Fishery Data Series No. 18-14

Sonar Estimation of Summer Chum and Pink Salmon in the Anvik River, Alaska, 2017

by

Jody D. Lozori

April 2018

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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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, 2017. Apportionment to species was determined from data collected from tower counts. A total of 415,139 (SE 2,614) summer chum and 865 (SE 300) 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, believed to be the largest producer of summer chum salmon in the Yukon River drainage (Bergstrom et al. 1999). Additional major spawning populations of summer chum salmon occur in the following tributaries of the Yukon River: the Andreafsky River, Rodo River, Nulato River, Melozitna River, and Tozitna River. Spawning tributaries in the Koyukuk River drainage are the Gisasa River and Hogatza River; and in tributaries to the Tanana River drainage, which include the Chena River and the Salcha River (Figure 1).

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. 2013). Apportionment of pink salmon passage on the Anvik River during even years is necessary to accurately access summer chum salmon escapement from the total sonar passage estimate. Fall chum, which are a later run of chum salmon, and coho salmon *O. kisutch* have also been reported to spawn in the Anvik River drainage during the fall.

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 to 700,000 summer chum salmon is met (ADF&G 2004), while providing for 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 2). 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 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.

[1] Lebida, R. C. Unpublished.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

Shore based 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 for escapement estimates from 1980 to 2003. In 2003, a side-by-side comparison was done with Hydroacoustic Technology Incorporated (HTI) split-beam[2] 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 2015; Miller et al. 2014) 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 2017 and compares the results to previous years.

OBJECTIVES

The goal of this project in 2017 was to provide daily inseason estimates of adult summer chum and pink salmon escapement into the Anvik River to fishery managers. Primary objectives are 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 are detected within three-quarters of the ensonified range on both banks.

Secondary objectives are 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 are 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: September 7, 2017).

[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 2) 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 m from shore, and the left bank sloped steeply to the thalweg approximately 16 m from shore depending on water level (Figure 3).

HYDROACOUSTIC EQUIPMENT

A long range DIDSON operating at frequency of 1.2 MHz (high frequency option using 48 beams) was deployed on the right bank, and a standard DIDSON operating at frequency of 1.1 MHz (low frequency option using 48 beams) was deployed on the left bank (Table 1). Because of the shallow nature of the 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 4).

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 (Figure 3).

Both banks were ensonified on July 15, and operations ran continuously through 1200 on July 26. The DIDSONs were mounted on aluminum frames and aimed using manual crank-style rotators (Figure 5). 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. Both banks were ensonified approximately 20 m from the DIDSON. Approximately 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 it 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 (Figures 3 and 6). The weirs diverted migrating adult salmon offshore and in front of the DIDSONs to provide sufficient offshore distance for the 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 an 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 also 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:

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

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 one or multiple days were missed, daily passage was interpolated by averaging passage estimates from days before and after the missing day(s) as follows:

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

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 min 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 6). 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 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.

Daily sonar passage estimates ($\hat{y}$) by species (a) were apportioned to either pink or summer chum salmon by applying the estimated proportion ($\hat{p}$) to the unadjusted daily passage estimate for each bank (z) in reporting unit (r). For each bank, days were grouped into report units that were assigned such that each reporting unit contained at least 2 tower counting periods (i) 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. This was done to ensure adequate samples to compute the sampling variance. Water clarity was determined by visual observation during tower counts, and entered into the database as meters of visibility from transducer.

$$\hat{y}_{dza} = \hat{y}_{dz} \cdot \hat{p}_{rza} \tag{4}$$

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

$$Var(\hat{p}_{rza}) = \frac{\sum_i (\bar{p}_{rza} - \hat{p}_{riza})^2}{n(n-1)}, \tag{5}$$

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

$$\hat{V}ar(\hat{y}_{dza}) = \hat{y}_{dz}^2 \cdot \hat{V}ar(\hat{p}_{dza}) + \hat{p}_{dza}^2 \cdot \hat{V}ar(\hat{y}_{dz}) - \hat{V}ar(\hat{y}_{dz}) \cdot \hat{V}ar(\hat{p}_{dza}) \ . \tag{6}$$

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

$$\hat{y}_{da} = \sum_{z} \hat{y}_{dza} \ , \tag{7}$$

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

$$\hat{y}_a = \sum_{d} \sum_{z} \hat{y}_{dza} \ . \tag{8}$$

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

$$\hat{V}ar(\hat{y}_a) = \sum_{d} \sum_{z} \hat{V}ar(\hat{y}_{dza}) \ , \tag{9}$$

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

$$\hat{y}_a \pm 1.645 \sqrt{\hat{V}ar(\hat{y}_a)} \ . \tag{10}$$

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 had passed the sonar site. To determine inseason ASL sampling dates, historical mean quartile ASL dates were used (Table 2). The strata represent an attempt to sample the escapement in proportion to the total run.

To meet regional standards for the sample size needed to describe a salmon population, the initial seasonal ASL sample goal was 648 summer chum salmon, with a minimum of 162 summer chum salmon samples collected using beach seines during each temporal stratum (Bromaghin 1993). Sample size goals are based such that simultaneous 95% confidence intervals are no wider than 0.20 (d = 0.10 and (α) = 0.05) assuming 2 major age classes, 2 minor age classes, and a scale rejection rate of 15%.

The beach seining goal for Chinook and sockeye salmon was also developed to sample all fish captured while pursuing the summer chum salmon sampling goal.

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 and collect ASL data. 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 placed in a holding pen in the river and each were noted for sex, measured to the nearest 1 mm from mid-eye to tail fork, and one scale was taken for age determination. 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. Chinook and sockeye salmon were sampled using the same methods as summer chum salmon, except that 4 scale samples were taken from each fish.

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 as negative or positive increments from the initial reading of 0.0 cm. Water temperature was measured using a HOBO water temp 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 with estimation of salmon passage this season. The total summer chum salmon passage estimate at the Anvik River sonar site was 415,139 (SE 2,614) from June 15 to July 26. The first quarter point fell on June 30, the midpoint on July 4, and third quarter point on July 9. A peak daily passage estimate of 29,359 summer chum salmon occurred on June 30 and 923 summer chum salmon passed on July 26, the last day of sonar operation (Table 3). When compared to average historic run timing based on 2000–2016 runs, summer chum salmon passage dates were 3 days early at the first quartile and 4 days early at the third quartile (Table 2). Daily passage between the first and third quartile dates ranged from 8,488 (July 9) to 29,359 (June 30), and an estimated total of 212,038 summer chum salmon passed the sonar site during this time. The 2017 summer chum salmon escapement estimate was above the 2000–2016 average Anvik River escapement estimate of 404,218 fish, and was above the BEG of 350,000 to 700,000 summer chum salmon.

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 7). Historically, the percentage of Yukon River summer chum salmon bound for the Anvik River has fluctuated and can be broken into 2 distinct periods. During the period from 1995 to 2002 the average contribution was 41%. From 2003 to 2016, the average contribution was 22%. Approximately 13% of the summer chum salmon that were estimated to have passed Pilot Station (3,094,350)[4] were observed at the Anvik River sonar project this season.

Because sonar operations generally end before the pink salmon migration, calculations of quartile statistics are based on the proportion of the run during the time the sonar project was operational (Table 4). The total pink salmon passage estimate was 865 (SE 300) from June 1 to July 26, 2017. The first quarter point fell on July 4, the midpoint on July 8, and third quarter point on July 15. A peak daily passage estimate of 204 pink salmon occurred on July 6. Similar to other odd years, the total pink salmon escapement estimate on the Anvik River was negligible and only contributed approximately 0.21% of the total salmon passage estimate.

Total sonar passage estimates include expansions for sampling time missed. On the left bank, 1,923 minutes were missed, which accounted for an additional 1,724 fish, or approximately 2% of the total left bank estimate. On the right bank, 2,160 minutes were missed, which accounted for an additional 2,972 fish, or approximately 1% of the total right bank estimate (Table 5).

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[4] ADF&G (Alaska Department of Fish and Game) [Internet]. Yukon River (Pilot Station) chum salmon – Summer 2017. http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareayukon.salmon_escapement (Accessed: September 11, 2017).

The objective of estimating summer chum and pink salmon abundance in the Anvik River using DIDSON from approximately June 16 through July 26 was met.

