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Sonar Estimation of Salmon Passage in the Yukon River Near Pilot Station Alaska, 2018

by

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and

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August 2019

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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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 2018 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 4,077,096 fish passed through the sonar sampling area between June 1 and September 7. Of those fish, 997,745 passed along the right bank and 3,079,351 passed along the left bank. Included, with 90% confidence intervals, were 122,394 ± 18,687 large Chinook salmon (>655 mm mideye tail fork), 39,437 ± 15,904 small Chinook salmon (≤655 mm mideye tail fork), 1,612,688 ± 107,348 summer chum salmon, 928,664 ± 55,042 fall chum salmon, 136,347 ± 11,895 coho salmon, 689,607 ± 47,967 pink salmon, 334,832 ± 41,824 cisco, 124,576 ± 15,029 humpback whitefish, 14,695 ± 3,547 broad whitefish, 26,485 ± 9,329 sheefish, and 47,371 ± 5,858 other species.

Key words: 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, as well as to meet treaty obligations made under the U.S./Canada Yukon River Salmon Agreement. The diversity and number of fish stocks, combined with the geographic range of user groups, adds 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 multi-channel 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 (Figure 1). The Andreafsky River is the only major salmon spawning tributary downstream of the sonar site (Figure 2), therefore the majority of migrating salmon in the Yukon River pass the sonar project on their way to the spawning grounds.

The Alaska Department of Fish and Game's (ADF&G) primary role 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 (Yukon River Panel 2004). 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 harvests in both the United States and Canada in the future. 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 not only help managers regulate fishing inseason to meet harvest and escapement objectives, but are also used postseason to determine whether treaty obligations were met and to judge effects of management actions.

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 greater ensonification range by reducing signal loss, which helped to increase fish detection at longer ranges (Fleischman et al. 1995). The newly configured equipment's performance was verified using standard acoustic targets in the field.

Until 1995, ADF&G attempted to identify 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 2018 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 2002). Reference to the use of dual-beam sonar at the Pilot Station sonar project can be found in *Yukon River project report, 2000* (Rich 2001). The split-beam technology has the ability to estimate the 3-dimensional position of a target in space which allows the testing of assumptions about 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 2017). The selectivity parameters used in the species apportionment model were updated using the most current catch data prior to the 2018 field season. Species proportions and passage estimates reported in this document were generated using this apportionment model and are comparable to 1995–2017 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 close to shore to swim under the beam, which compromised detection. On June 9, 2005, a multi-beam dual-frequency identification sonar (DIDSON) (Belcher et al. 2002) was deployed in this area to verify nearshore fish detection.[1] The wider beam angle, video like images, and software algorithms that can remove bottom structure from the image, allowed the DIDSON system to detect fish passage within 20 m despite high water levels and problematic erosion, and was operated for the remainder of the season, supplanting split-beam counts in this section of 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-

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

beam sonar. The DIDSON sampled the first 20 m of the left bank nearshore stratum and the remainder of the range was sampled by the split-beam. Beginning in 2015, the DIDSON was replaced with an adaptive resolution imaging sonar (ARIS). The ARIS, when equipped with the telephoto lens, is capable of ensonifying the first 50 m of the left bank.

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

OBJECTIVES

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

Primary project objective was as follows:

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

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. Both the village of Pilot Station and the ADF&G sonar camp are located on the right bank.

The Yukon River, at the sonar site, is approximately 1,000 m wide between the left and right bank transducers (Figure 3). The left bank substrate, composed of silt and fine sand, drops off gradually at a vertical angle of approximately 2° to 4°. The right bank has a stable, rocky bottom that drops off uniformly to the thalweg at a vertical angle of approximately 10° (Figure 4). The thalweg is approximately 25 m deep and is located approximately 200 m offshore of the right bank. River height, as observed from 2007 to 2018 at the United States Geological Survey (USGS) gaging station located downstream of the project, has ranged from a maximum of 8.80 m to a minimum of 4.15 m from June 1 through September 7 (Figure 5).

METHODS

Daily upstream migration of targeted fish species are estimated by multiplying the daily sonar passage of all species and the daily proportions of each targeted fish species are estimated from the drift gillnet test fishery conducted in the same area as the sonar (Figure 6). Test fishery and sonar sampling were both 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 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 3° x 10° nominal beam width;
3. A 250 ft (76.2 m) HTI split-beam transducer cable connecting 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; and
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; and
3. Three 250 ft (228.6 m combined length) HTI split-beam cables connecting the sound 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 adequate field of view. The lengths of cable were necessary for flexibility in 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 necessary to achieve the sampling range.

After echogram files were recorded, Echotastic software was used to mark fish traces. Echograms and associated data were stored on a portable hard drive and transferred to an external redundant array of independent disks (RAID storage system).

Equipment Settings and Thresholds

The split-beam echosounders used a 40 log*R* time-varied gain (TVG) and 0.4 ms transmit pulse duration during all sampling activities. The receiver bandwidth was automatically determined by the equipment based on the transmit pulse duration. On the left bank, the 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 with a start range of 0.69 m and an end range of 50 m, in low-frequency mode (0.7 MHz) (Table 3). The digital sampling used by both the split-beam sonar and ARIS eliminated the use of thresholds during raw data 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).

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 always positioned and aimed to maximize fish detection. The transducer was located in the 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 water level, adjusting the aim between S1 (2–40 m) and S2 (40–150 m). The left bank split-beam transducer was positioned as close to shore as possible (depending on water level), and utilized 2 distinct aims to sample S4 (50–150 m) and S5 (150–300 m). The ARIS unit was normally deployed within 2 m of the split-beam transducer and ensonified S3 (0–50 m) (Figure 7). The ARIS's wider beam angle is 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. Faulkner and Maxwell (2009) further discuss aiming and sonar site selection protocols to count fish using side-looking sonar systems.

Fluctuating water levels required repositioning of the transducers, and subsequent re-aiming of the beams. To establish optimal aim, the transducer was panned horizontally upstream and downstream approximately 15° off perpendicular in 2° increments. 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.

Sampling Procedures

Acoustic sampling was conducted simultaneously on both banks during 3 hour periods 3 times 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 both the split-beam and the ARIS systems on electronic echograms using Echotastic software developed by ADF&G (Figure 9; C. Pfisterer, Commercial Fisheries Biologist, ADF&G, Fairbanks; personal communication). All personnel were trained to distinguish between fish tracings and non-target echoes. Echo traces were counted as a single fish if at least 2 pings in the cluster passed the threshold level (see Equipment Settings and Thresholds) and the targets did not resemble inert downstream objects. Valid downstream and upstream split-beam fish targets were marked when computing the total estimate of fish passage for consistency with historical methods. Individuals within groups of fish were distinguishable when the apparent direction of movement of 1 fish trace differed from that of an adjacent trace.

Echograms were reviewed daily by either the project or crew leader 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 bottom profile. Data was checked daily for data entry or marking errors, then processed in statistical software package *R*[2].

SYSTEM ANALYSES

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 prior to each sampling period, routine checks of water level near the pod, 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. Inseason, the 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 levels were sourced from the real-time USGS gaging station located approximately 500 m downstream of Pilot Station and used inseason. HOBO Water Temperature Loggers were deployed to record water temperature on both banks on May 31 and remained submerged until September 8. The data loggers were programed 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 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, except on days when commercial gillnet fishing was scheduled (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 were drifted within each of 3 zones for a total of 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 were 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

[2] R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

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 in duration, but were shortened as necessary to avoid snags or to limit catches during times of high fish passage.

Captured fish were identified to species and length measured to the nearest 1 mm. Salmon species were measured from mideye to fork of tail (METF); non-salmon 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 (*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. For Chinook salmon that were retained, sex was determined by internal examination of reproductive organs when time permitted. Fish species, length, and sex were recorded onto 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.

A minimum of 3 scale samples were collected from each Chinook salmon, 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 (e.g., Eaton 2016).

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., DeCovich and Howard 2011) and the U.S. Fish and Wildlife Service (USFWS) Conservation Genetics Laboratory (e.g., Flannery and Wenburg 2015) 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. 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 multi-component 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; and
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 in and 8.5 in); chum and coho salmon CPUE was calculated on the pooled catch and effort of the small mesh gillnets (5.25 in, 5.75 in and 6.5 in).

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

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

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:

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

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

To estimate species proportions, test fishery sampling was conducted on both banks. 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:

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

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):

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

To prevent individual fish with extremely low selectivity from inflating the CPUE unreasonably, a threshold was applied 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 ($\hat{p}_{dzi}$):

$$\hat{V}ar\left(\hat{p}_{dzi}\right) = \frac{\sum_{p} \left(\hat{p}_{dzi} - \hat{p}_{dzip}\right)^2}{n_p \left(n_p - 1\right)}, \tag{9}$$

where n_p is the number of test fishery sampling periods within the day.

In order to estimate variance accurately, days with missing test fishery periods were pooled with adjacent days such that there were at least 2 complete test fishery periods. When there is a large span of days with insufficient catches there are 2 options. First, test fishery periods can be pooled across multiple days, or second, a different test fishery zone can be used to apportion sonar strata. Large spans of insufficient catches generally only occur in test fishery Zone 3 (used to apportion sonar strata 4 and 5); in this case test fishery Zone 2 was used to apportion sonar strata 4 and 5.

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 number of hours actually sampled for the same 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:

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

where s^2 is the variance of the passage rate per period:

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

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 were multiplied by the species proportions for the test fishery zones as follows, test fishery Zone 1 was applied to the entire counting range of right bank (sonar strata S1 and S2 approximately 0–150 m). Test fishery Zone 2 was applied to the counting range corresponding to S3 (approximately 0–50 m on the left bank). Test fishery Zone 3 was applied to the counting range corresponding to S4 and S5 (approximately 50–150 m and 150–300 m on the left bank respectively) (Figure 7). The passage of species (i) at stratum (s) for each day was estimated by multiplying total passage ($\hat{y}_{ds}$) and proportion ($\hat{p}_{dzi}$):

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

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),

$$\hat{V}ar\left(\hat{y}_{dis}\right) = \hat{y}_{ds}^2 \bullet \hat{V}ar\left(\hat{p}_{dzi}\right) + \hat{p}_{dzi}^2 \bullet \hat{V}ar\left(\hat{y}_{ds}\right) - \hat{V}ar\left(\hat{y}_{ds}\right) \bullet \hat{V}ar\left(\hat{p}_{dzi}\right) \ . \quad (15)$$

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

$$\hat{y}_{di} = \sum_s \hat{y}_{dis} \text{ and } \hat{V}ar\left(\hat{y}_{di}\right) = \sum_s \hat{V}ar\left(\hat{y}_{dis}\right) \ . \quad (16)$$

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

$$\hat{y}_i = \sum_d \hat{y}_{di} \text{ and } \hat{V}ar\left(\hat{y}_i\right) = \sum_d \hat{V}ar\left(\hat{y}_{di}\right). \quad (17)$$

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

$$\hat{y}_i \pm 1.645\sqrt{\hat{V}ar\left(\hat{y}_i\right)} \ . \quad (18)$$

R program code (C. Pfisterer, Regional Sonar Coordinator, ADF&G, Anchorage; personal communication) was used to calculate CPUE, passage estimates, and estimates of variance.

RESULTS

The Pilot Station sonar project crew arrived at the sonar site on May 26 and began camp set up. Test fishing began during Period 1 on June 1. All sonars were deployed on May 31, and were operational starting Period 2 sonar on June 1. The project was fully operational beginning with Period 2 sonar on June 1 and continued operations through September 7. Passage estimates were transmitted to fishery managers in Emmonak daily.

ENVIRONMENTAL AND HYDROLOGICAL CONDITIONS

Ice break-up on the Yukon River at Pilot Station occurred on May 13, which was the 10-year average (Table 7). The water level near Pilot Station during the 2018 season was above the 2007–2017 mean from June 1 through July 26, then fell below the mean through August 24, again rising above the mean on August 25 and remained above throughout the rest of the season (Figure 5). Mean daily water temperatures on the left bank ranged from 9.6°C to 18.7°C, and from 9.0°C to 18.9°C on the right bank (Figure 10).

TEST FISHERY

Drift gillnetting resulted in the capture of 10,003 fish; 563 Chinook salmon, 2,855 summer chum salmon, 2,699 fall chum salmon, 730 coho salmon, and 3,156 fish of other species. Of the captured fish, 2,010 (20%) were retained as mortalities and delivered to local users within the nearby community of Pilot Station (Table 8). Of the 563 Chinook salmon captured in the test fishery, scale samples were collected from 560. Tissue samples for genetic stock identification were collected from 556 Chinook salmon and 5,495 chum salmon.

HYDROACOUSTIC ESTIMATES

An estimated 4,077,096 fish passed through the sonar sampling areas between June 1 and September 7. Of that total passage, 997,745 (approximately 25%) fish passed along the right bank, 3,079,351 (approximately 75%) fish passed along the left bank (Table 9). Total fish passage estimates, by zone and with associated errors, were calculated daily (Appendix C1).

On the left bank, over 90% of the fish passage occurred within 50 m of the transducer during the summer and approximately 90% of the fish passage occurred within 80 m during the fall season. On the right bank, approximately 90% of the fish passage occurred within 70 m during the summer and fall seasons (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 122,394 ± 18,687 large Chinook salmon (>655 mm METF), and 39,437 ± 15,904 small Chinook salmon (≤655 mm METF). Chum salmon cumulative passage estimates was 1,612,688 ± 107,348 summer chum salmon and 928,664 ± 55,042 fall chum salmon. Coho salmon cumulative passage estimate f was 136,347 ± 11,895 fish, and pink salmon (*O. gorbuscha*) was 689,607 ± 47,967 fish. The cisco cumulative passage estimate was 334,832 ± 41,824 fish, humpback whitefish was 124,576 ± 15,029 fish, broad whitefish was 14,695 ± 3,547, sheefish was 26,485 ± 9,329 fish, and other species (burbot, longnose sucker, Dolly Varden, sockeye salmon, and northern pike) was 47,371 ± 5,858 fish (Table 9).

The initial pulse of Chinook salmon began June 14 and the first pulse of summer chum salmon began 1 day later on June 15 (Figure 13). Compared to the 2007–2017 historical mean run timing, the midpoint of the Chinook salmon run occurred 1 day late (June 26), and summer chum salmon was 1 day late (June 29) (Figure 14; Appendices E and F).

There were 7 distinct fall chum salmon pulses that entered the Yukon River. The sixth pulse was the largest at approximately 239,000 fish in size, and the peak daily passage at the sonar occurred August 30 (Figure 15). Inseason mixed stock analysis (MSA) from the Pilot Station sonar project test fishery was used to generate stock composition estimates of pulses, which were distributed inseason to assist management decisions. Of the 7 pulses, the fall chum salmon composition ranged from 17.8% to 98.9% (Table 10). 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. The midpoint for the fall chum salmon run was August 17, which was 5 days late compared to 2007–2017 mean cumulative run timing (Figure 16; Appendices E and F).

The first pulse of coho salmon arrived approximately August 17 (Figure 15). As in most years, the project ended before the coho salmon run was complete therefore estimates were considered conservative and timing may not reflect the total run. The midpoint for the coho salmon run was August 23, which was 2 days late compared to 2007–2017 mean cumulative run timing (Figure 16; Appendices E and F).

MISSING DATA

Initially, there were 11 days (between June 1 and June 14) that had insufficient catches in at least 1 fishing zone, which made it necessary to pool reports periods to ensure reasonable species apportionment (Table 11).

The first commercial gillnet fishing period was July 7 in District 2 (Figure 1). Commercial fishing continued through the remainder of the summer season, for a total of 9 commercial periods. A total of 8 test fishery periods were affected by the summer commercial fishery schedule which necessitated cancelling 1 test fishery period for the day.

During the fall season, 21 commercial fishing periods occurred in District 2 and18 necessitated cancelling test fishery periods. There were 2 days during the fall season which had insufficient catches in at least 1 zone.

In order to estimate variance accurately, days with missing test fishery periods were pooled with adjacent days such that there were 2 complete test fishery periods, and zones with insufficient catches were pooled with zones with sufficient catches on adjacent days.

DISCUSSION

The right bank bottom profiles were similar to prior years with little or no change throughout the season. The left bank profiles remained linear throughout the season, and there were very few problems in finding suitable transducer locations.

From June 26 to July 11 high water necessitated the use of a spreader lens on the ARIS, which increased the vertical beam from 3° to approximately 14° (Figure 8). The increased vertical beam allowed better detection throughout the water column at close range. The combination of both a telephoto and spreader lens also improved detection at the outer range of the stratum (50 m) which had become limited from an increased sediment load in the water column. Later in the season (August 19 through September 7), water levels again began to rise, and silt attenuation hampered the ARIS ability to detect fish beyond 40 m. To improve detection, the ARIS range was reduced to 0.7–40 m and the left bank split-beam S4 stratum was increased to cover 40–150 m. The split-beam sonar provided improved images at 40–50 m. Because water levels continued to rise throughout the remainder of the season, this sampling scheme was continued through the last day of operation.

A total of 689,607 pink salmon were estimated to have migrated pass the Pilot Station sonar, which was the third highest pink salmon estimate since 2008 (Appendix G1). Because of the large run, there were apportionment concerns because the majority of the pink salmon migration was distributed close to the transducers within the ensonified area, which was difficult to adequately sample in the test fishery. In addition, the numbers of pink salmon were so high, it was not possible to sample them all in the time allotted and in conformity previous even-years, sampling ranges were adjusted to exclude pink salmon from sampling. To avoid a majority of the pink salmon, the nearshore sonar start range on the left bank was extended to 10 m (July 7–21) and to 7 m on the right bank (July 7–24) Test fishery zones were also adjusted to avoid catching fish that were not counted at the sonars. As the pink salmon run subsided, nearshore ranges were adjusted accordingly and the start range on both banks were reduced back to initial settings on August 1. Because the sonar ranges and test fishery zones were adjusted to exclude a portion of the pink salmon migration, the total estimated passage should be considered conservative because the entire run was not sampled.

Extending the start range of the sonar seems to be the most feasible method of avoiding apportionment problems during years of high pink salmon abundance. Simply moving transducers further offshore can be effective, however bottom profiles and water levels can limit this method. Efforts to apportion nearshore passage during years of high pink salmon abundance using nearshore deflection weirs in 2008 were attempted but found to inflate passage estimates of other species that were more catchable in the test fishery (Lozori and McIntosh 2013b).

Similarly, not monitoring or adjusting for high pink salmon passage can complicate apportionment of passage in the nearshore.

Although there were few problems this season, estimating fish passage on the Yukon River continues to present major technical and logistical 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 system employed at the Pilot Station sonar project appears to work well for the purpose of detecting migrating salmon, but successful estimation depends on constant attention to the frequent changes and diligent re-checking of every part of the acoustic and environmental system. In 2018, all project goals were met and passage estimates were given to fisheries managers daily during the season. Information generated at the Pilot Station sonar project was also disseminated weekly through multi-agency international teleconferences and data sharing with stakeholders in areas from the Lower Yukon River, all the way 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, 2018.

Time	Sonar Right bank	Sonar 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, 2018.

