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Sonar Estimation of Fall Chum Salmon in the Sheenjek River, Alaska, 2023

by

Ann Crane

and

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July 2025

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

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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 (DIDSON) and adaptive resolution imaging (ARIS) sonars were used to estimate adult fall chum salmon *Oncorhynchus keta* passage in the Sheenjek River from August 6 to September 25, 2023. A total of 13,371 (SE 163) fall chum salmon were estimated to have passed the sonar site. The fall chum salmon passage estimate was subsequently expanded to a total of 15,958 to include fish that may have passed after operations ceased. Both sonar systems functioned well with minimal interruptions to operation. The range of ensonification was considered adequate for most fish that migrated upstream. A beach seine sample fishery was conducted to collect age, sex, and length information; however, because of low salmon passage, no fish were caught.

Keywords: fall chum salmon, *Oncorhynchus keta*, dual-frequency identification sonar DIDSON, adaptive resolution imaging sonar ARIS, Sheenjek River, Yukon River

INTRODUCTION

Five species of anadromous Pacific salmon *Oncorhynchus* spp. are found in the Yukon River drainage. Chum salmon *O. keta* are the most abundant and occur in genetically distinct summer and fall runs (Seeb et al. 1995; Wilmot et al. 1992). Fall chum salmon are larger, spawn later, and are less abundant than summer chum salmon. Spawning occurs in upper portions of the drainage in spring-fed streams, which usually remain ice-free during the winter (Buklis and Barton 1984). Major fall chum salmon spawning areas occur within the Tanana, T'eedriinjik (formerly designated as the Chandalar), and Porcupine River systems, as well as portions of the upper Yukon River in Canada (Figure 1). The Sheenjek River is one of the most important producers of fall chum salmon in the Yukon River drainage (Dunbar 2012). Located above the Arctic Circle, it heads in glacial ice fields of the Romanzof Mountains, a northern extension of the Brooks Range, and flows southward approximately 400 km to the Porcupine River (Figure 2).

Historically, the Sheenjek River has been one of the most intensely monitored fall chum salmon spawning streams in the Yukon River drainage. Escapement observations date back to 1960 when the United States Fish and Wildlife Service (USFWS) reported fall chum salmon spawning in September. Between 1974 and 1981, escapement observations in the Sheenjek River were limited to aerial surveys flown in late September and early October (Barton 1984). Beginning in 1981, escapements were monitored using Bendix fixed-location, single-beam, side-looking sonar systems (Dunbar 2004). However, an early segment of the fall chum salmon run was not estimated prior to 1991 because the project typically began around August 25, after a portion of the run had passed. Beginning in 1991, the project start date was adjusted to begin about 2 weeks earlier to include the initial portion of the run. The sonar-estimated escapements for 1986 through 1990 have been expanded to include estimated early fish passage (Barton 1995). Termination of sonar counting was consistent between 1981 and 2012, averaging September 24, except in 2000 when the project was terminated early because of extremely low water (Barton 2002).

The Bendix single-beam sonar equipment functioned well, but the manufacturer ceased production and support in the mid-1990s. In 2000 and 2002, a Hydroacoustic Technology, Incorporated (HTI) model 241 split-beam echosounder was deployed alongside the existing single-beam sonar and produced comparable results (Dunbar 2004). In 2003 and 2004, the Bendix was replaced with the split-beam sonar system exclusively to enumerate chum salmon in the Sheenjek River.

In 2002, ADF&G began testing dual-frequency identification sonar (DIDSON), manufactured by Sound Metrics Corporation, for counting salmon in small rivers. This system appeared to be more accurate and easier to use, including the ability to operate across substrate profiles that were unacceptable for single-beam or split-beam systems (Maxwell and Gove 2004). The uneven substrate on the left bank of the Sheenjek River was selected as an ideal candidate for experimenting with this system.

Historically, because of unfavorable conditions for transducer and weir placement on the left bank, only the right bank of the Sheenjek River had been used to estimate fall chum salmon passage, except for 1985 through 1987 when single-beam sonar was tested on the left bank. Drift gillnet studies in the early 1980s suggested that the distribution of migrating fall chum salmon was primarily concentrated on the right bank, with a small but unknown proportion passing on the left bank (Barton 1985).

In 2003, a DIDSON was deployed on the previously unmonitored left bank. Using DIDSON data, it was estimated that approximately 33% of the fish were migrating up the left bank (Dunbar 2006). Given this surprisingly large number, it was proposed that DIDSON be deployed on both banks in the future. In 2004 and 2005, DIDSON and HTI split-beam sonars were deployed side-by-side on the right bank and found that DIDSON estimates were 20% higher than the split-beam estimates (Dunbar and Pfisterer 2009). The project used DIDSON from 2005 until the project was discontinued after the 2012 field season because of budgetary constraints. The project was restarted in 2022 and utilizes a combination of DIDSON on the right bank and ARIS (adaptive resolution imaging sonar on the unstable left bank (Table 1), which provides more flexibility and improved image resolution and control over range[1].

From 1992 through 2000, the Sheenjek River biological escapement goal (BEG) was set at 64,000 fall chum salmon. This goal was based upon aerial survey and hydroacoustic data collected between 1974 and 1990 (Buklis 1993). In 2001, ADF&G completed a review of the escapement goals for Yukon River fall chum salmon stocks, including the Sheenjek River. Based on this review of long-term escapement, catch, and age composition data, the BEG for the Sheenjek River was set at a range of 50,000 to 104,000 fall chum salmon on the right bank (Eggers 2001). The goal was removed in 2015 because the Sheenjek sonar assessment project had been terminated for 3 years with no plans for restarting operations (Conitz et al. 2015). In 2022, ADF&G received increased funding for Yukon salmon research, and given its long historical dataset, the Sheenjek River sonar project was one of the prioritized projects. Given the 10-year gap in the dataset, it will probably be several years before an escapement goal can be reestablished because the productivity of the system may have changed over this time.

OBJECTIVES

The goal of this project in 2023 was to provide daily inseason estimates of adult fall chum salmon escapement into the Sheenjek River. Primary objectives were as follows:

1. Estimate daily fall chum salmon passage in the Sheenjek River using DIDSON and ARIS sonar; and
2. Collect biological samples necessary to characterize age and sex composition of the spawning fall chum salmon population from a minimum of 30-35 vertebrae samples per week up to 180 for the season, such that simultaneous 95% confidence intervals of age composition are no wider than 0.20 (α = 0.05 and d = 0.10).

[1] ADF&G (Alaska Department of Fish and Game). 2024. Alaska Fisheries sonar, sonar tools. Sonar Tools: DIDSON, Alaska Fisheries Sonar, Alaska Department of Fish and Game (accessed January 16, 2024).

Secondary objectives were as follows:

1. Collect selected climate and hydrologic data daily at the project site.

METHODS

STUDY AREA

The site is located approximately 10 km upstream from the mouth of the Sheenjek River at the historical project location (Figure 2). Although created by glaciers, the Sheenjek River has numerous clearwater tributaries. Water clarity in the lower river is somewhat unpredictable but generally clearest during periods of low water. Historically, the water level begins to drop in late August or early September. Upwelling groundwater makes up a significant portion of the river flow volume, especially in winter. It is in these spring areas that fall chum salmon spawn, particularly within the lower 160 km.

SONAR EQUIPMENT AND OPERATION

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 an ARIS Explorer 1200 operating at a frequency of 1.2 MHz (high frequency option using 48 beams) was deployed on the left bank (Table 2). The right bank had a gradual slope of approximately 2°. For this reason, a concentrator lens with a vertical beam width of approximately 2° was used to reduce surface and bottom reverberation. The DIDSON was controlled with a laptop computer running DIDSON software on the right bank. A wireless access point connected to a directional antenna transferred data from the left-bank ARIS to the controlling laptop running ARIS software on the right bank. External hard drives connected to each laptop were used to store data (Figure 3).