SPATIAL AND TEMPORAL DISTRIBUTION

On the left bank, approximately 95% of the fish were detected within 16 m of the transducer, and on the right bank approximately 95% of the fish were detected within 17 m of the transducer (Figure 8). Unlike historical passage distributions, which have been predominately shore oriented, passage was more dispersed throughout the counting range this season. Because of the unusual distribution at the far end of the counting ranges, there were concerns about double counting fish which crossed over from one bank to the other within the ensonified range. From June 22 through July 7, fish passing beyond 15 m on the left bank were not counted to avoid double counting fish crossing from one bank to the other. The objective to operate imaging sonar such that 95% of the migrating salmon are detected within three-quarters (15 m) of the ensonified area on both banks was not met, however, given the coverage of the beams, we feel confident very few fish passed undetected.

Approximately 71% of the total summer chum salmon passage occurred on the right bank, which was consistent with the most recent 10 year passage trends.

Overall, when considering both banks combined, there was a diurnal pattern of fish passage on the Anvik River this season, and a higher proportion of passage occurred during darker hours of the day (Figure 9).

SPECIES APPORTIONMENT

Summer chum salmon were the most prominent salmon species observed on both banks during tower counts. Tower counts began on June 16, and the first pink salmon was observed on July 1 (Table 6). Proportionally, summer chum salmon accounted for approximately 98% of the total tower count on both banks

Weather conditions were favorable this season and there were no days that the minimum range of visibility was not met because of environmental conditions. The only days which required pooling report periods were those with insufficient numbers of fish observed (Table 7).

SUMMER CHUM AGE AND SEX COMPOSITION

From June 23 through July 19, a total of 717 ASL samples were obtained and, from these samples, 672 scales were analyzed as ageable postseason[5]. In 2017, strata were defined as: June 15–June 29, June 30–July 3, July 4–July 8, and July 9–July 26.

Scale sample analysis indicated that there were 2 major age classes, age 0.3 (53%) and age 0.4 (45%), as well as 2 minor classes, age 0.2 and 0.5 (Table 8 and Figure 10).

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. The summer chum salmon passage observed this season was consistent with this trend (Figure 10). Female

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[5] 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.

summer chum salmon accounted for approximately 48% of the entire run, which was below the 1997–2016 average of approximately 55% (Figure 11).

The objective of collecting a minimum of 162 readable summer chum salmon scale samples in each of 4 temporal strata was not met this in season.

HYDROLOGIC AND CLIMATOLOGICAL CONDITIONS

The objective of monitoring hydrological parameters daily at the project site was met in 2017. The water level remained below the zero datum mark (starting level) and the lowest level was recorded on July 15 (Figure 12). Overall, between June 16 and July 25, minimum and maximum water level differed by 27 cm. Water temperatures at the project ranged from 11.2°C on June 29, to a high of 19.6°C on July 14 (Figure 13). The average air temperature was 19.6°C and temperatures ranged from a high of 29.5°C on July 13 to a low of 13.6°C on June 26 (Appendix A).

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TABLES AND FIGURES

Table 1.–Technical specifications for dual-frequency identification sonars (DIDSON) at the Anvik River sonar, 2017.

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

Table 2.–Annual passage estimates and passage timing for summer chum salmon runs, at the Anvik River sonar, 2000–2017.

						Days between			
Year	Sonar passage estimate	First count	First quartile	Median	Third quartile	First count & first quartile	First quartile & median	Median & third quartile	First & third quartile
2000	196,349	6/21	7/08	7/11	7/13	17	3	2	5
2001	224,058	6/26	7/06	7/10	7/15	10	4	5	9
2002	459,058	6/22	7/03	7/07	7/12	11	4	5	9
2003	256,920	6/21	7/05	7/10	7/15	14	5	5	10
2004	365,353	6/22	6/29	7/05	7/09	7	6	4	10
2005	525,391	6/26	7/04	7/10	7/15	8	6	5	11
2006	605,485	6/28	7/03	7/06	7/12	5	3	6	9
2007	460,121	6/26	7/05	7/10	7/17	9	5	7	12
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	8
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	13	4	5	9
Average	404,218	6/20	7/3	7/8	7/13	14	5	5	10
Median	396,173	6/18	7/4	7/8	7/14	14	5	5	10
SD	133,945	4.0	2.9	2.5	2.6	4.7	1.3	1.6	2.0

Table 3.–Summer chum salmon daily and cumulative counts, at the Anvik River sonar, 2017.

				Cumulative	
Date	Left bank	Right bank	Daily total	Count	Proportion
6/15	27	296	323	323	0.001
6/16	285	108	393	716	0.002
6/17	324	630	954	1,670	0.004
6/18	282	782	1,064	2,734	0.007
6/19	222	722	944	3,678	0.009
6/20	148	956	1,104	4,782	0.012
6/21	354	2,436	2,790	7,572	0.018
6/22	290	1,473	1,763	9,335	0.022
6/23	498	11,928	12,426	21,761	0.052
6/24	414	13,746	14,160	35,921	0.087
6/25	497	12,795	13,292	49,213	0.119
6/26	340	16,982	17,322	66,535	0.160
6/27	340	6,282	6,622	73,157	0.176
6/28	738	11,422	12,160	85,317	0.206
6/29	596	15,870	16,466	101,783	0.245
6/30[a]	2,471	26,888	29,359	131,142	0.316
7/01	3,083	24,082	27,165	158,307	0.381
7/02	1,992	24,154	26,146	184,453	0.444
7/03	2,698	19,661	22,359	206,812	0.498
7/04[b]	4,238	16,444	20,682	227,494	0.548
7/05	6,714	20,454	27,168	254,662	0.613
7/06	2,876	12,063	14,939	269,601	0.649
7/07	5,258	13,478	18,736	288,337	0.695
7/08	4,962	12,034	16,996	305,333	0.735
7/09[c]	1,425	7,063	8,488	313,821	0.756
7/10	554	4,282	4,836	318,657	0.768
7/11	2,128	6,774	8,902	327,559	0.789
7/12	3,196	7,792	10,988	338,547	0.816
7/13	2,202	6,208	8,410	346,957	0.836
7/14	2,044	5,404	7,448	354,405	0.854
7/15	1,223	5,473	6,696	361,101	0.870
7/16	633	3,992	4,625	365,726	0.881
7/17	1,040	4,436	5,476	371,202	0.894
7/18	1,044	5,592	6,636	377,838	0.910
7/19	4,315	8,498	12,813	390,651	0.941
7/20	4,364	5,688	10,052	400,703	0.965
7/21	2,716	3,226	5,942	406,645	0.980
7/22	1,726	2,173	3,899	410,544	0.989
7/23	710	1,284	1,994	412,538	0.994
7/24	178	494	672	413,210	0.995
7/25	250	756	1,006	414,216	0.998
7/26	208	715	923	415,139	1.000
Total	69,603	345,536	415,139		
SE			2,614		

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

[a] First quarter point.

[b] Midpoint.

[c] Third quarter point.

Table 4.–Pink salmon daily and cumulative counts, at the Anvik River sonar, 2017.

Date	Left bank	Right bank	Daily total	Cumulative Count	Cumulative 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	0	0	0	0	0.000
6/26	0	0	0	0	0.000
6/27	0	0	0	0	0.000
6/28	0	0	0	0	0.000
6/29	8	0	0	0	0.000
6/30	0	0	0	0	0.000
7/01	0	13	13	13	0.015
7/02	0	93	93	106	0.123
7/03	0	60	60	166	0.192
7/04[b]	0	56	56	222	0.257
7/05	0	0	0	222	0.257
7/06	0	204	204	426	0.492
7/07	0	0	0	426	0.492
7/08[c]	0	21	21	447	0.517
7/09	0	57	57	504	0.583
7/10	0	0	0	504	0.583
7/11	0	0	0	504	0.583
7/12	0	0	0	504	0.583
7/13	0	0	0	504	0.583
7/14	12	0	12	516	0.597
7/15[d]	87	127	214	730	0.844
7/16	45	0	45	775	0.896
7/17	0	0	0	775	0.896
7/18	0	0	0	775	0.896
7/19	47	0	47	822	0.950
7/20	0	0	0	822	0.950
7/21	0	0	0	822	0.950
7/22	0	0	0	822	0.950
7/23	0	0	0	822	0.950
7/24	0	0	0	822	0.950
7/25	0	22	22	844	0.976
7/26	0	21	21	865	1.000
Total	191	675	865		
SE			300		

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.–Number of minutes by bank and day that were adjusted to calculate the daily salmon passage, and the resulting number of fish added to the estimate, at the Anvik River sonar, 2017.

