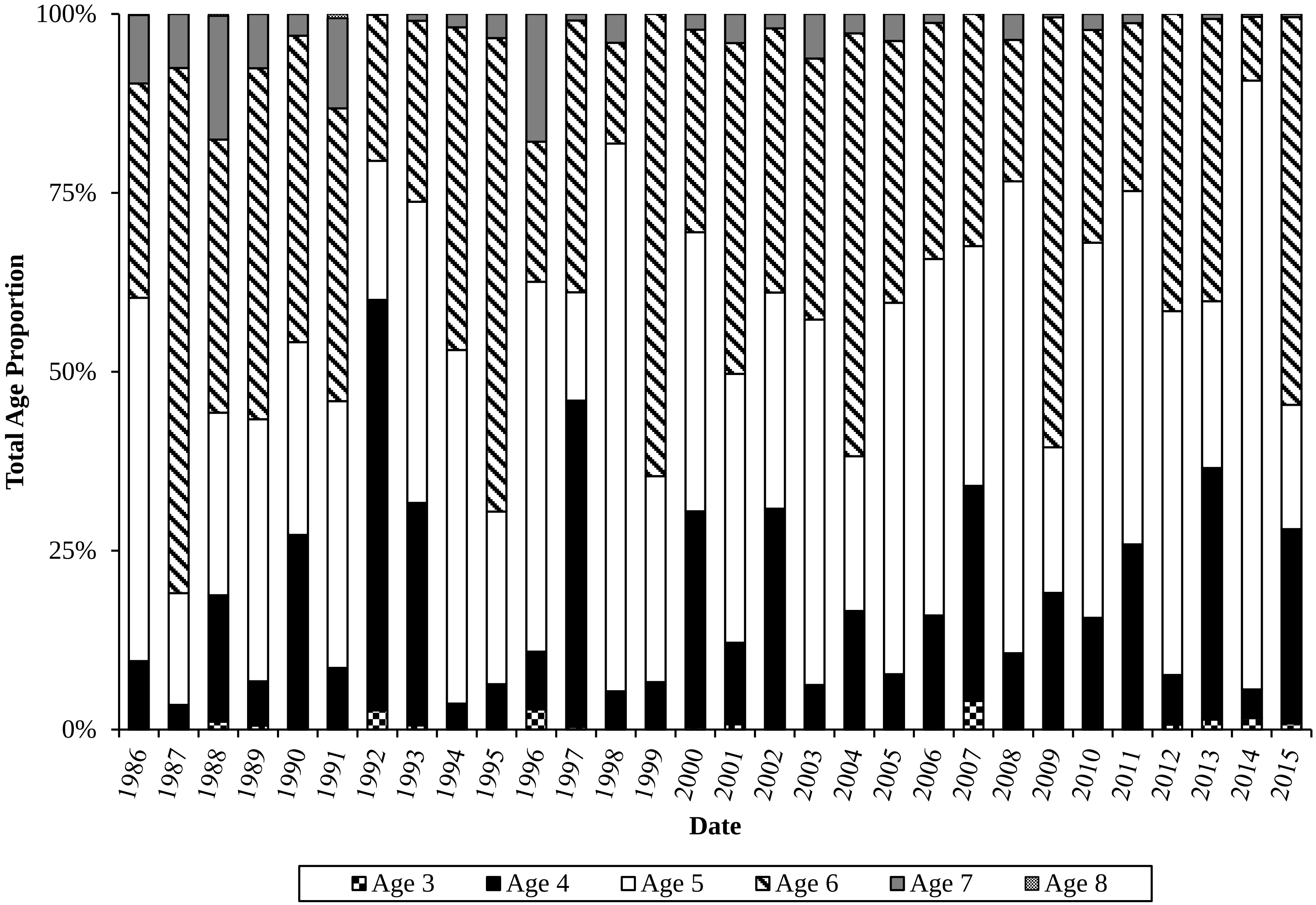

Figure 7.–Age proportions by year for Chinook salmon sampled during mark–recapture events (electrofishing; 1986–1992, 1995–1996, 2000, and 2002) and carcass sampling (second event, counting tower, sonar).

Table 8.–Minimum estimates of escapement for Delta Clearwater River coho salmon, 1980–2015.

Year	Survey Date	Minimum Escapement
1980	28 Oct	3,946
1981	21 Oct	8,563
1982	3 Nov	8,365
1983	25 Oct	8,019
1984	6 Nov	11,061
1985	13 Nov	6,842
1986	21 Oct	10,857
1987	27 Oct	22,300
1988	28 Oct	21,600
1989	25 Oct	12,600
1990	26 Oct	8,325
1991	23 Oct	23,900
1992	26 Oct	3,963
1993	21 Oct	10,875
1994	24 Oct	62,675
1995	23 Oct	20,100
1996	29 Oct	14,075
1997	24 Oct	11,525
1998	20 Oct	11,100
1999	28 Oct	10,975
2000	24 Oct	9,225
2001	19 Oct	46,875
2002	31 Oct	38,625
2003	21 Oct	105,850
2004	27 Oct	37,950
2005	25 Oct	34,293
2006	24 Oct	16,748
2007	31 Oct-1 Nov	14,650
2008	30 Oct	7,500
2009	26 Oct	16,850
2010	30 Oct	5,867
2011	28 Oct	16,544
2012	19 Oct	5,230
2013	24 Oct	6,222
2014	4 Nov	4,285
2015	22 Oct	19,553
Average		18,831

The increase in female proportion in 2015 was due to an increase in the number of age 6 (1.4) fish. Typically 6-year-old Chinook salmon tend to be predominantly females and the smaller age 4 (1.2) fish are usually male (Groot and Margolis 1991). Lewis et al. (2015) reported that statewide declines in size and age of Alaska Chinook salmon have been noted and may have negative implications for the long-term viability of Alaska's fisheries. Downward shifts in size at age and age at maturity affect fitness by reducing fecundity and reproductive rates (Healey and Heard 1984). Larger females generally have larger and more numerous eggs, which produce larger juveniles, which tend to have higher survival rates (Quinn 2005). What has been driving earlier maturation and declines in size may be attributable to ocean conditions or competitive interactions with other species as well as size-selective harvest, but the evidence is inconclusive for any specific cause (Lewis et al. 2015). Given concerns in statewide downward trending age at maturity for Chinook salmon, the results of the 2015 carcass survey show a promising trend that will hopefully continue in subsequent years.

