Fishery Data Series No. 14-22

Sonar Estimation of Salmon Passage in the Yukon River near Pilot Station, 2012

by

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and

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April 2014

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

FISHERY DATA SERIES NO. 14-22

SONAR ESTIMATION OF SALMON PASSAGE IN THE YUKON RIVER NEAR PILOT STATION, 2012

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ABSTRACT

The Pilot Station sonar project has provided daily passage estimates for Chinook *Oncorhynchus tshawytscha*, chum *O. keta*, and coho salmon *O. kisutch* for most years since 1986. Fish passage estimates for each species were generated in 2012 through a 2-component process: (1) estimation of total fish passage with 120 kHz split-beam sonar and a dual-frequency identification sonar (DIDSON), and (2) apportionment to species by sampling with a suite of gillnets of various mesh sizes. An estimated 4,057,322 fish passed through the sonar sampling area between June 1 and September 7—801,804 along the right bank and 3,255,518 along the left bank. Included were 90,936 ± 15,895 large Chinook salmon (>655 mm mideye tail fork), 15,790 ± 4,849 small Chinook salmon (≤655 mm mideye tail fork), 2,130,404 ± 85,038 summer chum salmon, 682,510 ± 63,708 fall chum salmon, and 106,782 ± 16,730 coho salmon.

Key words: Yukon River, Chinook salmon, *Oncorhynchus tshawytscha*, chum salmon, *Oncorhynchus keta*, hydroacoustic, riverine, sonar, run strength, species apportionment, net selectivity, DIDSON.

INTRODUCTION

BACKGROUND

Within Alaska, 3 species of Pacific salmon (Chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, and chum salmon *O. keta*) are managed inseason for harvest by commercial, sport, and subsistence fisheries over 2,200 km of the Yukon River, as well as to meet treaty commitments made under the U.S./Canada *Yukon River Salmon Agreement* (Yukon River Panel 2004). 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 along the river, 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 fisheries managers for most years since 1986. The estimates from this project complement information obtained from other sources. Located in a single-channel environment at river km 197 near Pilot Station, the project is far enough upriver to avoid the wide, multiple channels of the Yukon River Delta. Because salmon migrate from the river mouth to the sonar site in 2 to 3 days, the project provides timely abundance information to managers of downstream fisheries (Figure 1). The Andreafsky River is the only significant salmon spawning tributary downstream of the sonar site (Figure 2), therefore the majority of migrating salmon in the Yukon River pass the sonar project on their way to the spawning grounds.

The Alaska Department of Fish and Game's (ADF&G) primary role is to manage for sustained yield under Article VIII of the Alaska Constitution, but Alaska is also obligated to manage Yukon River salmon stocks according to precautionary, abundance-based harvest-sharing principals set forth in the Yukon River Salmon Agreement (Yukon River Panel 2004). The goal of bi-national, coordinated management of Chinook and chum salmon stocks is to meet escapement requirements that will ensure sufficient fish availability for sustained harvests in both the United States and Canada in the future. Furthermore, managers follow guidelines specified in state regulations as 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, they are also used postseason to determine whether treaty obligations were met and to judge effects of management actions.

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 City 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°. 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 2008 at the United States Geological Survey (USGS) gaging station located downstream of the project, has ranged from a maximum of 27.4 ft to a minimum of 13.6 ft from June 1 through September 7 (Figure 4).

Prior to 1993, ADF&G used dual-beam sonar equipment that operated at 420 kHz. For the 1993 season, ADF&G changed the existing sonar equipment to operate at a frequency of 120 kHz to allow greater ensonification range by reducing signal loss (Fleischman et al. 1995). The newly configured equipment's performance was verified using standard acoustic targets in the field. Use of lower frequency equipment increased fish detection at longer ranges.

Up until 1995, ADF&G attempted to identify direction of travel of detected targets by aiming the acoustic beam 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). Because of this and subsequent changes in counting methodology, data collected from 1995 through 2012 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). This system is similar to the split-beam used on the Kenai River during 2008 and 2009, although the Kenai River sonar operated at 200 kHz (Miller et al. 2012). Further discussion of dual-beam sonar at the Pilot Station sonar can be found in the *Yukon River project report, 2000* (Rich 2001). The split-beam technology allows testing of assumptions about direction of travel and vertical distribution as the target moves through the acoustic beam through the ability to estimate the 3-dimensional position of a target in space (Burwen et al. 1995).

The project uses a combination of fixed-location split-beam sonar and multi-beam dual-frequency identification sonar (DIDSON[1]; Belcher et al. 2002) to estimate the daily upstream passage of fish. A series of gillnets with different mesh sizes are drifted through the acoustic sampling areas to apportion the passage estimates to species. In 2004, the selectivity model used in species apportionment was refined through biometric review and analysis of historical catch data from the project test fishery. The model providing the best overall fit to the data was a Pearson model with a tangle parameter. Species proportions and passage estimates reported here were generated with this apportionment model, and are comparable with estimates from 1995 to

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

the present, as historical estimates have been regenerated using the most current model and methodology (Bromaghin 2004).

Early in the 2005 season, the Yukon River experienced high water levels and erosion in the bottom profile on the left bank. The erosion limited detection in the narrow nearshore portion of the sonar beam by allowing fish to swim under the beam and caused silt plumes that attenuated the sonar signal. Along with a combination of increased nearshore fish distribution, the high water affected detection of fish with the split-beam sonar within 20 m of shore on the left bank. On 19 June 2005, a DIDSON was deployed in this area to verify nearshore fish detection. With its wider beam angle, video-like images, and software algorithms that can remove bottom structure from the image, the DIDSON system was able to detect fish passage within 20 m despite high water levels and problematic erosion nearshore, and it was operated for the remainder of the season, supplanting split-beam counts in this section of nearshore region. DIDSON has been used in the Anvik and Sheenjek rivers to give daily passage estimates where bottom profile and river width are appropriate for the wider beam angle and shorter range capabilities of this sonar (McEwen 2010; Dunbar 2012). Since 2006, the DIDSON has been integrated into the sampling routine on the left bank, operating side-by-side with the split-beam sonar. The DIDSON samples the first 20 m of the nearshore stratum with the remainder of the range sampled by the split beam.

During the 2008 season, ADF&G implemented a feasibility study to validate a complete switch from paper charts to electronic echograms for enumerating fish traces (C.T. Pfisterer, Commercial Fisheries Biologist, ADF&G, Fairbanks; personal communication). The 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 for counting fish traces (Lozori and McIntosh 2013).

Many sonar projects operate 24 hours per day, including the Sheenjek and Eagle River sonars (Dunbar 2012; Crane and Dunbar 2011), as did the Pilot Station sonar project occasionally during developmental years in 1984 and 1985 (Mesiar et al. 1986). Funding reductions during the 1986 season necessitated staff reductions, and a systematic sampling schedule of three 3-hour sonar periods per day was adopted (Mesiar and LaFlamme 1991). The presence of diel migration patterns would have invalidated this sort of sample design; however, Nickerson and Gaudet (1985) found no evidence of such patterns. Variance estimates for total fish passage were first developed by Brannian in 1986[2] and for passage by species by Fleischman et al. (1992). Parametric and non-parametric confidence intervals were developed in 1993 (Fleischman et al. 1995).

The Pilot Station sonar project provides timely and accurate information to Yukon River fishery managers. DIDSON and split-beam sonars were used to collect fish passage estimates. A gillnet test fishery was used to collect age sex and length (ASL) and genetic data, as well as data for species apportionment. This report presents data collected in 2012 and compares the results to previous years.

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[2] Brannian, L. 1986. Development of an approximate variance for sonar counts. 24 December Memorandum to William Arvey, AYK Regional Research Biologist, Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage.

STUDY AREA

The study site is located approximately 1.6 km upstream of the village of Pilot Station (Figure 3). The Yukon River, at the sonar site, is approximately 1,000 m wide between the left and right bank transducers. 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°. The thalweg is approximately 25 m deep and is located approximately 200 m offshore of the right bank.

The Yukon River Basin is the fourth largest basin in North America, with a drainage area of 857,300 km^2 and an average annual discharge of 6,400 m^3/s. Flows are highest in June, with greatest variability in flow occurring in May, after which discharge and the variability in discharge decline. The Yukon River is turbid and silty in the summer and fall with an estimated annual suspended sediment load at Pilot Station of 60,000,000 tons (Brabets et al. 2000).

River height, as observed from 2001 to 2010 at the United States Geological Survey (USGS) gaging station located downstream of the project, has ranged from a maximum of 27.4 ft to a minimum of 13.6 ft from June 1 through September 7 (Figure 4).

OBJECTIVES

The primary goal of this project is to accurately estimate daily fish passage, by species, during upstream migration past the sonar site. Project objectives were to:

1. Provide managers with timely estimates, and associated confidence intervals, of daily and seasonal passage of adult Chinook, chum and coho salmon;
2. Collect biological data from all fish captured in the test fishery, including species, sex, length, and scales as appropriate;
3. Assist in the collection of Chinook and chum salmon tissue samples for separate genetic stock identification projects; and
4. Collect water temperature data representative of the ensonified areas of the river.

METHODS

Estimates of upstream migration of targeted fish species were produced from a combination of independently generated estimates of fish movements past the sonar site using hydroacoustic equipment, and species proportions based upon the results of drift gillnetting in the same area (Figure 5).

HYDROACOUSTIC DATA ACQUISITION

Equipment

Left bank sonar equipment included

1. a Hydroacoustic Technology Inc. (HTI) Model 244 echosounder configured to transmit and receive at 120 kHz, controlled via Digital Echo Processing (DEP) software installed on a laptop PC,
2. an HTI 120 kHz split-beam transducer with a 2.8°x10° nominal beam width,

3. three 250 ft (228.6 m combined length) HTI split-beam transducer cables connecting the sounder to the transducer,
4. a DIDSON-LR (Long Range) unit (14ºx29º nominal beam dimension), configured to transmit and receive at 1.2 MHz, and controlled via software installed on a laptop PC, and
5. one 500 ft DIDSON underwater cable connecting the DIDSON to the “topside breakout box” and laptop PC.

Right bank sonar equipment included

1. an HTI Model 244 echosounder configured to operate at 120 kHz, controlled via DEP software installed on a laptop PC,
2. an HTI split-beam 120 kHz transducer with a 6°x10° nominal beam width,
3. three 250 ft (228.6 m combined length) HTI split-beam cables connecting the sounder to the transducer.

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 6). Rotator movements were controlled with HTI model 660-2 rotator controllers with position feedback to the nearest 0.1º. Data were stored on a portable hard drive and transferred to an external RAID storage system. Gasoline generators (3000 W) supplied 120 VAC power.

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 (Table 1). The receiver bandwidth was automatically determined by the equipment based on the transmit pulse duration. On the left bank, the nearshore stratum pulse repetition rate was set to 5 pings per second (pps), the midshore stratum was set at 3 pps, and the offshore stratum was set at 1.3 pps. The pulse repetition rate for the right bank nearshore was set at 5 pps, and the offshore stratum was set at 3 pps. Because of a high amount of signal attenuation on the left bank, the split-beam threshold setting ranged from -43dB to -70dB depending on the signal loss at the time. A -43dB setting is considered optimal because the theoretical on-axis target strength of a 450 mm chum salmon is approximately -32 dB (Love 1977) and 10 dB lower allows detection of a fish this size over the nominal beam. The DIDSON (Table 2) operated at an average rate of 8 frames/s with a starting range of 0.83 m and an end range of 20.84 m, in high-frequency mode (1.2 MHz).

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. With the transducer located in the area with the best bottom profile, 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 along the river bottom through as much of the range as possible. The right bank transducer was positioned approximately 3 m from shore, adjusting the aim between 2 strata (S1; 0–50 m, and S2; 50–150 m). The left bank split-beam transducer was positioned as close to shore as possible depending on water height and utilized 3 distinct aims to sample a nearshore stratum (S3; 0–50 m), a midshore stratum (S4; 50–150 m), and an offshore stratum (S5; 150–300 m). The DIDSON was normally deployed within 2 m of the split-beam transducer and ensonified the first 2 sectors of the nearshore stratum (S3; 0–20 m) (Figure 7). The DIDSON's wider beam angle should detect close fish targets better than the split beam, which is narrower in the extreme nearshore. Therefore, when aiming the split beam for the nearshore stratum from 0 to 50 m, when necessary for best detection, the aim is optimized for the 20 to 50 m portion of the stratum, which is not ensonified by the DIDSON. In this way, the sonar systems are used in concert to maximize detection for the entire nearshore stratum on left bank. The counts from the 2 systems cannot directly be compared for the 0 to 20 m nearshore, because the aiming strategy optimizes fish detection for DIDSON but not the split beam within this range. Additional aiming and sonar site selection protocols for fish counting with side-looking sonar systems can be found in Faulkner and Maxwell 2009.

Fluctuating water levels required repositioning and subsequent re-aiming of the transducers. To establish an optimal aim, the transducer was panned horizontally upstream and downstream approximately 15º off perpendicular in 2º increments. At each increment, the vertical tilt was adjusted to obtain the best possible bottom picture using an oscilloscope to confirm that the sonar beam was skimming the substrate. The left bank transducers were re-aimed more often to compensate for the dynamic bottom conditions and continual morphological changes associated with the bank. Once an optimal aim was obtained, the rotator settings were documented and screen captures of echograms made available for visual reference.

Sampling Procedures

Acoustic sampling was conducted simultaneously on both banks during three 3 h periods each day (Table 3). Sample periods were scheduled from 0530 to 0830, 1330 to 1630, and 2130 to 0030 hours, alternating sequentially between strata every 30 minutes. In stratum S3, the DIDSON generated sonar counts supplanted those of the split beam in the range the systems overlapped if they were greater.

Operators counted fish traces for both the split-beam and the DIDSON system on electronic echograms using Echotastic software. All personnel were trained to distinguish between fish traces and non-target echoes. Echo traces were counted as a single fish if at least 2 pings in the cluster passed the threshold level (see *Equipment Settings and Thresholds*) and the targets did not resemble inert downstream objects. Valid downstream fish targets were retained and adjusted into the total estimate of fish passage for consistency with historic methodology. 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 in bottom reverberation markings, which could indicate either movement of the transducer or a change in bottom profile.

Fish traces were tallied on electronic echograms (Figure 8). The data was checked daily for data entry or tallying errors, then processed in statistical software (SAS®) using routines developed by Toshihide Hamazaki, Commercial Fisheries Biometrician, Anchorage.

SYSTEM ANALYSES

Performance of the split-beam hydroacoustic system was routinely monitored following procedures first established in 1995 (Maxwell et al. 1997). Monitoring of the DIDSON included daily checks of sonar settings prior to each sampling period, routine checks of water height near pod, checking aim settings, as well as monthly 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 level was monitored using a staff gage located offshore on the right bank near the field camp. To standardize measurements with observations from previous years, water level measurements were adjusted to the USGS Water Resources Division reference located approximately 500 m downstream of Pilot Station. The information collected from the staff gage was used inseason as a relative water height indicator, and to gather information as a backup for times when the USGS water data was unavailable.

Electronic data loggers were deployed on the right bank on June 4 and on the left bank on June 2. Both loggers remained submerged until September 7.

SPECIES APPORTIONMENT

To estimate species composition, gillnets were drifted through 3 zones (right bank, left bank nearshore, and left bank offshore) corresponding to sonar sampling strata (Figure 7). 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 4). 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 was conducted twice daily between sonar periods, from 0900 to 1200 hours and 1700 to 2000 hours. During each sampling period, 4 different nets were drifted within each of 3 zones for a total of 24 drifts per day (Table 5). 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 held approximately 5 to 10 m from the sonar transducers. The left bank offshore drift was approximately 65 m offshore of the transducers so as not to 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 measured to the nearest 1 mm length. Salmon species were measured from mideye to fork of tail (METF); non-salmon species were measured from snout to fork of tail (FL). 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.

The probability of a fish of a given species and length being captured in a net is dependent on mesh size. To adjust for the effect of net selectivity, a selectivity model is used with coefficients generated for large and small Chinook salmon; summer and fall chum salmon; coho salmon; pink salmon *O. gorbuscha*; least cisco *Coregonus sardinella*; Bering cisco *C. laurettae*; humpback whitefish *C. pidschian*; and broad whitefish *C. nasus*. In addition, coefficients have also been generated for a mixed group of other species containing sheefish *Stenodus leucichthys*; burbot *Lota lota*; longnose sucker *Catostomus catostomus*; Dolly Varden *Salvelinus malma*; sockeye salmon *O. nerka*; and northern pike *Esox lucius* (Appendix A). Details of the apportionment model can be found in Bromaghin 2004.

Species apportionment is complicated by the presence of cisco and whitefish in the same spatial strata as the target salmon species. These small fish are visible with the sonar at the thresholds used by the project and therefore must be sampled with small-mesh gillnets in order to estimate their relative abundance. It is theoretically possible to set voltage thresholds that would exclude small fish from detection by sonar. However, analysis of split-beam data has shown extremely high variability (as high as 6 dB standard deviation) in the strength of returning echoes in the noisy riverine environment, even from perfect spherical targets held stationary in the beam. Considering the additional variability introduced by irregular-shaped targets (fish gas bladders) presented at varying aspects and at different locations in the beam, we have essentially ruled out voltage thresholds as a means of accurately excluding non-target fish from detection.

Scale samples were collected from Chinook salmon and mounted on scale cards, and scale and card numbers were recorded on the test fish data sheets. Data were transferred from data sheets into a database. ASL data were processed, analyzed, and reported by ADF&G staff based in Anchorage. Handling mortalities among the captured fish were distributed to the local community, with fish dispersal documented daily.

Genetic tissue samples from both Chinook and chum salmon were also collected. Age, sex, and length data were cross-referenced with each tissue sample. The ADF&G Gene Conservation Laboratory and the USFWS Conservation Genetics Laboratory independently processed and analyzed these samples.

Chinook salmon were classified as either 'large' (> 655 mm METF) or 'small' (≤ 655 mm METF), with small Chinook salmon serving as a proxy for 1-ocean 'jacks'. Although there are 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 those encountered after July 18 were designated as fall chum salmon.

ANALYTICAL METHODS

Daily estimates were produced from a multi-component process that involved the following:

1. Hydroacoustic estimates of all fish targets passing the site, without regard to species.
2. Species composition derived from test fishing results and applied to the undifferentiated hydroacoustic estimates.

3. Traditional CPUE estimates, used as a separate index by the managers and calculated on a subset of the test fishing data.

Sparse and Missing Data

Test fishing was not conducted during commercial fishery periods and occasionally, during times of low salmon passage, catches were too sparse to accurately estimate species proportions and associated error bounds. 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*.

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

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

The report unit was then also appended to the corresponding days and zones of sonar passage estimates. In effect, any unique combination of day and zone having sufficient test fish catch was also assigned a unique report unit *u*, while combinations not having sufficient catch were pooled by assigning the same report unit either across zones or days.

CPUE

Traditional CPUE measures 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″, 5.75″ and 6.5″).

The duration of the j^{th} test fish drift in minutes *t* was calculated as

$$t_j = \left(SIj - FOj\right) + \frac{\left(FOj - SOj\right)}{2} + \frac{\left(FIj - SIj\right)}{2} , \tag{2}$$

where *SO* is the time the net is initially set out, *FO* is the time the net is fully set out, *SI* is the time the net starts back in, and *FI* is the time the net is fully retrieved.

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

Test fishing drifts were made at stations in each of 3 zones (1, 2, and 3). Zone 1 consisted of the entire counting range on the right bank, zone 2 was from approximately 0–50 m on the left bank, and zone 3 was from approximately 50–300 m on the left bank. The results of the test fishing were used to generate species proportions for each zone, which were then applied to the corresponding sonar passage estimate in that zone.

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 period 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* derived from the Pearson T net selectivity model

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

and the CPUE of the catch of each species *i* of length *l* was calculated as

$$CPUE'_{uil} = \frac{c_{uil}}{f'_{uil}}. \tag{9}$$

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,

$$\hat{p}_{ui} = \frac{\sum_{l} CPUE'_{uil}}{\sum_{i,l} CPUE'_{uil}}, \tag{10}$$

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

$$\hat{V}ar(\hat{p}_{ui}) = \frac{\sum\left(\hat{p}_{ui} - \hat{p}_{udxi}\right)^2}{n_u \cdot \left(n_u - 1\right)}, \tag{11}$$

where n_u = number of test fish 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 test fish species apportionment. Zone 1 consisted of the entire counting range on the right bank, corresponding to strata 1 and 2 (approximately 0–150 m). Zone 2 consisted of the counting range corresponding to stratum 3 (approximately 0–50 m on the left bank). Zone 3 consisted of the counting range corresponding to stratum 4 and stratum 5 (approximately 50–150 m and 150 – 300 m on the left bank, respectively).

Within zone 2, passage was simultaneously estimated in sectors 1 and 2 (representing approximately the first 20 m of stratum 3) using both the DIDSON and the HTI sonar. Although the DIDSON data were primarily used to generate estimates in those 2 sectors, the HTI system data were also tallied because operating it in sectors 3, 4, and 5 also entailed operating in sectors 1 and 2. Because the ranges of the 2 systems did not always precisely overlap, a passage rate for the DIDSON (targets per meter per hour) was first calculated then expanded by the sector width and count time of the corresponding HTI sample to provide consistent width and count time for all sectors 1 through 5. This was done primarily as a matter of calculation convenience.

First, for sectors 1 and 2 of stratum 3, the sector widths w in meters were calculated for all samples q on day d, period p for both the DIDSON and HTI data. The DIDSON unit ensonifies over a single continuous range while the HTI subdivides this range into equal width sectors (k) 1 and 2 of stratum (s) 3. Sector widths for both systems are based on the start and end points of the range in meters referenced from the face of the transducer, such that,

$$w_{dpskq} = End_{dpskq} - Start_{dpskq} \,. \tag{12}$$

The mean width of sectors (k) 1 and 2 of the HTI samples were calculated

$$w_{HTI} = \frac{\sum\limits_{s=3} \sum\limits_{q} w_{dpksq}}{n}, \tag{13}$$

and the width of the DIDSON

$$w_{DID} = \frac{\sum\limits_{q} w_{dpq}}{n}, \tag{14}$$

where n is the number of samples. The total hours h sampled with the HTI system,

$$h_{HTI} = \sum_{q} h_{dpkq} , \tag{15}$$

and the DIDSON,

$$h_{DID} = \sum_{q} h_{dpq} , \tag{16}$$

were summed, as were the total upstream counts *y*,

$$y_{HTI} = \sum_{q} y_{dpkq} , \tag{17}$$

$$y_{DID} = \sum_{q} y_{dpq} . \tag{18}$$

Passage rates (*r*) in fish per hour per meter were then calculated for both the DIDSON and the HTI systems,

$$r_{DID} = \frac{y_{DID}}{w_{DID} \cdot h_{DID}} , \tag{19}$$

$$r_{HTI} = \frac{y_{HTI}}{w_{HTI} \cdot h_{HTI}} . \tag{20}$$

Due to better detection capabilities at close range and the aiming protocol described above, it was typical that the DIDSON passage rate would exceed the HTI passage rate in both sectors 1 and 2. In this case, a passage estimate was generated for the time sampled by expanding the DIDSON using the HTI sector width and hours:

$$y_{dpk} = r_{DID} \cdot w_{HTI} \cdot h_{HTI} . \tag{21}$$

However, in the event of a system failure or data loss using the DIDSON, the HTI estimate for those 2 sectors would be retained and used in subsequent calculations. In this case, the estimates for this time period would be considered conservative.