	Left bank		Right bank	
Date	Minutes	Fish	Minutes	Fish
6/15	510	19	540	222
6/16	210	83	600	90
6/17	213	96	270	236
6/18	0	0	0	0
6/19	0	0	0	0
6/20	0	0	0	0
6/21	0	0	0	0
6/22	30	12	30	61
6/23	0	0	0	0
6/24	0	0	0	0
6/25	30	21	30	533
6/26	0	0	0	0
6/27	0	0	0	0
6/28	0	0	0	0
6/29	0	0	0	0
6/30	30	103	0	0
7/1	210	899	0	0
7/2	0	0	0	0
7/3	0	0	0	0
7/4	0	0	0	0
7/5	0	0	0	0
7/6	0	0	0	0
7/7	0	0	0	0
7/8	0	0	30	502
7/9	60	119	60	593
7/10	0	0	0	0
7/11	0	0	0	0
7/12	0	0	0	0
7/13	0	0	0	0
7/14	0	0	0	0
7/15	0	0	0	0
7/16	0	0	0	0
7/17	0	0	0	0
7/18	0	0	0	0
7/19	0	0	0	0
7/20	0	0	0	0
7/21	0	0	0	0
7/22	90	216	60	181
7/23	0	0	0	0
7/24	0	0	0	0
7/25	0	0	0	0
7/26	540	156	540	552
Total	1,923	1,724	2,160	2,972

Table 6.–Salmon species and proportion of summer chum salmon observed during tower counts by day and bank at the Anvik River sonar, 2017.

	Left bank					Right bank				
Date	Chum	Chinook	Pink	Sockeye	Proportion chum	Chum	Chinook	Pink	Sockeye	Proportion chum
6/16	0	0	0	0	0.00	2	0	0	0	1.00
6/17	0	0	0	0	0.00	12	0	0	0	1.00
6/18	1	0	0	0	1.00	7	0	0	0	1.00
6/19	0	0	0	0	0.00	8	0	0	0	1.00
6/20	0	0	0	0	0.00	3	0	0	0	1.00
6/21	2	0	0	0	1.00	116	0	0	0	1.00
6/22	11	0	0	0	1.00	45	0	0	0	1.00
6/23	8	0	0	0	1.00	349	0	0	0	1.00
6/24	32	0	0	0	1.00	553	0	0	1	1.00
6/25	1	0	0	0	1.00	408	2	0	0	1.00
6/26	13	0	0	0	1.00	625	0	0	2	1.00
6/27	1	0	0	0	1.00	57	0	0	0	1.00
6/28	1	0	0	0	1.00	196	1	0	2	0.98
6/29	7	0	0	0	1.00	413	3	0	2	0.99
6/30	205	0	0	1	1.00	1,122	0	0	7	0.99
7/01	99	0	0	1	0.99	832	1	1	5	0.99
7/02	62	0	0	0	1.00	652	2	1	8	0.98
7/03	66	0	0	0	1.00	627	10	2	6	0.97
7/04	94	0	0	0	1.00	379	3	1	3	0.98
7/05	366	3	0	7	0.97	632	12	0	8	0.97
7/06	62	0	0	0	1.00	441	7	1	1	0.98
7/07	98	2	0	0	0.98	432	8	0	3	0.98
7/08	104	1	0	4	0.95	568	7	1	4	0.98
7/09	4	0	0	0	1.00	104	2	1	4	0.94
7/10	9	0	0	0	1.00	53	1	0	1	0.96
7/11	13	0	0	0	1.00	284	2	0	11	0.96
7/12	58	1	0	0	0.98	249	9	0	6	0.94
7/13	87	0	0	2	0.98	193	8	0	2	0.95
7/14	63	1	1	0	0.97	143	14	0	7	0.87
7/15	10	0	1	0	0.91	64	4	1	1	0.91

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Table 6.–Page 2 of 2.

	Left bank					Right bank				
Date	Chum	Chinook	Pink	Sockeye	Proportion chum	Chum	Chinook	Pink	Sockeye	Proportion chum
7/17	7	0	0	0	1.00	51	2	0	2	1.00
7/18	9	0	0	0	1.00	145	2	0	3	1.00
7/19	191	1	2	4	0.96	247	6	0	9	0.96
7/20	122	1	0	0	0.99	152	4	0	3	0.99
7/21	61	0	0	0	1.00	102	3	0	5	1.00
7/22	25	0	0	2	0.93	38	5	0	6	0.93
7/23	5	0	0	0	1.00	15	2	0	0	1.00
7/24	0	0	0	0	0.00	10	0	0	0	0.00
7/25	1	0	0	0	1.00	31	5	1	1	1.00
7/26	0	0	0	0	0.00	4	0	0	0	0.00
Total	1,910	10	4	21	0.98	10,463	126	10	115	0.98

Table 7.–Reporting units and tower counts pooled at the Anvik River sonar, 2017.

	Left bank			Right bank		
Date	Report Period	Number of useable tower counts	Reason for combining report period [a]	Report Period	Number of useable tower counts	Reason for combining report period [a]
6/15	28	4	NF	67	2	NF
6/16	28	4	NF	67	2	NF
6/17	28	4	NF	66	3	NF
6/18	28	4	NF	66	3	NF
6/19	28	4	NF	65	3	NF
6/20	28	4	NF	65	3	NF
6/21	28	4	NF	64	4	
6/22	27	2		63	3	
6/23	26	3		62	4	
6/24	25	4	NF	61	4	
6/25	25	4	NF	60	4	
6/26	24	4	NF	59	4	
6/27	24	4	NF	58	4	
6/28	24	4	NF	57	4	
6/29	23	2		56	4	
6/30	22	4		55	4	
7/01	21	4		54	4	
7/02	20	4		53	4	
7/03	19	4		52	4	
7/04	18	4		51	4	
7/05	17	4		50	4	
7/06	16	4		49	4	
7/07	15	4		48	4	
7/08	14	7	NF	47	4	
7/09	14	7	NF	46	4	
7/10	13	3		45	4	
7/11	12	3		44	4	
7/12	11	4		43	4	
7/13	10	2		42	4	
7/14	9	3		41	4	
7/15	8	5	NF	40	4	
7/16	8	5	NF	39	4	
7/17	7	4		38	4	
7/18	6	3		37	4	
7/19	5	4		36	4	
7/20	4	4		35	4	
7/21	3	4		34	4	
7/22	2	3		33	4	
7/23	1	3	NF	32	4	
7/24	1	3	NF	31	3	
7/25	1	3	NF	30	5	NF
7/26	1	3	NF	30	5	NF

[a] NF denotes that the minimum of 2 tower counting periods with at least 5 fish in each period were not observed in tower counts. MV denotes that the minimum range of visibility during tower counts was not met.

Table 8.–Age and sex composition of summer chum salmon, Anvik River sonar, 2017.

Sample dates (Strata)	Samples[a] (*n*)	Sex	Brood year (age) 2015 (0.2) Estimate	2015 (0.2) %	2014 (0.3) Estimate	2014 (0.3) %	2013 (0.4) Estimate	2013 (0.4) %	2012 (0.5) Estimate	2012 (0.5) %	Total Estimate	Total %
6/23-25,28 (6/15-29)	164	Male	0	0.00	13,033	12.80	45,306	0.45	2,483	0.02	60,822	0.60
		Female	0	0.00	9,309	9.15	31,652	0.31	0	0.00	40,961	0.40
		Subtotal	0	0.00	22,342	22.00	76,958	0.76	2,483	0.02	101,783	100.00
7/02-03, (6/30-7/03)	130	Male	0	0.00	25,853	0.25	29,085	0.28	0	0.00	54,938	0.52
		Female	0	0.00	21,006	0.20	28,277	0.27	808	0.01	50,091	0.48
		Subtotal	0	0.00	46,859	0.45	57,362	0.55	808	0.01	105,029	100.00
7/05 (7/04-08)	37	Male	0	0.00	26,627	0.27	18,639	18.92	0	0.00	45,266	0.46
		Female	0	0.00	21,302	0.22	31,953	32.43	0	0.00	53,255	0.54
		Subtotal	0	0.00	47,929	0.49	50,592	51.35	0	0.00	98,521	100.00
7/10-12,16-19 (7/09-7/26)	341	Male	322	0.29	35,099	31.96	17,389	15.84	0	0.00	52,810	0.48
		Female	322	0.29	44,438	40.47	12,236	11.14	0	0.00	56,996	0.52
		Subtotal	644	0.59	79,537	72.43	29,625	26.98	0	0.00	109,806	100.00
Season	672	Male	322	0.15	100,613	25.60	110,419	25.3	2,483	0.60	213,836	51.64
		Female	322	0.15	96,054	27.83	104,118	20.24	808	0.15	201,303	48.36
		Total	644	0.3	196,667	53.42	214,537	45.54	3,291	1.00	415,139	100.00

Note: The number of fish per strata and age class were based on the sonar estimate multiplied by percent of fish in the 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 October 25, 2017).

