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Sonar Estimation of Salmon Passage in the Yukon River Near Pilot Station, Alaska, 2022

by

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and

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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

FISHERY DATA SERIES NO. 23-39

SONAR ESTIMATION OF SALMON PASSAGE IN THE YUKON RIVER NEAR PILOT STATION, 2022

by
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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

The Pilot Station sonar project has provided daily passage estimates of Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), and coho (*O. kisutch*) salmon for most years since 1986. Fish passage estimates for each species were generated in 2022 using a 2-component process: (1) estimation of total fish passage with 120 kHz split-beam sonar and an adaptive resolution imaging sonar, and (2) apportionment to species by sampling using a suite of gillnets of various mesh sizes. An estimated 1,562,996 fish passed through the sonar sampling area between June 1 and September 7. Of those fish, 249,826 passed along the right bank, and 1,313,170 passed along the left bank. Included, with 90% confidence intervals, were 33,159 ± 6,494 large Chinook salmon (>655 mm from middle of eye to tail fork [METF]), 15,280 ± 3,506 small Chinook salmon (≤655 mm METF), 463,806 ± 24,817 summer chum salmon, 325,717 ± 19,197 fall chum salmon, 92,102 ± 7,500 coho salmon, 4,184 ± 2,412 sockeye salmon, 158,767 ± 21,735 pink salmon, 238,030 ± 32,773 cisco, 170,551 ± 17,565 humpback whitefish, 22,019 ± 5,535 broad whitefish, 28,902 ± 6,003 sheefish, and 10,479 ± 2,211 other species.

Keywords: Chinook salmon *Oncorhynchus tshawytscha*, chum salmon *O. keta,* coho salmon *O. kisutch*, hydroacoustic, split-beam sonar, riverine, sonar, run strength, species apportionment, net selectivity, adaptive resolution imaging sonar ARIS, Yukon River

INTRODUCTION

BACKGROUND

Within Alaska, Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), and coho (*O. kisutch*) salmon are managed inseason for harvest by commercial, subsistence, and sport fisheries within the Alaska portion of the Yukon River drainage (Figure 1), as well as to meet treaty obligations made under the U.S./Canada *Yukon River Salmon Agreement*. The diversity and number of fish stocks and the geographic range of user groups add complexity to management decisions. Escapement estimates and run strength indices are generated by various projects within the drainage, providing stock-specific abundance and timing information; however, much of this information is obtained after the fish have become unavailable to the fisheries. Timely indices of run strength are provided by gillnet test fisheries conducted in the Lower Yukon River, but the functional relationship between catch per unit effort (CPUE) and actual abundance is confounded by varying migration patterns through the multichannel environment, gear selectivity, environmental conditions, and changes in net site characteristics.

The Pilot Station sonar project has provided daily salmon passage estimates, run timing, and biological information to fishery managers for most years since 1986. The project is located at river km 197 in a single-channel environment near the village of Pilot Station. This location is upriver enough to avoid the multiple-channel environment of the Yukon River Delta. The project is able to provide timely abundance information to managers because travel time for salmon from the mouth of the river to the sonar site is 2 to 3 days. The Andreafsky River is the only major salmon spawning tributary downstream of the sonar site and most migrating salmon in the Yukon River pass the sonar project on their way to the spawning grounds (Figure 1).

The primary role of Alaska Department of Fish and Game (ADF&G) is to manage for sustained yield under Article VIII of the Alaska Constitution, but Alaska is also obligated to manage Yukon River salmon stocks according to precautionary, abundance-based harvest-sharing principals set forth in the *Yukon River Salmon Agreement*. The goal of bi-national, coordinated management of Chinook and chum salmon stocks is to meet escapement requirements that will ensure sufficient fish availability for sustained future harvests in both the United States and Canada. Furthermore, managers follow guidelines specified by Alaska regulations through management plans for Yukon River Chinook, summer chum, fall chum, and coho salmon.

Accurate daily salmon abundance estimates help managers regulate fishing during the season to meet harvest and escapement objectives and are also used postseason to determine whether treaty obligations were met and to judge the effects of management actions.

Since its inception, the Pilot Station sonar project has undergone many changes in equipment and methodology. Prior to 1993, ADF&G used dual-beam sonar equipment that operated at 420 kHz. In 1993, ADF&G changed the existing sonar equipment to operate at a frequency of 120 kHz to allow a greater ensonification range by reducing signal loss, which helped to increase fish detection at longer ranges (Fleischman et al. 1995). The newly configured performance of the equipment was verified using standard acoustic targets in the field.

Until 1995, ADF&G attempted to identify the direction of travel of detected targets by aiming transducers at an upstream or downstream oblique angle relative to fish travel. This technique was discontinued in 1995 in favor of aiming transducers perpendicular to fish travel to maximize fish detection (Maxwell et al. 1997). Due to this change and subsequent changes to counting procedures, data collected from 1995 to 2022 are not directly comparable to previous years. In 2001, the equipment was changed from dual-beam to the current split-beam sonar system configured to operate at 120 kHz (Pfisterer et al. 2002). Reference to the use of dual-beam sonar at the Pilot Station sonar project can be found in Rich 2001. The split-beam technology can estimate the 3-dimensional position of a target in space, allowing the testing of assumptions about the direction of travel and vertical distribution of fish moving through the acoustic beam (Burwen et al. 1995).

A series of gillnets using different mesh sizes were drifted through the acoustic sampling areas to apportion the passage estimates to species. In 2004, the selectivity model used in species apportionment was refined through biometric review and analysis of historical catch data from the project's test fishery. The model that provided the best overall fit to the data was a Pearson model with a tangle parameter (Bromaghin 2004). In 2016, minimum selectivity thresholds were implemented into the model for species apportionment to prevent individual fish from skewing estimates dramatically (Pfisterer et al. 2017). The selectivity parameters used in the species apportionment model were updated using the most current catch data prior to the 2022 field season. Species proportions and passage estimates reported in this document were generated using this apportionment model and are comparable to 1995–2021 estimates because estimates from those years have been regenerated using the most current model.

Early in the 2005 season, the Yukon River experienced high water levels and erosion, which caused the formation of a cut bank and steepened the bottom profile on the left bank. The altered bottom profile allowed fish near the shore to swim under the beam, compromising detection. On June 9, 2005, a multibeam dual-frequency identification sonar (DIDSON; Belcher et al. 2002) was deployed to verify nearshore fish detection. The wider beam angle, video-like images, and software algorithms that can remove the bottom structure from the image allowed the DIDSON system to detect fish passage within 20 m despite high water levels and problematic erosion. It was operated for the remainder of the season, supplanting split-beam counts in this section of the nearshore region. From 2005 until 2014, the DIDSON was integrated into the sampling routine on the left bank and operated side-by-side with the split-beam sonar. The DIDSON sampled the first 20 m of the left bank nearshore strata, and the split-beam sampled the remainder of the range. Beginning in 2015, the DIDSON was replaced with an adaptive resolution imaging sonar (ARIS), and the counting range was increased to 40 m (Schumann et al. 2017).

In 2008, electronic charts were tested prior to the switch from paper charts used to count fish traces. Electronic charts were found to provide many advantages, including increased threshold levels, better consistency (no ribbons that fade), less downtime related to paper jams, and the ability to easily determine the direction of travel. In 2009, electronic echograms replaced paper charts to count fish traces (Lozori and McIntosh 2013).

For consistency with prior years when paper charts were used, all targets up and downstream were counted from 2010 to 2019 by right-clicking the computer mouse on downstream targets and left-clicking on upstream targets. In 2020, a review of 2010–2019 data determined that the overall percentage of downstream targets observed was insignificant compared to the total passage estimates, and counting downstream targets was discontinued (Morrill et al. 2021).

This report presents results from the Lower Yukon River sonar project for the 2022 field season. Included are data from an extension in project operations 1 week prior and past the normal start/end dates through a grant from the Yukon River Panel Research and Enhancement Fund. With these extensions, sonar operated from June 1 until September 7, 2022.

OBJECTIVES

The primary goal of this project was to estimate daily fish passage by species during upstream migration past the sonar site.

The primary project objective was as follows:

1. Provide fishery managers daily and cumulative passage estimates and associated confidence intervals of adult Chinook, chum, and coho salmon.

The secondary project objectives were as follows:

1. Collect biological data from all fish captured in the test fishery, including species, sex, length, and scales, as appropriate;
2. Collect Chinook and chum salmon tissue samples for separate genetic stock identification projects; and,
3. Collect water temperature data representative of the ensonified areas of the river.

STUDY SITE

Locations in this report are referenced by the proximate bank of the Yukon River relative to a downstream perspective. At the sonar site, the left bank is south of the right bank. The village of Pilot Station and the ADF&G sonar camp are on the right bank.

At the sonar site, the Yukon River is approximately 1,000 m wide between the left and right bank transducers (Figure 2). The left bank substrate, made of silt and fine sand, drops off gradually at a vertical angle of approximately 2° to 3°. The right bank has a stable, rocky bottom that drops off uniformly to the thalweg at a vertical angle of approximately 7° (Figure 3). The thalweg is approximately 25 m deep and approximately 200 m offshore of the right bank (Figure 4). River discharge, as observed from 2012 to 2021 at the United States Geological Survey (USGS) gauging station located downstream of the project, has ranged from a maximum of 23,219 m^3/s to a minimum of 7,787 m^3/s from June 1 through September 7 (Figure 5).

METHODS

Daily upstream migration of targeted fish species is estimated by multiplying the daily sonar passage of all species by the daily proportions of each targeted fish species that are estimated from the drift gillnet test fishery conducted in the same area as the sonar (Figure 6). Test fishing and sonar sampling were stratified temporally and physically. Temporal stratification occurs through multiple test fishing and sonar periods per day (Table 1). The physical stratification for test fishery sampling was accomplished using different fishing zones and for sonar sampling by dividing the right bank into 2 range strata (S1 and S2) and dividing the left bank into 3 strata (S3, S4, and S5; Figure 7).

HYDROACOUSTIC DATA ACQUISITION

Equipment

Left bank sonar equipment included the following:

1. A Hydroacoustic Technology Inc. (HTI) Model 244 echosounder configured to transmit and receive at 120 kHz, controlled via Digital Echo Processing (DEP) software installed on a laptop PC.
2. An HTI 120 kHz split-beam transducer with a 2.8° x 10° nominal beam width.
3. A 250 ft (76.2 m) HTI split-beam transducer cable connects the sounder to the transducer.
4. An ARIS Explorer 1200 unit equipped with a telephoto lens, configured to transmit and receive at 0.7 MHz and controlled via software installed on a laptop PC.
5. A 150 m ARIS underwater cable connecting the ARIS to the command module and laptop PC.

Right bank sonar equipment included the following:

1. An HTI Model 244 echosounder configured to operate at 120 kHz, controlled via DEP software installed on a laptop PC.
2. An HTI split-beam 120 kHz transducer with a 6° x 10° nominal beam width.
3. Three 250 ft (228.6 m combined length) HTI split-beam cables connect the sounder to the transducer.

The HTI Model 244 echosounders were ideal for the project due to configurability and power. The echosounders were set to transmit and receive at 120 kHz, which was necessary to achieve the sampling ranges. The beam heights for each split-beam transducer were chosen to fit the water column between the bottom and surface with minimal interference, and the 10° width provided an adequate field of view. The lengths of cable were necessary for flexibility in the placement of the transducers. Transducers were mounted on metal tripods and remotely aimed with Remote Ocean Systems (ROS) Model PT-25 rotators (Figure 8), which allows precision in aiming, especially at range with the split-beam sonar. Rotator movements were controlled with HTI Model 660-2 rotator controllers with position feedback to the nearest 0.1°. The ARIS was ideal in the left bank nearshore stratum because it was much more robust to bottom and surface interference, and the telephoto lens was used to achieve the sampling range.

After recording echogram files, Echotastic software, developed by ADF&G staff, was used to mark fish traces. Echograms and associated data were stored on a portable hard drive and transferred onto two 2-terabyte external hard drives.

Equipment Settings and Thresholds

The split-beam echosounders used a 40 log*R* time-varied gain (TVG) and 0.4 milliseconds (ms) transmit pulse duration during all sampling activities. The equipment automatically determined the receiver bandwidth based on the transmit pulse duration. On the left bank, the initial pulse repetition rate (ping rate) for S4 was set at 3 pings per second (pps), and S5 was set at 1.2 pps. On the right bank, the ping rate for S1 was set at 5 pps, and S2 was set at 3.5 pps (Table 2). On the left bank, S3 was sampled by the ARIS, which operated at an average rate of 4 frames per second. The target sampling range of the ARIS is 0.7–50 m, depending on river conditions. In 2022, increased turbidity due to high water limited our end range to 25 m until June 20. (Table 3). River conditions improved on June 20, and the S3 end range was increased to 40 m. This range was increased to 45 m on August 6 and remained that length for the duration of the summer. The digital sampling used by the split-beam sonar and ARIS does not threshold the data during collection; however, thresholds were applied to the electronic echogram files when viewed in Echotastic to reduce background noise and improve fish trace detection (Table 4). Thresholds were adjusted throughout the season depending on silt loads and other river conditions.

Aiming

Transducers were deployed on both the left and right banks in an area where the river is approximately 1,000 m wide. The transducers were positioned and aimed to maximize fish detection. Transducers were deployed in an area with the best bottom profile, and the beam was oriented approximately perpendicular to the current so that migrating fish would present the largest possible reflective surface. Because many fish travel close to the substrate, the maximum response angle of the beam was oriented slightly above the river bottom through as much of the range as possible. The right bank transducer was positioned as close to shore as possible depending on the water level, adjusting the aim between S1 (0–40 m) and S2 (40–150 m). The left bank split-beam transducer was positioned as close to shore as possible (depending on the water level) and initially utilized 2 distinct aims to sample S4 (40–150 m) and S5 (150–300 m). The ARIS unit was normally deployed within 2 m of the split-beam transducer, and when conditions were favorable, ensonified S3 (0.7–40 m; Figure 7). The ARIS's wider beam angle was ideal for the less linear nature of the eroded left bank nearshore stratum, enabling it to detect fish targets throughout more of the water column than the narrower split-beam.

Fluctuating water levels required repositioning the transducers and subsequent re-aiming of the beams. The transducer was panned horizontally upstream and downstream approximately 15° off perpendicular in 2° increments to establish optimal aim. At each increment, the vertical tilt was adjusted to obtain the best possible bottom picture using an electronic echogram to confirm that the sonar beam was oriented slightly above the river bottom. The left bank transducers were re-aimed more often to compensate for the dynamic bottom conditions and continual changes associated with that bank. Once an optimal aim was obtained, the rotator settings were documented, and the auto-rotator settings were changed to the new optimal aim. Faulkner and Maxwell (2009) discuss aiming and sonar site selection protocols to count fish using side-looking sonar systems.

Sampling Procedures

Acoustic sampling was conducted simultaneously on both banks during three 3-hour periods each day (Table 1). Sample periods were 0530–0830, 1330–1630, and 2130–0030 hours, alternating sequentially between strata every 30 minutes.

Operators marked fish traces for the split-beam and the ARIS on electronic echograms using Echotastic software developed by ADF&G (Figure 9). All personnel were trained to distinguish between valid upstream split-beam fish traces and non-target echoes. Echo traces were counted as a single fish if at least 2 pings in the cluster passed the threshold level, and the targets did not resemble inert downstream objects. Individuals within groups of fish were distinguishable when the apparent direction of movement of 1 fish trace differed from that of an adjacent trace.

Project leaders reviewed echograms daily to monitor the accuracy of the marked fish tracings and reduce individual biases. Each echogram was checked for indications of signal loss and changes to bottom reverberation markings, which could indicate either movement of the transducer or a change in the bottom profile. Data was checked daily for data entry or marking errors, then processed in the statistical software package *R*.[1]

SYSTEM ANALYSES

The performance of the split-beam hydroacoustic system was monitored following many of the procedures first established in 1995 (Maxwell et al. 1997). Monitoring of the ARIS included daily checks of sonar settings before each sampling period, routine checks of water level near the transducers, checking aim settings, and periodic cleaning of the transducer lens. System analyses included equipment performance checks, bottom profiles using down-looking sonar, and hydrologic measurements.

Bottom Profiles

Bottom profiles were recorded along both banks using a Lowrance LCX15MT recording fathometer with GPS capabilities to locate deployment sites with suitable linear bottom profiles. All bottom profiles were recorded and stored electronically. During the season, a fathometer was used regularly to monitor changing bottom conditions and to watch for the formation of sandbars capable of re-routing fish to unensonified areas.

Hydrological Measurements

Water discharge data were sourced from the real-time USGS gauging station located approximately 500 m downstream of Pilot Station and used throughout the season (Figure 5). HOBO water temperature loggers were deployed to record water temperature on both banks on May 30 and remained submerged until September 8. The data loggers were programmed to record the water temperature once every hour. Daily temperature was calculated as the mean of all recorded temperatures for the day.

SPECIES APPORTIONMENT

A total of 8 different mesh sizes were fished throughout the season to effectively capture all size classes of fish present and detectable by the hydroacoustic equipment (Table 5). All nets were

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[1] The R Project for statistical computing. R version 4.0.0 (Arbor Day). (released April 24, 2020, cited May 9, 2022). Available for download from http://www.r-project.org/.

25 fathoms (45.7 m) long and approximately 8 m deep. All nets were constructed of shade 11 or equivalent, double knot multifilament nylon twine and hung "even" at a 2:1 ratio of web to corkline.

Test fishing began as soon as practical and continued through the last day of sonar operation. Test fishing was conducted twice daily between sonar periods from 0900 to 1200 hours and 1700 to 2000 hours. (Table 1). On days of commercial gillnet fishing, only 1 test fishing period was conducted to prevent interference or overlap with the scheduled commercial period or a sonar operation period. During each normal sampling period, 4 different mesh sizes drifted within each of 3 zones for 24 drifts per day, except when only 1 test fishing period was conducted in which all 6 mesh sizes were fished (Table 6). The order of drifts was (1) left bank nearshore zone, (2) right bank zone, and (3) left bank offshore zone, with a minimum of 20 minutes between drifts in the same zone. Each mesh size was fished in all 3 zones before switching to the next mesh size. The shoreward end of the left bank nearshore drift was approximately 5 to 10 m offshore of the sonar transducers. The left bank offshore drift was approximately 65 m offshore of the transducers to avoid overlap with the nearshore drift. Drifts were approximately 8 minutes but were shortened as necessary to avoid snags or limit catches during high fish passage times.

Captured fish were identified to species and length was measured to the nearest 1 mm. Salmon species were measured from the middle of the eye to fork of tail (METF); nonsalmon species were measured from tip of snout to fork of tail (FL). Non-salmon species captured and identified included cisco (*Coregonus* spp.), humpback whitefish (*C. pidschian*), broad whitefish (*C. nasus*), sheefish/inconnu (*Stenodus leucichthys*), burbot (*Lota lota*), longnose sucker (*Catostomus catostomus*), Dolly Varden (*Salvelinus malma*), and northern pike (*Esox lucius*). Sex was recorded only for salmon species and was determined by examination of external features. Fish species, length, and sex were recorded on field data sheets. Each drift record included the date, sampling period, zone, drift start and end times, mesh size, length of net, and captain's initials. Handling mortalities among the captured fish were distributed to the local community, and fish dispersal was documented daily.

Four scale samples were collected from each Chinook salmon and mounted on scale cards, and fish and card numbers were recorded on the test fishery data sheets. Data were transferred from data sheets into a Microsoft Access database. Age, sex, and length (ASL) data are processed, analyzed, and reported annually by ADF&G staff based in Anchorage.

Individual genetic tissue samples from Chinook and chum salmon were also collected in the form of an axillary process clip and placed in vials for several stock identification projects in conjunction with the test fishery portion of the project. ASL data were cross referenced with each tissue sample. The ADF&G Gene Conservation Laboratory (e.g., Larson et al. 2020) and the U.S. Fish and Wildlife Service (USFWS) Conservation Genetics Laboratory (Flannery 2020) independently processed and analyzed these tissue samples.

Chinook salmon were classified as either large (>655 mm METF) or small (≤655 mm METF), and small Chinook salmon served as a proxy for jacks. The 655 mm length cutoff was derived from analysis of ASL data when it was determined this was the average length separating 4- and 5-year-old Chinook salmon (Pfisterer and Maxwell 2000). Although there was some temporal overlap between the summer and fall runs of chum salmon, for the purposes of estimating passage, all chum salmon encountered through July 18 were designated as summer chum salmon, and after July 18 were designated as fall chum salmon.

ANALYTICAL METHODS

Daily estimates were produced from a multicomponent process that involved the following:

1. Hydroacoustic estimates of all fish targets passing the site and species composition derived from test fishery results were applied to the undifferentiated hydroacoustic estimates.
2. CPUE estimates were used as a separate index by the managers and calculated on a subset of the test fishery data.

Catch Per Unit Effort

CPUE estimates used as separate indexes by the managers, and not for species apportionment, were calculated for each day (*d*) and bank (*b*) using 2 gillnet suites (*g*) of specific size mesh sizes (*m*). Chinook salmon CPUE was calculated on the pooled catch (*c*) and effort (*f*) of the large mesh gillnets (7.5 inch and 8.5 inch); chum and coho salmon CPUE was calculated on the pooled catch and effort of the small mesh gillnets (5.25 inch, 5.75 inch, and 6.5 inch).

The duration of the test fishery drift (*j*) in minutes (*t*) was calculated as:

$$t_j = SI_j - FO_j + \frac{\left(FO_j - SO_j\right)}{2} + \frac{\left(FI_j - SI_j\right)}{2}, \tag{1}$$

where:

SO = the time the net is initially set out,

FO = the time the net is fully set out,

SI = the time the net starts back in, and

FI = the time the net is fully retrieved in.

The total fishing effort (in fathom-hours) for each day, bank, and gillnet suite was calculated as:

$$e_{dbg} = \sum_m \frac{25 \cdot t_{dbgm}}{60}, \tag{2}$$

because all nets were 25 fathoms (45.7 m) in length. CPUE estimates (in catch per fathom-hour) for each species (*i*) were made daily for the right and left banks as:

$$CPUE_{dbig} = \frac{\sum_m c_{dbigm}}{e_{dbg}}. \tag{3}$$

Species Composition

Test fishery sampling was conducted on both banks to estimate species proportions. The right bank has only 1 zone (Z1), and the left bank was divided into 2 zones (Z2 [0–50 m] and Z3 [50–300 m]). In relation to acoustic sampling, Z1 corresponds to sonar strata S1 and S2, Z2 corresponds to S3, and Z3 corresponds to S4 and S5 (Figure 7). Test fishing was conducted twice daily between sonar periods; P1 was 0900–1200, and P2 was 1700–2000 hours. This was considered 2-stage systematic sampling, in which CPUE of species (*i*) passing at zone (*z*), during period (*p*), of day (*d*) (C_{dzpi}), was considered the primary sampling unit of measurement.