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

$$y_{dpzs} = \sum_{q} \sum_{k} y_{dpzsqk} , \tag{22}$$

and the duration, in hours *h*, of the time sampled as,

$$h_{dpzs} = \sum_{q} \sum_{k} h_{dpzsqk} . \tag{23}$$

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

$$r_{dpz} = \frac{\sum_{s} y_{dpzs}}{\sum_{s} h_{dpzs}}. \tag{24}$$

Total passage of fish in report unit was estimated as the product of the average hourly passage rate and the total hours encompassed by the report unit,

$$\hat{y}_u = \left(d_2 - d_1 + 1\right)_u \cdot 24 \cdot \left(\frac{\sum_{d,p,z \in u} r_{dpz}}{n_u} \right), \tag{25}$$

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 overestimate of the variance of the total, because sonar counts are highly autocorrelated (Wolter 1985). To accommodate these data characteristics, a variance estimator based on the squared differences of successive observations, recommended by Brannian (1986)[3] and modified from Wolter (1985), was employed;

$$\hat{Var}(\hat{y}_u) = \left[\left(d_2 - d_1 + 1\right)_u \cdot 24\right]^2 \cdot \left[1 - \frac{h_u}{\left(d_2 - d_1 + 1\right)_u \cdot 24}\right] \cdot \frac{\sum_{p=2}^{n_u} (\hat{r}_{up} - \hat{r}_{u,p-1})^2}{2n_u(n_u - 1)}, \tag{26}$$

where $\hat{r}_{up}$ is the estimated passage rate in reporting unit (*u*) for period (*p*), and

$$1 - \frac{h_u}{\left(d_2 - d_1 + 1\right)_u \cdot 24}, \tag{27}$$

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 26)

$$\hat{y}_{ui} = \hat{y}_u \cdot \hat{p}_{ui}. \tag{28}$$

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),

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[3] Brannian, L. 1986. Development of an approximate variance for sonar counts. 24 December Memorandum to William Arvey, AYK Regional Research Biologist, Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage.

$$\hat{V}ar\left(\hat{y}_{ui}\right)=\hat{y}_{u}^{2}\cdot\hat{V}ar\left(\hat{p}_{ui}\right)+\hat{p}_{ui}^{2}\cdot\hat{V}ar\left(\hat{y}_{u}\right)-\hat{V}ar\left(\hat{y}_{u}\right)\cdot\hat{V}ar\left(\hat{p}_{ui}\right)\ . \tag{29}$$

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

$$\hat{V}ar\left(\hat{y}_{i}\right)=\sum_{u}\hat{V}ar\left(\hat{y}_{ui}\right)\ . \tag{30}$$

Because most users of this data were interested in daily passage by species rather than passage for reporting units, the 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,

$$\hat{p}_{dz}=\frac{r_{udz}}{r_{u}}, \tag{31}$$

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

$$\hat{y}_{dzi}=\hat{y}_{ui}\cdot\hat{p}_{dz}\,. \tag{32}$$

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

$$\hat{y}_{di}=\sum_{z}\hat{y}_{dzi}\ . \tag{33}$$

At this stage, there were 2 potential ways of calculating total season passage by 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 $y_{i,}$ (because this is how the estimates are reported),

$$\hat{y}_{i}=\sum_{d}\sum_{z}\hat{y}_{dzi}\,. \tag{34}$$

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

$$\hat{y}_{i}\pm 1.645\sqrt{\hat{V}ar(\hat{y}_{i})}\ . \tag{35}$$

SAS® program code (Toshihide Hamazaki, Commercial Fisheries Biometrician, ADF&G, Anchorage; personal communication) was used to calculate CPUE, passage estimates, and estimates of variance.

RESULTS

The Pilot Station sonar project was fully operational from June 1 through September 7. Passage estimates were transmitted to fishery managers in Emmonak daily.

ENVIRONMENTAL AND HYDROLOGICAL CONDITIONS

Ice breakup on the Yukon River was sufficiently early to allow for camp setup before June 1. The water level during the 2012 season was uncharacteristically high near Pilot Station, and it remained above the 2001–2011 mean throughout most of the season (Figure 4). Mean water temperatures on the left bank ranged from 10.8°C to 17.7°C, and 9.7°C to 17.1°C on the right bank (Figure 9).

TEST FISHING

Drift gillnetting resulted in the capture of 9,845 fish: 461 Chinook salmon, 4,119 summer chum salmon, 2,015 fall chum salmon, 519 coho salmon, and 2,731 fish of other species. Of the captured fish, 3,408 (35%) were retained as mortalities and delivered to local users to help meet subsistence needs within the nearby community of Pilot Station (Table 6).

Daily CPUE data are reported in Appendices B1 and B2. The relationship between daily passage estimates and test fishery CPUE for Chinook salmon, summer and fall chum salmon, and coho salmon were all significant (Figure 10). The correlation coefficient for Chinook salmon was $r = 0.931$ ($P < 0.001$), summer chum salmon was $r = 0.878$ ($P < 0.001$), fall chum salmon was $r = 0.911$ ($P < 0.001$), and coho salmon was $r = 0.704$ ($P < 0.001$).

HYDROACOUSTIC ESTIMATES

An estimated 4,057,322 fish passed through the sonar sampling areas between June 1 and September 7: 801,804 (20%) along the right bank, 2,672,061 (66%) along the left bank nearshore, and 583,457 (14%) along the left bank offshore (Table 7). Total fish passage estimates, by species and zone with their associated errors, were calculated daily (Appendix C).

On the left bank, approximately 90% of the fish passage occurred within 90 m of the transducer in the summer season. During the fall season, distribution was slightly more dispersed and 90% of the fish passage occurred within 110 m. On the right bank, approximately 90% of the fish passage occurred within 70 m during both summer and fall seasons (Figure 11).

SPECIES ESTIMATES

Fish passage estimates by species were generated and reported daily to fishery managers (Appendix D1). Cumulative passage estimates[4] for chum salmon comprised 2,130,404 ± 85,038 summer chum and 682,510 ± 63,708 fall chum salmon. Chinook salmon comprised 90,936 ± 15,896 large Chinook salmon (>655 mm METF) and 15,790 ± 4,849 small Chinook salmon (≤655 mm METF). Coho salmon passage estimates were 106,782 ± 16,730, and the estimates of pink salmon were 352,518 ± 55,861. Other species, totaling 678,382 ± 57,266 fish, included whitefish, cisco, sheefish, burbot, longnose sucker, Dolly Varden, sockeye salmon, and northern pike (Appendix D1).

Within the 0 to 20 m region of the left bank nearshore (where the DIDSON was the primary sonar used for generating passage estimates) 38,498 Chinook salmon, 607,450 summer chum salmon, 129,404 fall chum salmon, and 66,817 coho salmon were additionally counted by the DIDSON over and above the split-beam passage estimates. Daily DIDSON estimates of fish passing through this region of left bank and the associated proportion, also referred to as the DIDSON contribution (Appendices E1 and E2), were monitored daily to evaluate the performance of the split-beam.

The initial pulse of Chinook and summer chum salmon began on approximately June 16 (Figure 12). Compared to historical mean run timing for 2001–2011, the midpoint of the Chinook salmon

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[4] Cumulative passage estimates for all fish species include 90% confidence intervals.

run occurred 3 days late (June 28), and 1 day late (June 29) for summer chum salmon (Figure 13; Appendix F).

For daily reporting purposes, chum salmon migrating past the Pilot Station sonar project after July 18 are considered fall chum salmon. There were 5 pulses of fall chum salmon, with the first pulse occurring on approximately July 19 (Figure 14). Inseason mixed stock analysis (MSA) from the Pilot Station test fishery was used to identify stock composition estimates of pulses, which was distributed inseason to assist in management decisions. Of the 5 pulses, the fall chum salmon composition was 26.8% (July 19 through July 24), 78.7 % (July 25 through August 2), 88.9% (August 3 through August 10), 98.2% (August 11 through August 22), and 90.9% (August 23 through September 7) (B. M. Borba, Commercial Fisheries Biologist, ADF&G, Fairbanks, personal communication). The midpoint for the fall chum salmon run was August 9, which was 1 day early compared to 2001–2011 mean cumulative run timing (Figure 15; Appendix F).

The first significant pulse of coho salmon arrived on approximately August 15. There were 2 additional pulses of coho salmon through September 7. As in most years, the project ends before the coho salmon run is complete, so estimates are considered conservative. Coho salmon continued to enter Yukon River drainage after September 7 and were monitored at 2 lower river test fisheries, but no additional pulses were observed.[5] The midpoint for the coho salmon run was on August 18, which was 1 day early (Figure 15; Appendix F).

MISSING DATA

During the fall season, 10 commercial fishing periods occurred in District 2 during at least 1 of the test fishing periods. There were 13 days between June 1 and June 15 when insufficient numbers of fish were captured. In order to estimate variance accurately, days with missing test fishing periods were pooled with adjacent days that had 2 complete test fishing periods, and zones with insufficient catches were pooled with zones with sufficient catches on adjacent days (Table 8).

DISCUSSION

During the 2012 season, the ice broke on the Yukon River on May 17 at Pilot Station, which was 1 day late compared to the 2001–2011 average (Figure 16). Throughout the field season, water levels remained above average except for a short period between August 16 and August 28, when the water level regressed close to the mean level (Figure 4).

Inseason Chinook salmon estimates were well below average, and there were no directed Chinook salmon commercial fisheries on the lower Yukon River. Chinook salmon passage estimates at the Pilot Station project were the lowest compared to 2002–2011 passage estimates (Appendix G). Despite the low Chinook salmon return, summer chum salmon estimates were above average, and the summer chum commercial harvest was 84% above the 2002–2011 average harvest[6].

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[5] Estensen J. 2012. Yukon River fall season summary. Alaska Department of Fish and Game, Division of Commercial Fisheries, News Release, Juneau Alaska. [issued 2012 November 23; cited February 28, 2013] Available from: http://www.adfg.alaska.gov/static/home/news/pdfs/newsreleases/cf/238374496.pdf (Accessed February 2013).

[6] Hayes, S. 2012. 2012 Preliminary Yukon River summer season summary. Alaska Department of Fish and Game, Division of Commercial Fisheries, News Release, Juneau, AK. [issued 2012 October 1; cited 2013 January 31]. Available from: http://www.adfg.alaska.gov/static/home/news/pdfs/newsreleases/cf/229271472.pdf (Accessed January 2013).

During the fall season, the first pulse of chum salmon occurred on July 19. The pulses that passed through August 8 occurred regularly at a rate of about once per week between pulses. Daily passage of fall chum salmon past the project was steady with numbers mostly above 3,000 fish. A lull in fall chum salmon passage occurred from August 9 through August 18, followed by the fifth and largest pulse. At this point the run assessment continued to show a commercial surplus and regular commercial fishing periods in the lower river were scheduled throughout the remaining season. Coho salmon passage estimates at the Pilot Station sonar project were below average throughout the season. Coho salmon were harvested incidentally in fall chum salmon directed commercial openings. Because of their high incidental commercial harvest, along with below-average passage based on the Pilot Station sonar estimates, as well as 2 additional lower river test fisheries in Emmonak and Mountain Village, there were no directed coho commercial fisheries in the lower river in 2012.

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. Bathymetric surveys of the sonar site this season indicated little change from previous surveys conducted during the Pilot Station acoustic tagging study in 2010 (B. C. McIntosh, Commercial Fisheries Biologist, ADF&G, Fairbanks, personal communication). A concern in recent years has been the left bank sandbar downstream of the ensonified area. During periods of low water, this sandbar, which is located in the left bank nearshore test fish zone, can cause nets to drag the bottom and stall. It is uncertain whether the sandbar causes net avoidance issues during times that water levels are low, but during the 2009 field season, it was speculated that fall chum salmon estimates may have been underestimated because of effects caused by the sandbar (Lozori and McIntosh 2013). The left bank sandbar did not seem to affect distribution or the test fishery this season. Additional investigations should be considered in the future to compare alternative test fishing protocols, including using CPUE data from alternate test fish sites to increase the accuracy of salmon passage estimates generated at Pilot Station during periods when this sandbar is shallow enough to cause issues with the project’s test fishery and fish passage distribution.

The DIDSON contribution is defined as the additional fish count supplemented over and beyond the split-beam estimate within the first 20 m of the left bank nearshore stratum. During the summer season, the DIDSON contributed an additional 36% Chinook and 31.5% summer chum, 19% fall chum, and 13.1% coho salmon. Although not significantly different than 2008, the DIDSON contribution for Chinook as well as both summer and fall chum salmon was the highest contribution compared to all years the DIDSON has been deployed at the project (Figure 17). This highlights that although the DIDSON complements the sonar sampling plan on the left bank, the nature of the left bank substrate, water level, and fish distribution all are factors in determining the DIDSON’s relative contribution to the overall passage estimate in any given season.

Chinook salmon retained this season were sexed internally by making a small incision into the abdominal cavity of each fish and visually inspecting for ovaries or testes. Historically, sex determination of salmon at the project has been by external characteristics, visually examining features such as development of the kype, roundness of the belly, presence or absence of an ovipositor, and overall size. This is similar to the sampling routine used in the Kuskokwim River area (Molyneaux et al. 2010). External sex identification of Chinook salmon is difficult at the Pilot Station sonar project, because the fish have not fully developed the external morphological characteristics relied upon for identification, and live fish are released. Any data analysis including sex identification from the Pilot Station sonar project should be approached with caution, and possible misclassification should be noted. Reference to sexual identification methodology (Internal, External, Unknown) was submitted in a spreadsheet along with ASL data.

In 2005, a fecundity study at both the Pilot Station and Eagle sonar projects were conducted (Jasper and Evenson 2006). Data collected at the Pilot Station project during the study showed 30% of males were misclassified as females, and 36% of females were misclassified as males when externally identified (Figure 18). The association between internal and external sex determination was examined using a chi-square test. The relationship between the 2 variables was highly significant (df = 1, $P<0.01$) (Table 9).

Additional considerations should be made to improve sexual identification of Chinook salmon at the project to improve the project's data set for future analysis of data produced at the project. The use of ultrasound may be a tool for nonlethal sex determination; this type of technology has been used for determination of sex and maturity of Pacific herring *Clupea pallasii* (Bonar et al. 1989). At this time, investigations using ultrasound have not been reliable at other lower river projects in Emmonak or the East Fork of the Andreafsky (K. J. Schumann, Division of Commercial Fisheries Biologist, ADF&G, Anchorage; J.D. Mears, Subsistence Fisheries Biologist, USFWS, Fairbanks, personal communication 2013). In 2010, Mears successfully collected images in 17-mile slough on the Nenana River from mature Coho salmon but was unsuccessful in collecting quality images on the Andreafsky River weir from immature Chinook salmon. In addition to secondary external characteristics, a hand-held ultrasound unit was used to determine sex of all salmon sampled at the Andreafsky River weir in 2011 (Mears 2012). It is unknown whether immaturity of gametes, insufficient training and unfamiliarity with equipment, or other factors play a role in unsuccessful sex determination using ultrasound technology in the lower Yukon River. Future research of ultrasound setting and alternative units available may, however, prove to offer a possible rapid nonlethal method of sexual determination.

Two species of cisco (Bering and least) are commonly sampled at the Pilot Station sonar project. Recently, due to increased interest in a commercial fishery, several projects investigating the life history and population composition of harvest have been initiated for Bering cisco at the mouth of the Yukon River (Brown et al. 2012). During the 2011 and 2012 field seasons, all cisco sampled during normal scheduled test fisheries at Pilot Station were identified by species using external identification characteristics. Of the total cisco sampled, approximately 34% in 2011 and 30% in 2012 were identified as Bering cisco. The average length (FL) of Bering cisco was 354 mm (n = 393), and 309 mm (n = 822) for least cisco (Figure 19).

Bering cisco are anadromous, migrating from salt water to fresh water to spawn. Of the total sample, 3 Bering cisco < 240 mm were identified, which suggests species misidentification, because there are no records of Bering cisco rearing in freshwater (R. J. Brown, Fisheries Biologist U.S. Fish and Wildlife Service, Fairbanks, personal communication 2012; Brown et al. 2007; COSEWIC 2004). Unfortunately, the accuracy of these data cannot be confirmed, but it would be beneficial in the future to confirm Bering cisco sampled < 250 mm (FL) by counting gill rakers, and determine whether the fish show signs of spawning intention, because this would be valuable biological information. Additionally, Bering cisco were retained during 2012 from the project test fishery and were donated to the local fish processor to collect the gonadsomatic index (GSI) values of females, as well as otolith collection for aging. Continued data collection of cisco at the project should be considered because the information may prove useful to other researchers and management in the future.

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 in 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 2012, 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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TABLES AND FIGURES

Table 1.–Initial split-beam sonar settings at the Pilot Station sonar project on the Yukon River, 2012.

			Bank	
Component	Setting	Stratum	Left	Right
Transducer	Beam size (h x w)		2.8º x 10.0º	6.0º x 10.0º
Echosounder	Transmit power (dB)	S1		27.0
		S2		27.0
		S3	24.0	
		S4	27.0	
		S5	30.0	
	Receiver gain (dB)	S1		-12.0
		S2		-12.0
		S3	-12.0	
		S4	-12.0	
		S5	0.0	
	Source Level (dB)	S1		216.9
		S2		216.9
		S3	219.0	
		S4	222.1	
		S5	225.2	
	Through-system gain (dB)		-161.5	-162.5
	Pulse width (ms)		0.4	0.5
	Blanking range (m)		2.0	2.0
	Ping rate (pps)	S1		5.0
		S2		3.0
		S3	5.0	
		S4	3.0	
		S5	1.3	
	Range (m)	S1		50
		S2		150
		S3	50	
		S4	250	
		S5	300	

Table 2.–Technical specifications for the dual-frequency identification sonar at the Pilot Station sonar project on the Yukon River, 2012.

Identification Mode		
	Operating Frequency	1.2 MHz
	Beam width (two-way)	0.8° H by 14° V
	Number of beams	48
Range Settings		
	Start range	0.83 m
	Window length	20.01 m
Range bin size		39 mm
Pulse length		46 µs
Frame rate		8 frames/s
Field of view (horizontal)		29°

Table 3.–Daily sampling schedule for sonar and test fish.

	Sonar		
Time	Right Bank	Left Bank	Test fishing
	Period 1		
530	S1	S3	
600	S2	S4	
630	S1	S5	
700	S2	S3	
730	S1	S4	
800	S2	S5	
830			
900			Period 1
930			
1000			
1030			
1100			
1130			
1200			
1230			
1300	Period 2		
1330	S1	S3	
1400	S2	S4	
1430	S1	S5	
1500	S2	S3	
1530	S1	S4	
1600	S2	S5	
1630			
1700			Period 2
1730			
1800			
1830			
1900			
1930			
2000			
2030			
2100	Period 3		
2130	S1	S3	
2200	S2	S4	
2230	S1	S5	
2300	S2	S3	
2330	S1	S4	
0000	S2	S5	

Note: S1 = stratum 1, S2 = stratum 2, etc. at the Pilot Station sonar project on the Yukon River, 2012.

Table 4.–Specifications for drift gillnets used for test fishing by season, at the Pilot Station sonar project on the Yukon River, 2012.

Season	Stretch mesh size (in)	Stretch mesh size (mm)	Mesh diameter (mm)	Meshes deep (MD)	Depth (m)
Summer	2.75	70	44	131	8.0
(6/01–7/18)	4.00	102	65	90	8.0
	5.25	133	85	69	8.0
	6.50	165	105	55	7.9
	7.50	191	121	48	8.0
	8.50	216	137	43	8.1
Fall	2.75	70	44	131	8.0
(7/19–9/07)	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 5.–Schedule for drift gillnets used for test fishing by season, at the Pilot Station sonar project on the Yukon River, 2012.

		Odd Day Mesh Size (in)		Even Day Mesh Size (in)	
Season	Period	Drift 1	Drift 2	Drift 1	Drift 2
Summer	1	2.75	5.25	8.50	4.00
(6/01–7/18)		7.50	6.50	7.50	6.50
	2	7.50	6.50	7.50	6.50
		8.50	4.00	2.75	5.25
Fall	1	4.00	5.75	2.75	7.50
(7/19–9/07)		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 6.–Number of fish caught and retained in the Pilot Station sonar test fishery, on the Yukon River 2012.

Total Catch	Chinook	Summer Chum	Fall Chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others [a]	Total
June	304	2,435	0	0	0	31	7	56	2	135	10	2,980
July	157	1,684	941	7	10	1,051	127	143	5	34	14	4,173
August	0	0	976	0	369	112	563	286	18	6	20	2,350
September	0	0	98	1	140	0	51	44	6	0	2	342
Total	461	4,119	2,015	8	519	1,194	748	529	31	175	46	9,845

Fish Retained

	Chinook	Summer Chum	Fall Chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others	Total
June	131	1,368	0	0	0	0	0	43	0	55	2	1,599
July	68	488	189	3	3	0	68	111	3	16	1	950
August	0	0	192	0	148	7	327	68	8	2	5	757
September	0	0	46	0	42	0	11	1	2	0	0	102
Total	199	1,856	427	3	193	7	406	223	13	73	8	3,408

Proportion Retained

	Chinook	Summer Chum	Fall Chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others	Total
June	0.431	0.562	0.000	0.000	0.000	0.000	0.000	0.768	0.000	0.407	0.200	0.537
July	0.433	0.290	0.201	0.429	0.300	0.000	0.535	0.776	0.600	0.471	0.071	0.228
August	0.000	0.000	0.197	0.000	0.401	0.063	0.581	0.238	0.444	0.333	0.250	0.322
September	0.000	0.000	0.469	0.000	0.300	0.000	0.216	0.023	0.333	0.000	0.000	0.298
Total	0.432	0.451	0.212	0.375	0.372	0.006	0.543	0.422	0.419	0.417	0.174	0.346

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

Table 7.–Cumulative fish passage estimates by zone and species at the Pilot Station sonar project on the Yukon River, with standard errors (SE) and 90% confidence intervals (CI), 2012.

