Fishery Data Series No. 16-24

Sonar Estimation of Summer Chum Salmon in the Anvik River, Alaska, 2015

by

Jody D. Lozori

June 2016

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

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ABSTRACT

A dual-frequency identification sonar (DIDSON) was used to estimate summer chum salmon *Oncorhynchus keta* passage in the Anvik River from June 17 to July 27, 2015. A total of 374,968 summer chum salmon were estimated to have passed the sonar site. A beach seine sample fishery was conducted to collect age, sex, and length (ASL) and genetic information. Both systems functioned well with minimal interruptions to operation. The range of ensonification was considered adequate for most fish that migrated upstream.

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

INTRODUCTION

The purpose of the Anvik River sonar project is to monitor escapement of adult summer chum *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. Fall chum, which are a later run of chum salmon (Estensen et al. 2013), and coho salmon *O. kisutch* have been reported to spawn in the Anvik River drainage during the fall.

Timely and accurate reporting of summer chum escapement from the Anvik River sonar project helps Yukon River Alaska Department of Fishery (ADF&G) fishery managers ensure the Anvik River biological escapement goal (BEG) of 350,000 to 700,000 summer chum salmon is met (ADF&G 2004). This assessment is necessary to determine if summer chum salmon abundance will meet downstream subsistence and commercial harvest, as well as upstream escapement needs. Subsistence and commercial fishery openings and closures may be based, in part, upon this assessment.

High abundance of pink salmon occurs 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.

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, 1976; 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, 5 km below Theodore Creek at lat 62°44.208′N, long 160°40.724′W. The land is public, managed by the Bureau of Land Management (BLM), and leased to 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.

Single-beam echocounting sonar manufactured by Bendix Corporation[2] 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). The Bendix 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 sonar equipment where it was found that the Bendix and HTI produced similar abundance estimates (Dunbar and Pfisterer 2007). In 2004, the change was made to HTI sonar equipment. In 2006, a side-by-side comparison was done between HTI and dual-frequency identification sonars (DIDSON; Belcher et al. 2002). High water for most of the season prevented normal operation of the split-beam sonar, but it was found that 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 2015a and 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 change was made to DIDSON sonar.

The Anvik River sonar project provides timely and accurate information to Yukon River fishery managers. DIDSON are used to collect salmon passage data and tower estimates are used to apportion the counts to chum or pink salmon during even years when pink salmon are abundant. Beach seines are used to collect age, sex, and length (ASL) data. HOBO temperature loggers are used to monitor hydrologic parameters daily. This report presents data collected in 2015 and compares the results to previous years.

OBJECTIVES

The goal of this project in 2015 was to provide daily inseason estimates of adult summer chum salmon escapement into the Anvik River to fishery managers. Primary objectives included the following:

1. Estimate summer chum salmon abundance in the Anvik River using DIDSON sonar, and determine if the summer chum salmon BEG is met from approximately June 16 through July 26.
2. Operate DIDSON such that 95% of migrating salmon are detected within three quarters of the ensonified range on both banks.

Secondary objectives included the following:

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

[2] 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 mile (rkm) 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 with past years, we were able to use the same location, because of the site's stability. The river substrate at the sonar site is fine, smooth gravel, sand, and silt. The right bank sloped gradually to the thalweg approximately 36 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

Two DIDSONs manufactured by Sound Metrics Corporation were deployed at the Anvik River sonar site. A long range DIDSON operating at frequency of 1.2 MHz (high frequency option using 48 beams) on the right bank, and a Standard DIDSON operating at frequency of 1.8 MHz (high frequency option using 96 beams) on the left bank (Table 1). Because of the shallow right bank bottom profile, a concentrator lens (approximately 2º) was used to lessen interference from 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 transects made from bank-to-bank using a boat-mounted Humminbird 998C SI fathometer with GPS capabilities and plotted (Figure 3).

Both banks were ensonified on July 17, and operations ran continuously through 1100 on July 27. 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 2 m from the left bank (Figure 3). 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 the right bank, the river was ensonified approximately 20 m from the DIDSON, and on the left bank the river was ensonified approximately 10 m from the DIDSON. Approximately 68% 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 they needed to be repositioned to accommodate changing water levels.

Partial weirs were erected perpendicular to the current and extended from the shore out 1 to 3 m beyond each DIDSON (Figures 3 and 6). The weirs diverted migrating adult salmon offshore and in front of the DIDSON to provide sufficient offshore distance for fish to be detected in the sonar beam, while allowing passage of small, resident, non-target species (Arctic grayling *Thymallus arcticus*, northern pike *Esox lucius*, longnose sucker *Catostomus catostomus*, and whitefish *Coregonus* spp.) 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 the generator was 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 manually except for small fish (<400 mm), which were assumed not to be salmon. Fish length measurements were made manually 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 as follows:

$$\hat{y}_{ds} = 24 \bullet \frac{\sum_{p=1}^{n} \frac{y_{dsp}}{f_{dsp}}}{n_{ds}} \quad (1)$$

,

where f_{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 overestimate of the variance of the total because sonar counts are highly autocorrelated. 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 follows:

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

.

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), $h_{ds,p}$ is the fraction of the hour sampled (typically 0.5), and y_{dsp} is the hourly count for day

(d) in stratum (s) for sample (p). Given that the passage estimates are assumed independent between strata and among days, the total variance was estimated as the sum of the variances:

$$\hat{V}ar(\hat{y}) = \sum_{d}\sum_{s}\hat{V}ar(\hat{y}_{ds}) \quad . \tag{3}$$

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, the relationship of daily passage between banks was assessed. An XY scatterplot with a regression line was plotted using the observed passage from the previous days for each bank. If the regression was significant ($p < 0.05$), the linear regression equation of the line was then used to calculate missing passage for each missing day (d):

$$\hat{y}_d = a + bx_d, \tag{4}$$

where a and b are the regression coefficients, x equals the passage for day (d) on the opposite bank, and $\hat{y}_d$ is the estimated passage for missing day (d).

If the regression of daily passage by bank was not significant, daily passage was interpolated by averaging passage estimates from days before and after the missing day(s) as follows:

$$\hat{y}_d = \left(1/n\sum_{i=1}^{n}x_i\right)\begin{Bmatrix} d=1, n=4 \\ d=2, n=6 \\ d=3, n=8 \end{Bmatrix}, \tag{5}$$

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 sample.

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

Although apportionment of salmon was not conducted this season, tower counts were carried out 4 times per day (0730, 1300, 1700, and 2000) for 15 minutes on each bank. On the right bank, a 4.5 m tower was anchored in the river just downstream of the sonar at the end of the weir. On the left bank, a tower was erected on shore just upriver of the sonar (Figure 6). Technicians stood on top of the towers with 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® Excel spreadsheet; non-salmon species were not counted or recorded. Information from tower counts was used to compare visual fish distributions with passage distributions derived from the sonar counts and to monitor the presence of pink and Chinook salmon.

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 when 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 for ASL information 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 on a 95% confidence with an accuracy (d) and precision (α) objectives of $d = 0.10$ and $\alpha = 0.05$, assuming 2 major age classes, and 2 minor age classes with a scale rejection rate of 15%. The beach seining goal for Chinook 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 mobile holding pen deployed in the river and each were noted for sex, measured to the nearest 1 mm from mid eye to tail fork, and 1 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 salmon were sampled using the same methods as summer chum salmon, except that 4 scale samples were taken from each fish.

CLIMATE AND HYDROLOGIC 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 temperature logger, which electronically recorded the temperature every hour on the hour for the duration of the project. Subjective notes on wind speed and direction, cloud cover, and precipitation were also recorded.

RESULTS

SUMMER CHUM 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 374,968 from June 17 to July 27, 2015. The first quarter point fell on July 5, the midpoint on July 7, and third quarter point on July 12. A peak daily passage estimate of 45,370 occurred on July 6 and 2,460 fish passed the last day of sonar operation on July 27 (Table 3). When compared to median historic run timing based on 1979–1984 and 1987–2014 runs, the summer chum salmon passage date for the first quartile was 1 day late and third quartile was 2 days late (Table 2). Daily passage between the first and third quartile dates ranged from 45,370 (July 6) to 16,220 (July 12) with an estimated total of 205,842 summer chum salmon passing by the sonar site during this time (Table 3). The 2015 summer chum salmon escapement estimate of 374,968 was less than

the average Anvik River escapement estimate of 582,003 fish (Table 2) but within the BEG of 350,000 to 700,000 summer chum salmon.

