Fishery Data Series No. 19-15

Sonar Estimation of Salmon Passage in the Yukon River Near Pilot Station Alaska, 2017

by

Jody D Lozori

and

Lindsey M. Dreese

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

FISHERY DATA SERIES NO. 19-15

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by
Jody D. Lozori and Lindsey M. Dreese
Alaska Department of Fish and Game, Division of Commercial Fisheries, Fairbanks

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

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Kyle J. Schumann and Lindsey M. Dreese
Alaska Department of Fish and Game, Division of Commercial Fisheries,
1300 College Rd., Fairbanks, AK, USA

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ABSTRACT

The Pilot Station sonar project has provided daily passage estimates for 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 2017 using a 2-component process: (1) estimation of total fish passage with 120 kHz split-beam sonar and an adaptive resolution imaging sonar (ARIS), and (2) apportionment to species by sampling using a suite of gillnets of various mesh sizes. An estimated 6,315,728 fish passed through the sonar sampling area between May 31 and September 7. Of those fish, 1,296,504 passed along the right bank and 5,019,224 passed along the left bank. Included, with 90% confidence intervals, were 217,821 ± 26,413 large Chinook salmon (>655 mm mideye tail fork), 45,193 ± 12,236 small Chinook salmon (≤655 mm mideye tail fork), 3,093,735 ± 138,259 summer chum salmon, 1,829,931 ± 89,124 fall chum salmon, 166,320 ± 33,529 coho salmon, 166,529 ± 31,240 pink salmon *O. gorbuscha*, 414,668 ± 51,705 cisco *Coregonus* spp., 231,428 ± 32,759 humpback whitefish *C. pidschian*, 37,799 ± 10,921 broad whitefish *C. nasus*, 32,865 ± 9,425 sheefish *Stenodus leucichthys*, and 79,439 ± 13,482 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 the 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 2016 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 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). Prior to the 2016 field season, minimum selectivity thresholds were implemented into the model for species apportionment to prevent individual fish from skewing estimates dramatically (C. Pfisterer, Commercial Fisheries Biologist, ADF&G, Fairbanks; personal communication). The selectivity parameters used in the species apportionment model were updated using the most current catch data prior to the 2017 field season. Species proportions and passage estimates reported in this document were generated using this apportionment model, and are comparable to 1995–2015 estimates because estimates from those years were 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

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

integrated into the sampling routine on the left bank, and operated side-by-side with the split-beam sonar. The DIDSON sampled the first 20 m of the left bank nearshore 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 2013).

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, with 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 2001 to 2017 at the United States Geological Survey (USGS) gaging station located downstream of the project, has ranged from a maximum of 28.9 ft to a minimum of 13.6 ft from June 1 through September 7 (Figure 5).

METHODS

Daily upstream migration of targeted fish species is estimated by multiplying the daily sonar passage of all species with the daily proportions of each targeted fish species 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. One 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. One 150 m ARIS underwater cable connecting the ARIS to the command module and laptop PC.

Right bank sonar equipment included the following:

1. HTI Model 244 echosounder configured to operate at 120 kHz, controlled via DEP software installed on a laptop PC;
2. 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 provides adequate field of view. The lengths of cable were necessary for flexibility in placement of the transducers. Each HTI system configuration of sounder, transducer, and cable was calibrated by the manufacturer prior to the field season. Transducers were mounted on metal tripods and remotely aimed with HTI Model 662H dual-axis rotators (Figure 8), which allows precision in aiming, especially at range with the split-beam sonar. Rotator movements were controlled using 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 (0–40 m) and the 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 for fish counting with 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 fish targets were marked along with upstream targets 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 leader 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. The data were checked daily for data entry or marking errors, and then processed in statistical software (SAS) using routines developed by the ADF&G Commercial Fisheries Biometrician, Toshihide Hamazaki, Anchorage.

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. Electronic temperature data loggers were deployed to record water temperature on both banks on May 31 and remained submerged until September 8. The electronic temperature data loggers were programed to record the water temperature once every hour at the top of the hour. Daily temperature was calculated as the mean of all recorded temperatures for the day.

SPECIES APPORTIONMENT

To estimate species composition of the sonar estimates, gillnets were drifted through 3 test fishery zones (right bank, left bank nearshore, and left bank offshore) that corresponded to sonar sampling strata (Figure 7). The results of the right bank drift (test fishery Zone 1) were applied to the 2 right bank sonar strata (S1 and S2). The results of the left bank nearshore drift (test fishery Zone 2) were applied only to the sonar estimates in the first stratum on the left bank (S3), and the left bank offshore drift (test fishery Zone 3) was applied to the remainder of the left bank sonar estimates (S4 and S5).

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, 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 fishery 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 fishery 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 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 was 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, 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:

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.

Sparse and Missing Data

When sufficient gillnet samples were not available for a given day and zone, the data were pooled with data from 1 or more adjacent days by assigning the same report unit (u). Sufficient gillnet samples were unavailable during commercial gillnet fishing periods, because test fishery was not conducted during these times, and during times of low fish passage when catches were too sparse to accurately estimate species proportions and associated error bounds.

CPUE estimates were calculated daily irrespective of catch size. In contrast, species passage estimates were first calculated on the basis of report units (encompassing 1 or more full days of sampling within a zone), and then apportioned into daily estimates. For any test fishery variable (x), the report unit (u) encompasses day (d), test fishery period (p), and zone (z) such that:

$$x_u = \sum_{d,p,z}^{u} x_{dpz} \,. \tag{1}$$

The report unit was also appended to the corresponding days and zones of sonar passage estimates. In effect, any unique combination of day and zone with sufficient test fishery catch data was assigned a unique report unit (u), whereas combinations without sufficient catch for accurate apportionment were initially pooled by assigning the same report unit across adjacent days within the same zone. When pooling resulted in sufficient test fishery catch, estimates by species could then be calculated, and those species estimates were in turn re-apportioned back into daily estimates on the basis of sonar passage estimates during that time-frame.

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 (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:

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

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,

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:

$$f_{dbg} = \sum_{g} \frac{25 \cdot t_{dbg}}{60}, \tag{3}$$

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:

$$CPUE_{dbi} = \frac{\sum_{g} c_{dbig}}{f_{dbg}}. \tag{4}$$

Species Composition

To estimate species proportions, first the total effort (f) (in fathom-hours) of drift (j) with mesh size (m) during report unit (u) was calculated by multiplying the drift time (t) (calculated as in Equation 3) for each mesh, drift, and reporting unit by 25 fathoms and dividing by 60 minutes per hour.

$$f_{umj} = \frac{25 \cdot t_{umj}}{60}. \tag{5}$$

Total effort for each mesh size fished was then summed over each report unit,

$$f_{um} = \sum_{j} f_{umj}, \tag{6}$$

and the catch of species (i) of length (l) in each report unit (u) was summed across all mesh sizes,

$$c_{uil} = \sum_{m} c_{uilm}. \tag{7}$$

For the catch of each species (i) of length (l), the associated effort was adjusted by applying a length-based selectivity parameter (S) (Appendix A1; Bromaghin 2004),

$$f'_{uil} = \sum_{m} \left(S_{ilm} \cdot f_{um} \right). \tag{8}$$

A threshold was applied to selectivity such that,

$$S_{ilm} = \begin{cases} S_{ilm} & S_{ilm} \geq 0.1 \\ 0.1 & \text{otherwise} \end{cases}. \tag{9}$$

CPUE of the catch of each species (i) of length (l) was calculated as:

$$CPUE'_{uil} = \frac{c_{uil}}{f'_{uil}}. \tag{10}$$

The proportion (p) of species (i) during report unit (u) was estimated as the ratio of the CPUE for species (i) to the CPUE of all species combined,

$$\hat{p}_{ui} = \frac{\sum_{l} CPUE'_{uil}}{\sum_{i,l} CPUE'_{uil}}, \tag{11}$$

and the variance was estimated from the squared differences between the proportion for each test fishery period (x) for each day (d) within the report unit ($\hat{p}_{udxi}$) and the proportion for the report unit as a whole ($\hat{p}_{ui}$):

$$\hat{V}ar(\hat{p}_{ui}) = \frac{\sum(\hat{p}_{ui} - \hat{p}_{udxi})^2}{n_u \cdot (n_u - 1)}, \tag{12}$$

where n_u is the number of test fishery sampling periods within the report unit.

Sonar Passage Estimates

Total fish passage was estimated separately for each of the same 3 zones used in the species apportionment. Test fishery Zone 1 consisted of the entire counting range on the right bank, corresponding to S1 and S2 (approximately 0–150 m). Test fishery Zone 2 consisted of the counting range corresponding to S3 (approximately 0–50 m on the left bank). Test fishery Zone 3 consisted of the counting range corresponding to S4 and S5 (approximately 50–150 m and 150–300 m on the left bank, respectively) (Figure 7).

Total upstream fish passage (y) on day (d), during sonar period (p), in zone (z), and stratum (s) was calculated by summing net upstream targets over all sectors (k) and samples (q),

$$y_{dpzs} = \sum_q \sum_k y_{dpzsqk}, \tag{13}$$

and the duration, in hours (h), of the time sampled as,

$$h_{dpzs} = \sum_q \sum_k h_{dpzsqk}. \tag{14}$$

The hourly passage rate (r) for day (d), sonar period (p), and zone (z) was computed as a ratio of the sum of the estimated upstream passage in strata (s) to the duration (in hours) of the sample,

$$r_{dpz} = \frac{\sum_s y_{dpzs}}{\sum_s h_{dpzs}}. \tag{15}$$

Total passage of fish in a report unit ($\hat{y}_u$) was estimated as the product of the average hourly passage rate and the total hours encompassed by the report unit,

$$\hat{y}_u = (d_2 - d_1 + 1)_u \cdot 24 \cdot \left(\frac{\sum_{d,p,z \in u} r_{dpz}}{n_u} \right), \tag{16}$$

where d_1 is the first day, d_2 is the last day, and n_u is the number of sonar sampling periods in report unit (u).

Sonar sampling periods, each 3 hours in duration, were spaced at regular (systematic) intervals of 8 hours. Treating the systematically sampled sonar counts as a simple random sample could yield an over-estimate of the variance of the total, because sonar counts are highly auto correlated (Wolter 1985). To accommodate these data characteristics, a variance estimator based on the squared differences of successive observations, recommended by Brannian (1986) and modified from Wolter (1985), was employed;

$$\hat{V}ar(\hat{y}_u) = \left[(d_2 - d_1 + 1)_u \cdot 24\right]^2 \cdot \left[1 - \frac{h_u}{(d_2 - d_1 + 1)_u \cdot 24}\right] \cdot \frac{\sum_{p=2}^{n_u}(r_{up} - r_{u,p-1})^2}{2n_u(n_u - 1)}, \tag{17}$$

where r_{up} is the passage rate in reporting unit (*u*) for period (*p*), and

$$1 - \frac{h_u}{(d_2 - d_1 + 1)_u \cdot 24}, \tag{18}$$

is the finite population correction factor.

Fish Passage by Species

The passage of species (*i*) was estimated for each report unit (*u*) as the product of the species proportion (*p*) (Equation 11) and sonar passage (*y*) (Equation 16):

$$\hat{y}_{ui} = \hat{y}_u \cdot \hat{p}_{ui}. \tag{19}$$

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 (daily species passage estimates y_{idz}) was estimated as the variance of the product of 2 independent random variables (Goodman 1960),

$$\hat{V}ar(\hat{y}_{ui}) = \hat{y}_u^2 \cdot \hat{V}ar(\hat{p}_{ui}) + \hat{p}_{ui}^2 \cdot \hat{V}ar(\hat{y}_u) - \hat{V}ar(\hat{y}_u) \cdot \hat{V}ar(\hat{p}_{ui}). \tag{20}$$

Passage estimates were assumed independent between reporting units, therefore the variance of their sum was estimated by the sum of their variances

$$\hat{V}ar(\hat{y}_i) = \sum_u \hat{V}ar(\hat{y}_{ui}). \tag{21}$$

Daily species passage by zone was estimated by calculating the proportion of the hourly passage rate for the day and zone to the hourly passage rate for the report unit,

$$\hat{p}_{dz} = \frac{r_{udz}}{r_u}, \tag{22}$$

and then applying the passage proportion (*p*) to the report unit estimate (*y*),

$$\hat{y}_{dzi} = \hat{y}_{ui} \cdot \hat{p}_{dz}. \tag{23}$$

Total daily passage by species was estimated by summing over all zones,

$$\hat{y}_{di} = \sum_z \hat{y}_{dzi}. \tag{24}$$

At this stage, there were 2 potential ways of calculating total season passage summing the estimates across days or reporting units. Each can produce slightly different totals due to small rounding errors. To prevent confusion, passage estimates were summed over all zones and days to obtain a seasonal estimate for species ($\hat{y_i}$), because this is how the estimates are reported.

$$\hat{y}_i = \sum_d \sum_z \hat{y}_{dzi} . \tag{25}$$

Assuming normally distributed errors, 90% confidence intervals were calculated as,

$$\hat{y}_i \pm 1.645\sqrt{\hat{V}ar(\hat{y}_i)} . \tag{26}$$

SAS® program code (ADF&G Commercial Fisheries Biometrician, Toshihide Hamazaki, Anchorage) 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 the evening of May 31. The right bank split-beam sonar was deployed and operational for Period 3 on May 31. The left bank split-beam sonar was deployed May 31 and was operational for Period 3 on May 31. The ARIS was deployed on May 31 and was operational for Period 3 on May 31. The project was fully operational beginning with Period 1 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 May 5, which was 10 days earlier than the 10-year average (Table 7). The water level near Pilot Station during the 2017 season was below the 2001–2016 mean from June 1 through August 17, then rose above the mean through August 23, again falling below the mean on August 24 and remaining below throughout the rest of the season. During a period from July 6 through July 22 the water level remained below the 2001–2016 minimum level (Figure 5). Mean daily water temperatures on the left bank ranged between 9.8°C–20.1°C and 11.0°C–19.8°C on the right bank (Figure 10).

TEST FISHERY

Drift gillnet catch was 10,490 fish: 613 Chinook salmon, 4,376 summer chum salmon, 3,136 fall chum salmon, 624 coho salmon, and 1,741 fish of other species. Of the captured fish, 2,195 (21%) were retained as mortalities and delivered to local users within the nearby community of Pilot Station (Table 8). Of the 613 Chinook salmon captured in the test fishery, scale samples were collected from 606. Tissue samples for genetic stock identification were collected from 606 Chinook salmon and 7,489 chum salmon (Appendices B1 and B2).

HYDROACOUSTIC ESTIMATES

An estimated 6,315,728 fish passed through the sonar sampling areas between May 30 and September 7. Of that total passage, 1,296,504 (approximately 21%) fish passed along the right bank, 3,068,347 (approximately 49%) fish passed along the left bank nearshore, and 1,950,877 (approximately 31%) fish passed along the left bank offshore (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 80 m of the transducer during the summer and approximately 90% of the fish passage occurred within 90 m during the fall season. On the right bank, approximately 90% of the fish passage occurred within 60 m during the summer and 70 m during the fall season (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 passage estimates, with 90% confidence intervals, were 217,821 ± 26,413 large Chinook salmon (>655 mm METF), and 45,193 ± 12,236 small Chinook salmon (≤655 mm METF). Chum salmon cumulative passage estimates was 3,093,735 ± 138,259 summer chum salmon and 1,829,931 ± 89,124 fall chum salmon. Coho salmon cumulative passage estimate was 166,320 ± 33,529 fish, and pink salmon *O. gorbuscha* was 166,529 ± 31,240 fish. The cisco cumulative passage estimate was 414,668 ± 51,705 fish, humpback whitefish 231,428 ± 32,759 fish, broad whitefish 37,799± 10,921, sheefish 32,865 ± 9,425 fish, and other species (burbot, longnose sucker, Dolly Varden, sockeye salmon, and northern pike) was 79,439 ± 13,482 fish (Table 9).

The initial pulse of Chinook salmon began June 9 and the first pulse of summer chum salmon began 5 days later on June 14 (Figure 13). Compared to the 2007–2016 historical mean run timing, the midpoint of the Chinook salmon run was 4 days early (June 21), and summer chum salmon was 5 days early on June 23 (Figure 14; Appendices E and F).

There were 7 distinct fall chum salmon pulses that entered the Yukon River[2]. The fourth pulse was the largest and approximately 1.1 million fish in size. The pulse was 7 days in duration and peak daily passage at the sonar occurred was August 16 (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 in management decisions. Of the 7 pulses, the fall chum salmon composition ranged from 38.0% to 98.8% (Table 10; B Flannery, USFWS Conservation Genetics Laboratory Anchorage, personal communication). The mean cumulative run timing, for both fall chum and coho salmon, is 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 fell on August 15, which was 6 days late when compared to 2007–2016 mean cumulative run timing (Figure 16; Appendices E and F).

The first pulse of coho salmon arrived approximately August 13. There were 4 additional pulses of coho salmon through September 7 (Figure 15). As in most years, the project ends before the coho salmon run is complete, so estimates are considered conservative and timing may not reflect the total run. Compared to historical project data, the midpoint, for the coho salmon run was on August 20, which was 1 day early when compared to 2007–2016 mean cumulative run timing (Figure 16; Appendices E and F).

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[2] Estensen, J. and B. Borba. 2017. 2017 Yukon Area Fall Season Summary, Alaska Department of Fish and Game, Division of Commercial Fisheries, News Release, Fairbanks Alaska. [issued 2017 December 5; cited September 05, 2018] Available from: http://www.adfg.alaska.gov/index.cfm?adfg=cfnews.search_results&mgmt=7&district=&spec=&gear=&act=&year=2017 (Accessed September 2018).

MISSING DATA

All sonars were fully functional on both banks starting on May 31 during the third sonar period. Initially, there were 10 days (May 31 through June 9) with insufficient catches in at least 1 fishing zone, which made it necessary to pool the report periods (Table 11).

The first commercial fishing period occurred on June 21 in District 2, which necessitated cancelling 1 test fishery period for that day[3]. Commercial fishing continued through the remainder of the summer season, with a total of 9 commercial periods in District 2. A total of 2 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, fifteen commercial fishing periods occurred in District 2 which necessitated cancelling 11 test fishery periods. There were 7 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 that had 2 complete test fishery periods, and zones with insufficient catches were pooled with zones with sufficient catches on adjacent days (Table 11).

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 no problems in finding suitable transducer locations. Although in previous years there have been problems with silt attenuation or reverberation bands, in 2017 there were no serious problems with either.

Chinook salmon passage estimates at the Pilot Station sonar project for 2017 were higher than the 2016 estimates, and ranked second since 1995. Both summer and fall chum salmon passage estimates for 2017 were above the 2016 estimates (Appendix G1 and G2).

