Fishery Data Series No. 19-23

Sonar Estimation of Summer Chum and Pink Salmon in the Anvik River, Alaska, 2018

by

Naomi B. Brodersen

August 2019

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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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Dual-frequency identification sonar (DIDSON) was used to estimate adult summer chum salmon *Oncorhynchus keta* and pink salmon *O. gorbuscha* passage in the Anvik River from June 15 to July 26, 2018. Apportionment to species was determined using data collected from tower counts. A total of 305,098 (SE 5,926) summer chum and 1,122,346 (SE 7,588) pink salmon were estimated to have passed the sonar site. A beach seine sample fishery was conducted to collect age, sex, and length information. Both sonar systems functioned well with minimal interruptions to operation. Range of ensonification was considered adequate for most fish that migrated upstream.

Key words: chum salmon, *Oncorhynchus keta*, pink salmon, *Oncorhynchus gorbuscha*, dual-frequency identification sonar DIDSON, Anvik River.

INTRODUCTION

The purpose of the Anvik River sonar project is to monitor escapement of adult summer chum salmon *Oncorhynchus keta* and pink salmon *O. gorbuscha* to the Anvik River drainage, one of the largest producers of summer chum salmon in the Yukon River drainage (Bergstrom et al. 1999, Larson et al. 2017) (Figure 1). Additional major spawning populations of summer chum salmon occur in the following tributaries of the Yukon River: the Koyukuk River, which includes the Gisasa River, Billy Hawk Creek, Dakli River, Hogatza River, and Henshaw Creek; and the Bonasila River (Larson et al. 2017) (Figure 2). Smaller populations of summer chum salmon occur in the Andreafsky River, Thompson Creek, the Nulato River, the Rodo River, Stink Creek, the Melozitna River, the Tozitna River, and the Tanana River, which includes the Chena River and Salcha River.

Chinook salmon *O. tshawytscha* and pink salmon spawn in the Anvik River concurrently with summer chum salmon, with high abundance of pink salmon occurring on even years in the Yukon River drainage (Estensen et al. 2018). Apportionment of pink salmon passage on the Anvik River during even years is necessary to accurately assess summer chum salmon escapement from the total sonar passage estimate. Fall chum, which are a later run of chum salmon, coho salmon *O. kisutch*, and sockeye salmon *O. nerka* have also been reported to spawn in the Anvik River drainage.

Timely and accurate reporting of summer chum salmon escapement from the Anvik River sonar project helps fishery managers ensure that the Anvik River biological escapement goal (BEG) of 350,000–700,000 summer chum salmon is met (ADF&G 2004), while providing downstream subsistence and commercial harvest. Subsistence and commercial fishery openings and closures may be based in part upon this assessment.

From 1972 to 1979, Anvik River summer chum and pink salmon escapements were partially estimated from visual counts made at counting towers above the confluence of the Anvik and Yellow rivers (Figure 3). A site 9 km above the Yellow River on the mainstem Anvik River was used from 1972 to 1975 (Lebida[1]; Trasky 1974; Mauney 1977). From 1976 to 1979, a site on the mainstem Anvik River near the confluence of Robinhood Creek and the Anvik River was used (Mauney 1979, 1980; Mauney and Geiger 1977). Since 1979, the Anvik River sonar project has been located approximately 76 km upstream of the confluence of the Anvik and Yukon rivers and 5 km below Theodore Creek at lat 62°44.21′N, long 160°40.72′W. The land is public, managed by the Bureau of Land Management (BLM), and leased to the Alaska Department of

[1] Lebida, R. C. Unpublished. Yukon River anadromous fish investigations, 1973. Alaska Department of Fish and Game, Juneau.

Fish and Game (ADF&G) for public purposes until 2023. Aerial survey data indicate that summer chum salmon spawn primarily upstream of this sonar site.

Shorebased sonar, capable of detecting migrating salmon along the banks, was first used at the current Anvik River sonar site in 1979 to determine the feasibility of using sonar to enumerate summer chum passage (Sandone 1993). Bendix[2,3] sonar equipment was used to estimate escapement from 1980 to 2003. In 2003, a side-by-side comparison was done with Hydroacoustic Technology Incorporated (HTI) split-beam sonar equipment when it was found that the Bendix and HTI produced similar abundance estimates (Dunbar and Pfisterer 2007). In 2004, the project changed to HTI sonar equipment for estimates. In 2006, a side-by-side comparison was done between HTI and a dual-frequency identification sonar (DIDSON) (Belcher et al. 2002). High water for most of the season prevented normal operation of the split-beam sonar, but it was found the DIDSON abundance estimate was 61% higher than the split-beam abundance estimate (McEwen 2007). DIDSON has been used in the Yukon and Kenai rivers (Lozori and Borden 2015; Key et al. 2016) to generate daily passage estimates where bottom profiles are appropriate for the wider beam angle and shorter range capabilities of this sonar. In 2007, the project transitioned to DIDSON sonar.

The Anvik River sonar project provides timely and accurate information to Yukon River fishery managers. DIDSON equipment is used to collect salmon passage data and tower estimates are used to apportion the counts to summer chum or pink salmon. Beach seines are used to collect age, sex, and length (ASL) data. HOBO data loggers are used to monitor water temperature daily. This report presents data collected in 2018 and compares the results to previous years.

OBJECTIVES

The goal of this project in 2018 was to provide daily inseason estimates of adult summer chum and pink salmon escapement into the Anvik River to fishery managers. Primary objectives were as follows:

1. Estimate daily summer chum and pink salmon abundance in the Anvik River from approximately June 16 through July 26 using DIDSON and tower counts for apportionment, and determine if the summer chum salmon BEG was met; and
2. Operate DIDSON such that 95% of migrating salmon were detected within three-quarters of the ensonified range on both banks.

Secondary objectives were as follows:

3. Using a beach seine, collect a minimum of 162 summer chum salmon samples during each of 4 temporal strata (corresponding to passage quartiles) throughout the season to estimate the ASL composition, such that simultaneous 95% confidence intervals of age composition in each sample were no wider than 0.20 ($\alpha = 0.05$ and $d = 0.10$); and
4. Collect daily weather and water measurements representative of the study area.

[2] ADF&G (Alaska Department of Fish and Game). [Internet]. Alaska fisheries sonar: sonar technology tools. www.adfg.alaska.gov/index.cfm?adfg=sonar.sonartools (Accessed: August 28, 2018).

[3] Product names used in this report are included for scientific completeness but do not constitute a product endorsement.

METHODS

STUDY AREA

The Anvik River originates at an elevation of 400 m and flows in a southerly direction approximately 230 km to its mouth at river kilometer 512 of the Yukon River (Figure 1). This narrow runoff stream has a substrate of mainly gravel and cobble. Bedrock is exposed in some of the upper reaches. The Yellow River (Figure 3) is a major tributary of the Anvik drainage and is located approximately 100 km upstream from the mouth of the Anvik River. Downstream from the confluence of the Yellow River, the Anvik River changes from a moderate-gradient system to a low-gradient system meandering through a much broader flood plain. Turbid waters from the Yellow River greatly reduce water clarity of the Anvik River below their confluence. Numerous oxbows, old channel cutoffs, and sloughs are found throughout the lower Anvik River.

At the sonar site, the Anvik River is characterized by broad meanders, with large gravel bars on inside bends and cut banks with exposed soil, tree roots, and snags on outside bends. As in past years, we were able to use the same location this season due to the site's stability. The river substrate at the sonar site is fine, smooth gravel, sand, and silt. This season the right bank sloped gradually to the thalweg approximately 32 to 45 m from shore, and the left bank sloped steeply to the thalweg approximately 16 to 20 m from shore depending on water level (Figure 4).

HYDROACOUSTIC EQUIPMENT

A long-range DIDSON operating at a frequency of 1.2 MHz (high frequency option using 48 beams) was deployed on the right bank and a standard DIDSON operating at a frequency of 1.1 MHz (low frequency option using 48 beams) was deployed on the left bank (Table 1). Because of the shallow right bank bottom profile, a concentrator lens (approximately 2°) was used to reduce surface and bottom reverberation. A laptop computer running DIDSON software controlled each DIDSON and an external hard drive was used to store data. A wireless Ethernet router transferred data from the left bank to the controlling laptop on the right bank (Figure 5).

SONAR DEPLOYMENT AND OPERATION

Prior to transducer deployment, the river bottom profile was checked to ensure the site was acceptable for ensonification. Range and depth data were collected from bank-to-bank transects using a boat-mounted Hummingbird 998C SI fathometer with GPS capabilities and plotted.

Both banks were ensonified on July 15, and operations ran continuously through July 26 at 1200. The DIDSONs were mounted on aluminum frames and aimed using manual crank-style rotators (Figure 6). The DIDSONs were placed offshore in a fixed location with the beams directed perpendicular to current flow, approximately 10 m from the right bank and approximately 3 m from the left bank depending on water level. Operators adjusted the pan and tilt by viewing the video-like acoustic image and relaying aiming instructions to a technician via handheld VHF radio. The wide axis of each beam was oriented horizontally and positioned close to the river bottom to maximize residence time of targets in the beam. On both banks, the ensonified range was 20 m, starting at 0.83 m from the DIDSON and ending at 20.83 m (Table 1). Approximately 60–85% of the river was ensonified depending on water level. Daily visual inspections of the sonar pods and images confirmed proper placement and orientation of the DIDSONs, and alerted operators when the pods needed to be repositioned to accommodate changing water levels.

Partial weirs were erected perpendicular to the current and extended from the shore outward 1 to 3 m beyond each DIDSON (Figure 7). The weirs diverted migrating adult salmon offshore and in front of the DIDSONs to provide sufficient offshore distance for fish to be detected in the sonar beam, while allowing passage of small, resident, non-target species through the weirs.

SONAR DATA PROCESSING AND PASSAGE ESTIMATION

Acoustic sampling was conducted on both banks starting at the top of each hour for 30 minutes, 24 hours per day, and 7 days per week, except for short periods when generators were serviced or adjustments were made to the sonars. Operators opened each 30 minute data file in the echogram viewer program, Echotastic (developed by ADF&G staff), and marked each upstream fish track with a computer mouse. All fish were counted except for small fish (<400 mm), which were assumed to not be salmon. Fish length measurements were made using DIDSON software marking tools. Upstream direction of travel was verified using the Echotastic video feature, which displayed the raw acoustic fish images. The 30 minute counts were saved as text files and recorded on a paper count form.

The daily passage ($\hat{y}$) for stratum (s) on day (d) was calculated by averaging the hourly passage rates for the hours sampled and then multiplying by the number of hours in a day as follows:

$$\hat{y}_{ds} = 24 \cdot \frac{\sum_{p=1}^{n} \frac{y_{dsp}}{f_{dsp}}}{n_{ds}}, \tag{1}$$

where h_{dsp} is the fraction of the hour sampled on day (d), stratum (s), period (p) and y_{dsp} is the count for the same sample.

Treating the systematically sampled sonar counts as a simple random sample would yield an over-estimate of the variance of the total because sonar counts are highly auto-correlated. To accommodate these data characteristics, a variance estimator based on the squared differences of successive observations was employed (Wolter 1985). The variance for the passage estimate for stratum (s) on day (d) is estimated as:

$$\hat{V}_{y_{ds}} = 24^2 \frac{1 - f_{ds}}{n_{ds}} \frac{\sum_{p=2}^{n_{ds}} \left(\frac{y_{dsp}}{h_{dsp}} - \frac{y_{ds,p-1}}{h_{ds,p-1}} \right)^2}{2(n_{ds} - 1)}, \tag{2}$$

where n_{ds} is the number of samples in the day (24), f_{ds} is the fraction of the day sampled (12/24 = 0.5), and y_{dsp} is the hourly count for day (d) in stratum (s) for sample (p).

MISSING DATA

Estimating daily passage by multiplying the average hourly passage rates by 24 (Equation 1) compensates for missing data (either shortened or missing periods) within a day and is reflected in the variance (Equation 2) by reducing the number of samples and the fraction of the day sampled. If 1 or multiple days were missed, daily passage was interpolated by averaging passage estimates from days before and after the missing day(s) as follows:

$$\hat{y}_d = \left(1/n\sum_{i=1}^{n} x_i\right)\begin{Bmatrix} d=1, n=4 \\ d=2, n=6 \\ d=3, n=8 \end{Bmatrix}, \quad (3)$$

where d is the number of missed days, n is the number of days used for interpolation (half before and half after the missing day(s)), and x_i is the passage for each day (i).