The DCR boat count was conducted in 2015 over 2 days in good conditions, which produced minimum estimates of escapement above the established SEG. Previous studies have expanded the boat count to account for the escapement to inaccessible tributaries in the DCR drainage. This expansion was done to conduct a spawner-recruit analysis and in no way was it used to evaluate whether or not the SEG was met. For this reason, the minimum escapement estimate used to evaluate the SEG will be the only one reported. The DCR sport fishery was not restricted because the run was projected to meet the SEG.

CONCLUSION

Continued assessment of the Chena, Salcha, and Delta Clearwater rivers is required to determine whether the established escapement goals for the largest Chinook and coho salmon stocks in the Alaskan portion of the Yukon River drainage are met. The fact the Chena River made escapement is promising considering the consistently poor returns over the last few years. In addition, size at age and percent of large females was more reminiscent of previous years' runs that met escapement values. Currently, the Alaska Sustainable Salmon Fund (AKSSF) is funding the Chena River counting tower through 2018. The coho salmon counts are annually funded through ADF&G base funds and the Salcha and Goodpaster river projects were funded through 2015 from Research and Management (R&M) Funds for the Yukon River distributed by USFWS.

ACKNOWLEDGEMENTS

The author would like to thank the following ADF&G Sport Fish staff who made the 2015 Chena River counting tower a success: the crew leaders Virgil Davis and Carmen Daggett; and the counting and DIDSON crews: Brett George, Matt Stoller, Eric Nakalsky, Kipp Wilkinson, Mary Webb, and David Spencer. Thanks to the assistant area manager, Brandy Baker, and field technician Ellie Mason, for performing the annual Delta Clearwater River coho salmon counts. Chad Bear spent numerous hours processing the DIDSON files. Anchorage Commercial Fisheries staff aged the Chinook salmon scale samples. Matt Tyers provided assistance with project planning, design and analysis. James Savereide helped with counting tower and sonar set up and advice and, along with Rachael Kvapil, edited and prepared the final report. The U.S. Army Corps of Engineers provided access to the Moose Creek Dam. Thanks to Chris Stark, and the technicians from the Bering Sea Fishermen's Association and Tanana Chiefs Conference who worked and supplied the Salcha and Goodpaster river counting tower data to the author.

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APPENDIX A:
JAGS CODE OF MIXTURE MODEL

Appendix A1.–JAGS code of mixture model[a].

```
model {
 for(i in 1:n.fish) {
  L.mm.D[i] ~ dnorm(muL[i],precL)
  muL[i] <- betaD0 + betaD1*L.mm.act[i]
  L.mm.act[i]~dnorm(mu[i],tau[i])
  mu[i]<-lambda[species[i],sex[i]]
  tau[i]<-prec[species[i],sex[i]]

  species[i]~dcat(ps[i,1:2])
  sex[i]~dcat(psex[species[i],1:2])

  logit(pi[i]) <- b0+b1*day[i]
  alpha.inf[i,1] <- pi[i]
  alpha.inf[i,2] <- (1-pi[i])
  ps[i,1:2]~ddirch(alpha.inf[i,1:2])
 }

 sig[1,1]<- 133.8666
 sig[2,1]<- 33.84357
 sig[1,2]<- 68.428
 sig[2,2]<- 31.1745

 prec[1,1]<-1/(sig[1,1]*sig[1,1])
 prec[1,2]<-1/(sig[1,2]*sig[1,2])
 prec[2,1]<-1/(sig[2,1]*sig[2,1])
 prec[2,2]<-1/(sig[2,2]*sig[2,2])

 for(j in 1:m) {
  DL.star[j] ~ dnorm(mu.star[j],prec.star)
  mu.star[j] <- betaD0 + betaD1*AL.star[j]
 }
 precL <- 1/(54.59*54.59)
 betaD0 ~ dnorm(0,0.01)
 betaD1 ~ dnorm(1,0.01)
 prec.star ~ dunif(0.0001,1000)
 sig.star <- 1/sqrt(prec.star)

 b1 <- -0.1642404
 b0 <- -0.7403224

 psex[1,1:2]~ddirch(alpha.sex.chin[])
 psex[2,1:2]~ddirch(alpha.sex.chum[])


lambda[1,1]~dnorm(703.9007,t1
lambda[1,2]~dnorm(851.3617,t2)
 lambda[2,1]~dnorm(583.6288,t4)
 lambda[2,2]~dnorm(552.9748,t5)

 t1<-1/(1.313744*1.313744)
 t2<-1/(0.7707537*0.7707537)
 t4<-1/(1.317359*1.317359)
 t5<-1/(1.133806*1.133806)
 N.chum <- sum(species[]) - n.fish    # posterior distributions of the totals of each species
 N.chin <- (2*n.fish) - sum(species[])

 }
```

[a]The species proportions p_c and p_k were coded as *ps* and the sex proportions θ's were coded as *psex*. Parameters *sig*'s refer to the standard deviations in the length distribution for Chinook and chum salmon.

APPENDIX B:
SALCHA RIVER
CHINOOK SALMON COUNTING TOWER DATA

INTRODUCTION

Bering Sea Fishermen's Association (BSFA) began tower counts on the Salcha River in 1999. Further details regarding this project can be obtained by contacting the project leader with BSFA.