Although there were very 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 we employ 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 2017, all project goals were met with passage estimates 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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[3] Carroll, H. and D. Jallen. 2017. 2017 Preliminary Yukon River summer season summary, Alaska Department of Fish and Game, Division of Commercial Fisheries, News Release, Fairbanks Alaska. [issued 2017 October 6; cited September 11, 2018] Available from: http://www.yukonsalmon.org/wp-content/uploads/2017-Preliminary-YR-Summer-Season-Summary.pdf (Accessed September 2018).

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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, 2017.

	Sonar		
Time	Right bank	Left bank	Test fishing
	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, 2017.

			Bank	
Component	Setting	Stratum	Left	Right
Transducer	Beam size (h x w)		3º x 10º	6º x 10º
Echosounder	Transmit power (dB)	S1		30.0
		S2		30.0
		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		40
		S2		150
		S4	150	
		S5	300	

Table 3.–Technical specifications for the Adaptive Resolution Imaging Sonar (ARIS), at the Pilot Station sonar project on the Yukon River, 2017.

Setting	Value
Field of view (h x w)	14º x 28º
Detection frequency (MHz)	0.7
Receiver gain (dB)	20.0
Samples/beam	1706.0
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, 2017.

		Threshold (dB)	
Bank	Stratum	Upper	Lower
Right	S1	-10	-75
	S2	-14	-65
Left	S3	0	-75
	S4	-5	-75
	S5	-5	-60

Table 5.–Specifications for drift gillnets used for test fishing, by season, at the Pilot Station sonar project on the Yukon River, 2017.

	Stretch mesh size		Mesh diameter	Meshes deep	Depth
Season	(in)	(mm)	(mm)	(MD)	(m)
Summer	2.75	70	44	131	8.0
(5/30–7/18)	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
(7/19–8/31)	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, 2017.

	Test fish	Mesh size (in)			
Season	period	Odd days		Even days	
Summer	1	2.75	5.25	8.50	4.00
(5/28–7/18)		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
(7/19–8/31)		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, 2001–2017.

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

Source: National Oceanic and Atmospheric Administration (NOAA). 2017. National Weather Service, Alaska-Pacific River Forecast Center. www.weather.gov/aprfc/breakupDB (Accessed August 12, 2017).

Table 8.–Number of fish caught and retained in the Pilot Station sonar project test fishery on the Yukon River, 2017.

Total catch	Chinook	S. chum	F. chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others [a]	Total
May	1	2	0	0	0	0	3	0	1	5	1	13
June	490	3,181	0	5	0	2	84	119	24	84	59	4,048
July	117	1,193	1,135	17	9	231	264	200	4	19	21	3,210
August	5	0	1,839	14	484	84	154	205	14	6	31	2,836
September	0	0	162	4	131	0	22	48	7	1	8	383
Total	613	4,376	3,136	40	624	317	527	572	50	115	120	10,490

Fish retained

	Chinook	S. chum	F. chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others [a]	Total
May	0	0	0	0	0	0	0	0	0	1	0	1
June	49	689	0	5	0	0	26	28	8	31	0	836
July	6	229	349	5	0	0	110	20	2	10	1	732
August	2	0	381	0	42	1	66	26	2	2	2	524
September	0	0	53	0	40	0	7	0	2	0	0	102
Total	57	918	783	10	82	1	209	74	14	44	3	2,195

Proportion retained

	Chinook	S. chum	F. chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others [a]	Total
May	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.077
June	0.100	0.217	0.000	1.000	0.000	0.000	0.310	0.235	0.333	0.369	0.000	0.207
July	0.051	0.192	0.307	0.294	0.000	0.000	0.417	0.100	0.500	0.526	0.048	0.228
August	0.400	0.000	0.207	0.000	0.087	0.012	0.429	0.127	0.143	0.333	0.065	0.185
September	0.000	0.000	0.327	0.000	0.305	0.000	0.318	0.000	0.286	0.000	0.000	0.266
Total	0.093	0.210	0.250	0.250	0.131	0.003	0.397	0.129	0.280	0.383	0.025	0.209

[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, 2017.

		Left bank				90% CI	
Species	Right bank	Nearshore	Offshore	Total passage	SE	Lower	Upper
Large Chinook [a]	20,278	115,238	82,305	217,821	16,056	191,408	244,234
Small Chinook [b]	6,501	29,702	8,990	45,193	7,438	32,957	57,429
Total Chinook	26,779	144,940	91,295	263,014	17,696	233,905	292,123
Summer chum	624,109	1,444,336	1,025,290	3,093,735	84,048	2,955,476	3,231,994
Fall chum	314,750	819,295	695,886	1,829,931	54,179	1,740,807	1,919,055
Coho	59,461	66,738	40,121	166,320	20,382	132,791	199,849
Pink	35,090	111,142	20,297	166,529	18,991	135,289	197,769
Cisco	94,784	273,587	46,297	414,668	31,432	362,963	466,373
Humpback Whitefish	69,525	143,932	17,971	231,428	19,914	198,669	264,187
Broad Whitefish	16,527	16,487	4,785	37,799	6,639	26,878	48,720
Sheefish	10,854	19,228	2,783	32,865	5,729	23,440	42,290
Other [c]	44,625	28,662	6,152	79,439	8,196	65,957	92,921
Total	1,296,504	3,068,347	1,950,877	6,315,728			

[a] Large Chinook salmon >655 mm.

[b] Small Chinook salmon ≤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, 2017.

	Percentage	
Date	Summer chum	Fall chum
5/31–6/19	99.5	0.5
6/20–6/26	99.6	0.4
6/27–7/09	96.5	3.5
7/10–7/18	98.6	1.4
7/19–7/22	62.0	38.0
7/23–8/02	26.6	73.4
8/3–8/12	13.9	86.1
8/13–8/20	1.2	98.8
8/21–8/28	2.9	97.1
8/29–9/07	4.0	96.0

Table 11.–Reporting units of zones pooled for the 2017 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]
5/31	100	200	300	IC
6/01				
6/02				
6/03				
6/04				
6/05				
6/06			301	IC
6/07				
6/08				
6/09	108			IC
6/10				
6/11				
6/12				
6/13				
6/13				
6/14				
6/15				
6/16				
6/17	115	213	310	SO
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				
7/08				
7/09				
7/10	137	235	332	CO
7/11				
7/12	138	236	333	CO
7/13				
7/14			334	IC
7/15				

-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]
7/16		239		IC
7/17				
7/18				
7/19				
7/20	145	242	337	CO
7/21				
7/22				
7/23		244	339	IC
7/24				
7/25	149	245	340	CO
7/26				
7/27				
7/28				
7/29				
7/30	153	249	344	CO
7/31				
8/01			345	IC
8/02				
8/03	156	252	346	CO
8/04				
8/05				
8/06				
8/07			349	IC
8/08	160	256		CO
8/09				
8/10				
8/11			351	IC
8/12	163	259		CO
8/13				
8/14	164	260	352	CO
8/15				
8/16				
8/17	165	261	353	CO
8/18				
8/19				
8/20				
8/21	168	264	356	CO
8/22				
8/23	169	265	357	CO
8/24				
8/25				
8/26				
8/27	172	268	360	CO
8/28				
8/29				
8/30		270		IC
8/31				

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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				
9/02		272		IC
9/03				
9/04				
9/05			368	IC
9/06				
9/07				

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

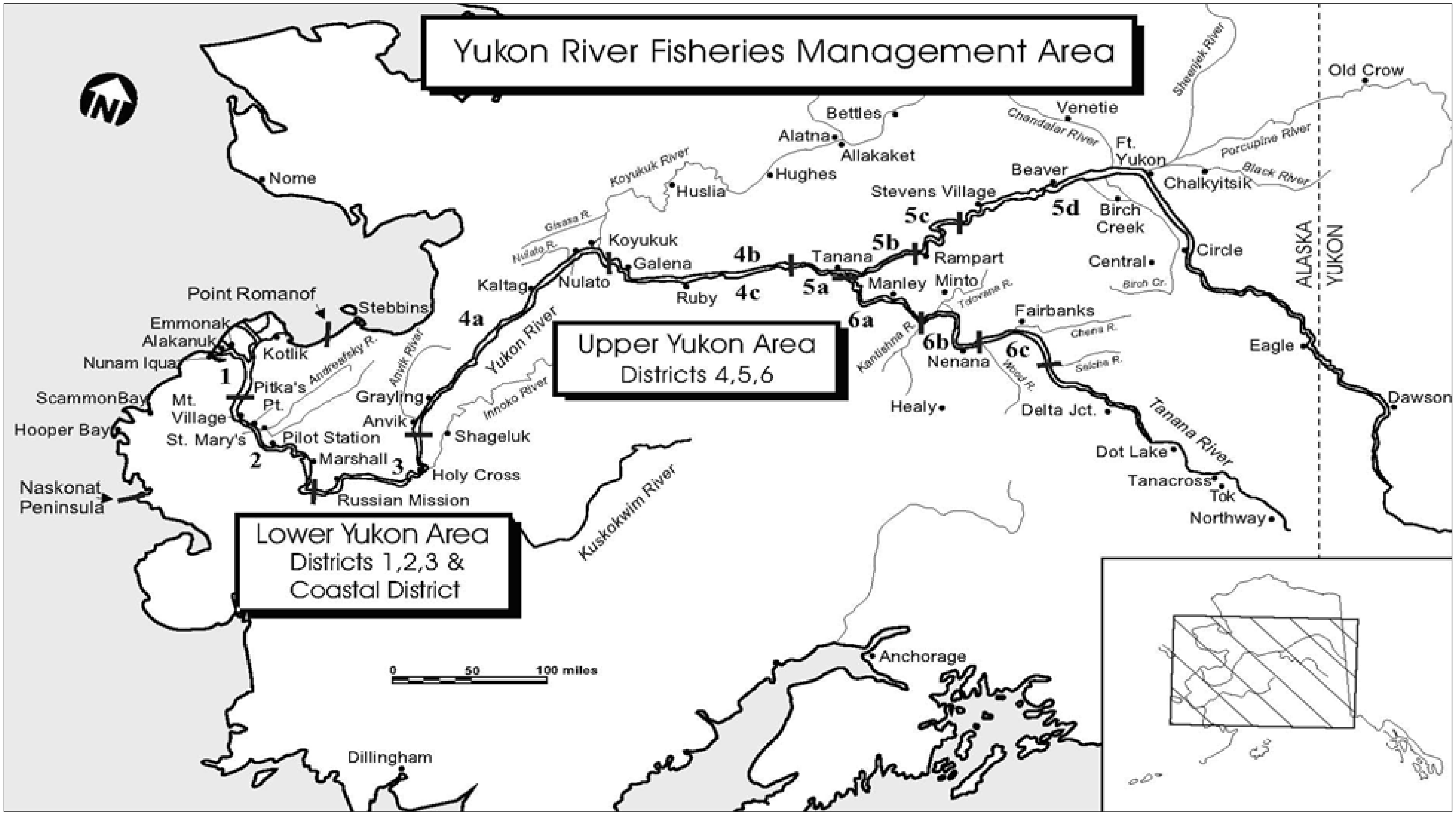


Figure 1.–Fishing districts and communities of the Yukon River drainage.

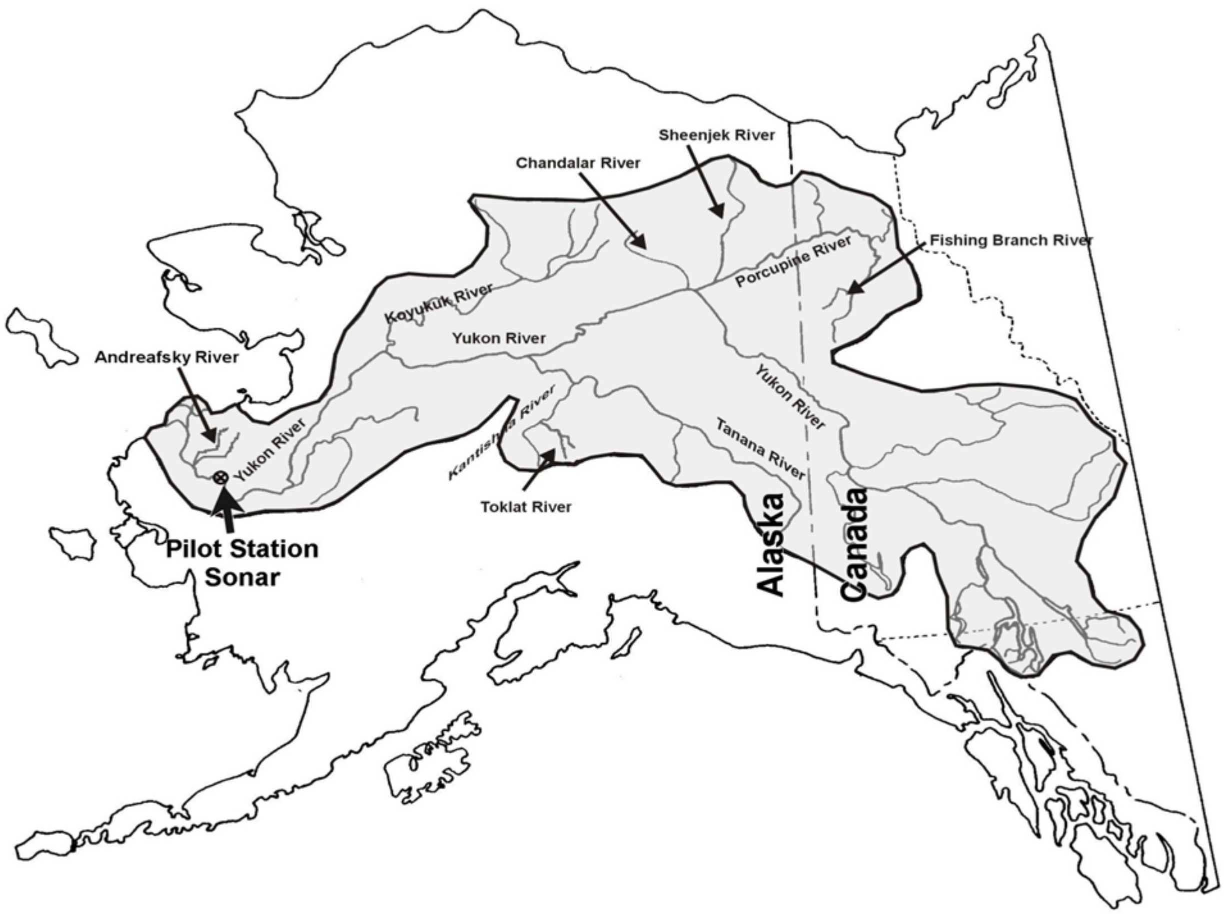


Figure 2.–Extent of the Yukon River watershed.

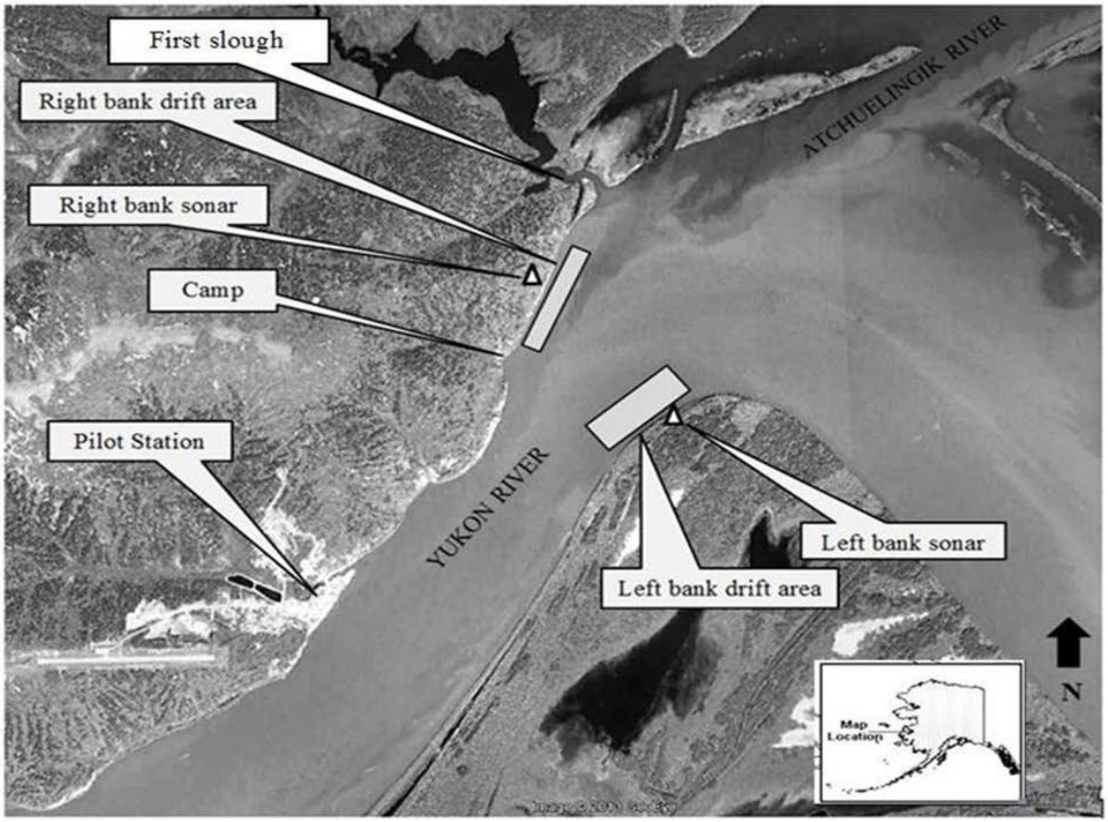
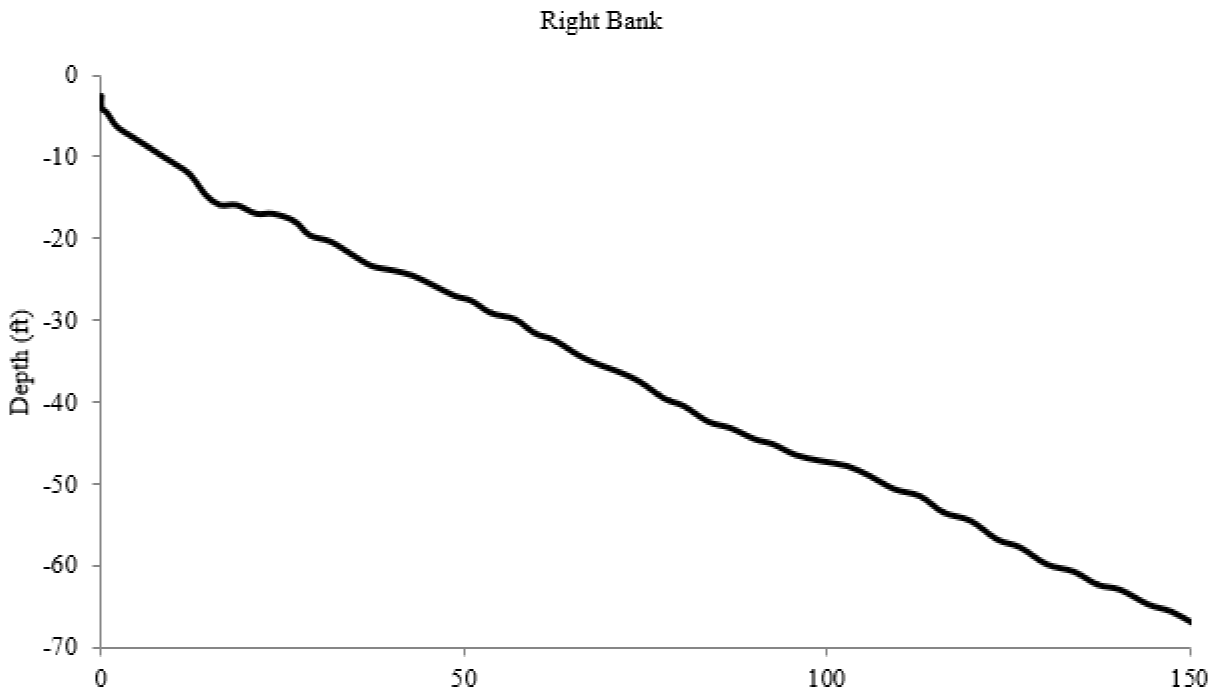


Figure 3.–Location of the Pilot Station sonar project on the Yukon River showing general transducer sites.