CPUE of species (i) passing zone (z) during period (p) of day (d) (C_{dzpi}) was calculated by dividing the sum of the number of species (i) of length (l) caught by meshes (m) (c_{dzpilm}) by the sum of length selectivity adjusted efforts by meshes (m) (f_{dzpilm}) and then summed across all lengths:

$$C_{dzpi}=\sum_{l}\left(\frac{\sum_m c_{dzpilm}}{\sum_m f_{dzpilm}}\right), \tag{4}$$

where length selectivity adjusted effort f_{dzpilm} is calculated as:

$$f_{dzpilm}=S_{ilm}\cdot e_{dzpm}, \tag{5}$$

and S_{ilm} is the net selectivity of the species (i) of length (l) caught by mesh (m), and e_{dzpm} is the effort (in fathom-hours) calculated by multiplying the drift time (t) (in minutes) by 25 fathoms and dividing by 60 minutes per hour (Appendix A1; Bromaghin 2004):

$$e_{dzpm}=\frac{25\cdot t_{dzpm}}{60}. \tag{6}$$

A threshold was applied to prevent individual fish with extremely low selectivity from inflating the CPUE unreasonably such that:

$$S_{ilm}=\begin{cases}S_{ilm} & S_{ilm}\geq 0.1\\ 0.1 & \text{otherwise}\end{cases}. \tag{7}$$

The proportion of species (i) passing zone (z) during period (p) of day (d) ($\hat{p}_{dzpi}$) and the proportion for day ($\hat{p}_{dzi}$):

$$\hat{p}_{dzpi}=\frac{C_{dzpi}}{\sum_i C_{dzpi}} \text{ and } \hat{p}_{dzi}=\frac{\sum_p C_{dzpi}}{\sum_p\sum_i C_{dzpi}}. \tag{8}$$

The variance of $\hat{p}_{dzi}$ was estimated from the squared differences between the proportion for each test fishery period within the day ($\hat{p}_{dzpi}$) and the proportion for the day as a whole ($\hat{p}_{dzi}$):

$$\widehat{Var}\left(\hat{p}_{dzi}\right)=\frac{\sum_p\left(\hat{p}_{dzi}-\hat{p}_{dzip}\right)^2}{n_p\left(n_p-1\right)}, \tag{9}$$

where n_p is the number of test fishery sampling periods within the day. Equation 9 requires n_p to be greater than 1, and days with less than 1 test fishery period were pooled with adjacent days such that there were at least 2 complete test fishery periods.

Sonar Passage Estimates

Fish passage was estimated separately for each sonar stratum. Let y_{dpsk} be defined as 30-minute subsampling acoustic counts (k) at stratum (s) during periods (p) of day (d). The hourly passage rate per stratum and period was calculated:

$$r_{dps}=\frac{\sum_k y_{dpsk}}{\sum_k h_{dpsk}}, \tag{10}$$

where h_{dpsk} is the fraction of the hour sampled for sample (k). Daily passage was then estimated as:

$$\hat{y}_{ds}=24\ \frac{\sum_p r_{dsp}}{n_p}\ , \tag{11}$$

where n_p was the number of periods in the day. The variance of $\hat{y}_{ds}$ was estimated as:

$$\hat{V}(\hat{y}_{ds})=24^2\left(\frac{s^2}{n_p}\right)\left(1-\frac{h_{ds}}{24}\right), \tag{12}$$

where s^2 is the variance of the passage rate for the day:

$$s^2=\left(\frac{\sum_p\left(r_{dsp}-\bar{r}_{ds}\right)^2}{n_p-1}\right). \tag{13}$$

Fish Passage by Species

The final step in the estimation process was combining the sonar estimates with the estimates of species proportions to compute passage by species. To estimate passage by species within each sonar stratum, the passage for each stratum was multiplied by the species proportions for the test fishery zones as follows: test fishery S1 was applied to the entire counting range of the right bank (sonar strata S1 and S2 approximately 0–150 m). Test fishery Z2 was applied to the counting range corresponding to S3 (approximately 0–50 m on the left bank). Test fishery Z3 was applied to the counting range corresponding to S4 and S5 (approximately 50–150 m and 150–300 m (Figure 7)). The passage of species (i) at stratum (s) for each day was estimated by multiplying total passage ($\hat{y}_{ds}$) and proportion ($\hat{p}_{dzi}$):

$$\hat{y}_{dis}=\hat{y}_{ds}\cdot\hat{p}_{dzi}\ , \tag{14}$$

Except for the timing of sonar and gillnet sampling periods, sonar-derived estimates of total fish passage were independent of gillnet-derived estimates of species proportions. Therefore, the variance of their product was estimated as the variance of the product of 2 independent random variables (Goodman 1960):

$$\widehat{Var}(y_{dis})=\hat{y}_{ds}^2\cdot\widehat{Var}(\hat{p}_{dzi})+\hat{p}_{dzi}^2\cdot\widehat{Var}(\hat{y}_{ds})-\widehat{Var}(\hat{y}_{ds})\cdot\widehat{Var}(\hat{p}_{dzi})\ . \tag{15}$$

Daily passage and variance of each species are the sum over all sonar strata:

$$\hat{y}_{di}=\sum_s\hat{y}_{dis}\ and\ \widehat{Var}\left(\hat{y}_{di}\right)=\sum_s\widehat{Var}(\hat{y}_{dis})\ . \tag{16}$$

Likewise, total passage and variance for the season of each species are the sum of the daily passage:

$$\hat{y}_i=\sum_d\hat{y}_{di}\ and\ \widehat{Var}(\hat{y}_i)=\sum_d\widehat{Var}\left(\hat{y}_{di}\right). \tag{17}$$

Assuming normally distributed errors, 90% confidence intervals are calculated as:

$$\hat{y}_i\pm1.645\sqrt{\widehat{Var}(\hat{y}_i)}\ . \tag{18}$$

R program code (Carl Pfisterer, Division of Commercial Fisheries, Regional Sonar Coordinator, ADF&G, Fairbanks) was used to calculate CPUE, passage estimates, and estimates of variance.

RESULTS

The Pilot Station sonar project's crew arrived at the sonar site on May 27 and began camp set up. Test fishing drift areas were dragged for snags on May 31, and test fishing began during P1 on June 1. The project was fully operational beginning with P2 sonar on June 1 and continued operations through September 7. Passage estimates were transmitted to fishery managers daily.

Environmental and Hydrological Conditions

Ice breakup on the Yukon River at Pilot Station occurred on May 9, which was earlier than the 10-year average of May 11 (Table 7). The water discharge near Pilot Station during the 2022 season was above the 10-year mean (2012–2021) for the entire season, with levels rising above the maximum average from June 27 to July 2 (Figure 5). Mean daily water temperatures on the left bank ranged from 10.1°C to 19.5°C and from 10.1°C to 19.0°C on the right bank (Figure 10). Water temperatures fell mostly below the 10-year averages on both banks, rising above the averages from June 5 to June 14 and from July 1 to July 20.

Test Fishery

Drift gillnetting resulted in the capture of 6,480 fish: 379 Chinook salmon (284 large and 95 small), 1,331 summer chum salmon, 1,576 fall chum salmon, 809 coho salmon, and 2,385 fish of other species. Of the captured fish, 1,338 (21%) were retained as mortalities and delivered to local users within the nearby community of Pilot Station (Table 8). Of the 379 Chinook salmon captured in the test fishery, scale samples were collected from 379 fish and 327 were ageable.[2] Tissue samples for genetic stock identification were collected from 375 Chinook salmon and 2,894 chum salmon.

Hydroacoustic Estimates

An estimated 1,562,996 fish passed through the sonar sampling areas between June 1 and September 7. Of that total passage, 249,826 (approximately 16%) fish passed along the right bank, and 1,313,170 (approximately 84%) fish passed along the left bank (Table 9). Total fish passage estimates (with associated errors) by zone were calculated daily (Appendix C1). Over 90% of the fish passage occurred within 40 m of the transducers on both the left and right banks during the summer. During the fall season, 90% of the passage occurred within 40 m meters on the right bank and 70 m on the left (Figures 11–12).

Species Estimates

Fish passage estimates by species were generated daily and reported to fishery managers each morning (Appendix D1). Chinook salmon cumulative inseason passage estimates, with 90% confidence intervals, were 33,159 ± 6,494 large Chinook salmon (>655 mm METF) and 15,280 ± 3,506 small Chinook salmon (≤655 mm METF). Chum salmon cumulative passage estimates were 463,806 ± 24,817 summer chum salmon and 325,717 ± 19,197 fall chum salmon.

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[2] Arctic–Yukon–Kuskokwim Database Management System (AYKDBMS). 2006– . Alaska Department of Fish and Game, Division of Commercial Fisheries. Juneau, AK. https://www.adfg.alaska.gov/CF_R3/external/sites/aykdbms_website/Default.aspx. (accessed January 5, 2023).

Coho salmon cumulative passage estimate was 92,102 ± 7,500 fish, sockeye salmon (*O. nerka*) was 4,184 ± 2,412 fish, and pink salmon (*O. gorbuscha*) was 158,767 ± 21,735 fish. The cisco cumulative passage estimate was 238,030 ± 32,773 fish, humpback whitefish was 170,551 ± 17,565 fish, broad whitefish was 22,019 ± 5,535 fish, sheefish was 28,902 ± 6,003 fish, and other species (burbot, longnose sucker, Dolly Varden, and northern pike) was 10,479 ± 2,211 fish (Table 9).

The initial pulse of Chinook salmon began approximately June 23 (Figure 13); however, the front end of the Chinook run had an unusually long and consistent flow of "tricklers" that lasted almost 3 weeks before the more distinctive first pulse arrived. The Chinook salmon estimate this season was the lowest in all the years of project operations from 1995 to 2022.

The summer chum salmon estimate this season was the fourth lowest in all the years of project operations (1995–2022). Three pulses of summer chum salmon were detected at the sonar project; the largest group consisted of approximately 202,000 fish and passed by the sonar between June 25 and July 2.[3] Compared to the 2012–2021 historical mean run timing, the midpoint of the Chinook salmon run occurred 4 days late (June 28) and 3 days late (July 2) for summer chum salmon (Figure 14; Appendices E and F).

There were 5 fall chum salmon pulses that passed the sonar project after July 19, and 85% of the chum salmon arriving through July 28 were genetically summer chum salmon.[3] After that, predominantly fall chum salmon entered the river, with peak daily passage occurring on August 8 (Figure 15). Mixed stock analysis (MSA) from the Pilot Station sonar project test fishery, utilizing genetic samples, was used to generate stock composition estimates of pulses, which were distributed inseason to assist management decisions. Run timing for both fall chum and coho salmon was restricted to July 19–August 31 to allow a more meaningful comparison with years that did not operate into September. The midpoint for the fall chum salmon run was August 11, which was 3 days early compared to 2012–2021 mean cumulative run timing (Figure 16; Appendices E and F).

There was a relatively steady increase in coho salmon passage until the first significant pulse on August 8 (Figure 15). As in most years, the project ended before the coho salmon run was complete, estimates were therefore considered conservative, and timing may not reflect the total run. The midpoint for the coho salmon run was August 23, which was a day earlier compared to 2012–2021 mean cumulative run timing (Figure 16; Appendices E and F).

MISSING DATA

Initially, 23 days (between June 1 and June 23) had insufficient catches in at least 1 fishing zone, which made it necessary to pool days to ensure reasonable species apportionment (Table 10). There were 65 days with insufficient catches, primarily in the offshore zone on the left bank (Z3). Unlike past years, no commercial fisheries this season affected the species apportionment test fishery, which would necessitate pooling days.

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[3] Jallen, D. 2022. 2022 Yukon River summer season summary. Alaska Department of Fish and Game, Division of Commercial Fisheries, Advisory Announcement, Juneau, Alaska. Issued November 21, 2002. Available from: https://www.adfg.alaska.gov/static/applications/dcfnewsrelease/1445996671.pdf (accessed January 2023).

DISCUSSION

Optimal aiming of the sonar beam is essential for detecting fish on both banks. The rocky substrate found on the right bank is less dynamic than the silty bottom of the left bank and, therefore, has little or no change in profile throughout the season. Upon deployment on the left bank, high water, silt attenuation, and an eroded nearshore substrate hampered the ARIS' ability to detect fish beyond 25 m. A spreader lens was installed to increase the vertical beam from 3° to approximately 14° to accommodate the uneven bottom profile and high water. Additionally, the end range in stratum S3 was reduced from 50 m to 25 m, and the range in S4 was changed to cover 25–55 m, and S5 covered 55–150 m. During this period (June 1–June 19), almost all the passage had been within the first 50 m of shore on the left bank. Conditions improved around June 20, and the S3 range was increased to 40 m, and S4 covered 40–150 m and S5 covered 150–300 m. The spreader lens was removed on August 6 once the water level dropped to near average. These higher water levels made deployment of the sonar and nets challenging, but there was no reason to believe that this affected the ability to estimate the fish passage.

Historically, there has been alternating years of high pink salmon abundance. The 20-year pink salmon average passage estimates during even years was 556,707, and the odd-year average was 53,498 (Appendix G1). This year's average was much closer to the odd-year average, and sonar ranges were not adjusted to exclude a portion of the pink salmon migration. Therefore, the total estimated pink salmon passage should not be considered conservative because most of the run was sampled.

Although there were a few problems this season, estimating fish passage on the Yukon River presents major technical and logistic challenges. The sampling environment is often demanding due to the extremely dynamic nature of the water level, turbidity, bottom substrate, and range dependent signal loss. The hydroacoustic systems employed at the Pilot Station sonar project worked well to detect migrating salmon, but successful estimation depends on constant attention to the frequent changes and diligent rechecking of every part of the acoustic and environmental system. In 2022, all project goals were met, and passage estimates were given to fisheries managers daily during the season. The information generated at the Pilot Station sonar project was also disseminated weekly through multiagency international teleconferences and data sharing with stakeholders in areas from the Lower Yukon River to the spawning grounds in Canada.

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TABLES AND FIGURES

Table 1.–Daily sampling schedule for sonar and test fishery at the Pilot Station sonar project on the Yukon River, 2022.

	Sonar (by stratum)		
Time	Right bank	Left bank	Test fishery
	Period 1		
0530	S1	S3/S4	
0600	S2	S5	
0630	S1	S3/S4	
0700	S2	S5	
0730	S1	S3/S4	
0800	S2	S5	
0830			
0900			Period 1
0930			
1000			
1030			
1100			
1130			
1200			
1230			
1300	Period 2		
1330	S1	S3/S4	
1400	S2	S5	
1430	S1	S3/S4	
1500	S2	S5	
1530	S1	S3/S4	
1600	S2	S5	
1630			
1700			Period 2
1730			
1800			
1830			
1900			
1930			
2000			
2030			
2100	Period 3		
2130	S1	S3/S4	
2200	S2	S5	
2230	S1	S3/S4	
2300	S2	S5	
2330	S1	S3/S4	
0000	S2	S5	

Table 2.–Initial split-beam sonar settings at the Pilot Station sonar project on the Yukon River, 2022.

			Bank	
Component	Setting	Stratum	Left	Right
Transducer	Beam size (h x w)		2.8° x 10°	6° x 10°
Echosounder	Transmit power (dB)	S1		27.0
		S2		27.0
		S4	27.0	
		S5	30.0	
	Receiver gain (dB)	S1		-6.0
		S2		-6.0
		S4	-12.0	
		S5	-12.0	
	Source level (dBµPa @ 1 m)	S1		216.8
		S2		216.8
		S4	222.1	
		S5	223.1	
	Through-system gain (dB)		-161.6	-162.0
	Pulse width (ms)		0.4	0.4
	Blanking range (m)		0	0
	Ping rate (pps)	S1		5.0
		S2		3.5
		S4	3.0	
		S5	1.2	
	Range (m)	S1		0–40
		S2		40–150
		S4	25–55	
		S5	55–150	

Note: ms = millisecond, dB = decibel, µPa = micropascal, pps = pings per second.

Table 3.–Technical specifications for the ARIS at the Pilot Station sonar project on the Yukon River, 2022.

Setting	Value
Field of view (h x w)	14° x 14°
Detection frequency (MHz)	0.7
Receiver gain (dB)	20.0
Samples/beam	1456.0
Start range (m)	0.7
Frame rate (f/s)	4.0
End range (m)	40.0

Table 4.–Initial range of lower and upper thresholds used in Echotastic at the Pilot Station sonar project on the Yukon River, 2022.

		Threshold (dB)	
Bank	Stratum	Upper	Lower
Right	S1	-30	-52
	S2	-23	-47
Left	S3	-16	-42
	S4	-31	-56
	S5	-25	-56

Table 5.–Specifications for drift gillnets used for test fishing, by season, at the Pilot Station sonar project on the Yukon River, 2022.

	Stretch mesh size		Mesh diameter	Meshes deep	Depth
Season	(in)	(mm)	(mm)	(md)	(m)
Summer	2.75	70	44	131	8.0
(6/1–7/18)	4.00	102	65	90	8.0
	5.25	133	85	69	8.0
	6.50	165	105	55	7.9
	7.50	191	121	48	8.0
	8.50	216	137	43	8.1
Fall	2.75	70	44	131	8.0
(7/19–9/7)	4.00	102	65	90	8.0
	5.00	127	81	72	8.0
	5.75	146	93	63	8.0
	6.50	165	105	55	7.9
	7.50	191	121	48	8.0

Table 6.–Fishing schedule for drift gillnets used for test fishing by season at the Pilot Station sonar project on the Yukon River, 2022.

Season	Test fishery period	Mesh size (inches)			
		Odd days		Even days	
Summer	1	2.75	5.25	8.50	4.00
(6/1–7/18)		7.50	6.50	7.50	6.50
	2	7.50	6.50	7.50	6.50
		8.50	4.00	2.75	5.25
Fall	1	4.00	5.75	2.75	7.50
(7/19–9/7)		5.00	6.50	5.00	6.50
	2	5.00	6.50	5.00	6.50
		2.75	7.50	4.00	5.75

Table 7.–Yukon River ice breakup dates at Pilot Station, 2001–2022.

Year	Breakup date
2001	5/29
2002	5/18
2003	5/15
2004	5/03
2005	5/11
2006	5/25
2007	5/11
2008	5/19
2009	5/17
2010	5/19
2011	5/17
2012	5/17
2013	5/31
2014	5/03
2015	5/14
2016	4/29
2017	5/05
2018	5/13
2019	5/07
2020	5/11
2021	5/13
2022	5/09

Source: National Oceanic and Atmospheric Administration (NOAA). 2022. National Weather Service, Alaska-Pacific River Forecast Center. www.weather.gov/aprfc/breakupDB (accessed October 19, 2022).

Table 8.–Number of fish caught and retained in the Pilot Station sonar project test fishery on the Yukon River, 2022.

Total catch	Chinook	S. Chum	F. Chum	Coho	Sockeye	Pink	Whitefish	Cisco	Burbot	Sheefish	Others[a]	Total
June	265	635	0	0	3	6	51	97	4	100	4	1,165
July	114	696	374	2	22	610	303	288	8	83	7	2,507
August	0	0	1,099	636	7	62	375	212	25	18	20	2,454
September	0	0	103	171	2	0	32	29	5	4	8	354
Total	379	1,331	1,576	809	34	678	761	626	42	205	39	6,480

Fish retained	Chinook	S. Chum	F. Chum	Coho	Sockeye	Pink	Whitefish	Cisco	Burbot	Sheefish	Others[a]	Total
June	144	214	0	0	0	0	7	0	0	17	0	382
July	60	149	76	0	7	0	126	1	2	4	0	425
August	0	0	273	55	1	0	146	2	1	0	0	478
September	0	0	20	15	1	0	15	0	1	1	0	53
Total	204	363	369	70	9	0	294	3	4	22	0	1,338

Proportion retained	Chinook	S. Chum	F. Chum	Coho	Sockeye	Pink	Whitefish	Cisco	Burbot	Sheefish	Others[a]	Total
June	0.543	0.337	0.000	0.000	0.000	0.000	0.137	0.000	0.000	0.170	0.000	0.328
July	0.526	0.214	0.203	0.000	0.318	0.000	0.416	0.003	0.250	0.048	0.000	0.170
August	0.000	0.000	0.248	0.086	0.143	0.000	0.389	0.009	0.040	0.000	0.000	0.195
September	0.000	0.000	0.194	0.088	0.500	0.000	0.469	0.000	0.200	0.250	0.000	0.150
Total	0.538	0.273	0.234	0.087	0.265	0.000	0.386	0.005	0.095	0.107	0.000	0.206

Note: "S. chum" = Summer chum; "F. chum" = Fall chum.

[a] Includes long nose sucker, northern pike, and Dolly Varden.

Table 9.–Cumulative fish passage estimates by zone and species with standard errors (SE) and 90% confidence intervals (CI) at the Pilot Station sonar project on the Yukon River, 2022.

Species	Right bank	Left bank	Total passage	SE	90% CI Lower	90% CI Upper
Large Chinook [a]	4,626	28,533	33,159	3,948	26,665	39,653
Small Chinook [b]	2,770	12,510	15,280	2,131	11,774	18,786
Total Chinook	7,396	41,043	48,439	4,486	41,060	55,818
Summer chum	49,897	413,909	463,806	15,086	438,989	488,623
Fall chum[c]	24,969	300,748	325,717	11,670	306,520	344,914
Coho[c]	23,150	68,952	92,102	4,559	84,602	99,602
Sockeye	2,578	1,606	4,184	1,466	1,772	6,596
Pink	58,872	99,895	158,767	13,213	137,032	180,502
Cisco	33,685	204,345	238,030	19,923	205,257	270,803
Humpback whitefish	24,615	145,936	170,551	10,678	152,986	188,116
Broad whitefish	6,442	15,577	22,019	3,365	16,484	27,554
Sheefish	10,900	18,002	28,902	3,649	22,899	34,905
Other [d]	7,322	3,157	10,479	1,344	8,268	12,690
Total	245,661	1,317,335	1,562,996			

[a] Large Chinook >655 mm METF.

[b] Small Chinook ≤655 mm METF.

[c] Because the fall chum and coho salmon migration continued after project operations, estimates are considered incomplete.

[d] Includes burbot, long nose sucker, Dolly Varden, and northern pike.

Table 10.–Dates of zones pooled for the 2022 season at the Pilot Station sonar project on the Yukon River.