Transducers were mounted on adjustable aluminum pods and aimed using manual crank-style rotators with threaded vertical rods, which tilted the transducers vertically up or down (Figure 4). Each transducer was placed offshore in a fixed location, and the beams were directed perpendicular to current flow at a depth of approximately 1 m. Because the slope of the river bottom differed substantially between banks, the DIDSON was located approximately 10 m from shore on the right bank, and the ARIS was approximately 2 m from shore on the left bank, depending on water level (Figure 5). Operators adjusted the pan and tilt by viewing the video-like acoustic image and relaying aiming instructions to a technician via handheld 2-way radios. The wide axis of each beam was oriented horizontally and positioned close to the river bottom to maximize the residence time of targets in the beam. The right-bank ensonified range was 20 m, starting at 0.83 m from the DIDSON and ending at 20.83 m. The left-bank ensonified range was 9.34 m, starting at 0.69 m from the ARIS and ending at 10 m (Table 2; Figure 5). The left bank end range was reduced from an initial 20 m down to 10 m because of the irregular substrate on that bank, which was responsible for beam obstructions and poor image quality beyond 10 m. The width of the river at this location varies between 50 and 90 m, depending on the river stage. Therefore, there is no overlap in the counting ranges between the 2 banks. Daily visual inspections of the sonar pods and images confirmed proper placement and orientation of the transducers, and alerted operators as to when the pods needed to be repositioned to accommodate changing water levels.

A weir was constructed shoreward from the transducer on the right bank to prevent upstream salmon passage inshore of the transducer. The weir was constructed of 1.2 m high orange safety fencing attached to 2.5 m metal "T" posts. The weir was positioned to guide fish beyond the near field of the sonar transducer and extended from shore outward 1 to 3 m beyond the DIDSON (Figure 6). Whenever the transducer was relocated because of rising or falling water levels, the beam was re-aimed to ensure proper ensonification, and the weir was repositioned as appropriate. The installation of a weir on the left bank was not feasible due to deep water and floating debris close to shore.

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. During assigned shifts, operators marked each upstream fish track using Echotastic, an echogram viewer program developed by ADF&G staff on recorded files (C. T. Pfisterer, Commercial Fisheries Biologist, ADF&G, Fairbanks, November 2024; personal communication).[2] All upstream fish tracks were counted except for small fish (<400 mm), which were assumed to be nonsalmon species. Fish lengths were measured using Echotastic marking tools but were not recorded. At the beginning of the season, when fish passage was low, most fish were measured, which trained technicians to estimate length visually. As technicians became more proficient with estimating length, fish were measured at the technicians' discretion. The 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 as follows:

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

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

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) was 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). Because the passage estimates are assumed independent between strata and among days, the total variance was estimated as the sum of the daily variances:

[2] Echotastic software. 2023. Version 3.0.14. Developed by Carl Pfisterer, ADF&G Division of Commercial Fisheries. (internal use only).

$$\hat{V}ar(\hat{y}) = \sum_d \sum_s \hat{V}ar\,(\hat{y}_{ds}). \tag{3}$$

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. Normally, if 1 or multiple days are missed, the relationship of daily passage between banks will be assessed by linear regression using the observed passage from the previous days for each bank. If the regression is significant ($p < 0.05$), the linear regression equation of the line will then be used to calculate the missing passage for each missing day (*d*):

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

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

If the regression of daily passage by bank is not significant or where both banks are inoperable, daily passage is interpolated by averaging passage estimates from days before and after the missing day(s) as follows:

$$\hat{y}_{ds} = (1/n \sum_{i=1}^{n} x_{is}) \begin{Bmatrix} d = 1, n = 4 \\ d = 2, n = 6 \\ d = 3, n = 8 \end{Bmatrix}, \tag{5}$$

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 day (*i*).

Because project operations ceased prior to the end of the fall chum salmon migration, the estimate for each bank was expanded separately through October 9 using a second-order polynomial equation:

$$\hat{y}_{is} = \frac{L_s}{d^2}(x_i - d)^2, \tag{6}$$

where y_i is the daily passage estimate for each bank on the *i*th day of expansion, *L* is the count on the last day of sonar operation, *d* is the total number of days expanding for (October 9 – September 27 = 13 days), and x_i is the day number being estimated. Daily passage estimates for each bank were then summed for a total daily passage estimate (Table 3). The final date of October 9 for postseason expansion is based on what is considered the most probable run timing scenario derived from historical data (1996–2006) using a 15-day lag time correlated to the end of the run at Rampart Rapids test fishery project (B. M. Borba, Commercial Fisheries Biologist, ADF&G, Fairbanks, November 2024; personal communication).

SPATIAL AND TEMPORAL DISTRIBUTIONS

Spatial distribution of fall chum salmon were examined inseason by binning marked fish by distance from the transducer. Two plots were produced for each bank for each day. The first plot displayed the range frequency distribution of fish marks for the most recent day, and the second plot displayed the range distribution of fish marks for the entire season. Comparing the daily to the season's distributions can be useful in identifying issues with transducer aim or changes in fish behavior.

Diel patterns of migration were examined postseason by binning fish counts by the hour in which samples occurred. Histograms were generated using the binned hourly data to look for temporal patterns of fish passage. Both spatial and temporal distributions were produced using the software package R[3].

AGE, SEX, AND LENGTH SAMPLING

Regionwide standards have been set for the sample size needed to describe the age composition of a salmon population. These standards apply to the period or stratum in which the sample is collected. These goals are based on a 0.10 probability (precision) of not having the true age proportion (p_i) within the interval $p_i \pm 0.05$ for all i ages (accuracy).

Vertebrae collections are the preferred method of aging Yukon River fall chum salmon in close proximity to their natal streams (Clark 1987). As described in Bromaghin (1993), a sample size of 150 chum salmon is needed, assuming 2 major age classes with minor ages pooled, and no unreadable vertebrae. Allowing for 20% unreadable vertebrae, the Sheenjek River sample size goal was $n = 30$ chum salmon per week, up to a maximum of $n = 180$ for the season.

A beach seine was periodically fished at the sonar site to collect adult salmon for age and sex composition. The beach seine (6.35 cm stretch measure) was 30 m in length by 55 meshes deep (~3 m) and appropriate for collecting a representative sample. Any fall chum salmon that were collected with the beach seine were enumerated by sex using external and internal characteristics, and measured to the nearest 1 mm, from mid eye to tail fork. Additionally, 3 vertebrae were taken from each fish and given to ADF&G research staff in Fairbanks for age determination.

CLIMATIC 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 cm. Air temperature, wind velocity, and direction were measured daily with a Kestrel 2000 handheld weather meter. Water temperature was measured using a HOBO U22 data logger, which electronically recorded the temperature every hour, on the hour, for the duration of the project. Subjective notes about cloud cover, precipitation, and water clarity were also recorded.

RESULTS AND DISCUSSION

FALL CHUM SALMON ESTIMATION

The DIDSON was deployed on August 6, and the right bank was ensonified at 2000 hours. The ARIS was deployed on August 7, and the left bank was ensonified at 1400 after several attempts to find a stable location for pod placement on the steep bank. The sonar equipment functioned well this season with no major interruptions. Normal sonar operations occurred on both banks through September 25. The sonar-estimated passage was 13,371 fall chum salmon.

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[3] The R Project for statistical computing. R version 4.2.1 (Funny-Looking Kid). [released June 23, 2022]. Available for download from http://www.r-project.org/

Daily sonar passage estimates were expanded inseason for sampling time missed due to generator and sonar maintenance, short sonar file times, and days when the sonar only operated for a partial day (i.e., project startup and breakdown). On the left bank, 2,274 minutes were missed, and on the right bank, 1,944 min were missed for a combination of these reasons, which resulted in a total of 608 fish being added to the daily sonar estimates (Table 4). In addition, the sonar-estimated passage was extrapolated postseason to account for fish that passed after termination of the project. Postseason expansions estimated 2,587 fish passed after sonar operations ceased. The total combined inseason and postseason expanded estimates were 3,195 fall chum salmon.