METHODS

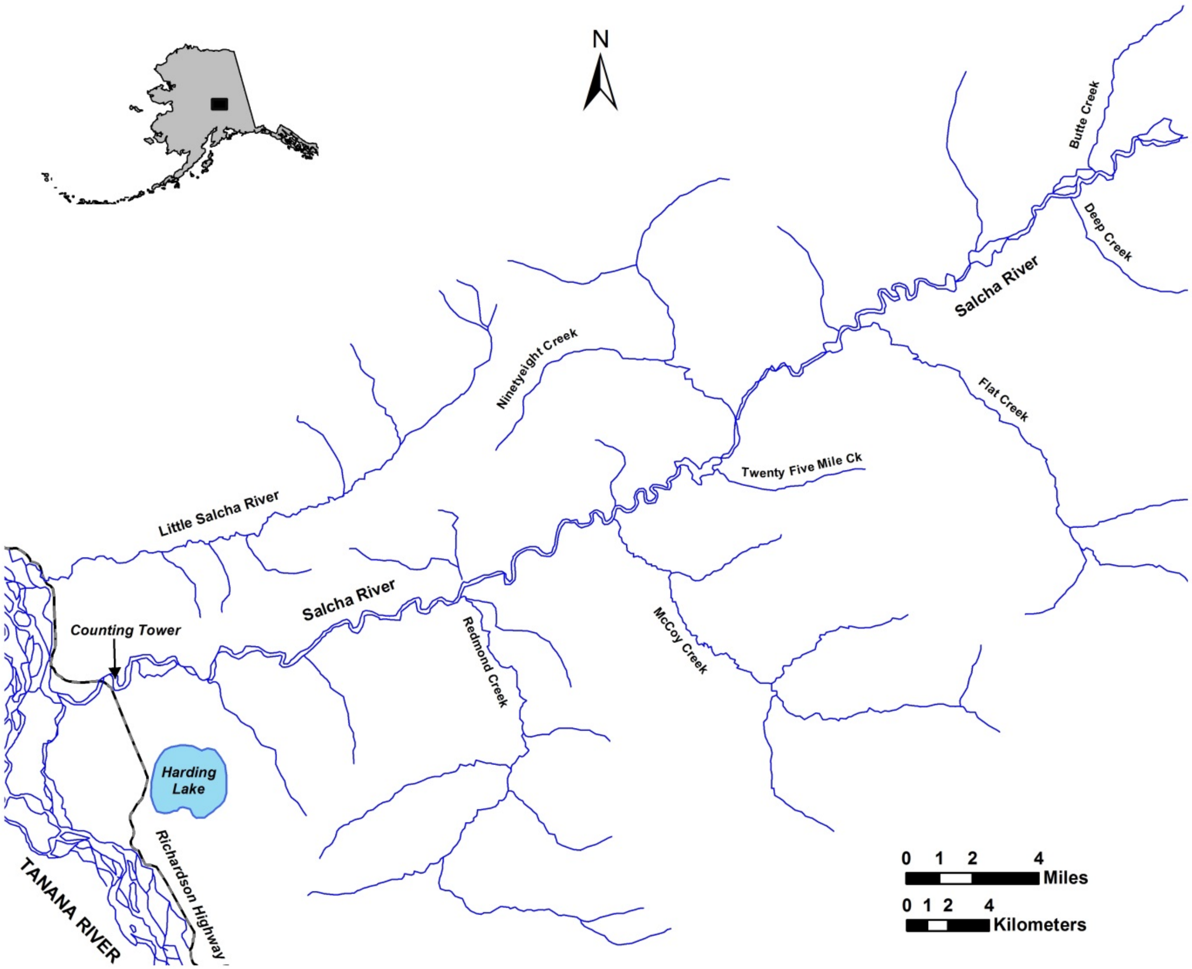
Project mobilization, escapement enumeration, and data analysis procedures for the Salcha River counting tower are virtually identical to those used for the Chena River, except there was no sonar assessment during periods of high water.

RESULTS

In 2014, the Salcha River counting tower (Appendix B1) operated from 12 July until 9 August. The estimated Chinook salmon escapement during that time was 6,287 (SE = 309). During the Chinook salmon run, chum salmon escapement was estimated to be 12,812 (SE = 310, Appendix B2). These estimates did not include the missed days from the start of the run until 12 July. By request, an estimate encompassing the 2 missing weeks prior to 12 July was made for the 2016 JTC report. For this, a binomial mixed-effects model was used to model the cumulative run proportion as a function of date and corresponding Chena River cumulative run proportions from 11 years of historical data, with a random term to account for year-to-year variability in the relationship. This model was then used to predict the proportion of the 2015 run that occurred before 12 July, given the corresponding timing and Chena River run. Modeling was performed in a Bayesian framework, to provide a posterior predictive distribution for the missed run proportion. This methodology produced a preliminary total escapement estimate of 6,879 (SE = 1,617) Chinook salmon. Nevertheless, the escapement goal was met because the incomplete estimate of 6,287 Chinook salmon was within the BEG range of 3,300-6,500 (Appendix B3 and B4).

AGE-SEX-LENGTH COMPOSITIONS

In 2015, a total of 533 Chinook salmon carcasses were collected along the Salcha River during 4–11 August (Appendix B5). The estimated proportion of females in the escapement from the carcass survey was 0.42 (SE = 0.02) and the gender-bias corrected estimate was 0.37 (SE = 0.08). The largest age class for males (22% of total fish) was age 1.2 and the largest for females (30% of total fish) was age 1.4 (Appendix B6).



Appendix B1.–Map of the Salcha River demarcating the counting tower.

Appendix B2.–Daily estimates of Salcha River Chinook and chum salmon escapement, 2015. Shaded cells denote days where counts could not be conducted due to high-water events and daily escapement and SE values were calculated using the moving average estimator.

	Chinook Salmon		Chum Salmon	
Date	Daily Escapement	Daily SE	Daily Escapement	Daily SE
12 Jul	1,008	253	72	10
13 Jul	678	77	33	9
14 Jul	660	54	18	7
15 Jul	672	54	24	6
16 Jul	300	42	21	9
17 Jul	270	30	186	23
18 Jul	348	42	189	21
19 Jul	315	24	264	36
20 Jul	99	25	0	0
21 Jul	216	54	173	24
22 Jul	192	48	160	22
23 Jul	233	51	254	34
24 Jul	243	30	225	25
25 Jul	186	29	909	46
26 Jul	192	30	1,755	81
27 Jul	223	33	779	53
28 Jul	151	38	986	138
29 Jul	105	26	942	132
30 Jul	57	14	587	82
31 Jul	5	4	500	113
1 Aug	0	0	735	60
2 Aug	0	0	336	42
3 Aug	3	3	492	33
4 Aug	27	10	762	76
5 Aug	60	11	1,005	72
6 Aug	45	18	630	69
7 Aug	0	0	399	13
8 Aug	0	0	171	20
9 Aug	0	0	207	30
Total	6,287	309	12,812	310

Appendix B3.–Estimates of the Salcha River Chinook salmon escapement, 1987–2015.