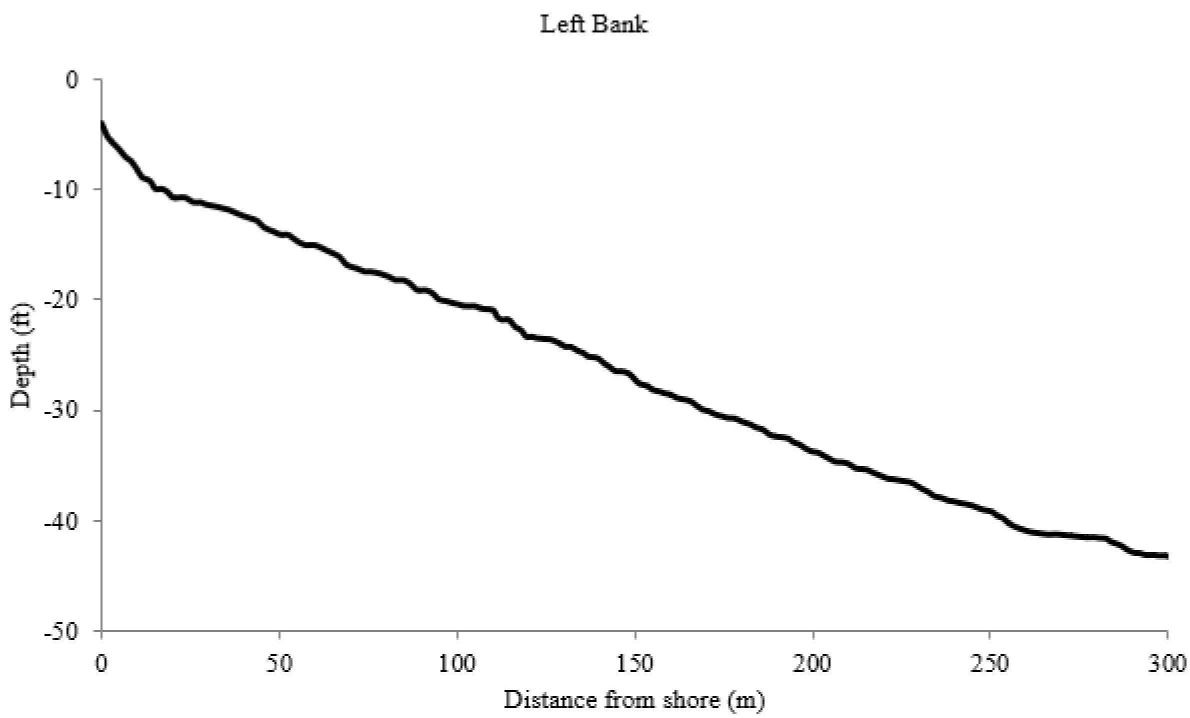


Figure 4.–Bottom profiles for the left bank (top) and right bank (bottom), at the Pilot Station sonar project on the Yukon River, 2017.

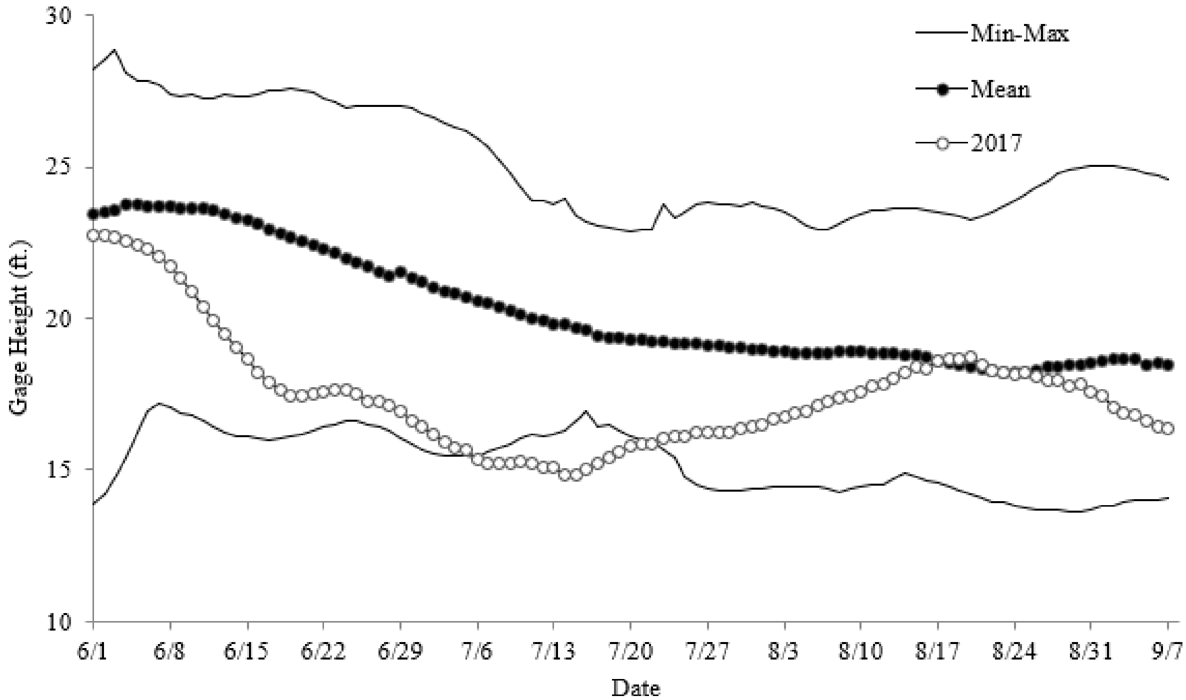


Figure 5.–Yukon River daily water level during the 2017 season at Pilot Station water gage compared to minimum, maximum, and mean gage height 2001 to 2016.

Source: United States Geological Service

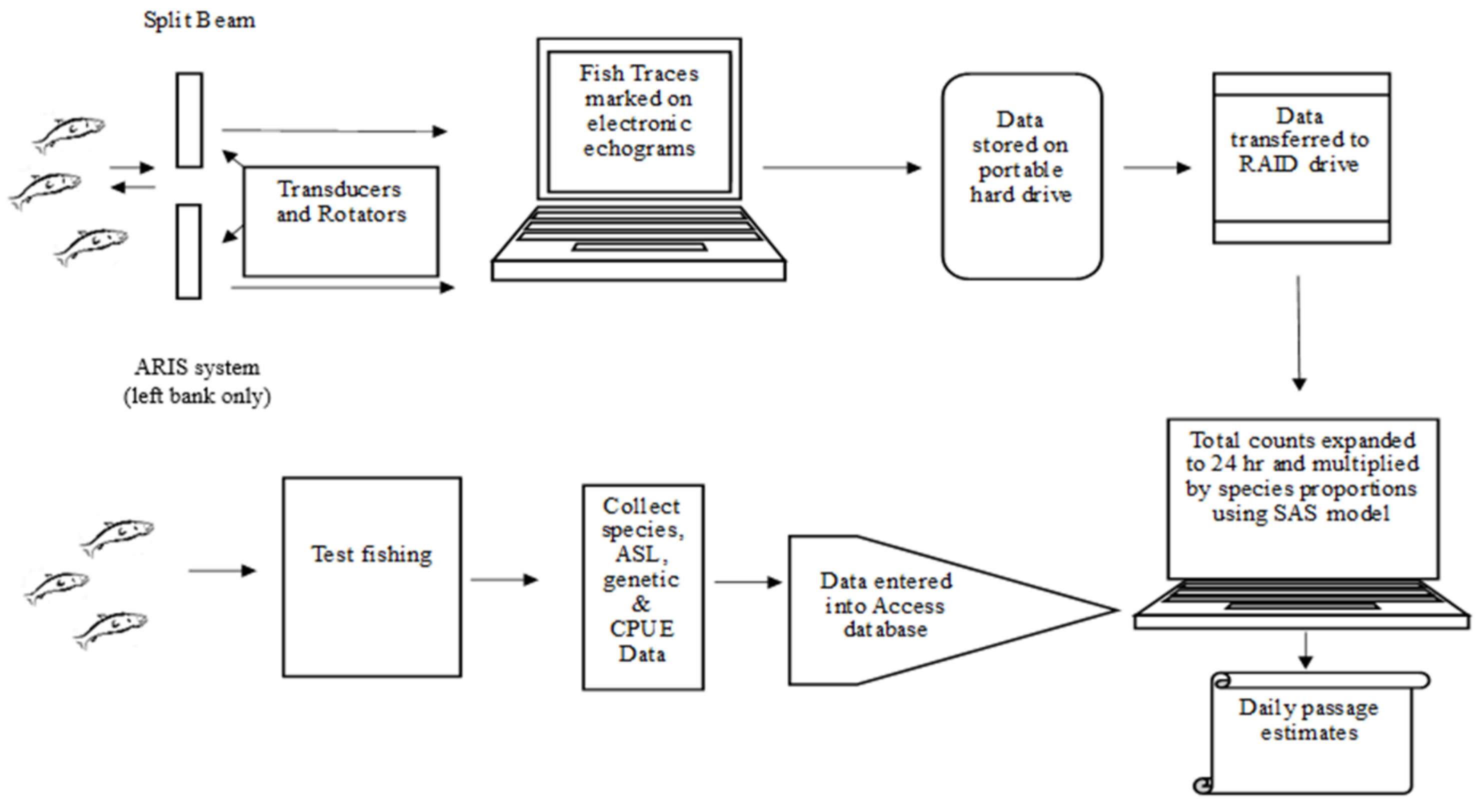


Figure 6.–Flow diagram of data collection and processing, at the Pilot Station sonar project on the Yukon River, 2017.

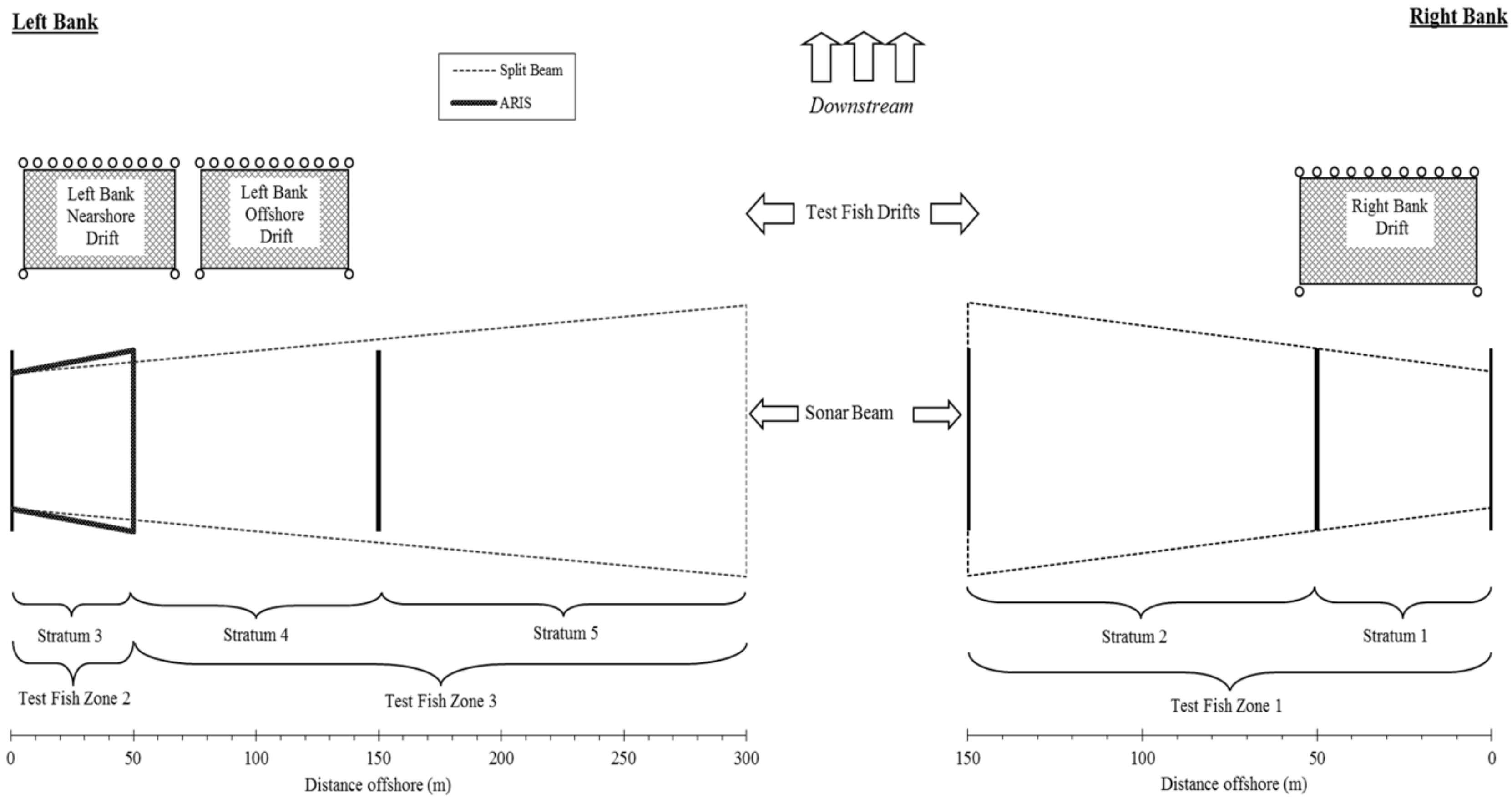


Figure 7.–Illustration of relationships between strata, zones, test fishery drifts, and approximate sonar ranges (not to scale), at the Pilot Station sonar project on the Yukon River, 2017.

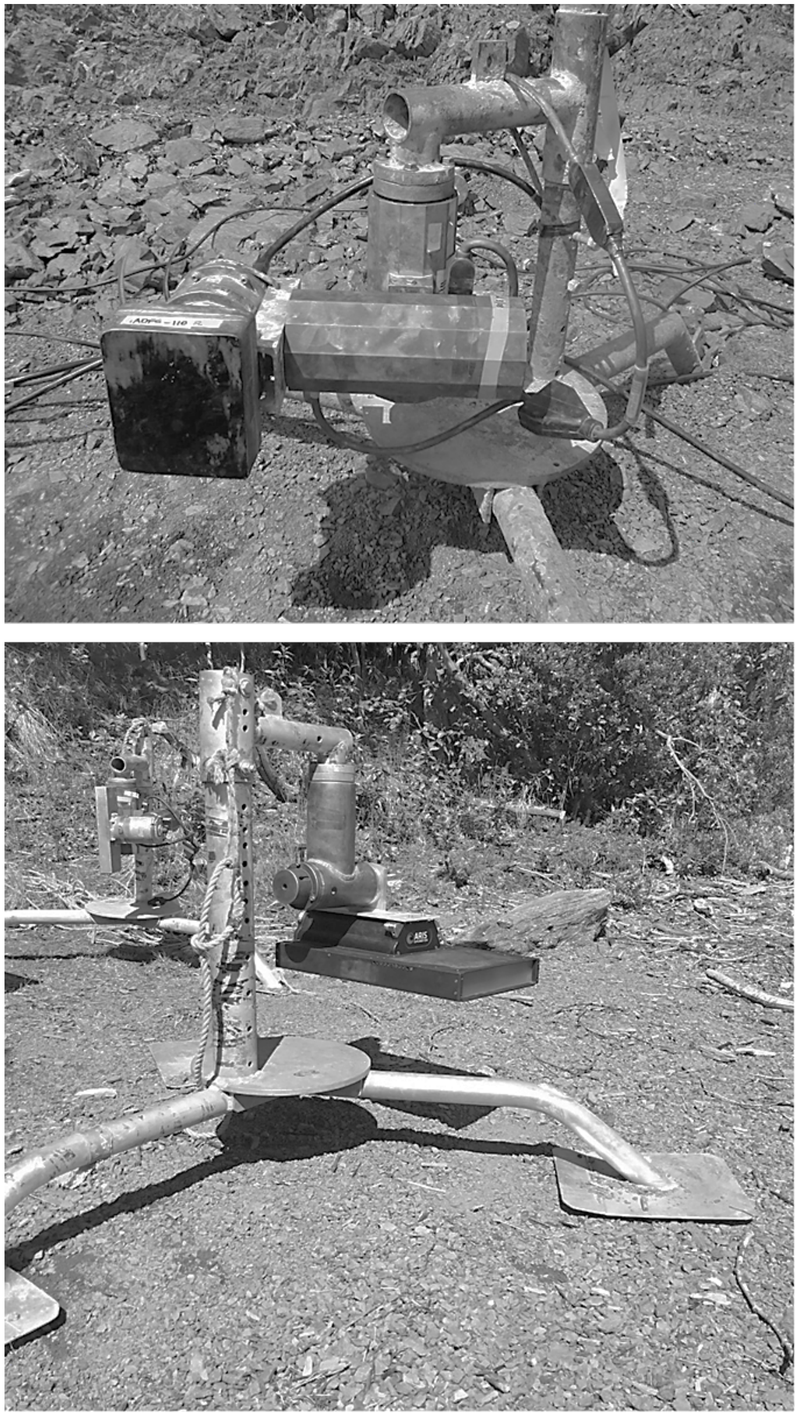


Figure 8.–Split-beam transducer mounted to pod with 662H dual axis rotators (top), and ARIS with telephoto lens mounted to pod with PT-25 rotator (bottom), at the Pilot Station sonar project on the Yukon River.