The timing of the summer chum salmon run into the Anvik River was roughly similar to the pattern observed at the lower Yukon River sonar project near the village of Pilot Station (Figure 7). Approximately 27% of the summer chum salmon that were estimated to have passed Pilot Station (1,385,083) were observed at the Anvik River sonar project, which is below the overall 1995–2014 contribution of 33%. Historically the percentage of Yukon River summer chum salmon bound for the Anvik River has fluctuated, and can be broken into 2 distinct periods (McEwen 2012). During the period from 1995 to 2002, the average contribution was approximately 50%, and from 2003 to 2014, the average contribution was approximately 23%, which was slightly less than what was observed in observed in 2015.

Total sonar passage estimates include expansions for sampling time missed. On the left bank, approximately 1,129 minutes were missed, which accounted for an additional 3,742 fish or 2.8% of the total left bank estimate. On the right bank, approximately 2,422 minutes were missed, which accounted for an additional 9,802 fish or 4.1% of the total right bank estimate (Table 4). Most of the estimates for missing counts were because of generator failures, adjusting weir panels, and re-aiming the sonar. There were no full days of missing data this season.

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

SPATIAL AND TEMPORAL DISTRIBUTION

Fish were shore-oriented on both banks (Figure 8). On the left bank, approximately 95% of the fish were detected within 7 m of the transducer, and 99% within 9 m. On the right bank, 95% of the fish were detected within 13 m of the transducer, and 99% within 17 m. The objective to operate imaging sonar such that 95% of the migrating salmon are detected within three quarters of the ensonified area on both banks was met. Approximately 64% of the total fish passage occurred on the right bank, which is consistent with historical migration trends at the project with the exception of 3 years: 1992 (43%), 1996 (45%), and 1997 (39%) (Sandone 1994; Fair 1997; Chapell 2001).

Overall, when considering both banks combined, there was a diurnal pattern of fish passage on the Anvik River this season, with the lowest passage occurring at 1400 (Figure 9). High passage tended to be between the hours of 2200 and 0700, and peak passage occurred at 0200.

SPECIES APPORTIONMENT

During tower counts 227 pink, 5,922 summer chum, and 27 Chinook salmon were observed this season (Table 5). Pink salmon passage was considered negligible compared to summer chum salmon passage and all counts were attributed to summer chum salmon.

SUMMER CHUM AGE AND SEX COMPOSITION

Because of low catches in the project test fishery at the beginning of the summer chum salmon run, the objective of collecting 162 summer chum salmon scale samples in each of 4 temporal strata was not entirely met this season. From July 2 through July 22, a total of 705 ASL samples were obtained, and from these samples, 638 scales were analyzed as ageable postseason. Strata

were defined in 2015 as follows: June 17–July 5, July 6–July 8, July 9–July 13, and July 14–July 27 (Table 6).

Scale sample analysis indicated that there were 2 major age classes of summer chum salmon, age-0.4 (61.8%) and age-0.3 (34.6%), as well as 2 minor classes, age-0.2 and age-0.5, both of which represented 1.8% of the total run (Table 6 and Figure 10). The age composition observed at the Anvik River sonar project was similar to the rest of the Yukon River drainage and the dominate age groups were age-0.4 and age-0.3.

Age and sex composition of summer chum salmon passing the sonar site changes through the duration of the run. Usually, the trend is an increasing proportion of younger salmon and a higher proportion of female salmon as the run progresses (Fair 1997); the 2015 run was consistent with this pattern (Table 6). Female summer chum salmon accounted for 54% of the entire run, which is close to the 1972–2014 average of 55.7% (Figure 11).

HYDROLOGIC AND CLIMATOLOGICAL CONDITIONS

The objective of monitoring hydrological parameters daily at the project site was met in 2015. The water level remained fairly low throughout the season and the lowest levels were recorded between July 2 and July 14 (Figure 12). There was 1 major increase, which began on July 15. The water level rose above the zero datum mark on July 16 and remained above through July 21. Overall, between June 22 and July 27, minimum and maximum water level differed by 26 cm. Water temperatures on the right bank ranged from 18.9°C on June 20 to 11.3°C on July 4 (Figure 13). The average air temperature was 21°C and temperatures ranged from a high of 27°C on June 23 to a low of 13°C on July 15 (Appendix A).

DISCUSSION

Prior to this season, passage estimation was calculated by hand entering DIDSON counts into a Microsoft® Excel spreadsheet. Computation in the spreadsheet expanded the counts for the full hour, adjusted counts for missing samples from both banks, and calculated the daily passage by summing the hourly passage rates for each hour (Lozori 2015b). This season, the use of Microsoft® Excel was eliminated, and text files output from Echotastic were directly imported into the statistical package R (R Core Team 2015). Passage estimation was calculated using an R script. This method simplified passage estimation by eliminating several calculations for missing data, as well as eliminating transcription errors. Additionally, the R script output provided diagnostic tables and charts, which presented daily information pertaining to hourly passage, fish distribution, and daily passage estimates by stratum. The output information was useful inseason for analysis of fish passage and helped evaluate performance of the sonar.

Next season, a Microsoft® Access database will replace the Excel sheet used in previous seasons (Lozori 2015b). The R script will use passage estimates as well the database entry to output an apportioned passage estimate of pink and summer chum salmon. Additionally, the database will provide diagnostic queries that will be used to quality check data entry, as well as provide convenient methods to export data sets for additional analysis.

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TABLES AND FIGURES

Table 1.–Technical specifications for dual frequency identification sonar (DIDSON) operated at the Anvik River sonar site, 2015.

Setting	Bank	Value
Mode	Right	High Frequency
	Left	High Frequency
Frequency (MHz)	Right	1.20
	Left	1.80
Number of beams	Right	48
	Left	96
Window length (m)	Right	20 m
	Left	10 m
Vertical beam width	Right	2°
	Left	14°
Start range (m)	Both	0.83
Frame rate	Both	6 frames/s
Duration in minutes	Both	30
Field of view	Both	29°

Table 2.–Annual passage estimates and passage timing for summer chum salmon run, at the Anvik River sonar, 1979–2015.

						Days between			
Year	Sonar passage estimate	First count	First quartile	Median	Third quartile	First count and first quartile	First quartile and median	Median and third quartile	First and third quartile
1979	277,712	6/23	7/2	7/8	7/12	9	6	4	10
1980	482,181	6/28	7/6	7/11	7/16	8	5	5	10
1981	1,479,582	6/20	6/27	7/2	7/7	7	5	5	10
1982	444,581	6/25	7/7	7/11	7/14	12	4	3	7
1983	362,912	6/21	6/30	7/7	7/12	9	7	5	12
1984	891,028	6/22	7/5	7/9	7/13	13	4	4	8
1985 [a]	1,080,243	7/5	7/10	7/13	7/16	5	3	3	6
1986 [a]	1,085,750	6/21	6/29	7/2	7/6	8	3	4	7
1987	455,876	6/21	7/5	7/12	7/16	14	7	4	11
1988	1,125,449	6/21	6/30	7/3	7/9	9	3	6	9
1989	636,906	6/20	7/1	7/7	7/13	11	6	6	12
1990	403,627	6/22	7/2	7/7	7/15	10	5	8	13
1991	847,772	6/21	7/1	7/10	7/16	10	9	6	15
1992	775,626	6/29	7/5	7/8	7/12	6	3	4	7
1993	517,409	6/19	7/5	7/12	7/18	16	7	6	13
1994	1,124,689	6/19	7/1	7/7	7/11	12	6	4	10
1995	1,339,418	6/19	7/1	7/6	7/11	12	5	5	10
1996	933,240	6/18	6/25	7/1	7/6	7	6	5	11
1997	605,752	6/19	6/28	7/3	7/10	9	5	7	12
1998	487,301	6/22	7/5	7/10	7/14	13	5	4	9
1999	437,356	6/27	7/6	7/10	7/16	9	4	6	10
2000	196,349	6/21	7/8	7/11	7/13	17	3	2	5
2001	224,058	6/26	7/6	7/10	7/15	10	4	5	9
2002	459,058	6/22	7/3	7/7	7/12	11	4	5	9
2003	256,920	6/21	7/5	7/10	7/15	14	5	5	10
2004	365,353	6/22	6/29	7/5	7/9	7	6	4	10
2005	525,391	6/26	7/4	7/10	7/15	8	6	5	11
2006	605,485	6/28	7/3	7/6	7/12	5	3	6	9

-continued-

Table 2.-Page 2 of 2.