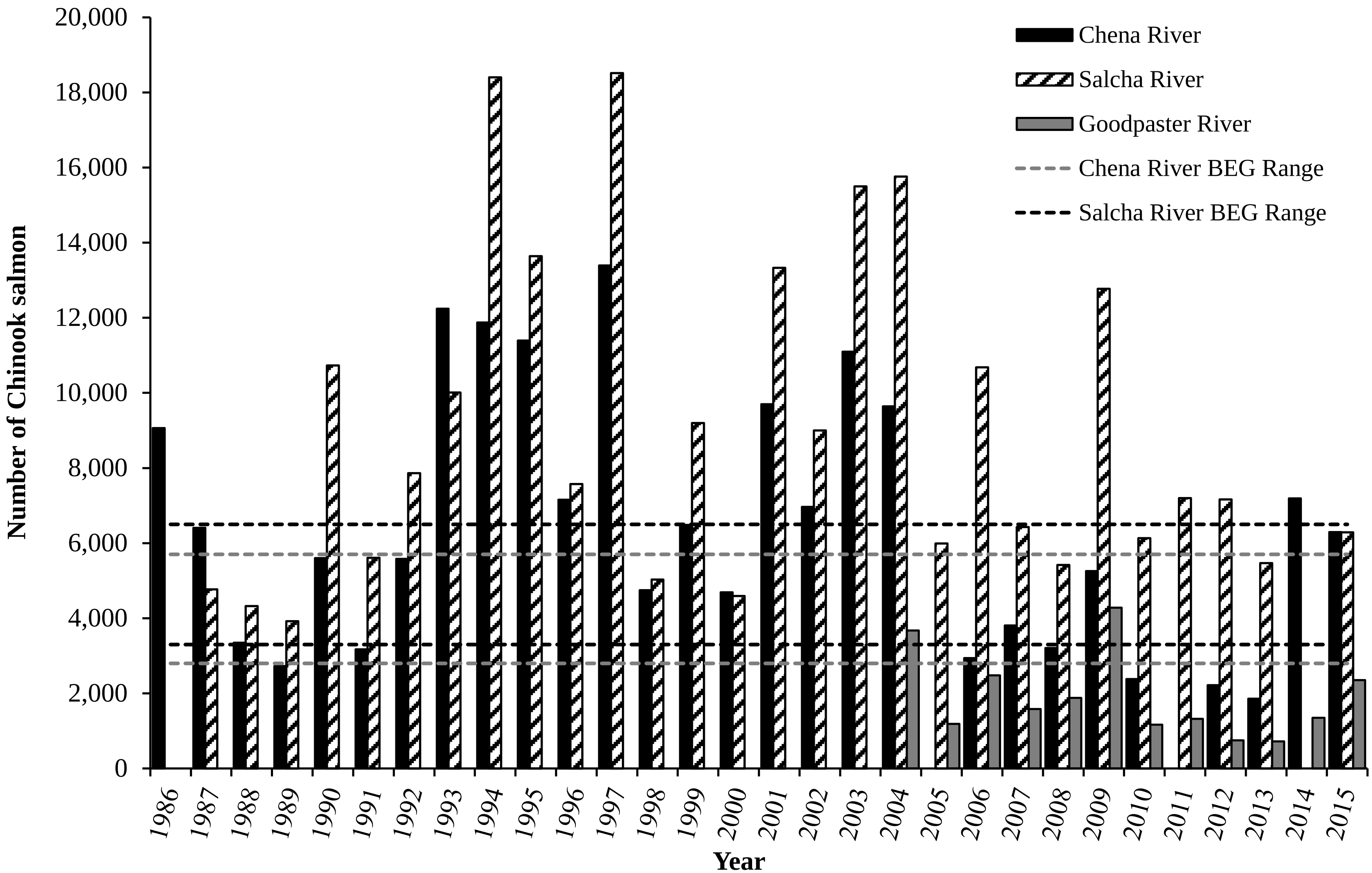
	Escapement		
Year	Estimate	SE	Method[b]
1987	4,771	504	M-R
1988	4,322	556	M-R
1989	3,294	630	M-R
1990	10,728	1,404	M-R
1991	5,608	664	M-R
1992	7,862	975	M-R
1993	10,007	360	CT
1994	18,399	549	CT
1995	13,643	471	CT
1996	7,570	1,238	M-R
1997	18,514	1,043	CT
1998	5,027	331	CT
1999	9,198	290	CT
2000	4,595	802	CT
2001	13,328	2,163	CT
2002	9,000[a]	160	CT
2003	15,500[a]	747	CT
2004	15,761	612	CT
2005	5,988	163	CT
2006	10,679	315	CT
2007	6,425	225	CT
2008	5,415[a]	169	CT
2009	12,774	405	CT
2010	6,135	170	CT
2011	7,200[a]	-[c]	CT
2012	7,165	163	CT
2013	5,465	282	CT
2014[d]	-	-	-
2015	6,287	309	CT

[a] Estimate was obtained from an expansion of the interrupted tower-count.

[b] Escapement estimates were obtained from either a counting tower (CT) assessment or a mark–recapture (MR) project.

[c] Standard error not reported by BSFA.

[d] Extensive flooding prevented operation of counting tower.



Appendix B4.–Estimates of Chinook salmon to the Chena, Salcha, and Goodpaster rivers with respective BEG ranges where applicable, 1986–2015.

Appendix B5.–Estimated proportions and mean length by age and sex of Chinook salmon sampled during the Salcha River carcass survey, 2015.