After editing was complete, an estimate of hourly, daily, and cumulative fish passage was produced and forwarded to the Fairbanks ADF&G office via email each day. The estimates produced during the field season were further reviewed postseason and adjusted as necessary.

SPECIES APPORTIONMENT

Tower counts were conducted 4 times per day (0730, 1300, 1700, and 2000) for 15 minutes on each bank to apportion the number of summer chum and pink salmon migrating past the sonar site. On both banks, a 4.5 m tower was anchored in the river just downstream of the sonar at the end of the weir (Figure 7). Technicians stood on top of the towers using polarized sunglasses and counted salmon, by species, passing the sonar. The number of salmon species for each bank and the visible range (meters from the transducer) were entered into a Microsoft Access database. Non-salmon species, which would be excluded from the sonar estimate, were not counted or recorded. Because of the low proportion of Chinook and sockeye salmon migrating past the sonar site, these species were not proportioned in the daily estimates.

Species proportions for each usable tower counting period (i) were calculated by dividing the count (c) for species (a) on day (d) and bank (z) by the count summed over all species in the same tower counting period:

$$p_{diza} = \frac{c_{diza}}{\sum_{a} c_{diza}} \quad . \quad (4)$$

The estimated proportion for each day, bank, and species was computed as the mean of the individual proportions in that day:

$$\hat{p}_{dza} = \frac{\sum_{di} p_{diza}}{n_{di}} \quad . \quad (5)$$

To compensate for days in which there were insufficient data from tower counts to accurately estimate species proportions, tower counts from multiple days were combined, which allowed for estimation of the sampling variance. Days were combined into groups such that each contained at least 2 tower counting periods with at least 5 fish and a minimum clarity of 2.0 m for the right bank and 1.0 m for the left bank.

Daily sonar passage estimates were apportioned to either pink or summer chum salmon by multiplying the estimated proportion by the unadjusted sonar passage estimate:

$$\hat{y}_{dza} = \hat{y}_{dz} \cdot \hat{p}_{rza} \quad . \quad (6)$$

With 2 species apportioned for, the variance of the proportion was computed based on the difference of the individual observations from the mean for each day:

$$Var\left(\hat{p}_{dza}\right) = \frac{\sum_{i}\left(\bar{p}_{dza} - \hat{p}_{diza}\right)^2}{n\left(n-1\right)} \quad , \tag{7}$$

and the variance of the species passage estimate was calculated as:

$$\hat{Var}\left(\hat{y}_{dza}\right) = \hat{y}_{dz}^2 \cdot \hat{Var}\left(\hat{p}_{dza}\right) + \hat{p}_{dza}^2 \cdot \hat{Var}\left(\hat{y}_{dz}\right) - \hat{Var}\left(\hat{y}_{dz}\right) \cdot \hat{Var}\left(\hat{p}_{dza}\right) \quad . \tag{8}$$

Total daily passage by species was estimated by summing both banks,

$$\hat{y}_{da} = \sum_{z} \hat{y}_{dza} \quad , \tag{9}$$

and passage estimates were summed over both banks and all days to obtain a seasonal estimate for each species:

$$\hat{y}_{a} = \sum_{d}\sum_{z} \hat{y}_{dza} \tag{10}$$

Finally, passage estimates were assumed independent between banks and among days, therefore the variance of their sum was estimated by the sum of their variances:

$$\hat{Var}(\hat{y}_a) = \sum_{d}\sum_{z} \hat{Var}(\hat{y}_{dza}) \quad , \tag{11}$$

and, assuming normally distributed errors, 90% confidence intervals were calculated as,

$$\hat{y}_a \pm 1.645\sqrt{\hat{Var}}(\hat{y}_a) \quad . \tag{12}$$

AGE, SEX, AND LENGTH SAMPLING

Temporal strata, used to characterize the age and sex composition of the summer chum salmon escapement, were defined as dates on which 25%, 50%, 75%, and 100% of the total run passed the sonar site. Historical mean quartile dates from 2000 to 2017 were used to determine inseason ASL sampling dates. These temporal strata represent an attempt to sample the escapement in proportion to the total run.

A minimum of 150 readable scales per temporal stratum was necessary to achieve simultaneous 95% confidence intervals no wider than 0.20 (d = 0.10 and (α) = 0.05), assuming 2 major age classes and 2 minor age classes (Bromaghin 1993). To meet the AYK Region standard, the seasonal ASL sample goal was set to a minimum of 162 summer chum salmon samples per stratum (648 total for the season), which accounted for a scale rejection rate of 7%.

A beach seine (31 m long, 66 meshes deep, 2.5 in mesh) was drifted, beginning approximately 10 m downstream of the sonar site, to capture summer chum salmon for ASL data collection. All resident freshwater fish captured were tallied by species and released. Pink salmon were counted by sex (based on external characteristics) and released. Summer chum salmon were held live in a submerged holding pen and each were noted for sex, measured to the nearest 1 mm from mid-

eye to tail fork, and 1 scale was taken to determine age. Scales were collected from an area posterior to the base of the dorsal fin and above the lateral line on the left side of the fish (Clutter and Whitesel 1956). The adipose fin was clipped on each sampled summer chum salmon to prevent resampling.

ASL data were collected for Chinook and sockeye salmon using the same methods except 4 scale samples were taken from each fish. This sampling was established to gain additional information on these species while pursuing the primary summer chum salmon sampling goal, at no extra cost to the project.

WEATHER AND WATER OBSERVATIONS

Climatic and hydrologic data were collected at approximately 1800 hours each day at the sonar site. River depth was monitored using a staff gauge marked in 1 cm increments. Change in water depth was presented in negative or positive increments from the initial reading of 0.0 cm. Water temperature was measured using a HOBO data logger, which electronically recorded the temperature every hour, on the hour, for the duration of the project. Subjective notes about wind speed and direction, cloud cover, and precipitation were also recorded.

RESULTS AND DISCUSSION

SUMMER CHUM AND PINK SALMON ESTIMATION

Overall there were no significant problems estimating salmon passage in 2018. The objective to estimate summer chum and pink salmon abundance using DIDSON from approximately June 16 through July 26 was met. The total summer chum salmon passage estimate at the Anvik River sonar site was 305,098 (SE 5,926) from June 15 through July 26. The first quarter point was July 3, the midpoint was July 11, and the third quarter point was July 15. The peak daily passage estimate of 24,952 summer chum salmon occurred on July 14 and 4,363 summer chum salmon passed the sonar on July 26, which was the last day of sonar operation (Table 2). When compared to mean historical run timing (2008–2017) the summer chum salmon migration was average at the first quartile and 2 days late at the third quartile (Table 3). Daily passage between the first and third quartile dates ranged from 4,782 (July 9) to 24,952 (July 14), and an estimated total of 168,303 summer chum salmon passed the sonar site. The 2018 summer chum salmon passage estimate was below the mean Anvik River passage estimate of 419,411 fish (2008–2017) and was below the BEG of 350,000 to 700,000 fish.

The timing of the summer chum salmon run into the Anvik River was similar to the pattern observed at the lower Yukon River sonar project near the village of Pilot Station (Figure 8). Historically, the percentage of Yukon River summer chum salmon bound for the Anvik River has fluctuated and can be broken into 2 distinct periods. From 1995 to 2002, the average contribution was 46%. From 2003 to 2017, the average contribution decreased to 21%. Of the 1,612,688[4] summer chum salmon that were estimated to have passed Pilot Station this season, approximately 19% were observed at the Anvik River sonar project.

The total pink salmon passage estimate was 1,122,346 (SE 7,588) from June 15 through July 26. The first quarter point was July 16, the midpoint was July 19, and the third quarter point was July

[4] ADF&G (Alaska Department of Fish and Game). [Internet]. Yukon River (Pilot Station) chum salmon – Summer 2018. http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareayukon.salmon_escapement (Accessed: December 4, 2018).

23. Because sonar operations ended before the completion of the pink salmon migration, calculations of quartile statistics were based on the proportion of the run when the sonar project was operational. The peak daily passage estimate of 92,267 pink salmon occurred July 18, and 73,381 pink salmon passed the sonar July 26 (Table 4). When compared to mean historical run timing (1994, 2000–2004, and 2008–2016, even years only) the pink salmon migration was 5 days late at the first quartile and 2 days late at the third quartile (Table 5). Daily passage between the first and third quartile dates ranged from 59,613 (July 20) to 92,267 (July 18), and an estimated total of 638,336 pink salmon passed the sonar site. The 2018 pink salmon passage estimate was above the mean Anvik River passage estimate of 432,166 fish (1994, 2000–2004, and 2008–2016, even years only).

Since 2008, pink salmon passage estimates during even years have exceeded summer chum salmon on the Anvik River (Figure 9). The 2018 pink salmon passage estimate was the highest estimate recorded since 1994, and surpassed the pink salmon estimate of 689,607[5] at the sonar project on the lower mainstem of the Yukon River near the village of Pilot Station (Figure 1), which is downriver from the Anvik River drainage. This difference is not unexpected given differences in passage estimation methods between the 2 projects. Because of apportionment concerns at the sonar project near Pilot Station, sonar and test fishery ranges are adjusted to avoid counting a majority of the pink salmon, which are generally distributed close to shore and within the ensonified region but difficult to adequately represent in the apportionment test fishery. In contrast, the partial weirs at the Anvik River sonar project are designed to direct all salmon into the ensonified region, which results in enumeration of most pink salmon migrating past the sonar site. So, whereas the Pilot Station sonar project actively avoids counting and catching pink salmon, the Anvik River sonar project estimates their passage.

Total sonar passage estimates include expansions for sampling time missed. On the left bank, 1,771 minutes were missed, which accounted for an additional 45,533 fish, or approximately 5% of the total left bank estimate (Tables 6 and 7). On the right bank, 1,279 minutes were missed, which accounted for an additional 17,657 fish, or approximately 3% of the total right bank estimate. A majority of the total expanded fish passage estimate was July 26 (38,898 fish), the last day of sonar operation, and the sonars were turned off at 1200. Proportionally, summer chum salmon only accounted for 5.6% of the total passage estimate that day (Table 7).

SPATIAL AND TEMPORAL DISTRIBUTION

Similar to historical range distributions, fish passage was predominantly shore-oriented in 2018. Approximately 95% of fish targets were detected within 4 m of the transducer on the left bank and 11 m on the right bank (Figure 10). The objective to operate the sonar such that 95% of migrating salmon were detected within three-quarters (15 m) of the ensonified range on both banks was met.

Approximately 81% of the total summer chum salmon passage and 28% of the total pink salmon passage occurred on the right bank.

In 2018, the right bank displayed a distinct diurnal pattern of fish passage and a higher proportion of passage occurred during darker hours of the day (Figure 11). This distinct pattern was less evident on the left bank, but fish passage did increase from 1900 to 2300. When both

[5] ADF&G (Alaska Department of Fish and Game). [Internet]. Yukon River (Pilot Station) pink salmon – Summer 2018. http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareayukon.salmon_escapement (Accessed: March 4, 2018).

banks were combined, the diurnal pattern was apparent but less pronounced than the right bank only.

SPECIES APPORTIONMENT

Summer chum and pink salmon were the most prominent salmon species observed on both banks during tower counts. Tower counts began June 16. The first summer chum salmon was observed June 21 and the first pink salmon was observed June 25 (Table 8). Proportionally, summer chum salmon accounted for approximately 5% of the total tower count on the left bank and 46% on the right bank.

Weather conditions were mostly favorable this season and there was only 1 day (June 21) when the minimum range of visibility from the counting towers was not observed. There were insufficient tower counts of fish June 15–26 on the left bank and June 15–21 on the right bank. Because of insufficient numbers of fish on these days, multiple days were combined to apportion sonar passage estimates to species. On the left bank, tower counts were combined into 2 groups: June 15–June 24 and June 25–June 26. On the right bank, tower counts were combined June 15–June 21. On July 26, only 1 tower counting period was recorded for each bank, which resulted in combining the day's count with July 25.