			Bank	
Component	Setting	Stratum	Left	Right
Transducer	Beam size (h x w)		3° x 10°	6° x 10°
Echosounder	Transmit power (dB)	S1		27.0
		S2		37.0
		S4	30.0	
		S5	30.0	
	Receiver gain (dB)	S1		-14.0
		S2		-14.0
		S4	-12.0	
		S5	-12.0	
	Source Level (dBµPa @ 1m)	S1		221.2
		S2		221.2
		S4	223.1	
		S5	223.1	
	Through-system gain (dB)		-161.5	-162.5
	Pulse width (ms)		0.4	0.4
	Blanking range (m)		2.0	2.0
	Ping rate (pps)	S1		5.0
		S2		3.5
		S4	3.0	
		S5	1.2	
	Range (m)	S1		2 to 40
		S2		40 to 150
		S4	50 to 150	
		S5	150 to 300	

Table 3.–Technical specifications for the Adaptive Resolution Imaging Sonar (ARIS), at the Pilot Station sonar project on the Yukon River, 2018.

Setting	Value
Field of view (h x w)	14° x 28°
Detection frequency (MHz)	0.7
Receiver gain (dB)	20.0
Samples/beam	1,706.0
Start range (m)	0.69
Frame rate (f/s)	4.0
Range (m)	50.0

Table 4.–Range of lower and upper thresholds used in Echotastic, at the Pilot Station sonar project on the Yukon River, 2018.

		Threshold (dB)	
Bank	Stratum	Upper	Lower
Right	S1	-12	-65
	S2	-13	-63
Left	S3	0	-52
	S4	-10	-52
	S5	-5	-52

Table 5.–Specifications for drift gillnets used for test fishing, by season, at the Pilot Station sonar project on the Yukon River, 2018.

Season	Stretch mesh size (in)	Stretch mesh size (mm)	Mesh diameter (mm)	Meshes deep (MD)	Depth (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, 2018.

	Test fishery	Mesh size (in)			
Season	period	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, 2001–2018.

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

Source: National Oceanic and Atmospheric Administration (NOAA). 2018. National Weather Service, Alaska-Pacific River Forecast Center. www.weather.gov/aprfc/breakupDB (Accessed September 27, 2018).

Table 8.–Number of fish caught and retained in the Pilot Station sonar project test fishery on the Yukon River, 2018.

Total catch	Chinook	S. chum	F. chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others [a]	Total
June	420	1,714	0	3	0	31	43	137	9	65	28	2,450
July	141	1,141	500	27	1	1,682	187	225	8	18	15	3,945
August	2	0	1,855	24	540	210	164	161	8	20	41	3,025
September	0	0	344	0	189	0	20	24	4	1	1	583
Total	563	2,855	2,699	54	730	1,923	414	547	29	104	85	10,003

Fish retained

	Chinook	S. chum	F. chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others [a]	Total
June	74	578	0	0	0	0	16	3	0	20	0	691
July	14	301	101	6	0	0	107	3	1	3	0	536
August	1	0	489	2	51	0	92	27	3	6	0	671
September	0	0	83	0	15	0	12	1	0	1	0	112
Total	89	879	673	8	66	0	227	34	4	30	0	2,010

Proportion retained

	Chinook	S. chum	F. chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others [a]	Total
June	0.176	0.337	0.000	0.000	0.000	0.000	0.372	0.022	0.000	0.308	0.000	0.282
July	0.099	0.264	0.202	0.222	0.000	0.000	0.572	0.013	0.125	0.167	0.000	0.136
August	0.500	0.000	0.264	0.083	0.094	0.000	0.561	0.168	0.375	0.300	0.000	0.222
September	0.000	0.000	0.241	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	0.158	0.308	0.249	0.148	0.090	0.000	0.548	0.062	0.138	0.288	0.000	0.201

[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, 2018.

					90% CI	
Species	Right bank	Left Bank	Total passage	SE	Lower	Upper
Large Chinook [a]	12,073	110,321	122,394	11,360	103,707	141,081
Small Chinook [b]	8,838	30,599	39,437	9,668	23,533	55,341
Total Chinook	20,911	140,920	161,831	14,917	137,292	186,370
Summer chum	179,758	1,432,930	1,612,688	65,257	1,505,340	1,720,036
Fall chum	142,969	785,695	928,664	33,460	873,622	983,706
Coho	68,352	67,995	136,347	7,231	124,452	148,242
Pink	367,176	322,431	689,607	29,159	641,640	737,574
Cisco	110,169	224,663	334,832	25,425	293,008	376,656
Humpback Whitefish	45,256	79,320	124,576	9,136	109,547	139,605
Broad Whitefish	9,141	5,554	14,695	2,156	11,148	18,242
Sheefish	16,479	10,006	26,485	5,671	17,156	35,814
Other [c]	37,534	9,837	47,371	3,561	41,513	53,229
Total	997,745	3,079,351	4,077,096			

[a] Large Chinook >655 mm.

[b] Small Chinook ≤655 mm.

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

Table 10.–Genetic composition of chum salmon, sampled at the Pilot Station sonar project on the Yukon River, 2018.

	Percentage	
Date	Summer chum	Fall chum
6/1–6/18	99.4	0.6
6/19–6/26	99.1	0.9
6/27–7/8	99.2	0.8
7/9–7/18	98.9	1.1
7/19–7/25	82.3	17.8
7/26–8/8	34.9	65.1
8/9–8/15	6.2	93.8
8/16–8/19	3.7	96.3
8/20–8/23	1.1	98.9
8/24–9/2	2.1	97.9
9/3–9/7	2.7	97.3

Table 11.–Dates of zones pooled for the 2018 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 [a]
6/01				
6/02				
6/03				IC
6/04				
6/05				
6/06				IC
6/07				
6/08				IC
6/09				
6/10				
6/11				
6/12				
6/13				
6/13				IC
6/14				
6/15				
6/16				
6/17				
6/18				
6/19				
6/20				
6/21				
6/22				
6/23				
6/24				
6/25				
6/26				
6/27				
6/28				
6/29				
6/30				
7/01				
7/02				
7/03				
7/04				
7/05				
7/06				
7/07				CO
7/08				
7/09				
7/10				CO
7/11				
7/12				
7/13				CO
7/14				
7/15				
7/16				CO

-continued-

Table 11.–Page 2 of 3.

Date	Right bank (Zone 1)	Left bank Nearshore (Zone 2)	Left bank Offshore (Zone 3)	Reason for pooling [a]
7/17				CO
7/18				
7/19				
7/20				
7/21				CO
7/22				
7/23				
7/24				CO
7/25				
7/26				
7/27				
7/28				CO
7/29				
7/30				IC
7/31				CO
8/01				
8/02				
8/03				
8/04				CO
8/05				
8/06				
8/07				CO
8/08				
8/09				
8/10				CO
8/11				CO
8/12				
8/13				
8/14				CO
8/15				
8/16				
8/17				CO
8/18				CO
8/19				
8/20				CO
8/21				
8/22				
8/23				
8/24				IC
8/25				CO
8/26				
8/27				
8/28				
8/29				CO
8/30				CO
8/31				CO

-continued-

Table 11.–Page 3 of 3.

Date	Right bank (Zone 1)	Left bank Nearshore (Zone 2)	Left bank Offshore (Zone 3)	Reason for pooling [a]
9/01				CO
9/02				
9/03				CO
9/04				
9/05				
9/06				
9/07				

[a] IC = insufficient catch, CO = commercial opener.

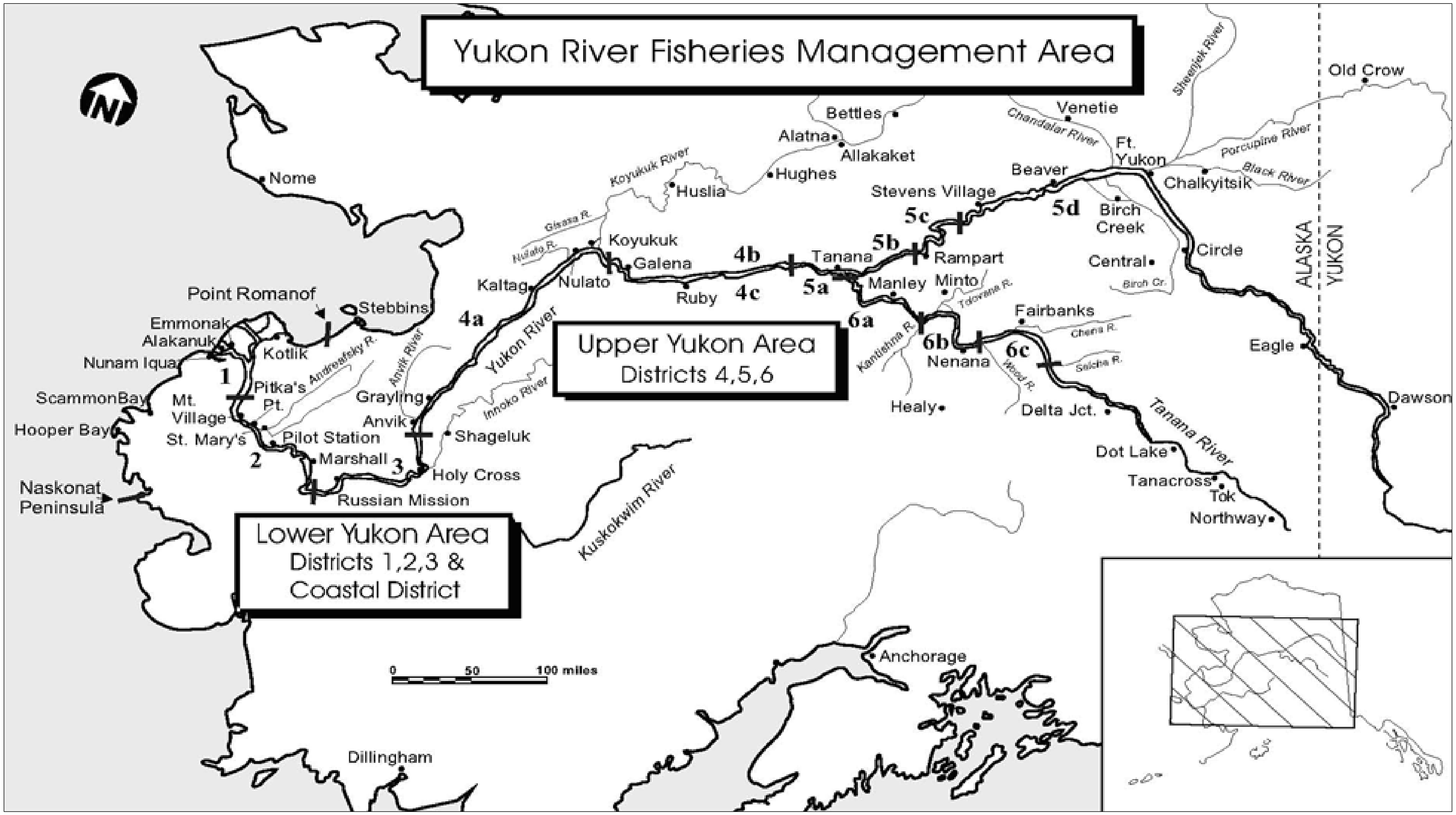


Figure 1.–Fishing districts and communities of the Yukon River drainage.

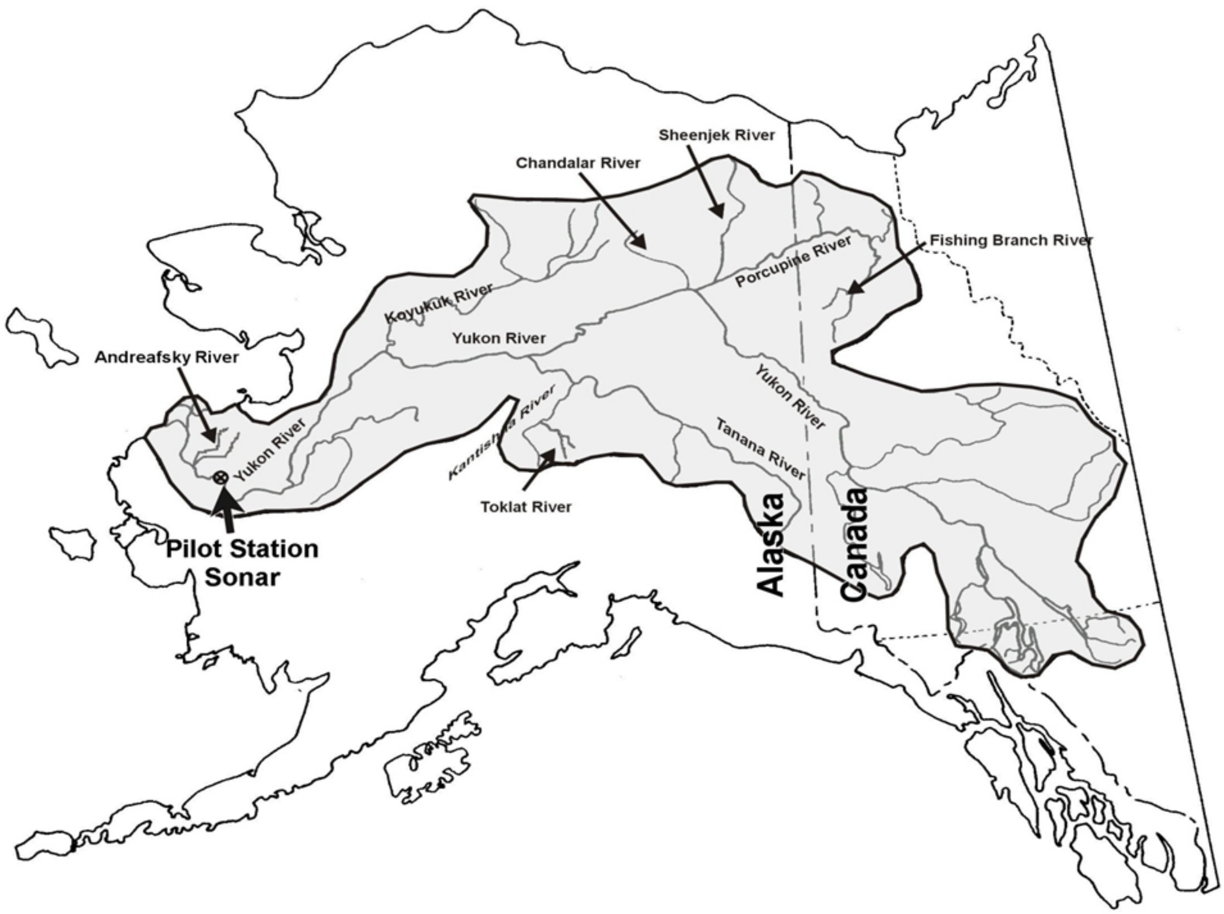


Figure 2.–Extent of the Yukon River watershed.

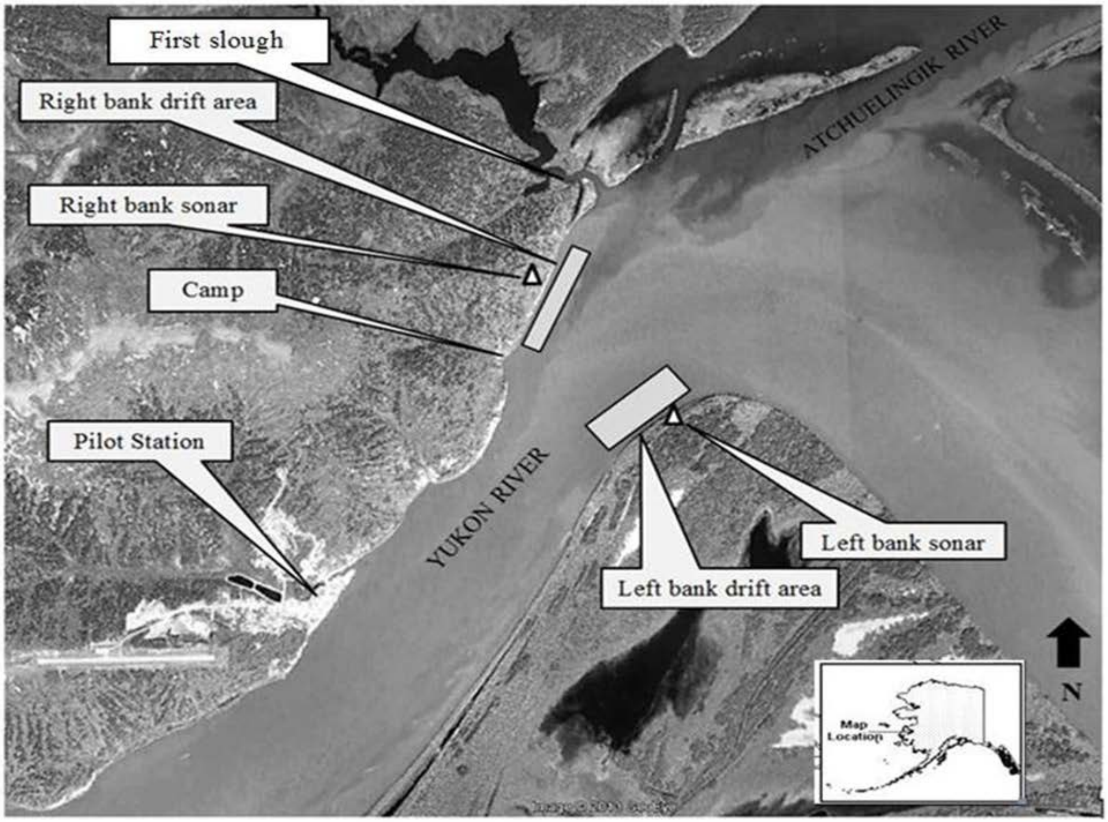


Figure 3.–Location of the Pilot Station sonar project on the Yukon River showing general transducer sites.