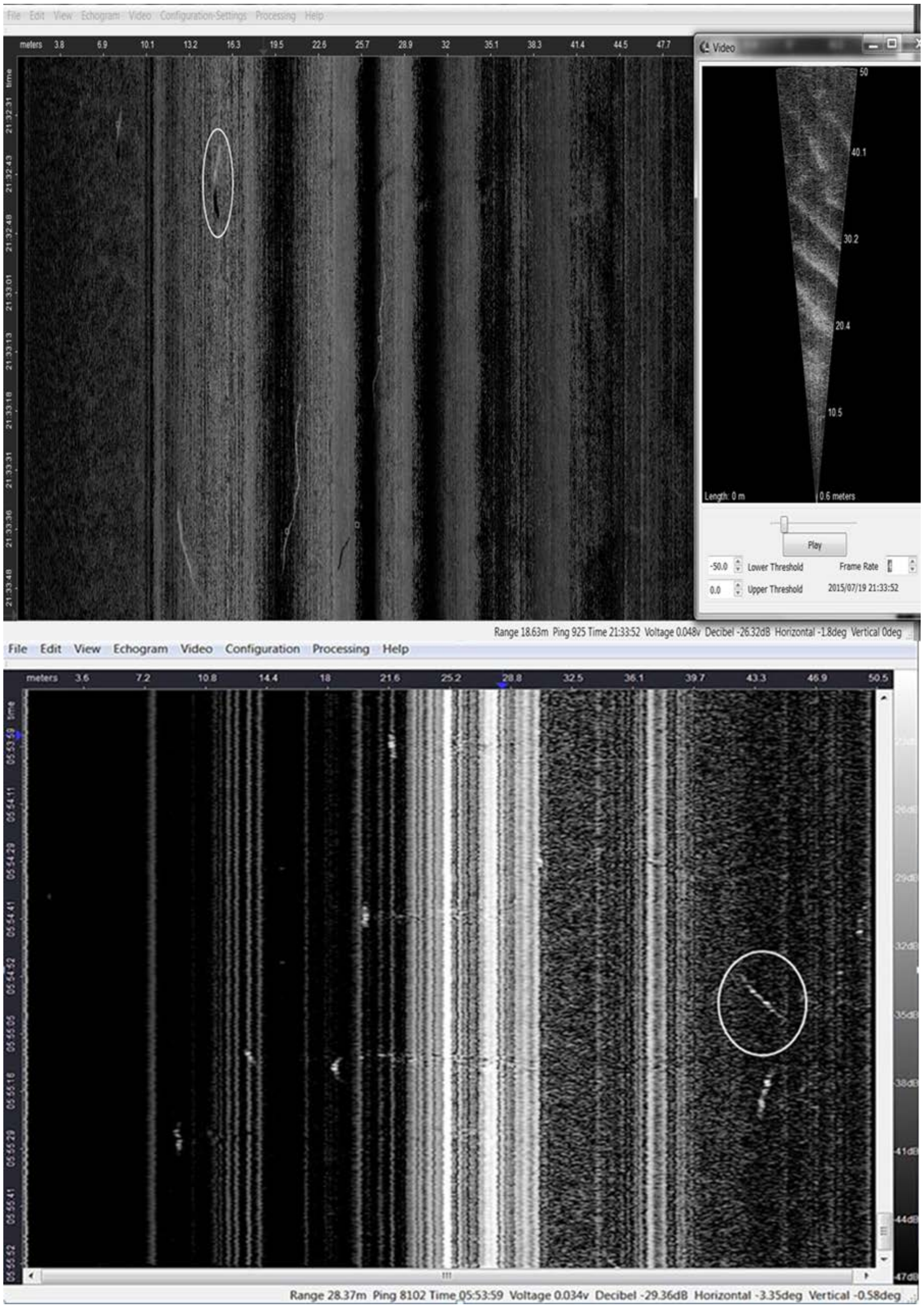


Figure 9.–Echogram of ARIS alongside video image (top) and split-beam sonar (bottom), with oval around representative fish.

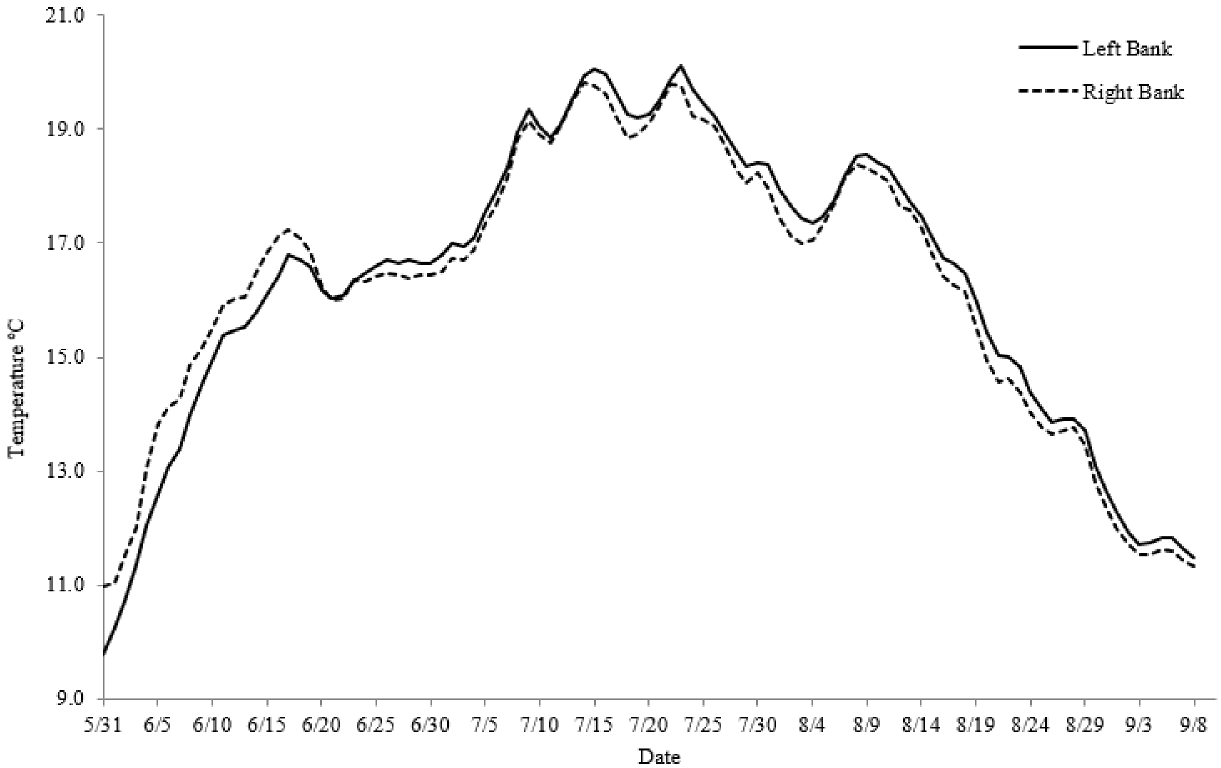


Figure 10.– Mean daily water temperatures recorded at the Pilot Station sonar project on the Yukon River with electronic data loggers by bank, 2017.

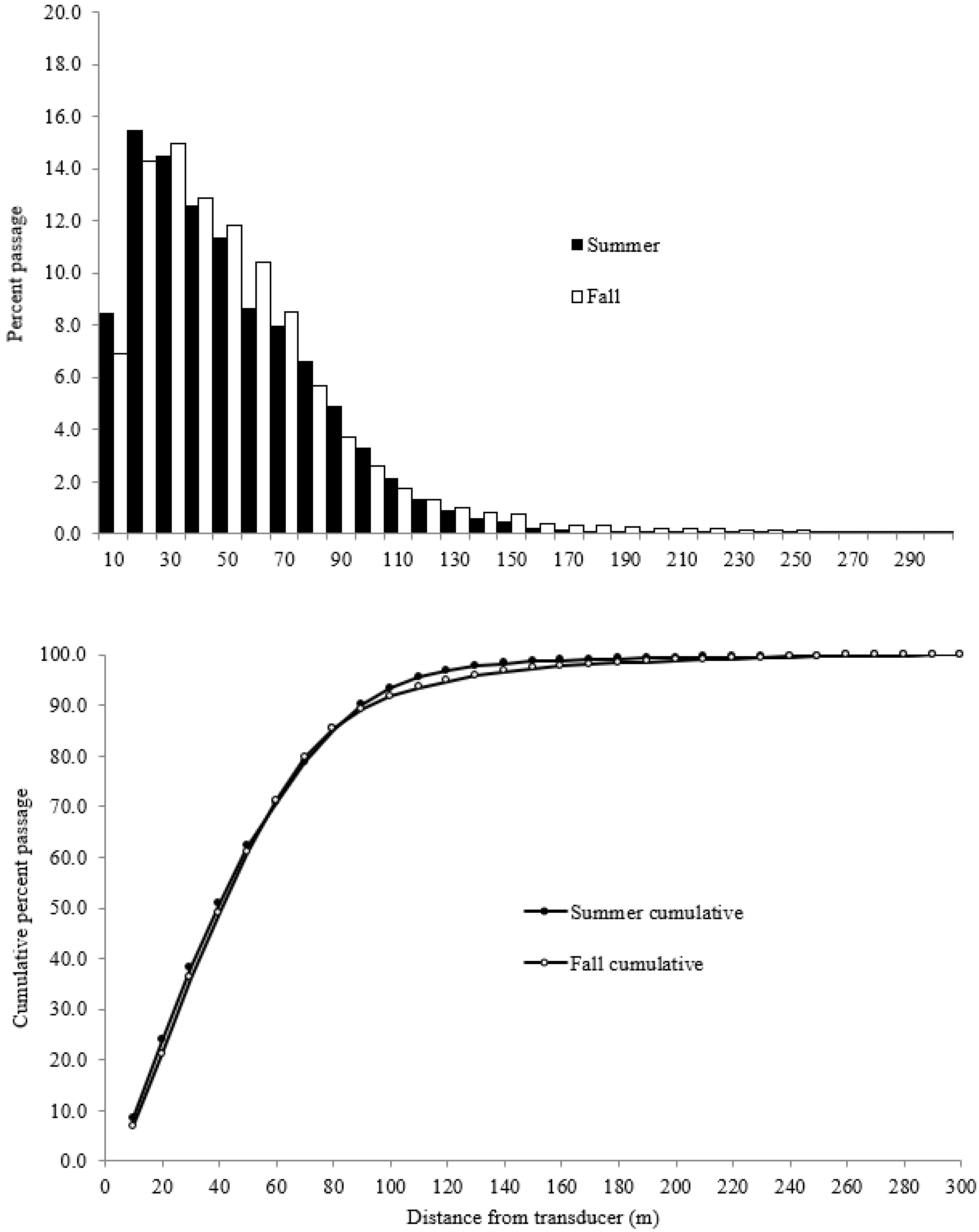


Figure 11.–Distribution of left bank passage (top) and cumulative passage as a function of range (bottom), at the Pilot Station sonar project on the Yukon River, 2017.

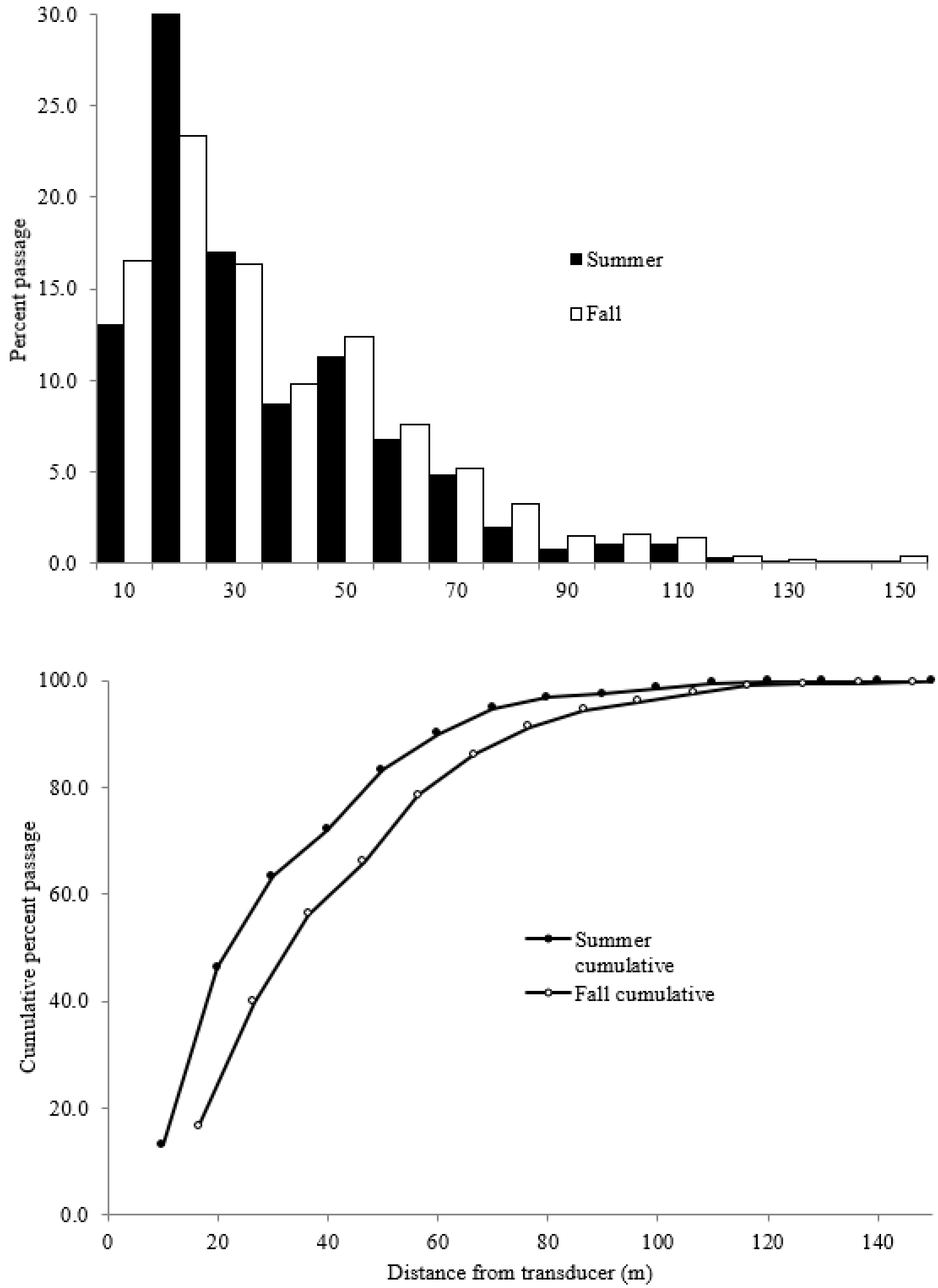


Figure 12.–Distribution of right bank passage (top) and cumulative passage as a function of range (bottom), at the Pilot Station sonar project on the Yukon River, 2017.

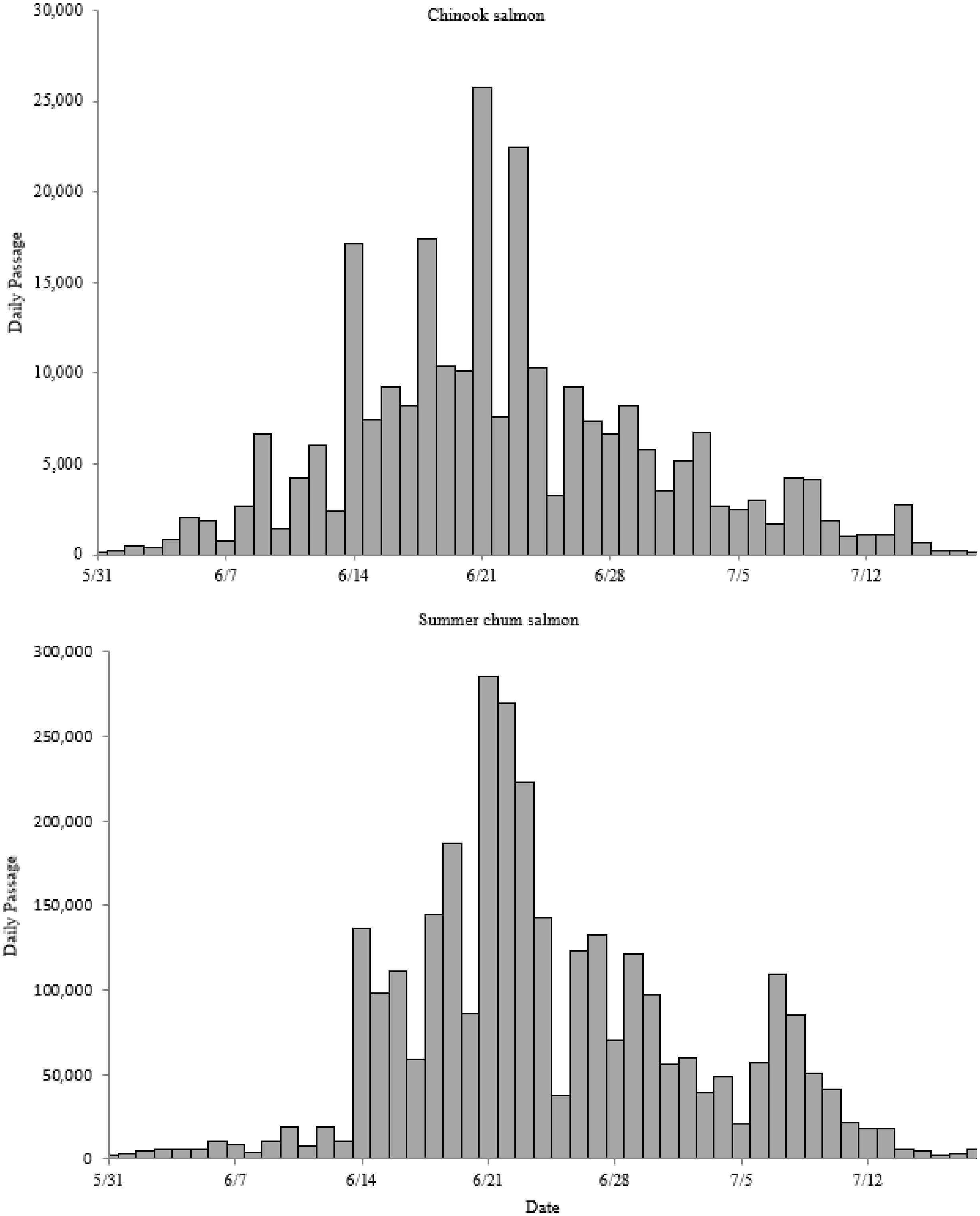


Figure 13.–Chinook and summer chum salmon daily passage estimates, at the Pilot Station sonar project on the Yukon River, 2017.