The total fall chum salmon passage estimate was 15,958 (SE 163) from August 6 through October 9 (Table 3). Expanded estimates accounted for 20% of the total passage estimate. The first quarter point occurred on September 10, the midpoint on September 15, and the third quarter point on September 23 (Table 3). The peak daily passage of 932 fall chum salmon occurred on September 11, and 619 fall chum salmon passed on September 25, the last day of sonar operation. The objective of estimating fall chum salmon passage in the Sheenjek River was met.

SPATIAL AND TEMPORAL DISTRIBUTION

Fish passage was spread throughout the counting range this season. Approximately 95% of fish targets were detected within 9 m of the transducer on the left bank and 20 m on the right bank (Figure 7). Approximately 74% of fall chum salmon passage occurred on the right bank (Table 3).

The left bank did not exhibit a temporal pattern of fish passage. The times with the greatest passage rates on the left bank were 0900, 1800, and 1900 hours. The right bank displayed a more evident diurnal pattern with an increase from approximately 2100 hours to 0500 hours. When both banks were combined, passage was highest at 0200 and lowest at 0800 (Figure 8).

FALL CHUM AGE AND SEX COMPOSITION

Beach seining was conducted intermittently from August 8 to September 19 but was unsuccessful due to low fall chum salmon passage. No fish were caught, and the objective of collecting a minimum of 30 samples per week was not met. Because the sample size was inadequate, ASL analysis could not be completed.

CLIMATIC AND HYDROLOGIC OBSERVATIONS

The objective of monitoring weather and water parameters daily at the project site was met in 2023. Water levels fluctuated over the course of the season (Figure 9). Water levels initially decreased for the first 2 weeks of project operation, then rapidly increased during the last week of August. Water levels fluctuated somewhat in September and stayed above the initial level recorded at the project's start date, but levels were decreasing when the project concluded. Water temperatures at the project ranged from a high of 17.3°C on August 8 to a low of 4.3°C on September 25 (Figure 10). Air temperatures ranged from a high of 30.7°C on August 7 to a low of 4.5°C on September 24 (Table 5).

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TABLES AND FIGURES

Table 1.–Annual passage estimates and passage timing for fall chum salmon runs at the Sheenjek River sonar project, 2003–2012 and 2022–2023.

Year	Start date	End date	Project duration	Sonar estimate	Expanded estimate
2003	8/09	9/26	49	38,321[a]	44,047[b]
2004	8/08	9/25	49	37,878	ND
2005	8/10	9/24	46	438,253[a]	561,863[b]
2006	8/09	9/24	47	160,178	ND
2007	8/11	9/24	45	65,435	ND
2008	8/09	9/24	47	42,842	50,353[b]
2009	8/15	9/24	41	46,926	54,126[b]
2010	8/18	9/24	38	22,053	ND
2011	8/08	9/24	48	81,980	97,976[b]
2012	8/09	9/24	47	86,192	104,702[b]
2022	8/08	9/26	50	12,356	13,957[b]
2023	8/06	9/25	51	13,371	15,958[b]
Mean	8/10	9/24	47	87,149	117,873

Note: The project did not operate from 2013 to 2021. ND means no data.

[a] Sonar estimate is based on right bank sonar operations only.

[b] Sonar-estimated escapement was expanded to include fish passing after sonar operations ended.

Table 2.–Technical specifications for dual-frequency identification sonar (DIDSON) and adaptive resolution imaging sonar (ARIS) at the Sheenjek River sonar project, 2023.

Setting	DIDSON	ARIS
Mode	High frequency	High frequency
Frequency (MHz)	1.20	1.20
Number of beams	48	48
Horizontal field of view (angular degrees)	29	28
Vertical beam width (angular degrees)	2	14
Samples/beam	512	1155
Start range (m)	0.83	0.69
End range (m)	20.83	10
Frame rate (per sec)	6	6
Duration (min)	30	30

Table 3.–Fall chum salmon daily and cumulative passage estimates at the Sheenjek River sonar project, 2023.

Date	Left bank	Right bank	Daily total	Cumulative Estimate	Cumulative Proportion
8/06	ND	48	48	48	0.003
8/07	0	34	34	82	0.005
8/08	2	28	30	112	0.007
8/09	2	13	15	127	0.008
8/10	6	12	18	145	0.009
8/11	2	4	6	151	0.009
8/12	0	8	8	159	0.010
8/13	4	10	14	173	0.011
8/14	6	16	22	195	0.012
8/15	4	12	16	211	0.013
8/16	4	18	22	233	0.015
8/17	16	32	48	281	0.018
8/18	6	28	34	315	0.020
8/19	8	24	32	347	0.022
8/20	10	22	32	379	0.024
8/21	6	30	36	415	0.026
8/22	8	20	28	443	0.028
8/23	26	44	70	513	0.032
8/24	30	104	134	647	0.041
8/25	28	106	134	781	0.049
8/26	19	73	92	873	0.055
8/27	56	52	108	981	0.061
8/28	20	94	114	1,095	0.069
8/29	12	84	96	1,191	0.075
8/30	13	76	89	1,280	0.080
8/31	11	61	72	1,352	0.085
9/01	22	94	116	1,468	0.092
9/02	12	98	110	1,578	0.099
9/03	18	146	164	1,742	0.109
9/04	20	194	214	1,956	0.123
9/05	22	124	146	2,102	0.132
9/06	65	196	261	2,363	0.148
9/07	106	356	462	2,825	0.177
9/08	142	308	450	3,275	0.205
9/09	112	380	492	3,767	0.236
9/10[a]	179	624	803	4,570	0.286
9/11	268	664	932	5,502	0.345
9/12	55	588	643	6,145	0.385
9/13	20	546	566	6,711	0.421

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Date	Left bank	Right bank	Daily total	Cumulative Estimate	Cumulative Proportion
9/14	21	627	648	7,359	0.461
9/15[b]	104	538	642	8,001	0.501
9/16	234	466	700	8,701	0.545
9/17	238	486	724	9,425	0.591
9/18	172	302	474	9,899	0.620
9/19	178	294	472	10,371	0.650
9/20	130	300	430	10,801	0.677
9/21	146	302	448	11,249	0.705
9/22	140	270	410	11,659	0.731
9/23[c]	160	368	528	12,187	0.764
9/24	193	372	565	12,752	0.799
9/25[d]	219	400	619	13,371	0.838
9/26[e]	189	345	534	13,905	0.871
9/27[e]	161	294	455	14,360	0.900
9/28[e]	135	247	382	14,742	0.924
9/29[e]	112	204	316	15,057	0.944
9/30[e]	91	165	256	15,313	0.960
10/1[e]	72	131	202	15,515	0.972
10/2[e]	55	100	155	15,670	0.982
10/3[e]	40	73	114	15,784	0.989
10/4[e]	28	51	79	15,863	0.994
10/5[e]	18	33	51	15,913	0.997
10/6[e]	10	18	28	15,942	0.999
10/7[e]	4	8	13	15,954	1.000
10/8[e]	1	2	3	15,958	1.000
10/9[e]	0	0	0	15,958	1.000
Total	4,190	11,767	15,958	NA	NA
SE	NA	NA	163	NA	NA

Note: The large box indicates the central 50% of the fall chum salmon run. ND indicates no data were recorded. NA means not applicable.

[a] First quarter point.

[b] Midpoint.

[c] Third quarter point.

[d] Last day of operation.

[e] Postseason extrapolated estimate.

Table 4.–Sampling time missed, and the resulting number of fish added to the estimate at the Sheenjek River sonar project, 2023.