		Left Bank				90% CI	
Species	Right Bank	Nearshore	Offshore	Total Passage	SE	Lower	Upper
Large Chinook [a]	9,873	74,101	6,962	90,936	9,663	75,041	106,831
Small Chinook	2,160	12,746	884	15,790	2,948	10,941	20,639
Summer chum	347,809	1,626,353	156,242	2,130,404	51,695	2,045,366	2,215,442
Fall chum	56,898	353,150	272,462	682,510	38,728	618,803	746,217
Coho	12,050	42,182	52,550	106,782	10,170	90,052	123,512
Pink	142,611	182,689	27,218	352,518	33,958	296,657	408,379
Other	230,403	380,840	67,139	678,382	34,812	621,116	735,648
Total	801,804	2,672,061	583,457	4,057,322			

[a] Large Chinook are >655 mm mideye to tail fork, small Chinook ≤655 mm mideye to tail fork.

Table 8.–Reporting units of zones pooled for the 2012 season at the Pilot Station sonar project on the Yukon River.

		Left Bank		
Date	Right Bank (Zone 1)	Nearshore (Zone 2)	Offshore (Zone 3)	Reason for pooling [a]
6/01				
6/02	1	2	3	IC
6/03				
6/04				
6/05				
6/06	9			IC
6/07				
6/08				
6/09		12		IC
6/10	13			IC
6/11		15		IC
6/12				
6/13				
6/14			6	IC
6/15	21			IC
7/14				
7/15	110	111	112	CO
7/17				
7/18	119	120	121	CO
7/21				
7/22	131	132	133	CO
7/25				
7/26	143	144	145	CO
7/29				
7/30	170	171	172	CO
7/31				
8/01	173	174	175	CO
8/18				
8/19	209	210	211	CO
8/21				
8/22	218	219	220	CO
8/26				
8/27	230	231	232	CO
8/28				
8/29	233	234	235	CO

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[a] CO denotes that a commercial opening prevented test fishing; therefore pooling across days enables the variance estimation of species proportions. IC denotes that zones were pooled when there was insufficient catch in the test fishery for variance estimation.

Table 9.–Association between internal and external sex determination of Chinook salmon at the Pilot Station sonar project on the Yukon River (data collected in 2006).

		External ID		
		M	F	N
Internal ID	Male	329	138	467
	Female	80	143	223
	N	409	281	690
chisq	73.3			
df	1			
p	1.104E-17			

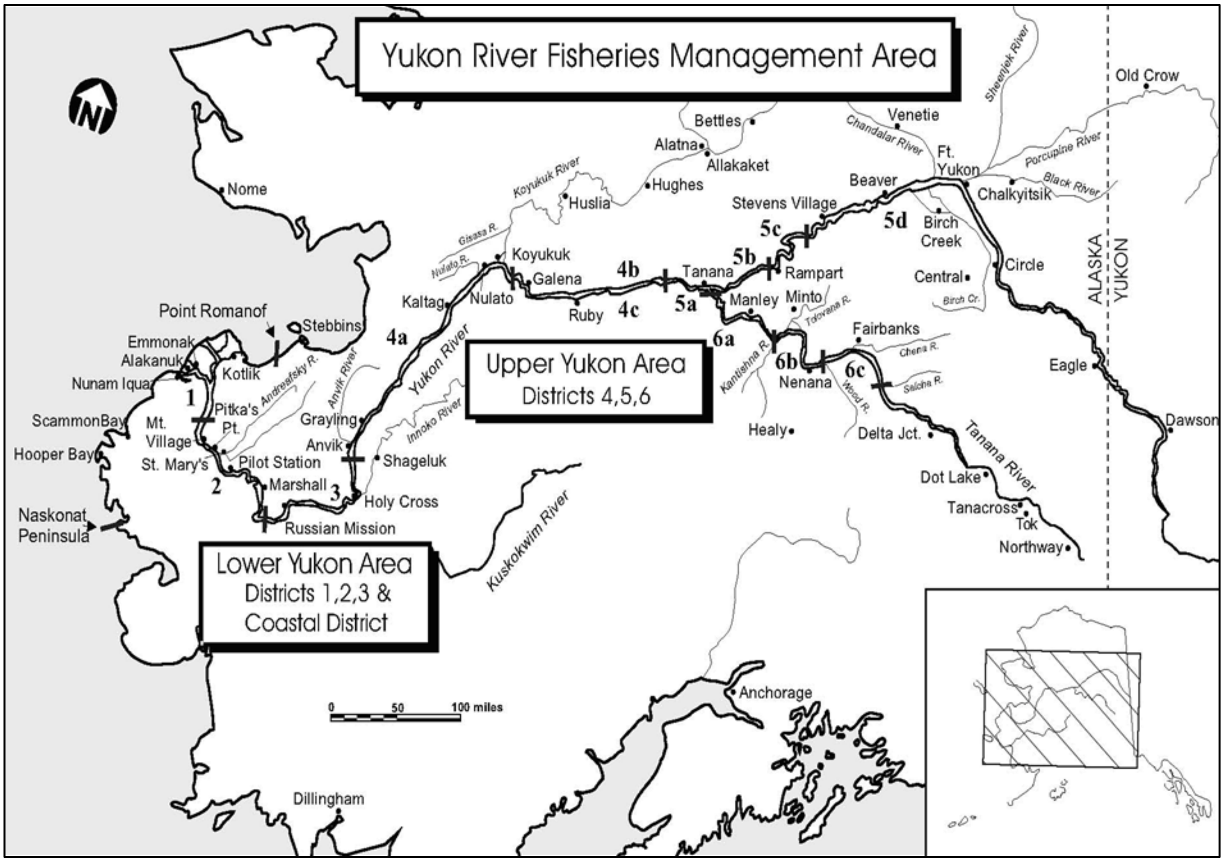


Figure 1.–Fishing districts and communities of the Yukon River watershed.

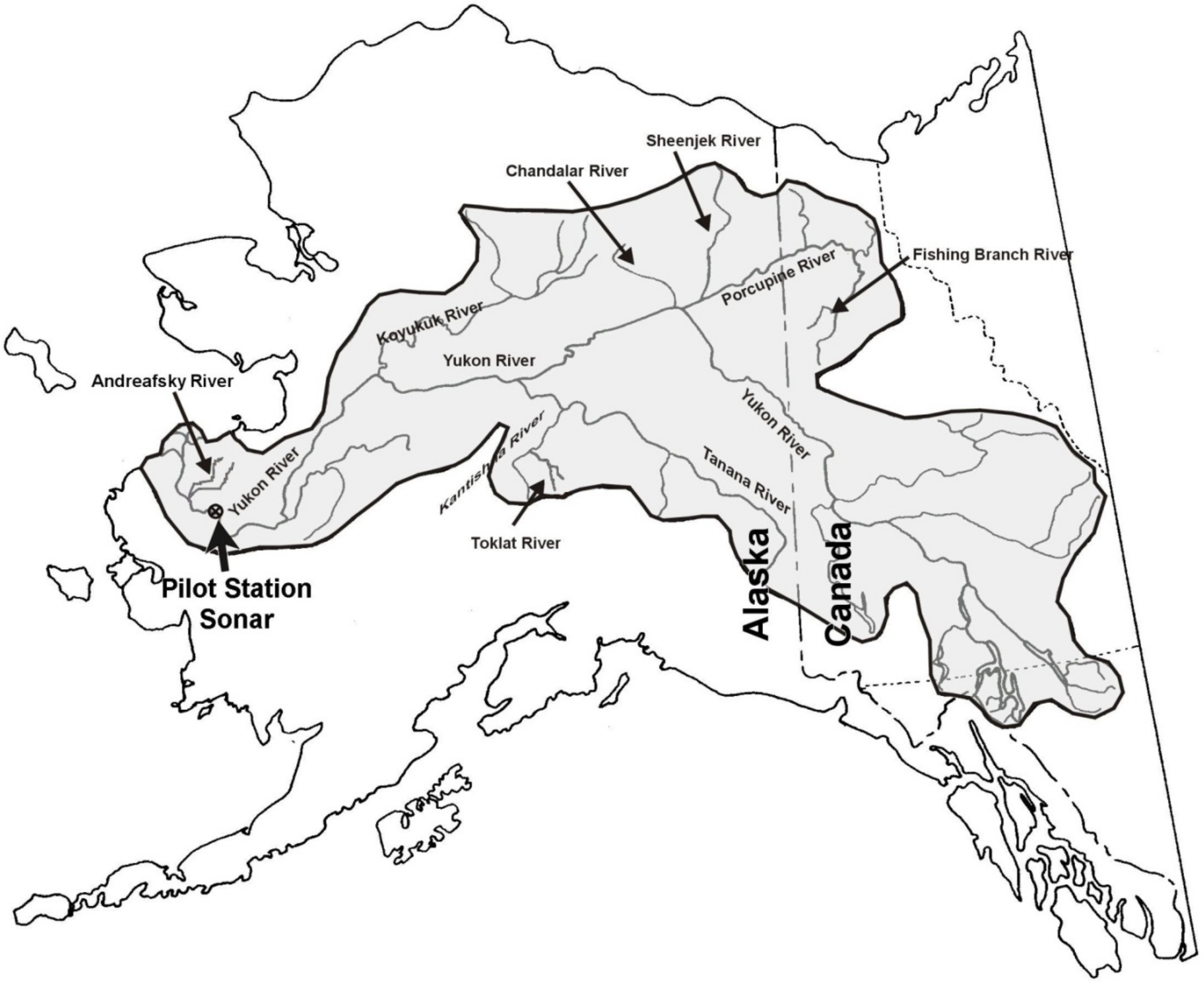


Figure 2.–Extent of Yukon River drainage.

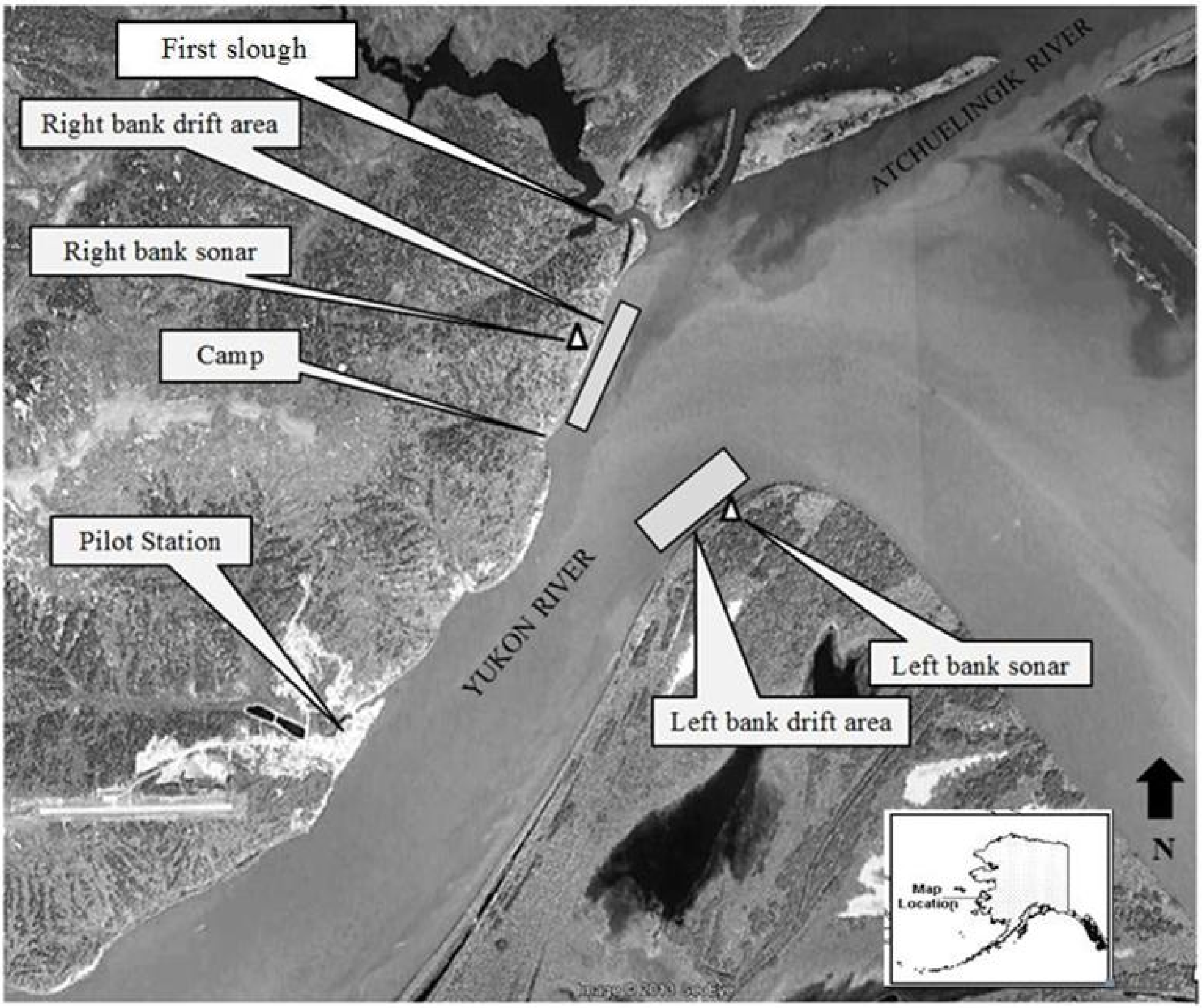
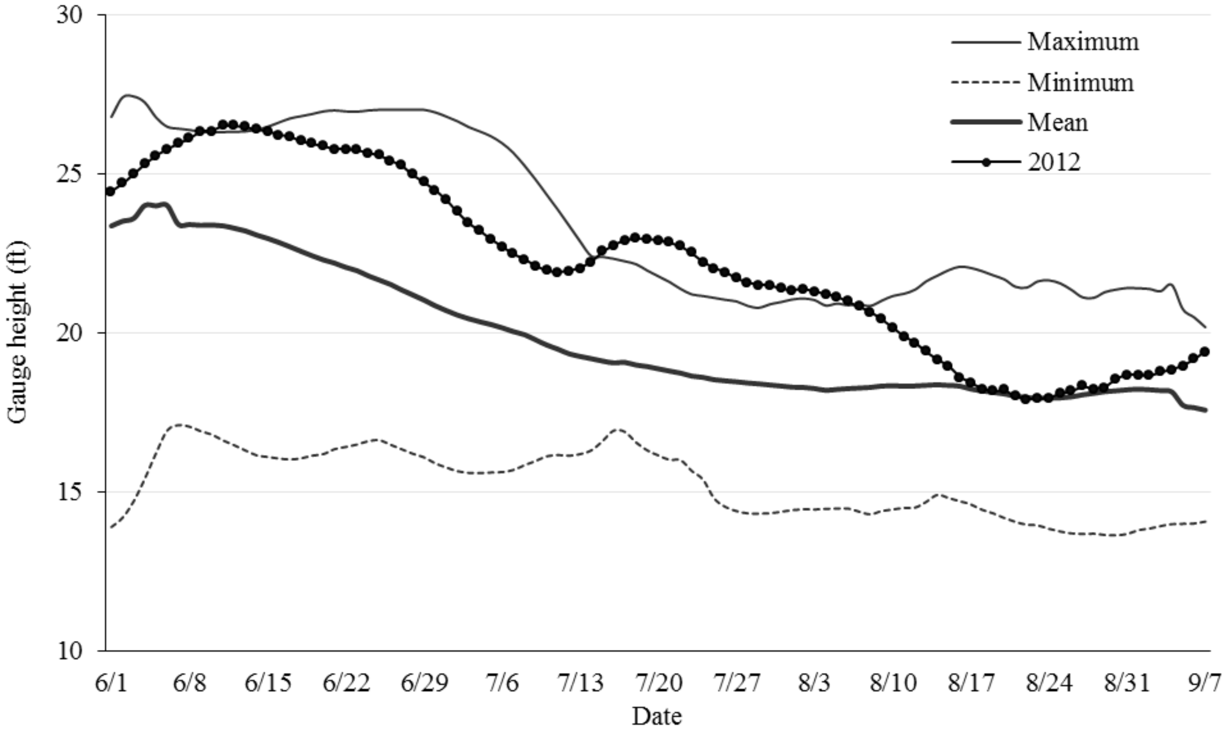


Figure 3.–Location of the Pilot Station sonar project on the Yukon River showing general transducer sites.



Source: United States Geological Service.

Note: Missing values were estimated using linear interpolation.

Figure 4.–Yukon River daily water level during the 2012 season at Pilot Station water gage compared to minimum, maximum, and mean gage height 2001 to 2011.

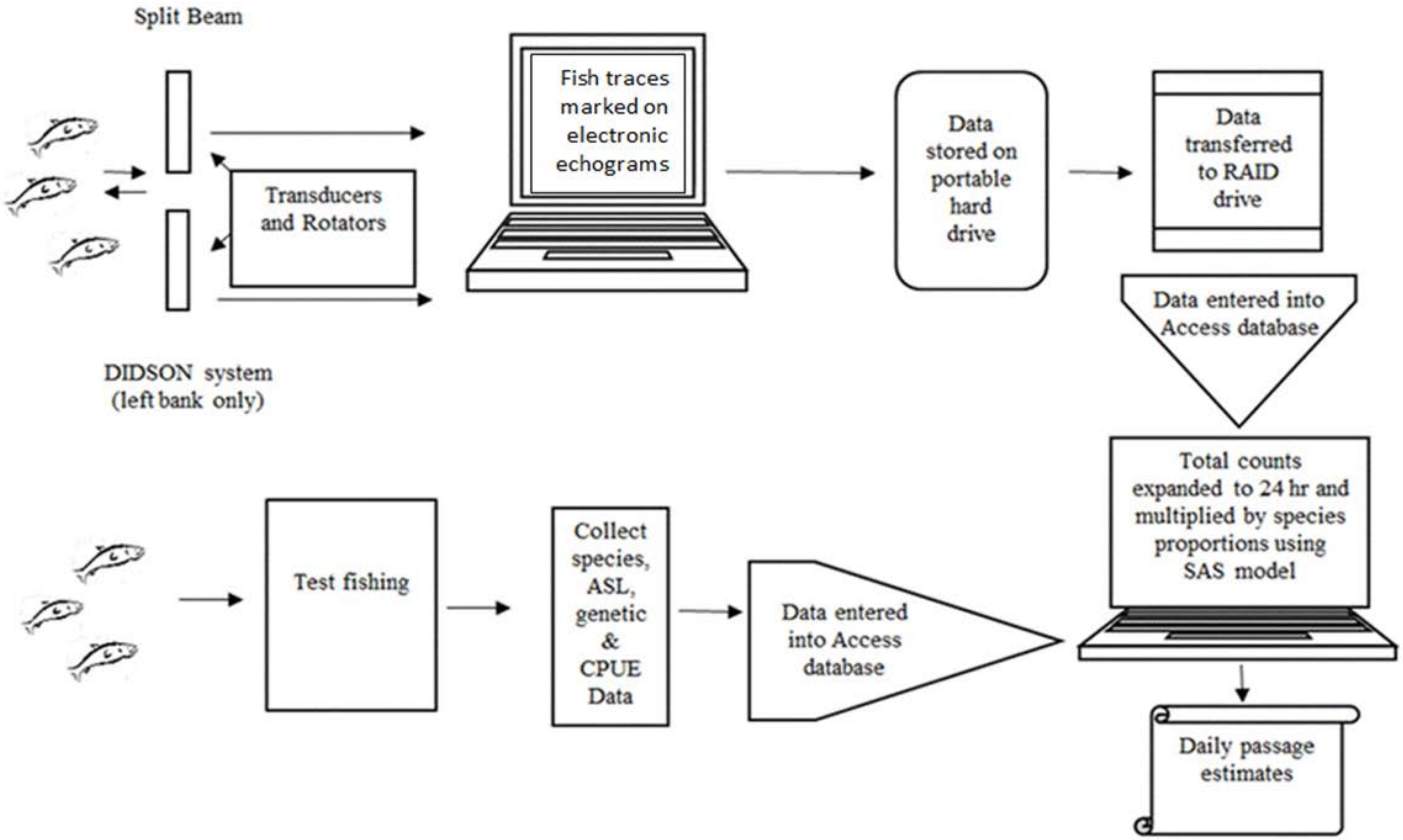


Figure 5.–Flow diagram of data collection and processing at the Pilot Station sonar project on the Yukon River, 2012.