Year	Sonar passage estimate	First count	First quartile	Median	Third quartile	Days between: First count and first quartile	First quartile and median	Median and third quartile	First and third quartile
2007	460,121	6/26	7/5	7/10	7/17	9	5	7	12
2008	374,928	6/18	7/5	7/8	7/16	17	3	8	11
2009	191,566	6/18	7/4	7/9	7/15	16	5	6	11
2010	396,173	6/16	7/8	7/12	7/18	22	4	6	10
2011	642,527	6/16	7/2	7/7	7/14	16	5	7	12
2012	484,090	6/18	7/9	7/14	7/18	21	5	4	9
2013	577,877	6/17	7/2	7/8	7/11	15	6	3	9
2014	399,796	6/17	7/1	7/5	7/10	14	4	5	9
2015	374,968	6/17	7/5	7/7	7/12	17	3	5	8
Average	582,003	6/21	7/3	7/8	7/13	12	5	5	10
Median	483,136	6/21	7/4	7/8	7/14	11	5	5	10
SD	311,093	3.5	3.2	3.0	3.0	4.1	1.4	1.4	1.9

[a] The mean, median, and standard deviation (SD) of the timing statistics includes estimates from years 1979–1984 and 1987–2014. In 1985 sonar counting operations began late and in 1986, sonar counting operations were terminated early, probably resulting in the incorrect calculation of the quartile statistics. Therefore, the 1985 and 1986 run timing statistics were excluded from the calculation of the overall mean and timing statistic and associated SD.

Table 3.–Summer chum salmon daily and cumulative counts, Anvik River sonar, 2015.

				Cumulative	
Date	Left bank	Right bank	Daily totals	Count	Proportion
6/17	0	36	36	36	0.00
6/18	200	393	593	629	0.00
6/19	504	836	1,340	1,969	0.01
6/20	628	1,099	1,727	3,696	0.01
6/21	878	1,175	2,053	5,749	0.02
6/22	512	1,634	2,146	7,895	0.02
6/23	524	1,976	2,500	10,395	0.03
6/24	461	3,664	4,125	14,520	0.04
6/25	834	5,120	5,954	20,474	0.05
6/26	960	8,474	9,434	29,908	0.08
6/27	1,410	1,672	3,082	32,990	0.09
6/28	1,090	3,888	4,978	37,968	0.10
6/29	1,647	10,271	11,918	49,886	0.13
6/30	1,035	7,106	8,141	58,027	0.15
7/01	1,158	6,616	7,774	65,801	0.18
7/02	810	2,936	3,746	69,547	0.19
7/03	988	2,939	3,927	73,474	0.20
7/04	1,560	8,500	10,060	83,534	0.22
7/05 [a]	14,576	20,750	35,326	118,860	0.32
7/06	26,492	18,878	45,370	164,230	0.44
7/07 [b]	9,785	18,455	28,240	192,470	0.51
7/08	7,790	10,778	18,568	211,038	0.56
7/09	5,958	14,484	20,442	231,480	0.62
7/10	6,354	11,010	17,364	248,844	0.66
7/11	9,796	14,516	24,312	273,156	0.73
7/12 [c]	6,410	9,810	16,220	289,376	0.77
7/13	10,618	10,478	21,096	310,472	0.83
7/14	6,568	8,500	15,068	325,540	0.87
7/15	3,458	5,254	8,712	334,252	0.89
7/16	2,218	4,702	6,920	341,172	0.91
7/17	1,798	4,130	5,928	347,100	0.93
7/18	1,006	2,778	3,784	350,884	0.94
7/19	1,492	3,144	4,636	355,520	0.95
7/20	918	2,830	3,748	359,268	0.96
7/21	1,042	2,388	3,430	362,698	0.97
7/22	614	1,264	1,878	364,576	0.97
7/23	464	1,420	1,884	366,460	0.98
7/24	584	1,552	2,136	368,596	0.98
7/25	428	1,506	1,934	370,530	0.99
7/26	374	1,604	1,978	372,508	0.99
7/27	608	1,852	2,460	374,968	1.00
Total	134,550	240,418	374,968		
Var	3,356,306	4,706,384	8,062,690		
SE	1,832	2,169	2,839		

Note: The large box indicates the central 50% of the summer chum salmon run (second and third quartiles).

[a] First quarter point.

[b] Midpoint.

[c] Third quarter point.

Table 4.–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, Anvik River sonar, 2015.

	Left bank		Right bank	
Date	Minutes	Fish	Minutes	Fish
6/17	-90	0	600	30
6/18	360	100	390	213
6/19	0	0	0	0
6/20	0	0	150	229
6/21	0	0	30	49
6/22	0	0	30	68
6/23	0	0	0	0
6/24	103	66	0	0
6/25	0	0	0	0
6/26	120	160	60	706
6/27	0	0	0	0
6/28	0	0	210	1,134
6/29	75	172	207	2,953
6/30	30	43	14	138
7/01	0	0	191	1,755
7/02	0	0	0	0
7/03	0	0	60	245
7/04	0	0	0	0
7/05	0	0	0	0
7/06	55	2,053	0	0
7/07	60	815	30	769
7/08	0	0	0	0
7/09	0	0	0	0
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	90	588
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	0	0	0	0
7/23	0	0	0	0
7/24	0	0	0	0
7/25	0	0	0	0
7/26	55	29	0	0
7/27	360	304	360	926
Total	1,129	3,742	2,422	9,802

Table 5.–Number of summer chum, Chinook, and pink salmon observed during tower counts by day and bank at the Anvik River sonar, 2015.

	Left bank			Right bank		
	Chum	Chinook	Pink	Chum	Chinook	Pink
6/23[a]	0	0	0	122	0	0
6/24	1	0	0	81	0	0
6/25	3	0	0	129	0	0
6/26	7	0	0	130	0	0
6/27	55	0	0	34	0	0
6/28	2	0	0	129	0	0
6/29	21	0	0	221	0	0
6/30	6	0	0	134	1	0
7/01	12	0	0	125	1	0
7/02	4	0	0	55	0	0
7/03	7	0	0	70	0	0
7/04	13	0	0	229	0	0
7/05	138	0	0	536	0	0
7/06	238	1	0	247	0	0
7/07	143	1	0	240	0	0
7/08	132	0	0	255	2	0
7/09	114	0	0	229	3	0
7/10	135	0	0	254	5	2
7/11	109	0	0	245	1	0
7/12	120	0	0	159	1	0
7/13	116	0	0	151	2	0
7/14	119	1	0	173	3	0
7/15	20	0	0	64	1	0
7/16	0	0	0	27	1	0
7/17	0	0	0	0	0	0
7/18	0	0	0	0	0	0
7/19	1	0	0	14	0	0
7/20	3	0	0	53	0	0
7/21	8	0	0	54	0	0
7/22	5	0	0	20	0	0
7/23	4	0	0	25	0	0
7/24	27	1	224	55	0	0
7/25	8	1	0	30	1	1
7/26	2	0	0	44	0	0
7/27	ND	ND	ND	15	0	0
Total	1,573	5	224	4,349	22	3

Note: ND indicates that data was not collected.

[a] First day of tower counts.

Table 6.–Age and sex composition of summer chum salmon at the Anvik River sonar, 2015.

Sample dates (Strata)	Samples (*n*)	Sex	Brood year (age) 2012 (0.2) Estimate	%	2011 (0.3) Estimate	%	2010 (0.4) Estimate	%	2009 (0.5) Estimate	%	Total Estimate	%
7/2/2005	98	Male	0	0	8,435	7.1	50,608	42.9	1,205	1	60,248	51
(6/17-7/05)		Female	0	0	15,664	13.3	40,969	34.7	1,205	1	57,838	49
		Subtotal	0	0	24,099	20.4	91,577	77.6	2,410	2	118,086	100
7/7/2008	106	Male	0	0	14,783	16	30,436	33	870	0.9	46,089	50
(7/06-08)		Female	1,739	1.9	16,522	17.9	25,219	27.4	2,609	2.8	46,089	50
		Subtotal	1,739	1.9	31,306	34	55,655	60.4	3,478	3.8	92,178	100
7/10-12	185	Male	1,075	1.1	17,737	17.8	26,874	27	537	0.5	46,223	46.5
(7/09-13)		Female	537	0.5	21,499	21.6	31,174	31.4	0	0	53,211	53.5
		Subtotal	1,612	1.6	39,236	39.5	58,048	58.4	537	0.5	99,434	100
7/15-19, 22	249	Male	1,036	1.6	10,620	16.5	8,030	12.4	0	0	19,686	30.5
(7/14-27)		Female	2,331	3.6	24,348	37.8	17,872	27.7	259	0.4	44,810	69.5
		Subtotal	3,367	5.2	34,968	54.2	25,902	40.2	259	0.4	64,496	100
Weighted total	638	Male	2,111	0.6	51,575	13.8	115,948	31	2,612	0.7	172,246	46
		Female	4,608	1.2	78,034	20.9	115,233	30.8	4,073	1.1	201,948	54
		Total	6,719	1.8	129,609	34.6	231,182	61.8	6,685	1.8	374,194	100
	95% CI (± %)		0.9		4		4.1		1.3		0.1	