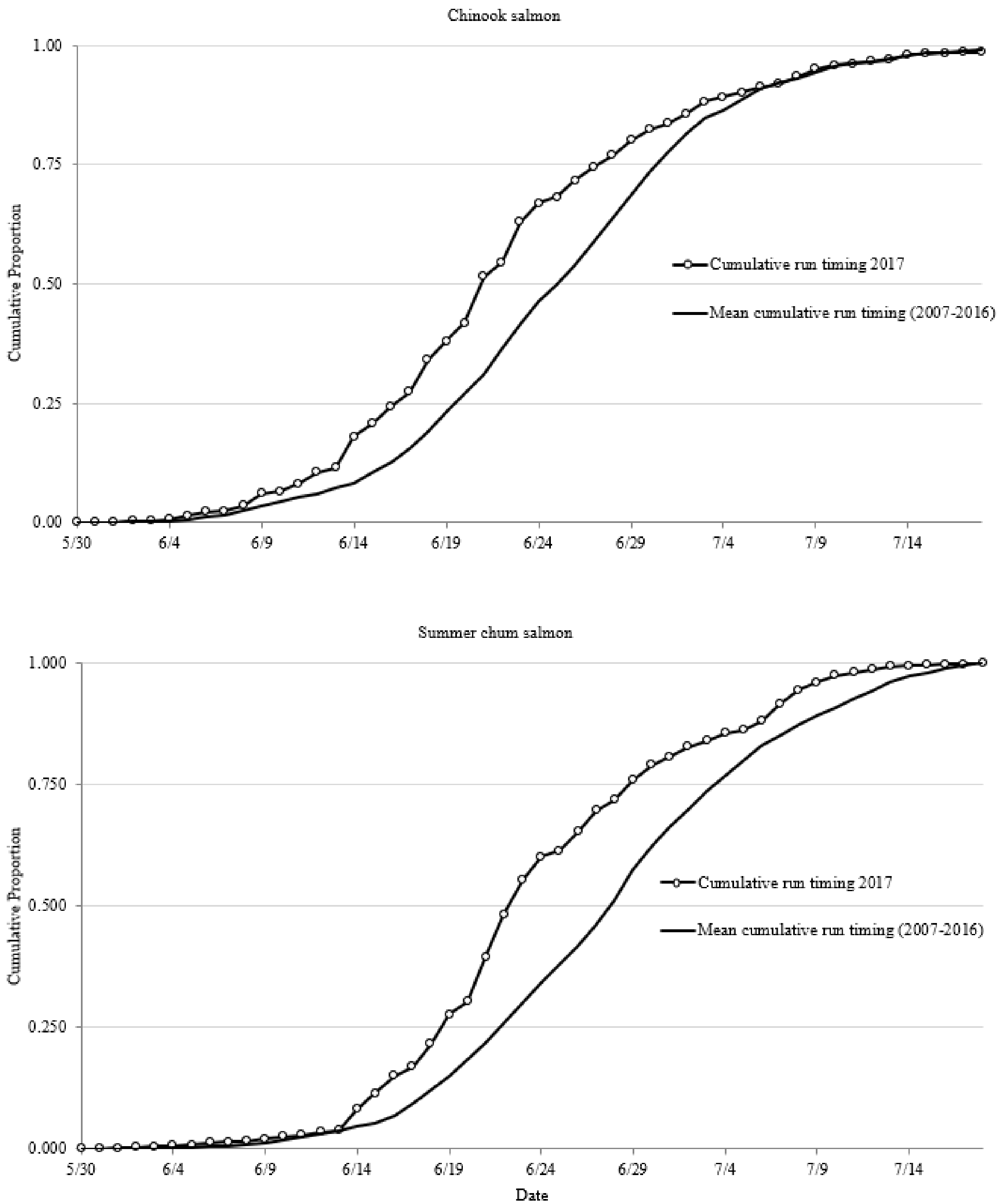


Figure 14.–2017 Chinook and summer chum salmon daily cumulative passage timing compared to the 2007-2016 mean passage timing, at the Pilot Station sonar project on the Yukon River.

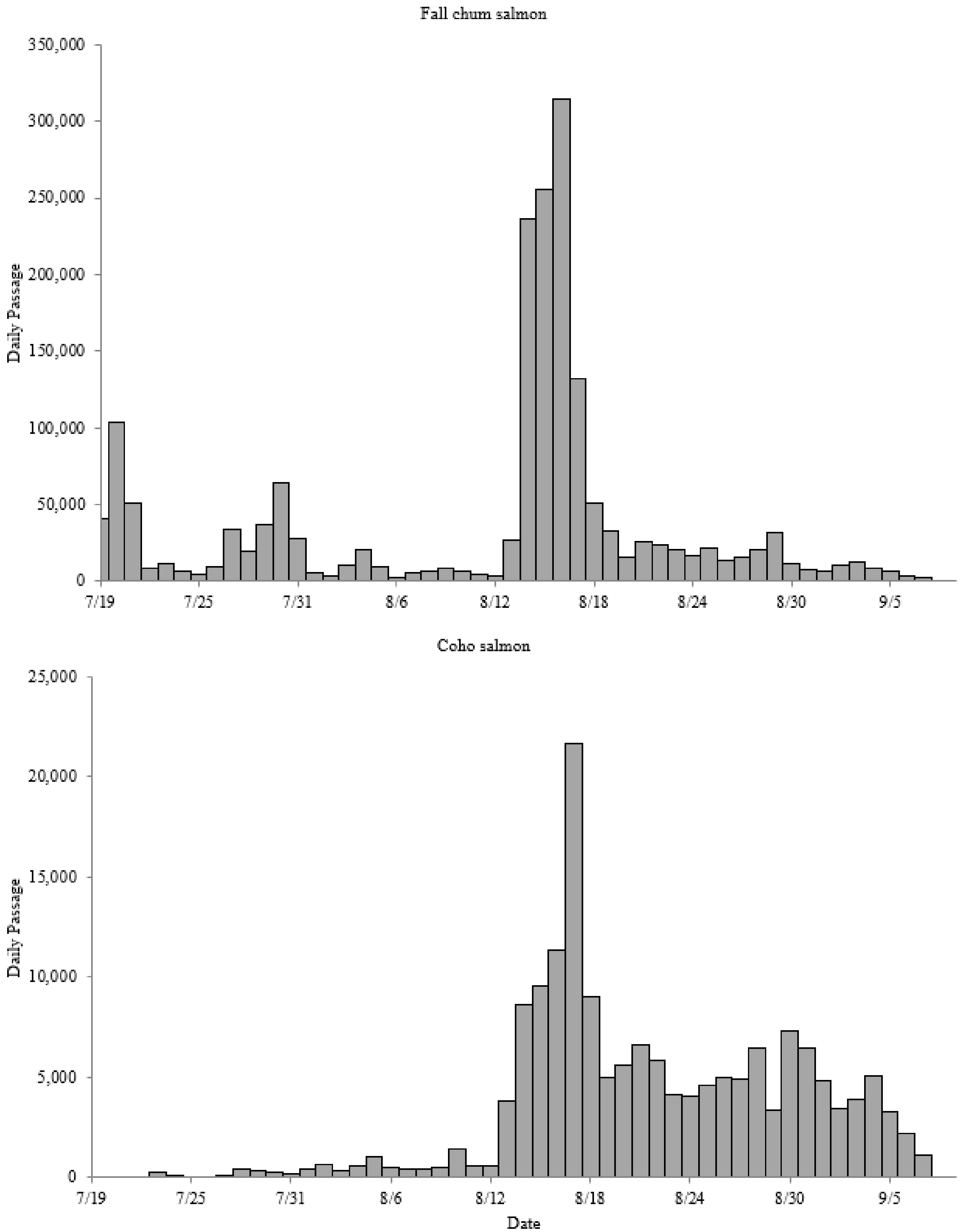
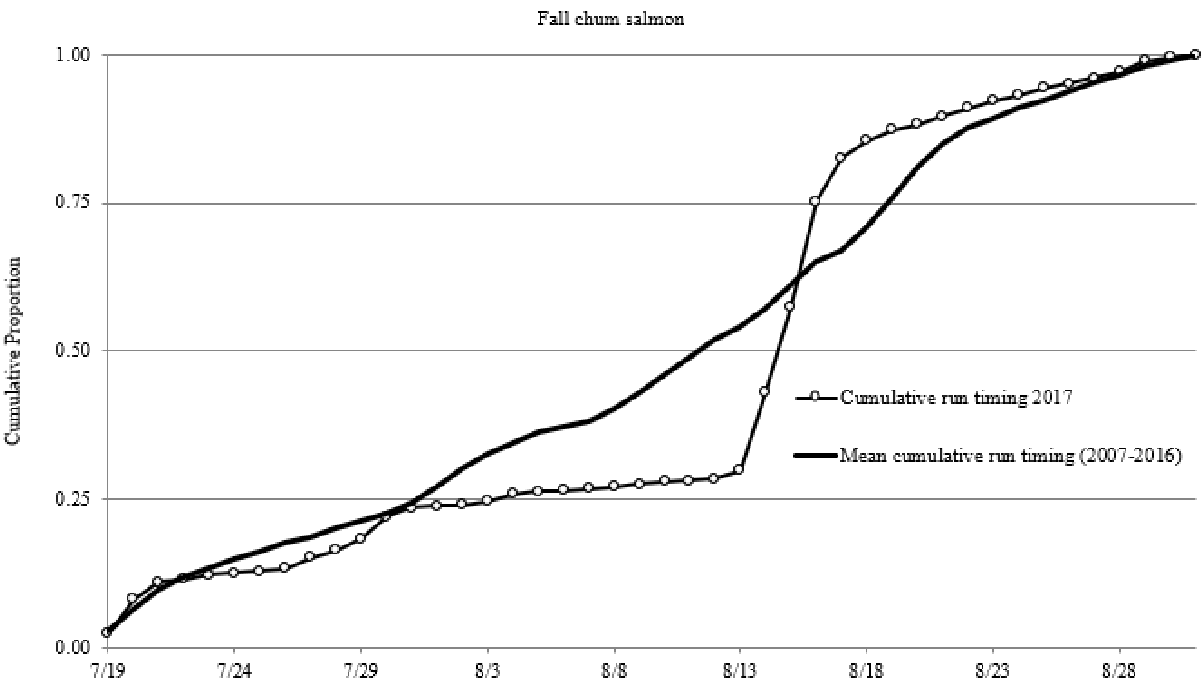


Figure 15.–Fall chum and coho salmon daily passage estimates, at the Pilot Station sonar project on the Yukon River, 2017.



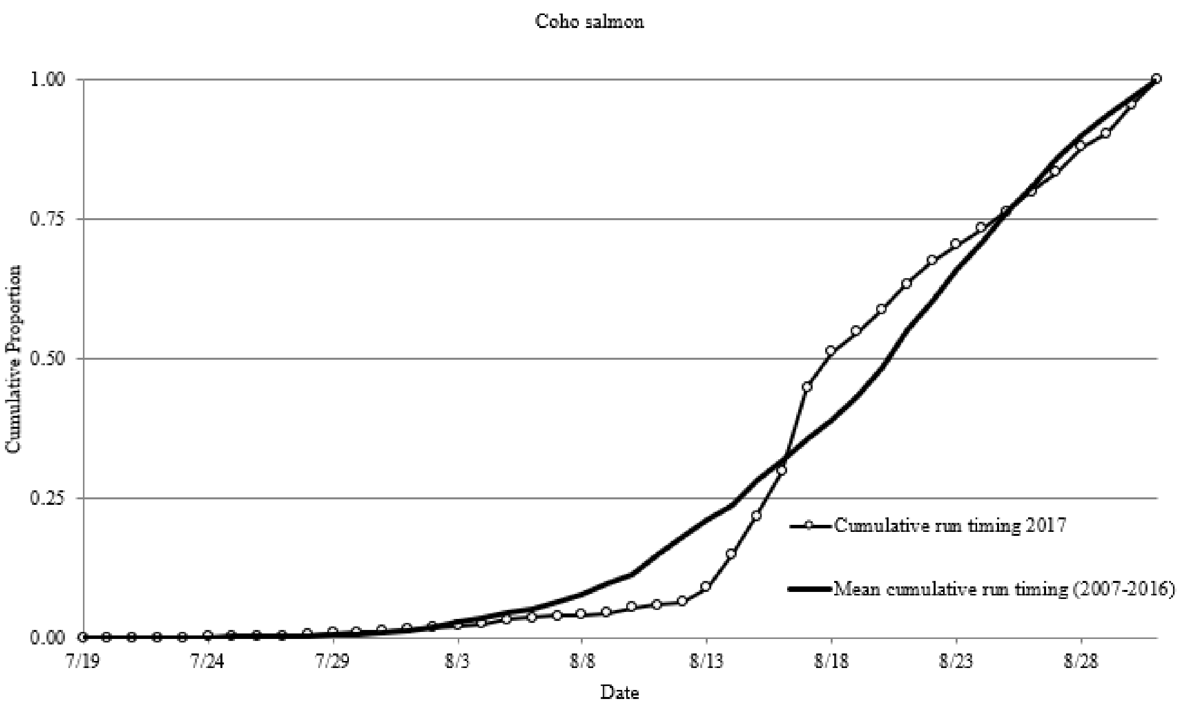


Figure 16.–2017 Fall chum and coho salmon daily cumulative passage timing compared to the 2007-2016 mean passage timing, at the Pilot Station sonar project on the Yukon River.

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, 2017.

Species	Tau	Sigma	Theta	Lambda	Tangle
large Chinook [a]	1.8873	0.1650	0.6169	-0.6916	0.0000
small Chinook [b]	1.8873	0.1650	0.6169	-0.6916	0.0000
summer chum	2.0463	0.1438	0.6701	0.0104	0.0569
fall chum	1.8618	0.2278	1.2979	-1.6313	0.0358
coho	1.9462	0.2869	0.7458	-1.4394	0.0000
pink	2.0226	0.1000	0.5183	-0.0294	0.0000
broad whitefish	1.8053	0.2022	0.9380	-1.5685	0.0217
humpback whitefish	1.9160	0.2444	1.0492	-1.9233	0.0373
cisco	2.1828	0.5507	3.2351	-2.8998	0.0239
sheefish	2.0953	0.1878	0.7310	-1.5943	0.0000
other [c]	2.2792	0.3312	0.8817	-1.4955	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, 2017.

	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
Date	fathom hours	Catch	CPUE	fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
5/31	10.08	1	0.10	5.42	0	0.00	0	0.00	0	0.00
6/01	17.36	0	0.00	14.93	2	0.13	0	0.00	0	0.00
6/02	14.97	0	0.00	14.42	3	0.21	0	0.00	0	0.00
6/03	13.44	1	0.07	12.41	7	0.56	0	0.00	0	0.00
6/04	13.74	0	0.00	13.35	3	0.22	0	0.00	0	0.00
6/05	15.05	2	0.13	15.20	11	0.72	0	0.00	0	0.00
6/06	10.69	3	0.28	13.84	16	1.16	0	0.00	0	0.00
6/07	15.38	2	0.13	17.33	12	0.69	0	0.00	0	0.00
6/08	16.82	2	0.12	15.75	4	0.25	0	0.00	0	0.00
6/09	17.94	12	0.67	16.60	17	1.02	0	0.00	0	0.00
6/10	14.89	3	0.20	14.83	34	2.29	0	0.00	0	0.00
6/11	15.57	11	0.71	15.25	14	0.92	0	0.00	0	0.00
6/12	15.70	7	0.45	16.60	22	1.32	0	0.00	0	0.00
6/13	16.87	6	0.36	16.45	20	1.22	0	0.00	0	0.00
6/14	10.43	20	1.92	8.22	95	11.56	0	0.00	0	0.00
6/15	14.91	13	0.87	11.07	91	8.22	0	0.00	0	0.00
6/16	13.36	15	1.12	10.53	108	10.25	0	0.00	0	0.00
6/17	13.05	5	0.38	10.93	58	5.31	0	0.00	0	0.00
6/18	7.14	27	3.78	3.16	80	25.32	0	0.00	0	0.00
6/19	14.16	12	0.85	7.33	75	10.23	0	0.00	0	0.00
6/20	15.51	21	1.35	11.37	73	6.42	0	0.00	0	0.00
6/21	7.16	25	3.49	6.70	123	18.36	0	0.00	0	0.00
6/22	10.60	9	0.85	7.32	116	15.86	0	0.00	0	0.00
6/23	11.74	16	1.36	6.57	61	9.29	0	0.00	0	0.00
6/24	14.68	9	0.61	7.94	66	8.31	0	0.00	0	0.00
6/25	16.15	3	0.19	14.88	17	1.14	0	0.00	0	0.00
6/26	15.87	11	0.69	9.44	79	8.36	0	0.00	0	0.00
6/27	15.06	9	0.60	10.94	79	7.22	0	0.00	0	0.00
6/28	15.95	7	0.44	13.13	52	3.96	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	14.90	9	0.60	8.97	65	7.25	0	0.00	0	0.00
6/30	14.55	10	0.69	12.99	75	5.77	0	0.00	0	0.00
7/01	15.64	4	0.26	14.96	35	2.34	0	0.00	0	0.00
7/02	16.43	9	0.55	16.90	60	3.55	0	0.00	0	0.00
7/03	14.70	4	0.27	14.75	31	2.10	0	0.00	0	0.00
7/04	15.43	2	0.13	17.19	23	1.34	0	0.00	0	0.00
7/05	15.49	3	0.19	15.09	14	0.93	0	0.00	0	0.00
7/06	15.43	2	0.13	10.71	46	4.29	0	0.00	0	0.00
7/07	14.18	2	0.14	10.75	60	5.58	0	0.00	0	0.00
7/08	16.14	4	0.25	15.61	52	3.33	0	0.00	0	0.00
7/09	16.33	5	0.31	14.52	22	1.51	0	0.00	0	0.00
7/10	14.22	2	0.14	13.83	53	3.83	0	0.00	0	0.00
7/11	8.59	0	0.00	8.33	9	1.08	0	0.00	0	0.00
7/12	15.79	1	0.06	17.09	8	0.47	0	0.00	0	0.00
7/13	10.85	2	0.18	12.69	16	1.26	0	0.00	0	0.00
7/14	17.43	2	0.11	15.93	2	0.13	0	0.00	0	0.00
7/15	15.94	0	0.00	14.69	3	0.20	0	0.00	0	0.00
7/16	16.02	0	0.00	15.08	2	0.13	0	0.00	0	0.00
7/17	15.60	0	0.00	18.25	1	0.05	0	0.00	0	0.00
7/18	16.72	0	0.00	17.20	9	0.52	0	0.00	0	0.00
7/19	9.40	0	0.00	13.60	0	0.00	23	1.69	0	0.00
7/20	4.92	0	0.00	6.97	0	0.00	98	14.07	0	0.00
7/21	5.12	0	0.00	5.76	0	0.00	31	5.38	0	0.00
7/22	4.64	0	0.00	15.66	0	0.00	9	0.57	0	0.00
7/23	6.53	0	0.00	15.17	0	0.00	12	0.79	0	0.00
7/24	5.53	0	0.00	16.67	0	0.00	3	0.18	0	0.00
7/25	6.04	0	0.00	17.13	0	0.00	1	0.06	0	0.00
7/26	4.89	0	0.00	10.61	0	0.00	8	0.75	0	0.00
7/27	4.40	0	0.00	15.06	0	0.00	35	2.32	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	5.10	0	0.00	14.38	0	0.00	23	1.60	0	0.00
7/29	3.26	0	0.00	12.24	0	0.00	57	4.66	0	0.00
7/30	4.62	0	0.00	15.15	0	0.00	60	3.96	0	0.00
7/31	4.56	0	0.00	9.04	0	0.00	22	2.43	0	0.00
8/01	5.19	1	0.19	14.87	0	0.00	10	0.67	0	0.00
8/02	5.28	0	0.00	16.10	0	0.00	4	0.25	1	0.06
8/03	4.42	0	0.00	16.20	0	0.00	15	0.93	0	0.00
8/04	4.96	0	0.00	10.08	0	0.00	12	1.19	0	0.00
8/05	5.52	0	0.00	15.49	0	0.00	11	0.71	0	0.00
8/06	5.13	0	0.00	13.84	0	0.00	5	0.36	0	0.00
8/07	5.05	0	0.00	16.88	0	0.00	5	0.30	0	0.00
8/08	5.61	1	0.18	14.94	0	0.00	4	0.27	0	0.00
8/09	4.32	0	0.00	10.12	0	0.00	12	1.19	0	0.00
8/10	4.83	0	0.00	12.61	0	0.00	4	0.32	0	0.00
8/11	5.69	0	0.00	15.87	0	0.00	8	0.50	0	0.00
8/12	4.47	0	0.00	14.08	0	0.00	6	0.43	1	0.07
8/13	4.72	0	0.00	9.43	0	0.00	13	1.38	1	0.11
8/14	3.13	0	0.00	6.41	0	0.00	116	18.09	0	0.00
8/15	2.10	0	0.00	5.32	0	0.00	56	10.53	1	0.19
8/16	2.17	0	0.00	3.69	0	0.00	45	12.19	1	0.27
8/17	4.25	0	0.00	5.30	0	0.00	83	15.67	2	0.38
8/18	4.00	0	0.00	7.73	0	0.00	39	5.05	1	0.13
8/19	5.04	0	0.00	13.75	0	0.00	36	2.62	3	0.22
8/20	4.95	0	0.00	14.74	0	0.00	15	1.02	5	0.34
8/21	4.83	0	0.00	15.52	0	0.00	28	1.80	8	0.52
8/22	3.89	0	0.00	7.28	0	0.00	22	3.02	4	0.55
8/23	3.85	0	0.00	9.71	0	0.00	30	3.09	3	0.31
8/24	5.02	0	0.00	6.07	0	0.00	3	0.49	0	0.00
8/25	6.24	0	0.00	15.86	0	0.00	28	1.76	3	0.19
8/26	4.84	0	0.00	15.74	0	0.00	22	1.40	3	0.19