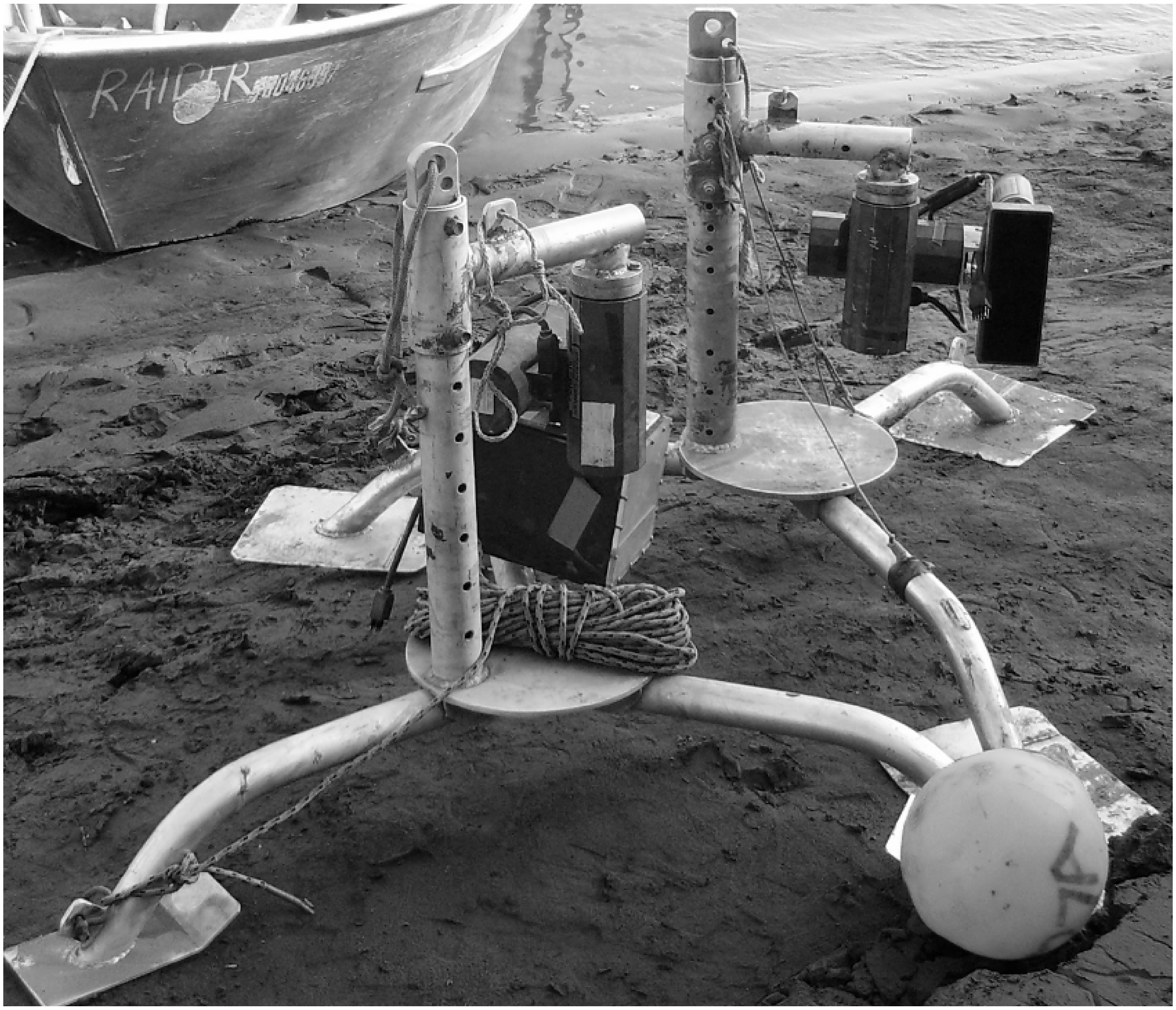


Figure 6.–DIDSON (front) and split-beam transducer mounted to pods with 662H dual axis rotators at the Pilot Station sonar project on the Yukon River.

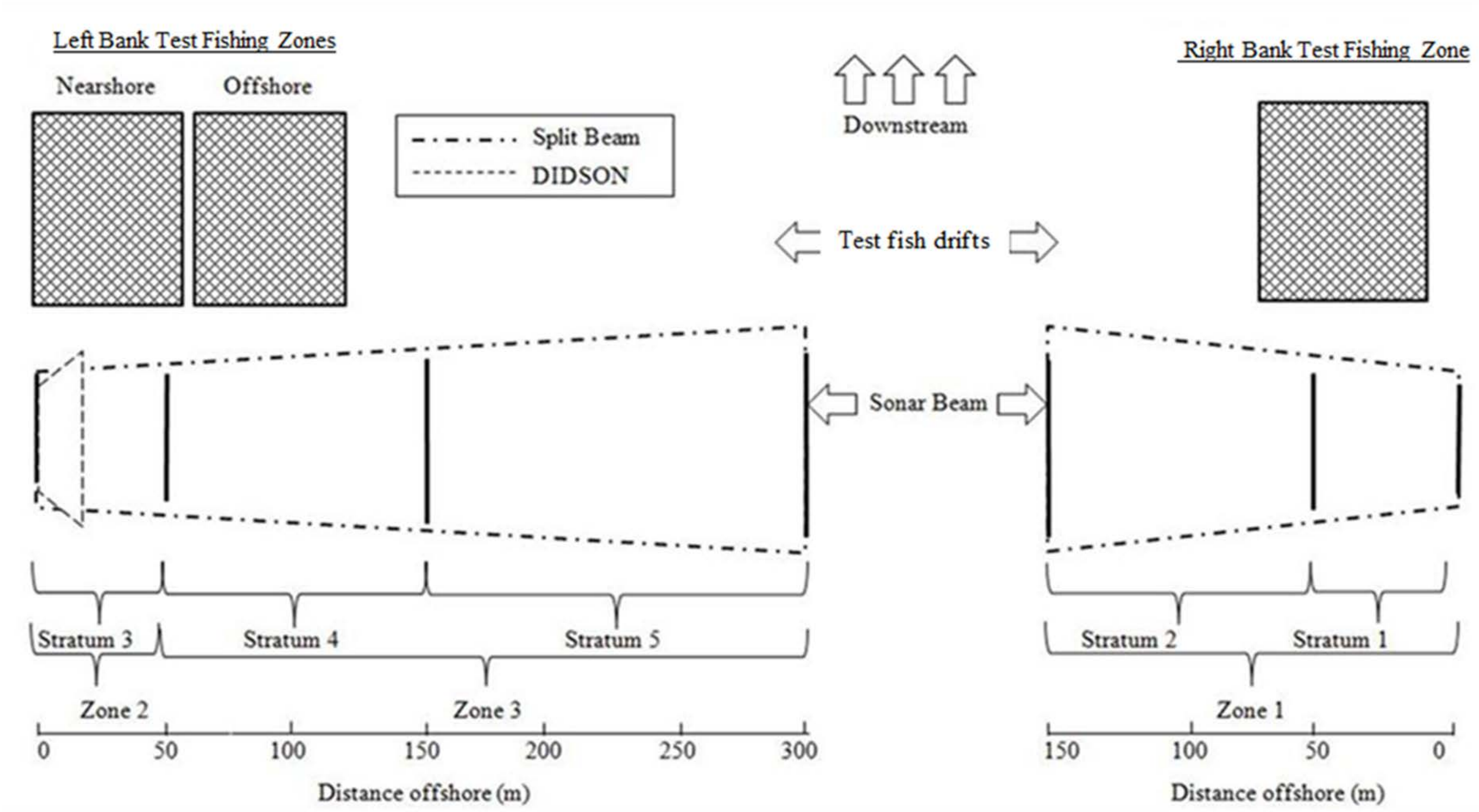
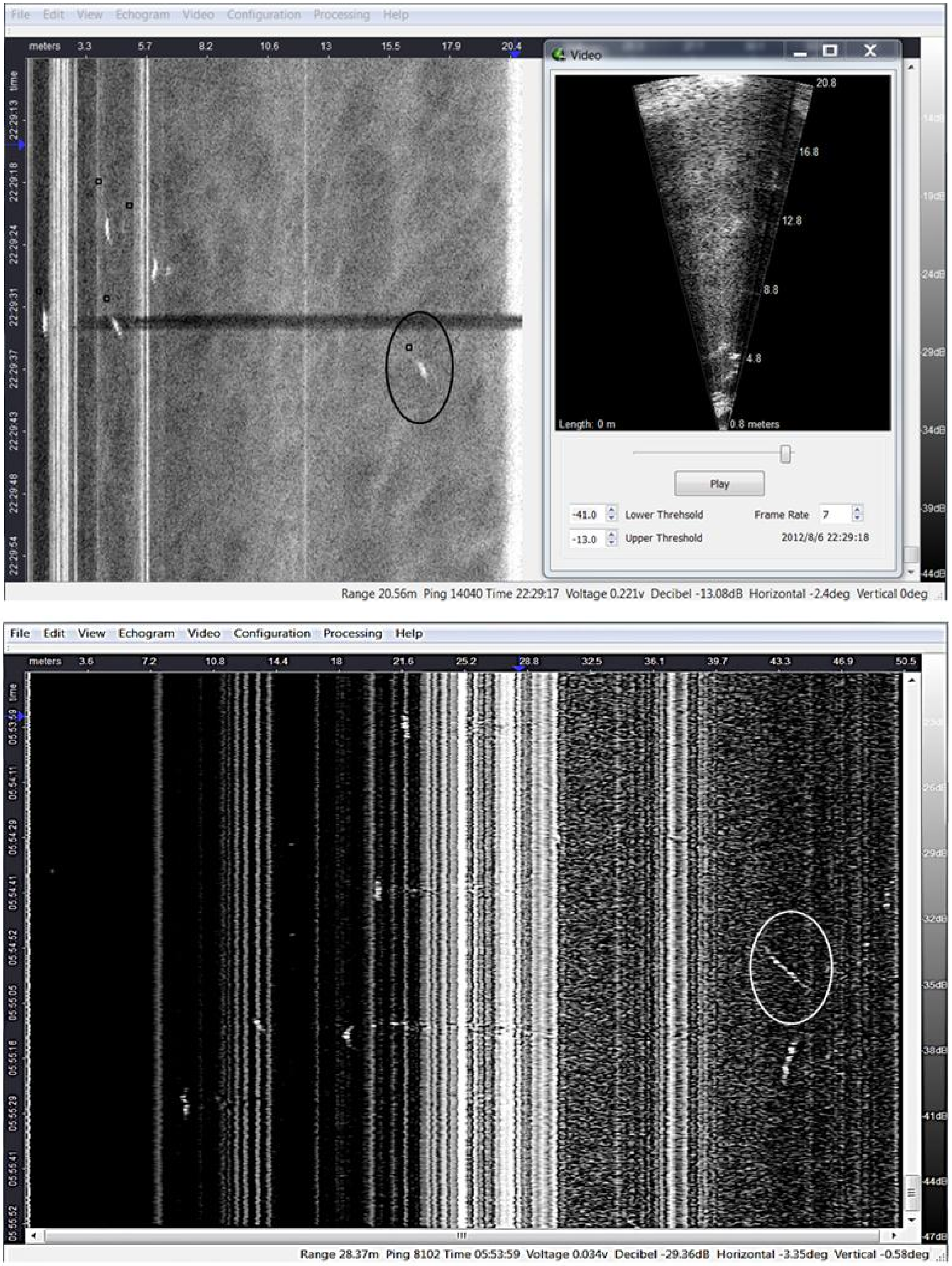


Figure 7.–Illustration of relationships between strata, sectors, zones, test fish drifts, and approximate sonar ranges (not to scale) at the Pilot Station sonar project, on the Yukon River 2012.



Length: 0 m 0.8 meters

-41.0 Lower Threhsold

-13.0 Upper Threshold

Frame Rate 7

2012/8/6 22:29:18

Range 20.56m Ping 14040 Time 22:29:17 Voltage 0.221v Decibel -13.08dB Horizontal -2.4deg Vertical 0deg

Range 28.37m Ping 8102 Time 05:53:59 Voltage 0.034v Decibel -29.36dB Horizontal -3.35deg Vertical -0.58deg

Figure 8.–Echogram of DIDSON alongside video image (top) and split-beam sonar (bottom), with oval around representative fish.

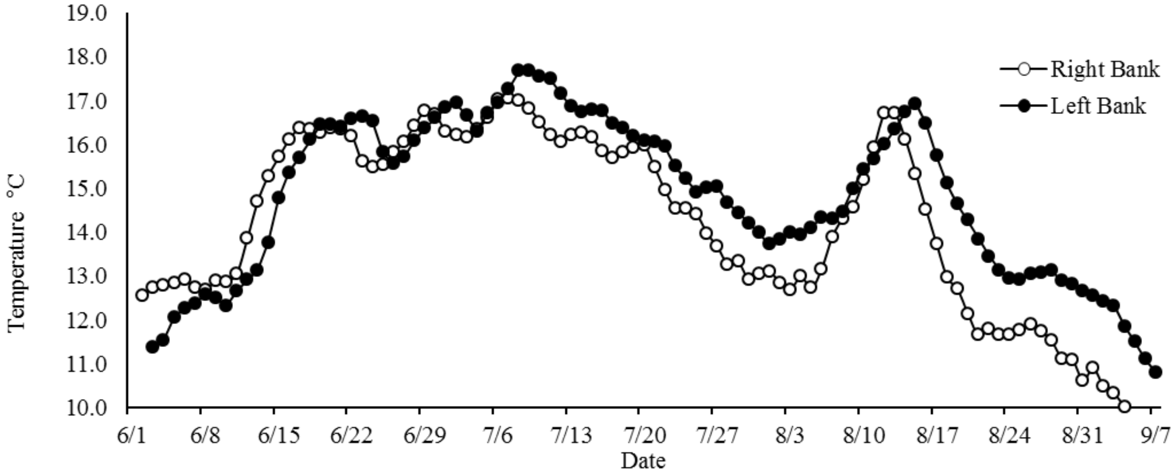


Figure 9.–Mean daily water temperatures recorded at the Pilot Station sonar project on the Yukon River with electronic data loggers by bank, 2012.

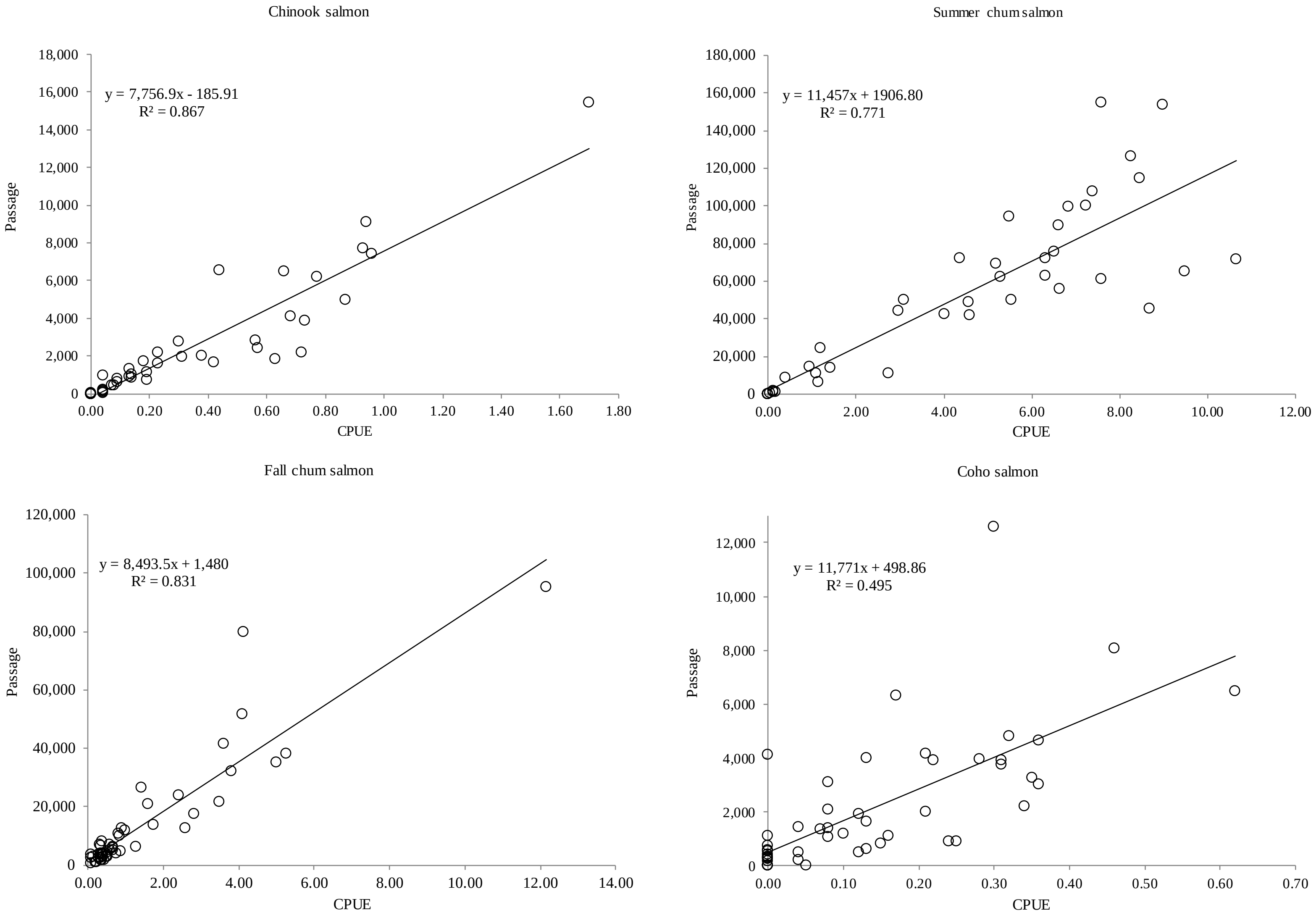


Figure 10.–Scatter plots of daily fish passage versus catch per unit of effort (CPUE) for Chinook, summer chum, fall chum, and coho salmon at the Pilot Station sonar site on the Yukon River, 2012.

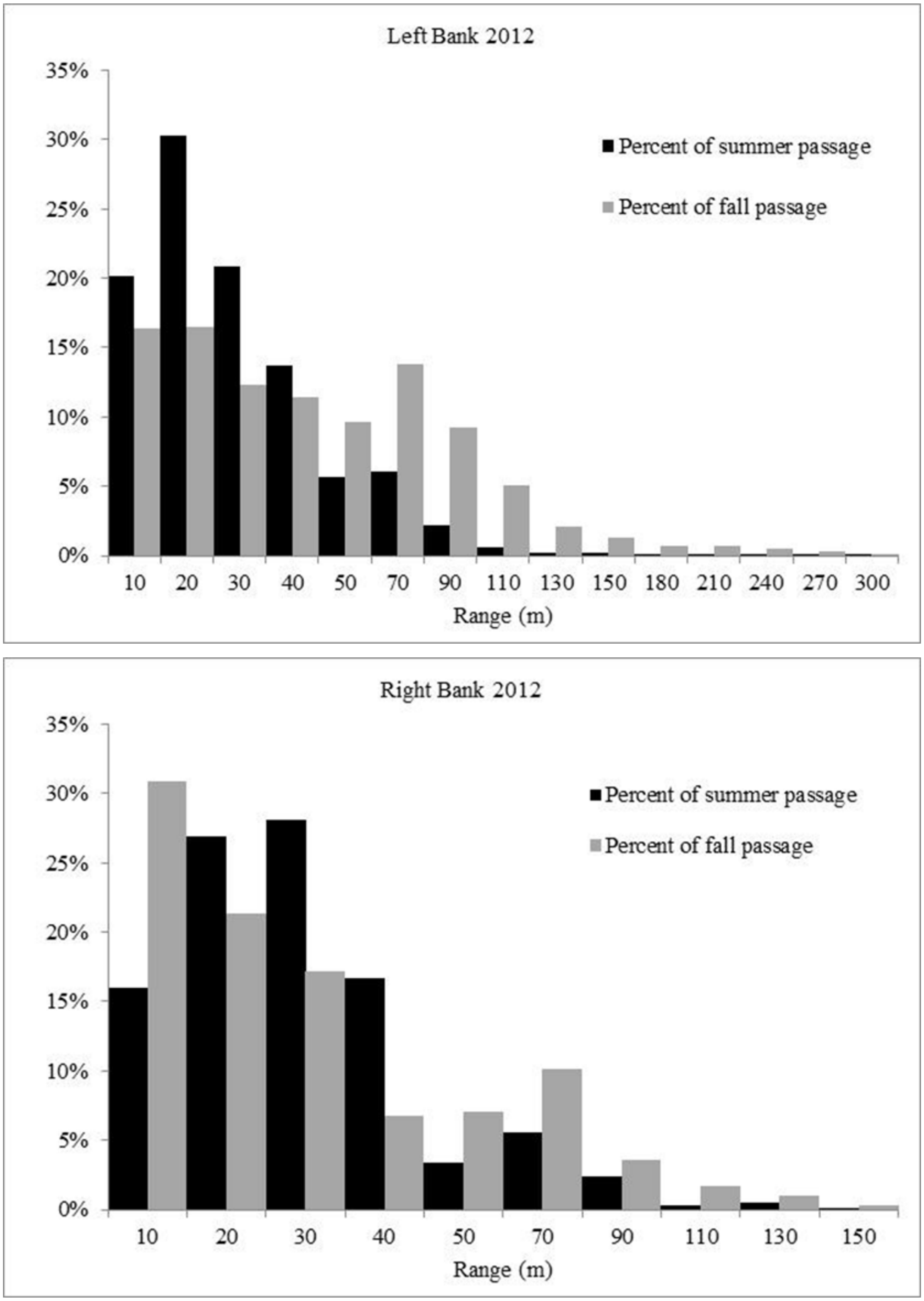


Figure 11.–Horizontal fish distribution (distance from transducer) by bank and season at the Pilot Station sonar site on the Yukon River, 2012.