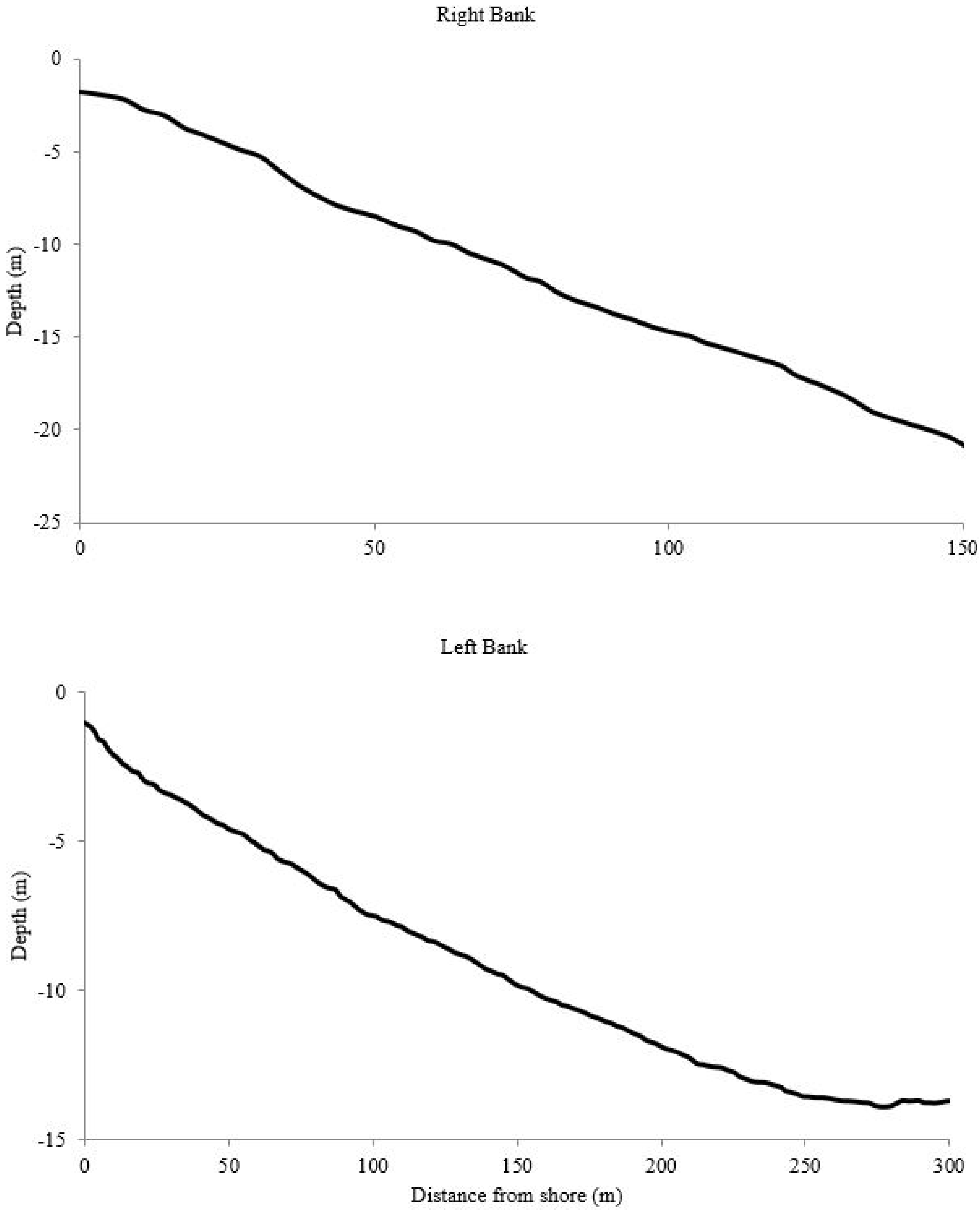


Figure 4.–Bottom profiles for the left bank (top) and right bank (bottom), at the Pilot Station sonar project on the Yukon River, 2018.

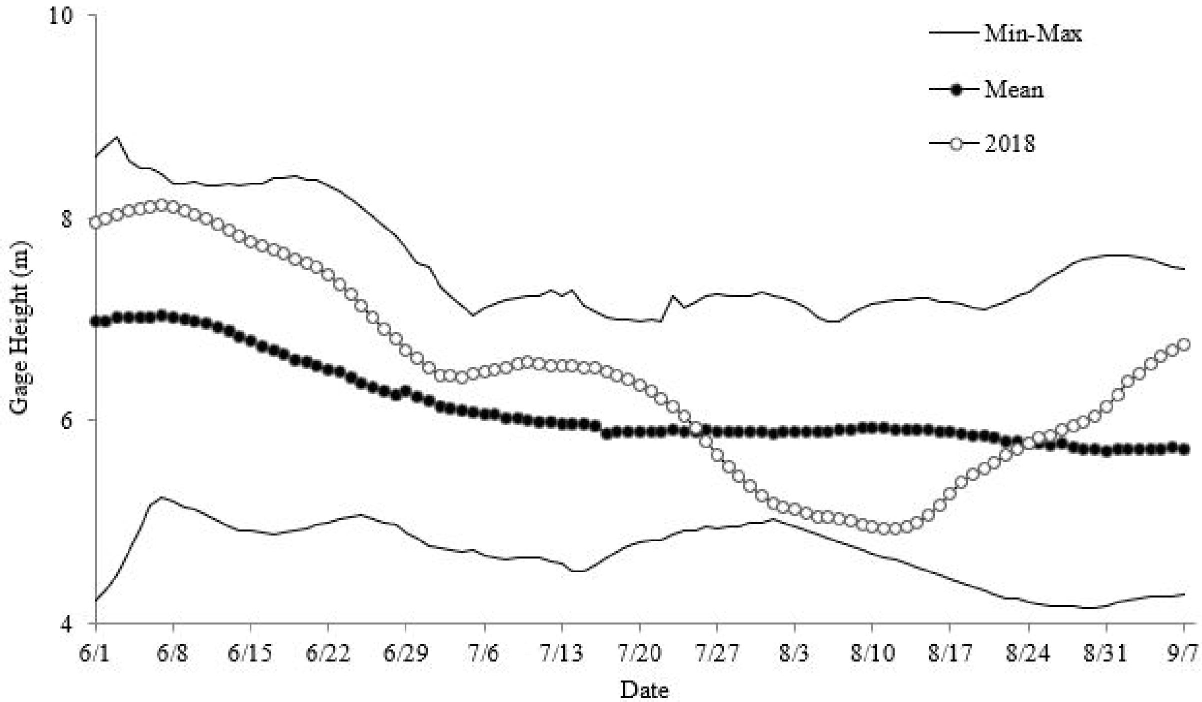


Figure 5.–Yukon River daily water level during the 2018 season at Pilot Station water gage compared to minimum, maximum, and mean gage height 2007 to 2017.

Source: United States Geological Service.

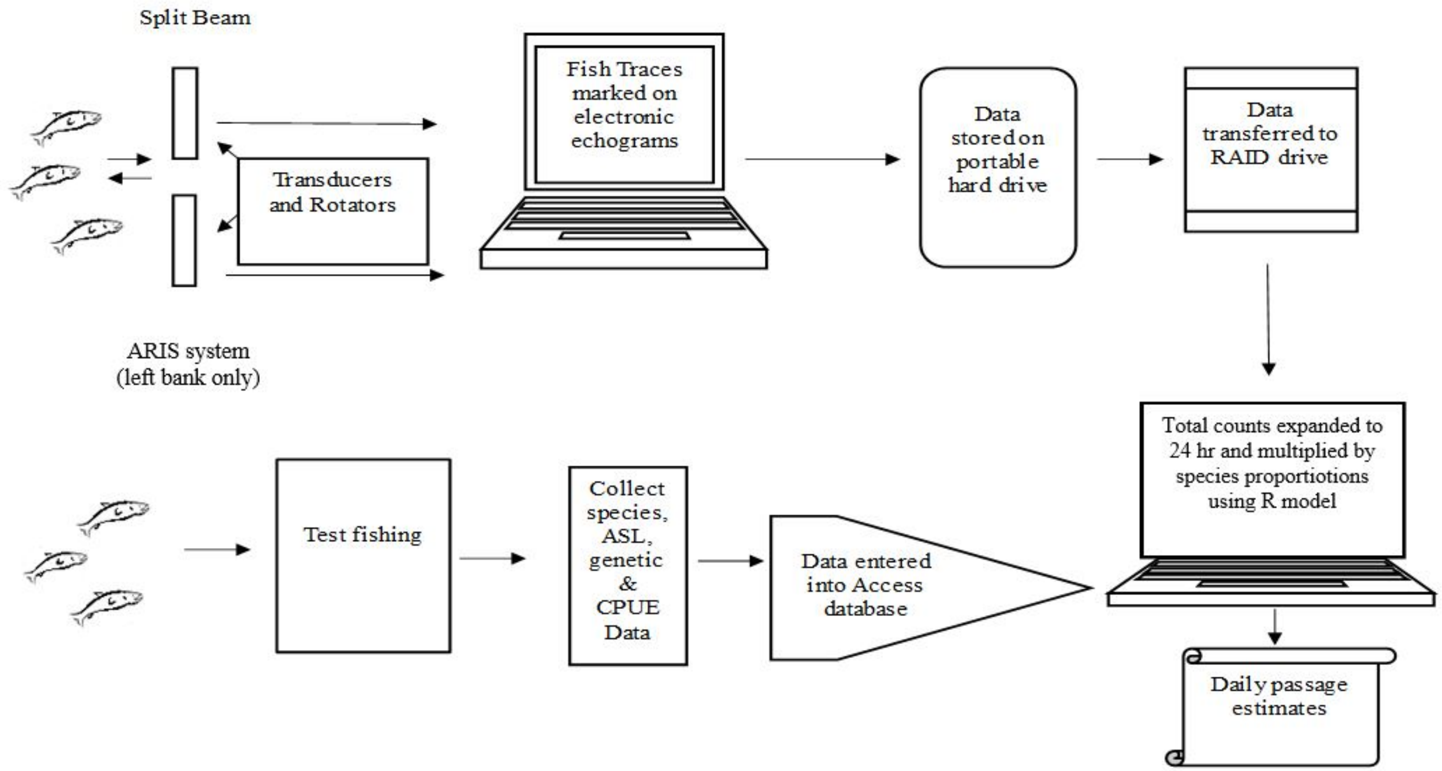


Figure 6.–Flow diagram of data collection and processing, at the Pilot Station sonar project on the Yukon River, 2018.

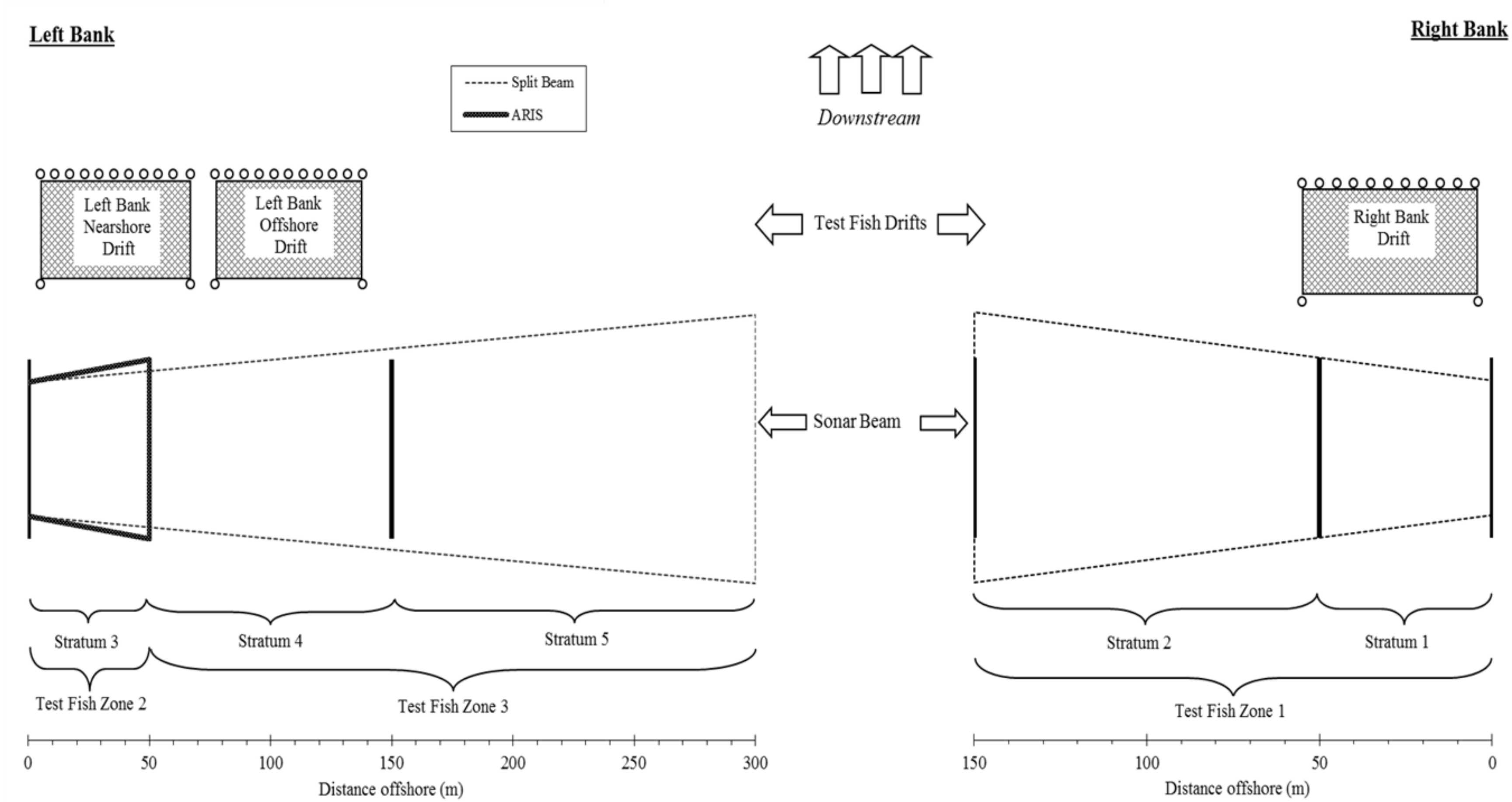


Figure 7.–Illustration of relationships between strata, zones, test fishery drifts, and approximate sonar ranges (not to scale), at the Pilot Station sonar project on the Yukon River, 2018.

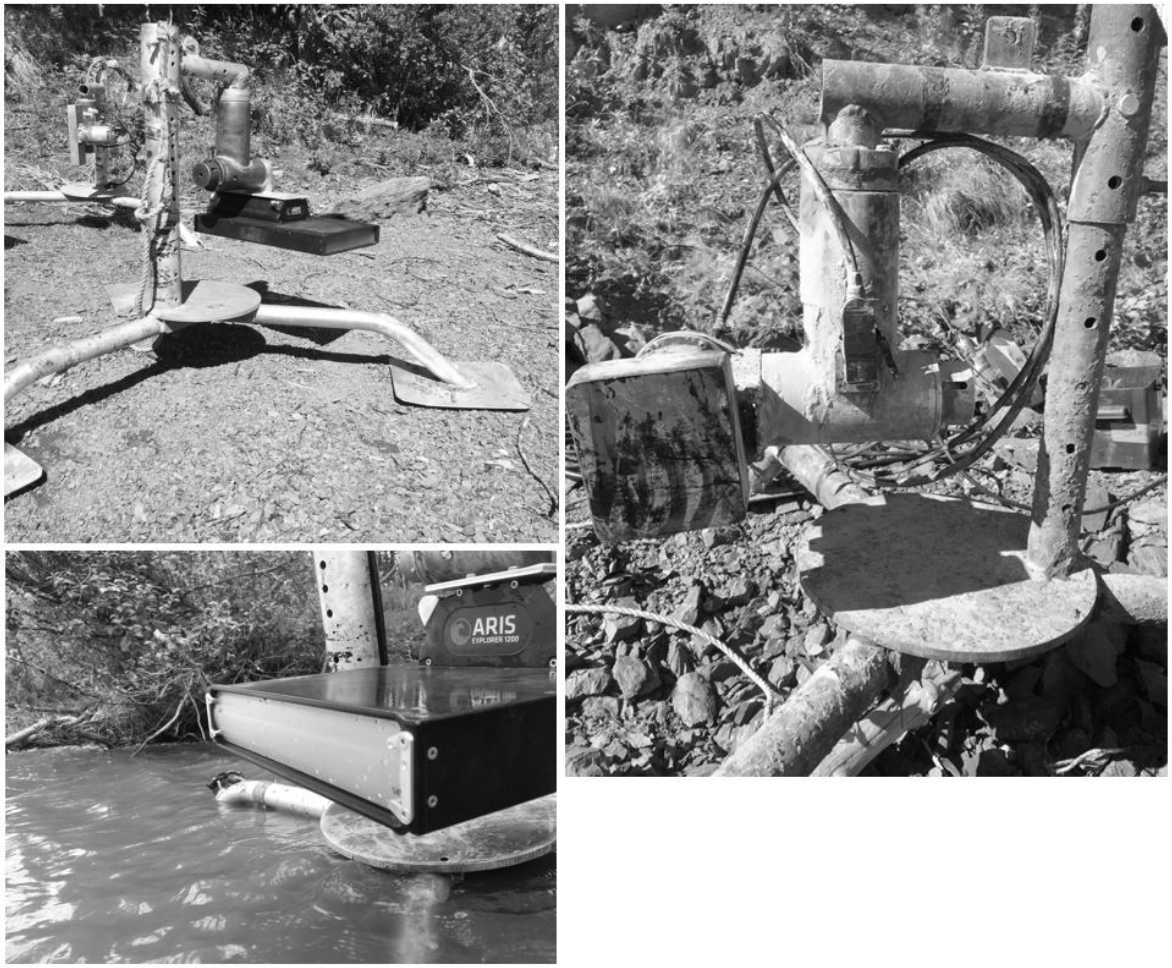


Figure 8.–ARIS with telephoto lens mounted to pod with PT-25 rotator (top left), ARIS with spreader lens installed on the front of the telephoto lens (lower left), and HTI split beam transducer mounted on pod with PT-25 rotator (right), at the Pilot Station sonar project on the Yukon River.

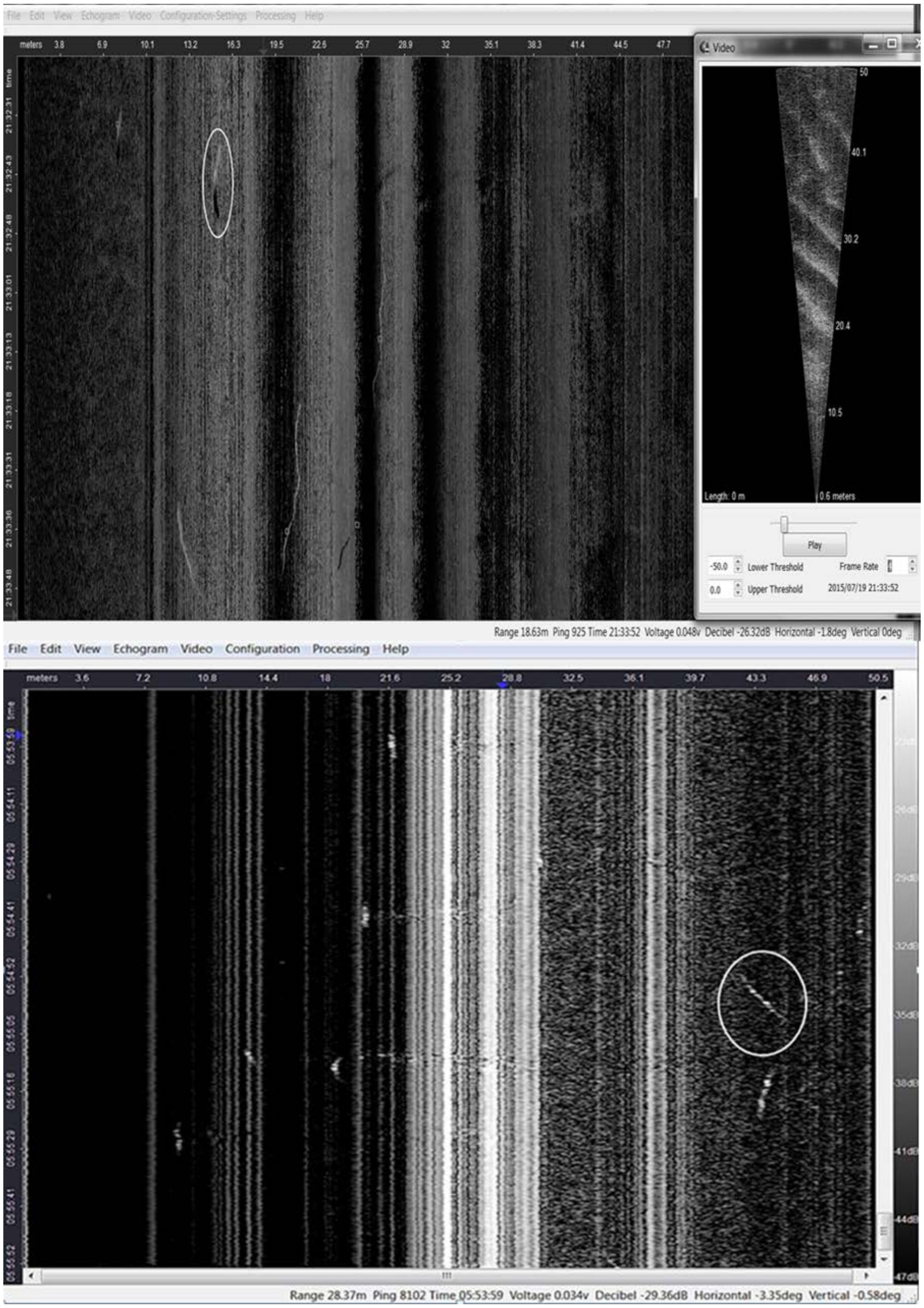


Figure 9.–Echogram of ARIS alongside video image (top) and split-beam sonar (bottom), with oval around representative fish.