SUMMER CHUM AGE AND SEX COMPOSITION

In 2018, temporal strata were defined as: June 15–July 2, July 3–July 10, July 11–July 14, and July 15–July 26 (Table 3). From June 28 through July 18, a total of 731 summer chum salmon ASL samples were obtained, 148 during the first quartile, 254 during the second quartile, 166 during the third quartile, and 163 during the fourth quartile. Of these samples, 679 scales were analyzed postseason as ageable.[6] The sample size goal of 162 summer chum salmon was not achieved in the first quartile; therefore, the objective of collecting a minimum of 162 samples during each temporal stratum was not met this season. In addition, the sample size goal of 150 readable scales per stratum was not achieved in the first and fourth quartiles (Table 9).

Scale sample analysis indicated that there were 2 major age classes, age 0.3 (63.6%) and age 0.4 (32.8%), as well as 2 minor classes, age 0.2 (0.7%) and 0.5 (2.9%) (Table 9 and Figure 12).

Fair (1997) documented that the age and sex composition of summer chum salmon passing the sonar site usually changes throughout the duration of the run, with an increasing proportion of younger salmon and a higher proportion of female salmon as the run progresses. Age composition was consistent with this pattern in 2018, but the proportion of females decreased slightly between the second and third strata (Figure 12). Female summer chum salmon accounted for approximately 51% of the entire run, which was below the 1998–2017 average of approximately 55% (Figure 13).

HYDROLOGIC AND CLIMATOLOGICAL CONDITIONS

The objective of monitoring hydrological parameters daily at the project site was met in 2018. Compared to observations from previous seasons, the water level was high when the project began. The water level increased slightly during the first week, then dropped for the majority of the season, with a slight increase mid-July. The lowest level was recorded on July 25 (Figure

[6] ADF&G (Alaska Department of Fish and Game). [Internet]. AYKDBMS [Arctic-Yukon-Kuskokwim Database Management System] Home Page. http://sf.adfg.state.ak.us/CommFishR3/WebSite/AYKDBMSWebsite/Default.aspx (Accessed September 25, 2018).

14). Overall, between June 16 and July 25, the minimum and maximum water level differed by 100 cm. Water temperatures at the project ranged from a low of 9.1°C on June 17 to a high of 17.4°C on July 25 (Figure 15). Air temperatures ranged from a low of 12.2°C on June 16 and June 19 to a high of 27.0°C on July 3 (Appendix A).

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TABLES AND FIGURES

Table 1.–Technical specifications for dual-frequency identification sonars (DIDSON) at the Anvik River sonar project, 2018.

Setting	Right bank	Left bank
Mode	High frequency	Low frequency
Frequency (MHz)	1.20	1.10
Number of beams	48	48
Horizontal field of view (angular degrees)	29	29
Vertical beam width (angular degrees)	2	14
Start range (m)	0.83	0.83
Window length (m)	20	20
Frame rate (per sec)	6	6
Duration (min)	30	30

Table 2.–Summer chum salmon daily and cumulative passage estimates at the Anvik River sonar project, 2018.

				Cumulative	
Date	Left bank	Right bank	Daily total	Estimate	Proportion
6/15	80	394	474	474	0.002
6/16[a]	82	370	452	926	0.003
6/17	100	308	408	1,334	0.004
6/18	84	324	408	1,742	0.006
6/19	169	280	449	2,191	0.007
6/20	106	272	378	2,569	0.008
6/21	278	536	814	3,383	0.011
6/22	863	1,413	2,276	5,659	0.019
6/23	780	1,149	1,929	7,588	0.025
6/24	720	1,809	2,529	10,117	0.033
6/25	467	2,761	3,228	13,345	0.044
6/26	249	2,163	2,412	15,757	0.052
6/27	959	4,991	5,950	21,707	0.071
6/28	1,547	4,645	6,192	27,899	0.091
6/29	1,317	6,261	7,578	35,477	0.116
6/30	2,797	9,106	11,903	47,380	0.155
7/01	1,804	8,762	10,566	57,946	0.190
7/02	2,428	8,957	11,385	69,331	0.227
7/03[b]	3,338	10,506	13,844	83,175	0.273
7/04	2,214	10,271	12,485	95,660	0.314
7/05	2,193	8,335	10,528	106,188	0.348
7/06	1,508	7,879	9,387	115,575	0.379
7/07	2,376	12,121	14,497	130,072	0.426
7/08	251	5,188	5,439	135,511	0.444
7/09	93	4,689	4,782	140,293	0.460
7/10	707	9,550	10,257	150,550	0.493
7/11[c]	1,221	6,501	7,722	158,272	0.519
7/12	1,856	11,408	13,264	171,536	0.562
7/13	3,180	15,018	18,198	189,734	0.622
7/14	6,517	18,435	24,952	214,686	0.704
7/15[d]	6,936	16,012	22,948	237,634	0.779
7/16	2,214	7,416	9,630	247,264	0.810
7/17	2,470	10,782	13,252	260,516	0.854
7/18	1,438	3,752	5,190	265,706	0.871
7/19	834	4,968	5,802	271,508	0.890
7/20	1,335	6,477	7,812	279,320	0.916
7/21	979	5,634	6,613	285,933	0.937
7/22	949	2,938	3,887	289,820	0.950
7/23	585	2,975	3,560	293,380	0.962
7/24	454	3,715	4,169	297,549	0.975
7/25	386	2,800	3,186	300,735	0.986
7/26	292	4,071	4,363	305,098	1.000
Total	59,156	245,942	305,098		
SE			5,926		

Note: The large box indicates the central 50% of the summer chum salmon run.

[a] First day of tower counts.

[b] First quarter point.

[c] Midpoint.

[d] Third quarter point.

Table 3.–Annual passage estimates and passage timing for summer chum salmon runs at the Anvik River sonar project, 2008–2018.

Year	Sonar passage estimate	First count	First quartile	Median	Third quartile	Days between: First count & first quartile	Days between: First quartile & median	Days between: Median & third quartile	Days between: First & third quartile
2008	374,928	6/18	7/05	7/08	7/16	17	3	8	11
2009	191,566	6/18	7/04	7/09	7/15	16	5	6	11
2010	396,173	6/16	7/08	7/12	7/18	22	4	6	10
2011	642,527	6/16	7/02	7/07	7/14	16	5	7	12
2012	484,090	6/18	7/09	7/14	7/18	21	5	4	9
2013	577,877	6/17	7/02	7/08	7/11	15	6	3	9
2014	399,795	6/17	7/01	7/05	7/10	14	4	5	9
2015	374,194	6/17	7/05	7/07	7/12	18	2	5	7
2016	337,819	6/16	6/28	7/05	7/13	12	7	8	15
2017	415,139	6/15	6/30	7/04	7/09	15	4	5	9
2018	305,098	6/15	7/03	7/11	7/15	18	8	4	12
Mean	419,411	6/16	7/03	7/07	7/13	17	5	6	10
Median	397,984	6/17	7/03	7/07	7/13	16	5	6	10
SD	119,420	1.0	3.3	3.0	3.0	2.9	1.4	1.6	2.1

Note: Mean, median, and standard deviation (SD) calculations include data from 2008 to 2017.

Table 4.–Pink salmon daily and cumulative passage estimates at the Anvik River sonar project, 2018.

				Cumulative	
Date	Left bank	Right bank	Daily total	Estimate	Proportion
6/15	0	0	0	0	0.000
6/16[a]	0	0	0	0	0.000
6/17	0	0	0	0	0.000
6/18	0	0	0	0	0.000
6/19	0	0	0	0	0.000
6/20	0	0	0	0	0.000
6/21	0	0	0	0	0.000
6/22	0	0	0	0	0.000
6/23	0	0	0	0	0.000
6/24	0	0	0	0	0.000
6/25	700	79	779	779	0.001
6/26	373	0	373	1,152	0.001
6/27	0	0	0	1,152	0.001
6/28	0	30	30	1,182	0.001
6/29	120	141	261	1,443	0.001
6/30	0	8	8	1,451	0.001
7/01	482	126	608	2,059	0.002
7/02	1,066	279	1,345	3,404	0.003
7/03	304	129	433	3,837	0.003
7/04	780	1,107	1,887	5,724	0.005
7/05	901	699	1,600	7,324	0.007
7/06	2,023	2,260	4,283	11,607	0.010
7/07	3,156	3,529	6,685	18,292	0.016
7/08	2,601	5,479	8,080	26,372	0.023
7/09	1,766	3,717	5,483	31,855	0.028
7/10	3,992	3,050	7,042	38,897	0.035
7/11	7,217	6,656	13,873	52,770	0.047
7/12	13,278	11,697	24,975	77,745	0.069
7/13	23,702	11,191	34,893	112,638	0.100
7/14	33,356	17,625	50,981	163,619	0.146
7/15	58,261	23,951	82,212	245,831	0.219
7/16[b]	52,208	18,381	70,589	316,420	0.282
7/17	57,204	24,325	81,529	397,949	0.355
7/18	67,490	24,777	92,267	490,216	0.437
7/19[c]	52,916	24,708	77,624	567,840	0.506
7/20	49,247	10,366	59,613	627,453	0.559
7/21	57,014	23,161	80,175	707,628	0.630
7/22	67,096	20,654	87,750	795,378	0.709
7/23[d]	69,075	19,714	88,789	884,167	0.788
7/24	64,001	16,631	80,632	964,799	0.860
7/25	70,203	13,963	84,166	1,048,965	0.935
7/26	53,076	20,305	73,381	1,122,346	1.000
Total	813,608	308,738	1,122,346		
SE			7,588		

Note: The large box indicates the central 50% of the pink salmon run.

[a] First day of tower counts.

[b] First quarter point.

[c] Midpoint.

[d] Third quarter point.

Table 5.–Annual passage estimates and passage timing for pink salmon runs (even years) at the Anvik River sonar project, 1994–2018.

Year	Sonar passage estimate	First count	First quartile	Median	Third quartile	Days between: First count & first quartile	Days between: First quartile & median	Days between: Median & third quartile	Days between: First & third quartile
1994	252,999	6/27	7/18	7/20	7/22	21	2	2	4
1996[a,b]	ND	7/01	ND	ND	ND	ND	ND	ND	ND
1998[c]	146,095	7/12	7/17	7/20	7/22	5	3	2	5
2000	24,859	7/07	7/13	7/16	7/21	6	3	5	8
2002	131,482	6/30	7/10	7/13	7/15	10	3	2	5
2004	4,512	7/05	7/17	7/19	7/22	12	2	3	5
2006[d,b]	ND	ND	ND	ND	ND	ND	ND	ND	ND
2008	734,837	6/29	7/15	7/19	7/22	16	4	3	7
2010[e]	505,509	6/30	7/10	7/15	7/21	10	5	6	11
2012	591,387	7/01	7/07	7/17	7/21	6	10	4	14
2014	973,254	6/26	7/04	7/16	7/21	8	12	5	17
2016	670,656	6/26	7/08	7/21	7/24	12	13	3	16
2018	1,122,346	6/25	7/16	7/19	7/23	21	3	4	7
Mean	432,166	6/30	7/11	7/17	7/21	11	6	4	10
Median	505,509	6/30	7/10	7/17	7/21	10	4	3	8
SD	323,744	3.6	4.5	2.4	2.3	4.6	4.2	1.3	4.7

Note: Mean, median, and standard deviation (SD) calculations include data from 1994, 2000–2004, and 2008–2016.

[a] Total pink salmon passage was not estimated.

[b] Because of missing data and incomplete passage estimates in 1996, 1998, and 2006, run timing statistics were excluded from the calculation of the overall mean, timing statistics, and associated standard deviation (SD).

[c] Because of high turbid water, tower counts used to apportion pink and summer chum salmon were delayed until July 12.

[d] No data available for 2006.

[e] First even-year flash panels were deployed to help apportion run.

Table 6.–Number of minutes by bank and day that were adjusted to calculate the daily salmon passage estimate, and the resulting number of fish added to the estimate at the Anvik River sonar project, 2018.

