Fishery Data Series No. 13-28

Sonar Estimation of Salmon Passage in the Yukon River near Pilot Station, 2009

by

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and

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June 2013

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 al (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

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

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ABSTRACT

The Pilot Station sonar project has provided daily passage estimates for Chinook salmon *Oncorhynchus tshawytscha*, chum salmon *O. keta*, and coho salmon *O. kisutch* for most years since 1986. Fish passage estimates for each species were generated in 2009 through a two-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 2,794,441 fish passed through the sonar sampling area between June 1 and September 7; 746,868 along the right bank and 2,047,573 (season average) along the left bank. Included were 108,361 ± 22,036 large Chinook salmon (>655 mm mideye tail fork); 35,688 ± 8,995 small Chinook salmon (≤655 mm METF); 1,421,646 ± 73,533 summer chum salmon, 233,307 ± 39,587 fall chum salmon; and 206,620 ± 31,067 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 United States / 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 multichannel environment, gear selectivity, environmental conditions, and changes in net site characteristics.

The Pilot Station sonar project has provided daily salmon passage estimates, run timing, and biological information to 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 25.7 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. 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. Because of this and subsequent changes in counting methodology, data collected from 1995 to 2009 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). Rich (2001) discusses use of dual-beam sonar at the Pilot Station sonar project. 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 three-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 the present, as historical estimates have been regenerated using the most current model and methodology (Bromaghin 2004).

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

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 which 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 June 19 2005, a DIDSON imaging sonar was deployed in this area to verify nearshore fish detection. With its wider beam angle, video like images, and software algorithms which 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 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 and 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 over from paper charts to electronic echograms for enumerating fish traces (C. 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.

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 are 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. 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. 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. Hewlett Packard (HP) Model 54501A digital storage oscilloscope,
5. 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
6. one 500 ft. DIDSON underwater cable connecting the DIDSON to the "topside breakout box" and laptop PC.

Right bank sonar equipment included

1. HTI Model 244 echosounder configured to operate at 120 kHz, controlled via DEP software installed on a laptop PC,
2. HTI split-beam 120 kHz transducer with a 6°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. Rotator movements were controlled with HTI model 660-2 rotator controllers with position feedback to the nearest 0.1^{o}. 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 2 pps initially and reduced to 1.3 pps on August 15. 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, with a -43db setting being considered optimum as the theoretical on-axis target strength of a 450 mm chum salmon of minimal length (Love 1977).

The DIDSON (Table 2) operated at an average rate of 8 frames/s with a start 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. Since 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 unit 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 6). Because the DIDSONs wider beam angle is ideal for the less linear nature of the eroded left bank nearshore, it is assumed that it will detect 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, since the aiming strategy optimizes fish detection for DIDSON but not the split beam within this range.

Fluctuating water levels required repositioning of the transducers, and subsequent re-aiming of the beams. 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 prints of echograms were copied of the new aim and were 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 higher.

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 tracings and non-target echoes. Echo traces were counted as a single fish if at least 2 pings in the cluster passed the threshold level (see Equipment Settings and Thresholds) and the targets did not resemble inert downstream objects. Valid downstream fish targets were retained and adjusted into the total estimate of fish passage. Groups of fish were distinguishable when the apparent direction of movement of one 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. The data was checked daily for data entry or tallying errors, then processed in statistical software (SAS®) using routines developed by the regional biometrician, Toshihide Hamazaki.

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 measured using a staff gage located slightly 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 left bank on June 15 and on the right bank on July 2. Both loggers remained submerged until September 7, with the exception of the period from June 24 to July 2, when the right bank logger was removed from the water (Figure 7).

SPECIES APPORTIONMENT

Equipment and Procedures

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 6). 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.

During the 2007 and 2008 season, as part of a separate Community Improvement Project funded genetic study, an extra period of gillnetting was conducted in order to collect additional Chinook salmon samples. The drifts were located both upriver and downriver of the area sampled by the sonar, and 3 gillnet mesh sizes (8.5-, 7.5-, 6.5-inch) were used to target all size classes of Chinook salmon. All other species captured during this extra period were immediately released, and therefore not sampled. In 2009 ADF&G continued to conduct this additional sampling but moved the sampling area approximately 2 miles downstream of the sonar site to try and increase the sample size of Chinook salmon.