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

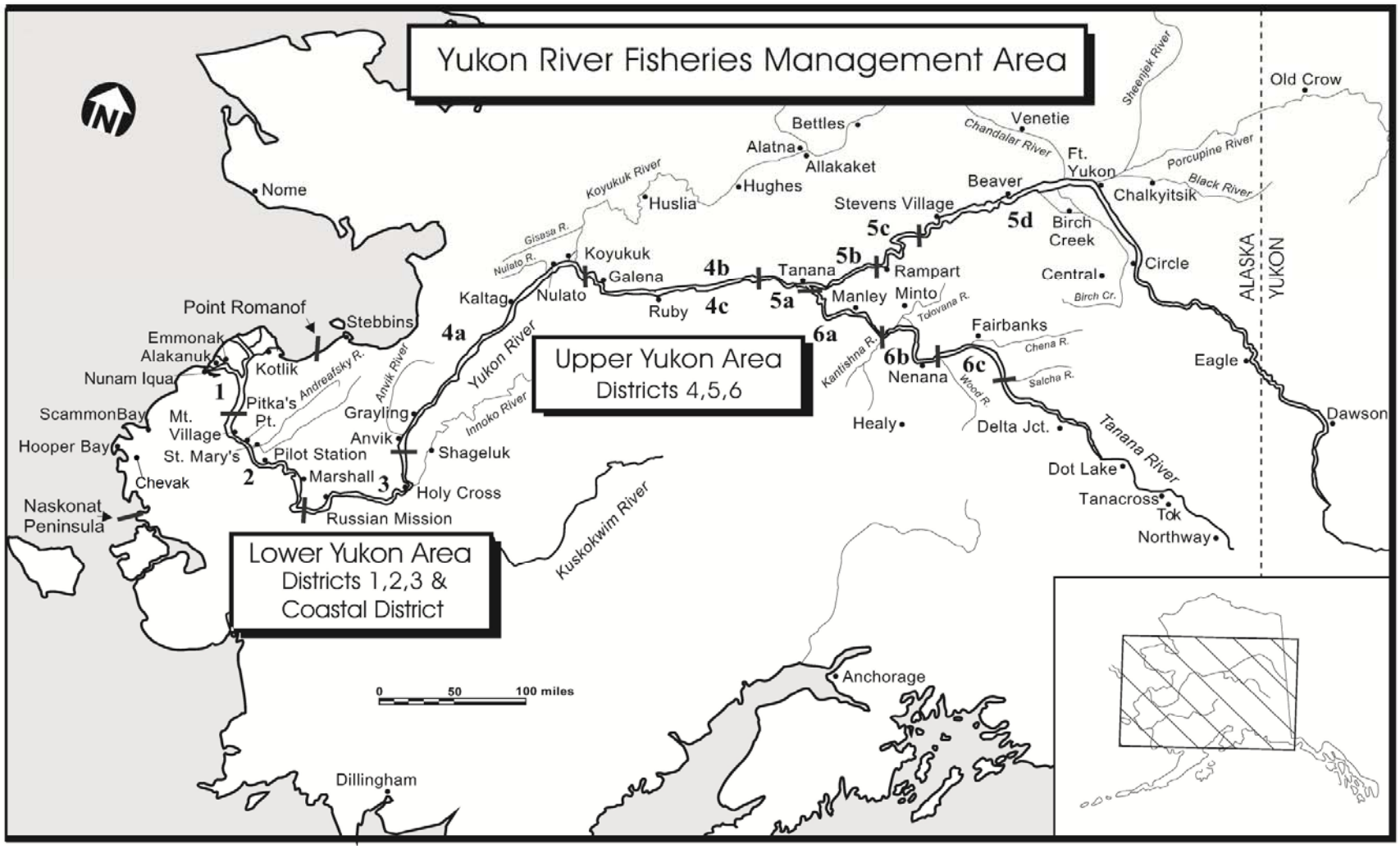

Figure 1.–Alaska portion of the Yukon River drainage with communities and fishing districts.

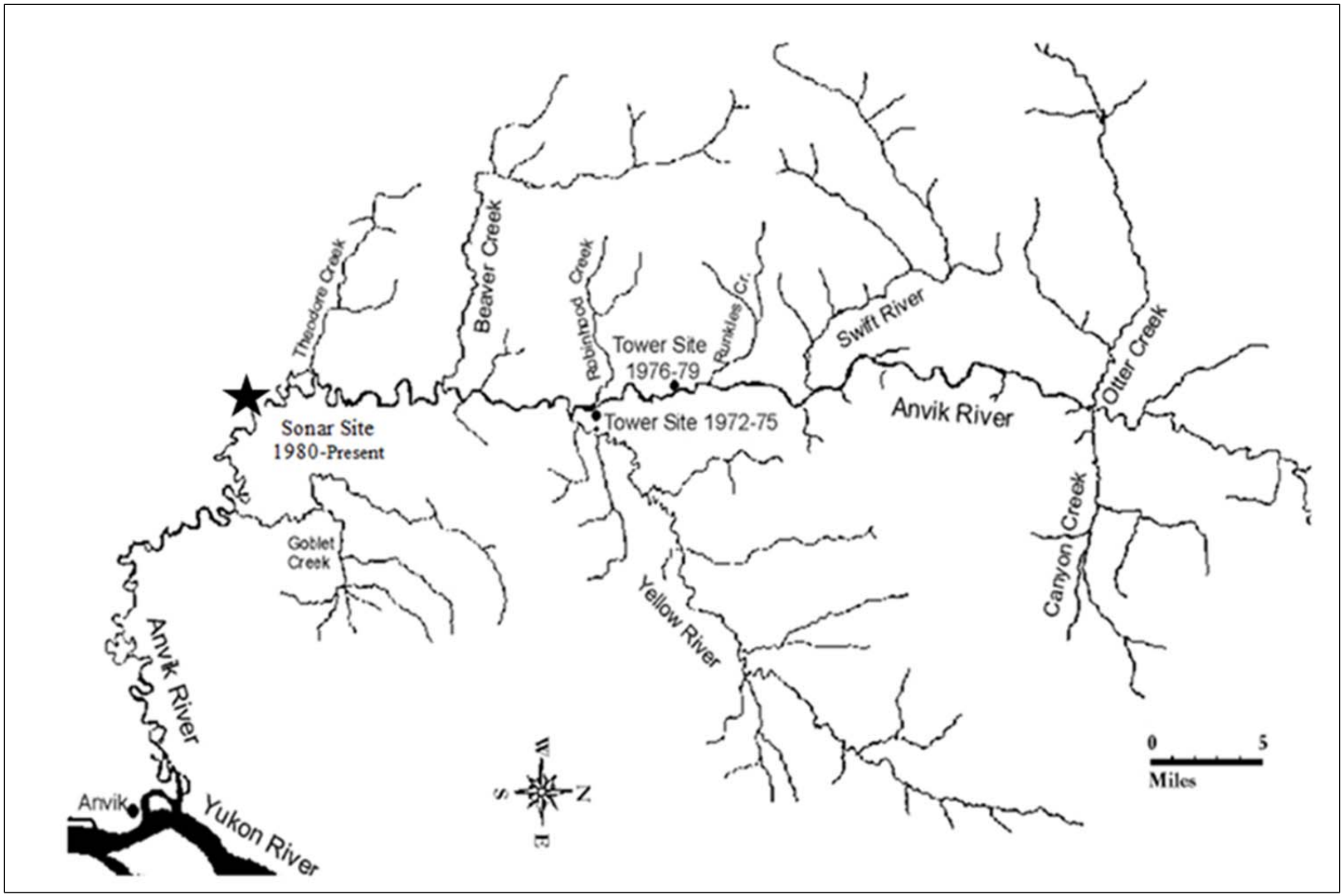

Figure 2.–Anvik River drainage with historical chum salmon escapement project locations.