	Left bank		Right bank	
Date	Minutes	Fish	Minutes	Fish
8/06	ND	ND	600.1	40
8/07	450.4	0	0.5	0
8/08	1.4	0	150.4	6
8/09	31.2	0	270.3	5
8/10	1.2	0	0.5	0
8/11	15.5	0	0.5	0
8/12	0.6	0	0.5	0
8/13	0.5	0	0.5	0
8/14	1.5	0	0.5	0
8/15	1.3	0	0.5	0
8/16	1.5	0	0.5	0
8/17	1.4	0	0.5	0
8/18	1.4	0	0.5	0
8/19	1.1	0	60.4	2
8/20	1.5	0	270.3	8
8/21	1.2	0	0.5	0
8/22	0.9	0	0.5	0
8/23	1.2	0	0.5	0
8/24	1.1	0	0.5	0
8/25	0.6	0	0.5	0
8/26	30.6	1	30.5	3
8/27	1.2	0	0.5	0
8/28	1.2	0	0.5	0
8/29	1.3	0	0.5	0
8/30	31.3	1	0.5	0
8/31	330.7	5	30.5	3
9/01	60.5	2	0.5	0
9/02	1.4	0	30.5	4
9/03	1.6	0	0.5	0
9/04	1.4	0	0.5	0
9/05	0.9	0	0.5	0
9/06	30.5	3	30.5	8
9/07	0.8	0	0.5	0
9/08	1.4	0	0.5	0
9/09	16.4	3	0.5	0
9/10	90.9	22.6	30.5	26
9/11	31.2	12	0.5	0
9/12	511.5	39.2	1.0	1
9/13	2.2	0	0.5	0
9/14	31.0	0.9	30.5	27
9/15	1.1	0	0.5	0
9/16	0.9	0.3	0.6	0
9/17	1.2	0	0.5	0

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	Left bank		Right bank	
Date	Minutes	Fish	Minutes	Fish
9/18	150.5	36	0.5	0
9/19	0.5	0	0.5	0
9/20	1.2	0	0.5	0
9/21	1.1	0	0.5	0
9/22	1.2	0	0.5	0
9/23	1.4	0	0.5	0
9/24	30.9	8	30.5	16
9/25	390.6	119	360.2	200
Total	2,274.0	254	1,943.9	354

Note: ND means no data. Reasons for missed sampling time included generator and sonar maintenance, short sonar file times, and days when the sonar did not operate for a full day (i.e., project startup and shutdown).

Table 5.–Climatic observations recorded daily at 1800 hours at the Sheenjek River sonar project site, 2023.

Date	Precipitation (code)[a]	Wind Direction[b]	Wind Velocity (kph)	Sky (code)[c]	Air temperature (°C)
8/07	A	N	2.7	C	30.7
8/08	B	NW	1.9	F	26.0
8/09	A	SW	1.0	F	25.8
8/10	A	W	5.0	F	24.0
8/11	A	SE	6.8	F	22.5
8/12	A	SE	9.2	F	21.5
8/13	A	SE	2.1	F	22.7
8/14	B	W	3.7	B	21.6
8/15	A	W	3.1	S	22.8
8/16	B	NE	1.6	S	24.3
8/17	A	NW	6.9	O	15.3
8/18	B	NW	6.0	O	15.5
8/19	B	W	3.9	O	14.7
8/20	C	N	4.3	O	12.1
8/21	B	NW	11.4	B	16.5
8/22	B	NW	5.6	B	17.1
8/23	B	NW	6.0	B	17.2
8/24	A	SW	1.3	S	20.3
8/25	B	W	6.9	O	15.8
8/26	B	SE	4.0	B	18.0
8/27	B	W	3.1	B	16.1
8/28	B	N	1.6	C	17.8
8/29	B	SE	11.6	S	12.6
8/30	B	E	1.3	O	13.4
8/31	B	E	1.9	O	12.3
9/01	B	NW	6.8	O	12.0
9/02	B	NW	4.5	O	11.1
9/03	A	SE	4.0	O	12.7
9/04	B	NW	2.7	O	13.7
9/05	B	SE	2.6	B	13.1
9/06	B	N	2.3	B	12.1
9/07	B	NA	0.0	B	8.6
9/08	A	SE	10.6	S	12.8
9/09	A	SE	6.0	O	12.3
9/10	A	SE	2.3	C	17.3
9/11	B	NW	5.3	O	11.6
9/12	A	N	6.3	C	16.5
9/13	A	N	1.4	C	15.4
9/14	B	NA	0.0	O	12.1
9/15	A	N	4.3	S	14.6
9/16	A	S	4.8	C	14.5
9/17	B	NW	3.2	O	12.0
9/18	A	N	7.6	C	9.6
9/19	A	N	3.2	C	9.9

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Date	Precipitation (code)[a]	Wind Direction[b]	Wind Velocity (kph)	Sky (code)[c]	Air temperature (°C)
9/20	B	NA	0.0	O	7.2
9/21	B	NE	1.3	B	10.3
9/22	A	E	1.4	B	5.2
9/23	E	SE	2.6	B	5.5
9/24	B	NA	0.0	S	4.5

[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; NA = Not applicable (no wind).

[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.

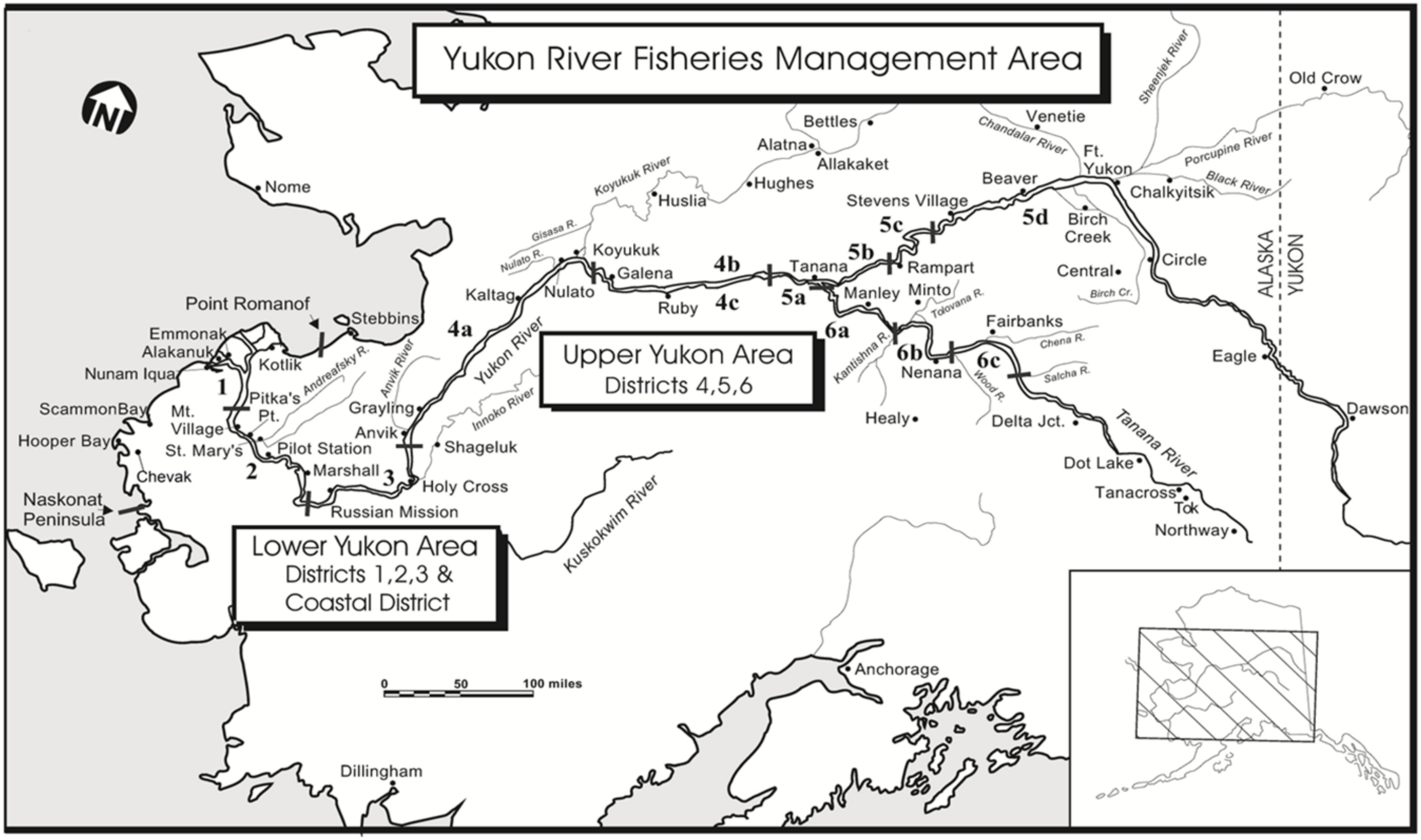

Figure 1.–Alaska portion of the Yukon River drainage showing communities and fishing districts.