	Left bank		Right bank	
Date	Minutes	Fish	Minutes	Fish
6/15	653.9	73	570.1	312
6/16	145.4	16	0.5	0
6/17	60.4	8	60.4	26
6/18	0.5	0	30.5	14
6/19	74.3	17	0.5	0
6/20	0.5	0	0.5	0
6/21	0.5	0	0.5	0
6/22	0.5	1	0.5	1
6/23	5.5	6	0.5	1
6/24	0.5	0	0.5	1
6/25	0.5	1	0.5	2
6/26	0.5	0	0.5	1
6/27	0.5	1	0.5	3
6/28	0.5	1	0.5	3
6/29	0.5	1	0.5	4
6/30	90.4	351	0.5	6
7/01	0.5	2	0.5	6
7/02	0.5	2	0.5	6
7/03	30.5	154	0.5	7
7/04	0.5	2	0.5	8
7/05	0.5	2	0.5	6
7/06	90.4	443	90.4	1,273
7/07	0.5	4	0.5	10
7/08	0.5	2	0.5	7
7/09	0.5	1	0.5	6
7/10	65.0	424	0.5	8
7/11	0.5	6	0.5	9
7/12	0.5	10	0.5	15
7/13	0.5	18	0.5	17
7/14	0.5	27	0.5	24
7/15	0.5	43	0.5	27
7/16	0.5	36	0.5	17
7/17	0.5	40	0.5	23
7/18	0.5	46	0.5	19
7/19	0.5	36	0.5	20
7/20	30.5	2,141	0.5	11
7/21	0.5	39	0.5	19
7/22	0.5	45	0.5	16
7/23	0.5	46	0.5	15
7/24	0.5	43	0.5	14
7/25	150.4	14,741	150.4	3,501
7/26	360.2	26,702	360.2	12,196
Total	1,771.3	45,533	1,279.3	17,657

Table 7.–Daily passage estimates by bank and species at the Anvik River sonar project, 2018.

	Left bank				Right bank				Both banks combined				
									Chum		Pink		
Date	Chum	Pink	Total	%	Chum	Pink	Total	%	Estimate	%	Estimate	%	Total
6/15	80	0	80	16.9	394	0	394	83.1	474	100.0	0	0.0	474
6/16	82	0	82	18.1	370	0	370	81.9	452	100.0	0	0.0	452
6/17	100	0	100	24.5	308	0	308	75.5	408	100.0	0	0.0	408
6/18	84	0	84	20.6	324	0	324	79.4	408	100.0	0	0.0	408
6/19	169	0	169	37.6	280	0	280	62.4	449	100.0	0	0.0	449
6/20	106	0	106	28.0	272	0	272	72.0	378	100.0	0	0.0	378
6/21	278	0	278	34.2	536	0	536	65.8	814	100.0	0	0.0	814
6/22	863	0	863	37.9	1,413	0	1,413	62.1	2,276	100.0	0	0.0	2,276
6/23	780	0	780	40.4	1,149	0	1,149	59.6	1,929	100.0	0	0.0	1,929
6/24	720	0	720	28.5	1,809	0	1,809	71.5	2,529	100.0	0	0.0	2,529
6/25	467	700	1,167	29.1	2,761	79	2,840	70.9	3,228	80.6	779	19.4	4,007
6/26	249	373	622	22.3	2,163	0	2,163	77.7	2,412	86.6	373	13.4	2,785
6/27	959	0	959	16.1	4,991	0	4,991	83.9	5,950	100.0	0	0.0	5,950
6/28	1,547	0	1,547	24.9	4,645	30	4,675	75.1	6,192	99.5	30	0.5	6,222
6/29	1,317	120	1,437	18.3	6,261	141	6,402	81.7	7,578	96.7	261	3.3	7,839
6/30	2,797	0	2,797	23.5	9,106	8	9,114	76.5	11,903	99.9	8	0.1	11,911
7/01	1,804	482	2,286	20.5	8,762	126	8,888	79.5	10,566	94.6	608	5.4	11,174
7/02	2,428	1,066	3,494	27.4	8,957	279	9,236	72.6	11,385	89.4	1,345	10.6	12,730
7/03	3,338	304	3,642	25.5	10,506	129	10,635	74.5	13,844	97.0	433	3.0	14,277
7/04	2,214	780	2,994	20.8	10,271	1,107	11,378	79.2	12,485	86.9	1,887	13.1	14,372
7/05	2,193	901	3,094	25.5	8,335	699	9,034	74.5	10,528	86.8	1,600	13.2	12,128
7/06	1,508	2,023	3,531	25.8	7,879	2,260	10,139	74.2	9,387	68.7	4,283	31.3	13,670
7/07	2,376	3,156	5,532	26.1	12,121	3,529	15,650	73.9	14,497	68.4	6,685	31.6	21,182
7/08	251	2,601	2,852	21.1	5,188	5,479	10,667	78.9	5,439	40.2	8,080	59.8	13,519
7/09	93	1,766	1,859	18.1	4,689	3,717	8,406	81.9	4,782	46.6	5,483	53.4	10,265

-continued-

Table 7.–Page 2 of 2.

	Left bank				Right bank				Both banks combined				
									Chum		Pink		
Date	Chum	Pink	Total	%	Chum	Pink	Total	%	Estimate	%	Estimate	%	Total
7/10	707	3,992	4,699	27.2	9,550	3,050	12,600	72.8	10,257	59.3	7,042	40.7	17,299
7/11	1,221	7,217	8,438	39.1	6,501	6,656	13,157	60.9	7,722	35.8	13,873	64.2	21,595
7/12	1,856	13,278	15,134	39.6	11,408	11,697	23,105	60.4	13,264	34.7	24,975	65.3	38,239
7/13	3,180	23,702	26,882	50.6	15,018	11,191	26,209	49.4	18,198	34.3	34,893	65.7	53,091
7/14	6,517	33,356	39,873	52.5	18,435	17,625	36,060	47.5	24,952	32.9	50,981	67.1	75,933
7/15	6,936	58,261	65,197	62.0	16,012	23,951	39,963	38.0	22,948	21.8	82,212	78.2	105,160
7/16	2,214	52,208	54,422	67.8	7,416	18,381	25,797	32.2	9,630	12.0	70,589	88.0	80,219
7/17	2,470	57,204	59,674	63.0	10,782	24,325	35,107	37.0	13,252	14.0	81,529	86.0	94,781
7/18	1,438	67,490	68,928	70.7	3,752	24,777	28,529	29.3	5,190	5.3	92,267	94.7	97,457
7/19	834	52,916	53,750	64.4	4,968	24,708	29,676	35.6	5,802	7.0	77,624	93.0	83,426
7/20	1,335	49,247	50,582	75.0	6,477	10,366	16,843	25.0	7,812	11.6	59,613	88.4	67,425
7/21	979	57,014	57,993	66.8	5,634	23,161	28,795	33.2	6,613	7.6	80,175	92.4	86,788
7/22	949	67,096	68,045	74.3	2,938	20,654	23,592	25.7	3,887	4.2	87,750	95.8	91,637
7/23	585	69,075	69,660	75.4	2,975	19,714	22,689	24.6	3,560	3.9	88,789	96.1	92,349
7/24	454	64,001	64,455	76.0	3,715	16,631	20,346	24.0	4,169	4.9	80,632	95.1	84,801
7/25	386	70,203	70,589	80.8	2,800	13,963	16,763	19.2	3,186	3.6	84,166	96.4	87,352
7/26	292	53,076	53,368	68.6	4,071	20,305	24,376	31.4	4,363	5.6	73,381	94.4	77,744
Total	59,156	813,608	872,764		245,942	308,738	554,680		305,098		1,122,346		1,427,444
Total %	6.8	93.2		61.1	44.3	55.7		38.9		21.4		78.6	

Table 8.–Salmon species and proportion of summer chum salmon observed migrating upstream during tower counts by day and bank at the Anvik River sonar project, 2018.

	Left bank					Right bank				
Date	Chum	Chinook	Pink	Sockeye	Proportion chum	Chum	Chinook	Pink	Sockeye	Proportion chum
6/16	0	0	0	0	0.000	0	0	0	0	0.000
6/17	0	0	0	0	0.000	0	0	0	0	0.000
6/18	0	0	0	0	0.000	0	0	0	0	0.000
6/19	0	0	0	0	0.000	0	0	0	0	0.000
6/20	0	0	0	0	0.000	0	0	0	0	0.000
6/21	0	0	0	0	0.000	2	0	0	0	1.000
6/22	0	0	0	0	0.000	44	0	0	0	1.000
6/23	0	0	0	0	0.000	7	0	0	0	1.000
6/24	2	0	0	0	1.000	44	0	0	0	1.000
6/25	5	0	2	0	0.714	54	0	1	0	0.982
6/26	0	0	2	0	0.000	52	0	0	0	1.000
6/27	7	0	0	0	1.000	139	0	0	0	1.000
6/28	41	0	0	0	1.000	181	0	1	0	0.995
6/29	11	1	1	0	0.846	173	0	4	0	0.977
6/30	48	0	0	0	1.000	413	1	1	1	0.993
7/01	15	0	3	0	0.833	268	0	4	0	0.985
7/02	51	1	7	0	0.864	248	0	5	0	0.980
7/03	62	1	8	0	0.873	409	2	5	1	0.981
7/04	43	1	15	1	0.717	462	2	34	2	0.924
7/05	50	1	11	0	0.806	402	0	24	0	0.944
7/06	30	2	35	1	0.441	333	3	73	0	0.814
7/07	72	0	102	5	0.402	408	6	115	2	0.768
7/08	8	1	83	5	0.082	157	10	155	7	0.477
7/09	5	4	59	1	0.072	117	1	76	1	0.600
7/10	29	7	143	7	0.156	186	1	57	1	0.759

-continued-

Table 8.–Page 2 of 2.

	Left bank					Right bank				
Date	Chum	Chinook	Pink	Sockeye	Proportion chum	Chum	Chinook	Pink	Sockeye	Proportion chum
7/11	47	3	268	10	0.143	195	2	190	5	0.497
7/12	71	9	525	5	0.116	404	2	444	8	0.471
7/13	138	8	1,019	16	0.117	451	2	344	2	0.564
7/14	253	9	1,302	13	0.160	540	6	542	7	0.493
7/15	248	13	2,093	14	0.105	463	4	746	10	0.379
7/16	101	9	2,536	14	0.038	189	4	471	4	0.283
7/17	108	12	2,606	6	0.040	332	1	773	7	0.298
7/18	58	6	3,024	9	0.019	134	4	915	2	0.127
7/19	44	1	2,700	13	0.016	162	1	807	2	0.167
7/20	75	2	2,604	11	0.028	101	2	199	1	0.333
7/21	51	2	3,065	6	0.016	133	1	798	1	0.143
7/22	45	4	3,126	3	0.014	76	0	619	2	0.109
7/23	29	4	3,308	10	0.009	58	0	383	2	0.131
7/24	22	2	3,088	5	0.007	55	0	422	1	0.115
7/25	20	1	3,050	1	0.007	36	1	205	0	0.149
7/26	1	0	795	1	0.001	6	1	169	0	0.034
Total	1,790	104	35,580	157	0.048	7,434	57	8,582	69	0.461

Table 9.–Age and sex composition of summer chum salmon at the Anvik River sonar project, 2018.

Sample dates (Strata)	Samples [a] (*n*)	Sex	Brood year (age) 2016 (0.2) Estimate	%	2015 (0.3) Estimate	%	2014 (0.4) Estimate	%	2013 (0.5) Estimate	%	Total Estimate	%
6/28-7/02	140	Male	0	0.0	18,323	26.4	18,818	27.1	2,476	3.6	39,618	57.1
(6/15-7/02)		Female	0	0.0	12,876	18.6	15,352	22.1	1,486	2.1	29,713	42.9
		Subtotal	0	0.0	31,199	45.0	34,170	49.3	3,962	5.7	69,331	100.0
7/03-08, 7/10	235	Male	0	0.0	22,465	27.7	13,479	16.6	1,037	1.3	36,981	45.5
(7/03-10)		Female	0	0.0	30,760	37.9	12,442	15.3	1,037	1.3	44,238	54.5
		Subtotal	0	0.0	53,224	65.5	25,921	31.9	2,074	2.6	81,219	100.0
7/11/2013	156	Male	0	0.0	21,379	33.3	10,278	16.0	1,233	1.9	32,890	51.3
(7/11-14)		Female	411	0.6	23,434	36.5	6,989	10.9	411	0.6	31,246	48.7
		Subtotal	411	0.6	44,813	69.9	17,267	26.9	1,645	2.6	64,136	100.0
7/15/2018	148	Male	0	0.0	28,101	31.1	10,996	12.2	0	0.0	39,097	43.2
(7/15-26)		Female	1,833	2.0	36,654	40.5	11,607	12.8	1,222	1.4	51,315	56.8
		Subtotal	1,833	2.0	64,755	71.6	22,603	25.0	1,222	1.4	90,412	100.0
Season	679	Male	0	0.0	90,268	29.6	53,572	17.6	4,746	1.6	148,586	48.7
		Female	2,244	0.7	103,723	34.0	46,390	15.2	4,155	1.4	156,512	51.3
		Total	2,244	0.7	193,991	63.6	99,962	32.8	8,902	2.9	305,098	100.0

Note: Number fish per strata and age class is based on the sonar estimate multiplied by percent of fish in age class.