Captured fish were identified to species and measured to the nearest one mm length. Salmon species were measured from mideye to fork of tail (METF); non-salmon species were measured from snout to fork of tail. 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;* cisco *Coregonus sardinella, C. laurettae;* humpback whitefish *C. pidschian*; and broad whitefish *C. nasus*. In addition, coefficients have also been generated for a 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.

Scale samples were collected from Chinook salmon, mounted on scale cards, and scale and card numbers were recorded on the test fishing data sheets. Data were transferred from data sheets into a database. Age, sex, length (ASL) data were processed, analyzed and reported by ADF&G staff based in Anchorage (Horne-Brine 2011). 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 for several other projects, in conjunction with the Pilot Station sonar project test fishing. Age, sex and length data were cross referenced with each tissue sample. The ADF&G Gene Conservation Laboratory (DeCovich and Howard 2010) and the USFWS Conservation Genetics Laboratory (Flannery et al. 2011) 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 one-ocean 'jacks'. Although there is 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 post July 18 were designated as fall chum salmon.

ANALYTICAL METHODS

Daily estimates were produced from a multi-component process involving:

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 openings and occasionally, during periods 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 one 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 one 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:

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

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- and 8.5-inch); 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-inch).

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

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

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 in.

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

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

since 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

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

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,

$$f_{umj} = \frac{25 \cdot t_{umj}}{60} \quad (5)$$

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

$$f_{um} = \sum_{j} f_{umj} \quad (6)$$

and the catch of species *i* of length *l* in each report period was summed across all mesh sizes,

$$c_{uil} = \sum_{m} c_{uilm} \quad (7)$$

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

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

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

$$CPUE'_{uil} = \frac{c_{uil}}{f'_{uil}}. \quad (9)$$

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 ($\hat{p}_{ui}$),

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

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 since operating it in sectors 3, 4, and 5 also entailed operating in sectors 1 and 2. Since 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

$$w_{HTI} = \frac{\sum_{s=3}^{} \sum_{q} w_{dpksq}}{n}, \quad (13)$$

and the width of the DIDSON,

$$w_{DID} = \frac{\sum_{q} w_{dpq}}{n}, \quad (14)$$

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

$$h_{HTI} = \sum_{q} h_{dpkq}, \quad (15)$$

and the DIDSON,

$$h_{DID} = \sum_{q} h_{dpq}, \quad (16)$$

were summed, as were the total upstream counts y,

$$y_{HTI} = \sum_{q} y_{dpkq}, \quad (17)$$

$$y_{DID} = \sum_{q} y_{dpq}. \quad (18)$$

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

$$r_{DID} = \frac{y_{DID}}{w_{DID} \cdot h_{DID}}, \quad (19)$$

$$r_{HTI} = \frac{y_{HTI}}{w_{HTI} \cdot h_{HTI}}. \quad (20)$$

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:

$$y_{dpk} = r_{DID} \cdot w_{HTI} \cdot h_{HTI}. \quad (21)$$

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,

$$y_{dpzs} = \sum_{q} \sum_{k} y_{dpzsqk} \quad (22)$$

,

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

$$h_{dpzs} = \sum_{q} \sum_{k} h_{dpzsqk} \quad (23)$$

.

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,

$$r_{dpz} = \frac{\sum_{s} y_{dpzs}}{\sum_{s} h_{dpzs}} \quad (24)$$

.