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Appendix B1.–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	4.41	0	0.00	8.82	0	0.00	9	1.02	2	0.23
8/28	4.24	0	0.00	8.55	0	0.00	20	2.34	0	0.00
8/29	5.44	0	0.00	13.72	0	0.00	25	1.82	1	0.07
8/30	4.96	0	0.00	14.69	0	0.00	11	0.75	2	0.14
8/31	5.43	0	0.00	16.14	0	0.00	6	0.37	3	0.19
9/01	4.74	0	0.00	15.62	0	0.00	8	0.51	3	0.19
9/02	5.26	0	0.00	15.49	0	0.00	14	0.90	2	0.13
9/03	4.79	0	0.00	15.57	0	0.00	10	0.64	3	0.19
9/04	5.44	0	0.00	15.32	0	0.00	14	0.91	2	0.13
9/05	6.25	0	0.00	15.41	0	0.00	13	0.84	6	0.39
9/06	5.58	0	0.00	17.81	0	0.00	2	0.11	5	0.28
9/07	4.90	0	0.00	18.00	0	0.00	2	0.11	0	0.00
Total	954.60	315.00	26.10	1,277.65	1,924.00	206.18	1,148.00	134.01	66.00	5.47

Appendix B2.–Left bank CPUE, by day and salmon species, at the Pilot Station sonar project on the Yukon River, 2017.

	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
Date	fathom hours	Catch	CPUE	fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
5/31	5.29	0	0.00	2.75	2	0.73	0	0.00	0	0.00
6/01	7.74	0	0.00	8.16	4	0.49	0	0.00	0	0.00
6/02	7.97	1	0.13	8.32	6	0.72	0	0.00	0	0.00
6/03	8.05	0	0.00	7.13	6	0.84	0	0.00	0	0.00
6/04	8.69	0	0.00	7.65	2	0.26	0	0.00	0	0.00
6/05	8.55	1	0.12	8.85	2	0.23	0	0.00	0	0.00
6/06	5.25	0	0.00	8.23	5	0.61	0	0.00	0	0.00
6/07	8.22	0	0.00	9.27	1	0.11	0	0.00	0	0.00
6/08	8.26	1	0.12	7.95	0	0.00	0	0.00	0	0.00
6/09	8.48	0	0.00	8.28	4	0.48	0	0.00	0	0.00
6/10	8.11	0	0.00	7.74	0	0.00	0	0.00	0	0.00
6/11	8.92	3	0.34	8.94	1	0.11	0	0.00	0	0.00
6/12	8.58	1	0.12	9.09	16	1.76	0	0.00	0	0.00
6/13	7.94	0	0.00	8.07	6	0.74	0	0.00	0	0.00
6/14	7.75	5	0.64	4.22	46	10.90	0	0.00	0	0.00
6/15	8.13	2	0.25	5.66	46	8.12	0	0.00	0	0.00
6/16	6.37	0	0.00	6.83	45	6.59	0	0.00	0	0.00
6/17	6.92	2	0.29	8.54	17	1.99	0	0.00	0	0.00
6/18	4.04	2	0.49	1.63	42	25.79	0	0.00	0	0.00
6/19	8.01	1	0.12	3.83	21	5.48	0	0.00	0	0.00
6/20	7.97	2	0.25	6.65	26	3.91	0	0.00	0	0.00
6/21	4.25	3	0.71	3.51	70	19.94	0	0.00	0	0.00
6/22	6.86	1	0.15	3.79	24	6.33	0	0.00	0	0.00
6/23	6.35	7	1.10	3.94	45	11.41	0	0.00	0	0.00
6/24	7.76	5	0.64	5.68	57	10.03	0	0.00	0	0.00
6/25	7.69	0	0.00	7.17	36	5.02	0	0.00	0	0.00
6/26	7.47	7	0.94	4.74	29	6.11	0	0.00	0	0.00
6/27	7.32	0	0.00	4.67	24	5.14	0	0.00	0	0.00
6/28	8.18	0	0.00	8.02	44	5.48	0	0.00	0	0.00

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Appendix B2.–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	7.59	0	0.00	5.01	26	5.19	0	0.00	0	0.00
6/30	7.71	0	0.00	5.99	33	5.51	0	0.00	0	0.00
7/1	7.75	0	0.00	7.70	55	7.14	0	0.00	0	0.00
7/2	8.86	3	0.34	8.38	23	2.75	0	0.00	0	0.00
7/3	7.47	2	0.27	6.04	23	3.81	0	0.00	0	0.00
7/4	8.04	0	0.00	7.87	25	3.18	0	0.00	0	0.00
7/5	15.49	3	0.19	15.09	14	0.93	0	0.00	0	0.00
7/6	15.43	2	0.13	10.71	46	4.29	0	0.00	0	0.00
7/7	14.18	2	0.14	10.75	60	5.58	0	0.00	0	0.00
7/8	16.14	4	0.25	15.61	52	3.33	0	0.00	0	0.00
7/9	16.33	5	0.31	14.52	22	1.51	0	0.00	0	0.00
7/10	14.22	2	0.14	13.83	53	3.83	0	0.00	0	0.00
7/11	8.59	0	0.00	8.33	9	1.08	0	0.00	0	0.00
7/12	15.79	1	0.06	17.09	8	0.47	0	0.00	0	0.00
7/13	10.85	2	0.18	12.69	16	1.26	0	0.00	0	0.00
7/14	17.43	2	0.11	15.93	2	0.13	0	0.00	0	0.00
7/15	15.94	0	0.00	14.69	3	0.20	0	0.00	0	0.00
7/16	16.02	0	0.00	15.08	2	0.13	0	0.00	0	0.00
7/17	15.60	0	0.00	18.25	1	0.05	0	0.00	0	0.00
7/18	16.72	0	0.00	17.20	9	0.52	0	0.00	0	0.00
7/19	9.40	0	0.00	13.60	0	0.00	23	1.69	0	0.00
7/20	4.92	0	0.00	6.97	0	0.00	98	14.07	0	0.00
7/21	5.12	0	0.00	5.76	0	0.00	31	5.38	0	0.00
7/22	4.64	0	0.00	15.66	0	0.00	9	0.57	0	0.00
7/23	6.53	0	0.00	15.17	0	0.00	12	0.79	0	0.00
7/24	5.53	0	0.00	16.67	0	0.00	3	0.18	0	0.00
7/25	6.04	0	0.00	17.13	0	0.00	1	0.06	0	0.00
7/26	4.89	0	0.00	10.61	0	0.00	8	0.75	0	0.00
7/27	4.40	0	0.00	15.06	0	0.00	35	2.32	0	0.00

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Appendix B2.–Page 3 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
7/28	2.89	0	0.00	7.42	0	0.00	32	4.31	0	0.00
7/29	1.51	0	0.00	6.71	0	0.00	56	8.35	0	0.00
7/30	1.74	0	0.00	6.15	0	0.00	26	4.23	0	0.00
7/31	2.22	0	0.00	5.10	0	0.00	18	3.53	0	0.00
8/1	2.48	0	0.00	7.62	0	0.00	3	0.39	0	0.00
8/2	2.63	0	0.00	6.83	0	0.00	4	0.59	0	0.00
8/3	2.27	0	0.00	7.70	0	0.00	8	1.04	0	0.00
8/4	2.60	0	0.00	4.98	0	0.00	5	1.00	0	0.00
8/5	2.51	0	0.00	6.93	0	0.00	8	1.15	2	0.29
8/6	2.49	0	0.00	6.69	0	0.00	5	0.75	0	0.00
8/7	2.51	0	0.00	7.55	0	0.00	6	0.79	0	0.00
8/8	2.87	0	0.00	8.04	0	0.00	6	0.75	2	0.25
8/9	2.01	0	0.00	4.59	0	0.00	2	0.44	1	0.22
8/10	2.31	0	0.00	6.59	0	0.00	2	0.30	1	0.15
8/11	2.97	0	0.00	7.33	0	0.00	4	0.55	0	0.00
8/12	2.80	0	0.00	6.33	0	0.00	1	0.16	0	0.00
8/13	2.14	0	0.00	4.36	0	0.00	1	0.23	1	0.23
8/14	1.47	0	0.00	2.86	0	0.00	63	22.05	0	0.00
8/15	0.96	0	0.00	1.71	0	0.00	47	27.51	3	1.76
8/16	1.40	0	0.00	2.21	0	0.00	46	20.83	0	0.00
8/17	2.18	0	0.00	3.05	0	0.00	18	5.90	2	0.66
8/18	2.24	0	0.00	3.61	0	0.00	13	3.60	10	2.77
8/19	2.30	0	0.00	6.98	0	0.00	12	1.72	5	0.72
8/20	2.04	0	0.00	6.60	0	0.00	6	0.91	5	0.76
8/21	2.48	0	0.00	6.90	0	0.00	5	0.72	8	1.16
8/22	2.04	0	0.00	3.07	0	0.00	8	2.61	5	1.63
8/23	1.73	0	0.00	4.35	0	0.00	3	0.69	5	1.15
8/24	2.18	0	0.00	3.14	0	0.00	1	0.32	1	0.32
8/25	2.54	0	0.00	6.68	0	0.00	6	0.90	4	0.60
8/26	2.33	0	0.00	7.73	0	0.00	9	1.16	6	0.78

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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	1.99	0	0.00	4.33	0	0.00	2	0.46	6	1.38
8/28	2.17	0	0.00	4.25	0	0.00	13	3.06	0	0.00
8/29	2.46	0	0.00	7.07	0	0.00	7	0.99	2	0.28
8/30	1.85	0	0.00	7.17	0	0.00	2	0.28	13	1.81
8/31	2.66	0	0.00	7.83	0	0.00	1	0.13	10	1.28
9/01	2.53	0	0.00	7.54	0	0.00	3	0.40	4	0.53
9/02	2.53	0	0.00	7.90	0	0.00	9	1.14	2	0.25
9/03	2.49	0	0.00	7.11	0	0.00	7	0.98	3	0.42
9/04	2.75	0	0.00	7.84	0	0.00	7	0.89	13	1.66
9/05	2.43	0	0.00	7.34	0	0.00	7	0.95	2	0.27
9/06	2.84	0	0.00	7.70	0	0.00	3	0.39	4	0.52
9/07	2.34	0	0.00	7.51	0	0.00	3	0.40	2	0.27
Total	488.96	64.00	9.00	642.59	1153.00	216.91	620.00	155.89	122.00	22.12

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, 2017.

		Left bank		Total		Percent by bank	
Date	Right bank	Nearshore	Offshore	Passage	SE	Right	Left
5/31	3,787	2,385	153	6,325	1,934	59.9	40.1
6/01	3,726	3,144	103	6,973	2,132	53.4	46.6
6/02	5,062	4,465	50	9,577	2,596	52.9	47.1
6/03	4,313	5,561	93	9,967	2,696	43.3	56.7
6/04	4,464	6,477	87	11,028	2,803	40.5	59.5
6/05	4,729	8,239	199	13,167	3,648	35.9	64.1
6/06	4,039	10,869	144	15,052	2,797	26.8	73.2
6/07	4,781	8,067	502	13,350	2,791	35.8	64.2
6/08	4,192	7,800	1,009	13,001	5,332	32.2	67.8
6/09	4,223	14,921	1,943	21,087	4,638	20.0	80.0
6/10	3,647	17,750	3,284	24,681	3,111	14.8	85.2
6/11	3,572	9,405	3,167	16,144	2,027	22.1	77.9
6/12	5,091	18,740	8,407	32,238	4,628	15.8	84.2
6/13	5,369	11,243	5,709	22,321	3,799	24.1	75.9
6/14	18,115	101,873	35,353	155,341	35,202	11.7	88.3
6/15	16,716	65,706	36,138	118,560	14,107	14.1	85.9
6/16	12,368	84,729	35,456	132,553	19,913	9.3	90.7
6/17	6,720	38,966	24,954	70,640	15,970	9.5	90.5
6/18	40,386	79,226	48,697	168,309	26,298	24.0	76.0
6/19	19,173	126,637	68,093	213,903	16,524	9.0	91.0
6/20	11,755	55,313	33,168	100,236	7,909	11.7	88.3
6/21	64,825	185,253	67,900	317,978	33,116	20.4	79.6
6/22	43,155	158,329	89,391	290,875	27,296	14.8	85.2
6/23	60,708	135,260	54,347	250,315	22,897	24.3	75.7
6/24	32,997	77,013	47,810	157,820	18,960	20.9	79.1
6/25	15,507	19,416	22,396	57,319	11,478	27.1	72.9
6/26	43,722	60,749	42,152	146,623	13,751	29.8	70.2
6/27	27,463	57,670	59,534	144,667	10,339	19.0	81.0
6/28	21,274	29,599	33,445	84,318	5,845	25.2	74.8
6/29	33,526	55,797	49,630	138,953	23,473	24.1	75.9
6/30	24,181	49,543	40,284	114,008	15,839	21.2	78.8
7/01	17,346	23,918	35,315	76,579	11,927	22.7	77.3
7/02	11,165	26,898	32,689	70,752	4,062	15.8	84.2
7/03	14,587	18,661	23,987	57,235	6,292	25.5	74.5
7/04	12,561	21,581	21,990	56,132	6,231	22.4	77.6
7/05	8,824	11,786	12,127	32,737	5,327	27.0	73.0
7/06	17,314	18,670	31,602	67,586	9,414	25.6	74.4
7/07	26,194	39,400	63,302	128,896	16,612	20.3	79.7
7/08	24,796	40,020	42,682	107,498	8,435	23.1	76.9
7/09	22,286	29,057	25,504	76,847	10,093	29.0	71.0
7/10	15,820	27,225	19,228	62,273	10,150	25.4	74.6
7/11	9,322	16,353	8,245	33,920	7,799	27.5	72.5
7/12	9,287	15,870	8,571	33,728	7,557	27.5	72.5
7/13	9,300	16,216	8,949	34,465	7,643	27.0	73.0
7/14	7,379	17,627	4,116	29,122	5,074	25.3	74.7
7/15	6,606	13,933	2,766	23,305	6,439	28.3	71.7
7/16	4,344	12,056	1,907	18,307	4,560	23.7	76.3
7/17	3,733	10,242	3,002	16,977	4,035	22.0	78.0
7/18	5,733	12,608	4,555	22,896	5,206	25.0	75.0

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Date	Right bank	Left bank		Total		Percent by bank	
		Nearshore	Offshore	Passage	SE	Right	Left
7/19	16,961	28,219	24,477	69,657	16,549	24.3	75.7
7/20	34,849	53,724	37,419	125,992	11,592	27.7	72.3
7/21	15,960	25,715	20,287	61,962	8,031	25.8	74.2
7/22	8,599	15,094	7,945	31,638	5,835	27.2	72.8
7/23	7,529	13,468	4,576	25,573	4,164	29.4	70.6
7/24	5,472	8,757	2,189	16,418	3,357	33.3	66.7
7/25	5,581	9,404	2,927	17,912	4,649	31.2	68.8
7/26	6,930	10,376	12,490	29,796	5,446	23.3	76.7
7/27	9,916	15,803	20,741	46,460	4,119	21.3	78.7
7/28	9,005	11,886	13,574	34,465	4,382	26.1	73.9
7/29	16,929	12,152	20,141	49,222	6,748	34.4	65.6
7/30	15,137	22,321	42,351	79,809	7,650	19.0	81.0
7/31	9,159	13,678	14,007	36,844	5,505	24.9	75.1
8/01	3,856	7,810	5,815	17,481	2,484	22.1	77.9
8/02	3,378	5,629	2,500	11,507	2,165	29.4	70.6
8/03	4,374	7,247	5,319	16,940	3,097	25.8	74.2
8/04	6,493	10,762	13,163	30,418	4,093	21.3	78.7
8/05	6,063	9,001	9,655	24,719	4,289	24.5	75.5
8/06	3,573	7,434	3,776	14,783	3,005	24.2	75.8
8/07	3,320	6,543	2,467	12,330	2,913	26.9	73.1
8/08	3,990	5,955	2,403	12,348	2,717	32.3	67.7
8/09	4,577	7,656	3,609	15,842	3,079	28.9	71.1
8/10	4,222	5,917	3,941	14,080	3,217	30.0	70.0
8/11	3,203	6,146	2,279	11,628	1,970	27.5	72.5
8/12	2,933	4,674	1,597	9,204	3,902	31.9	68.1
8/13	11,738	36,205	18,130	66,073	10,912	17.8	82.2
8/14	38,972	157,273	53,964	250,209	24,031	15.6	84.4
8/15	55,626	155,831	59,351	270,808	24,236	20.5	79.5
8/16	43,834	187,346	101,199	332,379	26,595	13.2	86.8
8/17	18,071	101,285	48,771	168,127	17,721	10.7	89.3
8/18	16,562	24,007	24,438	65,007	9,178	25.5	74.5
8/19	7,631	21,629	17,659	46,919	4,639	16.3	83.7
8/20	6,622	13,602	10,190	30,414	4,421	21.8	78.2
8/21	5,973	19,345	10,952	36,270	5,796	16.5	83.5
8/22	7,818	11,742	13,060	32,620	4,807	24.0	76.0
8/23	6,274	12,454	15,080	33,808	6,157	18.6	81.4
8/24	7,185	8,054	12,876	28,115	5,158	25.6	74.4
8/25	6,306	11,907	13,617	31,830	4,808	19.8	80.2
8/26	5,885	10,881	9,107	25,873	4,042	22.7	77.3
8/27	6,577	8,863	10,908	26,348	6,810	25.0	75.0
8/28	9,264	10,826	14,384	34,474	7,733	26.9	73.1
8/29	9,189	11,156	21,579	41,924	21,545	21.9	78.1
8/30	7,228	11,303	9,578	28,109	4,768	25.7	74.3
8/31	4,780	7,140	5,992	17,912	2,989	26.7	73.3

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		Left bank		Total		Percent by bank	
Date	Right bank	Nearshore	Offshore	Passage	SE	Right	Left
9/01	4,060	5,266	4,688	14,014	3,240	29.0	71.0
9/02	4,028	5,923	7,027	16,978	2,756	23.7	76.3
9/03	5,327	7,374	8,346	21,047	3,941	25.3	74.7
9/04	4,665	7,864	7,010	19,539	3,573	23.9	76.1
9/05	4,130	5,464	4,901	14,495	3,765	28.5	71.5
9/06	3,251	3,878	2,445	9,574	1,890	34.0	66.0
9/07	3,316	4,092	1,842	9,250	2,103	35.8	64.2
Season	1,296,504	3,068,347	1,950,877	6,315,728	112,068	20.5	79.5

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, 2017.