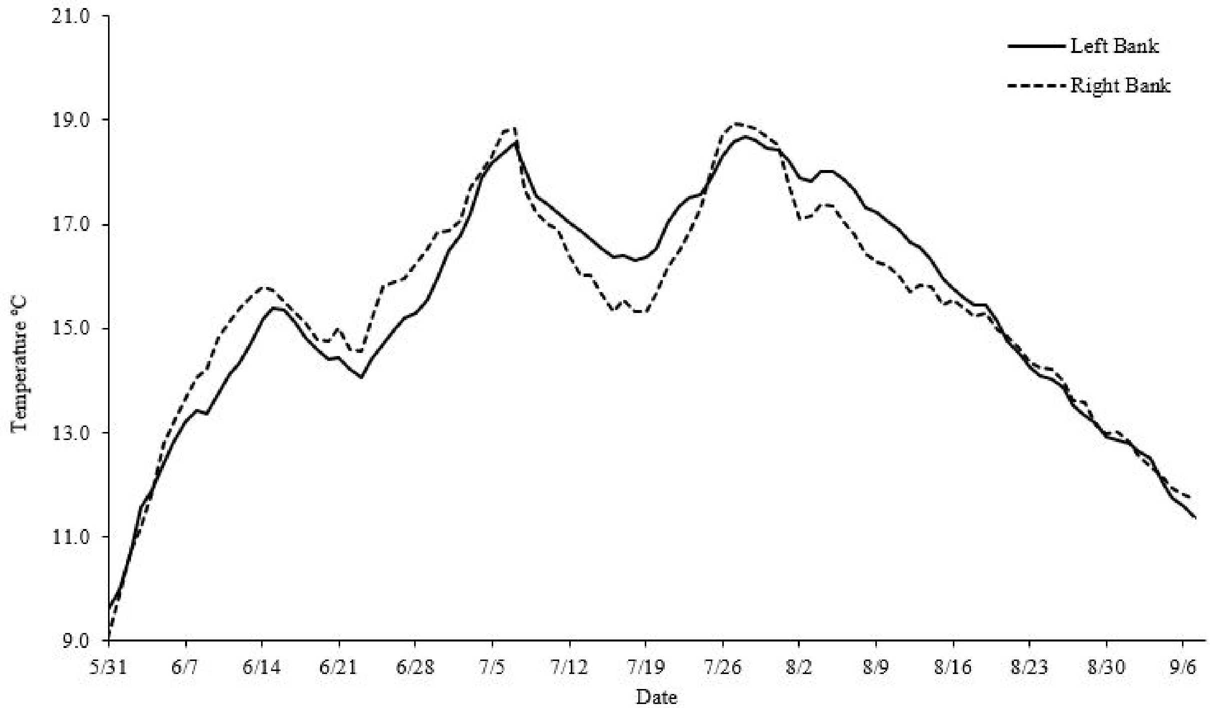


Figure 10.–Mean daily water temperatures recorded at the Pilot Station sonar project on the Yukon River with electronic data loggers by bank, 2018.

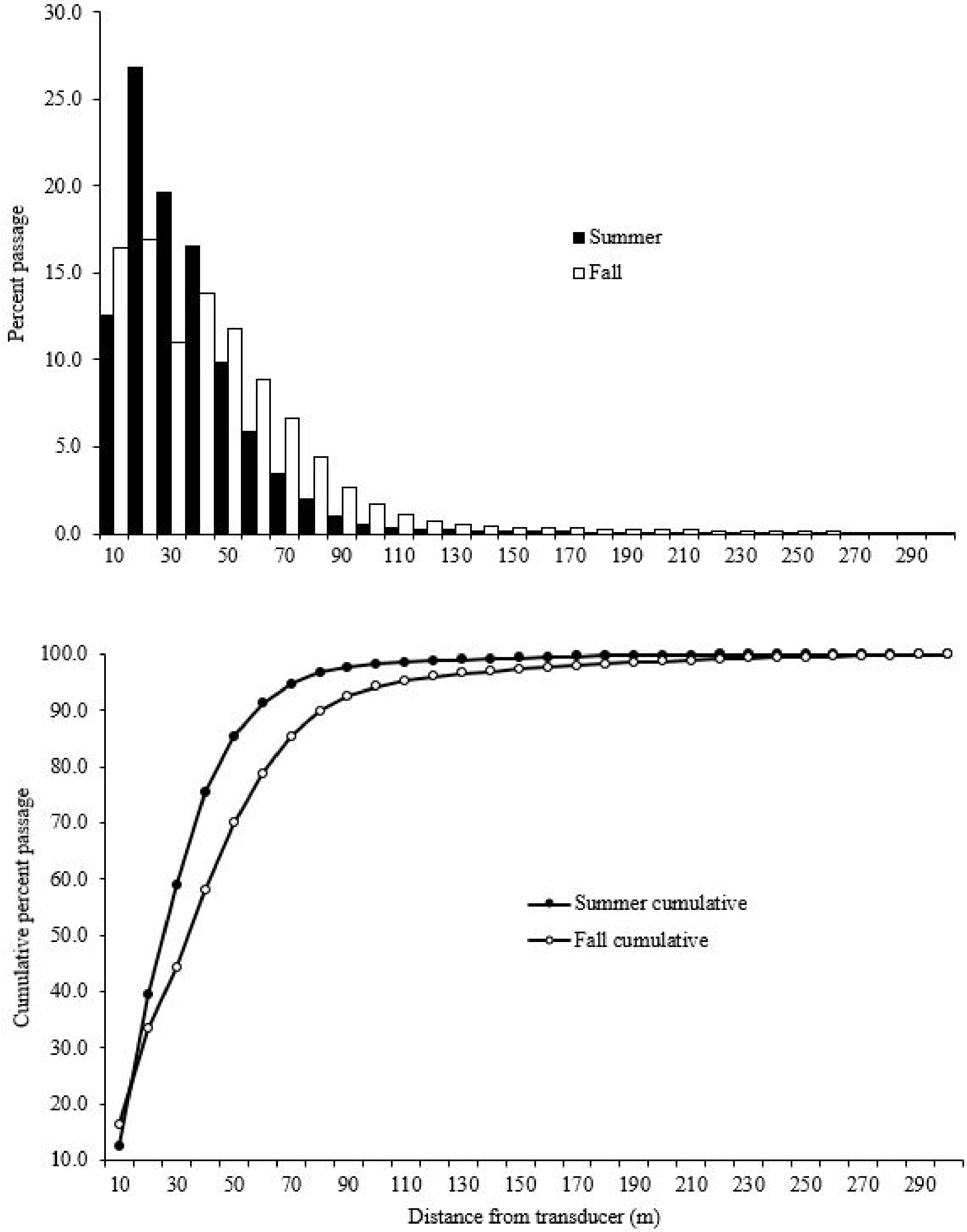


Figure 11.–Distribution of left bank passage (top) and cumulative passage as a function of range (bottom), at the Pilot Station sonar project on the Yukon River, 2018.

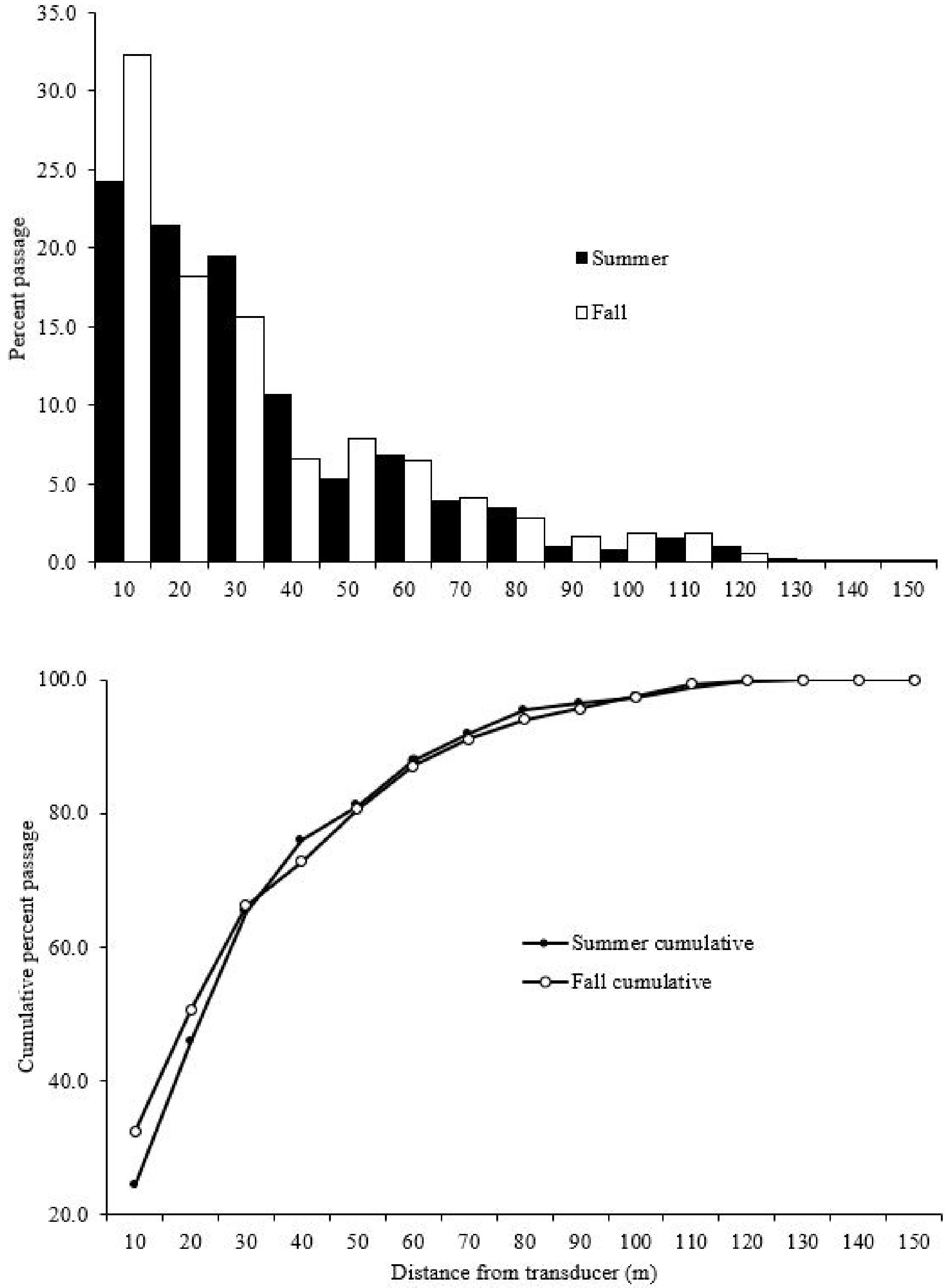


Figure 12.–Distribution of right bank passage (top) and cumulative passage as a function of range (bottom), at the Pilot Station sonar project on the Yukon River, 2018.

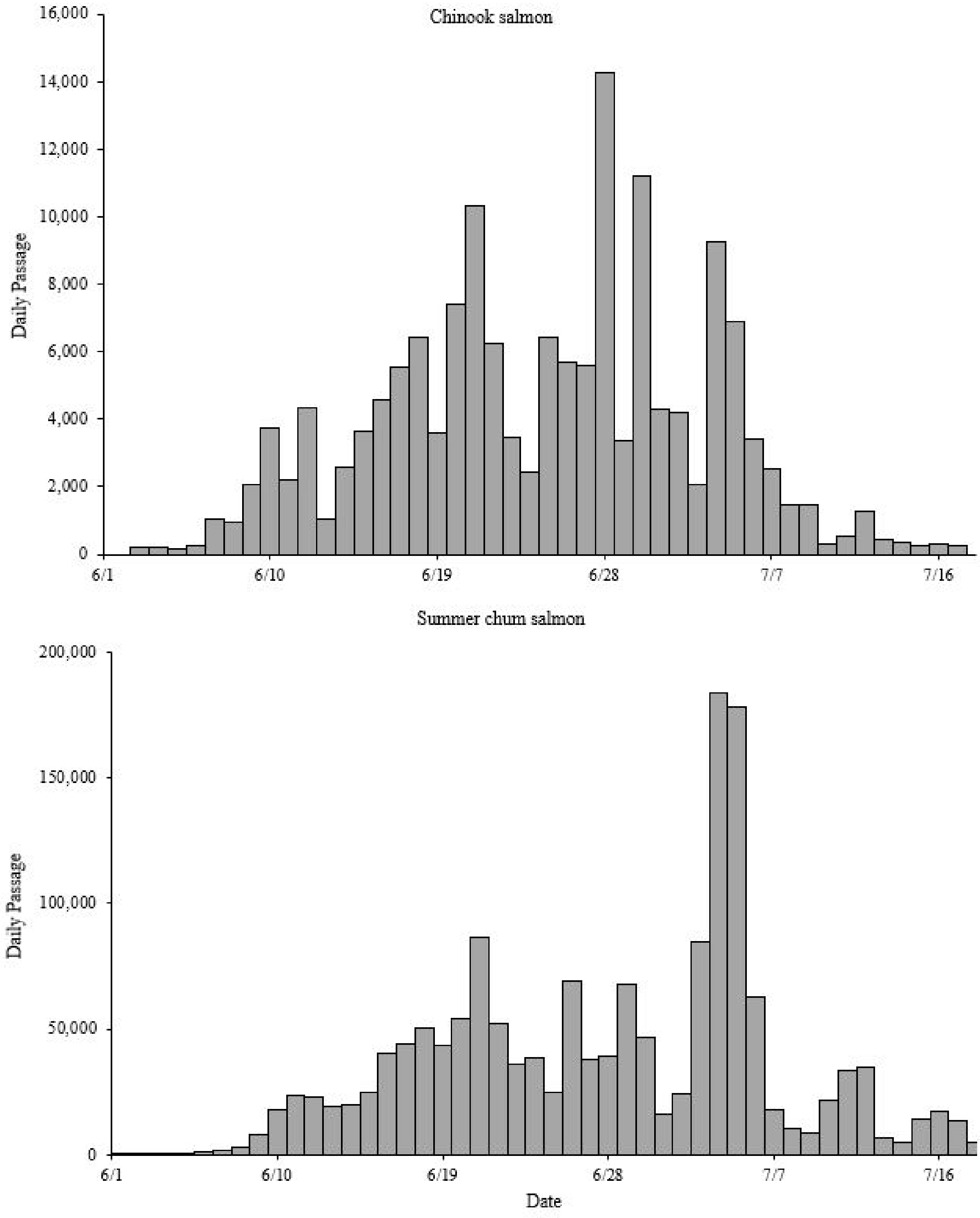
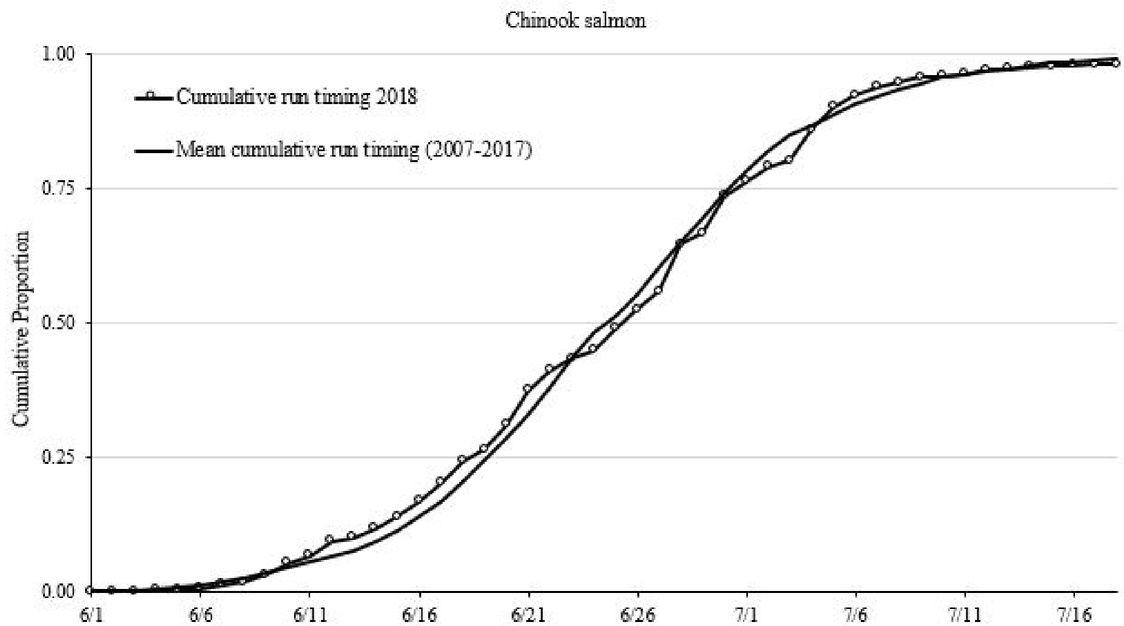


Figure 13.–Chinook and summer chum salmon daily passage estimates, at the Pilot Station sonar project on the Yukon River, 2018.