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,

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

,

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, since sonar counts are highly auto correlated (Wolter 1985). To accommodate these data characteristics, a variance estimator based on the squared differences of successive observations, recommended by Brannian (1986) and modified from Wolter (1985), was employed;

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

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

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

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),

$$\hat{Var}(\hat{y}_{ui}) = \hat{y}_u^2 \cdot \hat{Var}(\hat{p}_{ui}) + \hat{p}_{ui}^2 \cdot \hat{Var}(\hat{y}_u) - \hat{Var}(\hat{y}_u) \cdot \hat{Var}(\hat{p}_{ui}). \tag{29}$$

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

$$\hat{Var}(\hat{y}_i) = \sum_u \hat{Var}(\hat{y}_{ui}). \tag{30}$$

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 – 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, (since 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

Test fishing began on May 30, and the right bank split-beam sonar counts began on June 1. The split-beam sonar and DIDSON were operational on the left bank on June 3. The project was fully operational through September 7. Passage estimates were transmitted to fishery managers in Emmonak daily.

ENVIRONMENTAL AND HYDROLOGICAL CONDITIONS

Ice break-up on the Yukon River was sufficiently early which allowed for camp set up before June 1. The water levels during the 2009 season were uncharacteristically high near Pilot Station in early June and many areas along the river experienced flood conditions. Water levels then receded to below average depths by mid-July and remained unusually low throughout the remainder of the field season based on historical water levels from 2001 to 2008 (Figure 4). Temperatures on the left and right banks recorded on the data loggers ranged from 19.6°C on July 13 to 11.3°C on September 2 (Figure 7).

TEST FISHING

Drift gillnetting resulted in the capture of 6,101: 875 Chinook salmon, including 234 which were caught during the additional genetic study test fish period; 2,569 summer chum salmon; 440 fall chum salmon; 1,004 coho salmon; and 1,213 fish of other species. Of the captured fish, 2,452 (40%) 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 is 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 8). The correlation coefficient for Chinook salmon was $r = 0.655$ ($P < 0.001$), summer chum salmon was $r = 0.791$ ($P < 0.001$), fall chum salmon was $r = 0.841$ ($P < 0.001$), and coho salmon was $r = 0.858$ ($P < 0.001$).

HYDROACOUSTIC ESTIMATES

An estimated 2,794,441 fish passed through the sonar sampling areas between June 1 and September 7; 746,868 (26.7%) along the right bank, 1,073,591 (38.4%) along the left bank nearshore, and 973,982 (34.9%) along the left bank offshore (Table 7). Daily total passage estimates by zone, with their associated errors, are provided in Appendix C.

On the left bank, 93% of the fish passage occurred within 110 m from the transducer in the summer season (through July 18), but in the fall season (post July 18) distribution decreased to

71%. Ninety-seven percent of fish on the left bank were distributed less than 150 m from shore in the summer. Fish distribution was more dispersed during the fall with approximately 97% within 250 m of shore. On the right bank, approximately 98% of total fish passage occurred within 110 m in the summer and fall seasons (Figure 9).

SPECIES ESTIMATES

Daily passage estimates by species for the summer and fall seasons are listed in Appendix D. With the exception of others, chum salmon were the most abundant species during both summer and fall seasons. Cumulative passage estimates for all species from June 01 through September 7 totaled 2,794,441, comprised of 1,421,646 ± 73,533 (90% CI) summer chum salmon and 233,307 ± 39,587 fall chum salmon. Chinook salmon, were comprised of 108,361 ± 22,036 large Chinook salmon (>655 mm METF) and 35,688 ± 8,995 small Chinook salmon (≤655 mm METF). Coho salmon passage estimates were 206,620 ± 31,067, and the estimate of pink salmon was 23,679 ± 10,799. Other species, totaling 765,140 ± 57,206 fish, include whitefish, cisco, sheefish, burbot, longnose sucker, Dolly Varden, sockeye salmon, and northern pike. Historical passage estimates for all species are detailed in Appendix E.

Of the total passage, 9,056 Chinook salmon, 123,621 summer chum salmon, 4,227 fall chum salmon, and 5,648 coho salmon were additionally counted by the DIDSON within the 0 to 20 m region of the left bank nearshore (sectors 1 and 2 of stratum 3). The daily estimates of fish passing through this region of the left bank and the associated proportion (also referred to as the DIDSON contribution) of the total passage are detailed in Appendices F1 and F2.