		Left bank		
Date	Right bank (Zone 1)	Nearshore (Zone 2)	Offshore (Zone 3)	Reason for pooling
6/01				IC
6/02				
6/03				
6/04				IC
6/05				
6/06				IC
6/07				IC
6/08				
6/09				
6/10				IC
6/11				
6/12				IC
6/13				
6/14				IC
6/15				
6/16				
6/17				IC
6/18				
6/19				
6/20				IC
6/21				IC
6/22				IC
6/23				
6/24				
6/25				
6/26				
6/27				
6/28				
6/29				
6/30				
7/01				
7/02				
7/03				
7/04				IC
7/05				
7/06				
7/07				IC
7/08				
7/09				
7/10				
7/11				
7/12				
7/13				
7/14				IC
7/15				
7/16				IC
7/17				
7/18				
7/19				

-continued-

Table 10.–Page 2 of 2.

Date	Right bank (Zone 1)	Left bank Nearshore (Zone 2)	Left bank Offshore (Zone 3)	Reason for pooling
7/20				IC
7/21				
7/22				IC
7/23				
7/24				IC
7/25				
7/26				IC
7/27				
7/28				IC
7/29				
7/30				IC
7/31				
8/01				IC
8/02				
8/03				
8/04				IC
8/05				
8/06				IC
8/07				
8/08				
8/09				
8/10				
8/11				
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8/20				
8/21				
8/22				
8/23				
8/24				IC
8/25				IC
8/26				IC
8/27				
8/28				IC
8/29				
8/30				
8/31				
9/01				
9/02				IC
9/03				
9/04				
9/05				IC
9/06				
9/07				

Note: Days with insufficient catches (IC) in at least 1 fishing zone were pooled (boxes) to ensure reasonable species apportionment. There were no commercial fisheries this season that affected the species apportionment test fishery.

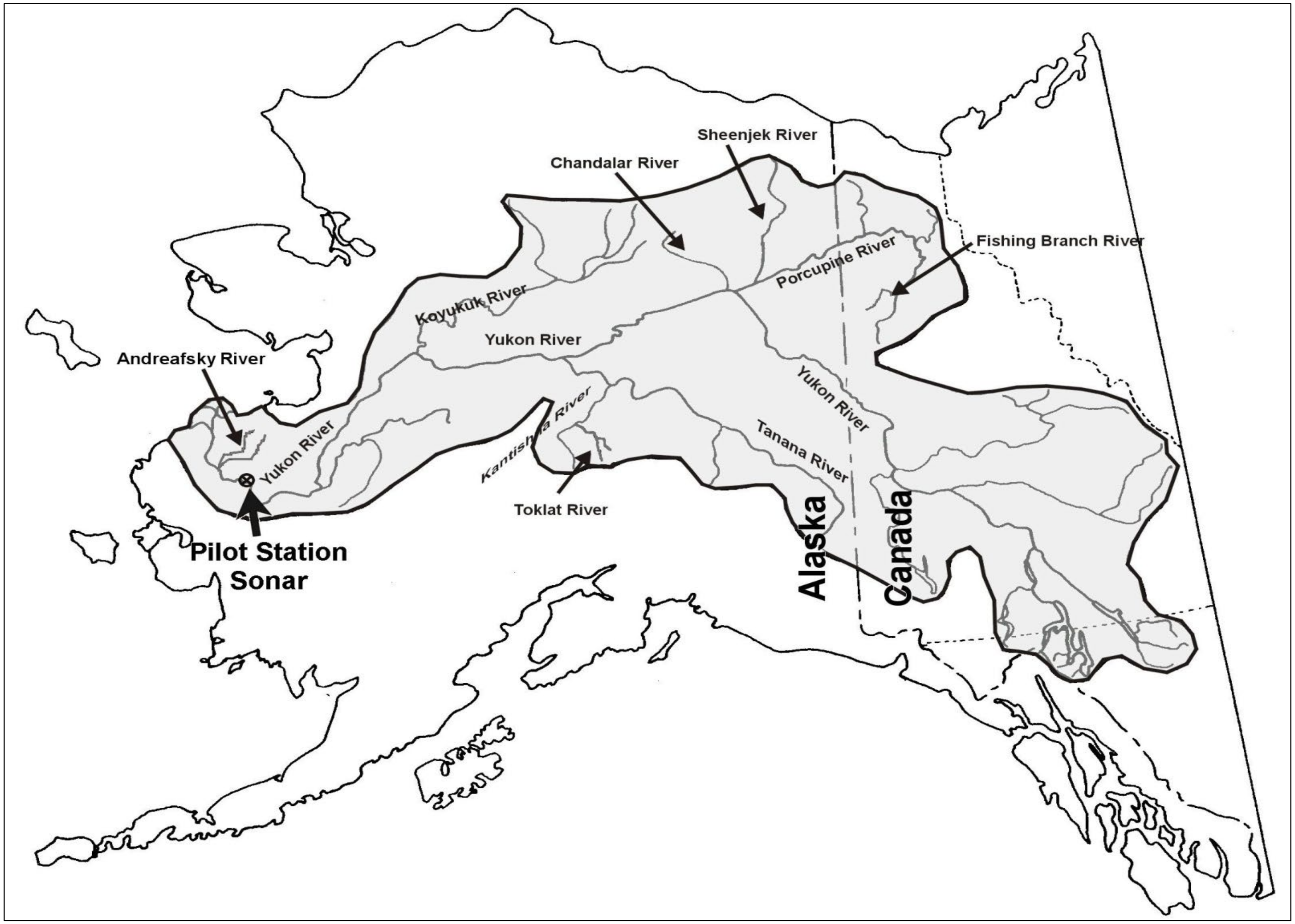

Figure 1.–Fishing districts and communities of the Yukon River drainage.

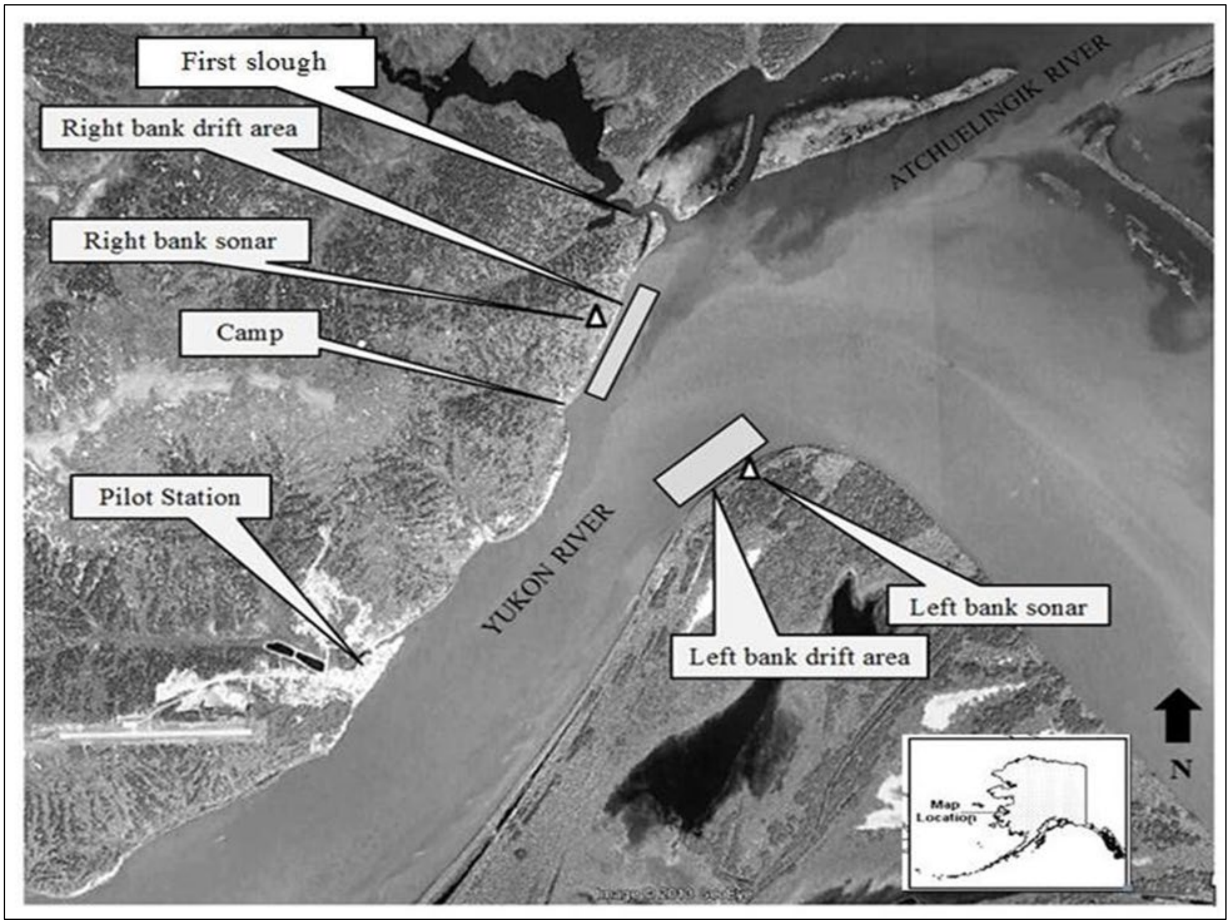

Figure 2.–Location of the Pilot Station sonar project on the Yukon River showing general transducer sites.

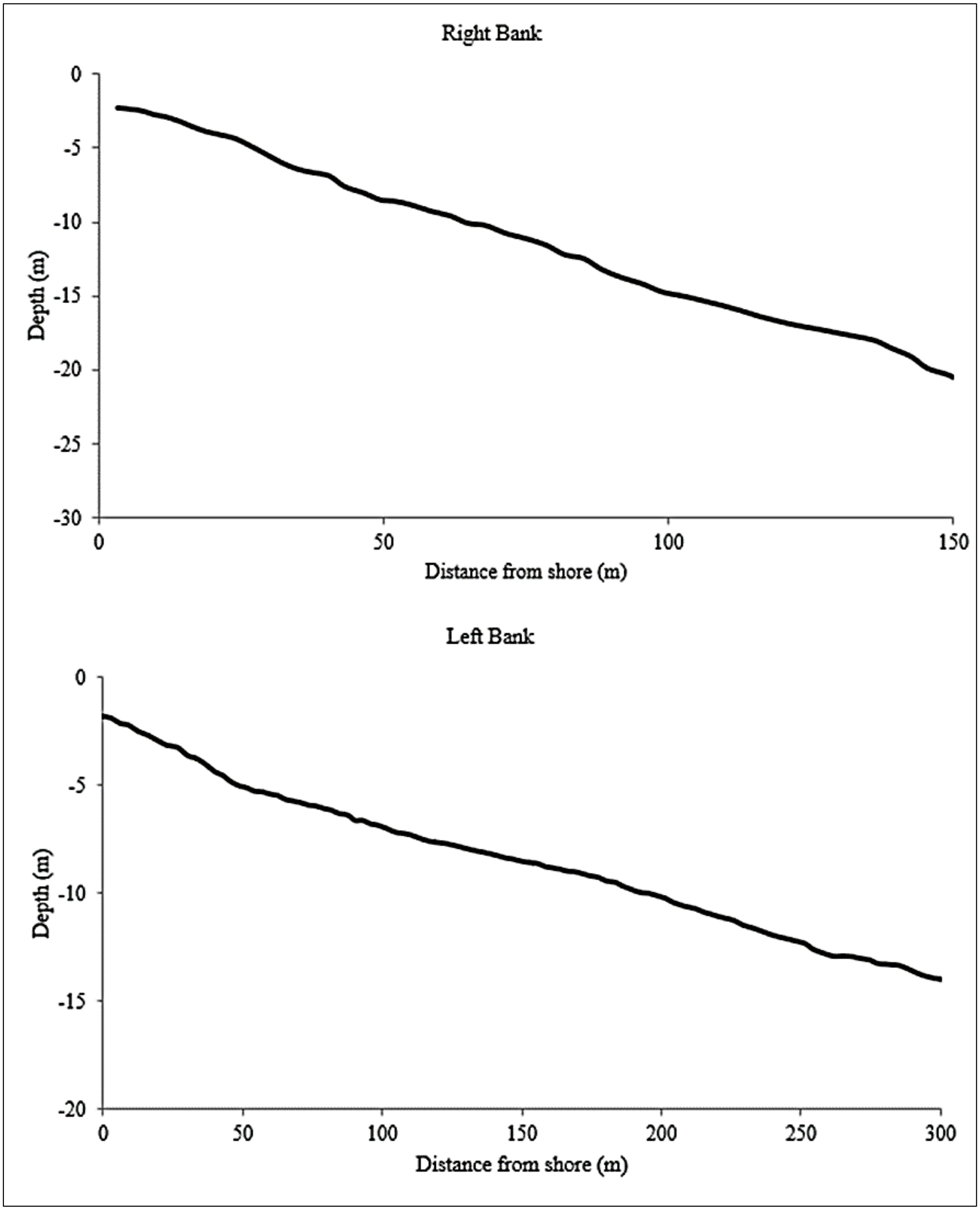

Figure 3.–Bottom profiles for the right bank (top) and left bank (bottom) at the Pilot Station sonar project on the Yukon River, 2022.

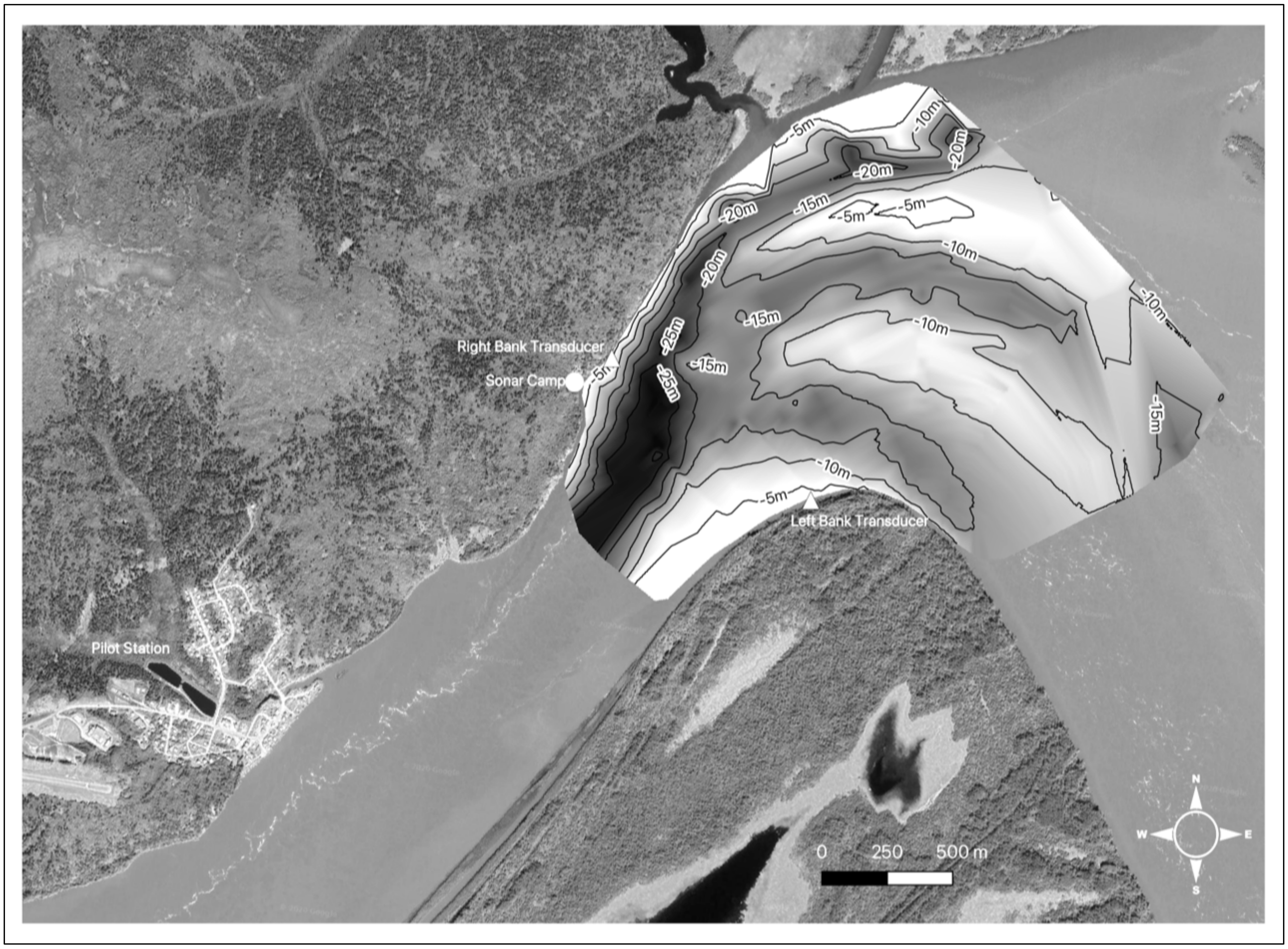

Figure 4.–Bathymetric map of the Yukon River in the vicinity of the Pilot Station sonar project.

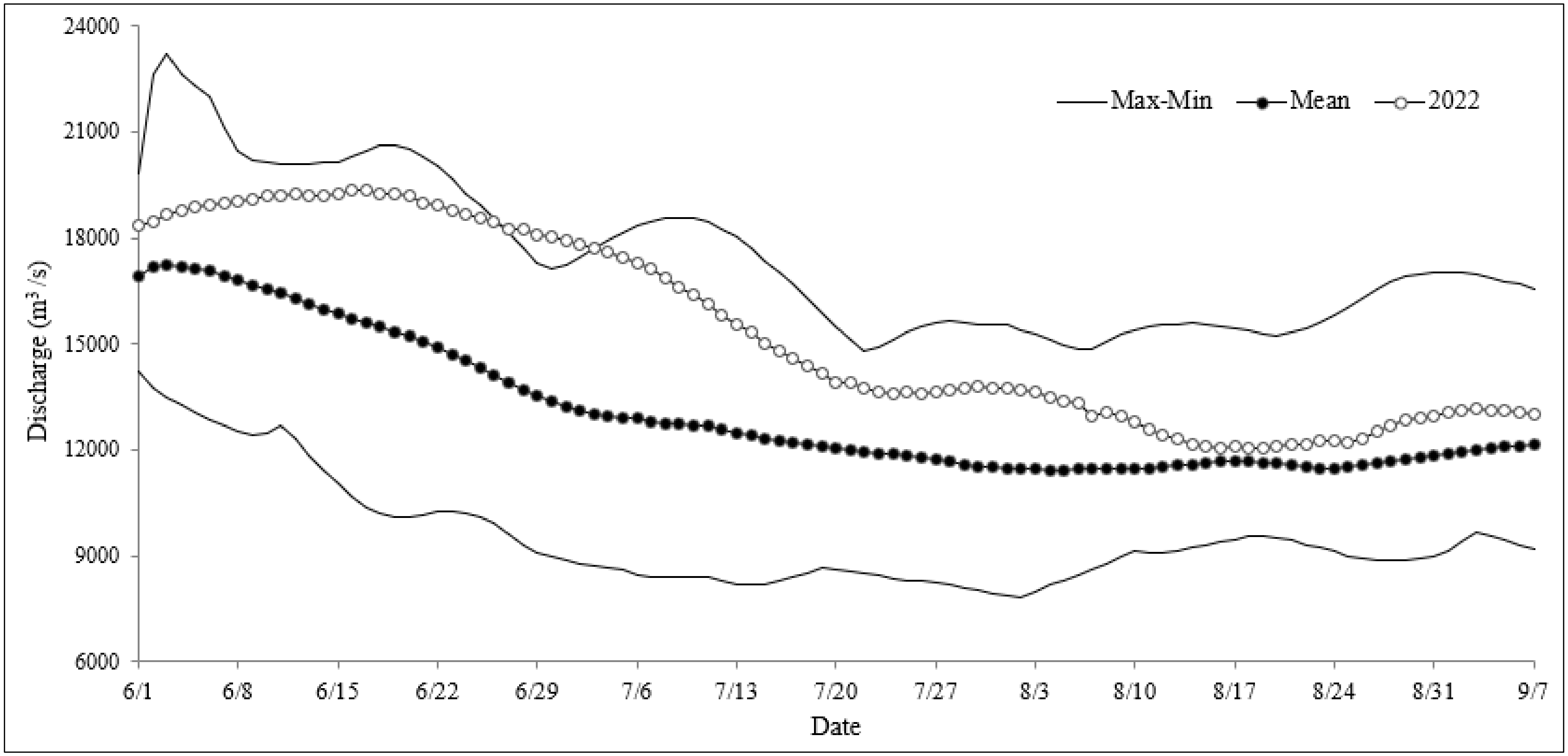

Figure 5.–Yukon River daily water discharge during the 2022 season at Pilot Station water gage compared to 2012–2021 minimum, maximum, and mean gage height.

Source: United States Geological Survey, October 26, 2022.