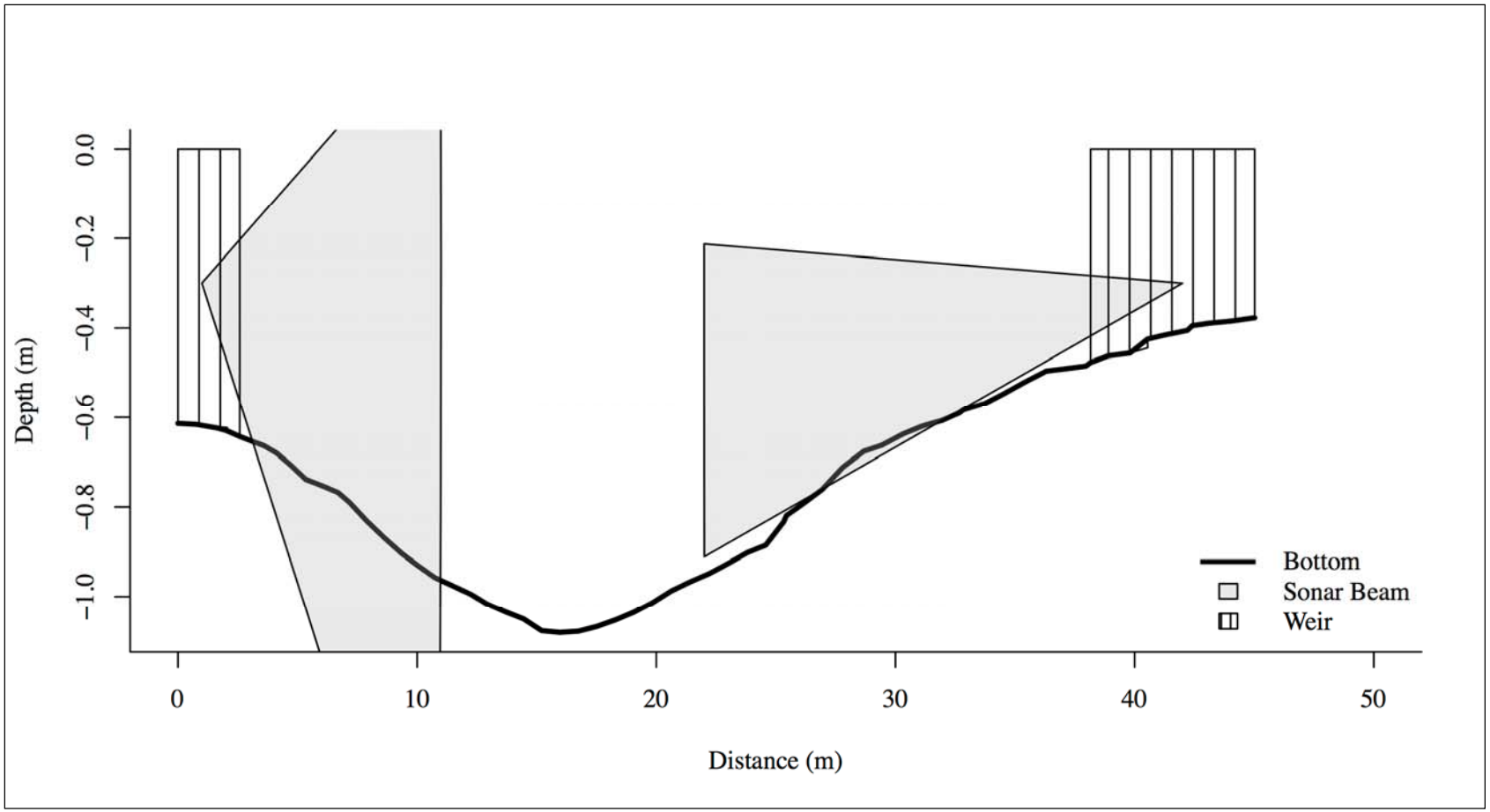

Figure 3.–Depth profile of the Anvik River (downstream view), and approximate sonar ranges at the Anvik River sonar project, 2015.

Note: To avoid damage to the outboard motor and transducer, bathymetric data collection began offshore at a depth of approximately 0.5 m.

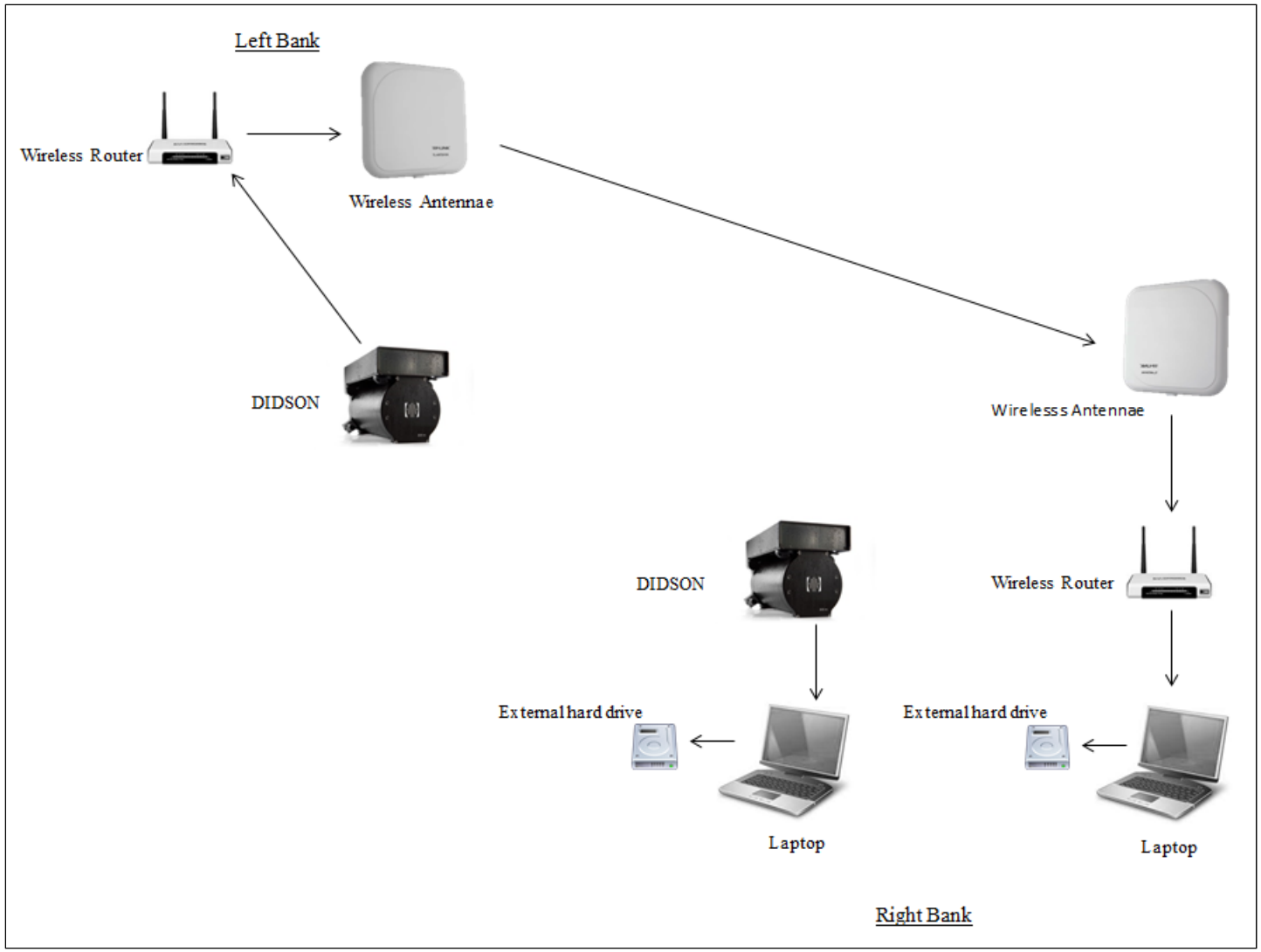

Figure 4.–DIDSON sonar equipment schematic, Anvik River sonar, 2015.

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 Sheenjek sonar project.

Note: This mount is comparable to the one used at the Anvik sonar project, on the Anvik River.