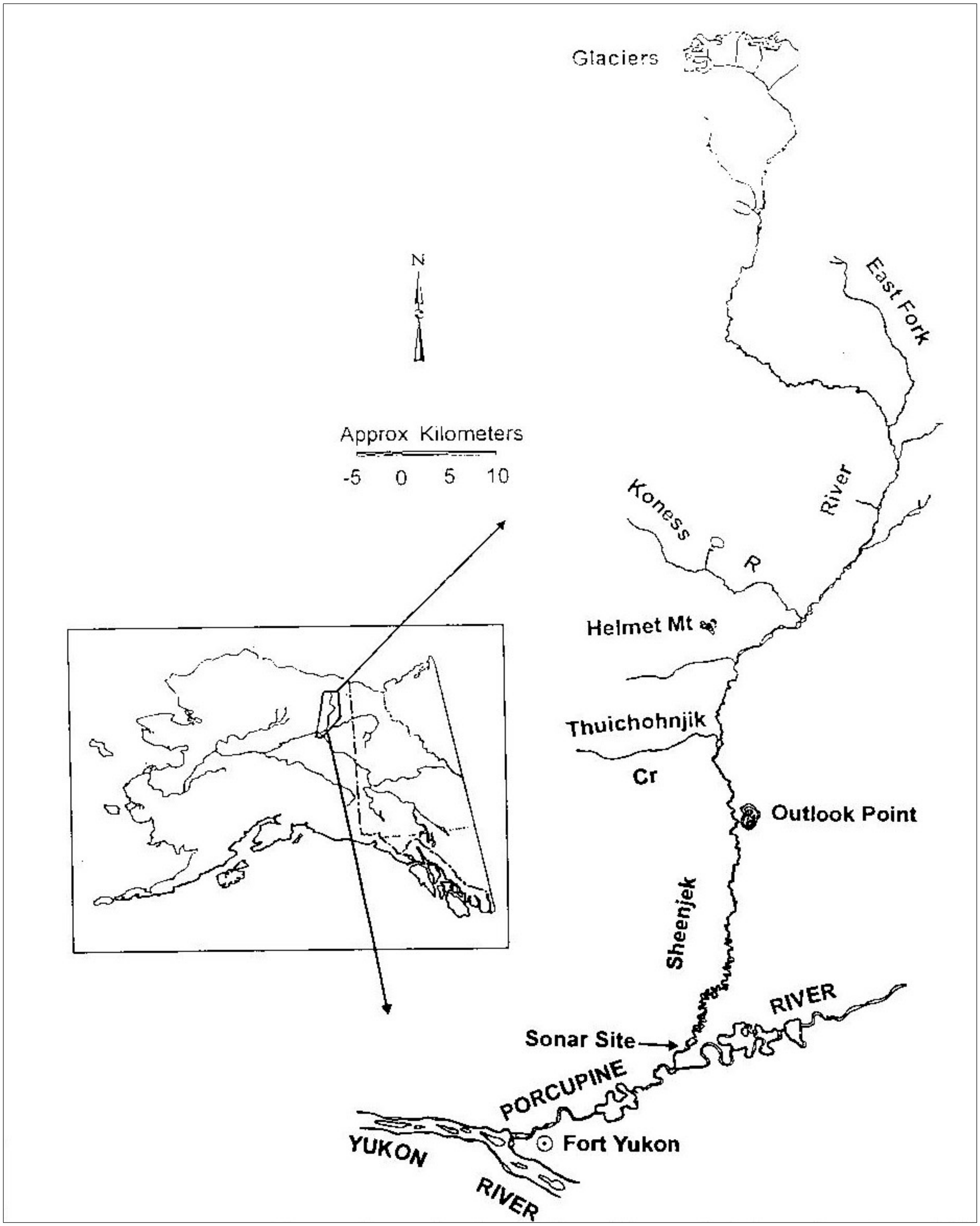

Figure 2.–The Sheenjek River drainage.

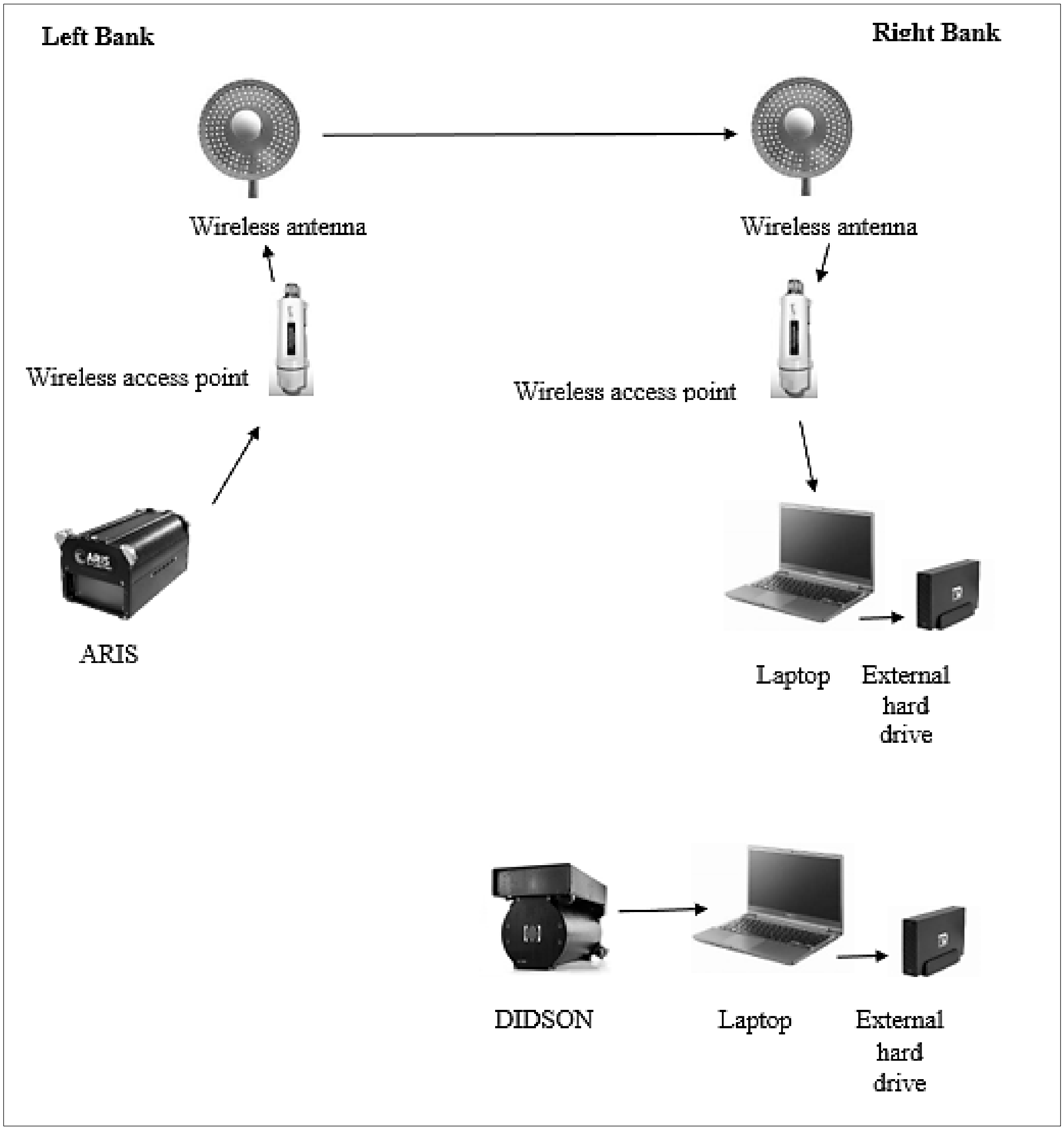

Figure 3.–ARIS (adaptive resolution imaging) and DIDSON (dual-frequency identification) sonar equipment schematic at the Sheenjek River sonar project, 2023.