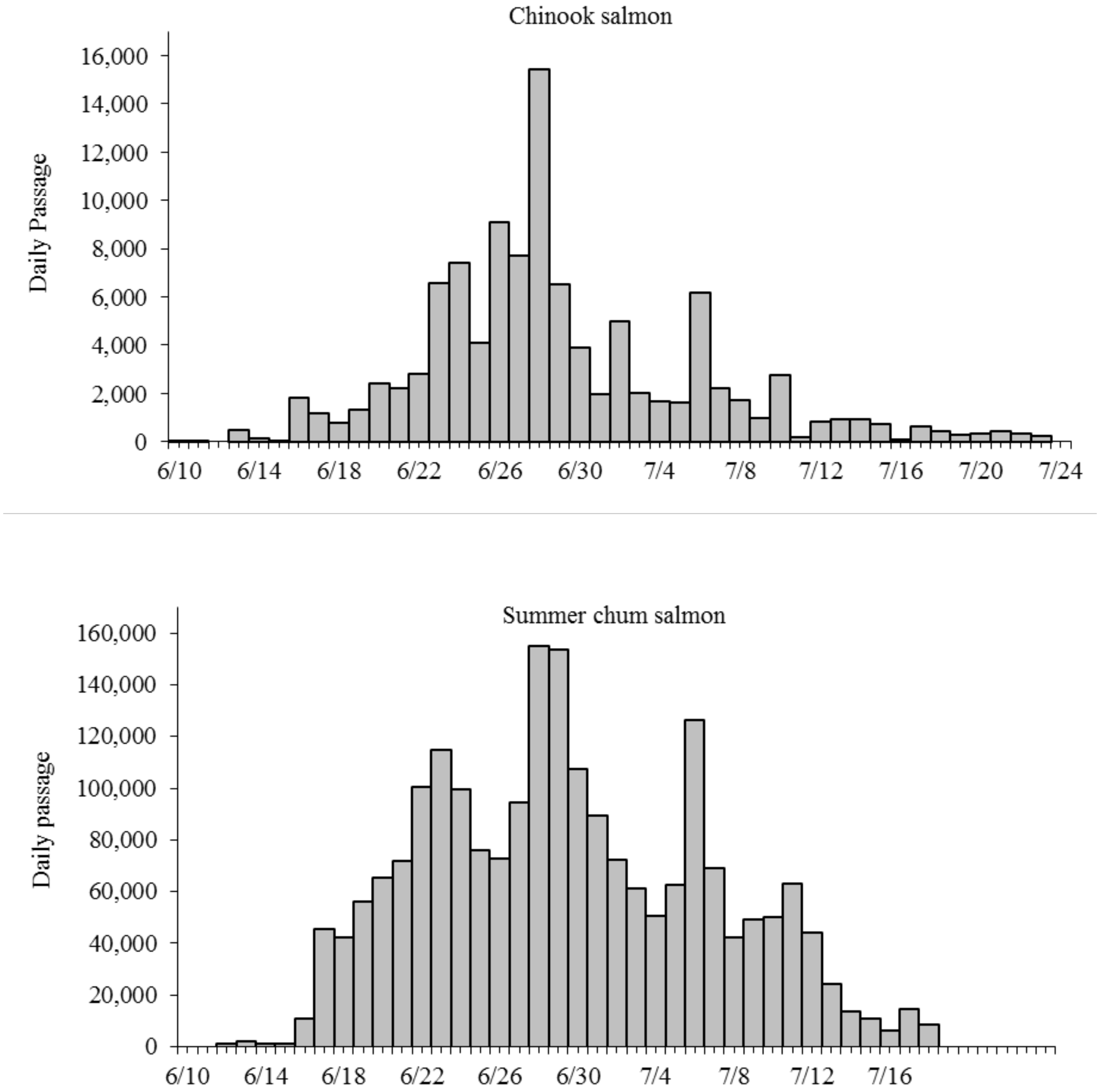


Figure 12.–Daily passage estimates for Chinook salmon (top) and summer chum salmon (bottom) at the Pilot Station sonar project on the Yukon River, 2012.

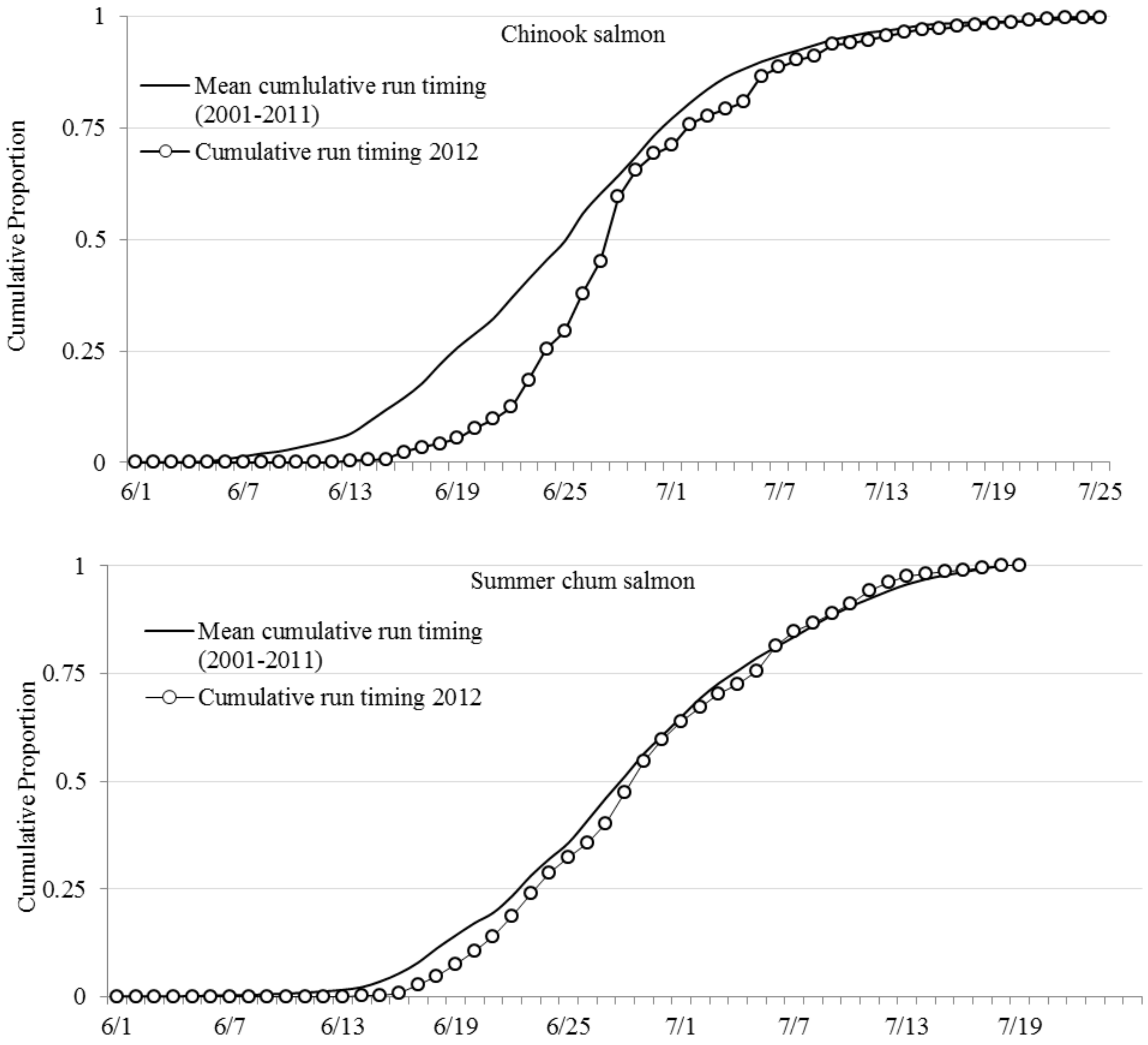


Figure 13.–2012 Daily cumulative passage timing for Chinook salmon (top) and summer chum salmon (bottom) compared to the 2001–2011 mean passage timing at the Pilot Station sonar project on the Yukon River.

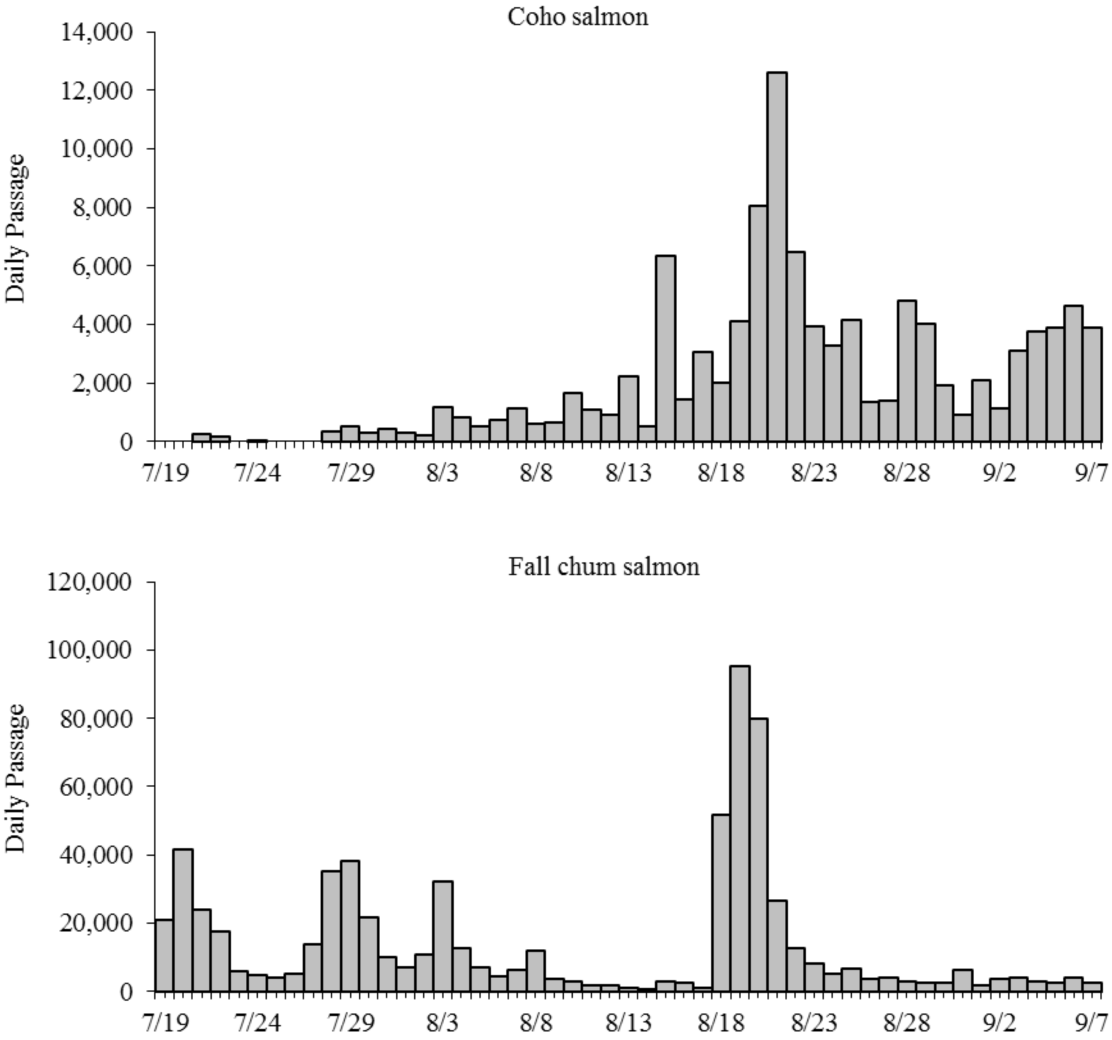


Figure 14.–Daily passage estimates for coho salmon (top) and fall chum salmon (bottom) at the Pilot Station sonar project on the Yukon River, 2012.

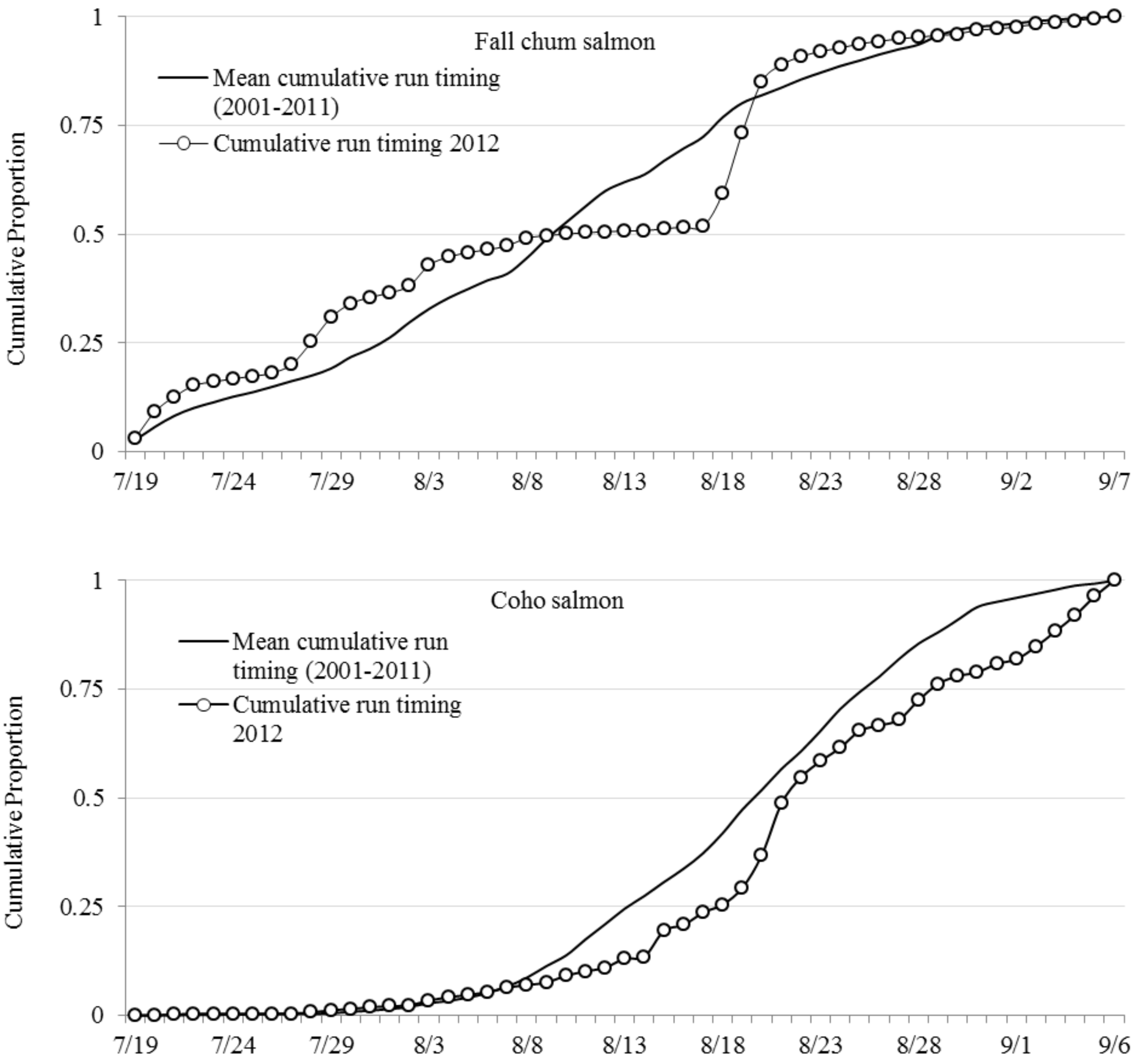
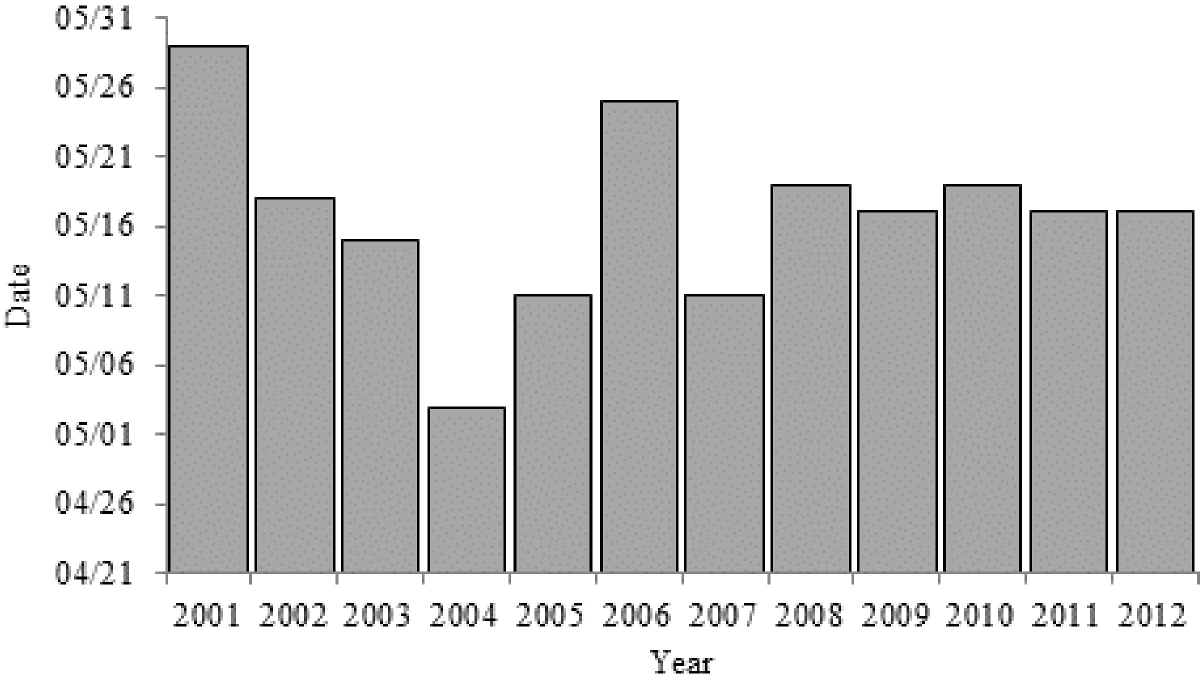


Figure 15.–2012 daily cumulative passage timing for fall chum salmon (top) and coho salmon (bottom) compared to the 2001–2011 mean passage timing at the Pilot Station sonar project, on the Yukon River.



Source: (NOAA) National Oceanic and Atmospheric Administration. http://aprfc.arh.noaa.gov/php/brkup/getbrkup.php?riverbasin=Yukon&river=Yukon+River

Figure 16.–Yukon River ice breakup dates at Pilot Station.

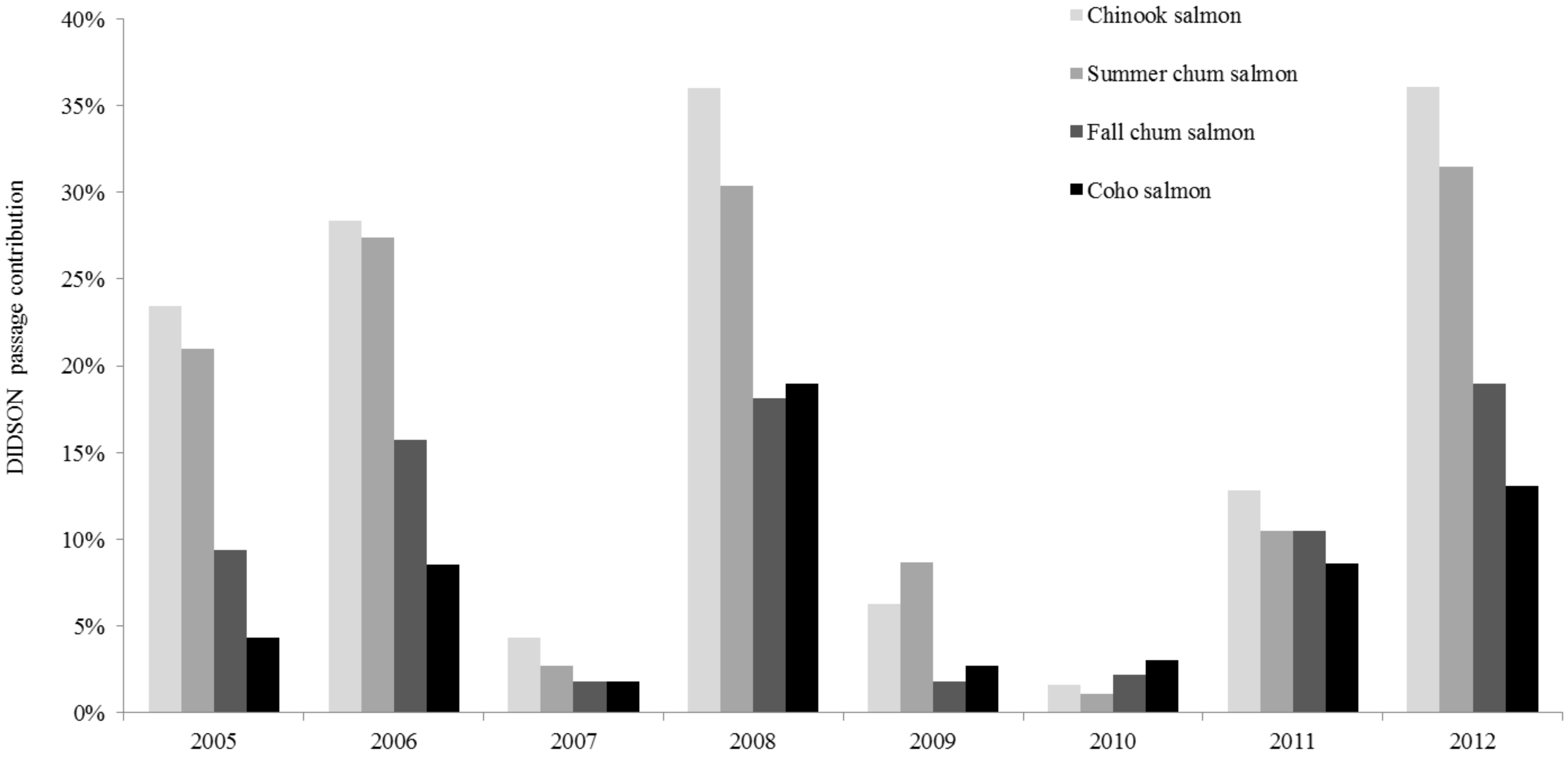


Figure 17.–Percent of additional passage contributed by the DIDSON from 2005 to 2012 at the Pilot Station sonar project on the Yukon river, relative to split beam in the same area (zone 2, sectors 1 and 2 in stratum 3).