Detected on June 9, The first major pulse of Chinook salmon began on approximately June 17, and the first pulse of summer chum salmon began on June 24 (Figure 10). The midpoints of the runs occurred on June 28 for both Chinook and summer chum salmon. Although both Chinook and summer chum salmon runs were uncharacteristically late during the first part of the run, comparison of the mean run timing for the years 2001 through 2008, indicate the overall timing of summer chum salmon was average and Chinook salmon run timing was one day early (Figure 11; Appendices G1 and G2).

The first major pulse of fall chum salmon occurred August 4 with the midpoint of the run passing Pilot Station on August 12. Coho salmon were first detected July 28, with 2 large pulses occurring on August 11 and August 18 (Figure 12). As in most years, the project ends before the coho salmon run is complete, so estimates are considered conservative. Similar to the Chinook and summer chum salmon run, fall chum salmon run timing early in the season appeared to be exceptionally late. As the run neared the midpoint, the cumulative timing normalized, and the fall chum salmon timing was 3 days late. The coho salmon run timing was 2 days late (Figure 13; Appendices G1 and G2).

MISSING DATA

In 2009, no data periods were lost due to heavy wind or wave action interfering with the sonar signal. However, the left bank substrate continued to be unstable, and problems with fish detection because of reverberation were encountered. As has been observed in prior years (Maxwell and Huttunen 1998; Maxwell 2000; Carroll and McIntosh 2008) the reverberation band was wide enough to obscure detection of fish. From June 3 to approximately June 23, bank erosion upstream caused large plumes of silt to pass through the sonar sampling area, undermining optimal detection of targets. On the echograms, the effect of the band was a dark

region with very low signal to noise ratio in which fish targets were hard to discern Those targets offshore of the band were highly attenuated, with fewer returns per target than they would normally in the absence of the band. Three data periods were lost on the left bank due to poor quality echograms as a result of the reverberation band. Three additional periods were also lost due to discrepancies between assigned rotator settings and actual rotator positioning. There are no missing data periods for the right bank. All periods lost occurred on different days, therefore passage estimates for these days were calculated based on the remaining periods.

During the summer season, 8 commercial fishing periods occurred in District 2 that interrupted 1 of the 2 daily test fishing periods. During the fall season, 3 commercial periods occurred during a test fishing period. The reporting units for these days were pooled with adjacent days that had 2 complete test fishery periods. There were 8 days during the 2009 season when insufficient numbers of fish were captured within one or more zone. Therefore, in order to estimate variance accurately those zones were pooled with zones which had sufficient catches on adjacent days. Zones that were pooled for variance estimation and the associated reason for pooling are listed with their corresponding reporting units in Table 8.

DISCUSSION

During the 2009 season, the ice on the Yukon River broke up on May 17 at Pilot Station (one day later than the historical 2001–2008 average), but ice flowing into the Andreafsky River delayed boat deployment and camp start up (which was scheduled for the fourth week of May). The ice break-up this year contributed to a series of natural disasters which included catastrophic flooding in many areas of the Yukon. Floods as a result of rapid melting snow resulted in high water levels which flooded over ice dams beyond the norm in many areas.

Because of high water levels and conditions as a result of the flooding early in the season, estimation of the early portion of the Chinook salmon run was challenging for all the lower river assessment projects. Summer and fall chum salmon estimates were below average with the fall chum run to be considered one of the lowest since 1995. Passage estimates for Chinook, summer and fall chum salmon this season are all considered conservative. Although the cumulative passage estimate of coho salmon at Pilot Station was well above average and correlated well with other down river assessment projects, coho salmon estimates have been regarded as inflated because of apportionment problems experienced during the fall season, as a result of record low water levels.