Note: Both the left-bank and right-bank laptops were housed in the right-bank sonar tent. DIDSON means dual-frequency identification sonar, and ARIS means adaptive resolution imaging.

Figure 4.–View of a DIDSON (dual-frequency identification sonar) mounted to an aluminum pod with a manual crank-style rotator at the Sheenjek River sonar project.

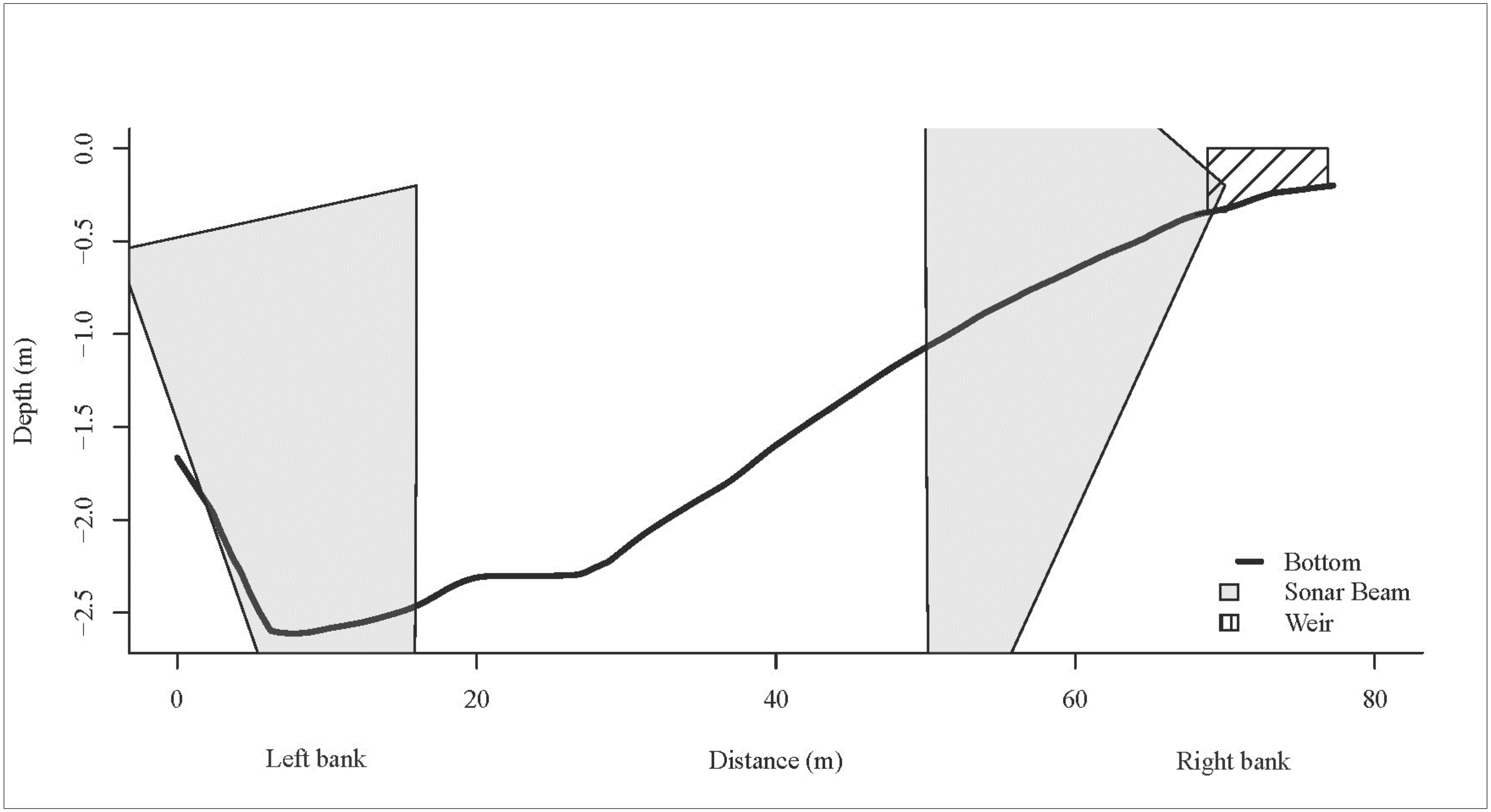

Figure 5.–Depth profile of the Sheenjek River and approximate sonar ranges (not to scale) at the Sheenjek River sonar project, August 6, 2023.