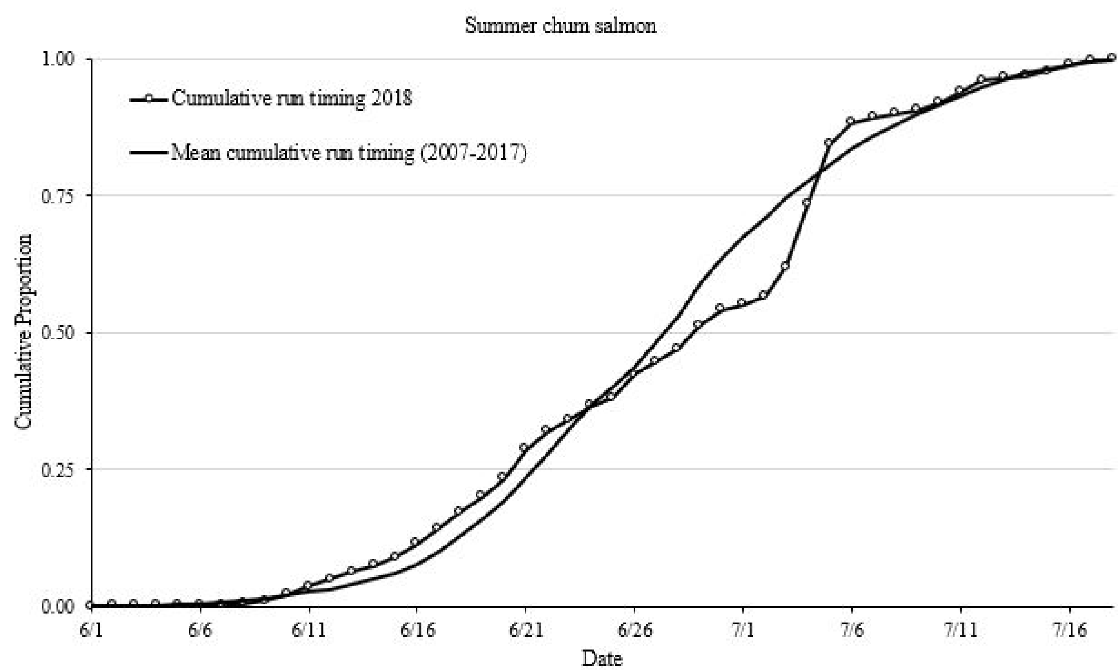


Figure 14.–2018 Chinook and summer chum salmon daily cumulative passage timing compared to the 2007-2017 mean passage timing, at the Pilot Station sonar project on the Yukon River.

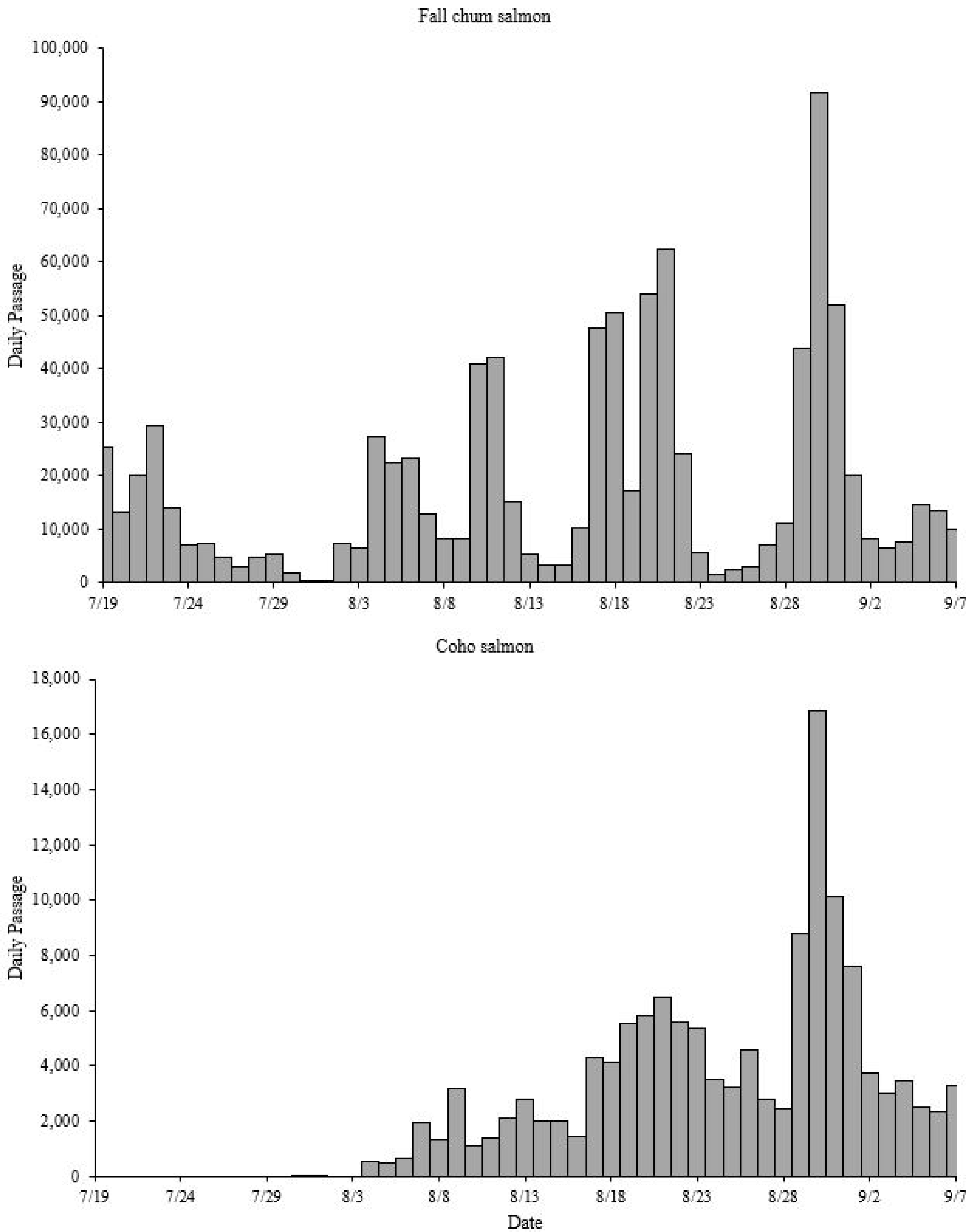
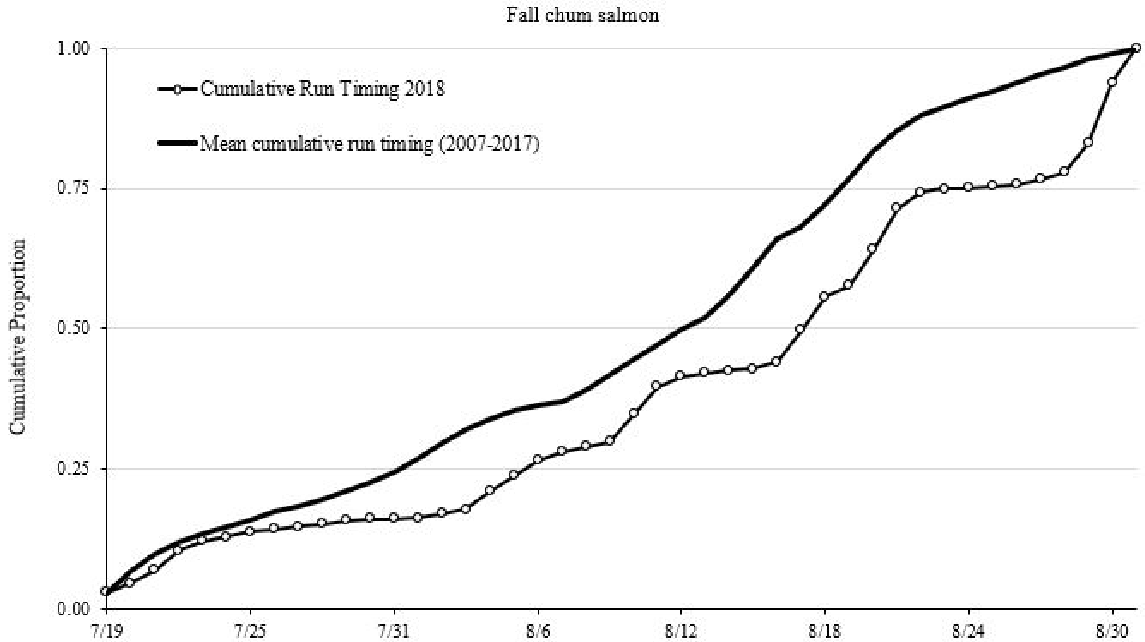


Figure 15.–Fall chum and coho salmon daily passage estimates, at the Pilot Station sonar project on the Yukon River, 2018.



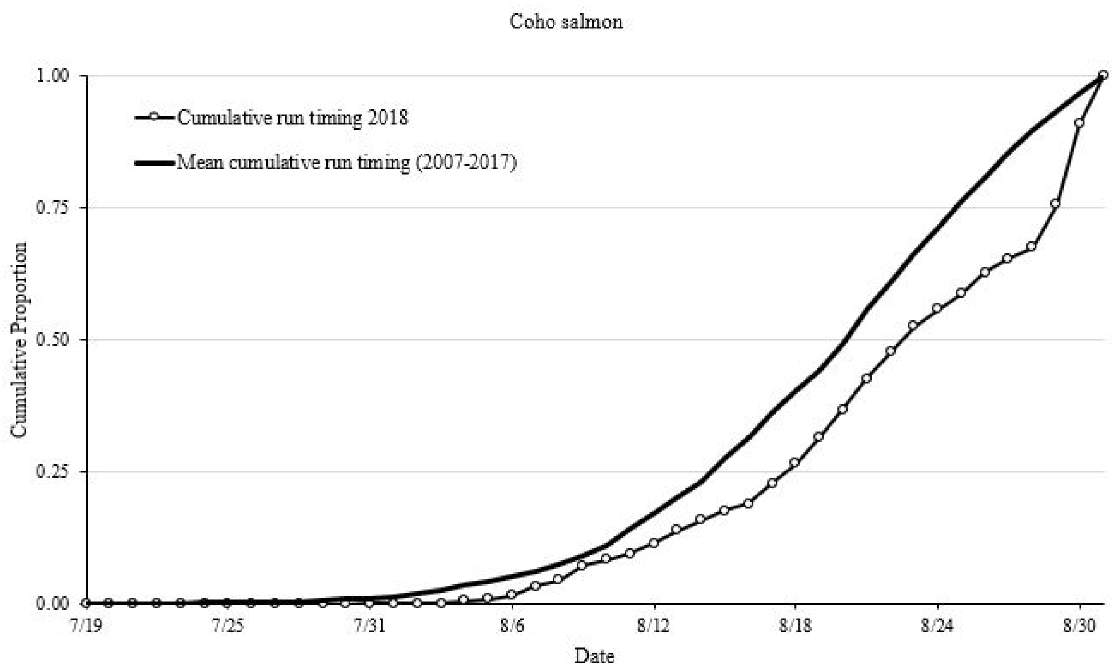


Figure 16.–2018 Fall chum and coho salmon daily cumulative passage timing compared to the 2007-2017 mean passage timing, at the Pilot Station sonar project on the Yukon River.

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, 2018.

Species	Tau	Sigma	Theta	Lambda	Tangle
Large Chinook [a]	1.8873	0.1663	0.6207	-0.7003	0.0000
Small Chinook [b]	1.8873	0.1663	0.6207	-0.7003	0.0000
Summer chum	2.0514	0.1355	0.6526	0.0286	0.0554
Fall chum	1.8898	0.4136	2.9553	-3.1053	0.0709
Coho	1.9452	0.2838	0.7337	-1.4000	0.0252
Pink	2.0223	0.1000	0.5154	-0.0267	0.0000
Broad whitefish	1.8039	0.1995	0.9336	-1.5736	0.0288
Humpback whitefish	1.9179	0.2428	1.0357	-1.9199	0.0393
Cisco	2.1917	0.5780	3.4385	-2.9399	0.0222
Sheefish	2.0966	0.1889	0.7286	-1.6127	0.0000
Other [c]	2.2888	0.3597	0.9004	-1.5057	0.0000

[a] Chinook salmon >655 mm.

[b] Chinook salmon ≤655 mm.

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

APPENDIX B: SALMON SPECIES CPUE BY DAY AND BANK

Appendix B1.–Left bank CPUE, by day and salmon species, at the Pilot Station sonar project on the Yukon River, 2018.

	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	17.92	0	0.00	19.18	1	0.05	0	0.00	0	0.00
6/02	16.71	0	0.00	15.64	3	0.19	0	0.00	0	0.00
6/03	15.75	0	0.00	16.58	2	0.12	0	0.00	0	0.00
6/04	19.06	1	0.05	17.28	0	0.00	0	0.00	0	0.00
6/05	17.38	0	0.00	16.92	0	0.00	0	0.00	0	0.00
6/06	17.58	5	0.28	16.94	7	0.41	0	0.00	0	0.00
6/07	16.17	5	0.31	16.33	6	0.37	0	0.00	0	0.00
6/08	17.32	4	0.23	16.33	14	0.86	0	0.00	0	0.00
6/09	16.05	3	0.19	16.32	14	0.86	0	0.00	0	0.00
6/10	15.88	10	0.63	15.93	38	2.39	0	0.00	0	0.00
6/11	16.02	10	0.62	12.71	46	3.62	0	0.00	0	0.00
6/12	17.22	12	0.70	13.76	64	4.65	0	0.00	0	0.00
6/13	17.31	0	0.00	12.77	50	3.92	0	0.00	0	0.00
6/14	15.53	8	0.51	13.59	36	2.65	0	0.00	0	0.00
6/15	14.90	12	0.81	12.59	60	4.77	0	0.00	0	0.00
6/16	14.93	7	0.47	14.11	44	3.12	0	0.00	0	0.00
6/17	13.26	8	0.60	9.24	48	5.20	0	0.00	0	0.00
6/18	14.88	13	0.87	10.91	62	5.68	0	0.00	0	0.00
6/19	15.03	12	0.80	10.00	55	5.50	0	0.00	0	0.00
6/20	13.98	13	0.93	6.86	37	5.40	0	0.00	0	0.00
6/21	15.03	4	0.27	10.14	50	4.93	0	0.00	0	0.00
6/22	14.07	10	0.71	10.20	47	4.61	0	0.00	0	0.00
6/23	15.28	5	0.33	10.67	40	3.75	0	0.00	0	0.00
6/24	15.83	9	0.57	10.97	59	5.38	0	0.00	0	0.00
6/25	13.90	12	0.86	14.08	29	2.06	0	0.00	0	0.00
6/26	13.44	8	0.60	8.84	51	5.77	0	0.00	0	0.00
6/27	14.74	7	0.47	11.71	45	3.84	0	0.00	0	0.00
6/28	13.64	18	1.32	10.87	46	4.23	0	0.00	0	0.00

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Appendix B1.–Page 2 of 4.

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
6/29	14.12	5	0.35	10.08	75	7.44	0	0.00	0	0.00
6/30	14.70	16	1.09	13.61	61	4.48	0	0.00	0	0.00
7/01	15.10	13	0.86	10.08	33	3.27	0	0.00	0	0.00
7/02	15.12	10	0.66	10.66	46	4.32	0	0.00	0	0.00
7/03	14.42	2	0.14	11.20	63	5.62	0	0.00	0	0.00
7/04	15.78	10	0.63	7.20	34	4.72	0	0.00	0	0.00
7/05	13.00	8	0.62	8.69	131	15.07	0	0.00	0	0.00
7/06	16.40	6	0.37	12.80	54	4.22	0	0.00	0	0.00
7/07	10.48	2	0.19	11.05	27	2.44	0	0.00	0	0.00
7/08	8.85	4	0.45	8.57	17	1.98	0	0.00	0	0.00
7/09	16.54	1	0.06	16.22	8	0.49	0	0.00	0	0.00
7/10	9.93	1	0.10	9.67	33	3.41	0	0.00	0	0.00
7/11	8.85	0	0.00	8.53	39	4.57	0	0.00	0	0.00
7/12	15.27	0	0.00	13.67	27	1.97	0	0.00	0	0.00
7/13	9.11	0	0.00	8.96	7	0.78	0	0.00	0	0.00
7/14	8.68	0	0.00	8.64	4	0.46	0	0.00	0	0.00
7/15	9.86	0	0.00	9.98	29	2.91	0	0.00	0	0.00
7/16	15.04	1	0.07	15.69	29	1.85	0	0.00	0	0.00
7/17	8.41	0	0.00	8.89	20	2.25	0	0.00	0	0.00
7/18	16.34	0	0.00	15.40	4	0.26	0	0.00	0	0.00
7/19	5.27	1	0.19	14.63	0	0.00	45	3.08	0	0.00
7/20	10.50	1	0.10	11.80	0	0.00	10	0.85	0	0.00
7/21	5.42	1	0.18	14.97	0	0.00	20	1.34	0	0.00
7/22	5.77	0	0.00	10.71	0	0.00	41	3.83	0	0.00
7/23	6.08	1	0.16	15.96	0	0.00	18	1.13	0	0.00
7/24	6.23	0	0.00	17.38	0	0.00	11	0.63	0	0.00
7/25	5.80	0	0.00	10.05	0	0.00	0	0.00	0	0.00
7/26	5.95	0	0.00	17.70	0	0.00	7	0.40	0	0.00
7/27	5.64	0	0.00	17.95	0	0.00	5	0.28	0	0.00

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Appendix B1.–Page 3 of 4.