Age[a]	Sample Size	Sample Proportion	Length (mm) Mean	SE	Min	Max
Males						
1.1	3	0.01	395	28	360	450
1.2	110	0.24	576	5	450	710
1.3	101	0.22	745	5	620	900
2.2	2	>0.01	550	50	500	600
1.4	49	0.10	845	9	570	1,010
2.3	2	>0.01	713	13	700	725
Total Aged	267	0.57				
Total Males[b]	307	0.58	692	7	360	1,010
Adjusted Total[c]		0.63				
Females						
1.3	59	0.13	787	5	700	865
2.2	1	>0.01	760	-	760	760
1.4	141	0.30	851	4	750	960
Total Aged	201	0.43				
Total Females[b]	226	0.42	831	3	685	960
Adjusted Total[c]		0.37				
Total						
Total Aged	468		750	6	360	1,010
Total Collected	533		751	5	360	1,010

[a] Age is represented by the number of annuli formed during river residence and ocean residence (i.e., an age of 1.4 represents 1 annulus formed during river residence and 4 annuli formed during ocean residence plus 1 year for year of spawning for a total age of 6 years).

[b] Totals include those Chinook salmon that could not be aged.

[c] Estimated proportion of females after apply a correction factor of 0.867.

Appendix B6.–Age composition and escapement estimates by gender and by all fish combined (unadjusted and adjusted) of Salcha River Chinook salmon, 1987–2015. Escapement estimates were obtained from either a counting tower (CT) assessment or mark–recapture (MR) experiment.

Males	Total Age (years)/European Age (freshwater years/ocean years)										Male	Male
	3	4	5		6		7		8		Unadjusted[a]	Adjusted[b]
Year	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5	Escapement	Escapement
1987	0.005	0.152	0.275	0.000	0.544	0.000	0.025	0.000	0.000	0.000	1,766	2,290
1988	0.007	0.333	0.330	0.000	0.243	0.000	0.083	0.003	0.000	0.000	2,223	2,363
1989	0.012	0.107	0.548	0.000	0.333	0.000	0.000	0.000	0.000	0.000	1,477	1,853
1990	0.004	0.333	0.352	0.000	0.268	0.000	0.042	0.000	0.000	0.000	5,832	6,845
1991	0.004	0.143	0.489	0.000	0.309	0.000	0.051	0.000	0.004	0.000	3,082	3,325
1992	0.019	0.543	0.338	0.007	0.084	0.005	0.005	0.000	0.000	0.000	5,020	5,031
1993	0.012	0.384	0.454	0.000	0.146	0.003	0.000	0.000	0.000	0.000	7,364	7,613
1994	0.010	0.035	0.561	0.000	0.366	0.000	0.028	0.000	0.000	0.000	9,825	11,251
1995	0.000	0.296	0.292	0.000	0.388	0.000	0.021	0.004	0.000	0.000	6,013	7,023
1996	0.054	0.118	0.567	0.000	0.177	0.000	0.084	0.000	0.000	0.000	3,777	5,588
1997	0.000	0.256	0.244	0.000	0.489	0.000	0.011	0.000	0.000	0.000	9,597	10,488
1998	0.035	0.070	0.756	0.000	0.128	0.000	0.012	0.000	0.000	0.000	3,532	3,716
1999	0.000	0.201	0.374	0.000	0.424	0.000	0.000	0.000	0.000	0.000	4,471	4,834
2000	0.000	0.304	0.565	0.000	0.130	0.000	0.000	0.000	0.000	0.000	2,776	2,846
2001	0.008	0.167	0.425	0.000	0.400	0.000	0.000	0.000	0.000	0.000	8,395	8,995
2002	0.000	0.554	0.190	0.000	0.179	0.000	0.076	0.000	0.000	0.000	5,907	6,288
2003	0.011	0.126	0.598	0.000	0.241	0.000	0.023	0.000	0.000	0.000	8,964	10,181
2004	0.000	0.247	0.176	0.000	0.576	0.000	0.000	0.000	0.000	0.000	5,910	7,168
2005	0.000	0.204	0.516	0.000	0.265	0.000	0.011	0.004	0.000	0.000	2,709	3,168
2006	0.000	0.101	0.715	0.000	0.174	0.000	0.010	0.000	0.000	0.000	5,989	6,659
2007	0.000	0.343	0.364	0.000	0.293	0.000	0.000	0.000	0.000	0.000	4,130	4,436
2008	0.011	0.163	0.658	0.000	0.168	0.000	0.000	0.000	0.000	0.000	3,307	3,571
2009	0.000	0.520	0.315	0.000	0.165	0.000	0.000	0.000	0.000	0.000	7,774	8,446
2010	0.007	0.352	0.571	0.007	0.052	0.010	0.000	0.000	0.000	0.000	4,250	4,501
2011	0.003	0.252	0.574	0.000	0.157	0.010	0.003	0.000	0.000	0.000	4,188	4,589
2012	0.006	0.148	0.509	0.000	0.337	0.000	0.000	0.000	0.000	0.000	2,957	3,517
2013	0.022	0.225	0.202	0.000	0.539	0.000	0.011	0.000	0.000	0.000	2,705	3,072
2014[d]	0.022	0.215	0.701	0.004	0.055	0.000	0.004	0.000	0.000	0.000	-	-
2015	0.011	0.402	0.391	0.008	0.180	0.008	0.000	0.000	0.000	0.000	3,621	3,976
Average	0.009	0.252	0.450	0.001	0.269	0.001	0.017	0.000	0.000	0.000	4,913	5,487