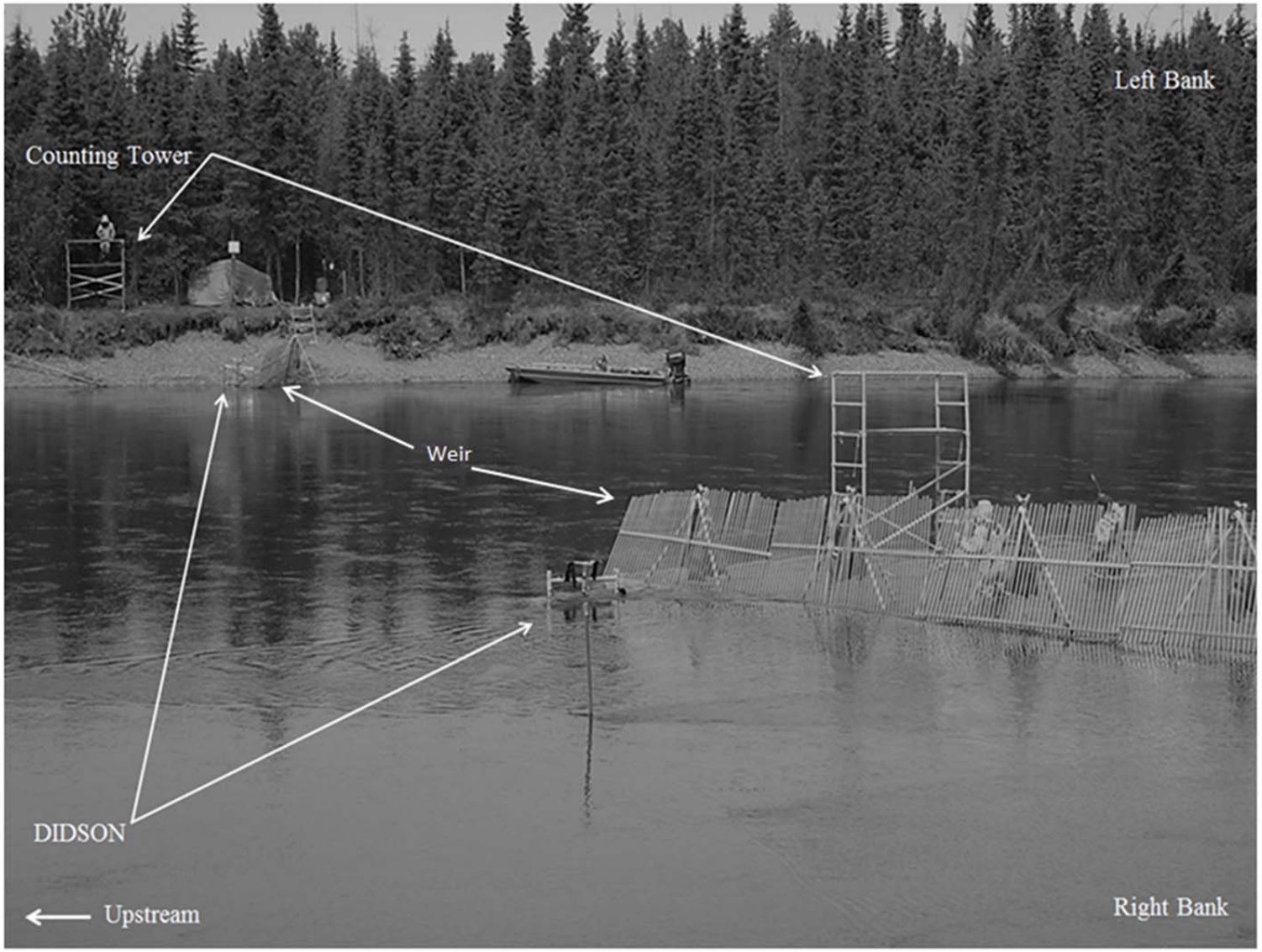

Figure 6.–Anvik River sonar site, illustrating locations of sonar, weirs, and counting towers on the Anvik River, 2015.

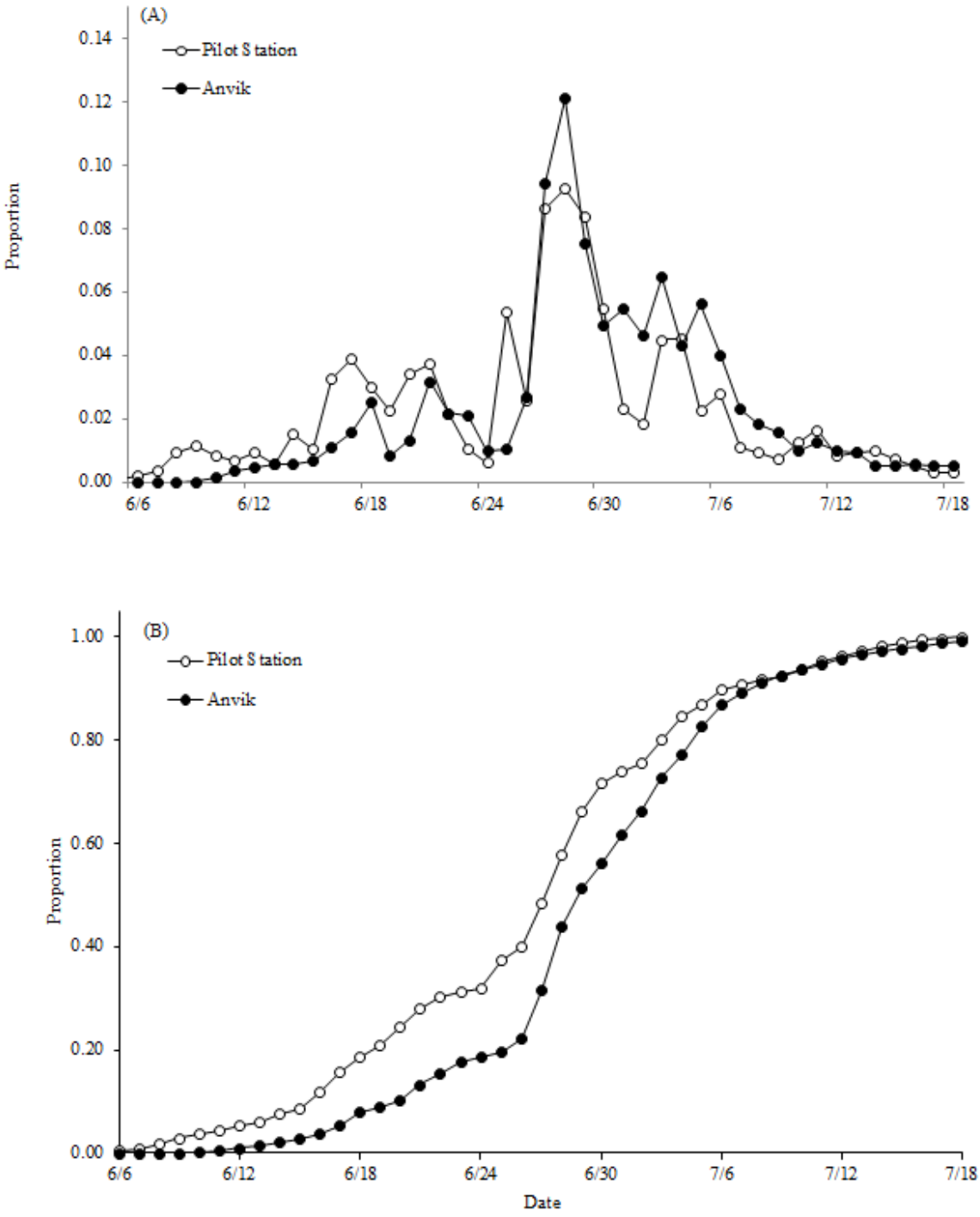

Figure 7.–(A) Daily proportion of summer chum salmon passage at the Anvik River sonar project compared to the proportion of summer chum salmon at the sonar project near the village of Pilot Station, and (B) cumulative proportions of summer chum salmon passage at both projects, 2015.

Note: The timing of Anvik summer chum salmon is lagged back 8 days to align with Pilot Station.