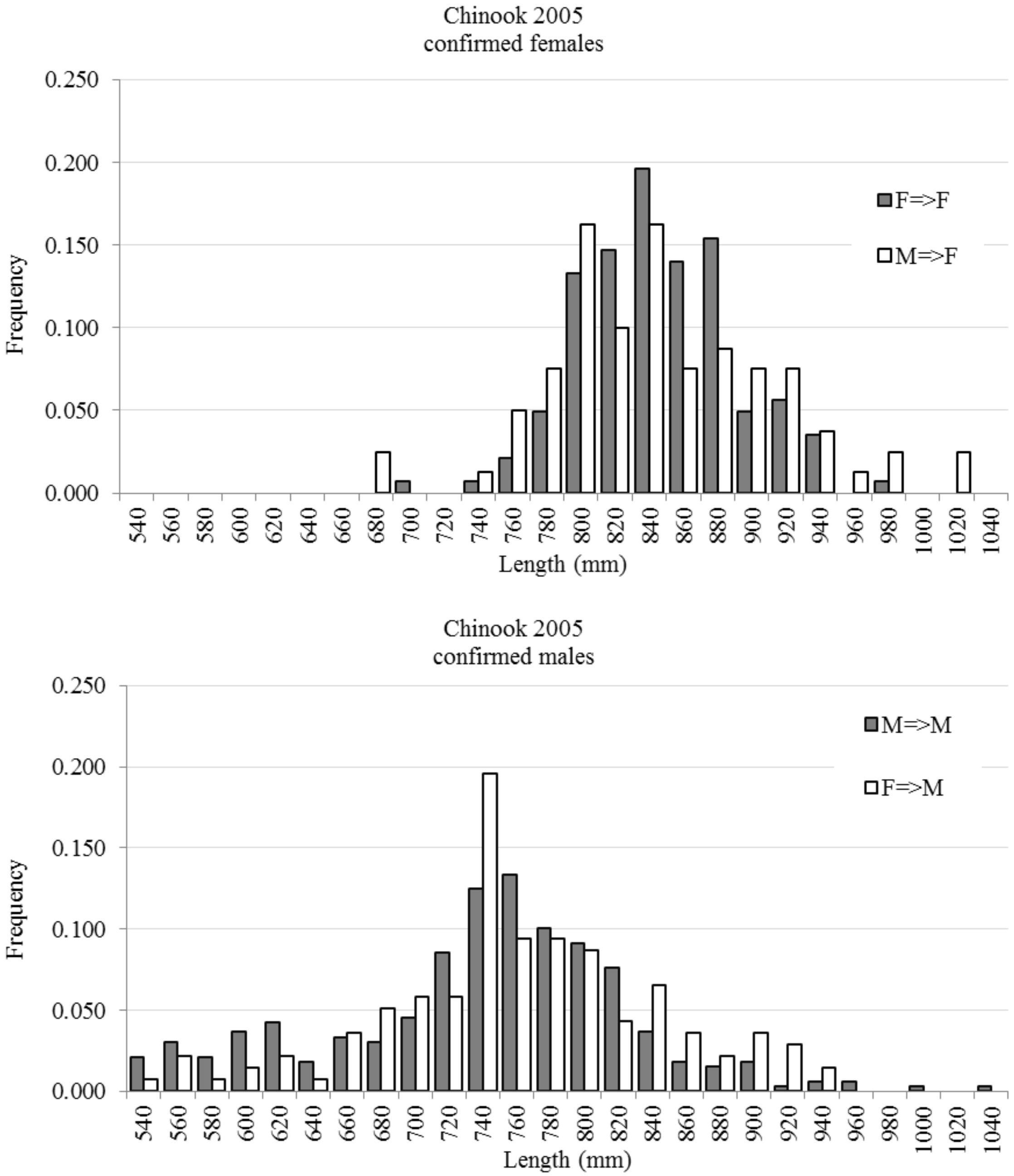


Figure 18.–Comparison of internal vs. external sex identification of Chinook salmon in 2005 at the Pilot Station sonar project on the Yukon River.

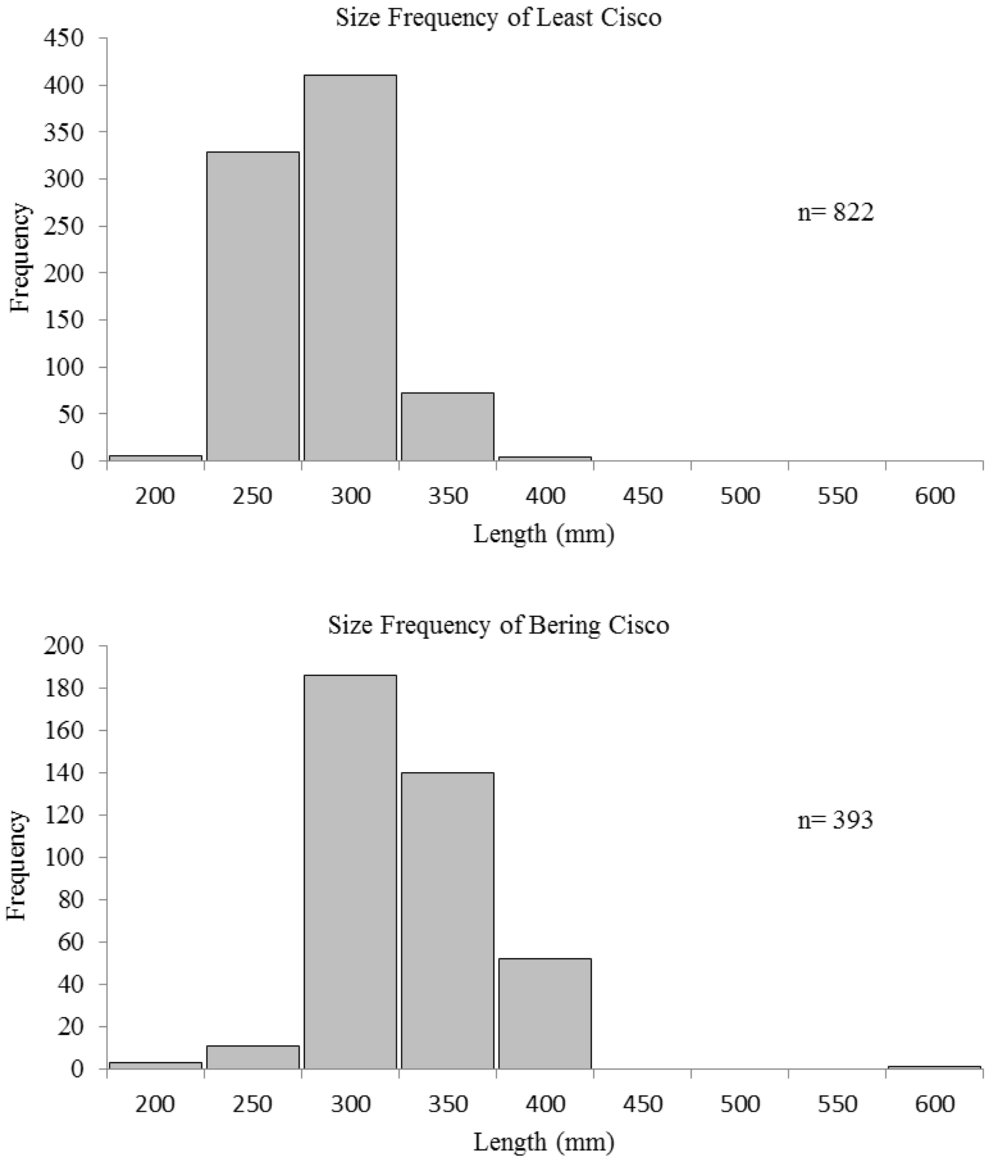


Figure 19.–Length and frequency of least cisco (top) and Bering cisco (bottom) sampled at the Pilot Station sonar project on the Yukon River, 2011 and 2012.

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, 2012.

Species	Tau	Sigma	Theta	Lambda	Tangle (w)
large Chinook [a]	1.9008	0.2050	0.5923	-0.4334	0.0239
small Chinook [b]	1.9008	0.2050	0.5923	-0.4334	0.0239
summer chum	1.9699	0.1543	0.7504	-0.4841	0.0000
fall chum	1.8632	0.2330	1.1954	-1.4361	0.0303
coho	1.9827	0.3269	0.8686	-1.4557	0.1185
pink	1.9805	0.2598	1.5542	1.2820	0.1649
broad whitefish	1.7774	0.2205	1.4018	-1.9341	0.0981
humpback whitefish	1.9021	0.2320	1.1103	-2.0546	0.0642
cisco	2.0830	0.2223	1.8771	-1.6381	0.1809
other	2.2604	0.3642	0.9881	-2.2990	0.0000

[a] Chinook salmon > 655 mm.

[b] Chinook salmon ≤ 655mm.

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

Appendix B1.–Left bank catch per unit of effort (CPUE) by day and salmon species at the Pilot Station sonar project on the Yukon River, 2012.

	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
Date	Fathom hours	Catch	CPUE	Fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
6/01	12.39	0	0.00	7.76	0	0	0	0.00	0	0.00
6/02	17.37	0	0.00	17.37	0	0	0	0.00	0	0.00
6/03	18.08	0	0.00	18.44	0	0	0	0.00	0	0.00
6/04	17.12	0	0.00	17.95	0	0	0	0.00	0	0.00
6/05	16.92	0	0.00	17.66	0	0	0	0.00	0	0.00
6/06	17.57	0	0.00	17.13	0	0	0	0.00	0	0.00
6/07	17.34	0	0.00	17.73	0	0	0	0.00	0	0.00
6/08	17.30	0	0.00	17.90	0	0	0	0.00	0	0.00
6/09	17.26	0	0.00	16.20	0	0	0	0.00	0	0.00
6/10	18.53	1	0.05	18.32	0	0	0	0.00	0	0.00
6/11	16.92	0	0.00	17.34	0	0	0	0.00	0	0.00
6/12	18.00	0	0.00	18.74	0	0	0	0.00	0	0.00
6/13	18.30	2	0.11	18.16	2	0.11	0	0.00	0	0.00
6/14	17.37	1	0.06	19.08	4	0.21	0	0.00	0	0.00
6/15	16.39	0	0.00	16.32	3	0.18	0	0.00	0	0.00
6/16	16.73	12	0.72	15.88	42	2.65	0	0.00	0	0.00
6/17	14.64	4	0.27	12.17	109	8.96	0	0.00	0	0.00
6/18	15.22	2	0.13	12.51	69	5.52	0	0.00	0	0.00
6/19	16.52	3	0.18	12.35	82	6.64	0	0.00	0	0.00
6/20	14.21	12	0.84	9.70	86	8.86	0	0.00	0	0.00
6/21	11.65	12	1.03	9.20	105	11.41	0	0.00	0	0.00
6/22	14.55	11	0.76	9.83	70	7.12	0	0.00	0	0.00
6/23	12.33	8	0.65	9.69	80	8.25	0	0.00	0	0.00
6/24	13.01	16	1.23	10.50	45	4.29	0	0.00	0	0.00
6/25	15.09	14	0.93	10.55	68	6.45	0	0.00	0	0.00
6/26	15.50	18	1.16	11.17	61	5.46	0	0.00	0	0.00
6/27	13.88	18	1.30	11.10	66	5.95	0	0.00	0	0.00
6/28	12.82	27	2.11	9.83	79	8.04	0	0.00	0	0.00
6/29	13.55	7	0.52	10.97	71	6.47	0	0.00	0	0.00
6/30	14.00	14	1.00	9.88	80	8.10	0	0.00	0	0.00
7/01	15.88	4	0.25	11.49	81	7.05	0	0.00	0	0.00
7/02	13.90	18	1.30	10.03	67	6.68	0	0.00	0	0.00
7/03	15.38	8	0.52	9.71	71	7.31	0	0.00	0	0.00
7/04	16.60	7	0.42	10.66	57	5.35	0	0.00	0	0.00
7/05	14.27	5	0.35	12.70	73	5.75	0	0.00	0	0.00

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Appendix B1.–Page 2 of 3.

	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
Date	Fathom hours	Catch	CPUE	Fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
7/06	14.09	13	0.92	8.18	88	10.76	0	0.00	0	0.00
7/07	14.81	3	0.20	10.29	58	5.64	0	0.00	0	0.00
7/08	15.87	4	0.25	13.28	57	4.29	0	0.00	0	0.00
7/09	14.66	1	0.07	12.84	69	5.37	0	0.00	0	0.00
7/10	16.32	6	0.37	14.38	45	3.13	0	0.00	0	0.00
7/11	16.06	1	0.06	11.06	67	6.06	0	0.00	0	0.00
7/12	14.89	3	0.20	13.36	43	3.22	0	0.00	0	0.00
7/13	15.78	1	0.06	16.80	20	1.19	0	0.00	0	0.00
7/14	16.38	0	0.00	15.38	18	1.17	0	0.00	0	0.00
7/15	10.85	3	0.28	9.97	13	1.30	0	0.00	0	0.00
7/16	15.90	0	0.00	16.00	16	1.00	0	0.00	0	0.00
7/17	16.20	0	0.00	15.87	16	1.01	0	0.00	0	0.00
7/18	9.96	1	0.10	4.81	3	0.62	0	0.00	0	0.00
7/19	5.15	0	0.00	14.52	0	0.00	29	2.00	0	0.00
7/20	5.45	0	0.00	13.12	0	0.00	55	4.19	0	0.00
7/21	4.96	1	0.20	11.58	0	0.00	28	2.42	0	0.00
7/22	4.47	0	0.00	7.95	0	0.00	16	2.01	0	0.00
7/23	5.83	0	0.00	16.54	0	0.00	12	0.73	0	0.00
7/24	6.09	0	0.00	14.23	0	0.00	14	0.98	0	0.00
7/25	4.76	0	0.00	9.67	0	0.00	10	1.03	0	0.00
7/26	4.83	0	0.00	15.42	0	0.00	10	0.65	0	0.00
7/27	5.33	0	0.00	14.92	0	0.00	20	1.34	0	0.00
7/28	4.77	0	0.00	12.59	0	0.00	46	3.65	0	0.00
7/29	4.67	0	0.00	12.16	0	0.00	59	4.85	0	0.00
7/30	4.49	0	0.00	8.38	0	0.00	37	4.41	0	0.00
7/31	11.51	0	0.00	11.11	0	0.00	13	1.17	0	0.00
8/01	5.26	0	0.00	11.09	0	0.00	8	0.72	0	0.00
8/02	5.34	0	0.00	15.25	0	0.00	15	0.98	0	0.00
8/03	4.95	0	0.00	12.89	0	0.00	52	4.04	1	0.08
8/04	5.27	0	0.00	8.33	0	0.00	26	3.12	1	0.12
8/05	6.30	0	0.00	18.12	0	0.00	6	0.33	2	0.11
8/06	5.55	0	0.00	16.39	0	0.00	9	0.55	0	0.00
8/07	4.99	0	0.00	4.40	0	0.00	6	1.36	0	0.00
8/08	5.16	0	0.00	16.53	0	0.00	23	1.39	0	0.00

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Appendix B1.–Page 3 of 3.

	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
Date	Fathom hours	Catch	CPUE	Fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
8/09	5.65	0	0.00	16.40	0	0.00	7	0.43	2	0.12
8/10	5.56	0	0.00	15.84	0	0.00	9	0.57	0	0.00
8/11	5.33	0	0.00	18.90	0	0.00	6	0.32	1	0.05
8/12	5.63	0	0.00	16.07	0	0.00	4	0.25	2	0.12
8/13	5.32	0	0.00	16.07	0	0.00	4	0.25	3	0.19
8/14	5.41	0	0.00	16.10	0	0.00	1	0.06	0	0.00
8/15	5.72	0	0.00	16.03	0	0.00	3	0.19	3	0.19
8/16	5.03	0	0.00	16.39	0	0.00	6	0.37	1	0.06
8/17	5.05	0	0.00	16.55	0	0.00	5	0.30	7	0.42
8/18	4.82	0	0.00	12.88	0	0.00	56	4.35	4	0.31
8/19	3.67	0	0.00	3.31	0	0.00	43	12.99	0	0.00
8/20	5.48	0	0.00	10.58	0	0.00	64	6.05	5	0.47
8/21	4.22	0	0.00	15.54	0	0.00	21	1.35	1	0.06
8/22	5.08	0	0.00	9.71	0	0.00	12	1.24	5	0.52
8/23	5.21	0	0.00	16.48	0	0.00	8	0.49	3	0.18
8/24	6.08	0	0.00	15.70	0	0.00	12	0.76	4	0.25
8/25	5.23	0	0.00	16.35	0	0.00	6	0.37	3	0.18
8/26	4.53	0	0.00	9.56	0	0.00	1	0.10	1	0.10
8/27	5.38	0	0.00	15.77	0	0.00	6	0.38	1	0.06
8/28	4.74	0	0.00	16.86	0	0.00	9	0.53	7	0.42
8/29	4.94	0	0.00	10.45	0	0.00	1	0.10	2	0.19
8/30	5.01	0	0.00	16.51	0	0.00	6	0.36	3	0.18
8/31	5.72	0	0.00	16.34	0	0.00	8	0.49	1	0.06
9/01	5.51	0	0.00	15.76	0	0.00	5	0.32	1	0.06
9/02	5.55	0	0.00	17.34	0	0.00	8	0.46	0	0.00
9/03	4.99	0	0.00	16.44	0	0.00	3	0.18	1	0.06
9/04	5.35	0	0.00	15.62	0	0.00	7	0.45	7	0.45
9/05	6.21	0	0.00	15.71	0	0.00	6	0.38	7	0.45
9/06	4.63	0	0.00	15.24	0	0.00	7	0.46	6	0.39
9/07	6.01	0	0.00	15.02	0	0.00	1	0.07	3	0.20
Total	1,010.55		261	1,348.95		1,984		829		88

Appendix B2.–Right bank by day and salmon species at the Pilot Station sonar project on the Yukon River, 2012.

	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
Date	Fathom hours	Catch	CPUE	Fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
6/01	5.88	0	0.00	2.02	0	0.00	0	0.00	0	0.00
6/02	8.57	0	0.00	8.53	0	0.00	0	0.00	0	0.00
6/03	9.05	0	0.00	8.37	0	0.00	0	0.00	0	0.00
6/04	8.92	0	0.00	8.9	0	0.00	0	0.00	0	0.00
6/05	7.42	0	0.00	8.01	0	0.00	0	0.00	0	0.00
6/06	7.99	0	0.00	8.44	0	0.00	0	0.00	0	0.00
6/07	7.68	0	0.00	8.13	0	0.00	0	0.00	0	0.00
6/08	7.76	0	0.00	8.18	0	0.00	0	0.00	0	0.00
6/09	7.76	0	0.00	7.33	0	0.00	0	0.00	0	0.00
6/10	8.21	0	0.00	7.44	0	0.00	0	0.00	0	0.00
6/11	8.24	0	0.00	8.60	0	0.00	0	0.00	0	0.00
6/12	7.90	0	0.00	8.88	1	0.11	0	0.00	0	0.00
6/13	8.09	0	0.00	8.32	1	0.12	0	0.00	0	0.00
6/14	8.21	0	0.00	8.23	1	0.12	0	0.00	0	0.00
6/15	7.63	0	0.00	7.30	0	0.00	0	0.00	0	0.00
6/16	8.86	4	0.45	9.69	28	2.89	0	0.00	0	0.00
6/17	6.13	0	0.00	3.73	29	7.78	0	0.00	0	0.00
6/18	7.31	0	0.00	6.65	19	2.86	0	0.00	0	0.00
6/19	6.00	0	0.00	5.73	38	6.63	0	0.00	0	0.00
6/20	6.83	0	0.00	3.38	38	11.25	0	0.00	0	0.00
6/21	6.43	1	0.16	3.09	26	8.41	0	0.00	0	0.00
6/22	6.89	1	0.15	4.56	34	7.46	0	0.00	0	0.00
6/23	5.85	0	0.00	3.20	29	9.05	0	0.00	0	0.00
6/24	5.76	2	0.35	4.58	58	12.65	0	0.00	0	0.00
6/25	6.85	1	0.15	4.49	30	6.69	0	0.00	0	0.00
6/26	6.82	3	0.44	5.11	10	1.96	0	0.00	0	0.00
6/27	6.46	1	0.15	5.51	25	4.54	0	0.00	0	0.00
6/28	6.00	5	0.83	4.30	28	6.51	0	0.00	0	0.00
6/29	6.21	6	0.97	3.84	62	16.14	0	0.00	0	0.00
6/30	6.44	1	0.16	4.61	27	5.86	0	0.00	0	0.00
7/01	6.61	3	0.45	4.25	23	5.41	0	0.00	0	0.00
7/02	6.87	0	0.00	5.35	30	5.61	0	0.00	0	0.00
7/03	5.87	0	0.00	4.02	33	8.21	0	0.00	0	0.00
7/04	6.95	3	0.43	5.99	35	5.84	0	0.00	0	0.00
7/05	7.07	0	0.00	4.32	17	3.94	0	0.00	0	0.00

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Appendix B2.–Page 2 of 3.

	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
Date	Fathom hours	Catch	CPUE	Fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
7/06	6.59	3	0.46	5.01	21	4.19	0	0.00	0	0.00
7/07	7.07	2	0.28	5.32	23	4.32	0	0.00	0	0.00
7/08	6.75	0	0.00	4.88	16	3.28	0	0.00	0	0.00
7/09	6.86	2	0.29	6.04	17	2.82	0	0.00	0	0.00
7/10	6.91	1	0.14	5.99	18	3.01	0	0.00	0	0.00
7/11	7.23	0	0.00	5.42	37	6.83	0	0.00	0	0.00
7/12	6.90	0	0.00	6.15	15	2.44	0	0.00	0	0.00
7/13	7.06	0	0.00	6.73	8	1.19	0	0.00	0	0.00
7/14	6.80	3	0.44	7.18	14	1.95	0	0.00	0	0.00
7/15	4.72	0	0.00	4.74	3	0.63	0	0.00	0	0.00
7/16	7.17	1	0.14	7.42	11	1.48	0	0.00	0	0.00
7/17	7.02	2	0.28	7.57	6	0.79	0	0.00	0	0.00
7/18	4.66	0	0.00	2.60	0	0.00	0	0.00	0	0.00
7/19	2.57	0	0.00	7.36	0	0.00	6	0.81	0	0.00
7/20	2.55	1	0.39	4.90	0	0.00	10	2.04	0	0.00
7/21	2.17	0	0.00	7.12	0	0.00	17	2.39	0	0.00
7/22	1.91	0	0.00	4.82	0	0.00	20	4.15	0	0.00
7/23	2.48	0	0.00	7.60	0	0.00	4	0.53	0	0.00
7/24	2.34	0	0.00	6.71	0	0.00	4	0.60	1	0.15
7/25	2.43	0	0.00	5.15	0	0.00	1	0.19	0	0.00
7/26	2.43	0	0.00	7.68	0	0.00	5	0.65	0	0.00
7/27	2.74	1	0.36	7.34	0	0.00	19	2.59	0	0.00
7/28	2.76	0	0.00	5.43	0	0.00	44	8.10	0	0.00
7/29	2.52	1	0.40	5.92	0	0.00	36	6.08	0	0.00
7/30	2.28	0	0.00	4.79	0	0.00	9	1.88	0	0.00
7/31	5.17	0	0.00	4.49	0	0.00	0	0.00	0	0.00
8/01	2.70	0	0.00	4.60	0	0.00	1	0.22	0	0.00
8/02	2.67	0	0.00	7.93	0	0.00	4	0.50	1	0.13
8/03	2.59	0	0.00	6.58	0	0.00	22	3.35	1	0.15
8/04	2.17	0	0.00	4.91	0	0.00	8	1.63	1	0.20
8/05	3.42	0	0.00	7.22	0	0.00	2	0.28	1	0.14
8/06	2.75	0	0.00	7.35	0	0.00	3	0.41	0	0.00
8/07	2.44	0	0.00	1.90	0	0.00	2	1.05	0	0.00
8/08	2.71	0	0.00	7.62	0	0.00	1	0.13	0	0.00

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Appendix B2.–Page 3 of 3.