The right bank bottom profiles were similar to prior years with little or no change throughout the season but, upon arrival, the left bank profiles were very rough and non-linear. As the season progressed, the dips in the left bank profile filled in with sediment and then resembled those recorded in previous years. Scouring and erosion on the left bank continued to cause challenges with finding optimal transducer deployment. In previous seasons, transducer deployment sites were forced farther downriver from the sonar tent to the limits of the sonar cabling. To alleviate this problem in 2006, the left bank sonar site was relocated approximately 200 m downstream where acceptable profiles were found and deployment options were increased within the range of the sonar cabling. However, sonar cabling issues were again a problem this season as sites were forced upriver of the sonar tent. Weekly underwater profiling was conducted and the split-beam sonar and DIDSON were redeployed frequently to adjust to constant changes of the bottom profile. Because of the high water levels, transducer deployments were often made offshore using a skiff until July 5, which increased the challenge of transducer placement. Because of the

uncertainty of transducer orientation during offshore deployments, the use of attitude sensors should be considered in the future; attitude sensors will provide a more reliable indicator of transducer directionality as well as provide a more accurate illustration of beam aim and coverage.

During the first week of the fall season, the water level decreased below the historical mean and continued to decline throughout the remainder of the season (Figure 4). Because of these conditions, test fishing on the left bank was problematic and species apportionment became difficult as the fall season progressed. The correlation between CPUE and passage became very poor in the left bank nearshore and offshore strata. Low catches in these ranges often necessitated pooling counts across many days into report periods which additionally would result in report periods with relatively high passages but low CPUEs. Experimental test fisheries below the sonar site were employed to determine the reliability of apportionment of the left bank passage. Results of the extra fishing periods showed an increased CPUE for fall chum salmon compared to the CPUE generated during normal test fishing. Because of these results, it is speculated that the low catches during the normal test fishery may have been due to net avoidance by fall chum salmon, caused by factors attributed to low water levels. Although catches downriver suggest that the fall chum salmon passage may have been misapportioned, the CPUE data collected could not be substituted and used in calculations of apportionment because of the uncertainty of upstream fish distribution past the transducers. Future considerations need to be made to re-evaluate the methodology of calculating passage estimates and applying some flexibility of using CPUE data collected from alternative sites. Additional investigations need to be made to compare alternative test fishing protocols including test fish net length, and alternative methods of passage detection to increase the accuracy of salmon passage estimates generated at Pilot Station.

Water levels and changes to the left bank profile are also thought to have changed fall season fish distribution and affected the proportions of total passage of fish in sectors 1 and 2 of the left bank nearshore (the area counted by the DIDSON). Though proportions of fish passage detected nearshore on left bank with the DIDSON were significant in 2005 and 2006, the 2009 DIDSON generated passage estimates contributed much less to the total passage than previous seasons (6.3% of Chinook, 8.7% of summer chum, 1.8% of fall chum, and 2.7% of coho salmon) and more closely resembled the passage estimates that were observed in 2007 (Figure 14). This indicates that the majority of fish were distributed further than 20 m from shore. Given the more linear profiles seen in the past, it is likely the split-beam system was detecting passage adequately inshore. Because of the unusual fish passage distribution observed this season, the split-beam was extended out to a range of 300 m from August 10 to September 7 to determine if fish passage was significant beyond the normal ensonified area. Passage estimates indicate that approximately 4.78% of the total left bank passage during this time was observed beyond 250 m thus verifying that a low percent of the passage occurred beyond the normal ensonified sampling area.

Two sandbars have been observed in past seasons (Maxwell et al. 1997; Maxwell and Huttunen 1998; Rich 2001; Pfisterer 2002); the Atchuelinguk sandbar which extends downstream along the right bank from the confluence of the Atchuelinguk and Yukon rivers to slightly downstream of the first slough entrance, and the mid-river sand bar which has extended from the river bend downstream past the left bank sampling area (Figure 15). In the past, the mid-river sandbar's morphology has been monitored and test fisheries have been conducted to document fish

distribution along the bar (Rich 2001). Bathymetric surveys of the river profile conducted in 2009 found that the mid-river sandbar had totally regressed. Considerable shallowing of the substrate on the left bank was also noted, and significant profile changes were observed compared to bathymetric profiling conducted in 2004 (Figure 16).