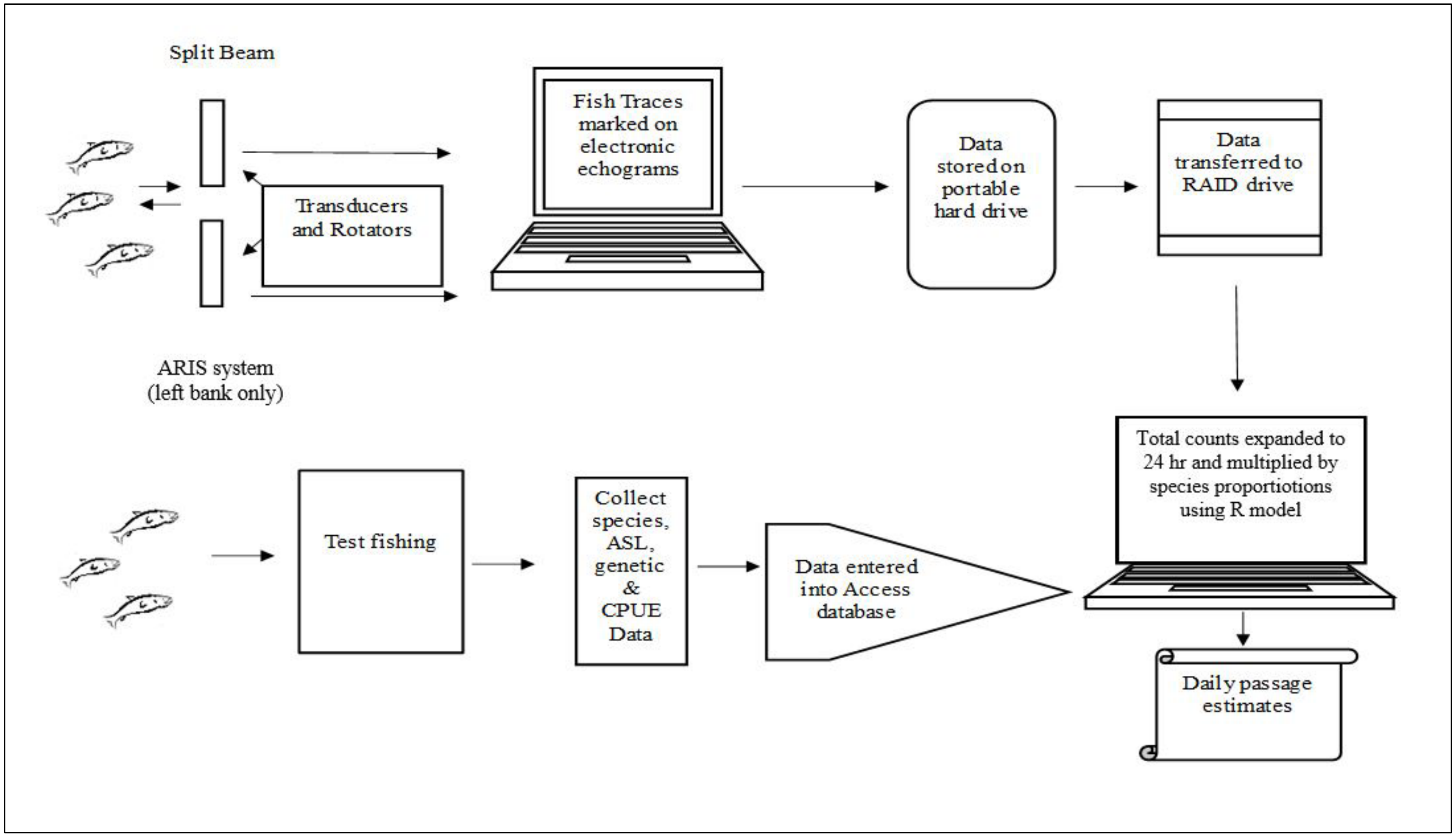

Figure 6.–Flow diagram of data collection and processing at the Pilot Station sonar project on the Yukon River, 2022.

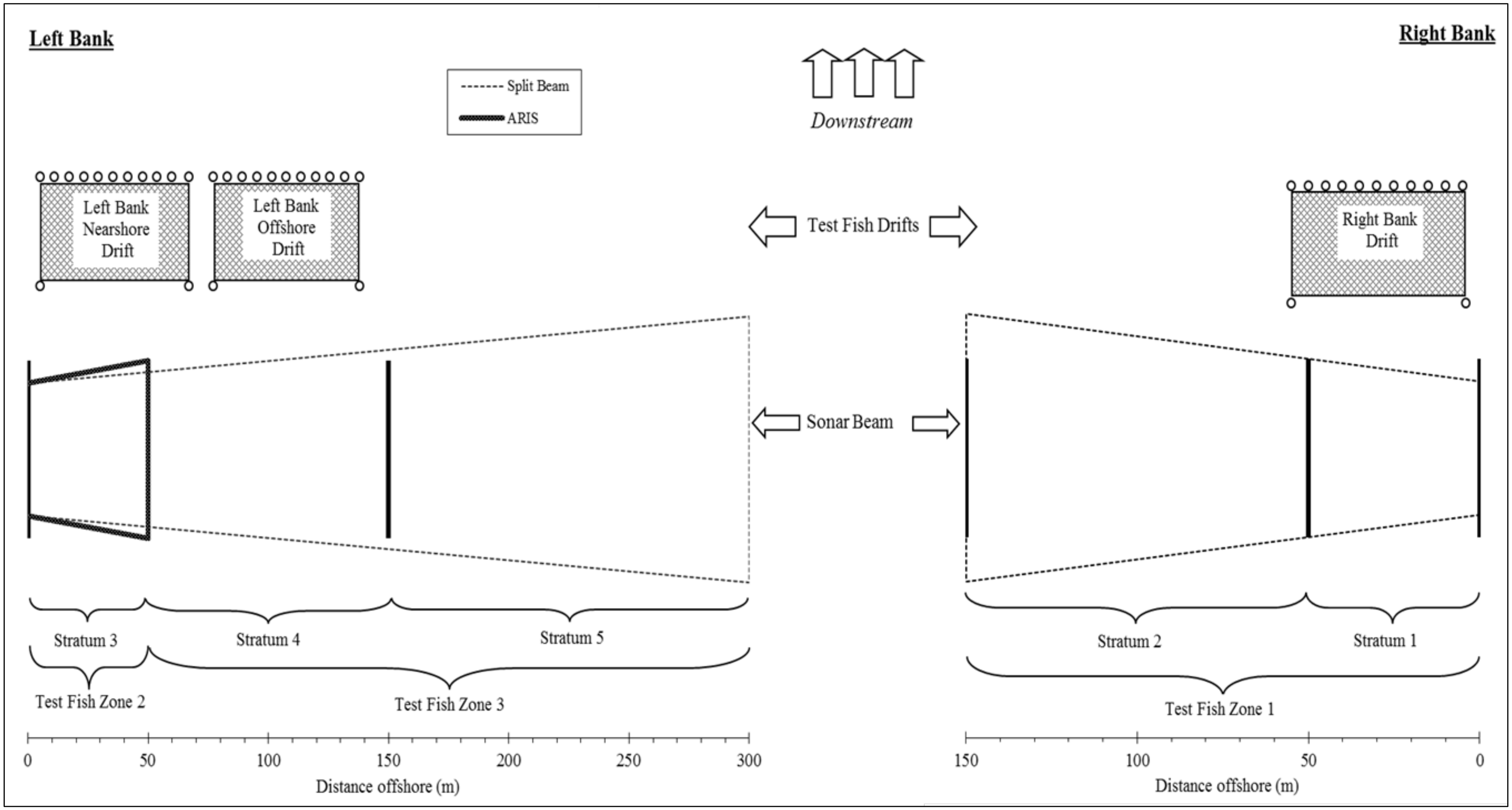

Figure 7.–Illustration of relationships between strata, zones, test fishery drifts, and approximate sonar ranges (not to scale) at the Pilot Station sonar project on the Yukon River, 2022.

Note: Strata ranges can vary during the season depending on river conditions.

Figure 8.–ARIS with a telephoto lens mounted to a pod with PT-25 rotator (top left), ARIS with spreader lens installed on the front of the telephoto lens (lower left), and HTI split beam transducer mounted on the pod with PT-25 rotator (right), at the Pilot Station sonar project on the Yukon River.

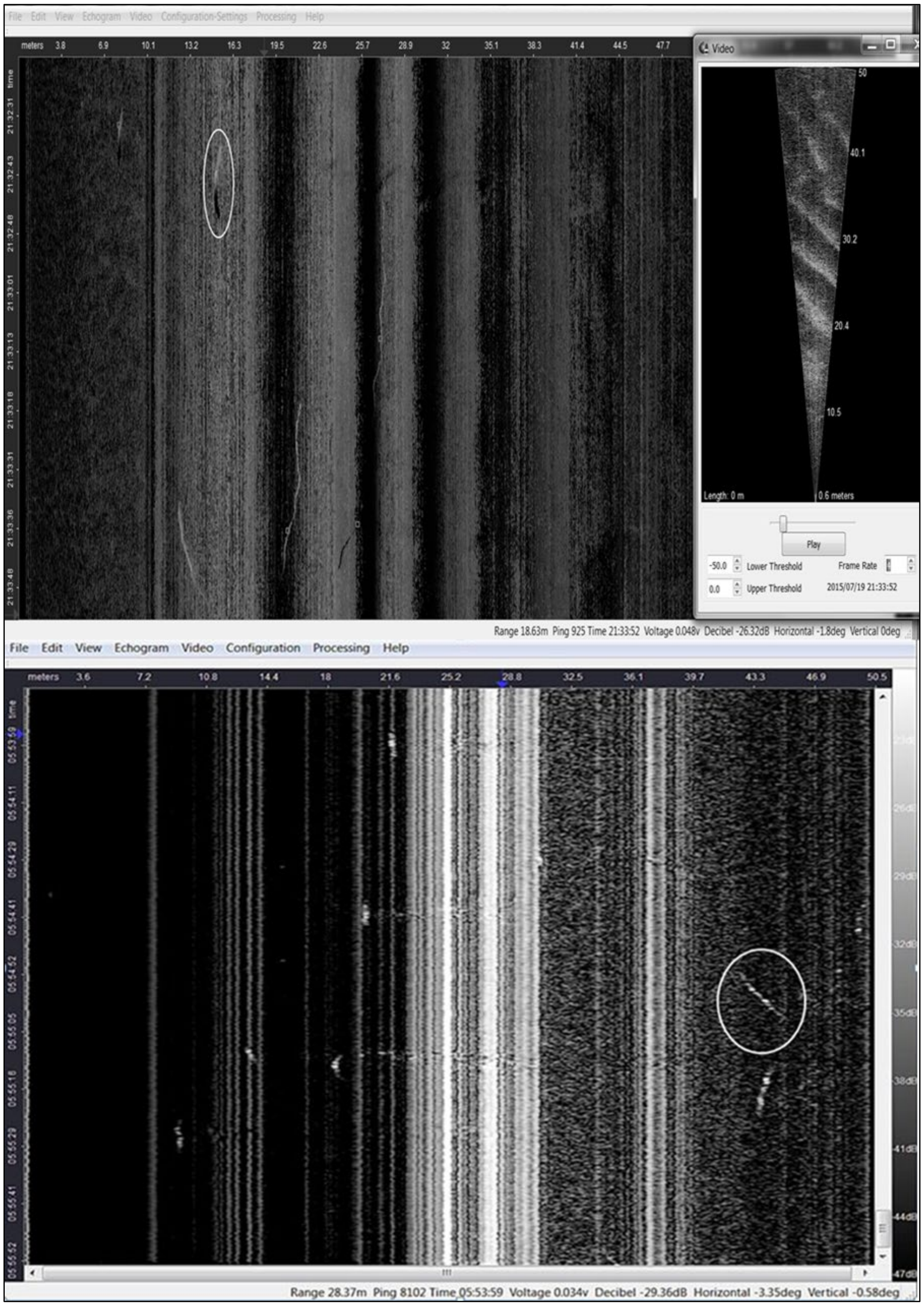

Figure 9.–Echogram of ARIS alongside video image (top) and split-beam sonar (bottom), with oval around representative fish.

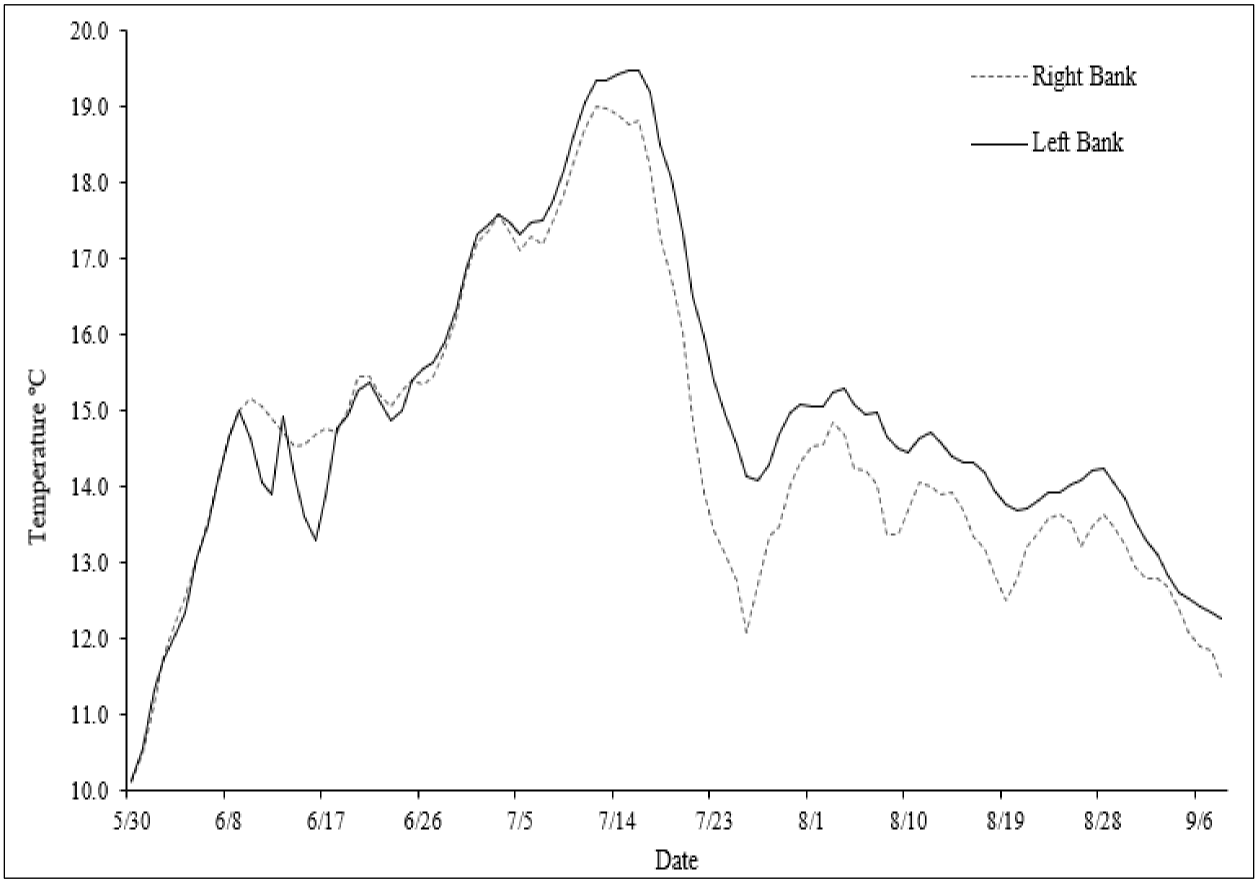

Figure 10.–Mean daily water temperatures recorded at the Pilot Station sonar project on the Yukon River with electronic data loggers by bank, 2022.

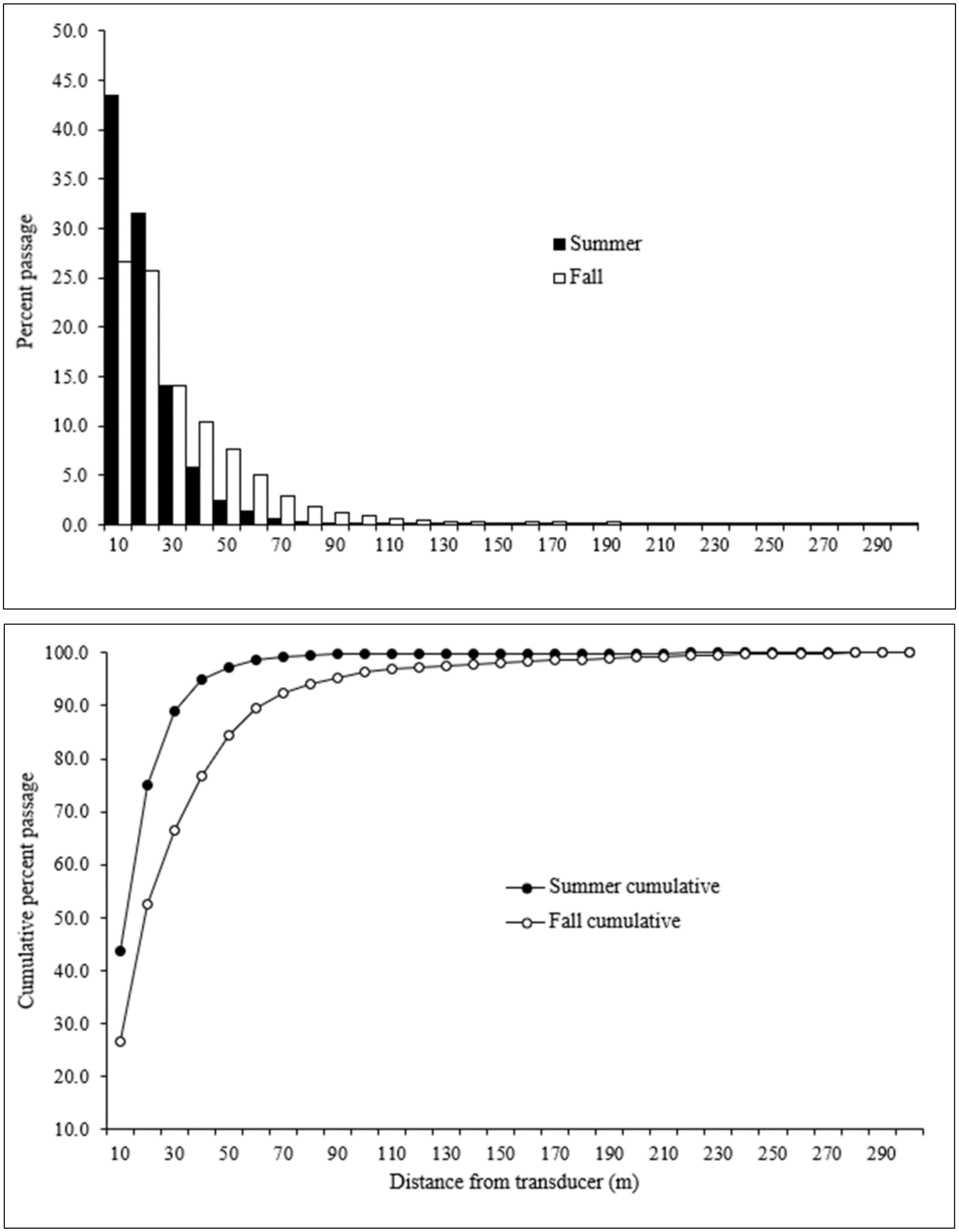

Figure 11.–Distribution of left bank passage (top) and cumulative passage as a function of range (bottom) at the Pilot Station sonar project on the Yukon River, 2022.

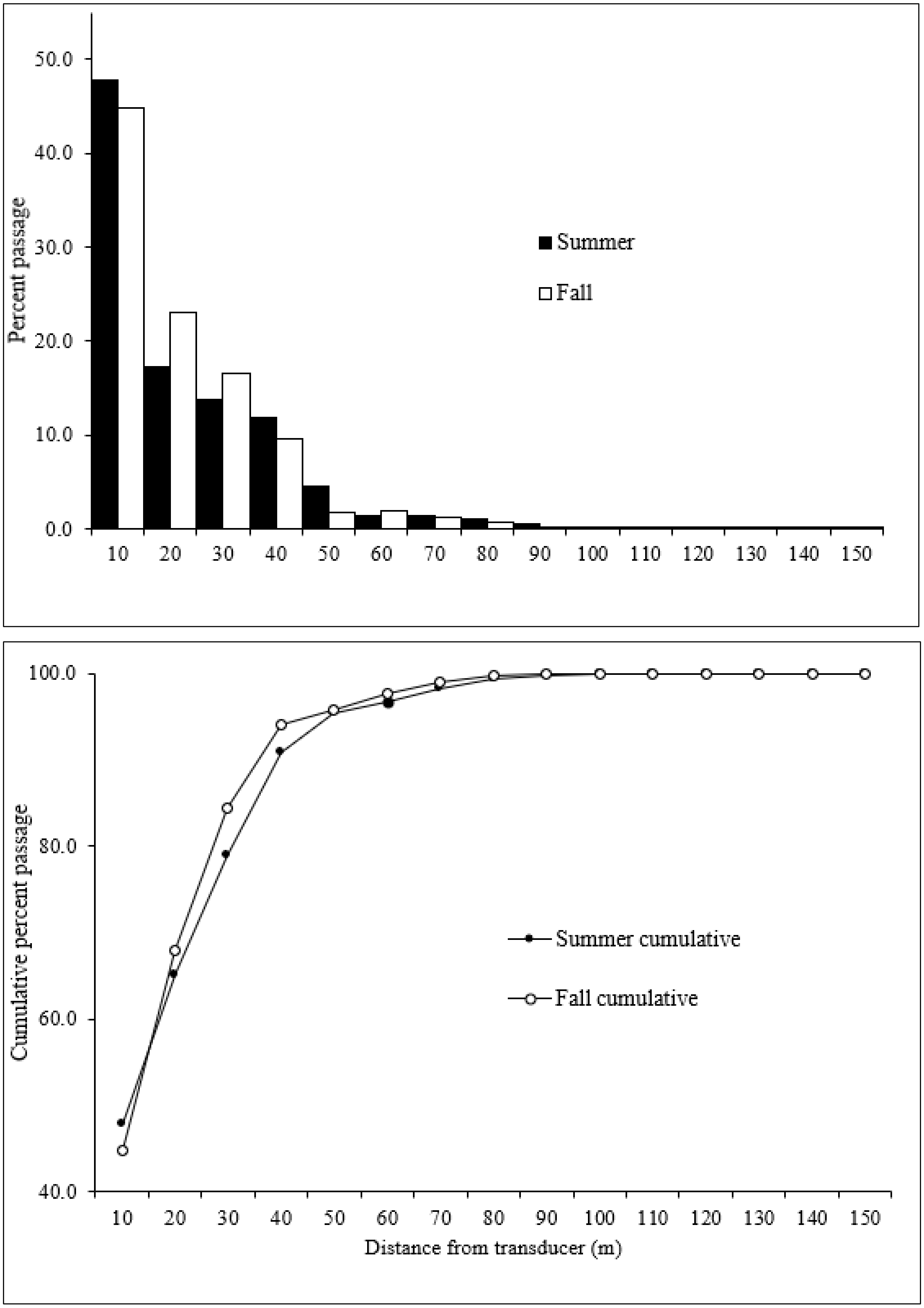

Figure 12.–Distribution of right bank passage (top) and cumulative passage as a function of range (bottom) at the Pilot Station sonar project on the Yukon River, 2022.