[a] ADF&G (Alaska Department of Fish and Game). [Internet]. AYKDBMS [Arctic-Yukon-Kuskokwim Database Management System] Home Page. http://sf.adfg.state.ak.us/CommFishR3/WebSite/AYKDBMSWebsite/Default.aspx (Accessed September 25, 2018).

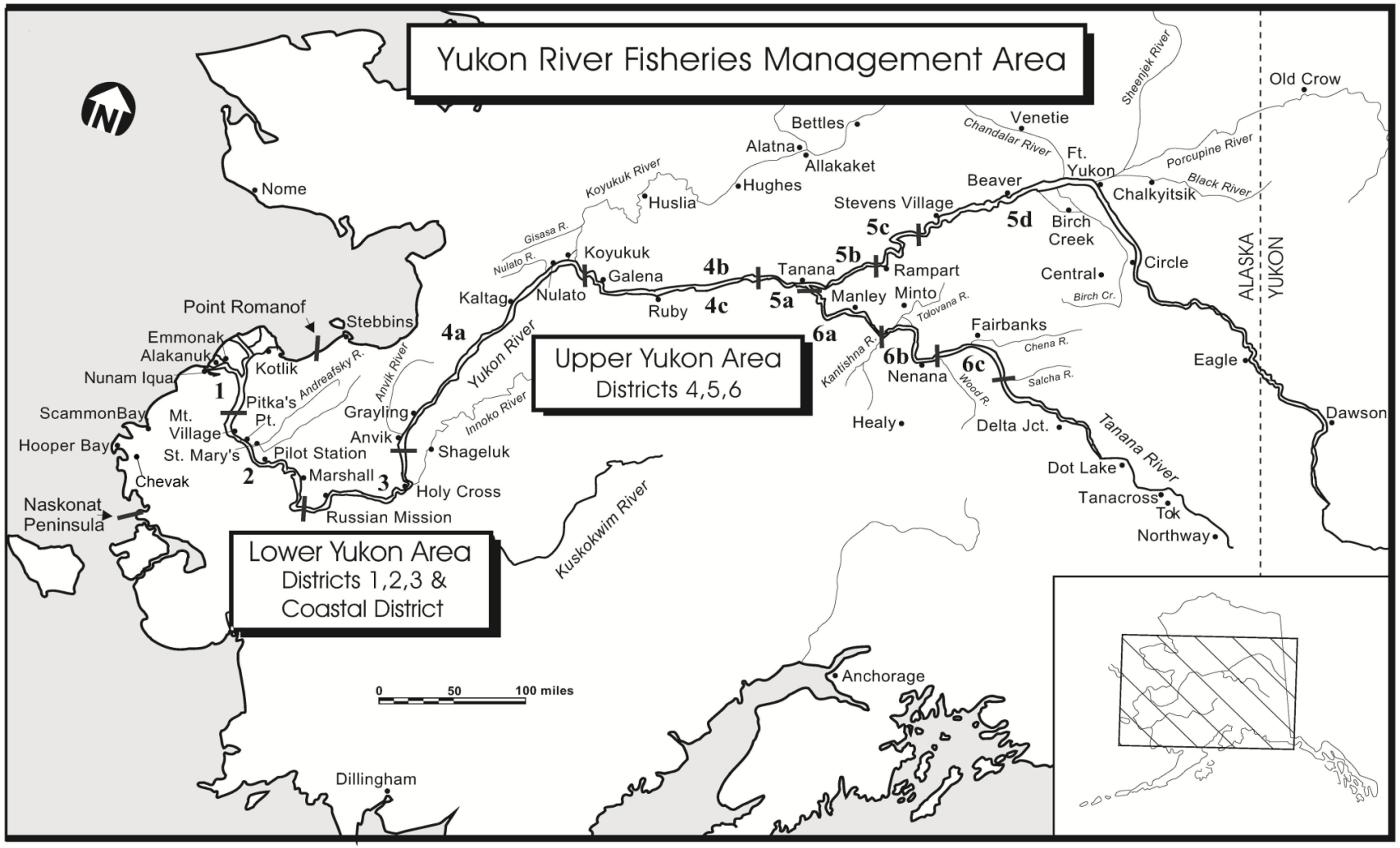

Figure 1.–Alaska portion of the Yukon River drainage showing communities and fishing districts.

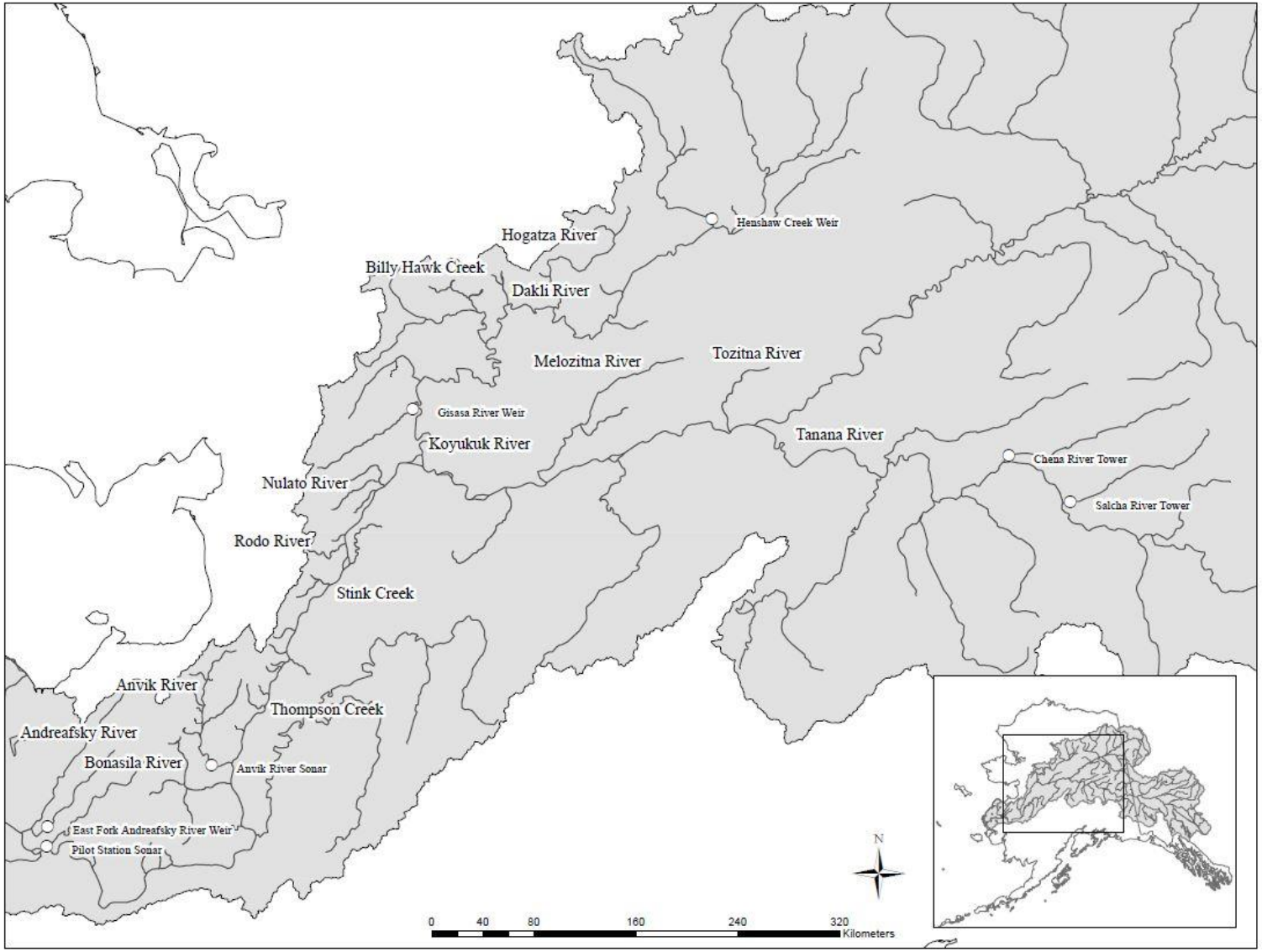

Figure 2.–Yukon River drainage showing major summer chum salmon spawning tributaries.

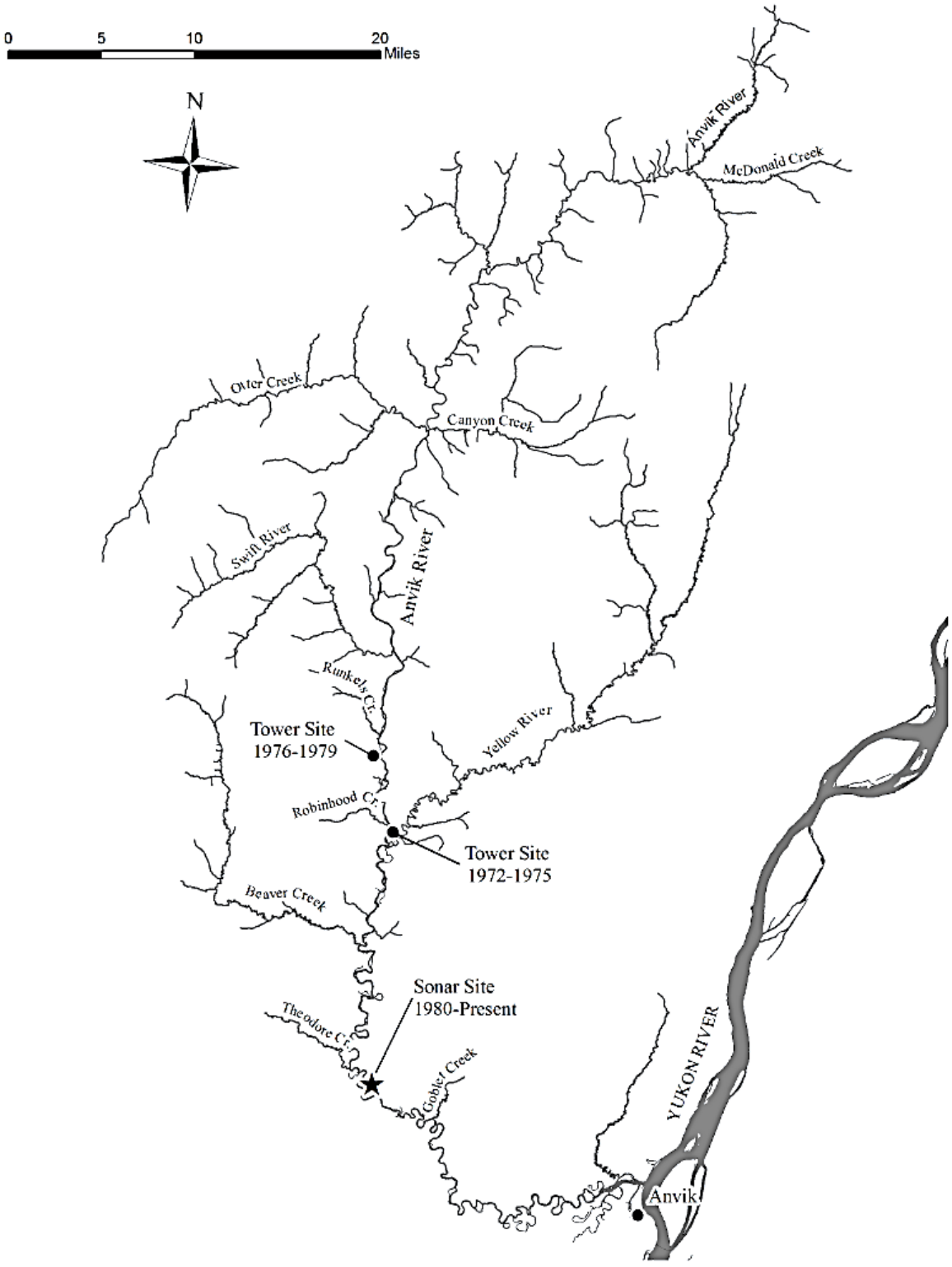

Figure 3.–Anvik River drainage with historical summer chum salmon escapement project locations.