	Chinook			Chum					Whitefish				
Date	Large[a]	Small[b]	Total	Summer	Fall	Coho	Pink	Cisco	Humpback	Broad	Sheefish	Other[c]	Total
5/31	162	0	162	2,471	0	0	0	553	897	404	751	1,087	6,325
6/01	207	0	207	2,928	0	0	0	666	883	397	767	1,125	6,973
6/02	485	0	485	5,483	0	0	0	1,605	362	228	182	1,232	9,577
6/03	359	0	359	5,584	0	0	0	1,420	484	279	965	876	9,967
6/04	794	0	794	5,890	0	0	0	1,062	378	0	968	1,936	11,028
6/05	1,132	869	2,001	5,980	0	0	0	3,130	285	258	1,147	366	13,167
6/06	1,454	389	1,843	10,204	0	0	0	30	503	0	1,646	826	15,052
6/07	764	0	764	8,396	0	0	0	1,350	1,294	470	687	389	13,350
6/08	2,693	0	2,693	4,568	0	0	0	837	868	1,089	683	2,263	13,001
6/09	5,351	1,320	6,671	10,913	0	0	0	309	946	428	940	880	21,087
6/10	1,099	352	1,451	19,212	0	0	0	1,321	817	370	750	760	24,681
6/11	3,513	737	4,250	7,467	0	0	0	2,110	389	287	1,335	306	16,144
6/12	5,458	573	6,031	19,253	0	0	0	967	670	448	2,300	2,569	32,238
6/13	2,180	197	2,377	10,308	0	0	0	5,284	1,206	1,040	1,358	748	22,321
6/14	14,842	2,276	17,118	135,953	0	0	0	283	1,618	0	0	369	155,341
6/15	5,610	1,815	7,425	97,798	0	0	0	7,942	2,441	265	2,046	643	118,560
6/16	7,204	2,047	9,251	111,187	0	0	0	6,107	1,188	623	1,122	3,075	132,553
6/17	7,924	308	8,232	59,529	0	0	0	2,009	175	0	364	331	70,640
6/18	16,775	625	17,400	144,351	0	0	0	4,250	356	0	1,035	917	168,309
6/19	8,119	2,287	10,406	187,011	0	0	0	10,994	1,245	2,462	924	861	213,903
6/20	8,320	1,761	10,081	85,803	0	0	0	2,948	0	1,404	0	0	100,236
6/21	25,702	0	25,702	284,951	0	0	0	4,169	0	2,284	872	0	317,978
6/22	6,276	1,344	7,620	269,131	0	0	0	9,047	2,434	0	829	1,814	290,875
6/23	14,697	7,761	22,458	222,811	0	0	0	3,503	652	472	0	419	250,315
6/24	7,173	3,138	10,311	143,035	0	0	415	2,583	1,307	0	169	0	157,820
6/25	1,380	1,921	3,301	37,412	0	0	0	10,116	3,594	284	1,349	1,263	57,319
6/26	8,812	403	9,215	123,733	0	0	0	7,970	2,602	535	1,194	1,374	146,623
6/27	7,348	0	7,348	132,573	0	0	534	2,176	473	1,033	0	530	144,667
6/28	5,159	1,452	6,611	70,052	0	0	0	5,060	463	0	412	1,720	84,318
6/29	8,212	0	8,212	121,879	0	0	0	5,389	619	0	432	2,422	138,953

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Appendix D1.–Page 2 of 4.

Date	Chinook			Chum		Coho	Pink	Cisco	Whitefish		Sheefish	Other[c]	Total
	Large[a]	Small[b]	Total	Summer	Fall				Humpback	Broad			
6/30	4,704	1,058	5,762	97,441	0	0	0	6,463	1,925	0	217	2,200	114,008
7/01	2,171	1,374	3,545	55,843	0	0	533	11,383	4,056	243	441	535	76,579
7/02	4,780	353	5,133	59,538	0	0	0	4,847	1,025	209	0	0	70,752
7/03	5,353	1,345	6,698	39,854	0	0	0	829	6,508	2,499	531	316	57,235
7/04	1,552	1,125	2,677	48,682	0	0	0	1,903	1,681	1,189	0	0	56,132
7/05	2,463	0	2,463	20,560	0	0	0	5,773	3,251	0	352	338	32,737
7/06	1,683	1,315	2,998	57,474	0	0	0	2,150	3,374	684	729	177	67,586
7/07	1,391	314	1,705	109,692	0	0	453	1,078	11,830	1,092	1,617	1,429	128,896
7/08	3,376	874	4,250	85,401	0	0	2,613	6,014	7,878	0	0	1,342	107,498
7/09	2,215	1,872	4,087	50,828	0	0	2,765	2,095	15,488	471	0	1,113	76,847
7/10	1,399	441	1,840	41,497	0	0	2,202	11,779	3,848	247	0	860	62,273
7/11	721	264	985	21,900	0	0	1,205	6,875	2,298	146	0	511	33,920
7/12	993	91	1,084	17,816	0	0	2,443	8,756	2,449	637	133	410	33,728
7/13	1,025	91	1,116	18,175	0	0	2,503	8,966	2,498	650	133	424	34,465
7/14	1,021	1,711	2,732	6,405	0	0	2,471	11,855	3,619	1,763	0	277	29,122
7/15	327	357	684	5,165	0	0	2,855	7,288	6,610	0	0	703	23,305
7/16	222	33	255	2,056	0	0	4,387	2,310	8,128	700	250	221	18,307
7/17	208	52	260	3,199	0	0	3,344	1,640	7,333	810	391	0	16,977
7/18	107	0	107	6,343	0	0	4,122	6,753	3,865	1,020	0	686	22,896
7/19	847	0	847	0	40,875	0	15,935	10,683	571	0	379	367	69,657
7/20	188	0	188	0	103,862	0	8,675	8,027	5,043	0	197	0	125,992
7/21	86	0	86	0	51,416	0	4,191	3,776	2,403	0	90	0	61,962
7/22	0	0	0	0	8,877	0	14,202	3,860	3,677	0	0	1,022	31,638
7/23	142	301	443	0	11,982	243	5,139	4,701	1,936	529	0	600	25,573
7/24	0	222	222	0	6,126	116	3,533	3,483	1,791	199	0	948	16,418
7/25	110	0	110	0	4,351	0	6,489	1,346	4,888	0	73	655	17,912
7/26	137	0	137	0	9,730	0	9,615	2,804	6,385	0	312	813	29,796
7/27	0	145	145	0	33,362	116	6,269	3,774	2,657	0	0	137	46,460
7/28	0	0	0	0	19,997	411	5,780	5,809	2,345	0	123	0	34,465
7/29	334	0	334	0	37,150	370	7,404	2,212	1,415	0	0	337	49,222

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Appendix D1.–Page 3 of 4.

Date	Chinook			Chum		Coho	Pink	Cisco	Whitefish		Sheefish	Other[c]	Total
	Large[a]	Small[b]	Total	Summer	Fall				Humpback	Broad			
7/30	0	0	0	0	63,714	294	6,295	5,488	3,872	146	0	0	79,809
7/31	0	0	0	0	27,263	178	3,832	3,363	2,120	88	0	0	36,844
8/01	263	0	263	0	5,751	440	4,885	3,122	2,370	203	268	179	17,481
8/02	113	0	113	0	3,074	626	2,830	3,570	968	0	0	326	11,507
8/03	0	0	0	0	10,637	357	1,321	1,422	1,996	105	0	1,102	16,940
8/04	0	0	0	0	20,594	530	2,426	2,112	2,964	155	0	1,637	30,418
8/05	0	0	0	0	9,837	1,013	4,294	6,548	1,986	627	0	414	24,719
8/06	0	103	103	0	2,469	484	2,556	4,550	3,334	62	57	1,168	14,783
8/07	0	0	0	0	5,035	441	2,805	1,548	1,077	280	0	1,144	12,330
8/08	190	0	190	0	6,268	411	499	1,130	2,730	406	150	564	12,348
8/09	245	0	245	0	8,215	471	692	1,406	3,471	466	193	683	15,842
8/10	251	0	251	0	6,415	1,383	1,162	3,033	1,711	125	0	0	14,080
8/11	0	177	177	0	4,557	597	650	1,993	3,450	204	0	0	11,628
8/12	0	0	0	0	3,112	599	856	2,136	1,568	272	61	600	9,204
8/13	0	0	0	0	26,535	3,790	6,383	12,685	10,851	1,891	476	3,462	66,073
8/14	0	0	0	0	236,252	8,633	0	1,061	2,783	0	0	1,480	250,209
8/15	0	0	0	0	255,251	9,552	0	1,150	3,105	0	0	1,750	270,808
8/16	0	0	0	0	314,791	11,357	0	1,248	3,263	0	0	1,720	332,379
8/17	0	0	0	0	131,998	21,647	1,552	10,273	1,956	0	0	701	168,127
8/18	0	0	0	0	50,576	8,992	665	3,519	612	0	0	643	65,007
8/19	0	0	0	0	32,911	5,020	895	5,459	1,419	0	0	1,215	46,919
8/20	0	0	0	0	15,666	5,570	0	7,574	608	545	356	95	30,414
8/21	0	0	0	0	26,158	6,651	339	2,699	301	0	0	122	36,270
8/22	0	0	0	0	23,642	5,860	206	2,358	394	0	0	160	32,620
8/23	0	0	0	0	21,094	4,165	706	5,715	1,193	0	0	935	33,808
8/24	0	0	0	0	17,080	4,081	603	4,395	1,190	0	0	766	28,115
8/25	0	0	0	0	21,722	4,609	0	3,821	182	180	0	1,316	31,830
8/26	0	0	0	0	13,126	4,988	0	5,848	1,047	332	0	532	25,873
8/27	0	0	0	0	15,966	4,910	0	3,672	441	0	0	1,359	26,348
8/28	0	0	0	0	20,900	6,422	0	4,777	622	0	0	1,753	34,474

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	Chinook			Chum					Whitefish				
Date	Large[a]	Small[b]	Total	Summer	Fall	Coho	Pink	Cisco	Humpback	Broad	Sheefish	Other[c]	Total
8/29	0	0	0	0	31,849	3,363	0	5,175	535	581	0	421	41,924
8/30	0	0	0	0	11,685	7,346	0	6,701	1,903	0	0	474	28,109
8/31	0	0	0	0	7,203	6,450	0	2,368	1,109	261	0	521	17,912
9/01	0	0	0	0	6,573	4,814	0	2,066	0	0	0	561	14,014
9/02	0	0	0	0	10,874	3,458	0	354	315	972	0	1,005	16,978
9/03	0	0	0	0	12,785	3,914	0	2,716	0	533	0	1,099	21,047
9/04	0	0	0	0	8,643	5,099	0	3,148	1,531	521	0	597	19,539
9/05	0	0	0	0	6,105	3,287	0	4,163	395	208	0	337	14,495
9/06	0	0	0	0	3,206	2,162	0	2,639	919	363	0	285	9,574
9/07	0	0	0	0	2,671	1,100	0	3,241	1,213	125	109	791	9,250
Total	217,821	45,193	263,014	3,093,735	1,829,931	166,320	166,529	414,668	231,428	37,799	32,865	79,439	6,315,728

[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, 2017.

	Chinook			Chum					Whitefish				
Date	Large [a]	Small [b]	Total	Summer	Fall	Coho	Pink	Cisco	Humpback	Broad	Sheefish	Other [c]	Total
5/31	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
6/01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.05	0.03	0.00
6/02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.05	0.04	0.00
6/03	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.03	0.08	0.05	0.01
6/04	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.03	0.11	0.08	0.01
6/05	0.01	0.02	0.02	0.01	0.00	0.00	0.00	0.02	0.01	0.04	0.15	0.08	0.01
6/06	0.02	0.03	0.02	0.01	0.00	0.00	0.00	0.02	0.02	0.04	0.20	0.09	0.01
6/07	0.02	0.03	0.03	0.02	0.00	0.00	0.00	0.02	0.02	0.05	0.22	0.10	0.01
6/08	0.04	0.03	0.04	0.02	0.00	0.00	0.00	0.03	0.03	0.08	0.24	0.13	0.02
6/09	0.06	0.06	0.06	0.02	0.00	0.00	0.00	0.03	0.03	0.09	0.27	0.14	0.02
6/10	0.07	0.06	0.07	0.03	0.00	0.00	0.00	0.03	0.03	0.10	0.29	0.15	0.02
6/11	0.08	0.08	0.08	0.03	0.00	0.00	0.00	0.03	0.04	0.11	0.33	0.15	0.03
6/12	0.11	0.09	0.11	0.04	0.00	0.00	0.00	0.04	0.04	0.12	0.40	0.18	0.03
6/13	0.12	0.10	0.11	0.04	0.00	0.00	0.00	0.05	0.04	0.15	0.44	0.19	0.03
6/14	0.19	0.15	0.18	0.08	0.00	0.00	0.00	0.05	0.05	0.15	0.44	0.20	0.06
6/15	0.21	0.19	0.21	0.11	0.00	0.00	0.00	0.07	0.06	0.16	0.50	0.21	0.08
6/16	0.24	0.23	0.24	0.15	0.00	0.00	0.00	0.08	0.07	0.17	0.54	0.24	0.10
6/17	0.28	0.24	0.27	0.17	0.00	0.00	0.00	0.09	0.07	0.17	0.55	0.25	0.11
6/18	0.36	0.25	0.34	0.22	0.00	0.00	0.00	0.10	0.07	0.17	0.58	0.26	0.14
6/19	0.40	0.31	0.38	0.28	0.00	0.00	0.00	0.13	0.07	0.24	0.61	0.27	0.17
6/20	0.43	0.34	0.42	0.30	0.00	0.00	0.00	0.13	0.07	0.28	0.61	0.27	0.19
6/21	0.55	0.34	0.52	0.40	0.00	0.00	0.00	0.14	0.07	0.34	0.63	0.27	0.24
6/22	0.58	0.37	0.54	0.48	0.00	0.00	0.00	0.16	0.08	0.34	0.66	0.29	0.28
6/23	0.65	0.55	0.63	0.56	0.00	0.00	0.00	0.17	0.09	0.35	0.66	0.30	0.32
6/24	0.68	0.62	0.67	0.60	0.00	0.00	0.00	0.18	0.09	0.35	0.66	0.30	0.35
6/25	0.69	0.66	0.68	0.61	0.00	0.00	0.00	0.20	0.11	0.36	0.71	0.32	0.36
6/26	0.73	0.67	0.72	0.65	0.00	0.00	0.00	0.22	0.12	0.37	0.74	0.33	0.38
6/27	0.76	0.67	0.75	0.70	0.00	0.00	0.01	0.23	0.12	0.40	0.74	0.34	0.40
6/28	0.79	0.70	0.77	0.72	0.00	0.00	0.01	0.24	0.12	0.40	0.75	0.36	0.42
6/29	0.82	0.70	0.80	0.76	0.00	0.00	0.01	0.25	0.13	0.40	0.77	0.39	0.44
6/30	0.84	0.72	0.82	0.79	0.00	0.00	0.01	0.27	0.13	0.40	0.77	0.42	0.46
7/01	0.85	0.75	0.84	0.81	0.00	0.00	0.01	0.30	0.15	0.40	0.79	0.43	0.47
7/02	0.88	0.76	0.86	0.83	0.00	0.00	0.01	0.31	0.16	0.41	0.79	0.43	0.48
7/03	0.90	0.79	0.88	0.84	0.00	0.00	0.01	0.31	0.18	0.48	0.80	0.43	0.49