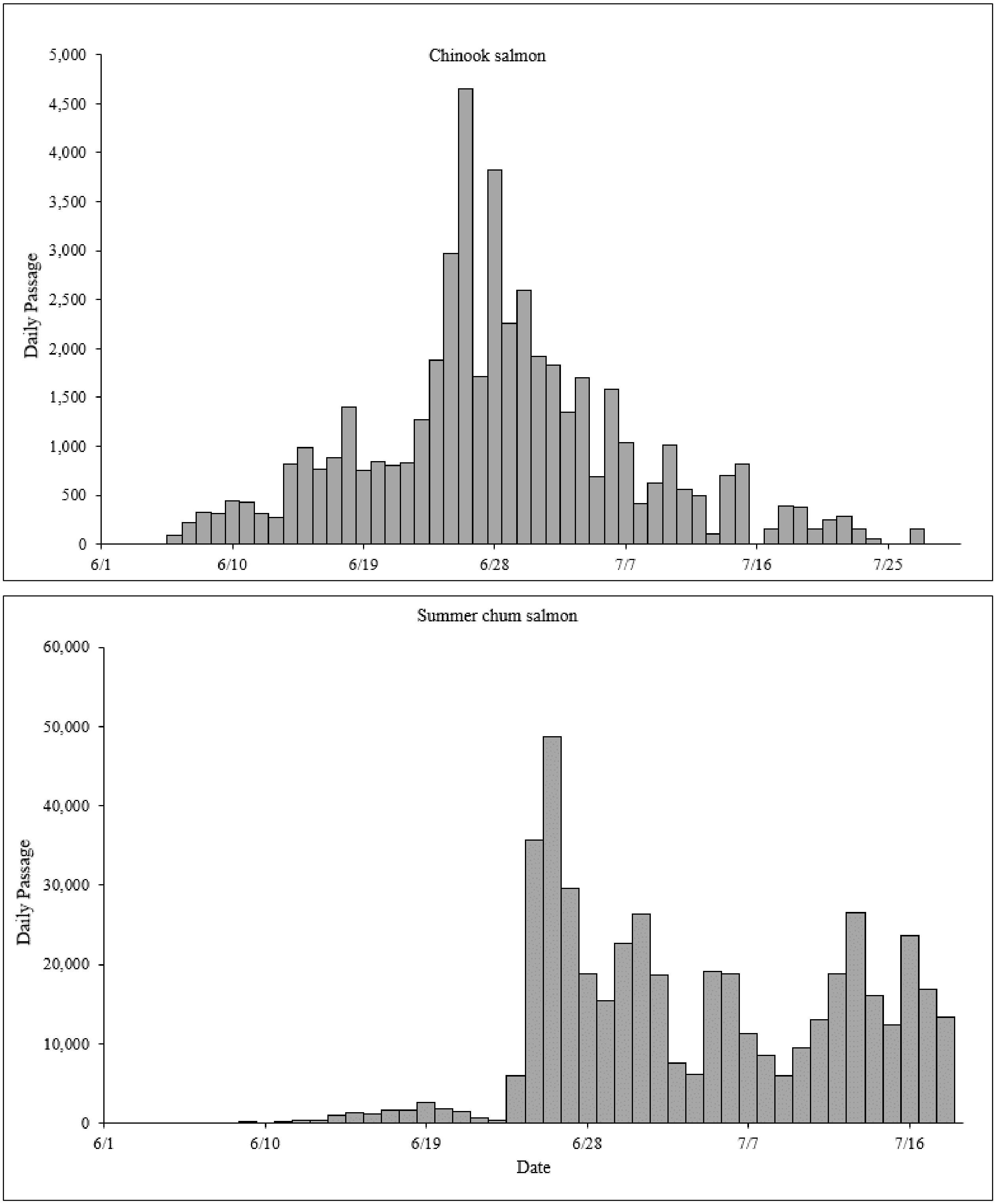

Figure 13.–Chinook (top) and summer chum salmon (bottom) daily passage estimates at the Pilot Station sonar project on the Yukon River, 2022.

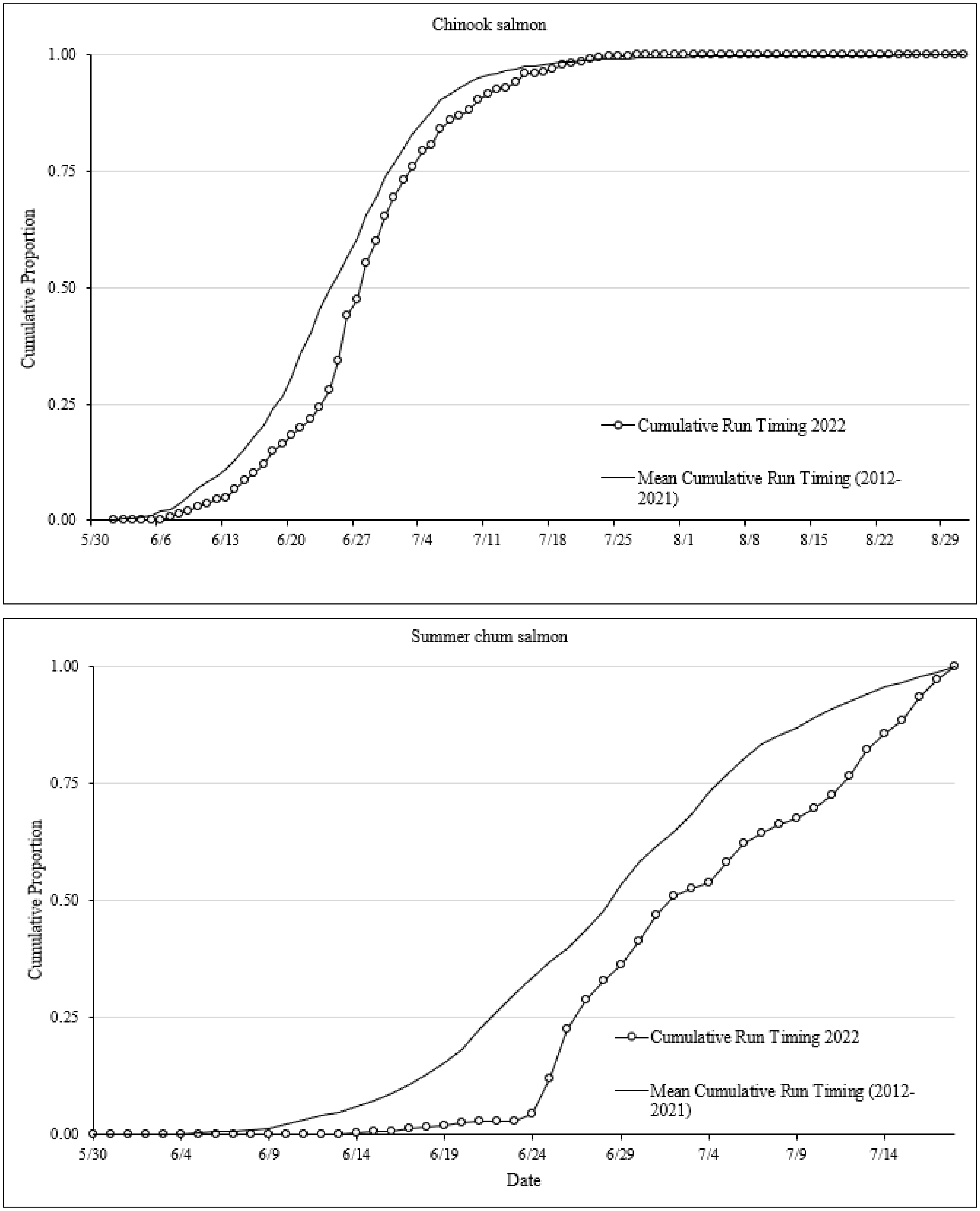

Figure 14.–2022 Chinook (top) and summer chum (bottom) salmon daily cumulative passage timing compared to the 2012–2021 mean passage timing at the Pilot Station sonar project on the Yukon River.

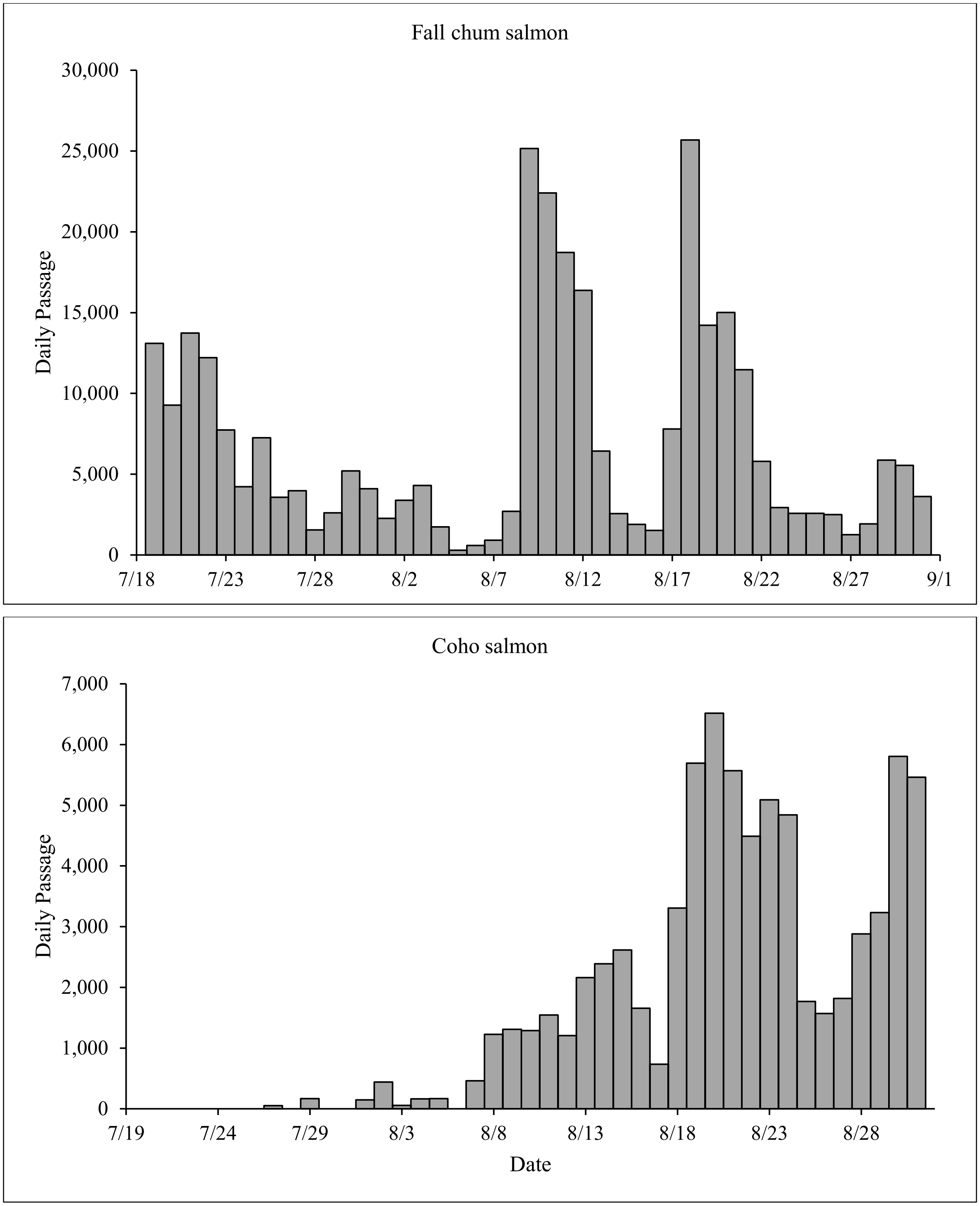

Figure 15.–Fall chum (top) and coho (bottom) salmon daily passage estimates at the Pilot Station sonar project on the Yukon River, 2022.

Note: The mean cumulative run timing for both fall chum and coho salmon was based on run timing from July 19 through August 31 in order to compare timing across years, despite years when the project was in operation until September 7.

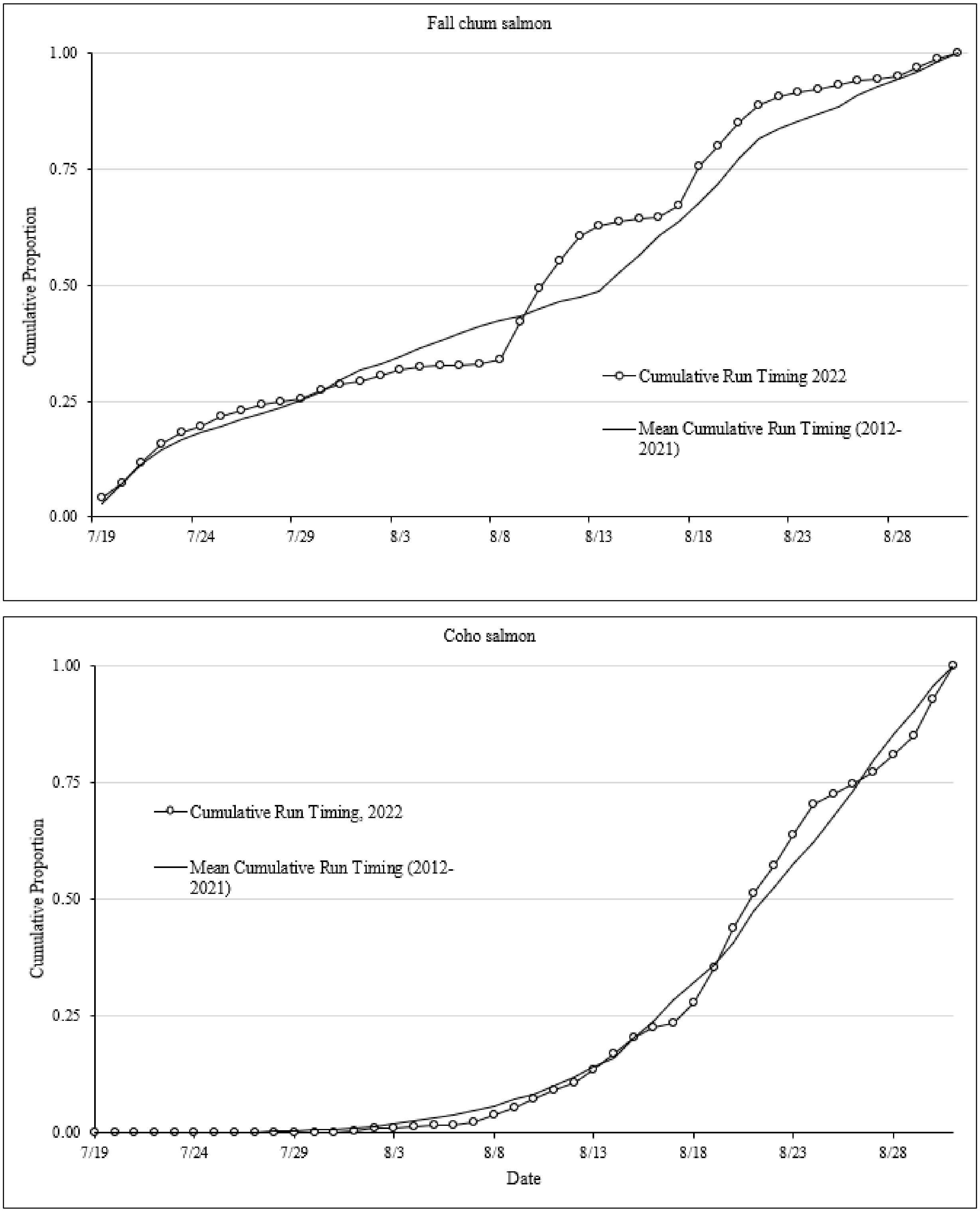

Figure 16.–2022 Fall chum (top) and coho (bottom) salmon daily cumulative passage timing compared to the 2012–2021 mean passage timing at the Pilot Station sonar project on the Yukon River.

Note: The mean cumulative run timing for both fall chum and coho salmon was based on run timing from July 19 through August 31 in order to compare timing across years, despite years when the project was in operation until September 7.

APPENDIX A: NET SELECTIVITY PARAMETERS USED IN FISH SPECIES APPORTIONMENT AT THE PILOT STATION SONAR PROJECT

Appendix A1.–Net selectivity parameters used in species apportionment, at the Pilot Station sonar project on the Yukon River, 2022.

Species	Tau	Sigma	Theta	Lambda	Tangle
Large Chinook [a]	1.9086	0.2234	0.6271	-0.4570	0.0034
Small Chinook [b]	1.9086	0.2234	0.6271	-0.4570	0.0034
Summer chum	1.9687	0.1468	0.7877	-0.4310	0.0413
Fall chum	1.8780	0.1850	0.9279	-0.8709	0.0000
Coho	1.9626	0.1509	0.4216	-0.6103	0.1483
Sockeye	1.9784	0.2863	0.7906	-1.2515	0.0326
Pink	1.9630	0.3577	2.6395	3.3087	0.1521
Broad whitefish	1.8116	0.2249	1.1176	-1.8781	0.1303
Humpback whitefish	1.9231	0.2561	1.1767	-2.1280	0.1283
Cisco	2.1555	0.3160	1.5502	-2.6748	0.2431
Sheefish	2.1692	0.2234	0.7686	-1.7161	0.0000
Other [c]	2.7244	0.5890	1.0437	-3.8246	0.0100

[a] Chinook salmon >655 mm METF.

[b] Chinook salmon ≤655 mm METF.

[c] Includes burbot, long nose sucker, Dolly Varden, and northern pike.

APPENDIX B: SALMON SPECIES CATCH PER UNIT EFFORT BY DAY AND BANK

Appendix B1.–Left bank CPUE, by day and salmon species, at the Pilot Station sonar project on the Yukon River, 2022.

	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
Date	fathom hours	Catch	CPUE	fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
6/01	20.95	0	0.00	18.36	0	0.00	0	0.00	0	0.00
6/02	19.47	0	0.00	19.90	0	0.00	0	0.00	0	0.00
6/03	19.48	0	0.00	20.51	0	0.00	0	0.00	0	0.00
6/04	18.00	0	0.00	17.66	0	0.00	0	0.00	0	0.00
6/05	19.74	0	0.00	18.69	0	0.00	0	0.00	0	0.00
6/06	18.09	0	0.00	18.22	0	0.00	0	0.00	0	0.00
6/07	19.18	1	0.05	18.58	0	0.00	0	0.00	0	0.00
6/08	18.16	0	0.00	19.06	0	0.00	0	0.00	0	0.00
6/09	18.67	2	0.11	18.06	0	0.00	0	0.00	0	0.00
6/10	18.54	0	0.00	18.41	0	0.00	0	0.00	0	0.00
6/11	16.94	1	0.06	18.05	0	0.00	0	0.00	0	0.00
6/12	18.52	0	0.00	18.05	0	0.00	0	0.00	0	0.00
6/13	19.48	0	0.00	19.36	1	0.05	0	0.00	0	0.00
6/14	18.89	2	0.11	18.58	1	0.05	0	0.00	0	0.00
6/15	14.68	4	0.27	19.28	2	0.10	0	0.00	0	0.00
6/16	19.05	6	0.31	18.89	9	0.48	0	0.00	0	0.00
6/17	18.66	7	0.38	19.71	9	0.46	0	0.00	0	0.00
6/18	17.94	4	0.22	18.12	5	0.28	0	0.00	0	0.00
6/19	18.35	3	0.16	19.31	11	0.57	0	0.00	0	0.00
6/20	18.56	5	0.27	18.88	11	0.58	0	0.00	0	0.00
6/21	17.47	5	0.29	19.48	5	0.26	0	0.00	0	0.00
6/22	18.51	1	0.05	19.10	2	0.10	0	0.00	0	0.00
6/23	18.19	10	0.55	18.77	1	0.05	0	0.00	0	0.00
6/24	17.83	11	0.62	18.46	21	1.14	0	0.00	0	0.00
6/25	16.95	9	0.53	15.32	57	3.72	0	0.00	0	0.00
6/26	17.00	15	0.88	12.52	95	7.59	0	0.00	0	0.00
6/27	18.33	8	0.44	13.89	67	4.83	0	0.00	0	0.00
6/28	17.01	8	0.47	14.33	30	2.09	0	0.00	0	0.00
6/29	18.21	13	0.71	16.16	26	1.61	0	0.00	0	0.00
6/30	17.29	4	0.23	15.99	47	2.94	0	0.00	0	0.00
7/01	18.31	6	0.33	15.68	56	3.57	0	0.00	0	0.00
7/02	18.58	3	0.16	16.85	38	2.25	0	0.00	0	0.00
7/03	16.85	2	0.12	16.56	22	1.33	0	0.00	0	0.00

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Date	Large mesh fathom hours	Chinook		Small mesh fathom hours	Summer chum		Fall chum		Coho	
		Catch	CPUE		Catch	CPUE	Catch	CPUE	Catch	CPUE
7/04	17.29	3	0.17	18.23	8	0.44	0	0.00	0	0.00
7/05	16.61	2	0.12	15.68	37	2.36	0	0.00	0	0.00
7/06	18.47	5	0.27	16.12	33	2.05	0	0.00	0	0.00
7/07	18.36	3	0.16	16.02	17	1.06	0	0.00	0	0.00
7/08	17.83	1	0.06	16.63	11	0.66	0	0.00	0	0.00
7/09	24.11	0	0.00	17.01	8	0.47	0	0.00	0	0.00
7/10	18.02	2	0.11	17.67	13	0.74	0	0.00	0	0.00
7/11	17.82	1	0.06	18.22	21	1.15	0	0.00	0	0.00
7/12	17.63	1	0.06	15.11	49	3.24	0	0.00	0	0.00
7/13	18.73	0	0.00	14.55	34	2.34	0	0.00	0	0.00
7/14	18.43	0	0.00	16.81	13	0.77	0	0.00	0	0.00
7/15	17.69	2	0.11	17.59	15	0.85	0	0.00	0	0.00
7/16	17.65	0	0.00	16.50	19	1.15	0	0.00	0	0.00
7/17	17.36	1	0.06	16.63	27	1.62	0	0.00	0	0.00
7/18	18.05	1	0.06	16.48	17	1.03	0	0.00	0	0.00
7/19	5.83	0	0.00	17.26	0	0.00	21	1.22	0	0.00
7/20	5.89	0	0.00	17.29	0	0.00	6	0.35	0	0.00
7/21	6.28	1	0.16	18.82	0	0.00	22	1.17	0	0.00
7/22	5.48	0	0.00	17.57	0	0.00	23	1.31	0	0.00
7/23	6.20	0	0.00	17.01	0	0.00	11	0.65	0	0.00
7/24	6.07	0	0.00	16.97	0	0.00	8	0.47	0	0.00
7/25	6.09	0	0.00	17.67	0	0.00	6	0.34	0	0.00
7/26	4.69	0	0.00	18.21	0	0.00	10	0.55	0	0.00
7/27	6.24	0	0.00	18.61	0	0.00	9	0.48	0	0.00
7/28	5.99	0	0.00	18.10	0	0.00	8	0.44	0	0.00
7/29	5.86	0	0.00	18.38	0	0.00	7	0.38	0	0.00
7/30	5.98	0	0.00	18.32	0	0.00	18	0.98	0	0.00
7/31	5.86	0	0.00	18.50	0	0.00	9	0.49	0	0.00
8/01	6.15	0	0.00	18.44	0	0.00	6	0.33	0	0.00
8/02	5.46	0	0.00	18.09	0	0.00	8	0.44	0	0.00
8/03	5.78	0	0.00	17.72	0	0.00	8	0.45	0	0.00
8/04	5.48	0	0.00	17.21	0	0.00	1	0.06	0	0.00
8/05	5.60	0	0.00	17.49	0	0.00	1	0.06	0	0.00

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Appendix B1.–Page 3 of 3.