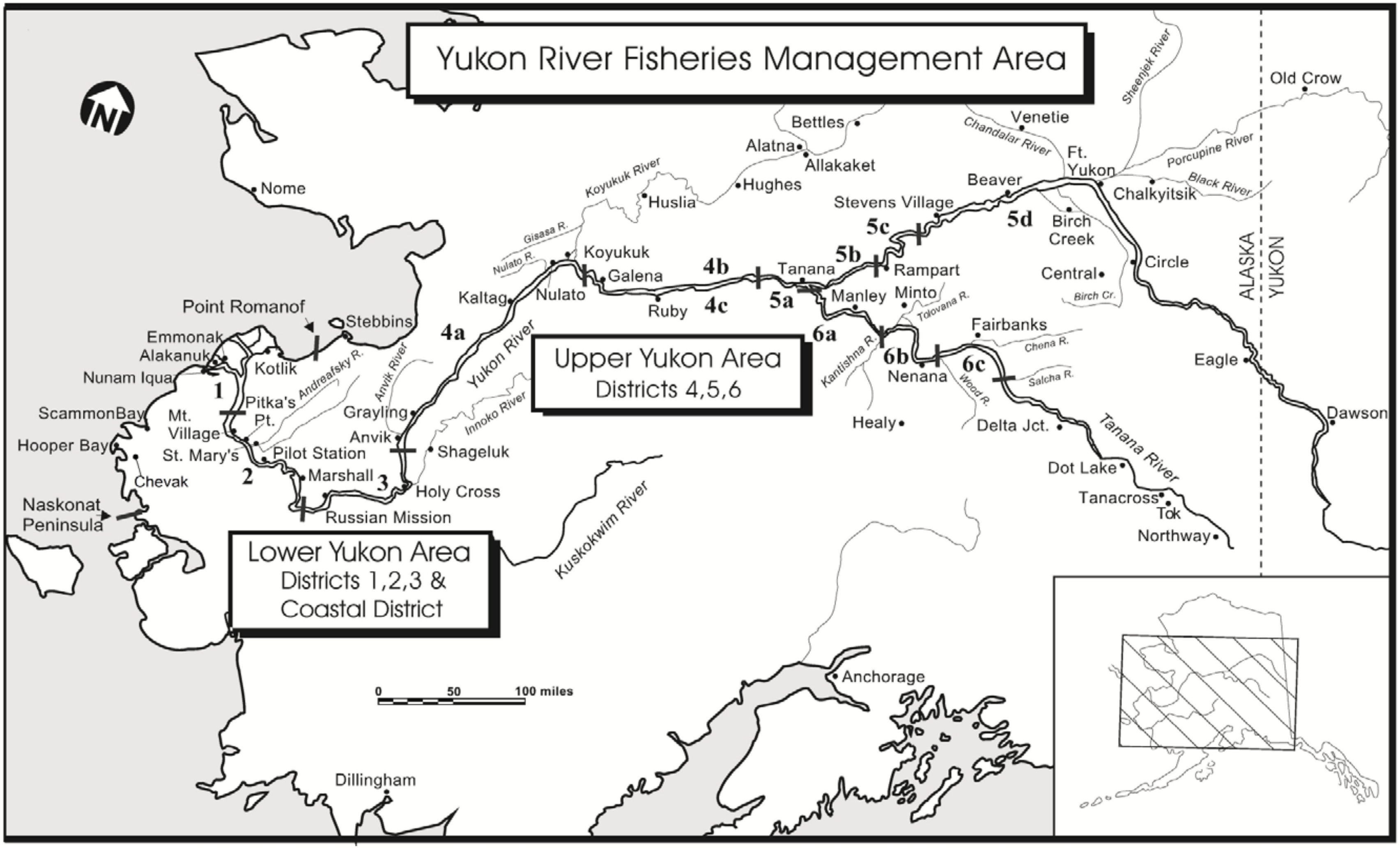

Figure 1.–Alaska portion of the Yukon River drainage showing communities and fishing districts.

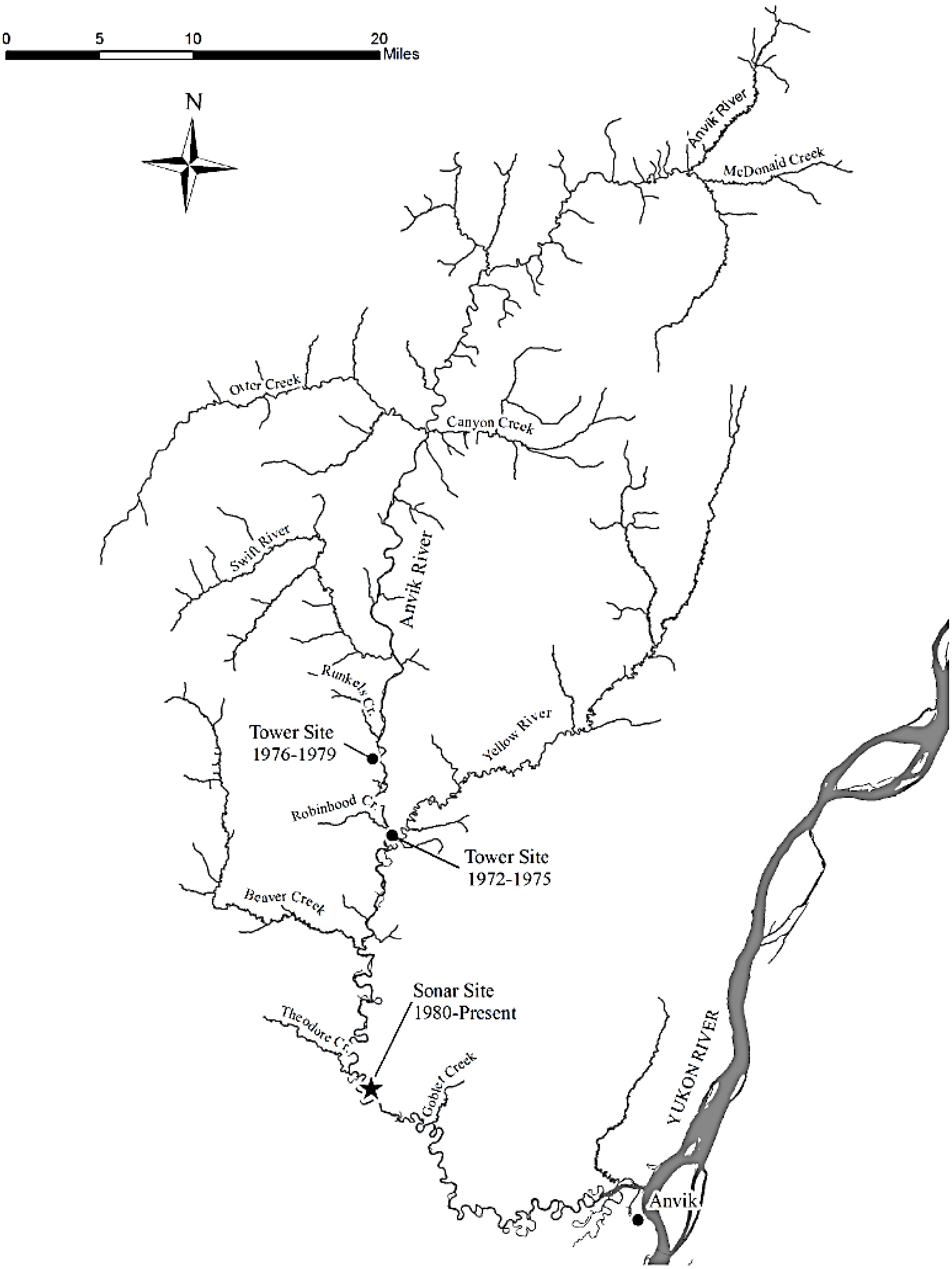

Figure 2.–Anvik River drainage with historical summer chum salmon escapement project locations.