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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	0.91	0.81	0.89	0.86	0.00	0.00	0.01	0.31	0.19	0.51	0.80	0.43	0.50
7/05	0.92	0.81	0.90	0.86	0.00	0.00	0.01	0.33	0.21	0.51	0.81	0.43	0.50
7/06	0.93	0.84	0.91	0.88	0.00	0.00	0.01	0.33	0.22	0.53	0.84	0.44	0.51
7/07	0.93	0.85	0.92	0.92	0.00	0.00	0.01	0.34	0.27	0.55	0.89	0.45	0.53
7/08	0.95	0.87	0.94	0.94	0.00	0.00	0.03	0.35	0.31	0.55	0.89	0.47	0.55
7/09	0.96	0.91	0.95	0.96	0.00	0.00	0.04	0.36	0.37	0.57	0.89	0.49	0.56
7/10	0.97	0.92	0.96	0.97	0.00	0.00	0.06	0.38	0.39	0.57	0.89	0.50	0.57
7/11	0.97	0.93	0.96	0.98	0.00	0.00	0.06	0.40	0.40	0.58	0.89	0.50	0.58
7/12	0.97	0.93	0.97	0.99	0.00	0.00	0.08	0.42	0.41	0.59	0.89	0.51	0.58
7/13	0.98	0.93	0.97	0.99	0.00	0.00	0.09	0.44	0.42	0.61	0.89	0.51	0.59
7/14	0.98	0.97	0.98	0.99	0.00	0.00	0.11	0.47	0.44	0.66	0.89	0.52	0.59
7/15	0.98	0.98	0.98	1.00	0.00	0.00	0.13	0.49	0.46	0.66	0.89	0.53	0.60
7/16	0.99	0.98	0.98	1.00	0.00	0.00	0.15	0.50	0.50	0.68	0.90	0.53	0.60
7/17	0.99	0.98	0.98	1.00	0.00	0.00	0.17	0.50	0.53	0.70	0.91	0.53	0.60
7/18	0.99	0.98	0.99	1.00	0.00	0.00	0.20	0.52	0.55	0.73	0.91	0.54	0.61
7/19	0.99	0.98	0.99	1.00	0.02	0.00	0.29	0.54	0.55	0.73	0.92	0.54	0.62
7/20	0.99	0.98	0.99	1.00	0.08	0.00	0.35	0.56	0.57	0.73	0.93	0.54	0.64
7/21	0.99	0.98	0.99	1.00	0.11	0.00	0.37	0.57	0.58	0.73	0.93	0.54	0.65
7/22	0.99	0.98	0.99	1.00	0.11	0.00	0.46	0.58	0.60	0.73	0.93	0.55	0.65
7/23	0.99	0.99	0.99	1.00	0.12	0.00	0.49	0.59	0.61	0.74	0.93	0.56	0.66
7/24	0.99	0.99	0.99	1.00	0.12	0.00	0.51	0.60	0.61	0.74	0.93	0.57	0.66
7/25	0.99	0.99	0.99	1.00	0.12	0.00	0.55	0.60	0.64	0.74	0.94	0.58	0.66
7/26	0.99	0.99	0.99	1.00	0.13	0.00	0.60	0.61	0.66	0.74	0.95	0.59	0.67
7/27	0.99	0.99	0.99	1.00	0.15	0.00	0.64	0.62	0.67	0.74	0.95	0.59	0.67
7/28	0.99	0.99	0.99	1.00	0.16	0.01	0.68	0.63	0.68	0.74	0.95	0.59	0.68
7/29	1.00	0.99	0.99	1.00	0.18	0.01	0.72	0.64	0.69	0.74	0.95	0.60	0.69
7/30	1.00	0.99	0.99	1.00	0.21	0.01	0.76	0.65	0.71	0.75	0.95	0.60	0.70
7/31	1.00	0.99	0.99	1.00	0.23	0.01	0.78	0.66	0.72	0.75	0.95	0.60	0.70
8/01	1.00	0.99	1.00	1.00	0.23	0.01	0.81	0.67	0.73	0.76	0.96	0.60	0.71
8/02	1.00	0.99	1.00	1.00	0.23	0.02	0.83	0.68	0.73	0.76	0.96	0.60	0.71
8/03	1.00	0.99	1.00	1.00	0.24	0.02	0.84	0.68	0.74	0.76	0.96	0.62	0.71
8/04	1.00	0.99	1.00	1.00	0.25	0.02	0.85	0.68	0.75	0.76	0.96	0.64	0.72
8/05	1.00	0.99	1.00	1.00	0.26	0.03	0.88	0.70	0.76	0.78	0.96	0.64	0.72
8/06	1.00	1.00	1.00	1.00	0.26	0.03	0.89	0.71	0.78	0.78	0.96	0.66	0.72

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Appendix E1.–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	1.00	1.00	1.00	1.00	0.26	0.03	0.91	0.71	0.78	0.79	0.96	0.67	0.73
8/08	1.00	1.00	1.00	1.00	0.26	0.04	0.91	0.72	0.79	0.80	0.96	0.68	0.73
8/09	1.00	1.00	1.00	1.00	0.27	0.04	0.92	0.72	0.81	0.81	0.97	0.69	0.73
8/10	1.00	1.00	1.00	1.00	0.27	0.05	0.92	0.73	0.81	0.82	0.97	0.69	0.73
8/11	1.00	1.00	1.00	1.00	0.27	0.05	0.93	0.73	0.83	0.82	0.97	0.69	0.73
8/12	1.00	1.00	1.00	1.00	0.28	0.05	0.93	0.74	0.84	0.83	0.97	0.70	0.74
8/13	1.00	1.00	1.00	1.00	0.29	0.08	0.97	**0.77**	0.88	0.88	0.99	0.74	**0.75**
8/14	1.00	1.00	1.00	1.00	0.42	0.13	0.97	0.77	0.90	0.88	0.99	**0.76**	0.79
8/15	1.00	1.00	1.00	1.00	**0.56**	0.19	0.97	0.77	0.91	0.88	0.99	0.78	0.83
8/16	1.00	1.00	1.00	1.00	**0.73**	**0.26**	0.97	0.78	0.92	0.88	0.99	0.80	0.88
8/17	1.00	1.00	1.00	1.00	**0.80**	0.39	0.98	0.80	0.93	0.88	0.99	0.81	0.91
8/18	1.00	1.00	1.00	1.00	0.83	0.44	0.98	0.81	0.93	0.88	0.99	0.82	0.92
8/19	1.00	1.00	1.00	1.00	0.85	0.47	0.99	0.82	0.94	0.88	0.99	0.83	0.93
8/20	1.00	1.00	1.00	1.00	0.86	**0.50**	0.99	0.84	0.94	0.89	1.00	0.84	0.93
8/21	1.00	1.00	1.00	1.00	0.87	0.54	0.99	0.85	0.94	0.89	1.00	0.84	0.94
8/22	1.00	1.00	1.00	1.00	0.88	0.58	0.99	0.85	0.95	0.89	1.00	0.84	0.94
8/23	1.00	1.00	1.00	1.00	0.90	0.60	1.00	0.87	0.95	0.89	1.00	0.85	0.95
8/24	1.00	1.00	1.00	1.00	0.91	0.63	1.00	0.88	0.96	0.89	1.00	0.86	0.95
8/25	1.00	1.00	1.00	1.00	0.92	0.66	1.00	0.89	0.96	0.90	1.00	0.88	0.96
8/26	1.00	1.00	1.00	1.00	0.92	0.69	1.00	0.90	0.96	0.91	1.00	0.88	0.96
8/27	1.00	1.00	1.00	1.00	0.93	0.71	1.00	0.91	0.96	0.91	1.00	0.90	0.96
8/28	1.00	1.00	1.00	1.00	0.94	**0.75**	1.00	0.92	0.97	0.91	1.00	0.92	0.97
8/29	1.00	1.00	1.00	1.00	0.96	0.77	1.00	0.93	0.97	0.92	1.00	0.93	0.98
8/30	1.00	1.00	1.00	1.00	0.97	0.82	1.00	0.95	0.98	0.92	1.00	0.93	0.98
8/31	1.00	1.00	1.00	1.00	0.97	0.86	1.00	0.96	0.98	0.93	1.00	0.94	0.98
9/01	1.00	1.00	1.00	1.00	0.98	0.89	1.00	0.96	0.98	0.93	1.00	0.95	0.99
9/02	1.00	1.00	1.00	1.00	0.98	0.91	1.00	0.96	0.98	0.95	1.00	0.96	0.99
9/03	1.00	1.00	1.00	1.00	0.99	0.93	1.00	0.97	0.98	0.97	1.00	0.97	0.99
9/04	1.00	1.00	1.00	1.00	0.99	0.96	1.00	0.98	0.99	0.98	1.00	0.98	0.99
9/05	1.00	1.00	1.00	1.00	1.00	0.98	1.00	0.99	0.99	0.99	1.00	0.99	1.00
9/06	1.00	1.00	1.00	1.00	1.00	0.99	1.00	0.99	0.99	1.00	1.00	0.99	1.00
9/07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Note: The 25th, 50th, and 75th percentiles are in bold.

[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, 2017

Appendix F1.–Daily cumulative fish passage proportions and timing by species, at the Pilot Station sonar project on the Yukon River, 2017.

	Chinook			Chum					Whitefish				
Date	Large [a]	Small [b]	Total	Summer	Fall	Coho	Pink	Cisco	Humpback	Broad	Sheefish	Other [c]	Total
5/31	162	0	162	2,471	0	0	0	553	897	404	751	1,087	6,325
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	197,764	36,830	234,594	2,647,224	0	0	1,482	130,615	44,344	19,200	26,416	34,152	3,138,027
7/05	200,227	36,830	237,057	2,667,784	0	0	1,482	136,388	47,595	19,200	26,768	34,490	3,170,764
7/06	201,910	38,145	240,055	2,725,258	0	0	1,482	138,538	50,969	19,884	27,497	34,667	3,238,350
7/07	203,301	38,459	241,760	2,834,950	0	0	1,935	139,616	62,799	20,976	29,114	36,096	3,367,246
7/08	206,677	39,333	246,010	2,920,351	0	0	4,548	145,630	70,677	20,976	29,114	37,438	3,474,744
7/09	208,892	41,205	250,097	2,971,179	0	0	7,313	147,725	86,165	21,447	29,114	38,551	3,551,591
7/10	210,291	41,646	251,937	3,012,676	0	0	9,515	159,504	90,013	21,694	29,114	39,411	3,613,864
7/11	211,012	41,910	252,922	3,034,576	0	0	10,720	166,379	92,311	21,840	29,114	39,922	3,647,784
7/12	212,005	42,001	254,006	3,052,392	0	0	13,163	175,135	94,760	22,477	29,247	40,332	3,681,512
7/13	213,030	42,092	255,122	3,070,567	0	0	15,666	184,101	97,258	23,127	29,380	40,756	3,715,977
7/14	214,051	43,803	257,854	3,076,972	0	0	18,137	195,956	100,877	24,890	29,380	41,033	3,745,099
7/15	214,378	44,160	258,538	3,082,137	0	0	20,992	203,244	107,487	24,890	29,380	41,736	3,768,404
7/16	214,600	44,193	258,793	3,084,193	0	0	25,379	205,554	115,615	25,590	29,630	41,957	3,786,711
7/17	214,808	44,245	259,053	3,087,392	0	0	28,723	207,194	122,948	26,400	30,021	41,957	3,803,688
7/18	214,915	44,245	259,160	3,093,735	0	0	32,845	213,947	126,813	27,420	30,021	42,643	3,826,584
7/19	215,762	44,245	260,007	3,093,735	40,875	0	48,780	224,630	127,384	27,420	30,400	43,010	3,896,241
7/20	215,950	44,245	260,195	3,093,735	144,737	0	57,455	232,657	132,427	27,420	30,597	43,010	4,022,233
7/21	216,036	44,245	260,281	3,093,735	196,153	0	61,646	236,433	134,830	27,420	30,687	43,010	4,084,195
7/22	216,036	44,245	260,281	3,093,735	205,030	0	75,848	240,293	138,507	27,420	30,687	44,032	4,115,833
7/23	216,178	44,546	260,724	3,093,735	217,012	243	80,987	244,994	140,443	27,949	30,687	44,632	4,141,406
7/24	216,178	44,768	260,946	3,093,735	223,138	359	84,520	248,477	142,234	28,148	30,687	45,580	4,157,824
7/25	216,288	44,768	261,056	3,093,735	227,489	359	91,009	249,823	147,122	28,148	30,760	46,235	4,175,736
7/26	216,425	44,768	261,193	3,093,735	237,219	359	100,624	252,627	153,507	28,148	31,072	47,048	4,205,532
7/27	216,425	44,913	261,338	3,093,735	270,581	475	106,893	256,401	156,164	28,148	31,072	47,185	4,251,992
7/28	216,425	44,913	261,338	3,093,735	290,578	886	112,673	262,210	158,509	28,148	31,195	47,185	4,286,457
7/29	216,759	44,913	261,672	3,093,735	327,728	1,256	120,077	264,422	159,924	28,148	31,195	47,522	4,335,679
7/30	216,759	44,913	261,672	3,093,735	391,442	1,550	126,372	269,910	163,796	28,294	31,195	47,522	4,415,488
7/31	216,759	44,913	261,672	3,093,735	418,705	1,728	130,204	273,273	165,916	28,382	31,195	47,522	4,452,332
8/01	217,022	44,913	261,935	3,093,735	424,456	2,168	135,089	276,395	168,286	28,585	31,463	47,701	4,469,813
8/02	217,135	44,913	262,048	3,093,735	427,530	2,794	137,919	279,965	169,254	28,585	31,463	48,027	4,481,320
8/03	217,135	44,913	262,048	3,093,735	438,167	3,151	139,240	281,387	171,250	28,690	31,463	49,129	4,498,260
8/04	217,135	44,913	262,048	3,093,735	458,761	3,681	141,666	283,499	174,214	28,845	31,463	50,766	4,528,678
8/05	217,135	44,913	262,048	3,093,735	468,598	4,694	145,960	290,047	176,200	29,472	31,463	51,180	4,553,397
8/06	217,135	45,016	262,151	3,093,735	471,067	5,178	148,516	294,597	179,534	29,534	31,520	52,348	4,568,180

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	Chinook			Chum					Whitefish				
Date	Large [a]	Small [b]	Total	Summer	Fall	Coho	Pink	Cisco	Humpback	Broad	Sheefish	Other [c]	Total
8/07	217,135	45,016	262,151	3,093,735	476,102	5,619	151,321	296,145	180,611	29,814	31,520	53,492	4,580,510
8/08	217,325	45,016	262,341	3,093,735	482,370	6,030	151,820	297,275	183,341	30,220	31,670	54,056	4,592,858
8/09	217,570	45,016	262,586	3,093,735	490,585	6,501	152,512	298,681	186,812	30,686	31,863	54,739	4,608,700
8/10	217,821	45,016	262,837	3,093,735	497,000	7,884	153,674	301,714	188,523	30,811	31,863	54,739	4,622,780
8/11	217,821	45,193	263,014	3,093,735	501,557	8,481	154,324	303,707	191,973	31,015	31,863	54,739	4,634,408
8/12	217,821	45,193	263,014	3,093,735	504,669	9,080	155,180	305,843	193,541	31,287	31,924	55,339	4,643,612
8/13	217,821	45,193	263,014	3,093,735	531,204	12,870	161,563	318,528	204,392	33,178	32,400	58,801	4,709,685
8/14	217,821	45,193	263,014	3,093,735	767,456	21,503	161,563	319,589	207,175	33,178	32,400	60,281	4,959,894
8/15	217,821	45,193	263,014	3,093,735	1,022,707	31,055	161,563	320,739	210,280	33,178	32,400	62,031	5,230,702
8/16	217,821	45,193	263,014	3,093,735	1,337,498	42,412	161,563	321,987	213,543	33,178	32,400	63,751	5,563,081
8/17	217,821	45,193	263,014	3,093,735	1,469,496	64,059	163,115	332,260	215,499	33,178	32,400	64,452	5,731,208
8/18	217,821	45,193	263,014	3,093,735	1,520,072	73,051	163,780	335,779	216,111	33,178	32,400	65,095	5,796,215
8/19	217,821	45,193	263,014	3,093,735	1,552,983	78,071	164,675	341,238	217,530	33,178	32,400	66,310	5,843,134
8/20	217,821	45,193	263,014	3,093,735	1,568,649	83,641	164,675	348,812	218,138	33,723	32,756	66,405	5,873,548
8/21	217,821	45,193	263,014	3,093,735	1,594,807	90,292	165,014	351,511	218,439	33,723	32,756	66,527	5,909,818
8/22	217,821	45,193	263,014	3,093,735	1,618,449	96,152	165,220	353,869	218,833	33,723	32,756	66,687	5,942,438
8/23	217,821	45,193	263,014	3,093,735	1,639,543	100,317	165,926	359,584	220,026	33,723	32,756	67,622	5,976,246
8/24	217,821	45,193	263,014	3,093,735	1,656,623	104,398	166,529	363,979	221,216	33,723	32,756	68,388	6,004,361
8/25	217,821	45,193	263,014	3,093,735	1,678,345	109,007	166,529	367,800	221,398	33,903	32,756	69,704	6,036,191
8/26	217,821	45,193	263,014	3,093,735	1,691,471	113,995	166,529	373,648	222,445	34,235	32,756	70,236	6,062,064
8/27	217,821	45,193	263,014	3,093,735	1,707,437	118,905	166,529	377,320	222,886	34,235	32,756	71,595	6,088,412
8/28	217,821	45,193	263,014	3,093,735	1,728,337	125,327	166,529	382,097	223,508	34,235	32,756	73,348	6,122,886
8/29	217,821	45,193	263,014	3,093,735	1,760,186	128,690	166,529	387,272	224,043	34,816	32,756	73,769	6,164,810
8/30	217,821	45,193	263,014	3,093,735	1,771,871	136,036	166,529	393,973	225,946	34,816	32,756	74,243	6,192,919
8/31	217,821	45,193	263,014	3,093,735	1,779,074	142,486	166,529	396,341	227,055	35,077	32,756	74,764	6,210,831
9/01	217,821	45,193	263,014	3,093,735	1,785,647	147,300	166,529	398,407	227,055	35,077	32,756	75,325	6,224,845
9/02	217,821	45,193	263,014	3,093,735	1,796,521	150,758	166,529	398,761	227,370	36,049	32,756	76,330	6,241,823
9/03	217,821	45,193	263,014	3,093,735	1,809,306	154,672	166,529	401,477	227,370	36,582	32,756	77,429	6,262,870
9/04	217,821	45,193	263,014	3,093,735	1,817,949	159,771	166,529	404,625	228,901	37,103	32,756	78,026	6,282,409
9/05	217,821	45,193	263,014	3,093,735	1,824,054	163,058	166,529	408,788	229,296	37,311	32,756	78,363	6,296,904
9/06	217,821	45,193	263,014	3,093,735	1,827,260	165,220	166,529	411,427	230,215	37,674	32,756	78,648	6,306,478
9/07	217,821	45,193	263,014	3,093,735	1,829,931	166,320	166,529	414,668	231,428	37,799	32,865	79,439	6,315,728

[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, 1995-2017

Appendix G1.–Salmon passage estimates, by species, at the Pilot Station sonar project on the Yukon River, 1995–2017.

	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	118,335	26,753	145,088	1,415,027	458,103	1,873,130	177,724	917,731	3,113,673
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

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

[b] Chinook salmon >655 mm MEFL.

[c] Chinook salmon ≤655 mm MEFL.

[d] This estimate may not include the entire run. However, in 2008 through 2014 and 2017, 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, 1995–2017.

		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	280,019	175,490	20,354	50,956	43,086	569,905
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

[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.