Date	Large mesh fathom hours	Chinook		Small mesh fathom hours	Summer chum		Fall chum		Coho	
		Catch	CPUE		Catch	CPUE	Catch	CPUE	Catch	CPUE
8/06	5.48	0	0.00	18.31	0	0.00	2	0.11	0	0.00
8/07	6.03	0	0.00	17.26	0	0.00	2	0.12	0	0.00
8/08	5.63	0	0.00	16.98	0	0.00	8	0.47	0	0.00
8/09	5.71	0	0.00	16.32	0	0.00	81	4.96	0	0.00
8/10	5.70	0	0.00	15.64	0	0.00	63	4.03	1	0.06
8/11	5.58	0	0.00	16.14	0	0.00	48	2.97	3	0.19
8/12	5.87	0	0.00	15.83	0	0.00	38	2.40	1	0.06
8/13	6.43	0	0.00	18.21	0	0.00	21	1.15	4	0.22
8/14	6.07	0	0.00	18.03	0	0.00	6	0.33	3	0.17
8/15	5.97	0	0.00	17.43	0	0.00	8	0.46	4	0.23
8/16	5.82	0	0.00	17.99	0	0.00	5	0.28	4	0.22
8/17	6.01	0	0.00	16.99	0	0.00	24	1.41	0	0.00
8/18	6.15	0	0.00	16.19	0	0.00	56	3.46	1	0.06
8/19	5.86	0	0.00	18.49	0	0.00	19	1.03	2	0.11
8/20	5.22	0	0.00	16.98	0	0.00	45	2.65	14	0.82
8/21	5.47	0	0.00	17.29	0	0.00	24	1.39	6	0.35
8/22	5.48	0	0.00	16.83	0	0.00	22	1.31	9	0.53
8/23	5.88	0	0.00	18.02	0	0.00	6	0.33	2	0.11
8/24	5.32	0	0.00	16.96	0	0.00	6	0.35	7	0.41
8/25	6.08	0	0.00	11.44	0	0.00	8	0.70	1	0.09
8/26	5.11	0	0.00	17.02	0	0.00	5	0.29	2	0.12
8/27	5.90	0	0.00	17.26	0	0.00	3	0.17	2	0.12
8/28	5.99	0	0.00	17.33	0	0.00	4	0.23	3	0.17
8/29	6.12	0	0.00	16.68	0	0.00	7	0.42	2	0.12
8/30	5.91	0	0.00	17.24	0	0.00	18	1.04	7	0.41
8/31	5.86	0	0.00	17.19	0	0.00	15	0.87	11	0.64
9/01	5.62	0	0.00	17.83	0	0.00	17	0.95	7	0.39
9/02	5.40	0	0.00	16.98	0	0.00	13	0.77	8	0.47
9/03	5.79	0	0.00	17.02	0	0.00	4	0.23	5	0.29
9/04	5.92	0	0.00	16.94	0	0.00	5	0.30	4	0.24
9/05	5.75	0	0.00	16.86	0	0.00	2	0.12	4	0.24
9/06	6.10	0	0.00	17.36	0	0.00	1	0.06	3	0.17
9/07	5.55	0	0.00	17.69	0	0.00	6	0.34	1	0.06
Total	1,171.64	153	8.72	1,720.43	838	53.98	774	45.87	121	7.07

Appendix B2.–Right bank CPUE, by day and salmon species, at the Pilot Station sonar project on the Yukon River, 2022.

	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
Date	fathom hours	Catch	CPUE	fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
6/01	8.50	0	0.00	8.26	0	0.00	0	0.00	0	0.00
6/02	8.87	0	0.00	10.40	0	0.00	0	0.00	0	0.00
6/03	8.81	0	0.00	7.34	0	0.00	0	0.00	0	0.00
6/04	8.78	0	0.00	8.92	0	0.00	0	0.00	0	0.00
6/05	7.98	0	0.00	9.51	0	0.00	0	0.00	0	0.00
6/06	7.72	0	0.00	9.18	0	0.00	0	0.00	0	0.00
6/07	9.44	0	0.00	5.72	0	0.00	0	0.00	0	0.00
6/08	8.66	0	0.00	8.24	0	0.00	0	0.00	0	0.00
6/09	6.21	0	0.00	5.82	0	0.00	0	0.00	0	0.00
6/10	6.36	1	0.16	8.22	0	0.00	0	0.00	0	0.00
6/11	7.27	0	0.00	7.12	0	0.00	0	0.00	0	0.00
6/12	8.70	0	0.00	9.45	1	0.11	0	0.00	0	0.00
6/13	9.12	1	0.11	10.35	0	0.00	0	0.00	0	0.00
6/14	9.10	0	0.00	8.08	0	0.00	0	0.00	0	0.00
6/15	8.56	0	0.00	8.36	0	0.00	0	0.00	0	0.00
6/16	11.74	1	0.09	9.33	2	0.21	0	0.00	0	0.00
6/17	8.71	0	0.00	9.20	1	0.11	0	0.00	0	0.00
6/18	8.30	1	0.12	6.62	0	0.00	0	0.00	0	0.00
6/19	7.84	1	0.13	8.65	0	0.00	0	0.00	0	0.00
6/20	7.34	0	0.00	8.22	0	0.00	0	0.00	0	0.00
6/21	7.81	0	0.00	9.14	4	0.44	0	0.00	0	0.00
6/22	8.24	1	0.12	8.51	0	0.00	0	0.00	0	0.00
6/23	7.80	1	0.13	8.57	0	0.00	0	0.00	0	0.00
6/24	8.59	0	0.00	8.40	7	0.83	0	0.00	0	0.00
6/25	6.60	2	0.30	7.65	16	2.09	0	0.00	0	0.00
6/26	8.36	3	0.36	8.47	17	2.01	0	0.00	0	0.00
6/27	7.94	2	0.25	6.46	23	3.56	0	0.00	0	0.00
6/28	7.52	0	0.00	7.99	10	1.25	0	0.00	0	0.00
6/29	8.95	1	0.11	8.32	14	1.68	0	0.00	0	0.00
6/30	8.02	1	0.12	7.67	5	0.65	0	0.00	0	0.00
7/01	7.15	1	0.14	7.75	8	1.03	0	0.00	0	0.00
7/02	8.57	1	0.12	8.28	2	0.24	0	0.00	0	0.00
7/03	8.64	0	0.00	8.87	5	0.56	0	0.00	0	0.00

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Appendix B2.–Page 2 of 3.

Date	Large mesh fathom hours	Chinook Catch	Chinook CPUE	Small mesh fathom hours	Summer chum Catch	Summer chum CPUE	Fall chum Catch	Fall chum CPUE	Coho Catch	Coho CPUE
7/04	8.23	1	0.12	7.09	2	0.28	0	0.00	0	0.00
7/05	8.17	1	0.12	8.31	11	1.32	0	0.00	0	0.00
7/06	8.04	1	0.12	8.55	7	0.82	0	0.00	0	0.00
7/07	7.48	2	0.27	7.11	6	0.84	0	0.00	0	0.00
7/08	8.53	1	0.12	8.18	1	0.12	0	0.00	0	0.00
7/09	8.56	0	0.00	8.46	2	0.24	0	0.00	0	0.00
7/10	7.60	0	0.00	7.72	2	0.26	0	0.00	0	0.00
7/11	7.19	0	0.00	7.60	3	0.39	0	0.00	0	0.00
7/12	7.54	0	0.00	7.45	7	0.94	0	0.00	0	0.00
7/13	8.88	1	0.11	7.18	4	0.56	0	0.00	0	0.00
7/14	8.33	0	0.00	7.83	7	0.89	0	0.00	0	0.00
7/15	7.85	0	0.00	8.68	8	0.92	0	0.00	0	0.00
7/16	7.91	0	0.00	8.93	11	1.23	0	0.00	0	0.00
7/17	8.03	0	0.00	6.69	6	0.90	0	0.00	0	0.00
7/18	8.40	0	0.00	8.80	4	0.45	0	0.00	0	0.00
7/19	2.67	0	0.00	8.39	0	0.00	5	0.60	0	0.00
7/20	2.87	0	0.00	8.09	0	0.00	1	0.12	0	0.00
7/21	2.88	0	0.00	8.50	0	0.00	5	0.59	0	0.00
7/22	2.78	1	0.36	8.25	0	0.00	4	0.48	0	0.00
7/23	3.00	0	0.00	7.83	0	0.00	1	0.13	0	0.00
7/24	3.17	0	0.00	9.11	0	0.00	2	0.22	0	0.00
7/25	2.57	0	0.00	8.48	0	0.00	1	0.12	0	0.00
7/26	2.92	0	0.00	8.53	0	0.00	8	0.94	0	0.00
7/27	3.11	0	0.00	8.57	0	0.00	3	0.35	0	0.00
7/28	3.06	0	0.00	8.69	0	0.00	1	0.12	0	0.00
7/29	3.17	0	0.00	8.60	0	0.00	2	0.23	0	0.00
7/30	2.98	0	0.00	8.98	0	0.00	1	0.11	0	0.00
7/31	2.56	0	0.00	8.77	0	0.00	1	0.11	0	0.00
8/01	2.89	0	0.00	8.69	0	0.00	0	0.00	1	0.12
8/02	2.65	0	0.00	8.35	0	0.00	0	0.00	0	0.00
8/03	2.95	0	0.00	8.69	0	0.00	0	0.00	1	0.12
8/04	2.77	0	0.00	8.31	0	0.00	2	0.24	0	0.00
8/05	2.90	0	0.00	8.89	0	0.00	1	0.11	0	0.00

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Appendix B2.–Page 3 of 3.

Date	Large mesh fathom hours	Chinook		Small mesh fathom hours	Summer chum		Fall chum		Coho	
		Catch	CPUE		Catch	CPUE	Catch	CPUE	Catch	CPUE
8/06	2.81	0	0.00	8.74	0	0.00	0	0.00	0	0.00
8/07	2.81	0	0.00	7.72	0	0.00	0	0.00	0	0.00
8/08	3.00	0	0.00	8.04	0	0.00	2	0.25	0	0.00
8/09	2.83	0	0.00	8.65	0	0.00	9	1.04	1	0.12
8/10	2.98	0	0.00	9.11	0	0.00	3	0.33	1	0.11
8/11	3.00	0	0.00	8.00	0	0.00	4	0.50	1	0.12
8/12	2.99	0	0.00	8.19	0	0.00	8	0.98	1	0.12
8/13	2.81	0	0.00	9.94	0	0.00	7	0.70	3	0.30
8/14	2.99	0	0.00	8.38	0	0.00	2	0.24	2	0.24
8/15	2.87	0	0.00	8.38	0	0.00	1	0.12	4	0.48
8/16	2.19	0	0.00	8.39	0	0.00	0	0.00	1	0.12
8/17	2.83	0	0.00	8.35	0	0.00	6	0.72	3	0.36
8/18	2.34	0	0.00	8.57	0	0.00	25	2.92	3	0.35
8/19	3.04	0	0.00	8.57	0	0.00	10	1.17	2	0.23
8/20	3.03	0	0.00	8.64	0	0.00	11	1.27	4	0.46
8/21	2.90	0	0.00	7.81	0	0.00	6	0.77	2	0.26
8/22	2.66	0	0.00	8.55	0	0.00	5	0.59	4	0.47
8/23	2.59	0	0.00	8.76	0	0.00	0	0.00	2	0.23
8/24	2.55	0	0.00	8.74	0	0.00	5	0.57	5	0.57
8/25	2.82	0	0.00	5.31	0	0.00	3	0.56	0	0.00
8/26	2.52	0	0.00	8.15	0	0.00	0	0.00	1	0.12
8/27	2.93	0	0.00	8.44	0	0.00	1	0.12	3	0.36
8/28	2.91	0	0.00	8.27	0	0.00	3	0.36	3	0.36
8/29	3.01	0	0.00	8.58	0	0.00	6	0.70	2	0.23
8/30	2.92	0	0.00	8.37	0	0.00	4	0.48	5	0.60
8/31	2.88	0	0.00	8.94	0	0.00	1	0.11	12	1.34
9/01	2.99	0	0.00	8.44	0	0.00	0	0.00	5	0.59
9/02	2.55	0	0.00	8.86	0	0.00	2	0.23	4	0.45
9/03	2.65	0	0.00	8.51	0	0.00	0	0.00	3	0.35
9/04	3.05	0	0.00	8.10	0	0.00	2	0.25	4	0.49
9/05	2.89	0	0.00	8.07	0	0.00	0	0.00	3	0.37
9/06	2.85	0	0.00	8.54	0	0.00	0	0.00	1	0.12
9/07	2.83	0	0.00	8.13	0	0.00	0	0.00	3	0.37
Total	537.86	26	3.48	821.61	196	24.93	164	19.45	90	10.53

APPENDIX C: DAILY FISH PASSAGE ESTIMATES BY ZONE WITH STANDARD ERRORS

Appendix C1.–Daily fish passage estimates by zone with standard errors (SE) at the Pilot Station sonar project on the Yukon River, 2022.

Date	Right bank	Left bank	Total		Percent by bank	
			Passage	SE	Right	Left
6/01	761	1,932	2,693	6,382	28.3	71.7
6/02	635	4,750	5,385	791	11.8	88.2
6/03	636	4,025	4,661	597	13.6	86.4
6/04	677	3,139	3,816	973	17.7	82.3
6/05	627	1,150	1,777	108	35.3	64.7
6/06	866	1,098	1,964	124	44.1	55.9
6/07	403	1,069	1,472	200	27.4	72.6
6/08	835	1,427	2,262	296	36.9	63.1
6/09	781	1,388	2,169	127	36.0	64.0
6/10	854	1,641	2,495	195	34.2	65.8
6/11	774	1,608	2,382	262	32.5	67.5
6/12	873	1,645	2,518	104	34.7	65.3
6/13	985	1,241	2,226	161	44.2	55.8
6/14	965	1,878	2,843	311	33.9	66.1
6/15	1,028	2,333	3,361	648	30.6	69.4
6/16	1,308	1,617	2,925	243	44.7	55.3
6/17	1,161	2,723	3,884	328	29.9	70.1
6/18	1,075	4,086	5,161	438	20.8	79.2
6/19	786	3,950	4,736	559	16.6	83.4
6/20	788	3,935	4,723	564	16.7	83.3
6/21	938	3,358	4,296	274	21.8	78.2
6/22	852	2,512	3,364	298	25.3	74.7
6/23	946	3,365	4,311	368	21.9	78.1
6/24	1,108	7,876	8,984	1,955	12.3	87.7
6/25	2,850	37,379	40,229	6,145	7.1	92.9
6/26	4,971	49,342	54,313	3,281	9.2	90.8
6/27	5,514	31,615	37,129	2,218	14.9	85.1
6/28	4,189	22,246	26,435	1,001	15.8	84.2
6/29	3,380	21,373	24,753	1,024	13.7	86.3
6/30	4,033	25,688	29,721	1,923	13.6	86.4
7/01	4,617	27,341	31,958	2,222	14.4	85.6
7/02	2,677	24,926	27,603	1,923	9.7	90.3
7/03	2,683	18,571	21,254	959	12.6	87.4
7/04	3,133	19,218	22,351	1,863	14.0	86.0
7/05	4,475	31,788	36,263	1,198	12.3	87.7
7/06	3,375	30,579	33,954	2,569	9.9	90.1
7/07	2,449	23,534	25,983	700	9.4	90.6
7/08	2,453	20,301	22,754	696	10.8	89.2
7/09	1,775	19,603	21,378	1,428	8.3	91.7
7/10	1,713	16,969	18,682	740	9.2	90.8
7/11	2,910	19,217	22,127	2,341	13.2	86.8
7/12	6,723	32,734	39,457	3,687	17.0	83.0
7/13	6,799	34,104	40,903	1,001	16.6	83.4
7/14	6,267	32,602	38,869	868	16.1	83.9
7/15	7,425	31,556	38,981	1,969	19.0	81.0
7/16	8,261	36,612	44,873	1,388	18.4	81.6
7/17	8,342	28,535	36,877	2,612	22.6	77.4
7/18	8,466	23,162	31,628	859	26.8	73.2
7/19	9,857	25,690	35,547	1,549	27.7	72.3
7/20	3,776	20,525	24,301	1,406	15.5	84.5

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Date	Right bank	Left bank	Total Passage	Total SE	Percent by bank Right	Percent by bank Left
7/21	3,125	18,699	21,824	664	14.3	85.7
7/22	2,940	18,746	21,686	1,129	13.6	86.4
7/23	1,894	16,396	18,290	956	10.4	89.6
7/24	2,857	13,145	16,002	1,100	17.9	82.1
7/25	1,810	8,530	10,340	495	17.5	82.5
7/26	2,237	5,493	7,730	1,099	28.9	71.1
7/27	2,597	8,466	11,063	772	23.5	76.5
7/28	2,714	8,406	11,120	396	24.4	75.6
7/29	2,224	8,922	11,146	396	20.0	80.0
7/30	1,624	9,332	10,956	499	14.8	85.2
7/31	1,747	8,478	10,225	164	17.1	82.9
8/01	2,311	7,227	9,538	483	24.2	75.8
8/02	1,848	7,488	9,336	416	19.8	80.2
8/03	2,346	8,476	10,822	459	21.7	78.3
8/04	1,694	6,758	8,452	365	20.0	80.0
8/05	1,589	6,259	7,848	275	20.2	79.8
8/06	1,899	5,494	7,393	427	25.7	74.3
8/07	1,634	5,798	7,432	332	22.0	78.0
8/08	1,659	7,593	9,252	696	17.9	82.1
8/09	3,943	27,204	31,147	3,432	12.7	87.3
8/10	2,951	30,129	33,080	2,203	8.9	91.1
8/11	2,659	22,271	24,930	721	10.7	89.3
8/12	2,411	19,724	22,135	673	10.9	89.1
8/13	2,251	13,836	16,087	995	14.0	86.0
8/14	1,642	9,755	11,397	665	14.4	85.6
8/15	1,489	7,695	9,184	428	16.2	83.8
8/16	1,854	6,433	8,287	377	22.4	77.6
8/17	2,658	14,986	17,644	3,385	15.1	84.9
8/18	2,472	33,525	35,997	956	6.9	93.1
8/19	2,850	24,528	27,378	1,415	10.4	89.6
8/20	2,536	23,754	26,290	665	9.6	90.4
8/21	2,943	19,259	22,202	1,111	13.3	86.7
8/22	2,498	12,243	14,741	700	16.9	83.1
8/23	2,114	8,798	10,912	287	19.4	80.6
8/24	2,633	6,101	8,734	790	30.1	69.9
8/25	1,367	5,443	6,810	315	20.1	79.9
8/26	1,619	4,957	6,576	273	24.6	75.4
8/27	1,473	3,925	5,398	365	27.3	72.7
8/28	2,362	5,211	7,573	700	31.2	68.8
8/29	3,249	8,622	11,871	736	27.4	72.6
8/30	2,624	10,499	13,123	593	20.0	80.0
8/31	2,359	8,883	11,242	245	21.0	79.0
9/01	2,165	10,137	12,302	448	17.6	82.4
9/02	1,622	7,531	9,153	712	17.7	82.3
9/03	1,596	4,699	6,295	286	25.4	74.6
9/04	1,474	3,874	5,348	281	27.6	72.4
9/05	1,126	3,153	4,279	221	26.3	73.7
9/06	969	3,263	4,232	181	22.9	77.1
9/07	1,393	4,070	5,463	274	25.5	74.5
Season	249,826	1,313,170	1,562,996	99,432	16.0	84.0

APPENDIX D: DAILY FISH PASSAGE ESTIMATES BY SPECIES

Appendix D1.–Daily fish passage estimates by species at the Pilot Station sonar project on the Yukon River, 2022.

	Chinook			Chum						Whitefish				
Date	Large[a]	Small[b]	Total	Summer	Fall	Coho	Sockeye	Pink	Cisco	Humpback	Broad	Sheefish	Other[c]	Total
6/01	0	0	0	0	0	0	0	0	1,227	0	968	324	174	2,693
6/02	0	0	0	0	0	0	0	0	2,668	0	1,957	457	303	5,385
6/03	0	0	0	0	0	0	0	0	2,288	0	1,692	414	267	4,661
6/04	0	0	0	0	0	0	0	0	2,617	0	232	899	68	3,816
6/05	0	0	0	0	0	0	0	0	1,066	0	215	433	63	1,777
6/06	0	92	92	0	0	0	0	0	1,202	0	219	393	58	1,964
6/07	174	43	217	0	0	0	0	0	608	319	102	199	27	1,472
6/08	232	88	320	0	0	0	0	0	933	425	211	317	56	2,262
6/09	227	83	310	1	0	0	0	0	893	414	197	302	52	2,169
6/10	336	107	443	0	0	0	0	0	695	642	302	413	0	2,495
6/11	325	100	425	1	0	0	0	0	668	603	281	404	0	2,382
6/12	226	87	313	327	0	0	0	0	523	269	283	766	37	2,518
6/13	212	66	278	290	0	0	0	0	394	304	238	680	42	2,226
6/14	815	0	815	1,072	0	0	0	0	0	171	215	570	0	2,843
6/15	991	0	991	1,296	0	0	0	0	0	215	229	630	0	3,361
6/16	610	155	765	1,226	0	0	0	0	0	4	291	639	0	2,925
6/17	657	229	886	1,586	0	0	0	0	711	0	228	400	73	3,884
6/18	879	524	1,403	1,604	0	0	0	0	961	0	468	657	68	5,161
6/19	446	312	758	2,549	0	0	0	0	612	0	154	613	50	4,736
6/20	598	247	845	1,815	0	0	0	0	1,599	0	0	388	76	4,723
6/21	494	310	804	1,436	0	0	0	0	1,088	503	0	375	90	4,296
6/22	594	232	826	708	0	0	0	0	723	377	0	579	151	3,364
6/23	966	300	1,266	349	0	0	0	0	1,772	0	0	756	168	4,311
6/24	1,593	286	1,879	5,962	0	0	0	0	40	86	0	1,017	0	8,984
6/25	2,119	852	2,971	35,735	0	0	0	0	919	0	0	604	0	40,229
6/26	2,087	2,563	4,650	48,685	0	0	0	0	781	0	0	197	0	54,313
6/27	635	1,082	1,717	29,621	0	0	0	0	3,874	1,455	0	462	0	37,129
6/28	2,819	1,003	3,822	18,884	0	0	102	378	1,147	972	0	1,130	0	26,435

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Appendix D1.–Page 2 of 4.