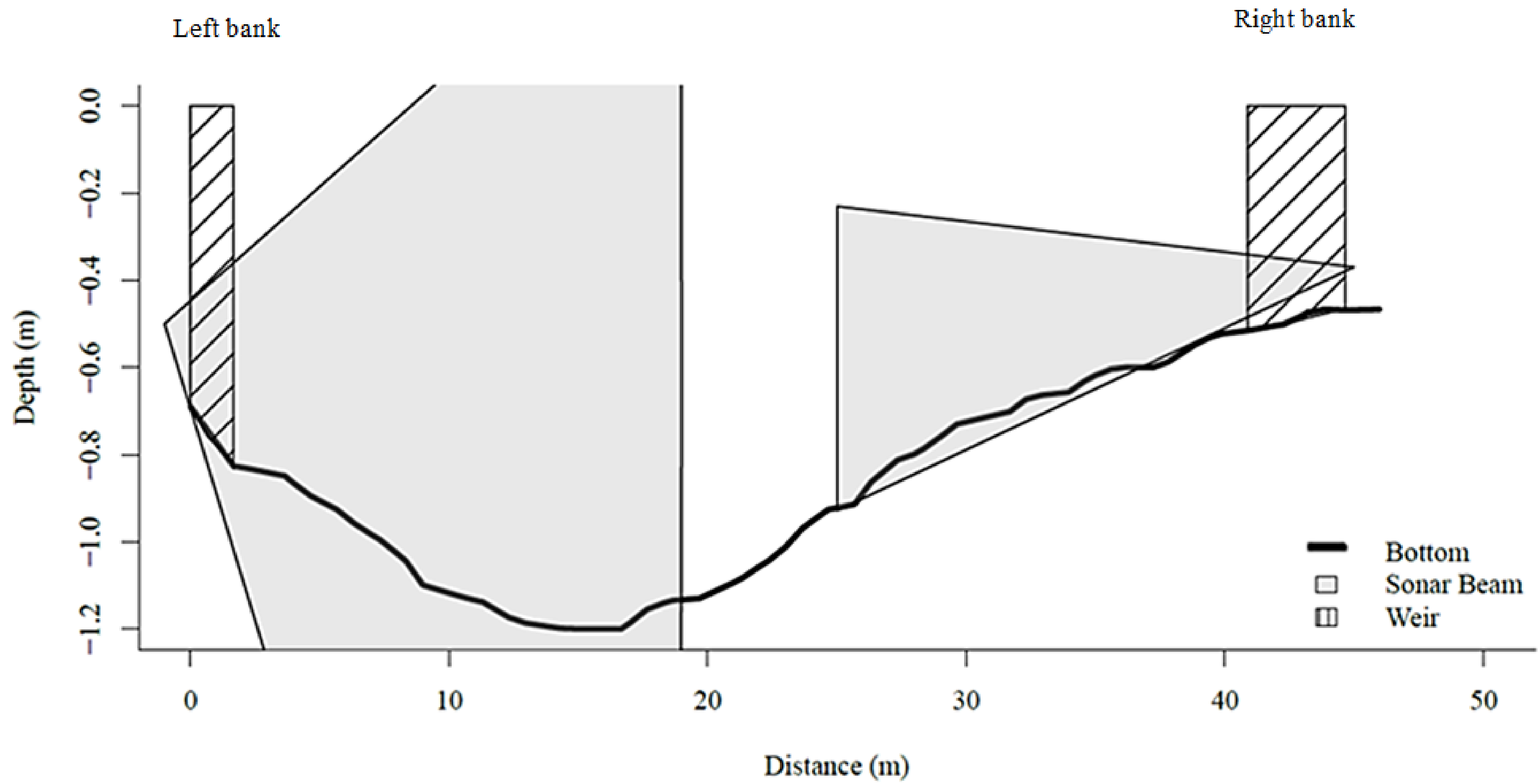

Figure 3.–Depth profile of the Anvik River, and approximate sonar ranges at the Anvik River sonar project, June 18, 2017.

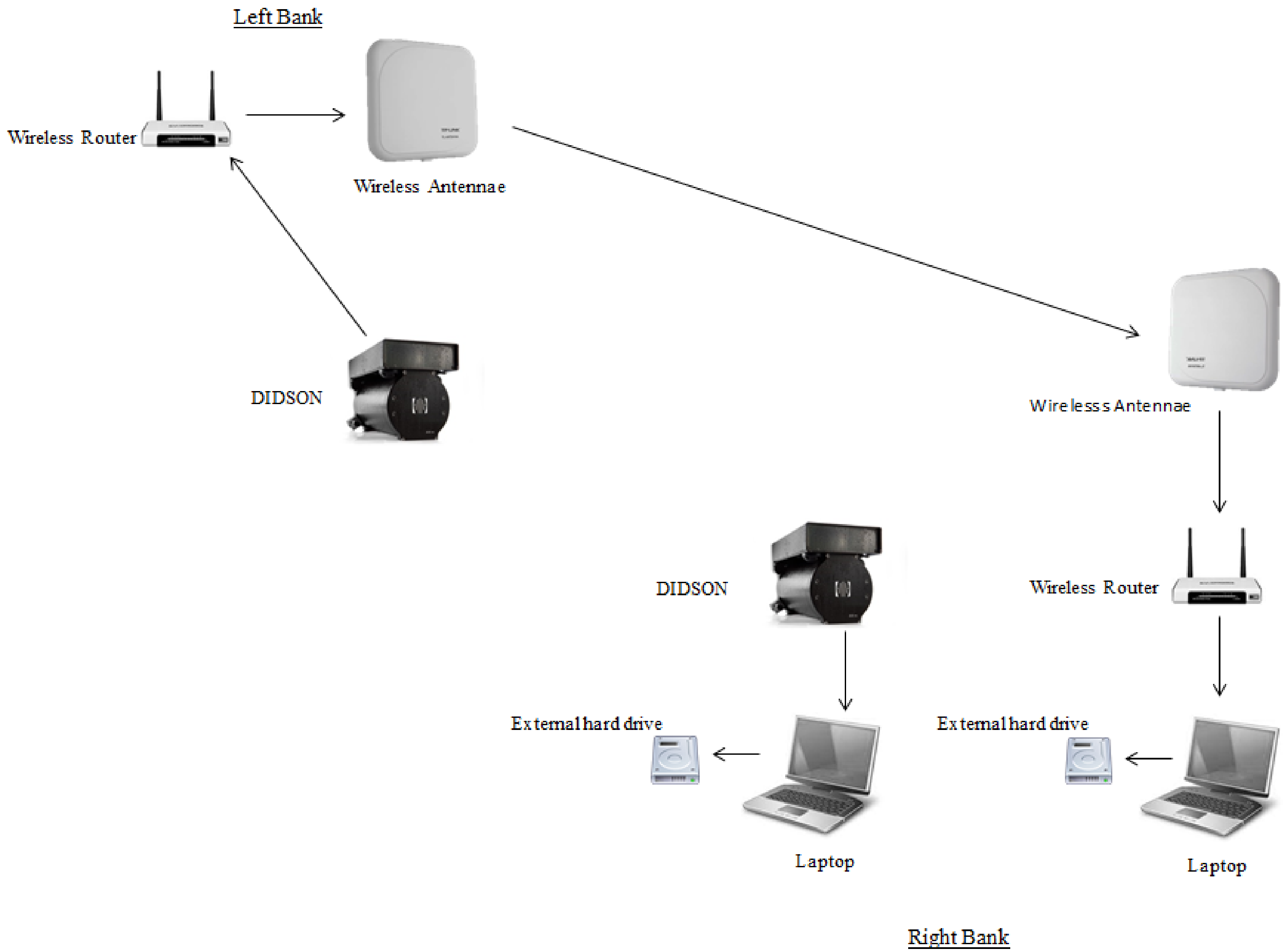

Figure 4.–DIDSON sonar equipment schematic, Anvik River sonar, 2017.