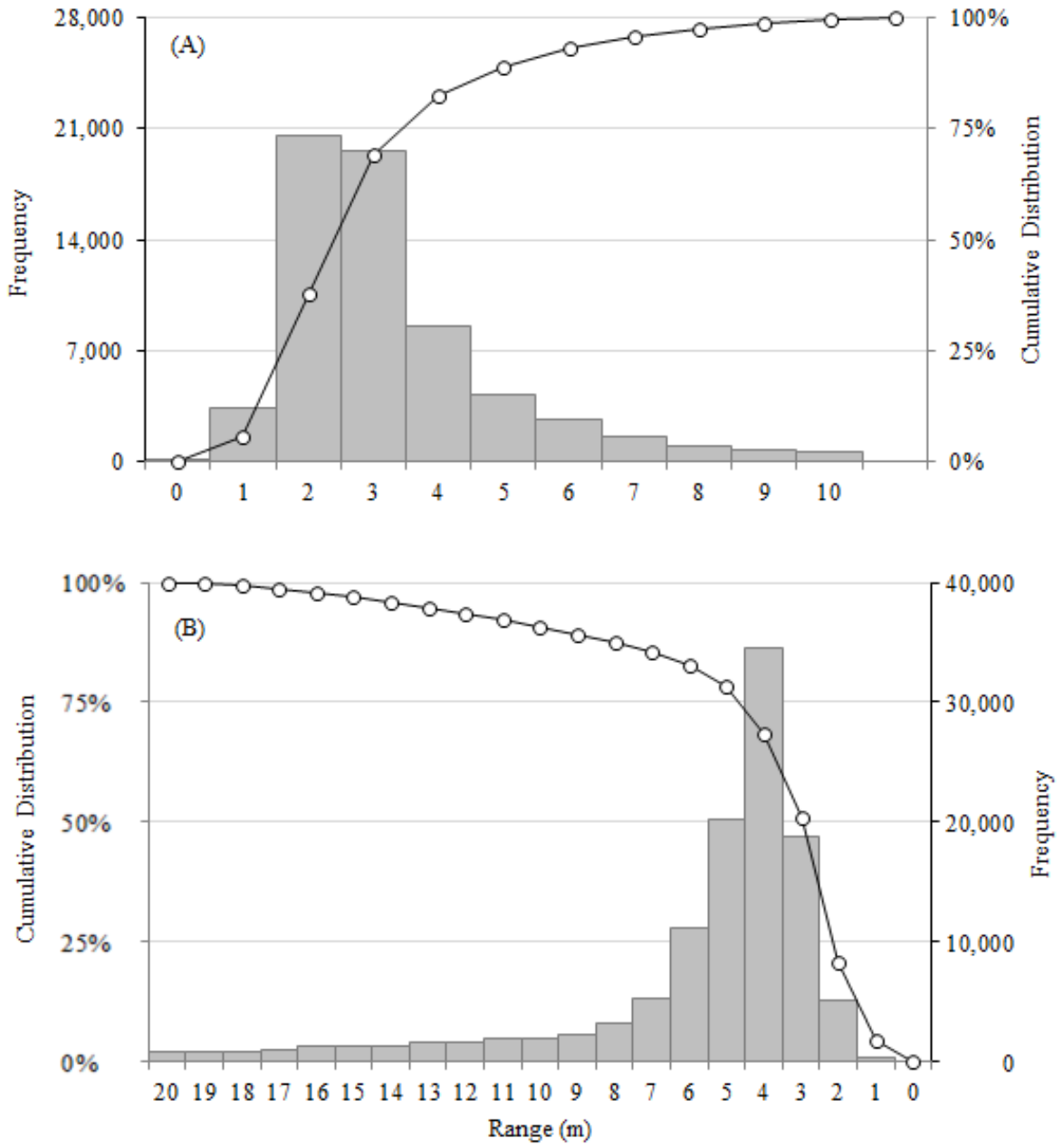

Figure 8.–Left bank (A) and right bank (B) horizontal distribution of upstream salmon passage at the Anvik River sonar project, June 17 through July 27, 2015.

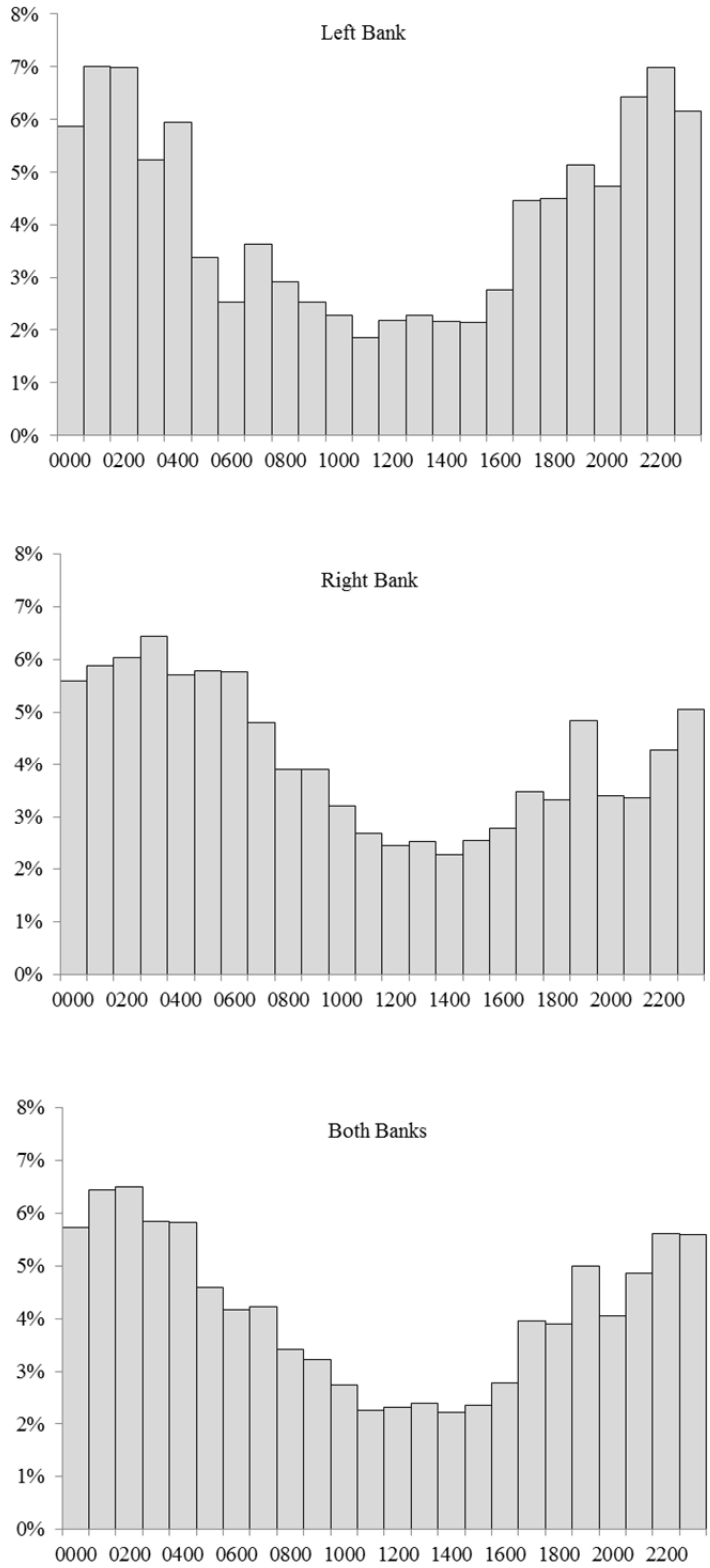

Figure 9.–Percentage of total summer chum passage, by hour, observed on the left bank (top), right bank (middle), and both banks combined (bottom) at the Anvik sonar project site, 2015.

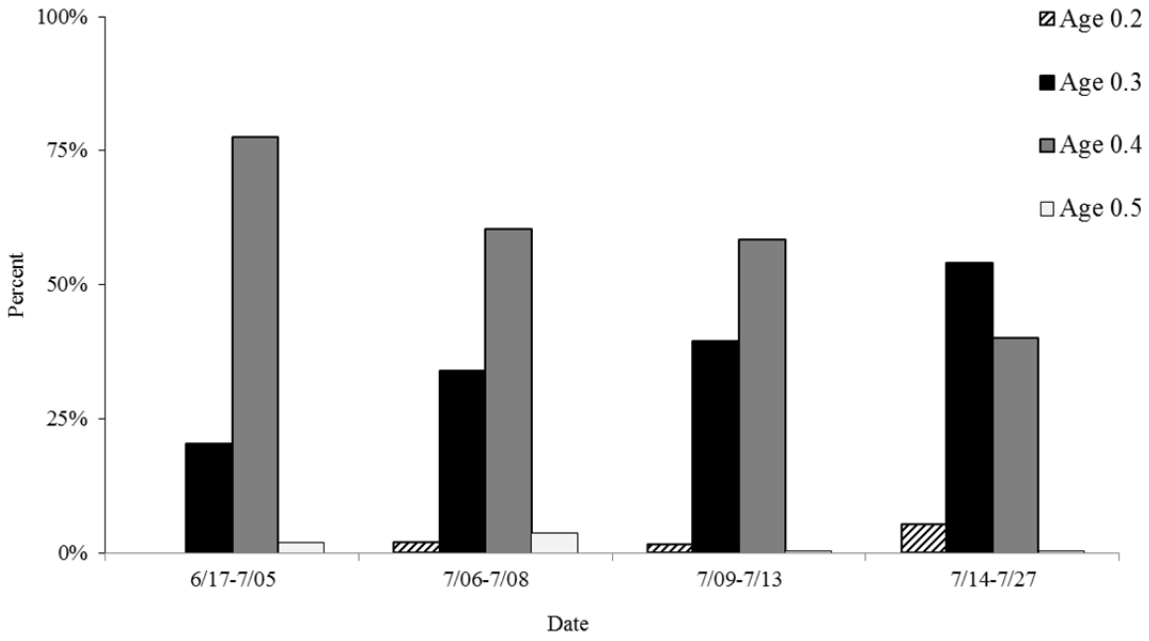

Figure 10.–Summer chum salmon age composition by sampling strata at the Anvik River sonar project, 2015.