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Females	Total Age (years)/European Age (freshwater years/ocean years)										Female	Female
	3	4	5		6		7		8		Unadjusted[a]	Adjusted[b]
Year	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5	Escapement	Escapement
1987	0.000	0.003	0.038	0.000	0.849	0.000	0.110	0.000	0.000	0.000	3,005	2,481
1988	0.000	0.005	0.066	0.000	0.690	0.000	0.239	0.000	0.000	0.000	2,099	1,959
1989	0.000	0.000	0.131	0.000	0.730	0.000	0.139	0.000	0.000	0.000	1,817	1,441
1990	0.000	0.008	0.147	0.000	0.713	0.000	0.132	0.000	0.000	0.000	4,896	3,883
1991	0.000	0.000	0.133	0.000	0.680	0.000	0.183	0.000	0.004	0.000	2,526	2,283
1992	0.000	0.005	0.327	0.000	0.650	0.000	0.014	0.005	0.000	0.000	2,842	2,831
1993	0.000	0.008	0.224	0.000	0.736	0.000	0.032	0.000	0.000	0.000	2,643	2,394
1994	0.000	0.017	0.185	0.000	0.721	0.004	0.073	0.000	0.000	0.000	8,574	7,148
1995	0.000	0.010	0.138	0.000	0.816	0.000	0.030	0.007	0.000	0.000	7,630	6,620
1996	0.000	0.005	0.205	0.000	0.390	0.000	0.400	0.000	0.000	0.000	3,793	1,982
1997	0.000	0.033	0.044	0.000	0.900	0.000	0.022	0.000	0.000	0.000	8,917	8,026
1998	0.000	0.000	0.649	0.000	0.297	0.000	0.054	0.000	0.000	0.000	1,495	1,311
1999	0.000	0.000	0.131	0.000	0.863	0.000	0.006	0.000	0.000	0.000	4,727	4,364
2000	0.000	0.111	0.389	0.000	0.389	0.000	0.111	0.000	0.000	0.000	1,819	1,749
2001	0.000	0.000	0.194	0.000	0.722	0.000	0.083	0.000	0.000	0.000	4,933	4,333
2002	0.000	0.000	0.041	0.000	0.776	0.000	0.184	0.000	0.000	0.000	3,093	2,712
2003	0.000	0.000	0.211	0.000	0.754	0.000	0.035	0.000	0.000	0.000	6,536	5,319
2004	0.000	0.000	0.028	0.000	0.958	0.000	0.014	0.000	0.000	0.000	9,851	8,593
2005	0.000	0.000	0.330	0.000	0.627	0.000	0.043	0.000	0.000	0.000	3,279	2,820
2006	0.000	0.000	0.204	0.000	0.760	0.005	0.032	0.000	0.000	0.000	4,690	4,020
2007	0.000	0.009	0.100	0.000	0.882	0.000	0.009	0.000	0.000	0.000	2,295	1,989
2008	0.000	0.000	0.303	0.000	0.655	0.000	0.042	0.000	0.000	0.000	2,108	1,844
2009	0.000	0.000	0.056	0.000	0.939	0.000	0.006	0.000	0.000	0.000	5,000	4,328
2010	0.000	0.032	0.584	0.000	0.344	0.000	0.016	0.024	0.000	0.000	1,885	1,634
2011	0.000	0.000	0.054	0.000	0.914	0.000	0.032	0.000	0.000	0.000	3,012	2,611
2012	0.000	0.000	0.207	0.000	0.765	0.000	0.028	0.000	0.000	0.000	4,208	3,648
2013	0.000	0.000	0.111	0.000	0.844	0.000	0.044	0.000	0.000	0.000	2,760	2,393
2014[d]	0.000	0.000	0.372	0.000	0.589	0.000	0.039	0.000	0.000	0.000	-	-
2015	0.000	0.000	0.299	0.000	0.701	0.000	0.000	0.000	0.000	0.000	2,666	2,311
Average	0.000	0.008	0.203	0.000	0.712	0.000	0.074	0.001	0.000	0.000	4,039	3,465

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Unadjusted[b]	Total Age (years)/European Age (freshwater years/ocean years)											
All Fish	3	4	5		6		7		8		Total	
Year	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5	Escapement	Method[c]
1987	0.002	0.058	0.126	0.000	0.736	0.000	0.078	0.000	0.000	0.000	4,771	MR
1988	0.004	0.203	0.225	0.000	0.421	0.000	0.145	0.002	0.000	0.000	4,322	MR
1989	0.005	0.041	0.290	0.000	0.579	0.000	0.086	0.000	0.000	0.000	3,294	MR
1990	0.002	0.169	0.249	0.000	0.492	0.000	0.087	0.000	0.000	0.000	10,728	MR
1991	0.002	0.076	0.322	0.000	0.483	0.000	0.113	0.000	0.004	0.000	5,608	MR
1992	0.012	0.361	0.334	0.005	0.276	0.003	0.008	0.002	0.000	0.000	7,862	MR
1993	0.009	0.280	0.391	0.000	0.309	0.002	0.009	0.000	0.000	0.000	10,007	CT
1994	0.006	0.027	0.392	0.000	0.525	0.002	0.048	0.000	0.000	0.000	18,399	CT
1995	0.000	0.136	0.206	0.000	0.628	0.000	0.026	0.006	0.000	0.000	13,643	CT
1996	0.027	0.061	0.383	0.000	0.286	0.000	0.245	0.000	0.000	0.000	7,570	MR
1997	0.000	0.144	0.144	0.000	0.694	0.000	0.017	0.000	0.000	0.000	18,514	CT
1998	0.024	0.049	0.724	0.000	0.179	0.000	0.024	0.000	0.000	0.000	5,027	CT
1999	0.000	0.091	0.241	0.000	0.664	0.000	0.003	0.000	0.000	0.000	9,198	CT
2000	0.000	0.220	0.488	0.000	0.244	0.000	0.049	0.000	0.000	0.000	4,595	CT
2001	0.005	0.104	0.339	0.000	0.521	0.000	0.031	0.000	0.000	0.000	13,328	CT
2002	0.000	0.362	0.138	0.000	0.387	0.000	0.113	0.000	0.000	0.000	9,000	CT
2003	0.007	0.076	0.444	0.000	0.444	0.000	0.028	0.000	0.000	0.000	15,500	CT
2004	0.000	0.092	0.083	0.000	0.817	0.000	0.009	0.000	0.000	0.000	15,761	CT
2005	0.000	0.093	0.415	0.000	0.462	0.000	0.028	0.002	0.000	0.000	5,988	CT
2006	0.000	0.057	0.493	0.000	0.428	0.002	0.020	0.000	0.000	0.000	10,679	CT
2007	0.000	0.224	0.269	0.000	0.503	0.000	0.003	0.000	0.000	0.000	6,425	CT
2008	0.007	0.099	0.518	0.000	0.360	0.000	0.017	0.000	0.000	0.000	5,415	CT
2009	0.000	0.317	0.214	0.000	0.467	0.000	0.002	0.000	0.000	0.000	12,774	CT
2010	0.005	0.255	0.575	0.005	0.141	0.007	0.005	0.007	0.000	0.000	6,135	CT
2011	0.002	0.146	0.355	0.000	0.476	0.006	0.015	0.000	0.000	0.000	7,200	CT
2012	0.002	0.060	0.329	0.000	0.593	0.000	0.017	0.000	0.000	0.000	7,165	CT
2013	0.011	0.112	0.156	0.000	0.693	0.000	0.028	0.000	0.000	0.000	5,465	CT
2014[d]	0.015	0.146	0.596	0.002	0.226	0.000	0.015	0.000	0.000	0.000	-	-
2015	0.006	0.229	0.351	0.004	0.405	0.004	0.000	0.000	0.000	0.000	6,287	CT
Average	0.005	0.148	0.338	0.001	0.463	0.001	0.044	0.001	0.000	0.000	8,952	