	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
Date	Fathom hours	Catch	CPUE	Fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
8/09	2.34	0	0.00	7.41	0	0.00	0	0.00	1	0.14
8/10	2.30	0	0.00	7.79	0	0.00	3	0.39	3	0.39
8/11	2.94	0	0.00	7.52	0	0.00	5	0.67	1	0.13
8/12	2.68	0	0.00	8.37	0	0.00	5	0.60	4	0.48
8/13	2.58	0	0.00	7.80	0	0.00	1	0.13	5	0.64
8/14	2.66	0	0.00	7.41	0	0.00	1	0.13	1	0.13
8/15	2.97	0	0.00	7.70	0	0.00	0	0.00	1	0.13
8/16	2.80	0	0.00	7.08	0	0.00	2	0.28	0	0.00
8/17	2.35	0	0.00	8.16	0	0.00	0	0.00	2	0.25
8/18	2.57	0	0.00	6.17	0	0.00	22	3.56	0	0.00
8/19	2.21	0	0.00	2.03	0	0.00	22	10.81	0	0.00
8/20	2.81	0	0.00	6.85	0	0.00	8	1.17	3	0.44
8/21	2.45	0	0.00	7.47	0	0.00	12	1.61	6	0.80
8/22	2.57	0	0.00	4.88	0	0.00	1	0.20	4	0.82
8/23	2.28	0	0.00	8.36	0	0.00	1	0.12	4	0.48
8/24	2.66	0	0.00	7.36	0	0.00	1	0.14	4	0.54
8/25	2.75	0	0.00	7.82	0	0.00	2	0.26	2	0.26
8/26	2.64	0	0.00	4.80	0	0.00	0	0.00	0	0.00
8/27	2.28	0	0.00	8.04	0	0.00	2	0.25	1	0.12
8/28	2.34	0	0.00	7.78	0	0.00	3	0.39	1	0.13
8/29	1.95	0	0.00	4.72	0	0.00	0	0.00	0	0.00
8/30	2.76	0	0.00	7.82	0	0.00	1	0.13	0	0.00
8/31	2.62	0	0.00	8.39	0	0.00	8	0.95	5	0.60
9/01	2.28	0	0.00	8.18	0	0.00	3	0.37	1	0.12
9/02	2.75	0	0.00	7.38	0	0.00	2	0.27	4	0.54
9/03	2.43	0	0.00	7.31	0	0.00	6	0.82	1	0.14
9/04	2.47	0	0.00	7.09	0	0.00	2	0.28	0	0.00
9/05	2.89	0	0.00	7.01	0	0.00	2	0.29	0	0.00
9/06	2.30	0	0.00	6.85	0	0.00	2	0.29	2	0.29
9/07	2.80	0	0.00	7.40	0	0.00	5	0.68	2	0.27
Total	469.49		48	628.5		811		340		63

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, 2012.

	Right Bank	Left Bank		Total		Percent by Bank	
Date		Nearshore	Offshore	Passage	SE	Right	Left
6/01	3,358	1,671	267	5,296	706	63.41	36.59
6/02	2,221	1,836	122	4,179	607	53.15	46.85
6/03	2,118	1,532	270	3,920	1,186	54.03	45.97
6/04	1,668	1,253	192	3,113	332	53.58	46.42
6/05	1,708	1,696	231	3,635	209	46.99	53.01
6/06	1,851	1,181	354	3,386	291	54.67	45.33
6/07	1,609	897	169	2,675	254	60.15	39.85
6/08	1,100	745	238	2,083	217	52.81	47.19
6/09	1,134	1,065	162	2,361	237	48.03	51.97
6/10	1,426	672	115	2,213	1,026	64.44	35.56
6/11	1,333	964	358	2,655	1,220	50.21	49.79
6/12	1,447	917	100	2,464	1,084	58.73	41.27
6/13	1,493	1,465	129	3,087	1,086	48.36	51.64
6/14	1,547	1,185	154	2,886	1,014	53.60	46.40
6/15	1,070	1,137	185	2,392	844	44.73	55.27
6/16	4,170	8,653	449	13,272	3,526	31.42	68.58
6/17	15,376	29,322	2,685	47,383	10,535	32.45	67.55
6/18	8,005	31,847	4,799	44,651	2,456	17.93	82.07
6/19	9,076	43,672	7,278	60,026	3,832	15.12	84.88
6/20	19,334	56,209	3,262	78,805	13,071	24.53	75.47
6/21	18,421	54,570	3,549	76,540	7,697	24.07	75.93
6/22	16,611	84,014	2,781	103,406	6,315	16.06	83.94
6/23	20,157	99,339	2,817	122,313	3,845	16.48	83.52
6/24	31,907	73,938	2,228	108,073	9,217	29.52	70.48
6/25	15,100	66,098	2,083	83,281	4,782	18.13	81.87
6/26	13,732	68,674	3,109	85,515	7,683	16.06	83.94
6/27	17,521	84,583	3,104	105,208	9,414	16.65	83.35
6/28	29,248	140,925	4,215	174,388	10,411	16.77	83.23
6/29	28,916	134,224	4,383	167,523	11,105	17.26	82.74
6/30	22,778	87,443	5,305	115,526	5,460	19.72	80.28
7/01	16,719	78,167	4,928	99,814	6,645	16.75	83.25
7/02	17,156	60,089	6,763	84,008	12,767	20.42	79.58
7/03	12,081	70,979	7,973	91,033	23,251	13.27	86.73
7/04	13,330	42,902	6,540	62,772	7,913	21.24	78.76
7/05	16,707	67,828	9,632	94,167	25,641	17.74	82.26
7/06	23,539	109,808	12,805	146,152	10,489	16.11	83.89
7/07	23,048	75,940	14,432	113,420	31,927	20.32	79.68
7/08	18,889	33,201	14,384	66,474	4,545	28.42	71.58
7/09	11,895	43,686	10,577	66,158	5,178	17.98	82.02
7/10	12,524	45,715	9,704	67,943	6,624	18.43	81.57
7/11	15,417	59,824	13,065	88,306	20,445	17.46	82.54
7/12	10,831	34,955	12,838	58,624	6,701	18.48	81.52
7/13	8,068	27,291	7,412	42,771	7,363	18.86	81.14
7/14	7,197	24,503	3,959	35,659	7,513	20.18	79.82
7/15	6,199	19,280	3,078	28,557	6,675	21.71	78.29
7/16	5,305	14,185	2,100	21,590	2,527	24.57	75.43
7/17	8,215	18,255	1,811	28,281	4,850	29.05	70.95
7/18	7,677	10,041	1,547	19,265	4,253	39.85	60.15
7/19	9,217	19,374	2,677	31,268	7,090	29.48	70.52
7/20	16,448	44,383	4,963	65,794	7,366	25.00	75.00

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	Right Bank	Left Bank		Total		Percent by Bank	
Date		Nearshore	Offshore	Passage	SE	Right	Left
7/21	10,796	32,190	4,976	47,962	8,519	22.51	77.49
7/22	7,150	24,587	3,102	34,839	7,419	20.52	79.48
7/23	5,660	16,493	4,309	26,462	6,336	21.39	78.61
7/24	3,448	13,122	2,861	19,431	5,639	17.74	82.26
7/25	2,949	9,857	2,820	15,626	3,215	18.87	81.13
7/26	4,770	10,927	3,862	19,559	3,472	24.39	75.61
7/27	6,394	18,293	3,566	28,253	3,553	22.63	77.37
7/28	9,625	36,778	10,699	57,102	8,267	16.86	83.14
7/29	11,135	39,138	12,317	62,590	5,376	17.79	82.21
7/30	7,748	18,444	8,900	35,092	3,850	22.08	77.92
7/31	6,285	15,307	6,347	27,939	4,089	22.50	77.50
8/01	5,240	10,751	4,584	20,575	3,467	25.47	74.53
8/02	8,710	16,147	5,721	30,578	7,448	28.48	71.52
8/03	9,602	28,219	8,214	46,035	12,805	20.86	79.14
8/04	5,516	16,571	8,422	30,509	4,897	18.08	81.92
8/05	4,677	9,303	4,439	18,419	3,770	25.39	74.61
8/06	3,020	10,576	3,189	16,785	3,372	17.99	82.01
8/07	4,274	11,466	6,490	22,230	4,078	19.23	80.77
8/08	4,617	13,667	8,341	26,625	9,374	17.34	82.66
8/09	4,987	8,695	3,222	16,904	3,325	29.50	70.50
8/10	2,886	9,640	3,179	15,705	4,005	18.38	81.62
8/11	3,374	11,313	3,935	18,622	6,732	18.12	81.88
8/12	4,314	10,543	2,959	17,816	1,543	24.21	75.79
8/13	4,175	12,682	2,109	18,966	11,552	22.01	77.99
8/14	4,273	11,897	2,187	18,357	1,594	23.28	76.72
8/15	3,581	13,434	2,348	19,363	4,046	18.49	81.51
8/16	2,640	9,943	3,110	15,693	1,841	16.82	83.18
8/17	3,260	6,742	3,045	13,047	3,930	24.99	75.01
8/18	8,327	38,978	16,181	63,486	19,699	13.12	86.88
8/19	17,430	55,357	45,735	118,522	24,820	14.71	85.29
8/20	7,056	39,129	56,998	103,183	9,199	6.84	93.16
8/21	6,130	23,871	31,352	61,353	10,142	9.99	90.01
8/22	5,999	11,400	14,027	31,426	6,910	19.09	80.91
8/23	4,148	8,206	8,806	21,160	2,297	19.60	80.40
8/24	2,597	8,014	6,245	16,856	2,489	15.41	84.59
8/25	2,685	7,768	6,065	16,518	4,940	16.25	83.75
8/26	3,467	4,203	4,026	11,696	2,865	29.64	70.36
8/27	3,194	4,018	4,551	11,763	2,838	27.15	72.85
8/28	3,170	6,132	5,369	14,671	3,141	21.61	78.39
8/29	2,124	3,563	5,336	11,023	2,644	19.27	80.73
8/30	2,887	3,402	3,269	9,558	1,186	30.21	69.79
8/31	2,952	3,002	3,678	9,632	1,947	30.65	69.35
9/01	2,937	2,858	3,967	9,762	1,360	30.09	69.91
9/02	2,904	3,022	3,874	9,800	2,561	29.63	70.37
9/03	2,628	3,858	3,216	9,702	1,013	27.09	72.91
9/04	2,779	3,498	4,342	10,619	1,183	26.17	73.83
9/05	2,418	4,779	3,765	10,962	1,757	22.06	77.94
9/06	2,292	4,782	3,264	10,338	1,310	22.17	77.83
9/07	2,677	3,363	3,857	9,897	2,080	27.05	72.95
Total	801,804	2,672,061	583,457	4,057,320			

APPENDIX D: DAILY FISH PASSAGE ESTIMATES BY SPECIES

Appendix D1.–Daily fish passage estimates by species at the Pilot Station sonar site on the Yukon River, 2012.

	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
6/01	0	0	0	0	0	0	0	5,296	5,296
6/02	0	0	0	0	0	0	0	4,179	4,179
6/03	0	0	0	0	0	0	0	3,920	3,920
6/04	0	0	0	0	0	0	0	3,113	3,113
6/05	0	0	0	0	0	0	0	3,635	3,635
6/06	0	0	0	0	0	0	0	3,386	3,386
6/07	0	0	0	0	0	0	0	2,675	2,675
6/08	0	0	0	0	0	0	0	2,083	2,083
6/09	0	0	0	0	0	0	0	2,361	2,361
6/10	22	0	22	0	0	0	0	2,191	2,213
6/11	32	0	32	0	0	0	0	2,623	2,655
6/12	0	0	0	955	0	0	0	1,509	2,464
6/13	458	0	458	1,973	0	0	0	656	3,087
6/14	152	0	152	1,382	0	0	0	1,352	2,886
6/15	36	0	36	1,079	0	0	0	1,277	2,392
6/16	1,761	67	1,828	11,006	0	0	0	438	13,272
6/17	798	367	1,165	45,385	0	0	0	833	47,383
6/18	641	138	779	42,105	0	0	0	1,767	44,651
6/19	973	358	1,331	56,263	0	0	0	2,432	60,026
6/20	1,850	548	2,398	65,323	0	0	0	11,084	78,805
6/21	1,979	215	2,194	71,861	0	378	0	2,107	76,540
6/22	1,897	911	2,808	100,329	0	0	0	269	103,406
6/23	5,935	621	6,556	114,772	0	0	0	985	122,313
6/24	6,595	841	7,436	99,712	0	0	0	925	108,073
6/25	2,777	1,331	4,108	75,954	0	1,928	0	1,291	83,281
6/26	7,168	1,931	9,099	72,545	0	979	0	2,892	85,515
6/27	6,453	1,277	7,730	94,446	0	2,422	0	610	105,208
6/28	14,100	1,328	15,428	155,152	0	3,808	0	0	174,388
6/29	4,810	1,695	6,505	153,646	0	4,227	0	3,145	167,523
6/30	3,882	0	3,882	107,512	0	3,321	0	811	115,526
7/01	1,616	356	1,972	89,615	0	4,049	0	4,178	99,814
7/02	4,087	916	5,003	72,279	0	5,944	0	782	84,008
7/03	1,644	360	2,004	61,258	0	26,284	0	1,487	91,033
7/04	1,303	354	1,657	50,429	0	9,065	0	1,621	62,772
7/05	1,621	0	1,621	62,523	0	26,783	0	3,240	94,167
7/06	5,385	786	6,171	126,342	0	11,883	0	1,756	146,152
7/07	2,021	173	2,194	69,105	0	31,973	0	10,148	113,420
7/08	1,733	0	1,733	42,351	0	14,142	0	8,248	66,474
7/09	442	552	994	49,116	0	5,685	0	10,363	66,158
7/10	2,782	0	2,782	50,195	0	9,184	0	5,782	67,943
7/11	206	0	206	62,981	0	19,442	0	5,677	88,306
7/12	820	0	820	44,228	0	8,721	0	4,855	58,624
7/13	940	0	940	24,397	0	10,039	0	7,395	42,771
7/14	829	73	902	13,827	0	9,718	0	11,212	35,659
7/15	659	63	722	10,984	0	7,845	0	9,006	28,557
7/16	63	0	63	6,329	0	9,698	0	5,500	21,590

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	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
7/17	295	341	636	14,354	0	9,977	0	3,314	28,281
7/18	237	188	425	8,691	0	7,724	0	2,425	19,265
7/19	278	0	278	0	21,064	5,428	0	4,498	31,268
7/20	346	0	346	0	41,471	11,969	0	12,008	65,794
7/21	454	0	454	0	23,934	9,584	237	13,753	47,962
7/22	339	0	339	0	17,386	6,741	181	10,192	34,839
7/23	247	0	247	0	5,874	7,615	0	12,726	26,462
7/24	0	0	0	0	4,824	3,893	16	10,698	19,431
7/25	0	0	0	0	3,964	3,224	0	8,438	15,626
7/26	0	0	0	0	4,979	4,244	0	10,336	19,559
7/27	112	0	112	0	13,760	5,726	0	8,655	28,253
7/28	0	0	0	0	35,015	9,061	326	12,700	57,102
7/29	93	0	93	0	38,243	11,967	525	11,762	62,590
7/30	65	0	65	0	21,806	6,621	304	6,296	35,092
7/31	0	0	0	0	9,910	5,180	409	12,440	27,939
8/01	0	0	0	0	7,165	4,046	287	9,077	20,575
8/02	0	0	0	0	10,936	4,314	198	15,130	30,578
8/03	0	0	0	0	32,316	1,817	1,187	10,715	46,035
8/04	0	0	0	0	12,798	2,078	835	14,798	30,509
8/05	0	0	0	0	7,175	1,402	498	9,344	18,419
8/06	0	0	0	0	4,440	426	750	11,169	16,785
8/07	0	0	0	0	6,228	559	1,106	14,337	22,230
8/08	0	0	0	0	11,926	202	598	13,899	26,625
8/09	0	0	0	0	3,820	417	636	12,031	16,904
8/10	0	0	0	0	2,812	290	1,659	10,944	15,705
8/11	0	0	0	0	1,792	0	1,083	15,747	18,622
8/12	0	0	0	0	1,694	413	896	14,813	17,816
8/13	0	0	0	0	1,029	32	2,211	15,694	18,966
8/14	0	0	0	0	502	50	498	17,307	18,357
8/15	0	0	0	0	3,050	0	6,331	9,982	19,363
8/16	0	0	0	0	2,640	0	1,426	11,627	15,693
8/17	0	0	0	0	1,078	0	3,036	8,933	13,047
8/18	0	0	0	0	51,645	0	1,987	9,854	63,486
8/19	0	0	0	0	95,367	0	4,105	19,050	118,522
8/20	0	0	0	0	79,913	0	8,056	15,214	103,183
8/21	0	0	0	0	26,603	0	12,605	22,145	61,353
8/22	0	0	0	0	12,817	0	6,494	12,115	31,426
8/23	0	0	0	0	8,269	0	3,951	8,940	21,160
8/24	0	0	0	0	5,219	0	3,275	8,362	16,856
8/25	0	0	0	0	6,750	0	4,155	5,613	16,518
8/26	0	0	0	0	3,727	0	1,339	6,630	11,696
8/27	0	0	0	0	4,086	0	1,388	6,289	11,763
8/28	0	0	0	0	2,742	0	4,800	7,129	14,671
8/29	0	0	0	0	2,389	0	3,998	4,636	11,023
8/30	0	0	0	0	2,349	0	1,936	5,273	9,558
8/31	0	0	0	0	6,092	0	918	2,622	9,632

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	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
9/01	0	0	0	0	1,771	0	2,092	5,899	9,762
9/02	0	0	0	0	3,502	0	1,129	5,169	9,800
9/03	0	0	0	0	3,982	0	3,100	2,620	9,702
9/04	0	0	0	0	2,891	0	3,774	3,954	10,619
9/05	0	0	0	0	2,447	0	3,906	4,609	10,962
9/06	0	0	0	0	3,937	0	4,638	1,763	10,338
9/07	0	0	0	0	2,381	0	3,903	3,613	9,897
Total	90,936	15,790	106,726	2,130,404	682,510	352,518	106,782	678,382	4,057,322

[a] Chinook salmon > 655 mm.

[b] Chinook salmon ≤ 655mm.

APPENDIX E: DIDSON-GENERATED COMPONENT AND PROPORTIONS OF THE LEFT BANK NEARSHORE DAILY FISH PASSAGE ESTIMATES

Appendix E1.–DIDSON-generated component of the left bank nearshore daily fish passage estimates at the Pilot Station sonar site on the Yukon River, 2012.

	Chinook			Chum					
Date	Large[a]	Small[b]	All	Summer	Fall	Coho	Pink	Other	Total
6/01	0	0	0	0	0	0	0	287	287
6/02	0	0	0	0	0	0	0	546	546
6/03	0	0	0	0	0	0	0	323	323
6/04	0	0	0	0	0	0	0	781	781
6/05	0	0	0	0	0	0	0	872	872
6/06	0	0	0	0	0	0	0	597	597
6/07	0	0	0	0	0	0	0	72	72
6/08	0	0	0	0	0	0	0	328	328
6/09	0	0	0	0	0	0	0	569	569
6/10	9	0	9	0	0	0	0	256	265
6/11	6	0	6	0	0	0	0	182	188
6/12	0	0	0	0	0	0	0	60	60
6/13	103	0	103	199	0	0	0	27	328
6/14	44	0	44	300	0	0	0	0	344
6/15	0	0	0	286	0	0	0	187	473
6/16	727	0	727	3,678	0	0	0	181	4587
6/17	313	65	378	16,158	0	0	0	43	16,579
6/18	241	0	241	13,843	0	0	0	60	14,144
6/19	361	97	458	17,689	0	0	0	199	18,346
6/20	523	148	671	15,884	0	0	0	48	16,603
6/21	484	66	550	15,892	0	0	116	166	16,724
6/22	771	412	1,184	36,868	0	0	0	0	38,052
6/23	2,717	301	3,017	44,933	0	0	0	167	48,117
6/24	2,579	390	2,969	31,019	0	0	0	287	34,276
6/25	1,153	428	1,580	29,135	0	0	496	189	31,399
6/26	2,676	925	3,601	28,877	0	0	0	409	32,886
6/27	3,076	391	3,467	40,466	0	0	411	0	44,344
6/28	6,807	691	7,497	69,376	0	0	1,136	0	78,009
6/29	1,903	860	2,763	62,872	0	0	1,471	1,002	68,108
6/30	1,239	0	1,239	32,320	0	0	179	82	33,820
7/01	371	0	371	25,969	0	0	788	1,266	28,395
7/02	1,135	245	1,380	16,959	0	0	1,285	259	19,883
7/03	226	83	309	10,622	0	0	5,510	0	16,441
7/04	224	50	274	9,786	0	0	1,234	84	11,378
7/05	557	0	557	15,646	0	0	6,698	405	23,306
7/06	1,225	126	1,350	30,203	0	0	1,245	0	32,798
7/07	440	0	440	15,023	0	0	4,666	1,675	21,805
7/08	143	0	143	8,542	0	0	1,157	81	9,924
7/09	83	178	262	11,841	0	0	465	1,557	14,125
7/10	901	0	901	14,216	0	0	1,120	77	16,314
7/11	53	0	53	16,460	0	0	6,332	760	23,604
7/12	201	0	201	9,167	0	0	724	1,593	11,685
7/13	121	0	121	5,773	0	0	2,051	1,584	9,529
7/14	385	0	385	5,599	0	0	2,206	4,545	12,736
7/15	263	0	263	3,825	0	0	1,507	3,104	8,699
7/16	0	0	0	1,510	0	0	2,543	2,022	6,076

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Appendix E1.–Page 2 of 3.