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

Figure 5.–View of a DIDSON mounted to aluminum H-mount with manual crank-style rotator at the Anvik River sonar project, 2017.

Figure 6.–Anvik River sonar site (2016), illustrating locations of sonars, weirs, and counting towers.

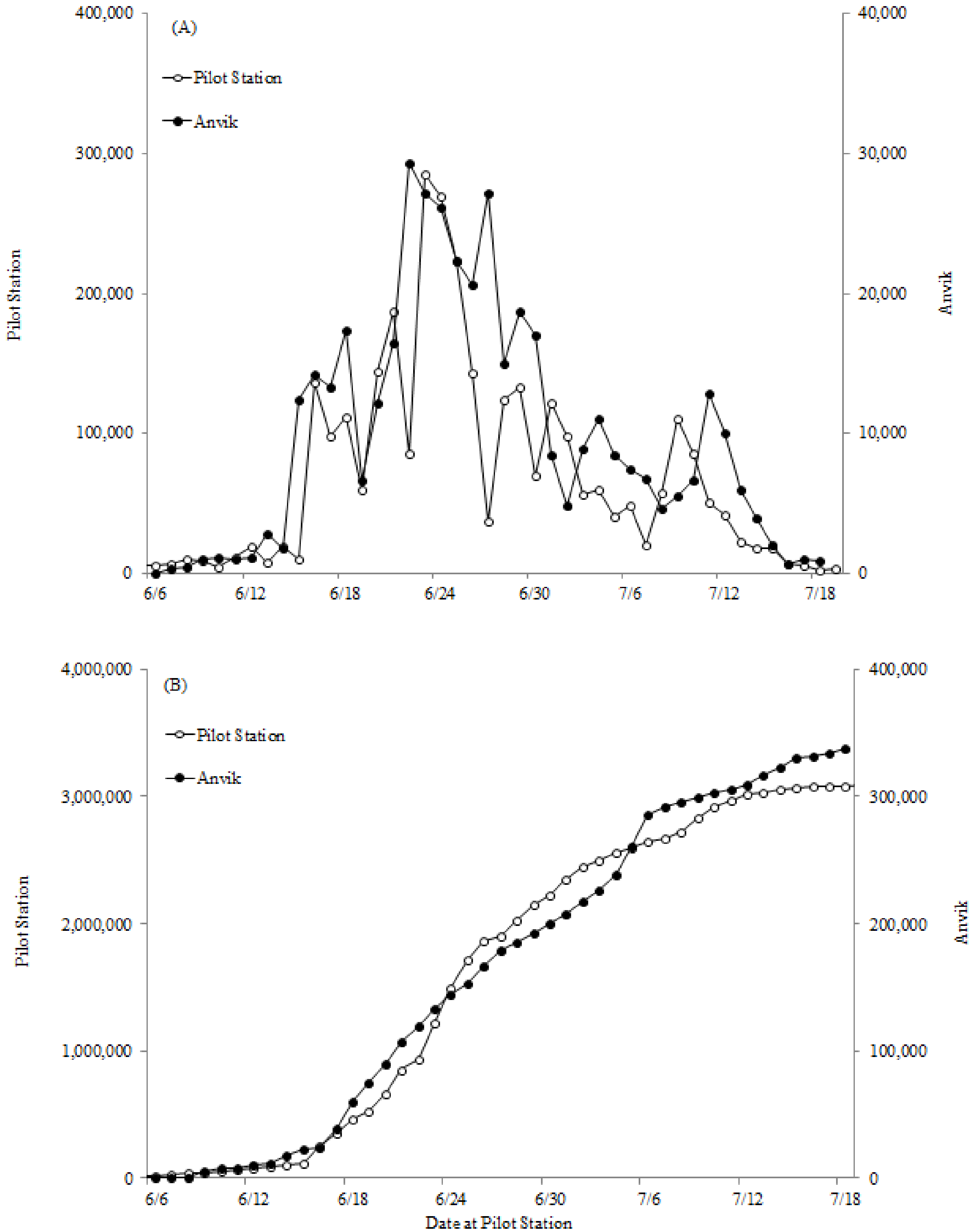

Figure 7.–Daily summer chum salmon passage at the Anvik River sonar and the sonar project near the village of Pilot Station (A), and cumulative summer chum salmon passage at both projects (B), 2017.

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

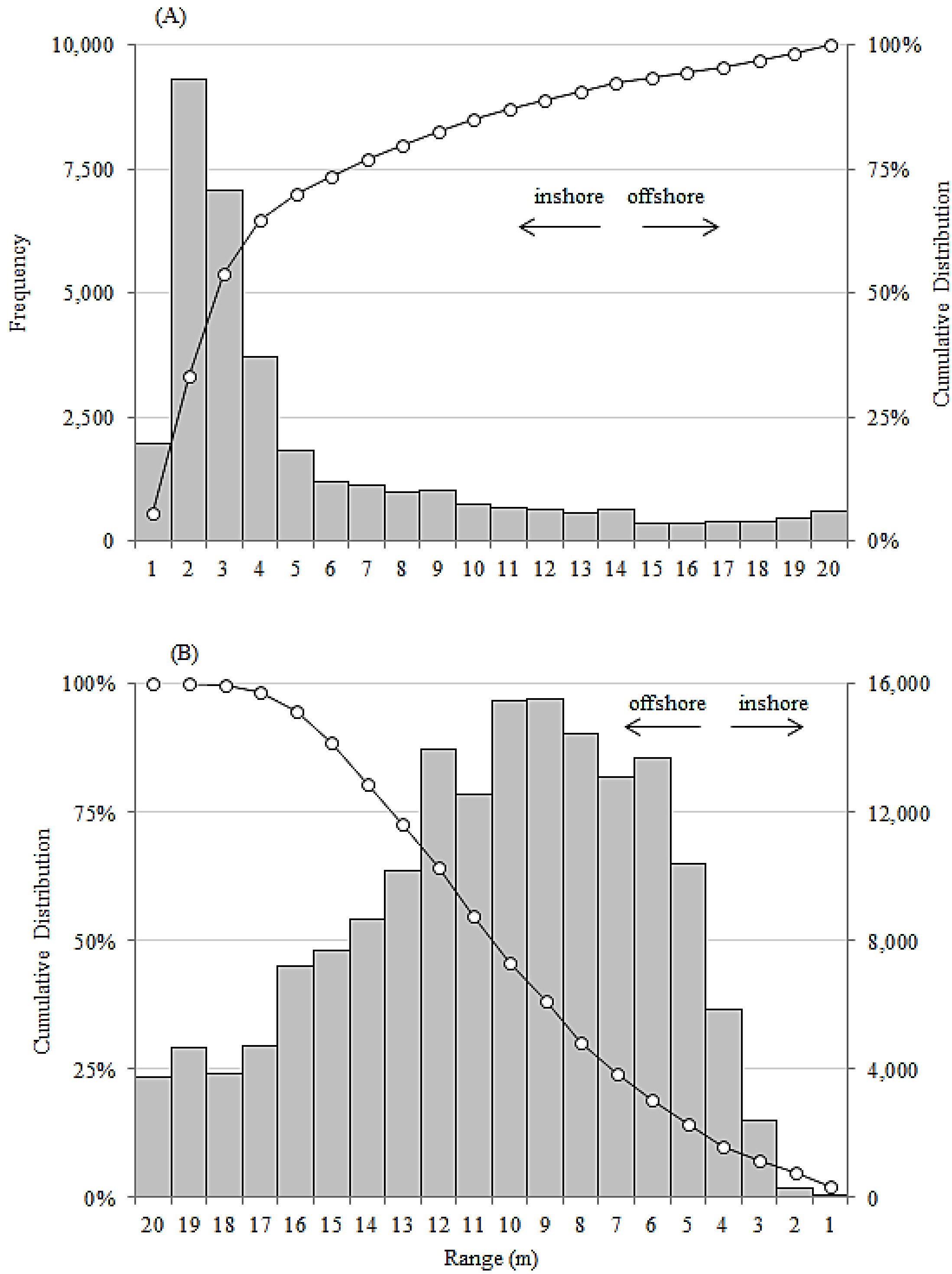

Figure 8.–Left bank (A) and right bank (B) horizontal distribution of unexpanded upstream salmon passage at the Anvik River sonar project, June 15–July 26, 2017.