	Chinook			Chum						Whitefish				
Date	Large[a]	Small[b]	Total	Summer	Fall	Coho	Sockeye	Pink	Cisco	Humpback	Broad	Sheefish	Other[c]	Total
6/29	1,634	620	2,254	15,473	0	0	192	768	4,593	855	0	618	0	24,753
6/30	2,589	0	2,589	22,620	0	0	0	1,003	2,944	0	0	0	565	29,721
7/01	1,401	520	1,921	26,358	0	0	144	303	2,156	819	0	257	0	31,958
7/02	711	1,124	1,835	18,640	0	0	219	390	5,142	169	0	864	344	27,603
7/03	629	716	1,345	7,634	0	0	380	1,820	8,907	616	135	417	0	21,254
7/04	1,275	422	1,697	6,156	0	0	0	4,773	6,370	2,752	0	348	255	22,351
7/05	478	207	685	19,105	0	0	0	3,749	8,243	4,305	0	76	100	36,263
7/06	780	799	1,579	18,816	0	0	94	1,938	4,714	6,319	0	494	0	33,954
7/07	914	121	1,035	11,227	0	0	292	4,514	7,403	1,069	0	244	199	25,983
7/08	413	0	413	8,473	0	0	0	3,572	5,465	4,038	0	793	0	22,754
7/09	622	0	622	5,940	0	0	0	6,425	6,163	1,896	0	278	54	21,378
7/10	740	271	1,011	9,445	0	0	0	3,956	2,559	1,070	406	173	62	18,682
7/11	564	0	564	13,030	0	0	0	3,364	3,943	953	0	186	87	22,127
7/12	258	238	496	18,875	0	0	140	7,020	6,413	5,190	321	1,002	0	39,457
7/13	0	104	104	26,494	0	0	0	5,642	4,589	3,509	0	565	0	40,903
7/14	700	0	700	16,111	0	0	284	10,913	7,333	3,264	176	88	0	38,869
7/15	505	310	815	12,451	0	0	369	11,147	2,003	11,813	0	383	0	38,981
7/16	0	0	0	23,610	0	0	117	11,357	4,094	5,243	0	452	0	44,873
7/17	157	0	157	16,832	0	0	0	7,235	3,419	9,011	0	223	0	36,877
7/18	0	385	385	13,369	0	0	356	9,445	3,724	4,349	0	0	0	31,628
7/19	198	181	379	0	13,098	0	0	9,073	4,615	7,177	0	692	513	35,547
7/20	157	0	157	0	9,280	0	0	7,387	4,409	902	1,632	534	0	24,301
7/21	243	0	243	0	13,727	0	0	2,946	2,060	2,397	107	344	0	21,824
7/22	106	182	288	0	12,212	0	0	2,477	5,387	277	571	474	0	21,686
7/23	0	163	163	0	7,738	0	0	4,712	2,935	1,983	30	729	0	18,290
7/24	50	0	50	0	4,229	0	0	6,971	1,060	3,478	0	107	107	16,002
7/25	0	0	0	0	7,261	0	142	841	621	1,039	0	436	0	10,340
7/26	0	0	0	0	3,574	0	97	2,002	998	913	39	107	0	7,730
7/27	0	156	156	0	3,974	51	0	3,037	1,862	1,863	120	0	0	11,063
7/28	0	0	0	0	1,550	0	29	4,832	2,742	1,495	207	183	82	11,120
7/29	0	0	0	0	2,612	166	47	2,068	3,216	2,588	0	323	126	11,146

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	Chinook			Chum						Whitefish				
Date	Large[a]	Small[b]	Total	Summer	Fall	Coho	Sockeye	Pink	Cisco	Humpback	Broad	Sheefish	Other[c]	Total
7/30	0	0	0	0	5,198	0	0	2,078	1,608	1,872	59	141	0	10,956
7/31	0	0	0	0	4,103	0	144	1,273	2,846	1,472	0	387	0	10,225
8/01	0	0	0	0	2,271	145	0	1,644	3,319	1,894	0	0	265	9,538
8/02	0	0	0	0	3,390	439	186	1,109	2,760	1,133	319	0	0	9,336
8/03	0	0	0	0	4,309	55	0	1,179	1,247	3,190	292	63	487	10,822
8/04	0	0	0	0	1,742	165	111	538	1,713	4,183	0	0	0	8,452
8/05	0	0	0	0	299	169	0	519	4,335	2,179	49	193	105	7,848
8/06	0	0	0	0	594	0	0	283	1,226	4,178	636	281	195	7,393
8/07	0	0	0	0	919	462	0	1,059	2,245	2,591	0	156	0	7,432
8/08	0	0	0	0	2,708	1,225	0	467	1,613	3,239	0	0	0	9,252
8/09	0	0	0	0	25,152	1,308	0	635	2,166	1,698	188	0	0	31,147
8/10	0	0	0	0	22,412	1,287	0	1,766	3,786	2,579	326	60	864	33,080
8/11	0	0	0	0	18,721	1,545	0	106	1,429	2,258	527	51	293	24,930
8/12	0	0	0	0	16,374	1,206	0	0	2,247	1,923	45	39	301	22,135
8/13	0	0	0	0	6,435	2,160	82	0	3,046	3,247	695	77	345	16,087
8/14	0	0	0	0	2,556	2,389	0	53	2,682	3,455	35	35	192	11,397
8/15	0	0	0	0	1,891	2,615	0	0	1,882	2,514	248	0	34	9,184
8/16	0	0	0	0	1,525	1,655	0	0	1,860	2,762	303	0	182	8,287
8/17	0	0	0	0	7,794	732	0	0	4,326	4,393	226	0	173	17,644
8/18	0	0	0	0	25,687	3,306	403	0	2,431	3,336	656	0	178	35,997
8/19	0	0	0	0	14,216	5,695	0	0	4,539	2,349	328	0	251	27,378
8/20	0	0	0	0	15,009	6,516	0	0	1,781	2,560	382	0	42	26,290
8/21	0	0	0	0	11,467	5,567	0	0	3,396	1,090	0	0	682	22,202
8/22	0	0	0	0	5,796	4,491	0	0	2,502	1,483	341	58	70	14,741
8/23	0	0	0	0	2,941	5,091	0	0	407	1,259	1,162	0	52	10,912
8/24	0	0	0	0	2,581	4,841	0	0	819	244	0	192	57	8,734
8/25	0	0	0	0	2,583	1,769	0	0	1,466	661	287	0	44	6,810
8/26	0	0	0	0	2,493	1,568	0	0	1,490	714	259	0	52	6,576
8/27	0	0	0	0	1,261	1,816	0	0	1,407	879	0	0	35	5,398

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Appendix D1.–Page 4 of 4.

	Chinook			Chum						Whitefish				
Date	Large[a]	Small[b]	Total	Summer	Fall	Coho	Sockeye	Pink	Cisco	Humpback	Broad	Sheefish	Other[c]	Total
8/28	0	0	0	0	1,931	2,882	0	0	1,174	1,212	263	0	111	7,573
8/29	0	0	0	0	5,869	3,234	0	0	1,474	865	309	120	0	11,871
8/30	0	0	0	0	5,538	5,806	71	0	147	886	481	194	0	13,123
8/31	0	0	0	0	3,616	5,460	66	0	1,106	613	167	214	0	11,242
9/01	0	0	0	0	5,489	4,069	0	0	2,269	205	60	0	210	12,302
9/02	0	0	0	0	4,302	3,304	75	0	357	608	262	80	165	9,153
9/03	0	0	0	0	1,957	2,821	0	0	647	396	362	47	65	6,295
9/04	0	0	0	0	1,672	2,398	0	0	387	833	0	0	58	5,348
9/05	0	0	0	0	690	1,345	42	0	1,849	0	0	0	353	4,279
9/06	0	0	0	0	1,162	1,122	0	0	591	724	526	0	107	4,232
9/07	0	0	0	0	1,809	1,227	0	0	1,364	763	0	106	194	5,463
Total	33,159	15,280	48,439	463,806	325,717	92,102	4,184	158,767	238,030	170,551	22,019	28,902	10,479	1,562,996

[a] Chinook salmon >655 mm METF.

[b] Chinook salmon ≤655 mm METF.

[c] Includes cisco, whitefish, sheefish, burbot, long nose sucker, Dolly Varden, and northern pike.

APPENDIX E: DAILY CUMULATIVE FISH PASSAGE PROPORTIONS AND TIMING BY SPECIES

Appendix E1.–Daily cumulative fish passage proportions and timing by species at the Pilot Station sonar project on the Yukon River, 2022.

	Chinook			Chum						Whitefish				
Date	Large [a]	Small [b]	Total	Summer	Fall	Coho	Sockeye	Pink	Cisco	Humpback	Broad	Sheefish	Other [c]	Total
6/01	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.044	0.011	0.017	0.002
6/02	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.000	0.133	0.027	0.046	0.005
6/03	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.000	0.210	0.041	0.071	0.008
6/04	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037	0.000	0.220	0.072	0.077	0.011
6/05	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.041	0.000	0.230	0.087	0.084	0.012
6/06	0.000	0.006	0.002	0.000	0.000	0.000	0.000	0.000	0.046	0.000	0.240	0.101	0.089	0.013
6/07	0.005	0.009	0.006	0.000	0.000	0.000	0.000	0.000	0.049	0.002	0.245	0.108	0.092	0.014
6/08	0.012	0.015	0.013	0.000	0.000	0.000	0.000	0.000	0.053	0.004	**0.254**	0.119	0.097	0.015
6/09	0.019	0.020	0.019	0.000	0.000	0.000	0.000	0.000	0.057	0.007	0.263	0.129	0.102	0.017
6/10	0.029	0.027	0.029	0.000	0.000	0.000	0.000	0.000	0.060	0.011	0.277	0.144	0.102	0.018
6/11	0.039	0.034	0.037	0.000	0.000	0.000	0.000	0.000	0.062	0.014	0.290	0.158	0.102	0.020
6/12	0.046	0.039	0.044	0.001	0.000	0.000	0.000	0.000	0.065	0.016	0.302	0.184	0.105	0.021
6/13	0.052	0.044	0.050	0.001	0.000	0.000	0.000	0.000	0.066	0.017	0.313	0.208	0.109	0.023
6/14	0.077	0.044	0.066	0.004	0.000	0.000	0.000	0.000	0.066	0.018	0.323	0.227	0.109	0.025
6/15	0.107	0.044	0.087	0.006	0.000	0.000	0.000	0.000	0.066	0.020	0.333	0.249	0.109	0.027
6/16	0.125	0.054	0.103	0.009	0.000	0.000	0.000	0.000	0.066	0.020	0.347	**0.271**	0.109	0.029
6/17	0.145	0.069	0.121	0.013	0.000	0.000	0.000	0.000	0.069	0.020	0.357	0.285	0.116	0.031
6/18	0.171	0.103	0.150	0.016	0.000	0.000	0.000	0.000	0.073	0.020	0.378	0.308	0.123	0.035
6/19	0.185	0.123	0.165	0.021	0.000	0.000	0.000	0.000	0.076	0.020	0.385	0.329	0.128	0.038
6/20	0.203	0.140	0.183	0.025	0.000	0.000	0.000	0.000	0.083	0.020	0.385	0.342	0.135	0.041
6/21	0.218	0.160	0.200	0.028	0.000	0.000	0.000	0.000	0.087	0.023	0.385	0.355	0.144	0.043
6/22	0.236	0.175	0.217	0.030	0.000	0.000	0.000	0.000	0.090	0.025	0.385	0.375	0.158	0.045
6/23	**0.265**	0.195	0.243	0.031	0.000	0.000	0.000	0.000	0.098	0.025	0.385	0.402	0.174	0.048
6/24	0.313	0.213	**0.282**	0.044	0.000	0.000	0.000	0.000	0.098	0.025	0.385	0.437	0.174	0.054
6/25	0.377	**0.269**	0.343	0.121	0.000	0.000	0.000	0.000	0.102	0.025	0.385	0.458	0.174	0.080
6/26	0.440	0.437	0.439	0.226	0.000	0.000	0.000	0.000	0.105	0.025	0.385	0.465	0.174	0.114
6/27	0.459	**0.508**	0.474	**0.289**	0.000	0.000	0.000	0.000	0.121	0.034	0.385	0.481	0.174	0.138
6/28	**0.544**	0.573	**0.553**	0.330	0.000	0.000	0.002	0.024	0.126	0.040	0.385	**0.520**	0.174	0.155
6/29	0.593	0.614	0.600	0.364	0.000	0.000	0.007	0.070	0.145	0.045	0.385	0.541	0.174	0.171
6/30	0.671	0.614	0.653	0.412	0.000	0.000	0.014	0.070	0.158	0.045	0.385	0.541	0.228	0.190
7/01	0.714	0.648	0.693	0.469	0.000	0.000	0.015	0.105	0.167	0.049	0.385	0.550	0.228	0.210
7/02	0.735	0.722	0.731	**0.509**	0.000	0.000	0.018	0.157	0.188	0.050	0.385	0.580	**0.261**	0.228
7/03	**0.754**	**0.768**	**0.758**	0.526	0.000	0.000	0.029	0.248	0.226	0.054	0.391	0.594	0.261	0.242
7/04	0.792	0.796	0.794	0.539	0.000	0.000	0.059	0.248	**0.253**	0.070	0.391	0.606	0.285	**0.256**
7/05	0.807	0.810	0.808	0.580	0.000	0.000	0.083	0.248	0.287	0.095	0.391	0.609	0.295	0.279
7/06	0.830	0.862	0.840	0.621	0.000	0.000	0.095	**0.270**	0.307	0.132	0.391	0.626	0.295	0.301

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Appendix E1.–Page 2 of 3.

	Chinook			Chum						Whitefish				
Date	Large [a]	Small [b]	Total	Summer	Fall	Coho	Sockeye	Pink	Cisco	Humpback	Broad	Sheefish	Other [c]	Total
7/07	0.858	0.870	0.862	0.645	0.000	0.000	0.124	0.340	0.338	0.139	0.391	0.634	0.314	0.318
7/08	0.870	0.870	0.870	0.663	0.000	0.000	0.146	0.340	0.361	0.162	0.391	0.662	0.314	0.332
7/09	0.889	0.870	0.883	0.676	0.000	0.000	0.187	0.340	0.387	0.174	0.391	0.671	0.319	0.346
7/10	0.911	0.888	0.904	0.696	0.000	0.000	0.212	0.340	0.398	0.180	0.410	0.677	0.325	0.358
7/11	0.928	0.888	0.916	0.725	0.000	0.000	0.233	0.340	0.414	0.185	0.410	0.684	0.333	0.372
7/12	0.936	0.903	0.926	**0.765**	0.000	0.000	**0.277**	0.374	0.441	0.216	0.424	0.719	0.333	0.397
7/13	0.936	0.910	0.928	0.822	0.000	0.000	0.313	0.374	0.461	0.236	0.424	0.738	0.333	0.423
7/14	0.957	0.910	0.942	0.857	0.000	0.000	0.381	0.441	0.491	**0.256**	0.432	0.741	0.333	0.448
7/15	0.973	0.930	0.959	0.884	0.000	0.000	0.451	**0.530**	**0.500**	0.325	0.432	**0.754**	0.333	0.473
7/16	0.973	0.930	0.959	0.935	0.000	0.000	**0.523**	0.558	0.517	0.356	0.432	0.770	0.333	**0.502**
7/17	0.977	0.930	0.962	0.971	0.000	0.000	0.569	0.558	0.531	0.408	0.432	0.778	0.333	0.525
7/18	0.977	0.955	0.970	1.000	0.000	0.000	0.628	0.643	0.547	0.434	0.432	0.778	0.333	0.546
7/19	0.983	0.967	0.978	1.000	0.040	0.000	0.685	0.643	0.566	0.476	0.432	0.802	0.382	0.568
7/20	0.988	0.967	0.981	1.000	0.069	0.000	0.732	0.643	0.585	0.481	**0.506**	0.820	0.382	0.584
7/21	0.995	0.967	0.986	1.000	0.111	0.000	**0.750**	0.643	0.593	0.495	0.511	0.832	0.382	0.598
7/22	0.998	0.979	0.992	1.000	0.148	0.000	0.766	0.643	0.616	0.497	0.537	0.848	0.382	0.612
7/23	0.998	0.990	0.996	1.000	0.172	0.000	0.796	0.643	0.628	**0.509**	0.539	0.874	0.382	0.624
7/24	1.000	0.990	0.997	1.000	0.185	0.000	0.839	0.643	0.633	0.529	0.539	0.877	0.392	0.634
7/25	1.000	0.990	0.997	1.000	0.207	0.000	0.845	0.677	0.636	0.535	0.539	0.892	0.392	0.640
7/26	1.000	0.990	0.997	1.000	0.218	0.000	0.857	0.700	0.640	0.540	0.540	0.896	0.392	0.645
7/27	1.000	1.000	1.000	1.000	0.231	0.001	0.876	0.700	0.648	0.551	0.546	0.896	0.392	0.652
7/28	1.000	1.000	1.000	1.000	0.235	0.001	0.907	0.707	0.659	0.560	0.555	0.903	0.400	0.659
7/29	1.000	1.000	1.000	1.000	0.243	0.002	0.920	0.718	0.673	0.575	0.555	0.914	0.412	0.667
7/30	1.000	1.000	1.000	1.000	**0.259**	0.002	0.933	0.718	0.679	0.586	0.558	0.919	0.412	0.674
7/31	1.000	1.000	1.000	1.000	0.272	0.002	0.941	**0.752**	0.691	0.595	0.558	0.932	0.412	0.680
8/01	1.000	1.000	1.000	1.000	0.279	0.004	0.951	0.752	0.705	0.606	0.558	0.932	0.437	0.686
8/02	1.000	1.000	1.000	1.000	0.289	0.009	0.958	0.797	0.717	0.613	0.572	0.932	0.437	0.692
8/03	1.000	1.000	1.000	1.000	0.302	0.009	0.966	0.797	0.722	0.631	0.586	0.934	0.484	0.699
8/04	1.000	1.000	1.000	1.000	0.308	0.011	0.969	0.823	0.729	0.656	0.586	0.934	0.484	0.705
8/05	1.000	1.000	1.000	1.000	0.309	0.013	0.972	0.823	0.747	0.669	0.588	0.941	0.494	0.710
8/06	1.000	1.000	1.000	1.000	0.311	0.013	0.974	0.823	**0.753**	0.693	0.617	0.951	**0.512**	0.714
8/07	1.000	1.000	1.000	1.000	0.313	0.018	0.981	0.823	0.762	0.708	0.617	0.956	0.512	0.719
8/08	1.000	1.000	1.000	1.000	0.322	0.031	0.984	0.823	0.769	0.727	0.617	0.956	0.512	0.725
8/09	1.000	1.000	1.000	1.000	0.399	0.045	0.988	0.823	0.778	0.737	0.625	0.956	0.512	0.745
8/10	1.000	1.000	1.000	1.000	0.468	0.059	0.999	0.823	0.794	**0.752**	0.640	0.958	0.595	**0.766**
8/11	1.000	1.000	1.000	1.000	**0.525**	0.076	1.000	0.823	0.800	0.766	0.664	0.960	0.623	0.782

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Appendix E1.–Page 3 of 3.

Date	Chinook			Chum		Coho	Sockeye	Pink	Cisco	Whitefish		Sheefish	Other [c]	Total
	Large [a]	Small [b]	Total	Summer	Fall					Humpback	Broad			
8/12	1.000	1.000	1.000	1.000	0.575	0.089	1.000	0.823	0.809	0.777	0.666	0.961	0.651	0.796
8/13	1.000	1.000	1.000	1.000	0.595	0.113	1.000	0.843	0.822	0.796	0.698	0.964	0.684	0.807
8/14	1.000	1.000	1.000	1.000	0.603	0.139	1.000	0.843	0.833	0.816	0.699	0.965	0.703	0.814
8/15	1.000	1.000	1.000	1.000	0.609	0.167	1.000	0.843	0.841	0.831	0.711	0.965	0.706	0.820
8/16	1.000	1.000	1.000	1.000	0.614	0.185	1.000	0.843	0.849	0.847	0.724	0.965	0.723	0.825
8/17	1.000	1.000	1.000	1.000	0.638	0.193	1.000	0.843	0.867	0.873	0.735	0.965	0.740	0.836
8/18	1.000	1.000	1.000	1.000	0.716	0.229	1.000	0.939	0.877	0.892	**0.764**	0.965	**0.757**	0.859
8/19	1.000	1.000	1.000	1.000	**0.760**	**0.291**	1.000	0.939	0.897	0.906	0.779	0.965	0.781	0.877
8/20	1.000	1.000	1.000	1.000	0.806	0.361	1.000	0.939	0.904	0.921	0.797	0.965	0.785	0.894
8/21	1.000	1.000	1.000	1.000	0.841	0.422	1.000	0.939	0.918	0.928	0.797	0.965	0.850	0.908
8/22	1.000	1.000	1.000	1.000	0.859	0.471	1.000	0.939	0.929	0.936	0.812	0.967	0.857	0.917
8/23	1.000	1.000	1.000	1.000	0.868	**0.526**	1.000	0.939	0.930	0.944	0.865	0.967	0.862	0.924
8/24	1.000	1.000	1.000	1.000	0.876	0.578	1.000	0.939	0.934	0.945	0.865	0.974	0.867	0.930
8/25	1.000	1.000	1.000	1.000	0.884	0.598	1.000	0.939	0.940	0.949	0.878	0.974	0.871	0.934
8/26	1.000	1.000	1.000	1.000	0.892	0.615	1.000	0.939	0.946	0.953	0.890	0.974	0.876	0.938
8/27	1.000	1.000	1.000	1.000	0.896	0.634	1.000	0.939	0.952	0.958	0.890	0.974	0.879	0.942
8/28	1.000	1.000	1.000	1.000	0.901	0.666	1.000	0.939	0.957	0.965	0.902	0.974	0.890	0.947
8/29	1.000	1.000	1.000	1.000	0.919	0.701	1.000	0.939	0.963	0.971	0.916	0.978	0.890	0.954
8/30	1.000	1.000	1.000	1.000	0.936	**0.764**	1.000	0.956	0.964	0.976	0.937	0.985	0.890	0.963
8/31	1.000	1.000	1.000	1.000	0.948	0.823	1.000	0.972	0.969	0.979	0.945	0.992	0.890	0.970
9/01	1.000	1.000	1.000	1.000	0.964	0.867	1.000	0.972	0.978	0.981	0.948	0.992	0.910	0.978
9/02	1.000	1.000	1.000	1.000	0.978	0.903	1.000	0.990	0.980	0.984	0.960	0.995	0.926	0.984
9/03	1.000	1.000	1.000	1.000	0.984	0.934	1.000	0.990	0.982	0.986	0.976	0.996	0.932	0.988
9/04	1.000	1.000	1.000	1.000	0.989	0.960	1.000	0.990	0.984	0.991	0.976	0.996	0.938	0.991
9/05	1.000	1.000	1.000	1.000	0.991	0.974	1.000	1.000	0.992	0.991	0.976	0.996	0.971	0.994
9/06	1.000	1.000	1.000	1.000	0.994	0.987	1.000	1.000	0.994	0.996	1.000	0.996	0.981	0.997
9/07	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Note: The 25th, 50th, and 75th percentiles are bold. The mean cumulative run timing for both fall chum and coho salmon was based on run timing from July 19 through August 31 in order to compare timing across years, despite years when the project was in operation until September 7.