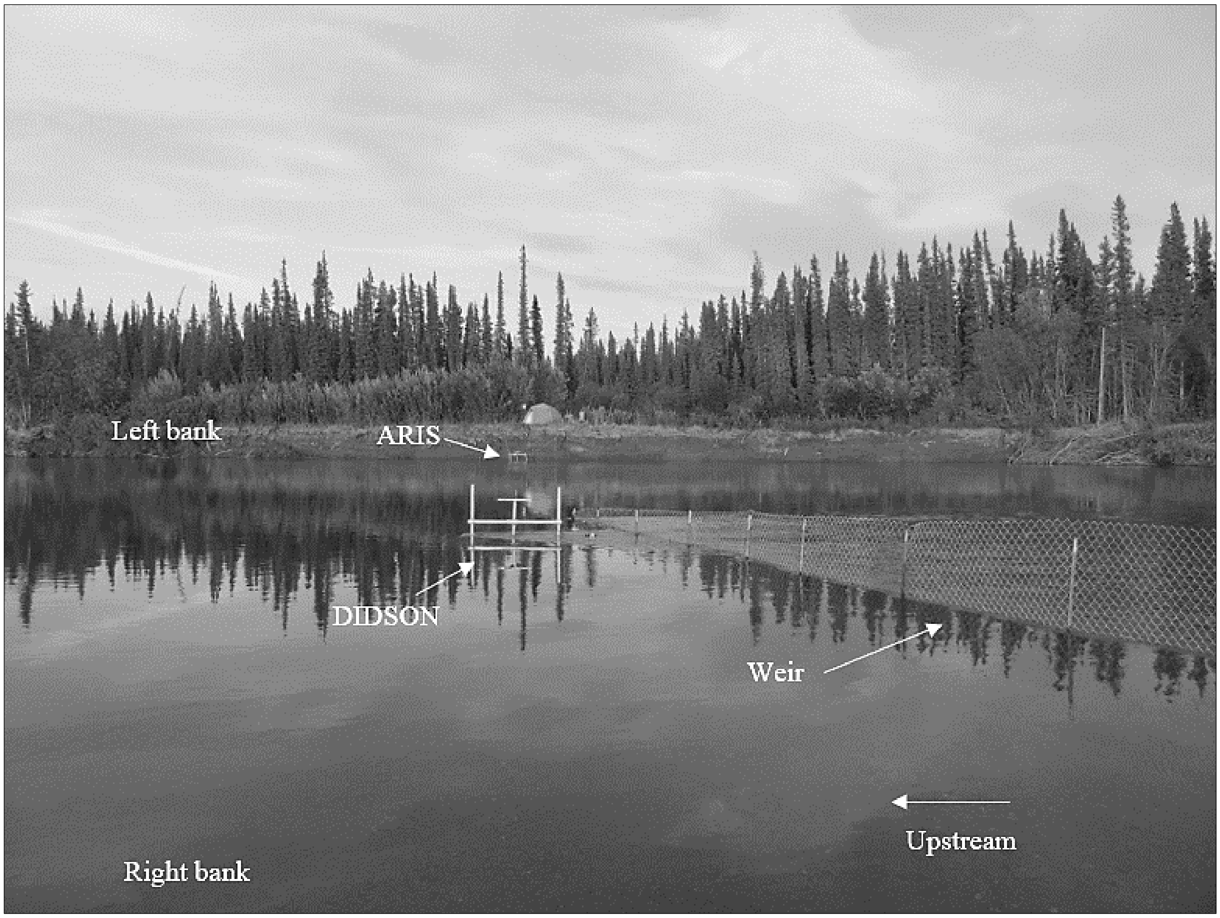

Figure 6.–Sheenjek River sonar project site illustrating locations of ARIS (adaptive resolution imaging) and DIDSON (dual-frequency identification) sonars and weir.

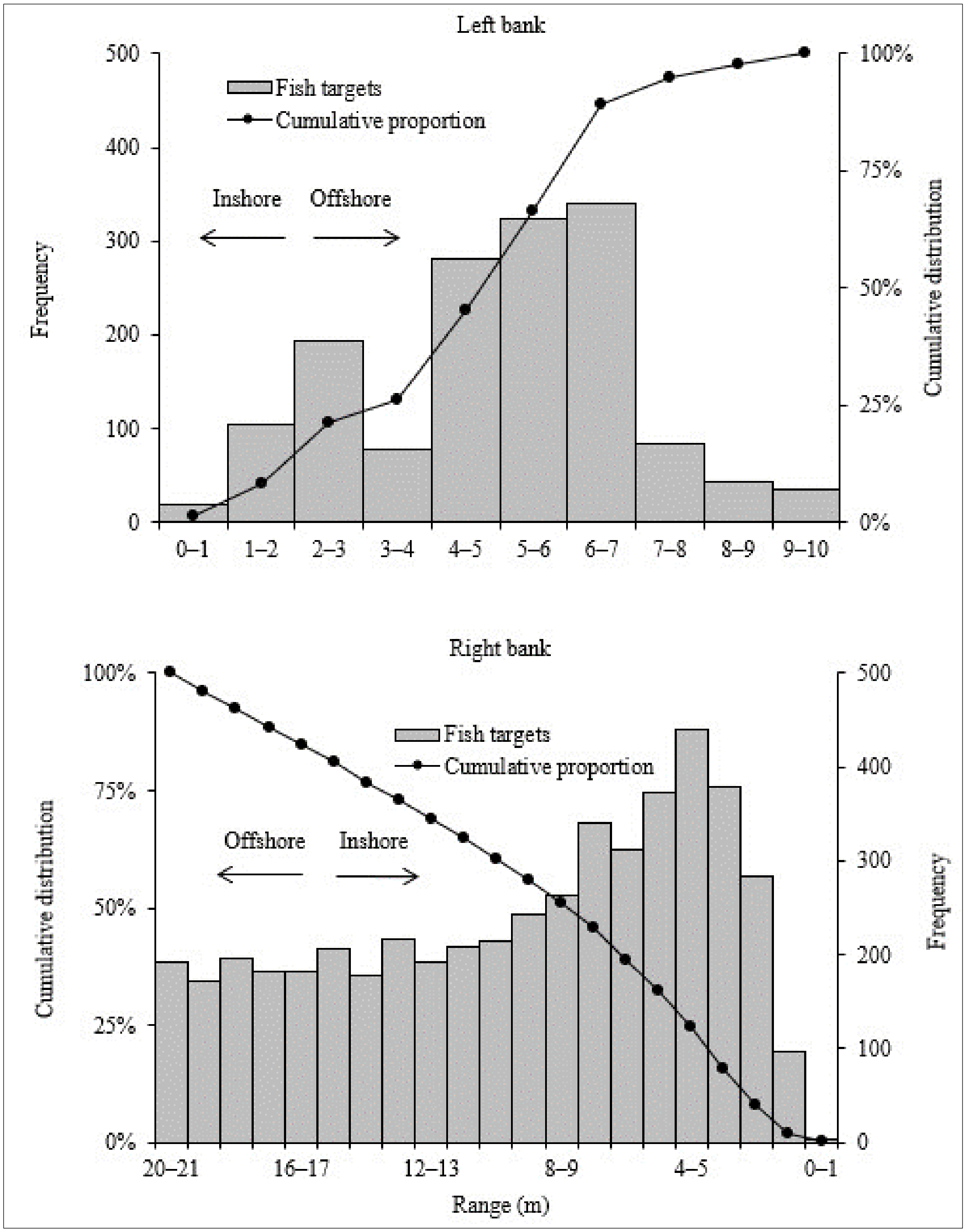

Figure 7.–Left- and right-bank horizontal distribution of unexpanded fish targets at the Sheenjek River sonar project, August 6 through September 25, 2023.

Note: The left-bank ensonified range was 10 m. The right-bank ensonified range was 20 m.