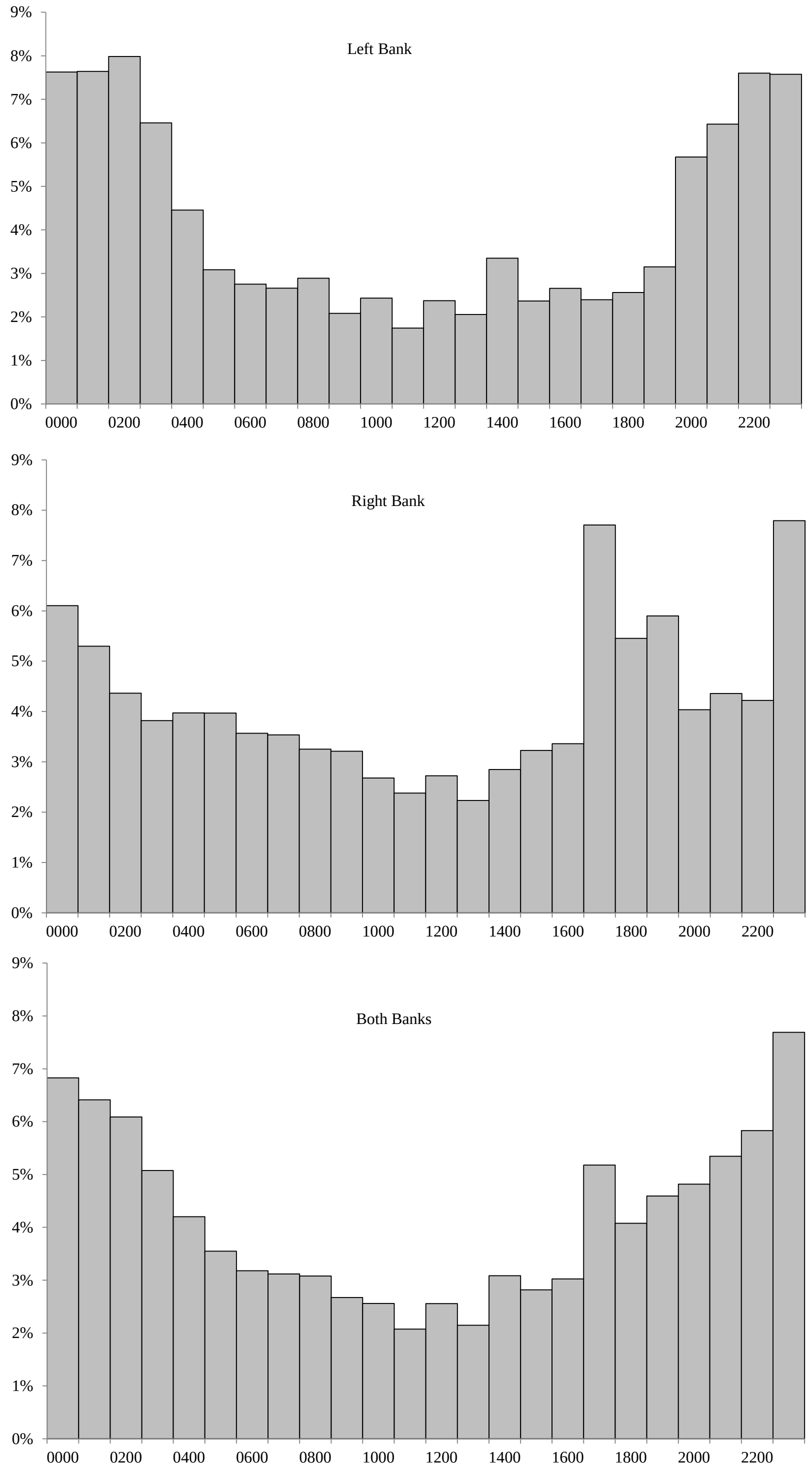

Figure 9.–Percentage of total passage, by hour, observed on the left bank (top), right bank (middle), and both banks combined (bottom), at the Anvik River sonar project, 2017.

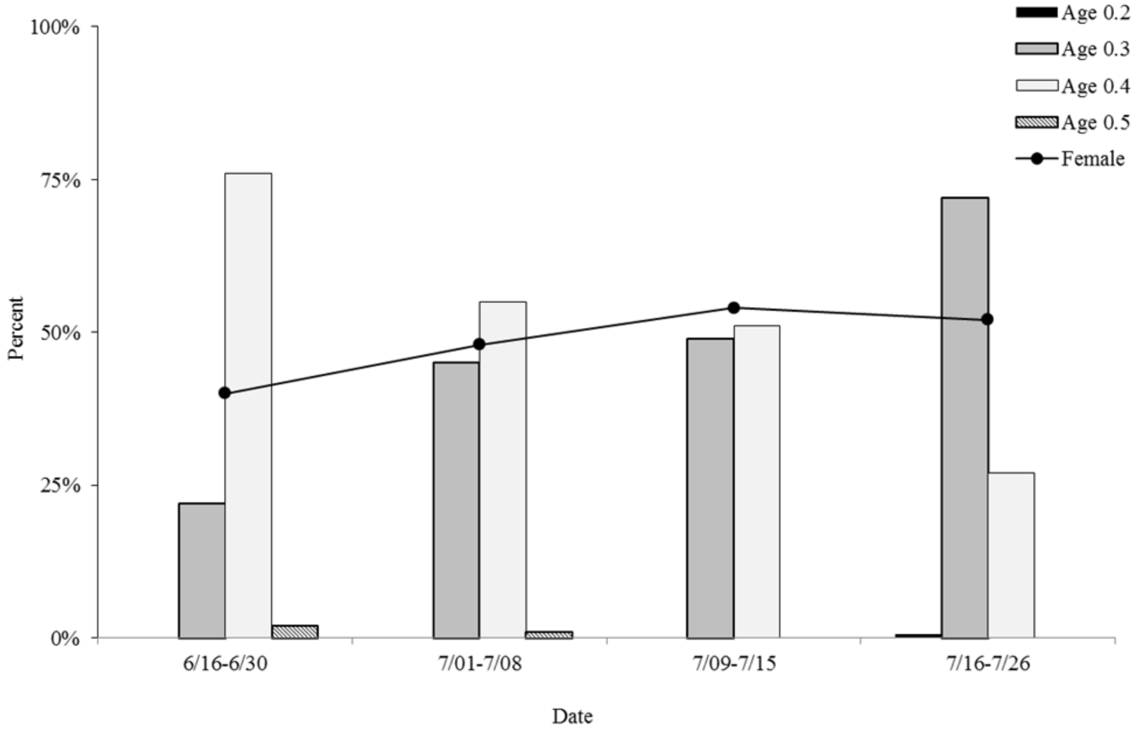

Figure 10.–Summer chum salmon age and percent female composition by sampling strata at the Anvik River sonar, 2017.

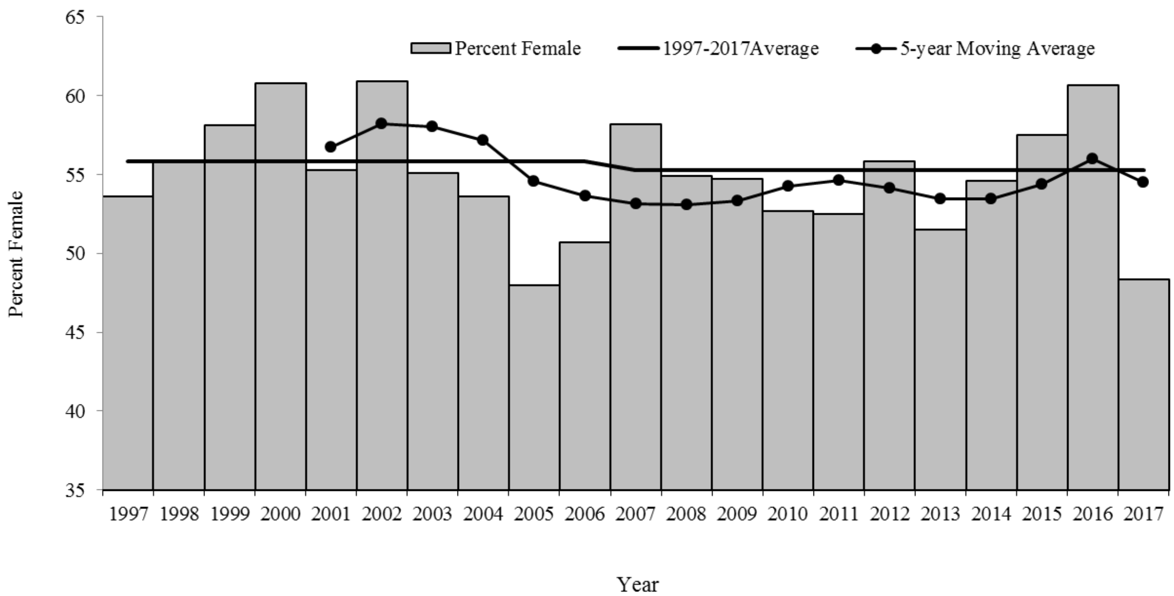

Figure 11.–Percent of female summer chum salmon escapement estimated at the Anvik River sonar project, 1997–2017.