-continued-

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Adjusted	Total Age (years)/European Age (freshwater years/ocean years)											
All Fish	3	4	5		6		7		8		Total	
Year	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5	Escapement	Method[c]
1987	0.002	0.074	0.151	0.000	0.703	0.000	0.069	0.000	0.000	0.000	4,771	MR
1988	0.004	0.185	0.210	0.000	0.446	0.000	0.154	0.002	0.000	0.000	4,322	MR
1989	0.007	0.060	0.366	0.000	0.507	0.000	0.061	0.000	0.000	0.000	3,294	MR
1990	0.002	0.215	0.278	0.000	0.429	0.000	0.075	0.000	0.000	0.000	10,728	MR
1991	0.002	0.085	0.344	0.000	0.460	0.000	0.105	0.000	0.004	0.000	5,608	MR
1992	0.012	0.349	0.334	0.004	0.288	0.003	0.008	0.002	0.000	0.000	7,862	MR
1993	0.009	0.298	0.402	0.000	0.281	0.002	0.007	0.000	0.000	0.000	10,007	CT
1994	0.006	0.028	0.409	0.000	0.509	0.002	0.046	0.000	0.000	0.000	18,399	CT
1995	0.000	0.158	0.217	0.000	0.595	0.000	0.025	0.005	0.000	0.000	13,643	CT
1996	0.040	0.089	0.472	0.000	0.233	0.000	0.167	0.000	0.000	0.000	7,570	MR
1997	0.000	0.163	0.161	0.000	0.661	0.000	0.016	0.000	0.000	0.000	18,514	CT
1998	0.026	0.052	0.728	0.000	0.172	0.000	0.023	0.000	0.000	0.000	5,027	CT
1999	0.000	0.112	0.266	0.000	0.620	0.000	0.003	0.000	0.000	0.000	9,198	CT
2000	0.000	0.238	0.505	0.000	0.219	0.000	0.038	0.000	0.000	0.000	4,595	CT
2001	0.006	0.113	0.351	0.000	0.503	0.000	0.027	0.000	0.000	0.000	13,328	CT
2002	0.000	0.389	0.146	0.000	0.357	0.000	0.108	0.000	0.000	0.000	9,000[c]	CT
2003	0.007	0.080	0.456	0.000	0.429	0.000	0.027	0.000	0.000	0.000	15,500[c]	CT
2004	0.000	0.113	0.096	0.000	0.783	0.000	0.008	0.000	0.000	0.000	15,761	CT
2005	0.000	0.107	0.428	0.000	0.437	0.000	0.026	0.002	0.000	0.000	5,988	CT
2006	0.000	0.062	0.520	0.000	0.397	0.002	0.019	0.000	0.000	0.000	10,679	CT
2007	0.000	0.240	0.282	0.000	0.475	0.000	0.003	0.000	0.000	0.000	6,425	CT
2008	0.007	0.108	0.538	0.000	0.333	0.000	0.014	0.000	0.000	0.000	5,415[c]	CT
2009	0.000	0.343	0.227	0.000	0.427	0.000	0.002	0.000	0.000	0.000	12,774	CT
2010	0.005	0.267	0.575	0.005	0.130	0.008	0.004	0.006	0.000	0.000	6,135	CT
2011	0.002	0.161	0.385	0.000	0.432	0.006	0.014	0.000	0.000	0.000	7,200[c]	CT
2012	0.003	0.073	0.355	0.000	0.555	0.000	0.014	0.000	0.000	0.000	7,165	CT
2013	0.013	0.126	0.162	0.000	0.673	0.000	0.026	0.000	0.000	0.000	5,465	CT
2014[d]	-	-	-	-	-	-	-	-	-	-	-	-
2015	0.007	0.254	0.357	0.005	0.372	0.005	0.000	0.000	0.000	0.000	6,287	CT
Average	0.006	0.162	0.347	0.001	0.444	0.001	0.039	0.001	0.000	0.000	8,952	

[a] Unadjusted escapement and composition estimates were derived from the observed sample proportions of males and females from carcass surveys.

[b] In years when mark–recapture experiments (MR) were conducted, males were more likely to be sampled during the first event (electroshocking) and overall less bias in estimating size and sex was noted from electroshocking than sampling carcasses (second event). As a result, an adjustment factor has been applied to the carcass samples, which have been the primary means of obtaining age, sex, and length since 1997.

[c] Estimate includes an expansion for missed counting days.

[d] Extensive flooding prevented operation of counting tower.

APPENDIX C: GOODPASTER RIVER CHINOOK SALMON COUNTING TOWER DATA

INTRODUCTION

The Chinook salmon counting tower on the Goodpaster River began operations in 2004. It is operated by staff from TCC and the Bering Sea Fisherman's Association. Further details regarding this project can be obtained by contacting the TCC.

Unlike the Chena and Salcha rivers, the Goodpaster River does not have an escapement goal and counts are not provided to the fisheries managers on a daily basis. In the future, as a longer time series is collected, a spawner-recruit analysis can be performed and an escapement goal may be developed with concurrent acquisition of composition data (ASL) and managed for as long as the data is there to support the analysis.