Date	Large mesh fathom hours	Chinook		Small mesh fathom hours	Summer chum		Fall chum		Coho	
		Catch	CPUE		Catch	CPUE	Catch	CPUE	Catch	CPUE
7/28	5.33	0	0.00	17.56	0	0.00	9	0.51	0	0.00
7/29	5.36	0	0.00	10.49	0	0.00	16	1.53	0	0.00
7/30	5.44	0	0.00	14.71	0	0.00	0	0.00	0	0.00
7/31	5.60	0	0.00	17.61	0	0.00	1	0.06	0	0.00
8/01	5.82	0	0.00	11.42	0	0.00	0	0.00	0	0.00
8/02	5.87	0	0.00	17.70	0	0.00	14	0.79	0	0.00
8/03	6.47	0	0.00	17.12	0	0.00	13	0.76	0	0.00
8/04	5.83	0	0.00	16.54	0	0.00	56	3.39	0	0.00
8/05	5.70	0	0.00	10.86	0	0.00	30	2.76	1	0.09
8/06	5.73	0	0.00	18.66	0	0.00	42	2.25	1	0.05
8/07	5.36	0	0.00	17.22	0	0.00	17	0.99	1	0.06
8/08	5.79	0	0.00	12.20	0	0.00	19	1.56	0	0.00
8/09	6.19	0	0.00	17.33	0	0.00	10	0.58	2	0.12
8/10	5.63	0	0.00	12.00	0	0.00	44	3.67	1	0.08
8/11	5.24	0	0.00	11.05	0	0.00	43	3.89	0	0.00
8/12	5.93	0	0.00	17.41	0	0.00	20	1.15	1	0.06
8/13	6.02	0	0.00	18.06	0	0.00	14	0.78	6	0.33
8/14	6.26	0	0.00	17.69	0	0.00	9	0.51	5	0.28
8/15	5.85	0	0.00	12.01	0	0.00	6	0.50	3	0.25
8/16	5.91	0	0.00	16.89	0	0.00	19	1.13	3	0.18
8/17	5.36	0	0.00	9.82	0	0.00	22	2.24	3	0.31
8/18	4.50	0	0.00	10.87	0	0.00	38	3.50	1	0.09
8/19	5.79	0	0.00	17.30	0	0.00	27	1.56	4	0.23
8/20	5.98	0	0.00	12.05	0	0.00	70	5.81	2	0.17
8/21	4.52	0	0.00	8.08	0	0.00	44	5.45	1	0.12
8/22	6.03	0	0.00	17.72	0	0.00	46	2.60	4	0.23
8/23	5.58	0	0.00	17.22	0	0.00	10	0.58	6	0.35
8/24	5.92	0	0.00	17.92	0	0.00	1	0.06	7	0.39
8/25	6.02	0	0.00	17.07	0	0.00	4	0.23	1	0.06
8/26	5.70	0	0.00	11.72	0	0.00	9	0.77	7	0.60

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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
8/27	5.60	0	0.00	17.97	0	0.00	18	1.00	0	0.00
8/28	6.58	0	0.00	16.46	0	0.00	25	1.52	1	0.06
8/29	5.85	0	0.00	12.00	0	0.00	30	2.50	5	0.42
8/30	4.24	0	0.00	6.64	0	0.00	89	13.40	6	0.90
8/31	6.02	0	0.00	9.59	0	0.00	53	5.53	7	0.73
9/01	5.30	0	0.00	17.22	0	0.00	49	2.85	8	0.46
9/02	5.41	0	0.00	11.33	0	0.00	13	1.15	2	0.18
9/03	0.00	0	0.00	23.32	0	0.00	27	1.16	11	0.47
9/04	5.34	0	0.00	10.82	0	0.00	8	0.74	1	0.09
9/05	5.85	0	0.00	16.81	0	0.00	35	2.08	3	0.18
9/06	6.02	0	0.00	17.46	0	0.00	40	2.29	3	0.17
9/07	6.29	0	0.00	18.18	0	0.00	33	1.82	6	0.33
Total	984.70	279.00	19.35	1,344.31	1,695.00	156.84	1,230.00	97.19	113.00	8.04

Appendix B2.–Right bank CPUE, by day and salmon species, at the Pilot Station sonar project on the Yukon River, 2018.

	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	2.96	0	0.00	5.62	0	0.00	0	0.00	0	0.00
6/02	1.27	0	0.00	5.15	1	0.19	0	0.00	0	0.00
6/03	7.50	0	0.00	7.09	0	0.00	0	0.00	0	0.00
6/04	2.75	0	0.00	2.64	0	0.00	0	0.00	0	0.00
6/05	8.73	0	0.00	5.64	0	0.00	0	0.00	0	0.00
6/06	8.61	0	0.00	8.28	0	0.00	0	0.00	0	0.00
6/07	7.94	0	0.00	7.94	2	0.25	0	0.00	0	0.00
6/08	8.84	1	0.11	8.39	0	0.00	0	0.00	0	0.00
6/09	7.84	1	0.13	8.26	1	0.12	0	0.00	0	0.00
6/10	8.36	4	0.48	7.81	12	1.54	0	0.00	0	0.00
6/11	7.01	0	0.00	7.76	20	2.58	0	0.00	0	0.00
6/12	7.82	0	0.00	6.23	6	0.96	0	0.00	0	0.00
6/13	8.05	0	0.00	7.15	2	0.28	0	0.00	0	0.00
6/14	8.03	1	0.12	7.06	1	0.14	0	0.00	0	0.00
6/15	7.43	0	0.00	7.64	1	0.13	0	0.00	0	0.00
6/16	8.25	0	0.00	8.32	2	0.24	0	0.00	0	0.00
6/17	8.18	2	0.24	6.34	4	0.63	0	0.00	0	0.00
6/18	8.60	0	0.00	6.12	5	0.82	0	0.00	0	0.00
6/19	8.06	0	0.00	6.75	3	0.44	0	0.00	0	0.00
6/20	8.26	1	0.12	6.03	14	2.32	0	0.00	0	0.00
6/21	7.83	1	0.13	6.39	14	2.19	0	0.00	0	0.00
6/22	7.30	0	0.00	7.58	16	2.11	0	0.00	0	0.00
6/23	7.82	1	0.13	6.96	5	0.72	0	0.00	0	0.00
6/24	7.82	0	0.00	8.30	6	0.72	0	0.00	0	0.00
6/25	6.53	0	0.00	7.07	1	0.14	0	0.00	0	0.00
6/26	7.51	0	0.00	6.67	11	1.65	0	0.00	0	0.00
6/27	7.76	2	0.26	7.38	5	0.68	0	0.00	0	0.00
6/28	7.63	1	0.13	7.58	1	0.13	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
6/29	7.13	1	0.14	6.74	15	2.22	0	0.00	0	0.00
6/30	8.22	2	0.24	7.89	4	0.51	0	0.00	0	0.00
7/01	7.35	2	0.27	7.51	3	0.40	0	0.00	0	0.00
7/02	7.28	0	0.00	6.80	4	0.59	0	0.00	0	0.00
7/03	7.65	1	0.13	7.65	7	0.91	0	0.00	0	0.00
7/04	8.62	0	0.00	5.63	45	8.00	0	0.00	0	0.00
7/05	7.45	4	0.54	5.42	26	4.80	0	0.00	0	0.00
7/06	7.87	1	0.13	6.01	14	2.33	0	0.00	0	0.00
7/07	5.17	0	0.00	3.79	4	1.06	0	0.00	0	0.00
7/08	3.77	1	0.26	3.75	3	0.80	0	0.00	0	0.00
7/09	7.92	2	0.25	7.98	11	1.38	0	0.00	0	0.00
7/10	5.14	0	0.00	4.96	7	1.41	0	0.00	0	0.00
7/11	4.07	1	0.25	4.04	11	2.72	0	0.00	0	0.00
7/12	7.35	0	0.00	6.57	12	1.83	0	0.00	0	0.00
7/13	4.66	1	0.21	4.42	2	0.45	0	0.00	0	0.00
7/14	4.16	0	0.00	4.41	3	0.68	0	0.00	0	0.00
7/15	4.61	0	0.00	5.01	10	2.00	0	0.00	0	0.00
7/16	7.40	0	0.00	7.09	5	0.70	0	0.00	0	0.00
7/17	4.48	0	0.00	4.40	1	0.23	0	0.00	0	0.00
7/18	7.92	0	0.00	6.97	8	1.15	0	0.00	0	0.00
7/19	2.55	0	0.00	7.19	0	0.00	6	0.83	0	0.00
7/20	5.03	0	0.00	5.26	0	0.00	2	0.38	0	0.00
7/21	2.73	0	0.00	6.76	0	0.00	10	1.48	0	0.00
7/22	2.63	0	0.00	5.52	0	0.00	28	5.07	0	0.00
7/23	2.46	0	0.00	8.01	0	0.00	2	0.25	0	0.00
7/24	2.75	0	0.00	8.56	0	0.00	2	0.23	0	0.00
7/25	2.76	0	0.00	4.53	0	0.00	1	0.22	0	0.00
7/26	2.78	0	0.00	8.61	0	0.00	2	0.23	0	0.00
7/27	2.67	0	0.00	8.72	0	0.00	2	0.23	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
7/28	2.59	0	0.00	7.78	0	0.00	2	0.26	0	0.00
7/29	2.75	0	0.00	4.52	0	0.00	2	0.44	0	0.00
7/30	2.94	0	0.00	8.61	0	0.00	2	0.23	0	0.00
7/31	2.50	0	0.00	8.50	0	0.00	0	0.00	0	0.00
8/01	2.75	0	0.00	5.75	0	0.00	0	0.00	0	0.00
8/02	2.86	0	0.00	8.08	0	0.00	2	0.25	0	0.00
8/03	2.88	0	0.00	8.28	0	0.00	2	0.24	0	0.00
8/04	2.92	0	0.00	8.34	0	0.00	17	2.04	0	0.00
8/05	2.86	0	0.00	5.22	0	0.00	17	3.26	1	0.19
8/06	3.02	0	0.00	8.84	0	0.00	17	1.92	0	0.00
8/07	2.62	0	0.00	8.71	0	0.00	13	1.49	2	0.23
8/08	2.77	0	0.00	6.04	0	0.00	8	1.32	1	0.17
8/09	2.98	0	0.00	8.74	0	0.00	6	0.69	1	0.11
8/10	2.88	0	0.00	5.96	0	0.00	6	1.01	1	0.17
8/11	2.78	0	0.00	6.27	0	0.00	17	2.71	1	0.16
8/12	2.89	0	0.00	8.68	0	0.00	7	0.81	5	0.58
8/13	3.01	0	0.00	8.64	0	0.00	2	0.23	1	0.12
8/14	2.91	0	0.00	8.36	0	0.00	5	0.60	1	0.12
8/15	2.79	0	0.00	5.64	0	0.00	5	0.89	4	0.71
8/16	2.85	0	0.00	9.57	0	0.00	7	0.73	3	0.31
8/17	2.64	0	0.00	5.08	0	0.00	23	4.53	6	1.18
8/18	2.73	0	0.00	5.41	0	0.00	9	1.66	3	0.55
8/19	2.91	0	0.00	8.72	0	0.00	9	1.03	5	0.57
8/20	2.58	0	0.00	6.97	0	0.00	54	7.75	6	0.86
8/21	2.72	0	0.00	3.59	0	0.00	43	11.99	2	0.56
8/22	2.84	0	0.00	8.31	0	0.00	10	1.20	9	1.08
8/23	2.65	0	0.00	8.71	0	0.00	3	0.34	3	0.34
8/24	2.91	0	0.00	8.72	0	0.00	5	0.57	8	0.92
8/25	3.22	0	0.00	8.04	0	0.00	3	0.37	11	1.37
8/26	2.81	0	0.00	5.73	0	0.00	1	0.17	3	0.52

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Appendix B2.–Page 4 of 4.

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
8/27	2.89	0	0.00	8.81	0	0.00	2	0.23	6	0.68
8/28	3.01	0	0.00	8.30	0	0.00	9	1.08	2	0.24
8/29	2.82	0	0.00	5.77	0	0.00	15	2.60	8	1.39
8/30	2.55	0	0.00	3.06	0	0.00	15	4.90	7	2.29
8/31	2.91	0	0.00	5.77	0	0.00	14	2.43	8	1.39
9/01	2.47	0	0.00	8.64	0	0.00	5	0.58	14	1.62
9/02	2.70	0	0.00	5.56	0	0.00	3	0.54	7	1.26
9/03	0.00	0	0.00	11.88	0	0.00	5	0.42	10	0.84
9/04	2.67	0	0.00	5.40	0	0.00	7	1.30	5	0.93
9/05	2.99	0	0.00	8.65	0	0.00	5	0.58	7	0.81
9/06	2.64	0	0.00	8.78	0	0.00	7	0.80	4	0.46
9/07	2.78	0	0.00	9.30	0	0.00	13	1.40	7	0.75
Total	474.26	31.00	4.27	684.08	328.00	53.15	452.00	74.51	162.00	23.48

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, 2018.

			Total		Percent by bank	
Date	Right bank	Left bank	Passage	SE	Right	Left
6/01	1,422	1,712	3,134	540	45.4	54.6
6/02	1,352	1,255	2,607	324	51.9	48.1
6/03	1,913	1,288	3,201	173	59.8	40.2
6/04	1,295	1,414	2,709	235	47.8	52.2
6/05	1,534	1,144	2,678	143	57.3	42.7
6/06	2,033	1,608	3,641	396	55.8	44.2
6/07	1,867	2,602	4,469	246	41.8	58.2
6/08	2,076	3,931	6,007	372	34.6	65.4
6/09	2,837	9,021	11,858	2,127	23.9	76.1
6/10	4,458	18,103	22,561	1,699	19.8	80.2
6/11	6,667	21,920	28,587	3,088	23.3	76.7
6/12	4,653	25,861	30,514	5,204	15.2	84.8
6/13	4,191	19,551	23,742	3,221	17.7	82.3
6/14	3,783	22,692	26,475	1,124	14.3	85.7
6/15	4,425	30,073	34,498	5,209	12.8	87.2
6/16	4,441	44,513	48,954	7,678	9.1	90.9
6/17	5,625	48,840	54,465	7,655	10.3	89.7
6/18	5,064	55,712	60,776	4,119	8.3	91.7
6/19	5,692	46,383	52,075	3,994	10.9	89.1
6/20	12,959	51,666	64,625	8,052	20.1	79.9
6/21	14,688	93,730	108,418	9,059	13.5	86.5
6/22	6,343	57,290	63,633	15,703	10.0	90.0
6/23	4,801	40,233	45,034	9,288	10.7	89.3
6/24	5,486	41,887	47,373	5,420	11.6	88.4
6/25	7,291	39,678	46,969	2,556	15.5	84.5
6/26	11,188	72,434	83,622	22,612	13.4	86.6
6/27	6,515	49,950	56,465	12,607	11.5	88.5
6/28	6,795	54,405	61,200	9,628	11.1	88.9
6/29	11,391	78,397	89,788	22,711	12.7	87.3
6/30	8,015	55,951	63,966	7,109	12.5	87.5
7/01	8,349	30,977	39,326	1,575	21.2	78.8
7/02	14,013	40,744	54,757	8,648	25.6	74.4
7/03	25,440	93,817	119,257	13,818	21.3	78.7
7/04	55,342	179,604	234,946	38,060	23.6	76.4
7/05	64,045	206,016	270,061	37,547	23.7	76.3
7/06	40,447	67,605	108,052	21,477	37.4	62.6
7/07	20,481	23,833	44,314	8,928	46.2	53.8
7/08	10,125	14,731	24,856	1,181	40.7	59.3
7/09	10,157	13,368	23,525	1,535	43.2	56.8
7/10	13,826	18,469	32,295	2,036	42.8	57.2
7/11	18,133	30,238	48,371	5,667	37.5	62.5
7/12	12,908	36,457	49,365	3,822	26.1	73.9
7/13	9,419	16,853	26,272	3,514	35.9	64.1
7/14	8,284	11,386	19,670	1,226	42.1	57.9
7/15	11,871	17,363	29,234	2,959	40.6	59.4
7/16	10,661	22,158	32,819	2,577	32.5	67.5
7/17	9,723	16,886	26,609	3,159	36.5	63.5
7/18	15,209	35,515	50,724	3,496	30.0	70.0

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Appendix C1.–Page 2 of 3.

Date	Right bank	Left bank	Total		Percent by bank	
			Passage	SE	Right	Left
7/19	12,576	32,086	69,657	16,549	28.2	71.8
7/20	11,217	21,812	125,992	11,592	34.0	66.0
7/21	8,913	30,755	61,962	8,031	22.5	77.5
7/22	17,277	41,392	31,638	5,835	29.4	70.6
7/23	16,045	34,635	25,573	4,164	31.7	68.3
7/24	15,840	25,776	16,418	3,357	38.1	61.9
7/25	15,737	27,639	17,912	4,649	36.3	63.7
7/26	17,408	30,221	29,796	5,446	36.5	63.5
7/27	15,972	25,776	46,460	4,119	38.3	61.7
7/28	11,449	20,003	34,465	4,382	36.4	63.6
7/29	15,183	21,590	49,222	6,748	41.3	58.7
7/30	10,638	21,283	79,809	7,650	33.3	66.7
7/31	8,900	16,708	36,844	5,505	34.8	65.2
8/01	8,118	10,385	17,481	2,484	43.9	56.1
8/02	7,365	15,073	11,507	2,165	32.8	67.2
8/03	6,658	13,878	16,940	3,097	32.4	67.6
8/04	7,076	33,487	30,418	4,093	17.4	82.6
8/05	7,118	27,078	24,719	4,289	20.8	79.2
8/06	8,810	29,172	14,783	3,005	23.2	76.8
8/07	7,191	18,322	12,330	2,913	28.2	71.8
8/08	6,143	10,473	12,348	2,717	37.0	63.0
8/09	3,549	14,461	15,842	3,079	19.7	80.3
8/10	6,042	46,757	14,080	3,217	11.4	88.6
8/11	6,784	46,684	11,628	1,970	12.7	87.3
8/12	5,258	18,594	9,204	3,902	22.0	78.0
8/13	3,123	8,081	66,073	10,912	27.9	72.1
8/14	2,460	6,650	250,209	24,031	27.0	73.0
8/15	2,535	6,456	270,808	24,236	28.2	71.8
8/16	3,533	12,963	332,379	26,595	21.4	78.6
8/17	11,224	46,834	168,127	17,721	19.3	80.7
8/18	9,784	50,676	65,007	9,178	16.2	83.8
8/19	9,207	19,652	46,919	4,639	31.9	68.1
8/20	22,668	39,195	30,414	4,421	36.6	63.4
8/21	25,106	45,980	36,270	5,796	35.3	64.7
8/22	10,898	23,615	32,620	4,807	31.6	68.4
8/23	5,215	8,428	33,808	6,157	38.2	61.8
8/24	3,882	4,644	28,115	5,158	45.5	54.5
8/25	3,491	4,389	31,830	4,808	44.3	55.7
8/26	5,307	5,409	25,873	4,042	49.5	50.5
8/27	6,155	9,021	26,348	6,810	40.6	59.4
8/28	5,876	10,632	34,474	7,733	35.6	64.4
8/29	14,510	43,433	41,924	21,545	25.0	75.0
8/30	23,974	93,952	28,109	4,768	20.3	79.7
8/31	15,479	52,222	17,912	2,989	22.9	77.1

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Appendix C1.–Page 3 of 3.

Date	Right bank	Left bank	Total		Percent by bank	
			Passage	SE	Right	Left
9/01	8,469	23,488	31,957	2,976	26.5	73.5
9/02	5,116	9,342	14,458	1,362	35.4	64.6
9/03	3,827	7,081	10,908	588	35.1	64.9
9/04	4,319	8,279	12,598	1,307	34.3	65.7
9/05	5,370	14,189	19,559	821	27.5	72.5
9/06	5,494	11,652	17,146	928	32.0	68.0
9/07	4,223	9,784	14,007	1,035	30.1	69.9
Season	997,745	3,079,351	4,077,096	523,718	24.5	75.5

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, 2018.