[a] Chinook salmon >655 mm METF.

[b] Chinook salmon ≤655 mm METF.

[c] Includes burbot, long nose sucker, Dolly Varden, and northern pike.

APPENDIX F: DAILY CUMULATIVE FISH PASSAGE ESTIMATES BY SPECIES AT THE PILOT STATION SONAR PROJECT ON THE YUKON RIVER

Appendix F1.–Daily cumulative fish passage estimates at the Pilot Station sonar project on the Yukon River, 2022.

	Chinook			Chum						Whitefish				
Date	Large [a]	Small [b]	Total	Summer	Fall	Coho	Sockeye	Pink	Cisco	Humpback	Broad	Sheefish	Other [c]	Total
6/01	0	0	0	0	0	0	0	0	1,227	0	968	324	174	2,693
6/02	0	0	0	0	0	0	0	0	3,895	0	2,925	781	477	8,078
6/03	0	0	0	0	0	0	0	0	6,183	0	4,617	1,195	744	12,739
6/04	0	0	0	0	0	0	0	0	8,800	0	4,849	2,094	812	16,555
6/05	0	0	0	0	0	0	0	0	9,866	0	5,064	2,527	875	18,332
6/06	0	92	92	0	0	0	0	0	11,068	0	5,283	2,920	933	20,296
6/07	174	135	309	0	0	0	0	0	11,676	319	5,385	3,119	960	21,768
6/08	406	223	629	0	0	0	0	0	12,609	744	5,596	3,436	1,016	24,030
6/09	633	306	939	1	0	0	0	0	13,502	1,158	5,793	3,738	1,068	26,199
6/10	969	413	1,382	1	0	0	0	0	14,197	1,800	6,095	4,151	1,068	28,694
6/11	1,294	513	1,807	2	0	0	0	0	14,865	2,403	6,376	4,555	1,068	31,076
6/12	1,520	600	2,120	329	0	0	0	0	15,388	2,672	6,659	5,321	1,105	33,594
6/13	1,732	666	2,398	619	0	0	0	0	15,782	2,976	6,897	6,001	1,147	35,820
6/14	2,547	666	3,213	1,691	0	0	0	0	15,782	3,147	7,112	6,571	1,147	38,663
6/15	3,538	666	4,204	2,987	0	0	0	0	15,782	3,362	7,341	7,201	1,147	42,024
6/16	4,148	821	4,969	4,213	0	0	0	0	15,782	3,366	7,632	7,840	1,147	44,949
6/17	4,805	1,050	5,855	5,799	0	0	0	0	16,493	3,366	7,860	8,240	1,220	48,833
6/18	5,684	1,574	7,258	7,403	0	0	0	0	17,454	3,366	8,328	8,897	1,288	53,994
6/19	6,130	1,886	8,016	9,952	0	0	0	0	18,066	3,366	8,482	9,510	1,338	58,730
6/20	6,728	2,133	8,861	11,767	0	0	0	0	19,665	3,366	8,482	9,898	1,414	63,453
6/21	7,222	2,443	9,665	13,203	0	0	0	0	20,753	3,869	8,482	10,273	1,504	67,749
6/22	7,816	2,675	10,491	13,911	0	0	0	0	21,476	4,246	8,482	10,852	1,655	71,113
6/23	8,782	2,975	11,757	14,260	0	0	0	0	23,248	4,246	8,482	11,608	1,823	75,424
6/24	10,375	3,261	13,636	20,222	0	0	0	0	23,288	4,332	8,482	12,625	1,823	84,408
6/25	12,494	4,113	16,607	55,957	0	0	0	0	24,207	4,332	8,482	13,229	1,823	124,637
6/26	14,581	6,676	21,257	104,642	0	0	0	0	24,988	4,332	8,482	13,426	1,823	178,950
6/27	15,216	7,758	22,974	134,263	0	0	0	0	28,862	5,787	8,482	13,888	1,823	216,079
6/28	18,035	8,761	26,796	153,147	0	0	102	378	30,009	6,759	8,482	15,018	1,823	242,514
6/29	19,669	9,381	29,050	168,620	0	0	294	1,146	34,602	7,614	8,482	15,636	1,823	267,267
6/30	22,258	9,381	31,639	191,240	0	0	294	2,149	37,546	7,614	8,482	15,636	2,388	296,988
7/01	23,659	9,901	33,560	217,598	0	0	438	2,452	39,702	8,433	8,482	15,893	2,388	328,946
7/02	24,370	11,025	35,395	236,238	0	0	657	2,842	44,844	8,602	8,482	16,757	2,732	356,549
7/03	24,999	11,741	36,740	243,872	0	0	1,037	4,662	53,751	9,218	8,617	17,174	2,732	377,803
7/04	26,274	12,163	38,437	250,028	0	0	1,037	9,435	60,121	11,970	8,617	17,522	2,987	400,154

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Appendix F1.–Page 2 of 3.

Date	Chinook			Chum						Whitefish				
	Large [a]	Small [b]	Total	Summer	Fall	Coho	Sockeye	Pink	Cisco	Humpback	Broad	Sheefish	Other [c]	Total
7/05	26,752	12,370	39,122	269,133	0	0	1,037	13,184	68,364	16,275	8,617	17,598	3,087	436,417
7/06	27,532	13,169	40,701	287,949	0	0	1,131	15,122	73,078	22,594	8,617	18,092	3,087	470,371
7/07	28,446	13,290	41,736	299,176	0	0	1,423	19,636	80,481	23,663	8,617	18,336	3,286	496,354
7/08	28,859	13,290	42,149	307,649	0	0	1,423	23,208	85,946	27,701	8,617	19,129	3,286	519,108
7/09	29,481	13,290	42,771	313,589	0	0	1,423	29,633	92,109	29,597	8,617	19,407	3,340	540,486
7/10	30,221	13,561	43,782	323,034	0	0	1,423	33,589	94,668	30,667	9,023	19,580	3,402	559,168
7/11	30,785	13,561	44,346	336,064	0	0	1,423	36,953	98,611	31,620	9,023	19,766	3,489	581,295
7/12	31,043	13,799	44,842	354,939	0	0	1,563	43,973	105,024	36,810	9,344	20,768	3,489	620,752
7/13	31,043	13,903	44,946	381,433	0	0	1,563	49,615	109,613	40,319	9,344	21,333	3,489	661,655
7/14	31,743	13,903	45,646	397,544	0	0	1,847	60,528	116,946	43,583	9,520	21,421	3,489	700,524
7/15	32,248	14,213	46,461	409,995	0	0	2,216	71,675	118,949	55,396	9,520	21,804	3,489	739,505
7/16	32,248	14,213	46,461	433,605	0	0	2,333	83,032	123,043	60,639	9,520	22,256	3,489	784,378
7/17	32,405	14,213	46,618	450,437	0	0	2,333	90,267	126,462	69,650	9,520	22,479	3,489	821,255
7/18	32,405	14,598	47,003	463,806	0	0	2,689	99,712	130,186	73,999	9,520	22,479	3,489	852,883
7/19	32,603	14,779	47,382	463,806	13,098	0	2,689	108,785	134,801	81,176	9,520	23,171	4,002	888,430
7/20	32,760	14,779	47,539	463,806	22,378	0	2,689	116,172	139,210	82,078	11,152	23,705	4,002	912,731
7/21	33,003	14,779	47,782	463,806	36,105	0	2,689	119,118	141,270	84,475	11,259	24,049	4,002	934,555
7/22	33,109	14,961	48,070	463,806	48,317	0	2,689	121,595	146,657	84,752	11,830	24,523	4,002	956,241
7/23	33,109	15,124	48,233	463,806	56,055	0	2,689	126,307	149,592	86,735	11,860	25,252	4,002	974,531
7/24	33,159	15,124	48,283	463,806	60,284	0	2,689	133,278	150,652	90,213	11,860	25,359	4,109	990,533
7/25	33,159	15,124	48,283	463,806	67,545	0	2,831	134,119	151,273	91,252	11,860	25,795	4,109	1,000,873
7/26	33,159	15,124	48,283	463,806	71,119	0	2,928	136,121	152,271	92,165	11,899	25,902	4,109	1,008,603
7/27	33,159	15,280	48,439	463,806	75,093	51	2,928	139,158	154,133	94,028	12,019	25,902	4,109	1,019,666
7/28	33,159	15,280	48,439	463,806	76,643	51	2,957	143,990	156,875	95,523	12,226	26,085	4,191	1,030,786
7/29	33,159	15,280	48,439	463,806	79,255	217	3,004	146,058	160,091	98,111	12,226	26,408	4,317	1,041,932
7/30	33,159	15,280	48,439	463,806	84,453	217	3,004	148,136	161,699	99,983	12,285	26,549	4,317	1,052,888
7/31	33,159	15,280	48,439	463,806	88,556	217	3,148	149,409	164,545	101,455	12,285	26,936	4,317	1,063,113
8/01	33,159	15,280	48,439	463,806	90,827	362	3,148	151,053	167,864	103,349	12,285	26,936	4,582	1,072,651
8/02	33,159	15,280	48,439	463,806	94,217	801	3,334	152,162	170,624	104,482	12,604	26,936	4,582	1,081,987
8/03	33,159	15,280	48,439	463,806	98,526	856	3,334	153,341	171,871	107,672	12,896	26,999	5,069	1,092,809
8/04	33,159	15,280	48,439	463,806	100,268	1,021	3,445	153,879	173,584	111,855	12,896	26,999	5,069	1,101,261
8/05	33,159	15,280	48,439	463,806	100,567	1,190	3,445	154,398	177,919	114,034	12,945	27,192	5,174	1,109,109
8/06	33,159	15,280	48,439	463,806	101,161	1,190	3,445	154,681	179,145	118,212	13,581	27,473	5,369	1,116,502
8/07	33,159	15,280	48,439	463,806	102,080	1,652	3,445	155,740	181,390	120,803	13,581	27,629	5,369	1,123,934

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Appendix F1.–Page 3 of 3.

	Chinook			Chum						Whitefish				
Date	Large [a]	Small [b]	Total	Summer	Fall	Coho	Sockeye	Pink	Cisco	Humpback	Broad	Sheefish	Other [c]	Total
8/08	33,159	15,280	48,439	463,806	104,788	2,877	3,445	156,207	183,003	124,042	13,581	27,629	5,369	1,133,186
8/09	33,159	15,280	48,439	463,806	129,940	4,185	3,445	156,842	185,169	125,740	13,769	27,629	5,369	1,164,333
8/10	33,159	15,280	48,439	463,806	152,352	5,472	3,445	158,608	188,955	128,319	14,095	27,689	6,233	1,197,413
8/11	33,159	15,280	48,439	463,806	171,073	7,017	3,445	158,714	190,384	130,577	14,622	27,740	6,526	1,222,343
8/12	33,159	15,280	48,439	463,806	187,447	8,223	3,445	158,714	192,631	132,500	14,667	27,779	6,827	1,244,478
8/13	33,159	15,280	48,439	463,806	193,882	10,383	3,527	158,714	195,677	135,747	15,362	27,856	7,172	1,260,565
8/14	33,159	15,280	48,439	463,806	196,438	12,772	3,527	158,767	198,359	139,202	15,397	27,891	7,364	1,271,962
8/15	33,159	15,280	48,439	463,806	198,329	15,387	3,527	158,767	200,241	141,716	15,645	27,891	7,398	1,281,146
8/16	33,159	15,280	48,439	463,806	199,854	17,042	3,527	158,767	202,101	144,478	15,948	27,891	7,580	1,289,433
8/17	33,159	15,280	48,439	463,806	207,648	17,774	3,527	158,767	206,427	148,871	16,174	27,891	7,753	1,307,077
8/18	33,159	15,280	48,439	463,806	233,335	21,080	3,930	158,767	208,858	152,207	16,830	27,891	7,931	1,343,074
8/19	33,159	15,280	48,439	463,806	247,551	26,775	3,930	158,767	213,397	154,556	17,158	27,891	8,182	1,370,452
8/20	33,159	15,280	48,439	463,806	262,560	33,291	3,930	158,767	215,178	157,116	17,540	27,891	8,224	1,396,742
8/21	33,159	15,280	48,439	463,806	274,027	38,858	3,930	158,767	218,574	158,206	17,540	27,891	8,906	1,418,944
8/22	33,159	15,280	48,439	463,806	279,823	43,349	3,930	158,767	221,076	159,689	17,881	27,949	8,976	1,433,685
8/23	33,159	15,280	48,439	463,806	282,764	48,440	3,930	158,767	221,483	160,948	19,043	27,949	9,028	1,444,597
8/24	33,159	15,280	48,439	463,806	285,345	53,281	3,930	158,767	222,302	161,192	19,043	28,141	9,085	1,453,331
8/25	33,159	15,280	48,439	463,806	287,928	55,050	3,930	158,767	223,768	161,853	19,330	28,141	9,129	1,460,141
8/26	33,159	15,280	48,439	463,806	290,421	56,618	3,930	158,767	225,258	162,567	19,589	28,141	9,181	1,466,717
8/27	33,159	15,280	48,439	463,806	291,682	58,434	3,930	158,767	226,665	163,446	19,589	28,141	9,216	1,472,115
8/28	33,159	15,280	48,439	463,806	293,613	61,316	3,930	158,767	227,839	164,658	19,852	28,141	9,327	1,479,688
8/29	33,159	15,280	48,439	463,806	299,482	64,550	3,930	158,767	229,313	165,523	20,161	28,261	9,327	1,491,559
8/30	33,159	15,280	48,439	463,806	305,020	70,356	4,001	158,767	229,460	166,409	20,642	28,455	9,327	1,504,682
8/31	33,159	15,280	48,439	463,806	308,636	75,816	4,067	158,767	230,566	167,022	20,809	28,669	9,327	1,515,924
9/01	33,159	15,280	48,439	463,806	314,125	79,885	4,067	158,767	232,835	167,227	20,869	28,669	9,537	1,528,226
9/02	33,159	15,280	48,439	463,806	318,427	83,189	4,142	158,767	233,192	167,835	21,131	28,749	9,702	1,537,379
9/03	33,159	15,280	48,439	463,806	320,384	86,010	4,142	158,767	233,839	168,231	21,493	28,796	9,767	1,543,674
9/04	33,159	15,280	48,439	463,806	322,056	88,408	4,142	158,767	234,226	169,064	21,493	28,796	9,825	1,549,022
9/05	33,159	15,280	48,439	463,806	322,746	89,753	4,184	158,767	236,075	169,064	21,493	28,796	10,178	1,553,301
9/06	33,159	15,280	48,439	463,806	323,908	90,875	4,184	158,767	236,666	169,788	22,019	28,796	10,285	1,557,533
9/07	33,159	15,280	48,439	463,806	325,717	92,102	4,184	158,767	238,030	170,551	22,019	28,902	10,479	1,562,996

Note: The mean cumulative run timing for both fall chum and coho salmon was based on run timing from July 19 through August 31 in order to compare timing across years, despite years when the project was in operation until September 7.

[a] Chinook salmon >655 mm METF.

[b] Chinook salmon ≤655 mm METF.

[c] Includes sockeye salmon, burbot, long nose sucker, Dolly Varden, and northern pike.

APPENDIX G: PILOT STATION SONAR FISH PASSAGE ESTIMATES BY SPECIES, 1995–2022

Appendix G1.–Salmon passage estimates, by species, at the Pilot Station sonar project on the Yukon River, 1995–2022.

	Chinook			Chum					
Year [a]	Large [b]	Small [c]	Total	Summer	Fall [d]	Total	Coho [d]	Pink	Total
1995	164,867	45,874	210,741	3,632,179	1,156,278	4,788,457	119,893	53,277	5,172,368
1997[e]	114,519	85,244	199,763	1,359,117	579,767	1,938,884	118,065	3,872	2,260,584
1998	88,129	19,909	108,038	824,901	375,222	1,200,123	146,365	103,416	1,557,942
1999	159,805	24,413	184,218	969,459	451,505	1,420,964	76,174	3,947	1,685,303
2000	48,321	6,239	54,560	448,665	273,206	721,871	206,365	61,389	1,044,185
2001[f]	104,060	17,029	121,089	442,546	408,961	851,507	160,272	2,846	1,135,714
2002	111,290	40,423	151,713	1,097,769	367,886	1,465,655	137,077	123,698	1,878,143
2003	287,729	30,359	318,088	1,183,009	923,540	2,106,549	280,552	11,370	2,716,559
2004	138,317	62,444	200,761	1,344,213	633,368	1,977,581	207,844	399,339	2,785,525
2005[g]	165,349	22,527	187,876	2,384,645	1,893,688	4,278,333	194,372	61,091	4,721,672
2006	192,296	36,467	228,763	3,780,760	964,238	4,744,998	163,889	183,006	5,320,656
2007	119,622	50,624	170,246	1,875,491	740,195	2,615,686	192,406	126,282	3,104,620
2008	138,220	36,826	175,046	1,849,553	636,525	2,486,078	145,378	580,127	3,386,629
2009[f]	128,154	49,642	177,796	1,477,186	274,227	1,751,413	240,779	34,529	2,204,517
2010	112,605	25,294	137,899	1,423,372	458,103	1,881,475	177,724	919,036	3,116,134
2011	117,213	31,584	148,797	2,051,501	873,877	2,925,378	149,533	9,754	3,233,462
2012	106,529	21,026	127,555	2,136,476	778,158	2,914,634	130,734	420,344	3,593,267
2013	120,536	16,269	136,805	2,849,683	865,295	3,714,978	110,515	6,126	3,968,424
2014	120,060	43,835	163,895	2,020,309	706,630	2,726,939	283,421	679,126	3,853,381
2015	105,063	41,796	146,859	1,591,505	669,483	2,260,988	121,193	39,690	2,568,730
2016	135,013	41,885	176,898	1,921,748	994,760	2,916,508	168,297	1,364,849	4,626,552
2017	217,821	45,193	263,014	3,093,735	1,829,931	4,923,666	166,320	166,529	5,519,529
2018	122,394	39,437	161,831	1,612,688	928,664	2,541,352	136,347	689,607	3,529,137
2019	172,242	47,382	219,624	1,402,925	842,041	2,244,966	86,401	42,353	2,593,344
2020	124,905	37,347	162,252	692,602	262,439	955,041	107,680	207,942	1,432,915
2021	104,267	20,578	124,845	153,718	146,197	299,915	22,181	37,255	484,196
2022	33,159	15,280	48,439	463,806	325,717	789,523	92,102	158,767	1,088,831

[a] Estimates for all years were generated with the most current apportionment model and may differ from earlier estimates.

[b] Chinook salmon >655 mm METF.

[c] Chinook salmon ≤655 mm METF.

[d] This estimate may not include the entire run. However, in 2008 through 2014, 2018, and 2020 through 2022, operations were extended to September 7 instead of the usual end date of August 31.

[e] The Pilot Station sonar project did not operate at full capacity in 1996, and there are no passage estimates for this year.

[f] High water levels were experienced at Pilot Station; therefore, passage estimates are considered conservative.

[g] Estimates include extrapolations for the dates June 10 to June 18 to account for the time before the DIDSON was deployed.

Appendix G2.–Other passage estimates, by species, at the Pilot Station sonar project on the Yukon River, 1995–2022.

			Whitefish				
Year[a]	Sockeye	Cisco	Humpback	Broad	Sheefish	Other[b]	Total
1995	–	312,907	27,788	297,888	37,322	32,842	708,747
1996[c]	–	–	–	–	–	–	–
1997	–	214,397	106,845	16,270	20,464	18,865	376,841
1998	–	118,820	57,477	6,489	13,513	14,378	210,677
1999	–	170,377	124,257	13,214	11,383	18,470	337,701
2000	–	167,897	66,479	7,362	9,725	11,164	262,627
2001[d]	–	150,350	76,722	6,848	18,894	12,935	265,749
2002	–	208,230	130,800	16,826	20,359	29,319	405,534
2003	–	123,129	169,423	31,368	20,902	34,829	379,651
2004	–	195,371	128,092	18,062	17,990	32,424	391,939
2005[e]	–	194,677	84,102	8,137	17,109	60,225	364,250
2006	–	258,877	188,407	18,768	37,875	27,120	531,047
2007	–	321,498	266,215	26,568	63,639	83,737	761,657
2008	–	150,308	101,799	10,104	32,399	11,615	306,225
2009[d]	–	257,549	231,742	24,532	33,424	42,669	589,916
2010	–	281,456	175,749	19,835	49,250	41,164	567,454
2011	–	242,950	152,164	14,671	25,139	18,613	453,537
2012	–	204,330	191,732	16,814	33,246	17,936	464,058
2013	–	383,326	250,518	16,554	49,568	32,043	732,009
2014	–	290,524	191,658	19,903	25,098	57,648	584,831
2015	–	438,860	261,688	23,122	50,261	80,058	853,989
2016	–	187,421	76,955	10,674	27,759	52,556	355,365
2017	–	414,668	231,428	37,799	32,865	79,439	796,199
2018	–	334,832	124,576	14,695	26,485	47,371	547,959
2019	–	270,434	196,905	25,694	22,673	52,870	568,576
2020	–	163,546	146,162	21,352	24,849	32,378	388,287
2021	–	195,566	264,160	23,859	34,820	38,059	556,464
2022[f]	4,184	238,030	170,551	22,019	28,902	10,479[f]	474,165

Note: En dash means no data.

[a] Estimates for all years were generated with the most current apportionment model and may differ from earlier estimates.

[b] Includes sockeye salmon, burbot, long nose sucker, Dolly Varden, and northern pike.

[c] The Pilot Station sonar project did not operate at full capacity in 1996, and there are no passage estimates for this year.

[d] High water levels were experienced at Pilot Station; therefore, passage estimates are considered conservative.

[e] Estimates include extrapolations for the dates June 10 to June 18 to account for the time before the DIDSON was deployed.

[f] 2022 was the first year of sockeye salmon selectivity curve implementation that produced independent sockeye salmon estimates.