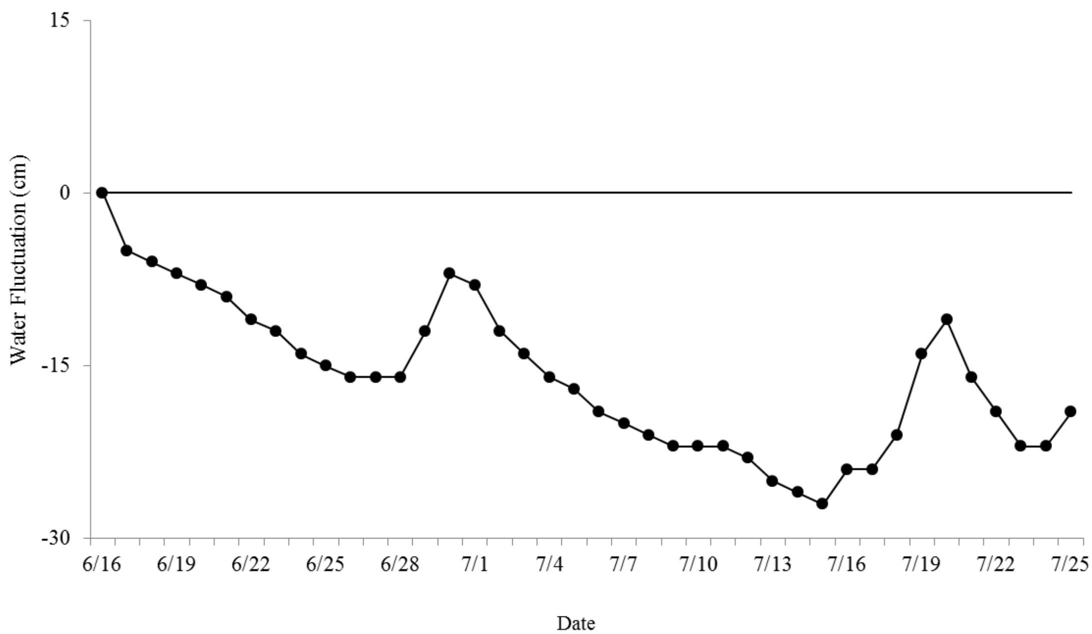

Figure 12.–Change in daily water elevation, relative to June 16, measured at the Anvik River sonar project, 2017.

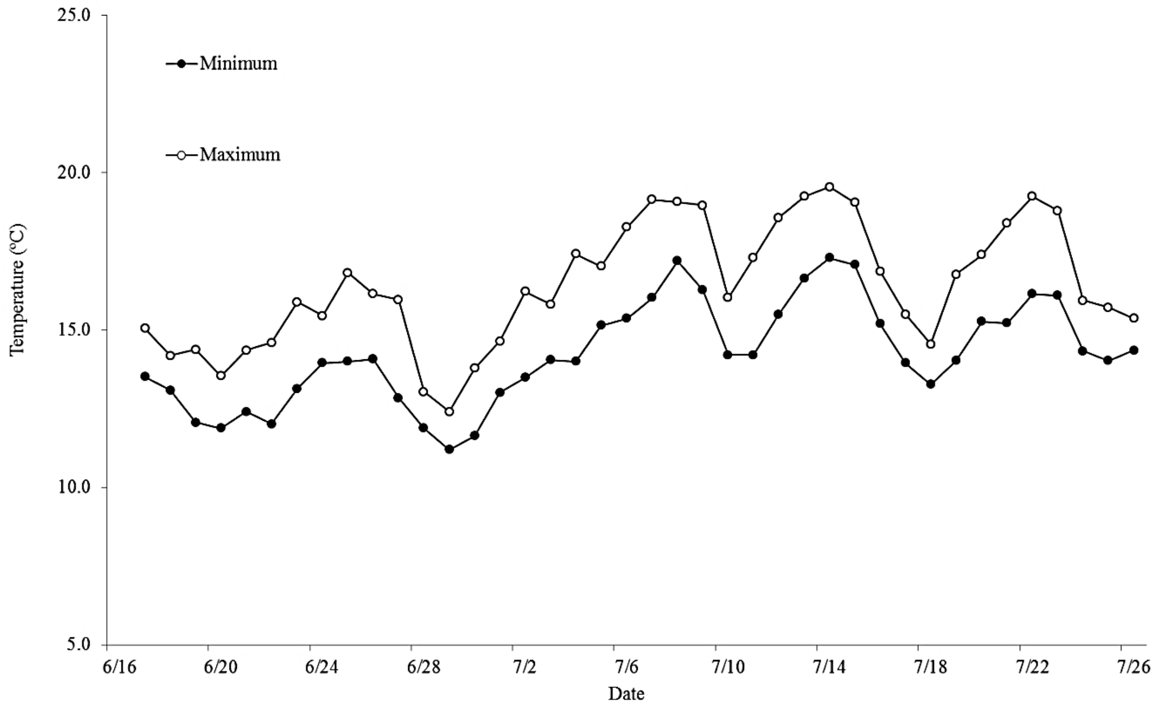

Figure 13.–Daily water temperatures on the left bank at the Anvik River sonar, 2017.

APPENDIX A: CLIMATE AND HYDROLOGIC OBSERVATIONS

Appendix A1.–Climatic observations recorded daily at 1600 hours, at the Anvik sonar project site, 2017.

		Wind			
Date	Precipitation (code)[a]	Direction[b]	Velocity (kph)	Sky (code)[c]	Air temperature (°C)
6/16	A	W	9.3	B	23.4
6/17	A	W	8.9	B	17.5
6/18	A	W	5.5	B	15.3
6/19	A	W	1.4	B	15.7
6/20	A	W	5.3	C	15.5
6/21	A	W	1.9	B	17.8
6/22	A	W	2.6	B	19.8
6/23	B	NE	1.6	B	25.7
6/24	A	W	3.9	B	16.9
6/25	A	NE	6.9	S	21.5
6/26	B	E	4.5	O	13.6
6/27	B	E	4.0	O	14.3
6/28	B	E	1.6	O	14.4
6/29	B	E	3.2	O	15.1
6/30	A	E	4.2	O	17.7
7/01	A	NW	1.8	O	18.2
7/02	A	E	7.9	S	19.0
7/03	A	E	8.0	B	19.5
7/04	A	W	6.1	C	20.7
7/05	A	E	4.8	B	21.7
7/06	A	W	5.5	C	23.9
7/07	A	W	2.4	S	26.0
7/08	A	E	5.6	S	21.7
7/09	B	E	7.7	O	16.5
7/10	A	E	1.8	O	17.8
7/11	A	W	1.1	S	23.9
7/12	A	E	2.3	F	25.2
7/13	A	W	0.0	F/S	29.5
7/14	A	W	2.6	B	22.4
7/15	B	W	1.6	O	17.6
7/16	A	NW	5.3	O	17.2
7/17	C	E	4.7	O	14.5
7/18	A	E	4.3	B	16.7
7/19	A	E	1.6	B	21.5
7/20	A	W	4.2	S	23.5
7/21	A	W	2.7	C	25.6
7/22	A	W	2.9	S	28.5
7/23	B	W	2.3	O	16.5
7/24	A	W	2.6	O	17.0
7/25	B	ND	0.0	O	18.2

Note: ND indicates that 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.