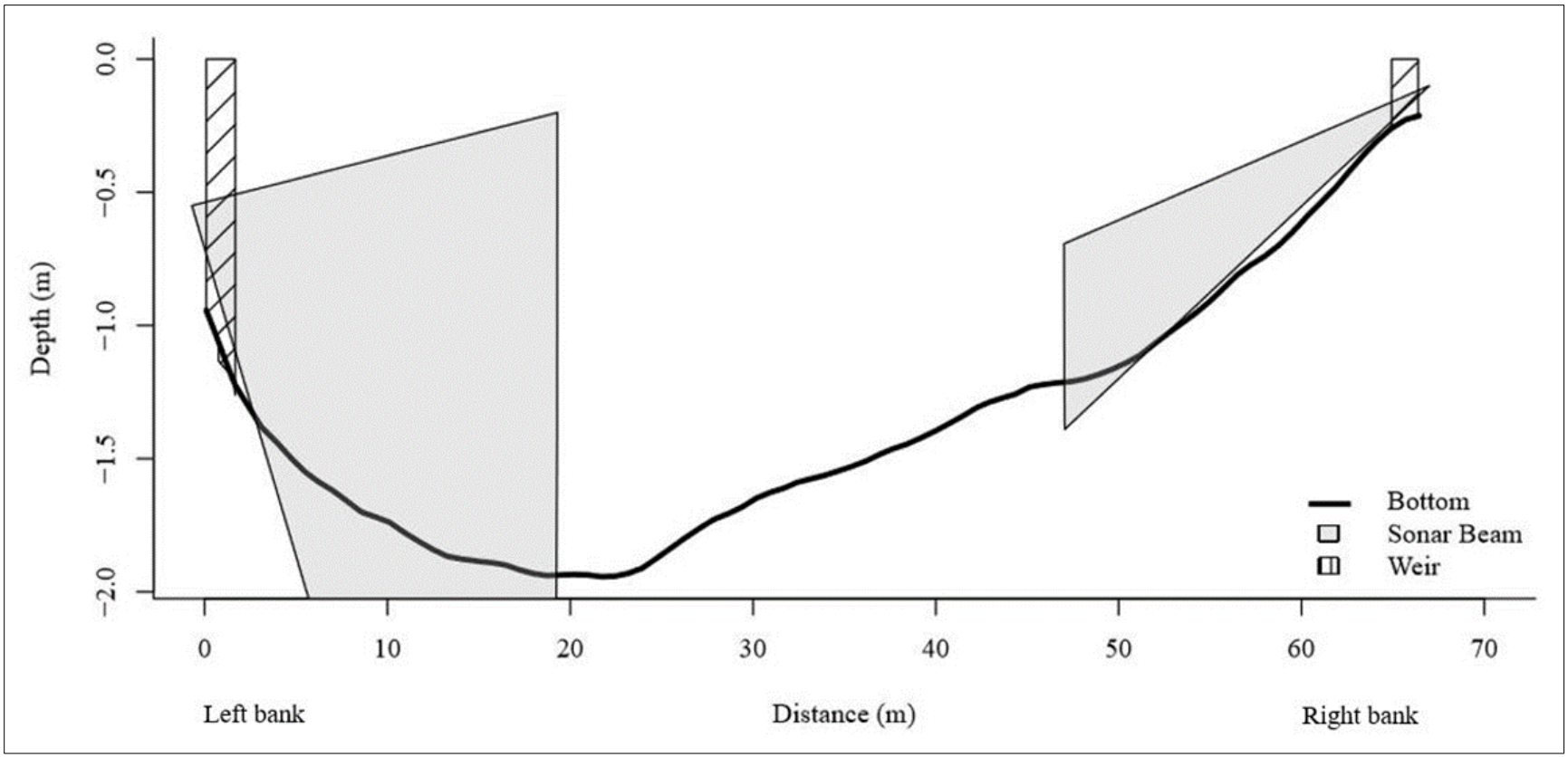

Figure 4.–Depth profile of the Anvik River and approximate sonar ranges (not to scale) at the Anvik River sonar project, June 15, 2018.

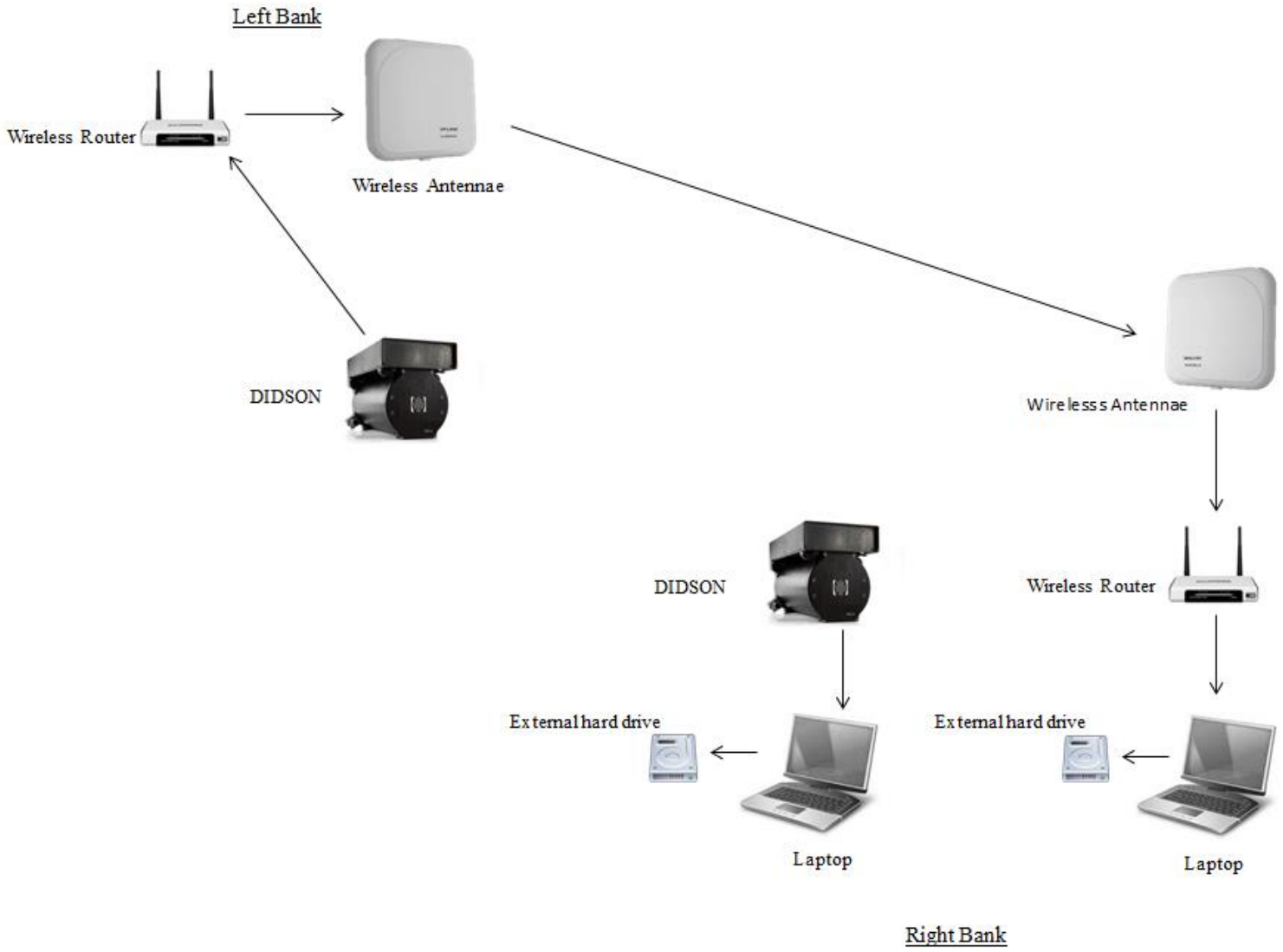

Figure 5.–DIDSON sonar equipment schematic at the Anvik River sonar project, 2018.

Note: Both the left bank and right bank laptops were housed in the right bank sonar tent.

Figure 6.–View of a DIDSON mounted to aluminum H-mount with manual crank-style rotator at the Anvik River sonar project, 2018. Photo taken 2017.

Figure 7.–Anvik River sonar project site (2016) illustrating locations of sonars, weirs, and counting towers.

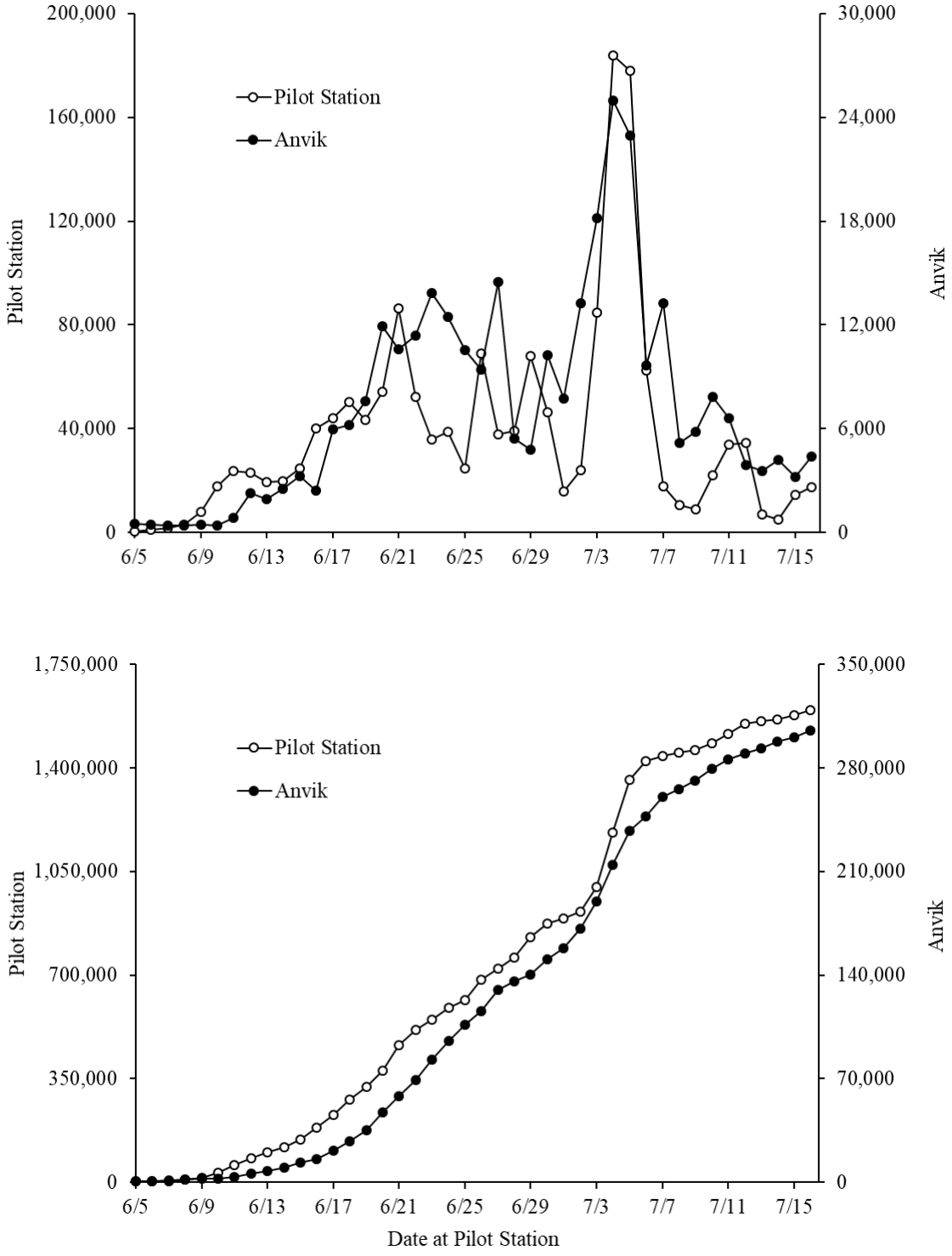

Figure 8.–Daily summer chum salmon passage at the Anvik River sonar project and the sonar project near the village of Pilot Station (top) and cumulative summer chum salmon passage at both projects (bottom), 2018.