	Chinook			Chum					Whitefish				
Date	Large[a]	Small[b]	Total	Summer	Fall	Coho	Pink	Cisco	Humpback	Broad	Sheefish	Other[c]	Total
6/01	0	0	0	645	0	0	0	1,212	0	203	635	439	3,134
6/02	0	0	0	527	0	0	0	922	0	193	548	417	2,607
6/03	207	0	207	517	0	0	0	888	0	382	617	590	3,201
6/04	228	0	228	428	0	0	0	891	0	304	459	399	2,709
6/05	184	0	184	430	0	0	0	771	0	316	504	473	2,678
6/06	212	66	278	969	0	0	0	874	0	290	603	627	3,641
6/07	1,058	0	1,058	1,639	0	0	0	897	518	0	357	0	4,469
6/08	942	0	942	3,022	0	0	0	1,011	362	0	513	157	6,007
6/09	1,803	268	2,071	7,750	0	0	0	543	494	0	1,000	0	11,858
6/10	3,304	430	3,734	17,869	0	0	0	0	451	0	358	149	22,561
6/11	1,407	793	2,200	23,715	0	0	0	712	277	791	626	266	28,587
6/12	2,742	1,594	4,336	23,143	0	0	0	1,064	500	169	535	767	30,514
6/13	852	185	1,037	19,456	0	0	0	884	696	248	136	1,285	23,742
6/14	2,073	526	2,599	19,636	0	0	0	2,770	266	310	110	784	26,475
6/15	2,948	712	3,660	24,570	0	0	0	4,259	0	604	591	814	34,498
6/16	3,721	849	4,570	40,101	0	0	0	1,942	1,570	0	771	0	48,954
6/17	3,595	1,940	5,535	44,118	0	0	0	2,151	1,163	604	297	597	54,465
6/18	5,133	1,291	6,424	50,319	0	0	386	3,248	0	0	399	0	60,776
6/19	2,963	620	3,583	43,446	0	0	0	1,536	0	840	1,300	1,370	52,075
6/20	6,261	1,124	7,385	54,171	0	0	547	1,587	0	629	306	0	64,625
6/21	3,740	6,594	10,334	86,214	0	0	0	11,185	0	0	685	0	108,418
6/22	4,625	1,620	6,245	52,350	0	0	0	5,038	0	0	0	0	63,633
6/23	2,964	513	3,477	35,855	0	0	0	4,427	467	254	554	0	45,034
6/24	2,167	291	2,458	38,636	0	0	349	4,740	520	0	394	276	47,373
6/25	5,428	1,013	6,441	24,714	0	0	614	14,837	0	0	363	0	46,969
6/26	3,719	1,972	5,691	68,999	0	0	3,211	2,460	828	0	352	2,081	83,622
6/27	4,007	1,562	5,569	37,894	0	0	4,211	6,478	1,108	0	731	474	56,465
6/28	12,840	1,426	14,266	39,004	0	0	5,623	911	546	414	436	0	61,200
6/29	2,672	672	3,344	67,810	0	0	5,338	9,979	1,906	0	541	870	89,788
6/30	9,457	1,748	11,205	46,434	0	0	913	1,397	504	0	816	2,697	63,966

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	Chinook			Chum					Whitefish				
Date	Large[a]	Small[b]	Total	Summer	Fall	Coho	Pink	Cisco	Humpback	Broad	Sheefish	Other[c]	Total
7/01	3,210	1,083	4,293	15,864	0	0	9,533	9,399	0	0	136	101	39,326
7/02	2,660	1,548	4,208	24,000	0	0	21,444	2,312	2,257	0	185	351	54,757
7/03	1,367	686	2,053	84,649	0	0	23,119	5,320	1,662	398	1,168	888	119,257
7/04	8,409	858	9,267	183,896	0	0	31,097	8,155	986	0	352	1,193	234,946
7/05	2,779	4,114	6,893	178,014	0	0	58,545	20,813	2,717	453	2,626	0	270,061
7/06	2,774	653	3,427	62,542	0	0	36,241	3,863	1,074	720	0	185	108,052
7/07	1,958	572	2,530	17,778	0	0	16,763	5,241	1,174	0	295	533	44,314
7/08	1,162	295	1,457	10,649	0	0	8,750	2,903	687	0	146	264	24,856
7/09	1,384	75	1,459	8,728	0	0	9,371	2,286	1,083	108	422	68	23,525
7/10	316	0	316	21,885	0	0	6,077	2,190	1,696	0	131	0	32,295
7/11	537	0	537	33,703	0	0	8,356	3,100	2,503	0	172	0	48,371
7/12	505	783	1,288	34,558	0	0	9,588	2,465	1,257	0	0	209	49,365
7/13	441	0	441	6,908	0	0	9,470	7,166	1,730	402	0	155	26,272
7/14	357	0	357	4,926	0	0	7,335	5,225	1,381	310	0	136	19,670
7/15	71	197	268	14,340	0	0	9,776	3,230	948	192	215	265	29,234
7/16	90	224	314	17,316	0	0	10,259	3,395	910	172	215	238	32,819
7/17	73	187	260	13,533	0	0	8,572	2,885	807	156	179	217	26,609
7/18	0	0	0	5,018	0	0	42,905	716	1,843	102	59	81	50,724
7/19	350	0	350	0	25,221	0	13,474	4,186	1,284	0	0	147	44,662
7/20	476	0	476	0	13,121	0	14,649	4,056	376	79	0	272	33,029
7/21	253	0	253	0	20,206	0	12,312	6,277	317	37	49	217	39,668
7/22	325	0	325	0	29,346	0	19,220	8,641	551	70	96	420	58,669
7/23	758	0	758	0	13,911	0	31,224	286	4,107	0	0	394	50,680
7/24	0	104	104	0	7,048	0	27,985	2,714	2,930	117	0	718	41,616
7/25	0	86	86	0	7,443	0	28,977	2,854	3,153	97	0	766	43,376
7/26	0	0	0	0	4,790	0	29,738	9,254	3,190	0	0	657	47,629
7/27	677	104	781	0	2,961	0	30,924	4,026	2,020	0	0	1,036	41,748
7/28	0	0	0	0	4,823	0	19,650	4,122	2,237	336	0	284	31,452
7/29	0	0	0	0	5,259	0	23,721	4,540	2,511	399	0	343	36,773
7/30	0	0	0	0	1,766	0	18,772	4,932	5,338	0	0	1,113	31,921

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	Chinook			Chum					Whitefish				
Date	Large[a]	Small[b]	Total	Summer	Fall	Coho	Pink	Cisco	Humpback	Broad	Sheefish	Other[c]	Total
7/31	0	0	0	0	540	29	16,322	3,785	3,265	350	343	974	25,608
8/01	0	0	0	0	505	28	11,911	2,569	2,244	226	279	741	18,503
8/02	0	59	59	0	7,428	0	10,218	1,727	2,423	46	0	537	22,438
8/03	0	0	0	0	6,539	0	7,537	2,605	2,913	336	0	606	20,536
8/04	122	0	122	0	27,288	524	2,960	6,940	1,964	178	430	157	40,563
8/05	88	0	88	0	22,531	481	2,777	5,942	1,638	180	402	157	34,196
8/06	0	0	0	0	23,343	633	5,197	4,304	4,042	0	141	322	37,982
8/07	0	0	0	0	12,934	1,930	2,820	3,443	3,949	0	156	281	25,513
8/08	0	0	0	0	8,175	1,314	2,020	2,141	2,594	0	133	239	16,616
8/09	0	0	0	0	8,129	3,151	343	3,760	2,005	0	228	394	18,010
8/10	0	0	0	0	40,905	1,085	1,353	4,920	2,599	0	432	1,505	52,799
8/11	0	0	0	0	42,266	1,385	1,270	4,050	2,627	0	358	1,512	53,468
8/12	0	0	0	0	15,209	2,094	4,208	646	861	0	135	699	23,852
8/13	0	0	0	0	5,462	2,786	179	1,288	502	587	205	195	11,204
8/14	0	0	0	0	3,310	1,998	580	1,107	1,557	58	167	333	9,110
8/15	0	0	0	0	3,274	1,997	504	1,406	1,316	61	133	300	8,991
8/16	0	0	0	0	10,220	1,443	0	2,622	1,137	0	0	1,074	16,496
8/17	0	0	0	0	47,618	4,309	0	3,063	1,916	0	0	1,152	58,058
8/18	0	0	0	0	50,569	4,134	0	2,729	2,023	0	0	1,005	60,460
8/19	0	0	0	0	17,303	5,557	369	1,728	2,915	0	0	987	28,859
8/20	0	0	0	0	53,920	5,799	0	1,369	466	126	183	0	61,863
8/21	0	0	0	0	62,406	6,497	0	1,355	486	140	202	0	71,086
8/22	0	0	0	0	24,293	5,569	0	3,000	1,418	233	0	0	34,513
8/23	0	0	0	0	5,528	5,374	0	1,641	693	0	0	407	13,643
8/24	0	0	0	0	1,453	3,505	0	2,120	1,003	0	0	445	8,526
8/25	0	0	0	0	2,427	3,215	0	944	543	92	173	486	7,880
8/26	0	0	0	0	3,058	4,558	0	1,364	687	139	232	678	10,716
8/27	0	0	0	0	6,989	2,788	0	3,050	1,224	0	0	1,125	15,176
8/28	0	0	0	0	11,076	2,436	0	2,496	247	253	0	0	16,508
8/29	0	0	0	0	43,946	8,796	0	3,039	1,204	110	0	848	57,943

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	Chinook			Chum					Whitefish				
Date	Large[a]	Small[b]	Total	Summer	Fall	Coho	Pink	Cisco	Humpback	Broad	Sheefish	Other[c]	Total
8/30	0	0	0	0	91,617	16,850	0	5,309	2,474	182	0	1,494	117,926
8/31	0	0	0	0	51,904	10,152	0	3,347	1,292	118	0	888	67,701
9/01	0	0	0	0	19,995	7,611	0	2,916	799	94	0	542	31,957
9/02	0	0	0	0	8,193	3,755	0	1,762	452	57	0	239	14,458
9/03	0	0	0	0	6,596	2,989	0	906	212	49	80	76	10,908
9/04	0	0	0	0	7,655	3,437	0	1,034	240	56	90	86	12,598
9/05	0	0	0	0	14,751	2,531	0	1,315	699	159	0	104	19,559
9/06	0	0	0	0	13,419	2,309	0	597	821	0	0	0	17,146
9/07	0	0	0	0	9,995	3,298	0	327	221	166	0	0	14,007
Season	122,394	39,437	161,831	1,612,688	928,664	136,347	689,607	334,832	124,576	14,695	26,485	47,371	4,077,096

[a] Chinook salmon >655 mm.

[b] Chinook salmon ≤655 mm.

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

APPENDIX E: DAILY CUMULATIVE FISH PASSAGE ESTIMATES, 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, 2018.

	Chinook			Chum					Whitefish				
Date	Large [a]	Small [b]	Total	Summer	Fall	Coho	Pink	Cisco	Humpback	Broad	Sheefish	Other [c]	Total
6/01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00
6/02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.04	0.02	0.00
6/03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.06	0.07	0.03	0.00
6/04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.08	0.09	0.04	0.00
6/05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.10	0.10	0.05	0.00
6/06	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.12	0.13	0.06	0.00
6/07	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.12	0.14	0.06	0.01
6/08	0.02	0.00	0.02	0.01	0.00	0.00	0.00	0.02	0.01	0.12	0.16	0.07	0.01
6/09	0.04	0.01	0.03	0.01	0.00	0.00	0.00	0.02	0.01	0.12	0.20	0.07	0.01
6/10	0.06	0.02	0.05	0.02	0.00	0.00	0.00	0.02	0.02	0.12	0.21	0.07	0.02
6/11	0.08	0.04	0.07	0.04	0.00	0.00	0.00	0.03	0.02	0.18	0.24	0.08	0.02
6/12	0.10	0.08	0.09	0.05	0.00	0.00	0.00	0.03	0.02	0.19	**0.26**	0.09	0.03
6/13	0.11	0.08	0.10	0.06	0.00	0.00	0.00	0.03	0.03	0.21	0.26	0.12	0.04
6/14	0.12	0.10	0.12	0.07	0.00	0.00	0.00	0.04	0.03	0.23	0.27	0.14	0.04
6/15	0.15	0.12	0.14	0.09	0.00	0.00	0.00	0.05	0.03	**0.27**	0.29	0.15	0.05
6/16	0.18	0.14	0.17	0.11	0.00	0.00	0.00	0.06	0.04	0.27	0.32	0.15	0.06
6/17	0.21	0.19	0.20	0.14	0.00	0.00	0.00	0.07	0.05	0.31	0.33	0.17	0.08
6/18	**0.25**	0.22	0.24	0.17	0.00	0.00	0.00	0.08	0.05	0.31	0.34	0.17	0.09
6/19	0.27	0.24	0.26	0.20	0.00	0.00	0.00	0.08	0.05	0.37	0.39	0.20	0.11
6/20	0.32	**0.26**	0.31	0.23	0.00	0.00	0.00	0.09	0.05	0.42	0.41	0.20	0.12
6/21	0.35	0.43	0.37	**0.29**	0.00	0.00	0.00	0.12	0.05	0.42	0.43	0.20	0.15
6/22	0.39	0.47	0.41	0.32	0.00	0.00	0.00	0.14	0.05	0.42	0.43	0.20	0.17
6/23	0.42	0.48	0.43	0.34	0.00	0.00	0.00	0.15	0.06	0.43	0.45	0.20	0.18
6/24	0.43	0.49	0.45	0.37	0.00	0.00	0.00	0.16	0.06	0.43	0.47	0.20	0.19
6/25	0.48	**0.52**	0.49	0.38	0.00	0.00	0.00	0.21	0.06	0.43	0.48	0.20	0.20
6/26	**0.51**	0.57	**0.52**	0.42	0.00	0.00	0.01	0.22	0.07	0.43	0.49	**0.25**	0.22
6/27	0.54	0.61	0.56	0.45	0.00	0.00	0.01	0.24	0.08	0.43	**0.52**	0.26	0.24
6/28	0.65	0.64	0.65	0.47	0.00	0.00	0.02	0.24	0.08	0.46	0.54	0.26	**0.25**
6/29	0.67	0.66	0.67	**0.51**	0.00	0.00	0.03	**0.27**	0.10	0.46	0.56	0.28	0.28
6/30	**0.75**	0.71	0.74	0.54	0.00	0.00	0.03	0.27	0.10	0.46	0.59	0.34	0.29
7/01	0.77	0.73	**0.76**	0.55	0.00	0.00	0.04	0.30	0.10	0.46	0.60	0.34	0.30
7/02	0.79	**0.77**	0.79	0.57	0.00	0.00	0.08	0.31	0.12	0.46	0.60	0.35	0.32
7/03	0.80	0.79	0.80	0.62	0.00	0.00	0.11	0.33	0.13	0.49	0.65	0.36	0.35

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Date	Chinook			Chum		Coho	Pink	Cisco	Whitefish		Sheefish	Other [c]	Total
	Large [a]	Small [b]	Total	Summer	Fall				Humpback	Broad			
7/04	0.87	0.81	0.86	0.73	0.00	0.00	0.15	0.35	0.14	0.49	0.66	0.39	0.40
7/05	0.90	0.92	0.90	**0.84**	0.00	0.00	0.24	0.42	0.16	**0.52**	**0.76**	0.39	0.47
7/06	0.92	0.93	0.92	0.88	0.00	0.00	**0.29**	0.43	0.17	0.58	0.76	0.39	**0.50**
7/07	0.93	0.95	0.94	0.89	0.00	0.00	0.32	0.44	0.18	0.58	0.77	0.41	0.51
7/08	0.94	0.95	0.95	0.90	0.00	0.00	0.33	0.45	0.19	0.58	0.78	0.41	0.52
7/09	0.96	0.96	0.96	0.91	0.00	0.00	0.34	0.46	0.20	0.58	0.79	0.41	0.52
7/10	0.96	0.96	0.96	0.92	0.00	0.00	0.35	0.47	0.21	0.58	0.80	0.41	0.53
7/11	0.96	0.96	0.96	0.94	0.00	0.00	0.36	0.48	0.23	0.58	0.80	0.41	0.54
7/12	0.97	0.98	0.97	0.96	0.00	0.00	0.38	0.48	0.24	0.58	0.80	0.42	0.56
7/13	0.97	0.98	0.97	0.97	0.00	0.00	0.39	**0.51**	**0.26**	0.61	0.80	0.42	0.56
7/14	0.97	0.98	0.97	0.97	0.00	0.00	0.40	0.52	0.27	0.63	0.80	0.42	0.57
7/15	0.97	0.98	0.98	0.98	0.00	0.00	0.42	0.53	0.28	0.65	0.81	0.43	0.58
7/16	0.97	0.99	0.98	0.99	0.00	0.00	0.43	0.54	0.28	0.66	0.82	0.43	0.58
7/17	0.98	0.99	0.98	1.00	0.00	0.00	0.44	0.55	0.29	0.67	0.83	0.44	0.59
7/18	0.98	0.99	0.98	1.00	0.00	0.00	**0.51**	0.55	0.30	0.68	0.83	0.44	0.60
7/19	0.98	0.99	0.98	1.00	0.03	0.00	0.52	0.57	0.32	0.68	0.83	0.44	0.61
7/20	0.98	0.99	0.98	1.00	0.05	0.00	0.55	0.58	0.32	0.68	0.83	0.45	0.62
7/21	0.98	0.99	0.99	1.00	0.07	0.00	0.56	0.60	0.32	0.69	0.83	0.45	0.63
7/22	0.99	0.99	0.99	1.00	0.10	0.00	0.59	0.62	0.33	0.69	0.84	0.46	0.65
7/23	0.99	0.99	0.99	1.00	0.12	0.00	0.64	0.62	0.36	0.69	0.84	0.47	0.66
7/24	0.99	0.99	0.99	1.00	0.13	0.00	0.68	0.63	0.38	0.70	0.84	0.49	0.67
7/25	0.99	1.00	0.99	1.00	0.14	0.00	0.72	0.64	0.41	0.71	0.84	**0.50**	0.68
7/26	0.99	1.00	0.99	1.00	0.14	0.00	**0.76**	0.67	0.44	0.71	0.84	0.52	0.69
7/27	1.00	1.00	1.00	1.00	0.15	0.00	0.81	0.68	0.45	0.71	0.84	0.54	0.71
7/28	1.00	1.00	1.00	1.00	0.15	0.00	0.84	0.70	0.47	0.73	0.84	0.55	0.71
7/29	1.00	1.00	1.00	1.00	0.16	0.00	0.87	0.71	0.49	**0.76**	0.84	0.55	0.72
7/30	1.00	1.00	1.00	1.00	0.16	0.00	0.90	0.72	**0.54**	0.76	0.84	0.58	0.73
7/31	1.00	1.00	1.00	1.00	0.16	0.00	0.92	0.74	0.56	0.78	0.85	0.60	0.74
8/01	1.00	1.00	1.00	1.00	0.16	0.00	0.94	0.74	0.58	0.80	0.86	0.62	0.74
8/02	1.00	1.00	1.00	1.00	0.17	0.00	0.95	**0.75**	0.60	0.80	0.86	0.63	**0.75**
8/03	1.00	1.00	1.00	1.00	0.18	0.00	0.96	0.76	0.63	0.83	0.86	0.64	0.75
8/04	1.00	1.00	1.00	1.00	0.21	0.01	0.97	0.78	0.64	0.84	0.88	0.64	0.76
8/05	1.00	1.00	1.00	1.00	0.24	0.01	0.97	0.80	0.66	0.85	0.89	0.65	0.77

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Appendix E1.–Page 3 of 3.