	Chinook			Chum					
Date	Large	Small	All	Summer	Fall	Coho	Pink	Other	Total
7/17	54	184	238	6,496	0	0	2,165	943	9,842
7/18	25	85	111	3,018	0	0	1,006	438	4,572
7/19	106	0	106	0	5,324	0	1,018	953	7,401
7/20	101	0	101	0	14,980	0	2,411	2,874	20,366
7/21	177	0	177	0	8,034	114	1,911	5,178	15,413
7/22	142	0	142	0	6,432	91	1,530	4,145	12,339
7/23	109	0	109	0	777	0	1,366	5,012	7,264
7/24	0	0	0	0	2,316	0	1,357	3,229	6,903
7/25	0	0	0	0	1,104	0	964	3,034	5,103
7/26	0	0	0	0	1,274	0	1,112	3,499	5,885
7/27	0	0	0	0	3,361	0	1,259	3,443	8,063
7/28	0	0	0	0	6,528	106	1,443	3,903	11,980
7/29	0	0	0	0	7,509	90	2,523	2,770	12,893
7/30	0	0	0	0	3,213	39	1,080	1,185	5,516
7/31	0	0	0	0	1,596	184	675	4,439	6,894
8/01	0	0	0	0	1,036	120	438	2,882	4,476
8/02	0	0	0	0	2,110	0	318	3,858	6,286
8/03	0	0	0	0	7,707	100	0	2,875	10,681
8/04	0	0	0	0	1,809	213	277	4,258	6,557
8/05	0	0	0	0	1,326	156	203	3,119	4,804
8/06	0	0	0	0	1,645	233	81	4,367	6,326
8/07	0	0	0	0	1,274	181	63	3,383	4,901
8/08	0	0	0	0	2,117	0	0	3,841	5,958
8/09	0	0	0	0	774	216	0	2,685	3,675
8/10	0	0	0	0	379	91	100	3,938	4,508
8/11	0	0	0	0	533	428	0	5,221	6,181
8/12	0	0	0	0	466	80	177	5,459	6,181
8/13	0	0	0	0	655	278	0	7,379	8,311
8/14	0	0	0	0	185	224	0	7,590	7,999
8/15	0	0	0	0	1,171	2,597	0	4,176	7,943
8/16	0	0	0	0	397	387	0	3,996	4,781
8/17	0	0	0	0	407	694	0	2,966	4,068
8/18	0	0	0	0	13,105	371	0	1,464	14,940
8/19	0	0	0	0	15,002	425	0	1,676	17,103
8/20	0	0	0	0	6,463	772	0	1,077	8,312
8/21	0	0	0	0	2,245	1,132	0	2,669	6,045
8/22	0	0	0	0	1,347	679	0	1,602	3,627
8/23	0	0	0	0	1,169	276	0	1,341	2,787
8/24	0	0	0	0	421	288	0	2,086	2,795
8/25	0	0	0	0	271	193	0	518	981
8/26	0	0	0	0	113	106	0	549	769
8/27	0	0	0	0	106	100	0	515	721
8/28	0	0	0	0	207	471	0	932	1,610
8/29	0	0	0	0	129	293	0	579	1,001
8/30	0	0	0	0	139	49	0	245	433
8/31	0	0	0	0	613	220	0	0	833

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Appendix E1.–Page 3 of 3.

	Chinook			Chum					
Date	Large	Small	All	Summer	Fall	Coho	Pink	Other	Total
9/01	0	0	0	0	33	178	0	294	505
9/02	0	0	0	0	57	41	0	451	549
9/03	0	0	0	0	126	90	0	32	248
9/04	0	0	0	0	59	82	0	107	248
9/05	0	0	0	0	485	545	0	547	1,577
9/06	0	0	0	0	798	686	0	0	1,484
9/07	0	0	0	0	77	361	0	619	1,057
Total	32,774	5,725	38,498	670,450	129,404	13,980	66,817	16,1273	1,080,420

[a] Chinook salmon > 655 mm.

[b] Chinook salmon ≤ 655mm.

Appendix E2.–Proportions by species of daily total passage (both banks combined) for sectors 1 and 2 of Stratum 3 of the left bank nearshore region generated by the DIDSON, at the Pilot Station sonar project on the Yukon River, 2012.

	Chinook			Chum					
Date	Large[a]	Small[b]	All	Summer	Fall	Coho	Pink	Other	Total
6/01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05
6/02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13
6/03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08
6/04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.25
6/05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.24
6/06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.18
6/07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03
6/08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.16
6/09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.24
6/10	0.41	0.00	0.41	0.00	0.00	0.00	0.00	0.12	0.12
6/11	0.19	0.00	0.19	0.00	0.00	0.00	0.00	0.07	0.07
6/12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02
6/13	0.22	0.00	0.22	0.10	0.00	0.00	0.00	0.04	0.11
6/14	0.29	0.00	0.29	0.22	0.00	0.00	0.00	0.00	0.12
6/15	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.15	0.20
6/16	0.41	0.00	0.40	0.33	0.00	0.00	0.00	0.41	0.35
6/17	0.39	0.18	0.32	0.36	0.00	0.00	0.00	0.05	0.35
6/18	0.38	0.00	0.31	0.33	0.00	0.00	0.00	0.03	0.32
6/19	0.37	0.27	0.34	0.31	0.00	0.00	0.00	0.08	0.31
6/20	0.28	0.27	0.28	0.24	0.00	0.00	0.00	0.00	0.21
6/21	0.24	0.31	0.25	0.22	0.00	0.00	0.31	0.08	0.22
6/22	0.41	0.45	0.42	0.37	0.00	0.00	0.00	0.00	0.37
6/23	0.46	0.48	0.46	0.39	0.00	0.00	0.00	0.17	0.39
6/24	0.39	0.46	0.40	0.31	0.00	0.00	0.00	0.31	0.32
6/25	0.42	0.32	0.38	0.38	0.00	0.00	0.26	0.15	0.38
6/26	0.37	0.48	0.40	0.40	0.00	0.00	0.00	0.14	0.38
6/27	0.48	0.31	0.45	0.43	0.00	0.00	0.17	0.00	0.42
6/28	0.48	0.52	0.49	0.45	0.00	0.00	0.30	0.00	0.45
6/29	0.40	0.51	0.42	0.41	0.00	0.00	0.35	0.32	0.41
6/30	0.32	0.00	0.32	0.30	0.00	0.00	0.05	0.10	0.29
7/01	0.23	0.00	0.19	0.29	0.00	0.00	0.19	0.30	0.28
7/02	0.28	0.27	0.28	0.23	0.00	0.00	0.22	0.33	0.24
7/03	0.14	0.23	0.15	0.17	0.00	0.00	0.21	0.00	0.18
7/04	0.17	0.14	0.17	0.19	0.00	0.00	0.14	0.05	0.18
7/05	0.34	0.00	0.34	0.25	0.00	0.00	0.25	0.13	0.25
7/06	0.23	0.16	0.22	0.24	0.00	0.00	0.10	0.00	0.22
7/07	0.22	0.00	0.20	0.22	0.00	0.00	0.15	0.17	0.19
7/08	0.08	0.00	0.08	0.20	0.00	0.00	0.08	0.01	0.15
7/09	0.19	0.32	0.26	0.24	0.00	0.00	0.08	0.15	0.21
7/10	0.32	0.00	0.32	0.28	0.00	0.00	0.12	0.01	0.24
7/11	0.26	0.00	0.26	0.26	0.00	0.00	0.33	0.13	0.27
7/12	0.25	0.00	0.25	0.21	0.00	0.00	0.08	0.33	0.20
7/13	0.13	0.00	0.13	0.24	0.00	0.00	0.20	0.21	0.22
7/14	0.46	0.00	0.43	0.40	0.00	0.00	0.23	0.41	0.36
7/15	0.40	0.00	0.36	0.35	0.00	0.00	0.19	0.34	0.30
7/16	0.00	0.00	0.00	0.24	0.00	0.00	0.26	0.37	0.28

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	Chinook			Chum					
Date	Large[a]	Small[b]	All	Summer	Fall	Coho	Pink	Other	Total
7/17	0.18	0.54	0.37	0.45	0.00	0.00	0.22	0.28	0.35
7/18	0.11	0.45	0.26	0.35	0.00	0.00	0.13	0.18	0.24
7/19	0.38	0.00	0.38	0.00	0.25	0.00	0.19	0.21	0.24
7/20	0.29	0.00	0.29	0.00	0.36	0.00	0.20	0.24	0.31
7/21	0.39	0.00	0.39	0.00	0.34	0.48	0.20	0.38	0.32
7/22	0.42	0.00	0.42	0.00	0.37	0.50	0.23	0.41	0.35
7/23	0.44	0.00	0.44	0.00	0.13	0.00	0.18	0.39	0.27
7/24	0.00	0.00	0.00	0.00	0.48	0.00	0.35	0.30	0.36
7/25	0.00	0.00	0.00	0.00	0.28	0.00	0.30	0.36	0.33
7/26	0.00	0.00	0.00	0.00	0.26	0.00	0.26	0.34	0.30
7/27	0.00	0.00	0.00	0.00	0.24	0.00	0.22	0.40	0.29
7/28	0.00	0.00	0.00	0.00	0.19	0.33	0.16	0.31	0.21
7/29	0.00	0.00	0.00	0.00	0.20	0.17	0.21	0.24	0.21
7/30	0.00	0.00	0.00	0.00	0.15	0.13	0.16	0.19	0.16
7/31	0.00	0.00	0.00	0.00	0.16	0.45	0.13	0.36	0.25
8/01	0.00	0.00	0.00	0.00	0.14	0.42	0.11	0.32	0.22
8/02	0.00	0.00	0.00	0.00	0.19	0.00	0.07	0.25	0.21
8/03	0.00	0.00	0.00	0.00	0.24	0.08	0.00	0.27	0.23
8/04	0.00	0.00	0.00	0.00	0.14	0.26	0.13	0.29	0.21
8/05	0.00	0.00	0.00	0.00	0.18	0.31	0.14	0.33	0.26
8/06	0.00	0.00	0.00	0.00	0.37	0.31	0.19	0.39	0.38
8/07	0.00	0.00	0.00	0.00	0.20	0.16	0.11	0.24	0.22
8/08	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.28	0.22
8/09	0.00	0.00	0.00	0.00	0.20	0.34	0.00	0.22	0.22
8/10	0.00	0.00	0.00	0.00	0.13	0.05	0.34	0.36	0.29
8/11	0.00	0.00	0.00	0.00	0.30	0.40	0.00	0.33	0.33
8/12	0.00	0.00	0.00	0.00	0.28	0.09	0.43	0.37	0.35
8/13	0.00	0.00	0.00	0.00	0.64	0.13	0.00	0.47	0.44
8/14	0.00	0.00	0.00	0.00	0.37	0.45	0.00	0.44	0.44
8/15	0.00	0.00	0.00	0.00	0.38	0.41	0.00	0.42	0.41
8/16	0.00	0.00	0.00	0.00	0.15	0.27	0.00	0.34	0.30
8/17	0.00	0.00	0.00	0.00	0.38	0.23	0.00	0.33	0.31
8/18	0.00	0.00	0.00	0.00	0.25	0.19	0.00	0.15	0.24
8/19	0.00	0.00	0.00	0.00	0.16	0.10	0.00	0.09	0.14
8/20	0.00	0.00	0.00	0.00	0.08	0.10	0.00	0.07	0.08
8/21	0.00	0.00	0.00	0.00	0.08	0.09	0.00	0.12	0.10
8/22	0.00	0.00	0.00	0.00	0.11	0.10	0.00	0.13	0.12
8/23	0.00	0.00	0.00	0.00	0.14	0.07	0.00	0.15	0.13
8/24	0.00	0.00	0.00	0.00	0.08	0.09	0.00	0.25	0.17
8/25	0.00	0.00	0.00	0.00	0.04	0.05	0.00	0.09	0.06
8/26	0.00	0.00	0.00	0.00	0.03	0.08	0.00	0.08	0.07
8/27	0.00	0.00	0.00	0.00	0.03	0.07	0.00	0.08	0.06
8/28	0.00	0.00	0.00	0.00	0.08	0.10	0.00	0.13	0.11
8/29	0.00	0.00	0.00	0.00	0.05	0.07	0.00	0.12	0.09
8/30	0.00	0.00	0.00	0.00	0.06	0.03	0.00	0.05	0.05
8/31	0.00	0.00	0.00	0.00	0.10	0.24	0.00	0.00	0.09

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Date	Chinook			Chum		Coho	Pink	Other	Total
	Large[a]	Small[b]	All	Summer	Fall				
9/01	0.00	0.00	0.00	0.00	0.02	0.09	0.00	0.05	0.05
9/02	0.00	0.00	0.00	0.00	0.02	0.04	0.00	0.09	0.06
9/03	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.01	0.03
9/04	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.03	0.02
9/05	0.00	0.00	0.00	0.00	0.20	0.14	0.00	0.12	0.14
9/06	0.00	0.00	0.00	0.00	0.20	0.15	0.00	0.00	0.14
9/07	0.00	0.00	0.00	0.00	0.03	0.09	0.00	0.17	0.11
Season Total	0.36	0.36	0.36	0.31	0.19	0.13	0.19	0.24	0.27

[a] Chinook salmon > 655 mm.

[b] Chinook salmon ≤ 655mm.

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

Appendix F1.–Daily cumulative fish passage proportions and timing by species at the Pilot Station sonar project on the Yukon River, 2012.

	Chinook			Chum				
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other
6/01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
6/02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
6/03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
6/04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
6/05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
6/06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
6/07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
6/08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
6/09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
6/10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
6/11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
6/12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
6/13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06
6/14	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.06
6/15	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.06
6/16	0.03	0.00	0.02	0.01	0.00	0.00	0.00	0.06
6/17	0.04	0.03	0.03	0.03	0.00	0.00	0.00	0.06
6/18	0.04	0.04	0.04	0.05	0.00	0.00	0.00	0.06
6/19	0.05	0.06	0.05	0.08	0.00	0.00	0.00	0.07
6/20	0.07	0.09	0.08	0.11	0.00	0.00	0.00	0.08
6/21	0.10	0.11	0.10	0.14	0.00	0.00	0.00	0.09
6/22	0.12	0.16	0.12	0.19	0.00	0.00	0.00	0.09
6/23	0.18	0.20	0.19	0.24	0.00	0.00	0.00	0.09
6/24	**0.25**	**0.26**	**0.25**	**0.29**	0.00	0.00	0.00	0.09
6/25	0.28	0.34	0.29	0.32	0.00	0.01	0.00	0.09
6/26	0.36	0.46	0.38	0.36	0.00	0.01	0.00	0.10
6/27	0.43	**0.54**	0.45	0.40	0.00	0.02	0.00	0.10
6/28	**0.59**	0.63	**0.60**	0.47	0.00	0.03	0.00	0.10
6/29	0.64	0.74	0.66	**0.55**	0.00	0.04	0.00	0.10
6/30	0.69	0.74	0.69	0.60	0.00	0.05	0.00	0.10
7/01	0.70	**0.76**	0.71	0.64	0.00	0.06	0.00	0.11
7/02	**0.75**	0.82	**0.76**	0.67	0.00	0.08	0.00	0.11
7/03	0.77	0.84	0.78	0.70	0.00	0.15	0.00	0.11
7/04	0.78	0.86	0.79	0.73	0.00	0.18	0.00	0.11
7/05	0.80	0.86	0.81	**0.75**	0.00	**0.25**	0.00	0.12
7/06	0.86	0.91	0.87	0.81	0.00	0.29	0.00	0.12
7/07	0.88	0.92	0.89	0.85	0.00	0.38	0.00	0.14
7/08	0.90	0.92	0.90	0.87	0.00	0.42	0.00	0.15
7/09	0.90	0.96	0.91	0.89	0.00	0.43	0.00	0.16
7/10	0.93	0.96	0.94	0.91	0.00	0.46	0.00	0.17
7/11	0.94	0.96	0.94	0.94	0.00	**0.51**	0.00	0.18
7/12	0.95	0.96	0.95	0.96	0.00	0.54	0.00	0.19
7/13	0.96	0.96	0.96	0.97	0.00	0.57	0.00	0.20
7/14	0.96	0.96	0.96	0.98	0.00	0.60	0.00	0.22
7/15	0.97	0.97	0.97	0.99	0.00	0.62	0.00	0.23
7/16	0.97	0.97	0.97	0.99	0.00	0.65	0.00	0.24

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Appendix F1.–Page 2 of 3.

	Chinook			Chum				
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other
7/17	0.98	0.99	0.98	1.00	0.00	0.67	0.00	0.24
7/18	0.98	1.00	0.98	1.00	0.00	0.70	0.00	**0.25**
7/19	0.98	1.00	0.98	1.00	0.03	0.71	0.00	0.25
7/20	0.99	1.00	0.99	1.00	0.09	0.74	0.00	0.27
7/21	0.99	1.00	0.99	1.00	0.13	**0.77**	0.00	0.29
7/22	0.99	1.00	1.00	1.00	0.15	0.79	0.00	0.31
7/23	1.00	1.00	1.00	1.00	0.16	0.81	0.00	0.32
7/24	1.00	1.00	1.00	1.00	0.17	0.82	0.00	0.34
7/25	1.00	1.00	1.00	1.00	0.17	0.83	0.00	0.35
7/26	1.00	1.00	1.00	1.00	0.18	0.85	0.00	0.37
7/27	1.00	1.00	1.00	1.00	0.20	0.86	0.00	0.38
7/28	1.00	1.00	1.00	1.00	**0.25**	0.89	0.01	0.40
7/29	1.00	1.00	1.00	1.00	0.31	0.92	0.01	0.42
7/30	1.00	1.00	1.00	1.00	0.34	0.94	0.01	0.43
7/31	1.00	1.00	1.00	1.00	0.35	0.95	0.02	0.44
8/01	1.00	1.00	1.00	1.00	0.37	0.97	0.02	0.46
8/02	1.00	1.00	1.00	1.00	0.38	0.98	0.02	0.48
8/03	1.00	1.00	1.00	1.00	0.43	0.98	0.03	**0.50**
8/04	1.00	1.00	1.00	1.00	0.45	0.99	0.04	0.52
8/05	1.00	1.00	1.00	1.00	0.46	0.99	0.05	0.53
8/06	1.00	1.00	1.00	1.00	0.46	0.99	0.05	0.55
8/07	1.00	1.00	1.00	1.00	0.47	1.00	0.06	0.57
8/08	1.00	1.00	1.00	1.00	0.49	1.00	0.07	0.59
8/09	1.00	1.00	1.00	1.00	**0.50**	1.00	0.08	0.61
8/10	1.00	1.00	1.00	1.00	0.50	1.00	0.09	0.62
8/11	1.00	1.00	1.00	1.00	0.50	1.00	0.10	0.65
8/12	1.00	1.00	1.00	1.00	0.51	1.00	0.11	0.67
8/13	1.00	1.00	1.00	1.00	0.51	1.00	0.13	0.69
8/14	1.00	1.00	1.00	1.00	0.51	1.00	0.14	0.72
8/15	1.00	1.00	1.00	1.00	0.51	1.00	0.19	0.73
8/16	1.00	1.00	1.00	1.00	0.52	1.00	0.21	**0.75**
8/17	1.00	1.00	1.00	1.00	0.52	1.00	0.24	0.76
8/18	1.00	1.00	1.00	1.00	0.59	1.00	**0.25**	0.78
8/19	1.00	1.00	1.00	1.00	0.73	1.00	0.29	0.80
8/20	1.00	1.00	1.00	1.00	**0.85**	1.00	0.37	0.83
8/21	1.00	1.00	1.00	1.00	0.89	1.00	0.49	0.86
8/22	1.00	1.00	1.00	1.00	0.91	1.00	**0.55**	0.88
8/23	1.00	1.00	1.00	1.00	0.92	1.00	0.58	0.89
8/24	1.00	1.00	1.00	1.00	0.93	1.00	0.62	0.90
8/25	1.00	1.00	1.00	1.00	0.94	1.00	0.65	0.91
8/26	1.00	1.00	1.00	1.00	0.94	1.00	0.67	0.92
8/27	1.00	1.00	1.00	1.00	0.95	1.00	0.68	0.93
8/28	1.00	1.00	1.00	1.00	0.95	1.00	0.72	0.94
8/29	1.00	1.00	1.00	1.00	0.96	1.00	**0.76**	0.95
8/30	1.00	1.00	1.00	1.00	0.96	1.00	0.78	0.96
8/31	1.00	1.00	1.00	1.00	0.97	1.00	0.79	0.96

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	Chinook			Chum				
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other
9/01	1.00	1.00	1.00	1.00	0.97	1.00	0.81	0.97
9/02	1.00	1.00	1.00	1.00	0.98	1.00	0.82	0.98
9/03	1.00	1.00	1.00	1.00	0.98	1.00	0.85	0.98
9/04	1.00	1.00	1.00	1.00	0.99	1.00	0.88	0.99
9/05	1.00	1.00	1.00	1.00	0.99	1.00	0.92	0.99
9/06	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.99
9/07	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 ≤ 655mm.

APPENDIX G: PILOT STATION SONAR FISH PASSAGE ESTIMATES, 2002–2012

Appendix G1.–Pilot Station sonar project passage estimates on the Yukon River, 2002–2012.

Species	2012	2011	2010	2009[a]	2008	2007	2006	2005 [b]	2004	2003	2002
Large Chinook[c]	90,936	100,217	100,699	108,361	106,708	90,184	145,553	142,007	110,236	245,037	92,584
Small Chinook	15,790	23,152	19,476	35,688	23,935	35,369	23,850	17,434	46,370	23,500	30,629
Chinook Total	106,726	123,369	120,175	144,049	130,643	125,553	169,403	159,441	156,606	268,537	123,213
Summer chum	2,130,404	1,977,808	1,405,533	1,421,646	1,665,667	1,726,885	3,767,044	2,439,616	1,357,826	1,168,518	1,088,463
Fall chum[d]	682,510	764,194	393,326	233,307	615,127	684,011	790,563	1,813,589	594,060	889,778	326,858
Total	2,812,914	2,742,002	1,798,859	1,654,953	2,280,794	2,410,896	4,557,607	4,253,205	1,951,886	2,058,296	1,415,321
Coho[d]	106,782	124,931	155,784	206,620	135,570	173,289	131,919	184,718	188,350	269,081	122,566
Pink	352,518	6,526	747,297	23,679	558,050	71,699	115,624	37,932	243,375	4,656	64,891
Other Species[e]	678,382	694,700	862,034	765,140	585,303	1,085,316	875,899	593,248	637,257	502,878	557,779
Season Total	4,057,322	3,691,528	3,684,149	2,794,441	3,690,360	3,866,753	5,850,452	5,228,544	3,177,474	3,103,448	2,283,770

Note: Estimates for all years were generated with the most current apportionment model and may differ from earlier estimates.

[a] High water levels were experienced at Pilot Station in 2009, and therefore passage estimates are considered conservative.

[b] Estimates include extrapolations for the dates June 10 to June 18, 2005, to account for the time before the DIDSON was deployed.

[c] Chinook salmon >655 mm.

[d] This estimate may not include the entire run.

[e] Includes sockeye salmon, cisco, whitefish, sheefish, burbot, suckers, Dolly Varden, and northern pike.