Note: The timing of Anvik River summer chum salmon is lagged back 10 days to align with Pilot Station.

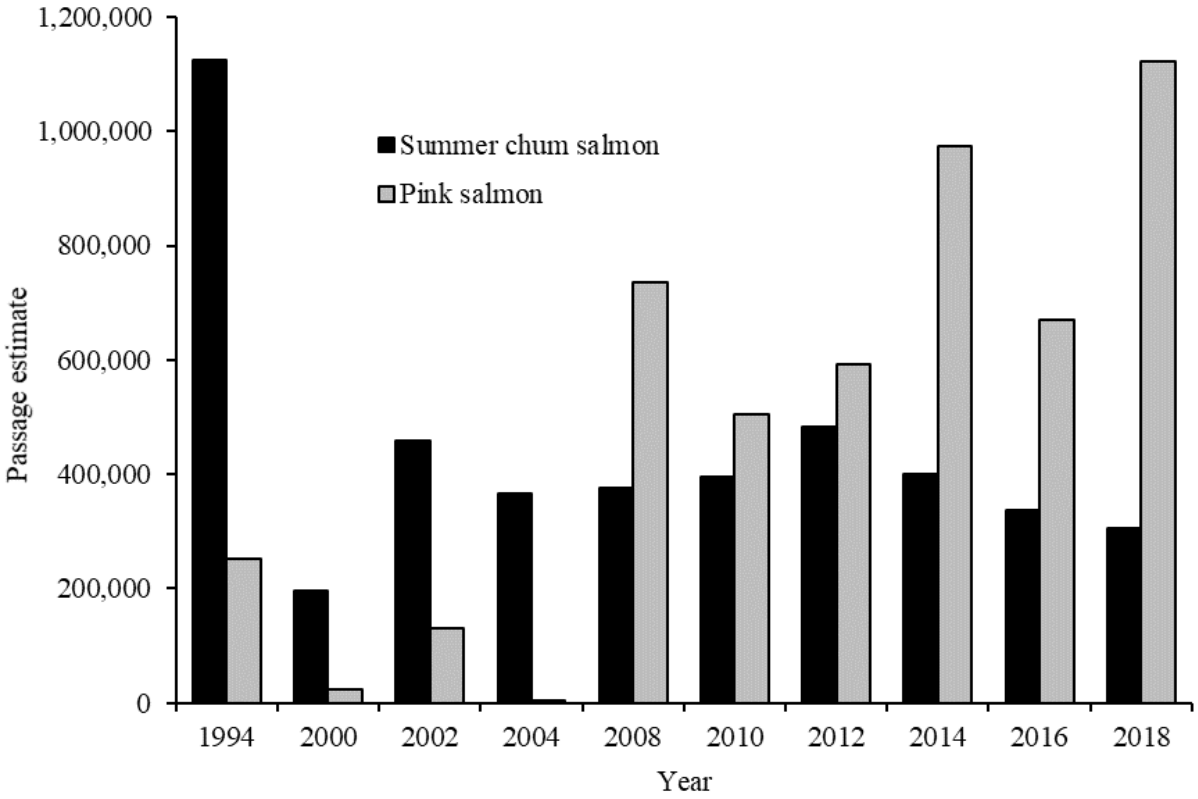

Figure 9.–Summer chum and pink salmon passage estimates during even years from 1994 through 2018 at the Anvik River sonar project.

Note: Pink salmon passage estimates were either incomplete or missing for 1996, 1998, and 2006.

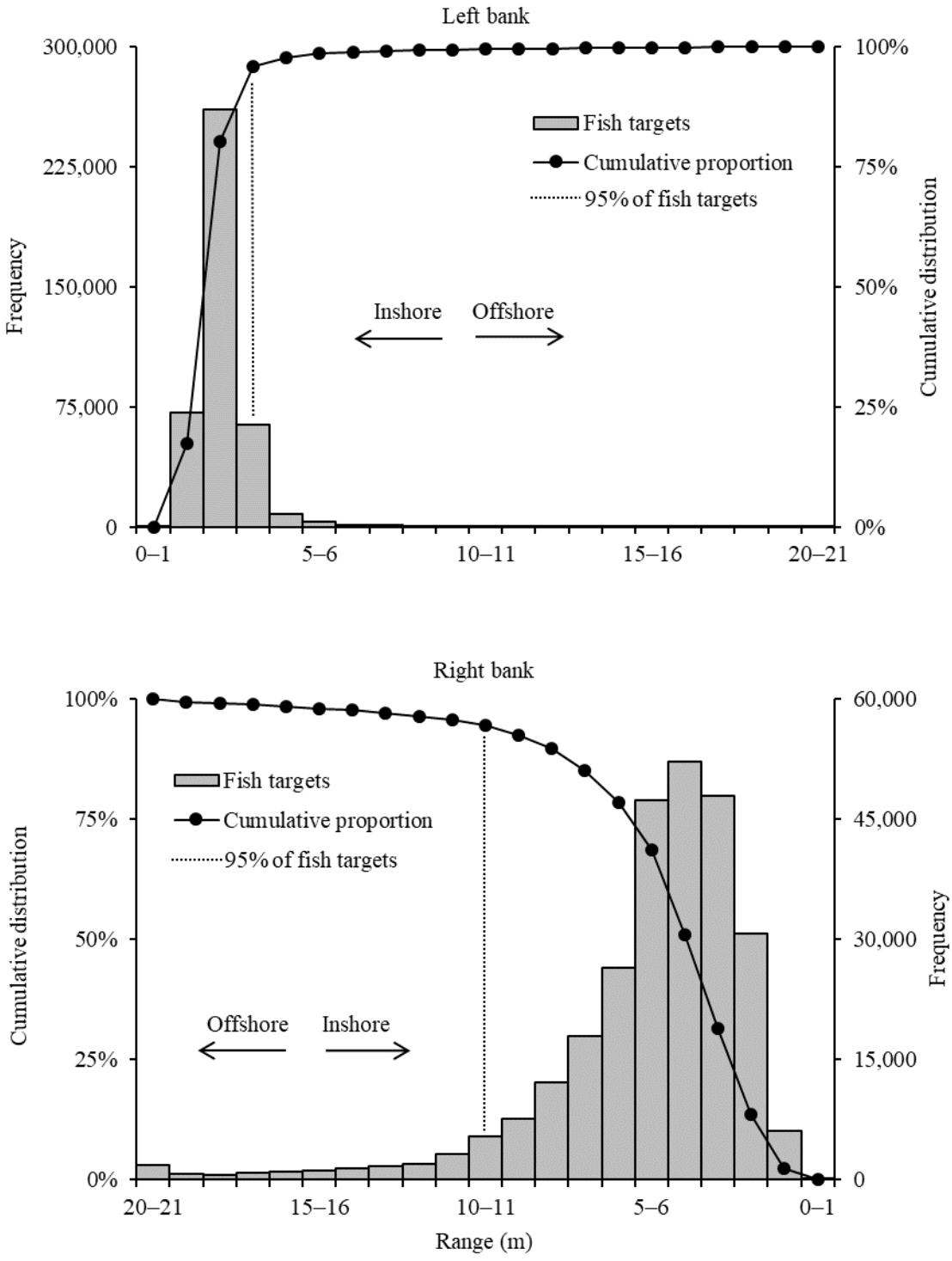

Figure 10.–Left and right bank horizontal distribution of unexpanded fish targets at the Anvik River sonar project, June 15 through July 26, 2018.

Note: For both banks, the ensonified range was 20 m, starting at 0.83 m from the DIDSON and ending at 20.83 m.

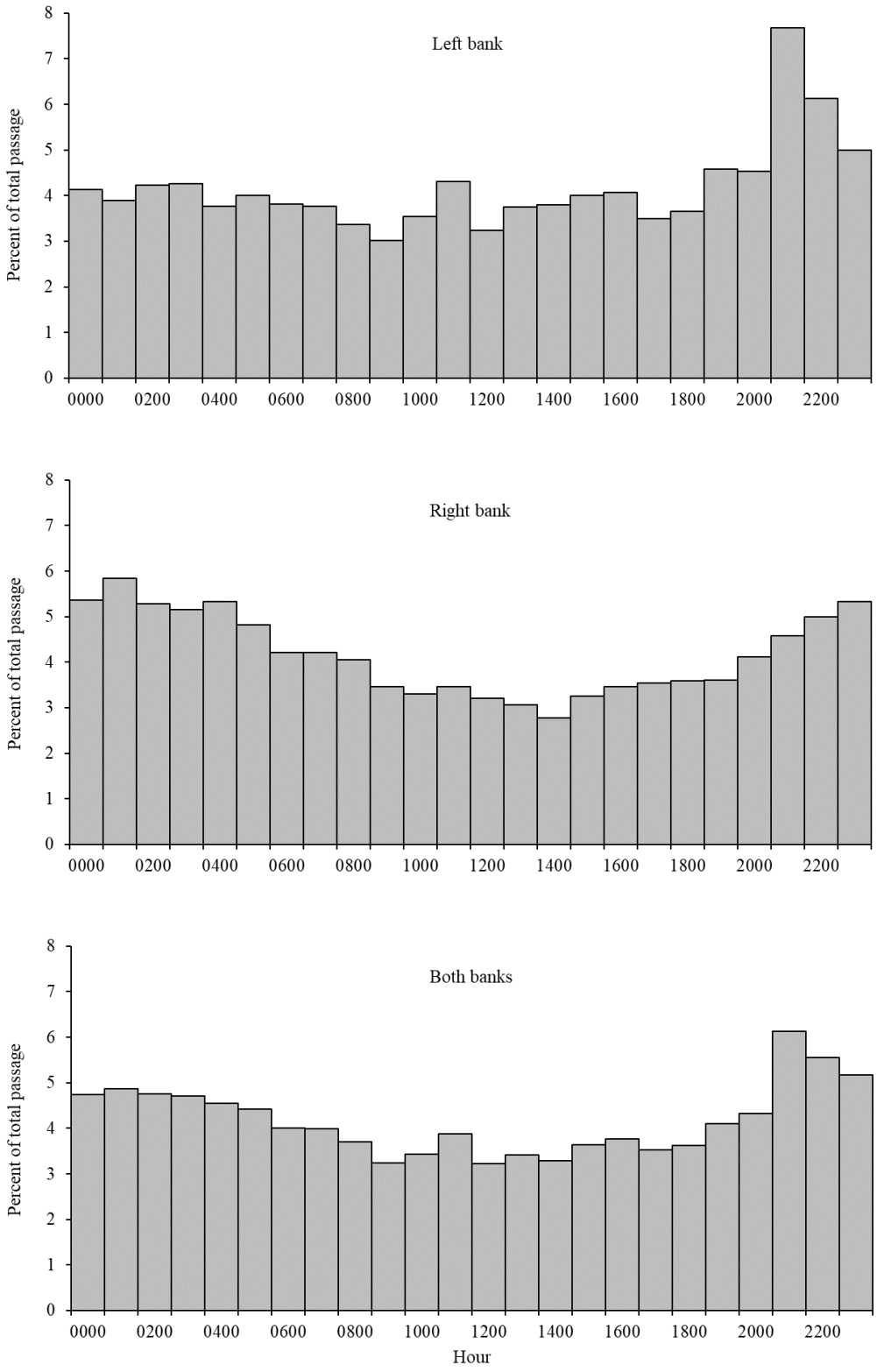

Figure 11.–Percent of total passage, by hour, observed on the left bank, right bank, and both banks combined at the Anvik River sonar project, 2018.

Note: Days with missing hourly passage rates were included in the calculations.