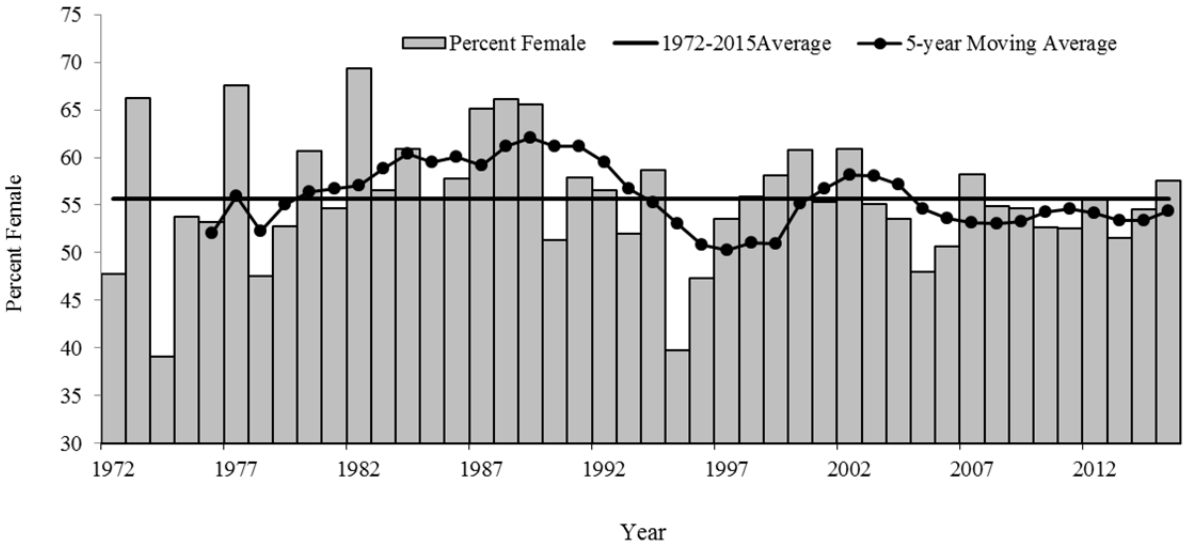

Figure 11.–Percent of female summer chum salmon escapement estimated at the Anvik River sonar project, 1972–2015.

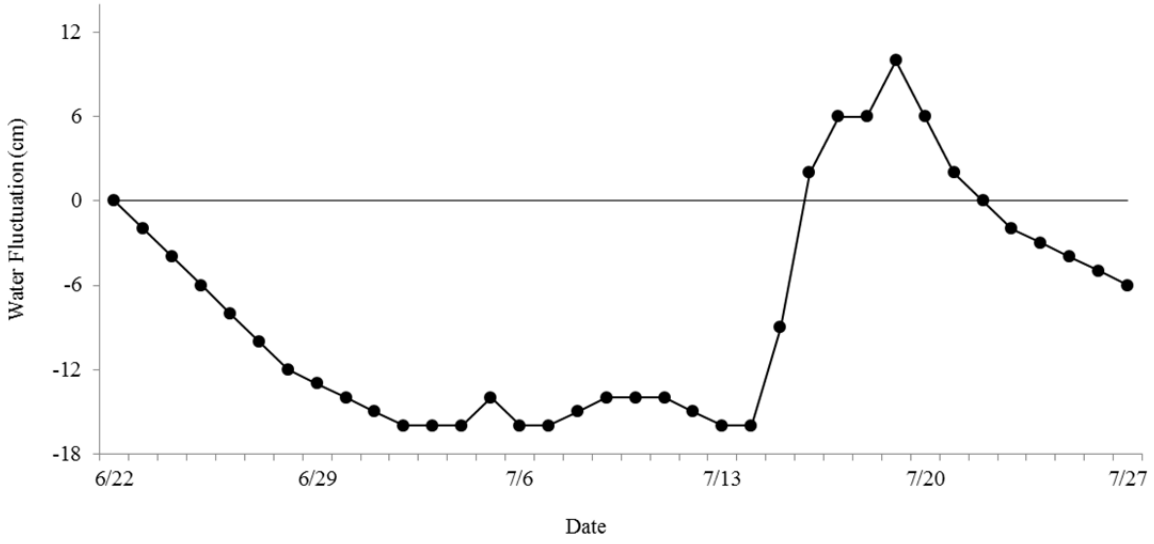

Figure 12.–Change in daily water elevation, relative to June 22, measured at the Anvik River sonar project, 2015.

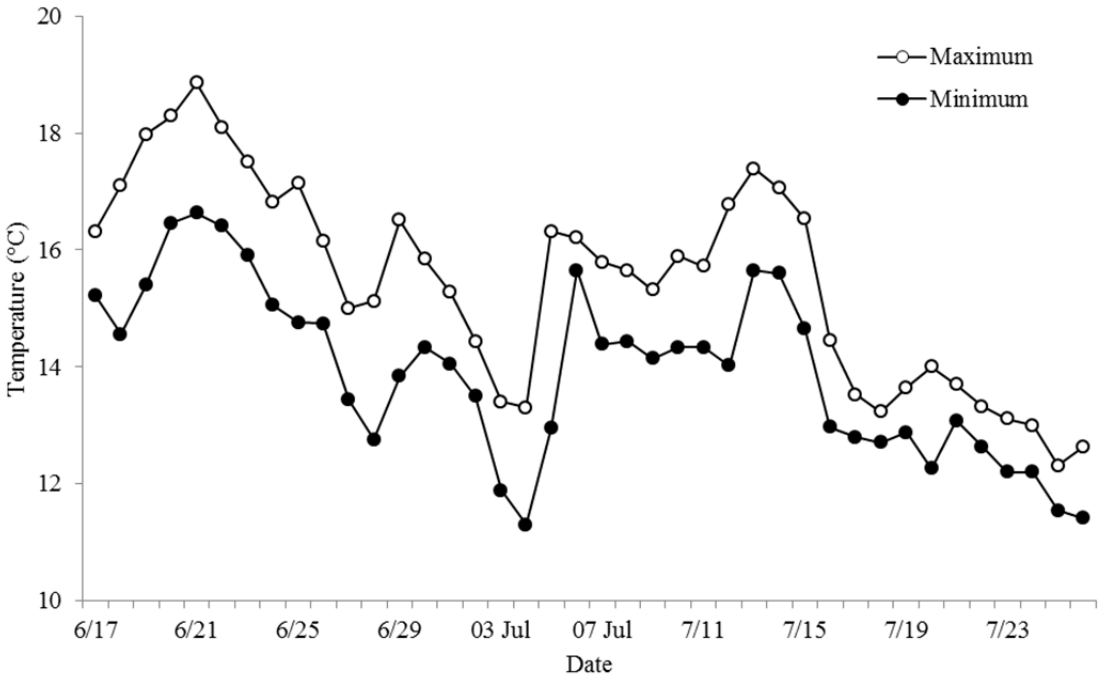

Figure 13.–Daily right bank water temperatures at the Anvik River sonar project, 2015.

APPENDIX A: CLIMATIC OBSERVATIONS

Appendix A1.–Climatic observations recorded daily at 1600 hours, at the Anvik sonar project site, 2015.

Date	Precipitation (code)[a]	Wind		Sky code[c]	Air temperature (°C)
		Direction[b]	Speed (kph)		
6/17	A	V	5–10	C	26
6/18	A	V	5–10	C	26
6/19	A	V	0–05	C	25
6/20	B	V	0–05	C	26
6/21	A	W	5–10	C	26
6/22	A	V	0–05	C	26
6/23	A	V	0–05	F	27
6/24	A	V	5–10	F	24
6/25	A	SW	15–20	C	25
6/26	A	SSW	8–12	C	20
6/27	B	V	6–10	O	16
6/28	A	V	10–14	C	21
6/29	A	V	9–15	S	20
6/30	B	V	5–10	B	19
7/01	B	V	5–10	B	19
7/02	A	SSW	5–10	O	18
7/03	B	W	5–10	O	21
7/04	A	E	15–20	O	19
7/05	B	E	10–20	S	22
7/06	B	E	5–10	B	19
7/07	A	E	0–10	B	21
7/08	B	V	0–10	B	19
7/09	B	E	5–10	O	19
7/10	B	V	0–05	B	22
7/11	A	E	10–15	B	20
7/12	A	E	5–10	S	24
7/13	B	V	5–10	ND	24
7/14	B	E	10–15	O	16
7/15	C	V	0–05	O	13
7/16	B	SE	10–20	O	14
7/17	C	SE	5–10	O	14
7/18	B	E	10–15	O	14
7/19	B	SE	0–05	O	15
7/20	C	S	0–10	ND	25
7/21	A	S	0–05	ND	21
7/22	B	S	5–10	ND	19
7/23	B	SE	0–10	ND	20
7/24	ND	SE	5–10	ND	24
7/25	A	E	5–10	ND	23
7/26	A	SE	5–10	ND	25
7/27	A	E	5–10	ND	25

[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.