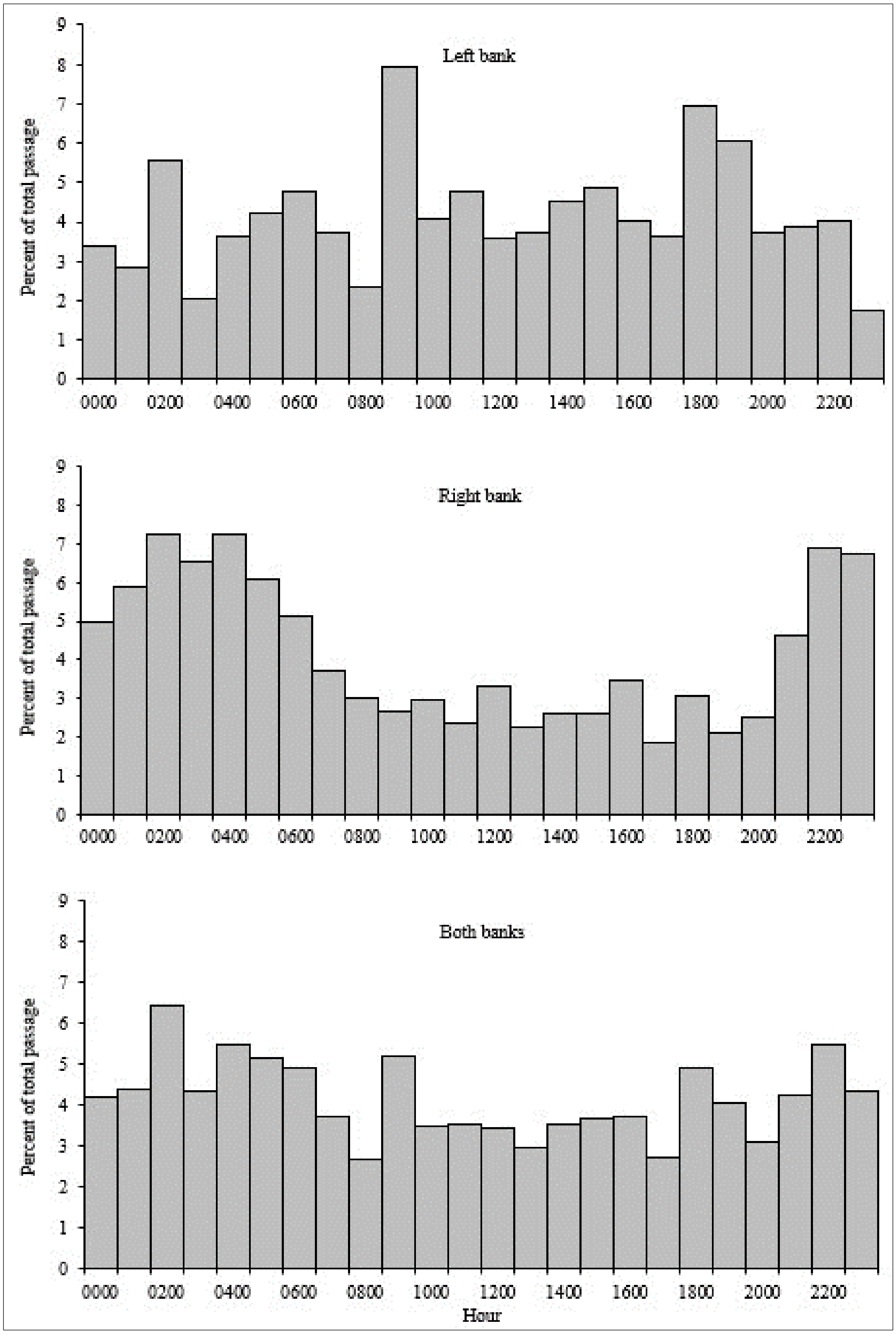

Figure 8.–Percent of total passage, by hour, observed on the left bank, right bank, and both banks combined at the Sheenjek River sonar project, 2023.

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

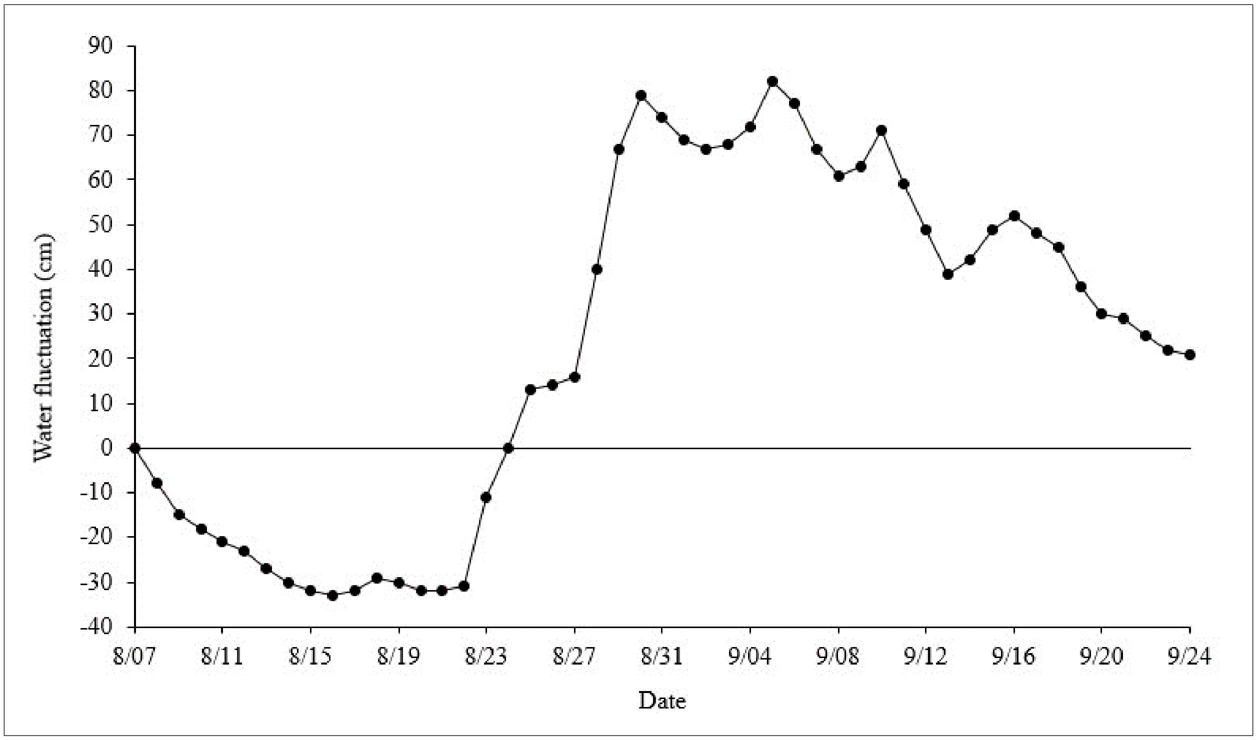

Figure 9.–Change in daily water elevation, relative to August 7, measured at the Sheenjek River sonar project, 2023.

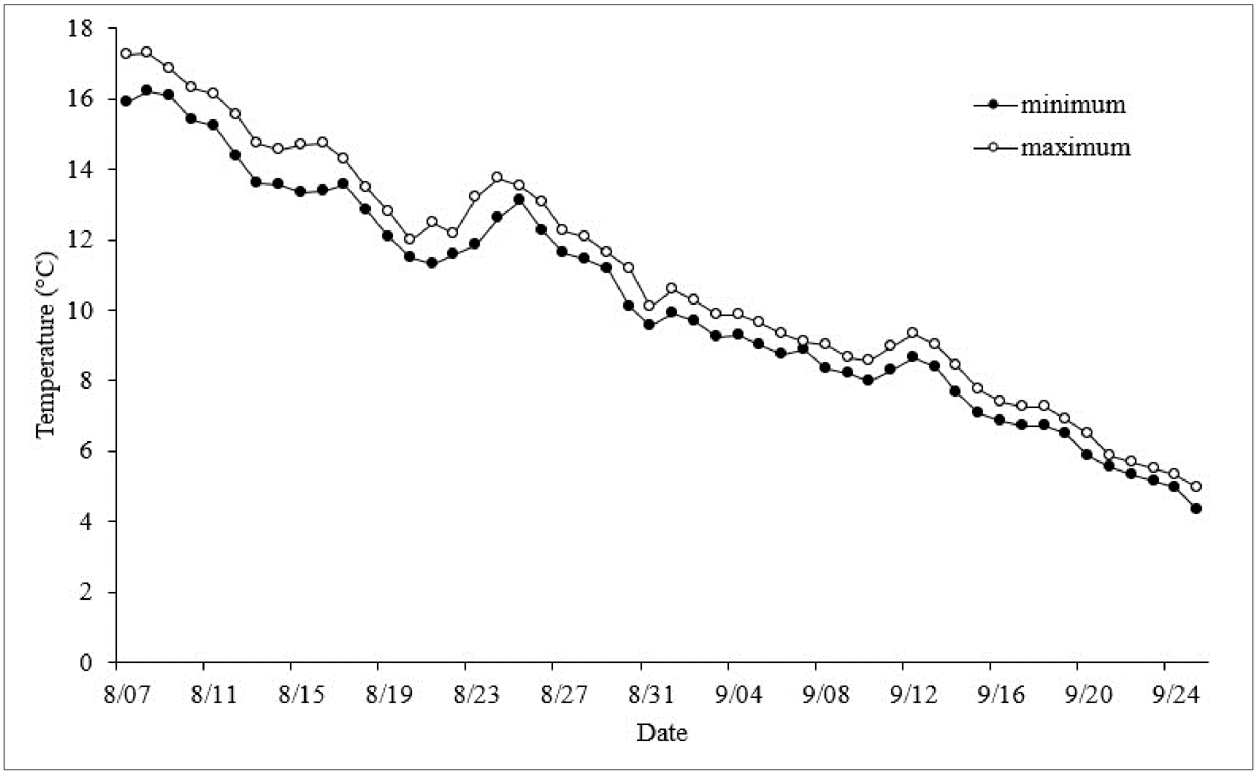

Figure 10.–Daily water temperatures on the left bank at the Sheenjek River sonar project, 2023.

Note: Water temperature was measured using a HOBO data logger, which electronically recorded the temperature every hour, on the hour.