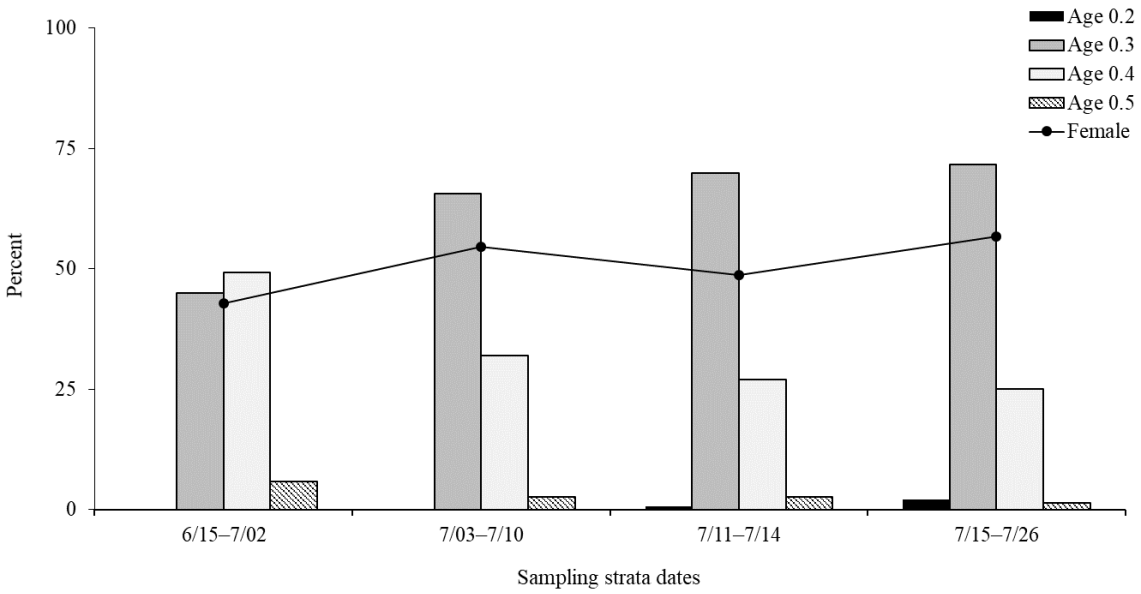

Figure 12.–Summer chum salmon age and percent female composition by sampling strata at the Anvik River sonar project, 2018.

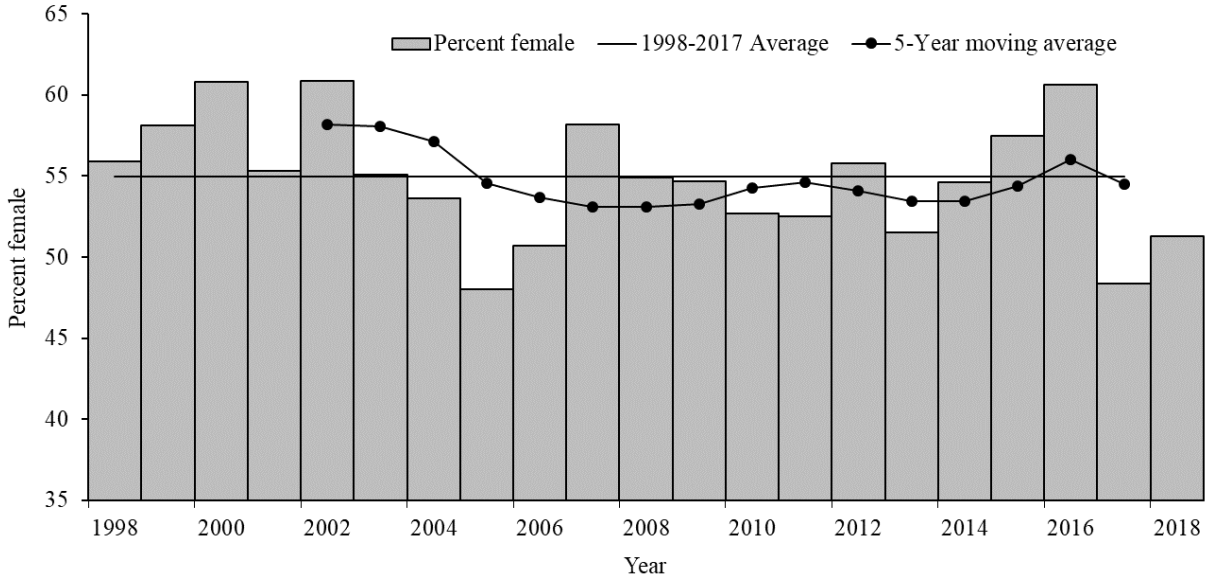

Figure 13.–Percent female summer chum salmon escapement estimated at the Anvik River sonar project, 1998–2018.

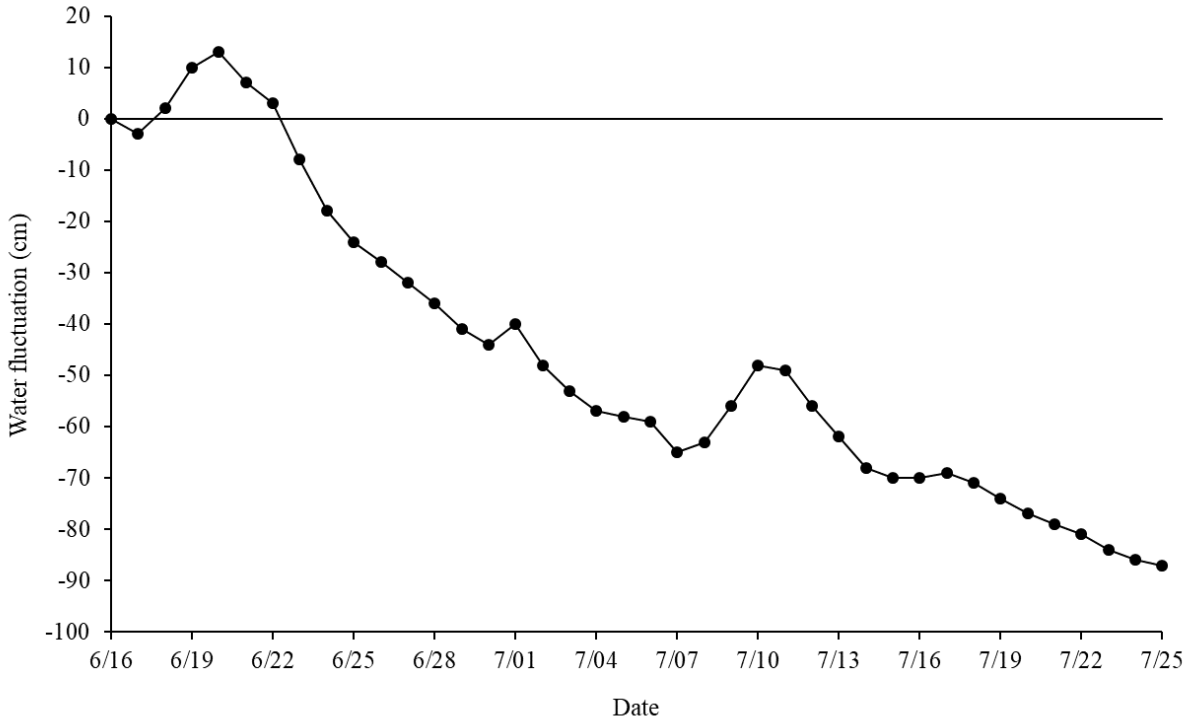

Figure 14.–Change in daily water elevation, relative to June 16, measured at the Anvik River sonar project, 2018.

Note: No data were collected on July 19. The water level for this day was estimated using linear interpolation.

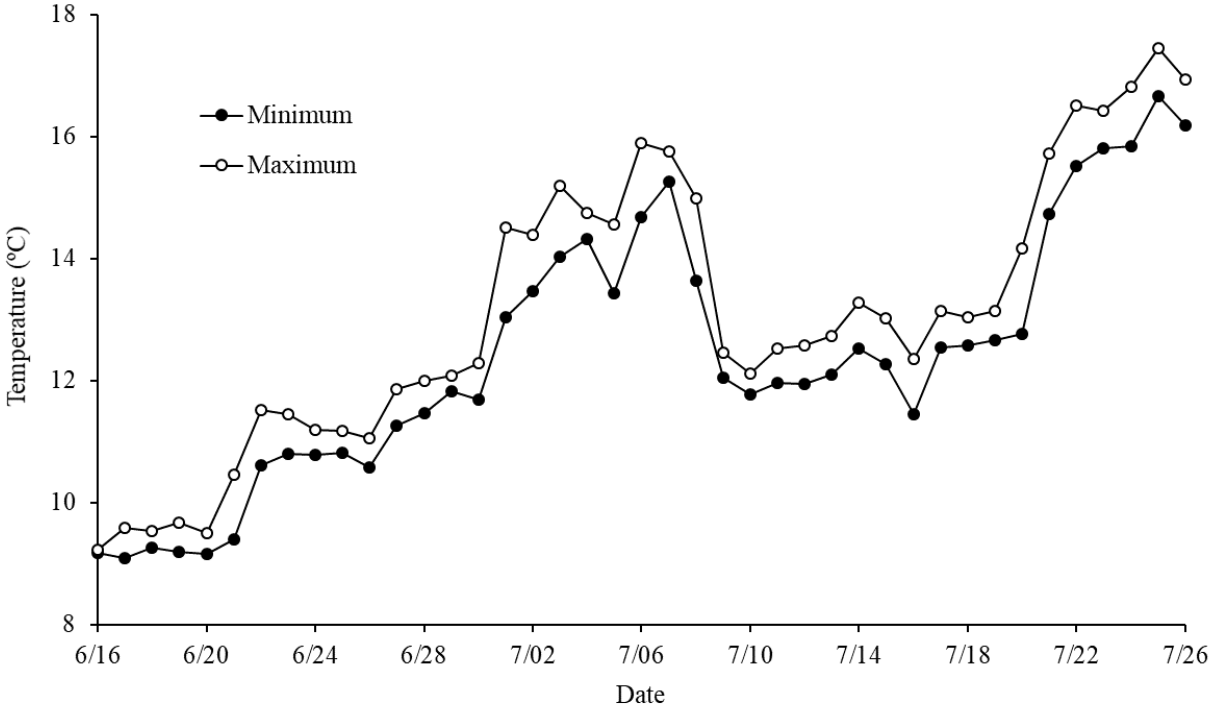

Figure 15.–Daily water temperatures on the left bank at the Anvik River sonar project, 2018.

APPENDIX A: CLIMATIC OBSERVATIONS

Appendix A1.–Climatic observations recorded daily at 1600 hours at the Anvik River sonar project site, 2018.

		Wind			
Date	Precipitation (code)[a]	Direction[b]	Velocity (kph)	Sky (code)[c]	Air temperature (°C)
6/16	C	W	2.1	O	12.2
6/17	B	W	1.5	O	12.5
6/18	B	E	1.7	O	15.6
6/19	B	W	0.6	B	12.2
6/20	B	E	1.3	O	16.1
6/21	A	W	3.0	S	15.7
6/22	A	E	1.8	S	14.5
6/23	A	W	2.0	B	16.4
6/24	B	W	0.8	B	16.3
6/25	B	E	2.7	S	17.4
6/26	A	NW	2.7	O	15.7
6/27	A	E	5.7	B	16.9
6/28	A	E	1.3	S	18.4
6/29	B	W	1.5	O	15.6
6/30	B	W	1.3	B	21.1
7/01	A	W	1.7	S	19.5
7/02	A	W	1.5	C	18.0
7/03	A	W	2.4	C	27.0
7/04	B	W	1.0	O	18.5
7/05	A	W	1.0	C	23.7
7/06	A	N	0.8	C	25.4
7/07	B	E	1.4	O	22.6
7/08	C	E	0.8	O	14.3
7/09	B	E	1.4	B	13.8
7/10	B	W	1.4	B	15.0
7/11	A	NE	0.8	B	16.3
7/12	A	NE	1.9	O	17.6
7/13	A	NE	1.9	O	16.5
7/14	A	W	1.5	B	16.6
7/15	B	W	4.7	O	13.1
7/16	A	W	2.7	S	16.4
7/17	B	W	3.6	O	15.9
7/18	A	NW	4.0	O	14.2
7/19	A	ND	ND	O	ND
7/20	A	NW	0.8	S	23.8
7/21	B	NW	2.4	O	22.2
7/22	A	N	1.0	B	22.1
7/23	B	N	1.2	B	18.1
7/24	A	E	1.0	S	25.0
7/25	A	W	1.0	S	26.3

Note: ND indicates no data was recorded.

[a] Precipitation code for the preceding 24-hour period: A = none; B = intermittent rain; C = continuous rain; D = snow and rain mixed; E = light snowfall; F = continuous snowfall; G = thunderstorm with or without precipitation.

[b] Wind direction code: N = North; S = South; E = East; W = West; V = Variable.

[c] Instantaneous cloud cover code: C = clear, cloud cover <10% of sky; S = cloud cover <60% of sky; B = cloud cover 60–90% of sky; O = overcast (100%); F = fog, thick haze, or smoke.