METHODS

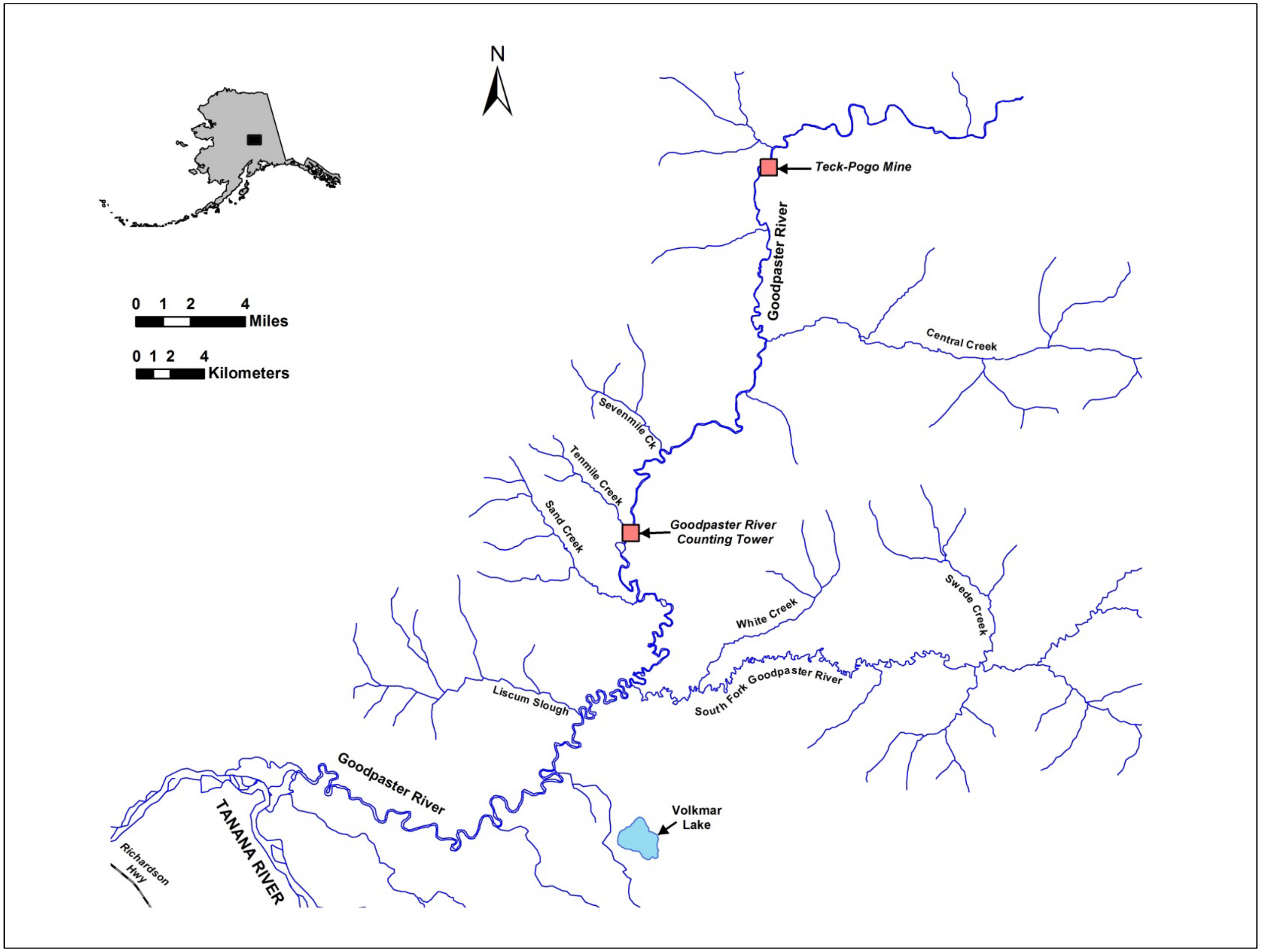
Project mobilization, escapement enumeration, and data analysis procedures for the Goodpaster River counting tower were similar to those used for the Chena River except there was no sonar assessment during periods of high water.

The Goodpaster River has not been sampled for Chinook salmon ASL composition since 2000, although samples have been taken sporadically for genetic identification.

RESULTS

In 2015, the Goodpaster River counting tower (Appendix C1) was in operation from 9–30 July. The estimated Chinook salmon escapement during that time was 2,353 (SE = 97) (Appendix C2 and C3). Chinook salmon escapements on the Goodpaster River are usually much lower than the Chena and Salcha rivers (Appendix B4).

It is unknown what proportion of the Goodpaster River Chinook salmon stock may spawn up the South Fork of the river, but various surveys have shown little if any spawning occurring on the South Fork as habitat is unsuitable for at least the vast majority of the drainage, and therefore the estimates of escapement produced by this project should not be considered totally inclusive but rather representative of the Goodpaster River, until such time as the significance of the South Fork can be ascertained.



Appendix C1.–Map of the Goodpaster River demarcating the counting tower.

Appendix C2.–Estimates of the Goodpaster River Chinook salmon escapement, 2004–2015.

	Escapement	
Year	Estimate	SE
2004	3,673	106
2005	1,184	70
2006	2,479	100
2007	1,581	82
2008	1,880	85
2009	4,280	167
2010	1,167	67
2011	1,325	Not Reported
2012	752	50
2013	723	44
2014	1,305	90
2015	2,353	97

Appendix C3.–Daily estimates of Goodpaster River Chinook salmon escapement, 2015.

Date	Daily Escapement	Daily SE
9-Jul	126	23
10-Jul	69	17
11-Jul	90	23
12-Jul	141	28
13-Jul	186	30
14-Jul	159	19
15-Jul	178	33
16-Jul	196	36
17-Jul	165	23
18-Jul	174	24
19-Jul	204	26
20-Jul	76	18
21-Jul	77	14
22-Jul	77	17
23-Jul	45	13
24-Jul	90	11
25-Jul	90	16
26-Jul	75	15
27-Jul	57	11
28-Jul	51	7
29-Jul	27	5
30-Jul	0	0
Total	2,353	97