Date	Chinook Large [a]	Chinook Small [b]	Chinook Total	Chum Summer	Chum Fall	Coho	Pink	Cisco	Whitefish Humpback	Whitefish Broad	Sheefish	Other [c]	Total
8/06	1.00	1.00	1.00	1.00	**0.26**	0.02	0.98	0.81	0.69	0.85	0.90	0.65	0.78
8/07	1.00	1.00	1.00	1.00	0.28	0.03	0.98	0.80	0.72	0.85	0.90	0.66	0.79
8/08	1.00	1.00	1.00	1.00	0.29	0.04	0.99	0.81	0.74	0.85	0.91	0.66	0.79
8/09	1.00	1.00	1.00	1.00	0.30	0.07	0.99	0.82	**0.76**	0.85	0.92	0.67	0.80
8/10	1.00	1.00	1.00	1.00	0.35	0.08	0.99	0.83	0.78	0.85	0.93	0.71	0.81
8/11	1.00	1.00	1.00	1.00	0.40	0.10	0.99	0.84	0.80	0.85	0.95	0.74	0.82
8/12	1.00	1.00	1.00	1.00	0.41	0.11	1.00	0.85	0.81	0.85	0.95	**0.75**	0.83
8/13	1.00	1.00	1.00	1.00	0.42	0.14	1.00	0.85	0.81	0.89	0.96	0.76	0.83
8/14	1.00	1.00	1.00	1.00	0.43	0.16	1.00	0.85	0.83	0.90	0.96	0.76	0.83
8/15	1.00	1.00	1.00	1.00	0.43	0.18	1.00	0.86	0.84	0.90	0.97	0.77	0.84
8/16	1.00	1.00	1.00	1.00	0.44	0.19	1.00	0.86	0.85	0.90	0.97	0.79	0.84
8/17	1.00	1.00	1.00	1.00	**0.50**	0.23	1.00	0.87	0.86	0.90	0.97	0.82	0.86
8/18	1.00	1.00	1.00	1.00	0.56	**0.27**	1.00	0.88	0.88	0.90	0.97	0.84	0.87
8/19	1.00	1.00	1.00	1.00	0.58	0.32	1.00	0.89	0.90	0.90	0.97	0.86	0.88
8/20	1.00	1.00	1.00	1.00	0.64	0.37	1.00	0.89	0.91	0.91	0.98	0.86	0.89
8/21	1.00	1.00	1.00	1.00	0.71	0.43	1.00	0.89	0.91	0.92	0.98	0.86	0.91
8/22	1.00	1.00	1.00	1.00	0.74	0.48	1.00	0.90	0.92	0.94	0.98	0.86	0.92
8/23	1.00	1.00	1.00	1.00	**0.75**	**0.53**	1.00	0.91	0.93	0.94	0.98	0.87	0.92
8/24	1.00	1.00	1.00	1.00	0.75	0.56	1.00	0.92	0.94	0.94	0.98	0.88	0.93
8/25	1.00	1.00	1.00	1.00	0.75	0.59	1.00	0.92	0.94	0.94	0.99	0.89	0.93
8/26	1.00	1.00	1.00	1.00	0.76	0.63	1.00	0.92	0.95	0.95	1.00	0.91	0.93
8/27	1.00	1.00	1.00	1.00	0.77	0.65	1.00	0.93	0.96	0.95	1.00	0.93	0.93
8/28	1.00	1.00	1.00	1.00	0.78	0.68	1.00	0.94	0.96	0.97	1.00	0.93	0.94
8/29	1.00	1.00	1.00	1.00	0.83	**0.76**	1.00	0.95	0.97	0.98	1.00	0.95	0.95
8/30	1.00	1.00	1.00	1.00	0.94	0.91	1.00	0.96	0.99	0.99	1.00	0.98	0.98
8/31	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	1.00	1.00	1.00	1.00	1.00

Note: The 25th, 50th, and 75th percentiles are bold. For consistency in comparing previous years, 2018 run timing is based on an end date of August 31, despite extended operations to September 7.

[a] Chinook salmon >655 mm.

[b] Chinook salmon ≤655 mm.

[c] Includes sockeye salmon, 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, 2018

Appendix F1.–Daily cumulative fish passage proportions and timing by species, at the Pilot Station sonar project on the Yukon River, 2018.

	Chinook			Chum					Whitefish				
Date	Large [a]	Small [b]	Total	Summer	Fall	Coho	Pink	Cisco	Humpback	Broad	Sheefish	Other [c]	Total
6/01	369	0	369	5,399	0	0	0	1,219	1,780	801	1,518	2,212	13,298
6/02	854	0	854	10,882	0	0	0	2,824	2,142	1,029	1,700	3,444	22,875
6/03	1,213	0	1,213	16,466	0	0	0	4,244	2,626	1,308	2,665	4,320	32,842
6/04	2,007	0	2,007	22,356	0	0	0	5,306	3,004	1,308	3,633	6,256	43,870
6/05	3,139	869	4,008	28,336	0	0	0	8,436	3,289	1,566	4,780	6,622	57,037
6/06	4,593	1,258	5,851	38,540	0	0	0	8,466	3,792	1,566	6,426	7,448	72,089
6/07	5,357	1,258	6,615	46,936	0	0	0	9,816	5,086	2,036	7,113	7,837	85,439
6/08	8,050	1,258	9,308	51,504	0	0	0	10,653	5,954	3,125	7,796	10,100	98,440
6/09	13,401	2,578	15,979	62,417	0	0	0	10,962	6,900	3,553	8,736	10,980	119,527
6/10	14,500	2,930	17,430	81,629	0	0	0	12,283	7,717	3,923	9,486	11,740	144,208
6/11	18,013	3,667	21,680	89,096	0	0	0	14,393	8,106	4,210	10,821	12,046	160,352
6/12	23,471	4,240	27,711	108,349	0	0	0	15,360	8,776	4,658	13,121	14,615	192,590
6/13	25,651	4,437	30,088	118,657	0	0	0	20,644	9,982	5,698	14,479	15,363	214,911
6/14	40,493	6,713	47,206	254,610	0	0	0	20,927	11,600	5,698	14,479	15,732	370,252
6/15	46,103	8,528	54,631	352,408	0	0	0	28,869	14,041	5,963	16,525	16,375	488,812
6/16	53,307	10,575	63,882	463,595	0	0	0	34,976	15,229	6,586	17,647	19,450	621,365
6/17	61,231	10,883	72,114	523,124	0	0	0	36,985	15,404	6,586	18,011	19,781	692,005
6/18	78,006	11,508	89,514	667,475	0	0	0	41,235	15,760	6,586	19,046	20,698	860,314
6/19	86,125	13,795	99,920	854,486	0	0	0	52,229	17,005	9,048	19,970	21,559	1,074,217
6/20	94,445	15,556	110,001	940,289	0	0	0	55,177	17,005	10,452	19,970	21,559	1,174,453
6/21	120,147	15,556	135,703	1,225,240	0	0	0	59,346	17,005	12,736	20,842	21,559	1,492,431
6/22	126,423	16,900	143,323	1,494,371	0	0	0	68,393	19,439	12,736	21,671	23,373	1,783,306
6/23	141,120	24,661	165,781	1,717,182	0	0	0	71,896	20,091	13,208	21,671	23,792	2,033,621
6/24	148,293	27,799	176,092	1,860,217	0	0	415	74,479	21,398	13,208	21,840	23,792	2,191,441
6/25	149,673	29,720	179,393	1,897,629	0	0	415	84,595	24,992	13,492	23,189	25,055	2,248,760
6/26	158,485	30,123	188,608	2,021,362	0	0	415	92,565	27,594	14,027	24,383	26,429	2,395,383
6/27	165,833	30,123	195,956	2,153,935	0	0	949	94,741	28,067	15,060	24,383	26,959	2,540,050
6/28	170,992	31,575	202,567	2,223,987	0	0	949	99,801	28,530	15,060	24,795	28,679	2,624,368
6/29	179,204	31,575	210,779	2,345,866	0	0	949	105,190	29,149	15,060	25,227	31,101	2,763,321
6/30	183,908	32,633	216,541	2,443,307	0	0	949	111,653	31,074	15,060	25,444	33,301	2,877,329
7/01	186,079	34,007	220,086	2,499,150	0	0	1,482	123,036	35,130	15,303	25,885	33,836	2,953,908
7/02	190,859	34,360	225,219	2,558,688	0	0	1,482	127,883	36,155	15,512	25,885	33,836	3,024,660
7/03	196,212	35,705	231,917	2,598,542	0	0	1,482	128,712	42,663	18,011	26,416	34,152	3,081,895

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Appendix F1.–Page 2 of 3.

Date	Chinook			Chum		Coho	Pink	Cisco	Whitefish		Sheefish	Other [c]	Total
	Large [a]	Small [b]	Total	Summer	Fall				Humpback	Broad			
7/04	106,898	31,984	138,882	1,182,790	0	0	106,385	114,800	17,081	6,949	17,378	18,065	1,602,330
7/05	109,677	36,098	145,775	1,360,804	0	0	164,930	135,613	19,798	7,402	20,004	18,065	1,872,391
7/06	112,451	36,751	149,202	1,423,346	0	0	201,171	139,476	20,872	8,122	20,004	18,250	1,980,443
7/07	114,409	37,323	151,732	1,441,124	0	0	217,934	144,717	22,046	8,122	20,299	18,783	2,024,757
7/08	115,571	37,618	153,189	1,451,773	0	0	226,684	147,620	22,733	8,122	20,445	19,047	2,049,613
7/09	116,955	37,693	154,648	1,460,501	0	0	236,055	149,906	23,816	8,230	20,867	19,115	2,073,138
7/10	117,271	37,693	154,964	1,482,386	0	0	242,132	152,096	25,512	8,230	20,998	19,115	2,105,433
7/11	117,808	37,693	155,501	1,516,089	0	0	250,488	155,196	28,015	8,230	21,170	19,115	2,153,804
7/12	118,313	38,476	156,789	1,550,647	0	0	260,076	157,661	29,272	8,230	21,170	19,324	2,203,169
7/13	118,754	38,476	157,230	1,557,555	0	0	269,546	164,827	31,002	8,632	21,170	19,479	2,229,441
7/14	119,111	38,476	157,587	1,562,481	0	0	276,881	170,052	32,383	8,942	21,170	19,615	2,249,111
7/15	119,182	38,673	157,855	1,576,821	0	0	286,657	173,282	33,331	9,134	21,385	19,880	2,278,345
7/16	119,272	38,897	158,169	1,594,137	0	0	296,916	176,677	34,241	9,306	21,600	20,118	2,311,164
7/17	119,345	39,084	158,429	1,607,670	0	0	305,488	179,562	35,048	9,462	21,779	20,335	2,337,773
7/18	119,345	39,084	158,429	1,612,688	0	0	348,393	180,278	36,891	9,564	21,838	20,416	2,388,497
7/19	119,695	39,084	158,779	1,612,688	25,221	0	361,867	184,464	38,175	9,564	21,838	20,563	2,433,159
7/20	120,171	39,084	159,255	1,612,688	38,342	0	376,516	188,520	38,551	9,643	21,838	20,835	2,466,188
7/21	120,424	39,084	159,508	1,612,688	58,548	0	388,828	194,797	38,868	9,680	21,887	21,052	2,505,856
7/22	120,749	39,084	159,833	1,612,688	87,894	0	408,048	203,438	39,419	9,750	21,983	21,472	2,564,525
7/23	121,507	39,084	160,591	1,612,688	101,805	0	439,272	203,724	43,526	9,750	21,983	21,866	2,615,205
7/24	121,507	39,188	160,695	1,612,688	108,853	0	467,257	206,438	46,456	9,867	21,983	22,584	2,656,821
7/25	121,507	39,274	160,781	1,612,688	116,296	0	496,234	209,292	49,609	9,964	21,983	23,350	2,700,197
7/26	121,507	39,274	160,781	1,612,688	121,086	0	525,972	218,546	52,799	9,964	21,983	24,007	2,747,826
7/27	122,184	39,378	161,562	1,612,688	124,047	0	556,896	222,572	54,819	9,964	21,983	25,043	2,789,574
7/28	122,184	39,378	161,562	1,612,688	128,870	0	576,546	226,694	57,056	10,300	21,983	25,327	2,821,026
7/29	122,184	39,378	161,562	1,612,688	134,129	0	600,267	231,234	59,567	10,699	21,983	25,670	2,857,799
7/30	122,184	39,378	161,562	1,612,688	135,895	0	619,039	236,166	64,905	10,699	21,983	26,783	2,889,720
7/31	122,184	39,378	161,562	1,612,688	136,435	29	635,361	239,951	68,170	11,049	22,326	27,757	2,915,328
8/01	122,184	39,378	161,562	1,612,688	136,940	57	647,272	242,520	70,414	11,275	22,605	28,498	2,933,831
8/02	122,184	39,437	161,621	1,612,688	144,368	57	657,490	244,247	72,837	11,321	22,605	29,035	2,956,269
8/03	122,184	39,437	161,621	1,612,688	150,907	57	665,027	246,852	75,750	11,657	22,605	29,641	2,976,805
8/04	122,306	39,437	161,743	1,612,688	178,195	581	667,987	253,792	77,714	11,835	23,035	29,798	3,017,368
8/05	122,394	39,437	161,831	1,612,688	200,726	1,062	670,764	259,734	79,352	12,015	23,437	29,955	3,051,564
8/06	122,394	39,437	161,831	1,612,688	224,069	1,695	675,961	264,038	83,394	12,015	23,578	30,277	3,089,546

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Appendix F1.–Page 3 of 3.

Date	Chinook			Chum		Coho	Pink	Cisco	Whitefish		Sheefish	Other [c]	Total
	Large [a]	Small [b]	Total	Summer	Fall				Humpback	Broad			
8/07	122,394	39,437	161,831	1,612,688	237,003	3,625	678,781	267,481	87,343	12,015	23,734	30,558	3,115,059
8/08	122,394	39,437	161,831	1,612,688	245,178	4,939	680,801	269,622	89,937	12,015	23,867	30,797	3,131,675
8/09	122,394	39,437	161,831	1,612,688	253,307	8,090	681,144	273,382	91,942	12,015	24,095	31,191	3,149,685
8/10	122,394	39,437	161,831	1,612,688	294,212	9,175	682,497	278,302	94,541	12,015	24,527	32,696	3,202,484
8/11	122,394	39,437	161,831	1,612,688	336,478	10,560	683,767	282,352	97,168	12,015	24,885	34,208	3,255,952
8/12	122,394	39,437	161,831	1,612,688	351,687	12,654	687,975	282,998	98,029	12,015	25,020	34,907	3,279,804
8/13	122,394	39,437	161,831	1,612,688	357,149	15,440	688,154	284,286	98,531	12,602	25,225	35,102	3,291,008
8/14	122,394	39,437	161,831	1,612,688	360,459	17,438	688,734	285,393	100,088	12,660	25,392	35,435	3,300,118
8/15	122,394	39,437	161,831	1,612,688	363,733	19,435	689,238	286,799	101,404	12,721	25,525	35,735	3,309,109
8/16	122,394	39,437	161,831	1,612,688	373,953	20,878	689,238	289,421	102,541	12,721	25,525	36,809	3,325,605
8/17	122,394	39,437	161,831	1,612,688	421,571	25,187	689,238	292,484	104,457	12,721	25,525	37,961	3,383,663
8/18	122,394	39,437	161,831	1,612,688	472,140	29,321	689,238	295,213	106,480	12,721	25,525	38,966	3,444,123
8/19	122,394	39,437	161,831	1,612,688	489,443	34,878	689,607	296,941	109,395	12,721	25,525	39,953	3,472,982
8/20	122,394	39,437	161,831	1,612,688	543,363	40,677	689,607	298,310	109,861	12,847	25,708	39,953	3,534,845
8/21	122,394	39,437	161,831	1,612,688	605,769	47,174	689,607	299,665	110,347	12,987	25,910	39,953	3,605,931
8/22	122,394	39,437	161,831	1,612,688	630,062	52,743	689,607	302,665	111,765	13,220	25,910	39,953	3,640,444
8/23	122,394	39,437	161,831	1,612,688	635,590	58,117	689,607	304,306	112,458	13,220	25,910	40,360	3,654,087
8/24	122,394	39,437	161,831	1,612,688	637,043	61,622	689,607	306,426	113,461	13,220	25,910	40,805	3,662,613
8/25	122,394	39,437	161,831	1,612,688	639,470	64,837	689,607	307,370	114,004	13,312	26,083	41,291	3,670,493
8/26	122,394	39,437	161,831	1,612,688	642,528	69,395	689,607	308,734	114,691	13,451	26,315	41,969	3,681,209
8/27	122,394	39,437	161,831	1,612,688	649,517	72,183	689,607	311,784	115,915	13,451	26,315	43,094	3,696,385
8/28	122,394	39,437	161,831	1,612,688	660,593	74,619	689,607	314,280	116,162	13,704	26,315	43,094	3,712,893
8/29	122,394	39,437	161,831	1,612,688	704,539	83,415	689,607	317,319	117,366	13,814	26,315	43,942	3,770,836
8/30	122,394	39,437	161,831	1,612,688	796,156	100,265	689,607	322,628	119,840	13,996	26,315	45,436	3,888,762
8/31	122,394	39,437	161,831	1,612,688	848,060	110,417	689,607	325,975	121,132	14,114	26,315	46,324	3,956,463
9/01	122,394	39,437	161,831	1,612,688	868,055	118,028	689,607	328,891	121,931	14,208	26,315	46,866	3,988,420
9/02	122,394	39,437	161,831	1,612,688	876,248	121,783	689,607	330,653	122,383	14,265	26,315	47,105	4,002,878
9/03	122,394	39,437	161,831	1,612,688	882,844	124,772	689,607	331,559	122,595	14,314	26,395	47,181	4,013,786
9/04	122,394	39,437	161,831	1,612,688	890,499	128,209	689,607	332,593	122,835	14,370	26,485	47,267	4,026,384
9/05	122,394	39,437	161,831	1,612,688	905,250	130,740	689,607	333,908	123,534	14,529	26,485	47,371	4,045,943
9/06	122,394	39,437	161,831	1,612,688	918,669	133,049	689,607	334,505	124,355	14,529	26,485	47,371	4,063,089
9/07	122,394	39,437	161,831	1,612,688	928,664	136,347	689,607	334,832	124,576	14,695	26,485	47,371	4,077,096

[a] Chinook salmon >655 mm.

[b] Chinook salmon ≤655 mm.

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

APPENDIX G: PILOT STATION SONAR FISH PASSAGE ESTIMATES BY SPECIES, 1995-2018

Appendix G1.–Salmon passage estimates, by species, at the Pilot Station sonar project on the Yukon River, 1995–2018.

	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
1996[e]	ND	ND	ND	ND	ND	ND	ND	ND	ND
1997	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

[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 thru 2014 and 2018, 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, 1995–2018.

		Whitefish				
Year [a]	Cisco	Humpback	Broad	Sheefish	Other [b]	Total
1995	312,907	27,788	297,888	37,322	32,842	708,747
1996[c]	ND	ND	ND	ND	ND	ND
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

[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.