Postseason linear regression analysis at Pilot Station in 2008 comparing split-beam data recorded both on electronic echograms and paper charts proved the overall effectiveness of enumerating passage estimates using echograms was suitable to be integrated at the project (Naomi Brodersen, Commercial Fisheries Biologist ADF&G, Fairbanks; personal communication). In 2009, electronic echograms replaced paper charts for counting fish traces. The introduction of electronic echograms this season was a smooth transition and proved to be a useful tool at the project. Because technicians were able to manually adjust threshold settings and manipulate echograms, fish trace detection was greatly improved. Direction of travel was easily determined and the threshold setting could be adjusted to eliminate environmental disturbances such as wave action and, in some cases, reverberation caused by the large sediment load observed this season. Echogram files stored on a RAID drive could be easily reviewed and edited by project leaders. Additionally, count files were linked to the SAS program, eliminating the need to manually enter count data into the database.

The established three 3 h sampling schedule and the 24 h sonar periods comparisons have historically shown relatively close agreement, but we expect the 24 h counts to be lower, and that is most often the case. Between 1998 and 2007, 47 continuous 24 h periods were conducted. Of the estimates produced in these periods, 39 agreed within +/- 10% of the three 3 h estimates, and as expected, 60% of the 24 h periods produced estimates that were lower than those produced from the standard three 3 h sampling as shown in Appendix H. This general agreement between the 24 h estimates and the standard estimates through time indicate that continued testing of the performance of the sampling plan is unnecessary. Furthermore, the costs of running the 24 h periods are high, and for these reasons are being discontinued at the project. During the 2009 season, 24 h sampling was conducted for 3 days in an effort to compare estimates during the fall chum salmon pulses. Because of low passage estimates and technical problems during the time of these sampling periods, the data collected was not used for 24 h comparisons.

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TABLES AND FIGURES

Table 1.–Initial split-beam sonar settings at the Pilot Station sonar site on the Yukon River, 2009.

Component	Setting	Stratum	Bank	
			Left	Right
Transducer	Beam size (h x w)		2.8º x 10.0º	6.0º x 10.0º
Echosounder	Transmit power (dB)		30.0	27.0
	Receiver gain (dB)	S1		-20.0
		S2		-20.0
		S3	-12.0	
		S4	-9.0	
		S5	-3.0	
	Source Level (dB)		225.5	216.8
	Through-system gain (dB)		-160.2	-160.9
	Pulse width (ms)		0.5	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	2.0	
	Range (m)	S1		50
		S2		150
		S3	50	
		S4	150	
		S5	300	

Table 2.–Technical specifications for the dual frequency identification sonar at the Pilot Station sonar site on the Yukon River, 2009.

Identification Mode		
	Operating Frequency	1.2 MHz
	Beam width (two-way)	0.5° H by 17 ° 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		29°

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

Time	Sonar		Test fishing
	Right Bank	Left Bank	
	Period 1		
0530	S1	S3	
0600	S2	S4	
0630	S1	S5	
0700	S2	S3	
0730	S1	S4	
0800	S2	S5	
0830			
0900			Period 1
0930			
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 site on the Yukon River, 2009.

Table 4.–Specifications for drift gillnets used for test fishing by season, at the Pilot Station sonar site on the Yukon River, 2009.

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 site on the Yukon River, 2009.

Season	Test fish Period	Calendar Day			
		Odd		Even	
		Mesh size (in)		Mesh size (in)	
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 2009.

Total Catch												
	Chinook [a]	S Chum	F Chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others [b]	Total
May	0	0	0	0	0	0	3	0	0	18	0	21
June	750	1,754	0	0	0	0	26	43	4	205	4	2786
July	125	815	101	11	3	40	172	145	28	24	21	1485
August	0	0	315	2	875	14	192	139	21	15	49	1622
September	0	0	24	0	126	0	20	13	2	1	1	187
Total	875	2,569	440	13	1,004	54	413	340	55	263	75	6,101

Fish Retained												
	Chinook	S Chum	F Chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others	Total
May	0	0	0	0	0	0	3	0	0	5	0	8
June	459	818	0	0	0	0	18	17	2	144	1	1459
July	47	239	29	5	2	0	96	14	9	17	0	458
August	0	0	194	2	165	0	112	0	3	5	2	483
September	0	0	16	1	14	0	10	1	1	1	0	44
Total	506	1,057	239	8	181	0	239	32	15	172	3	2,452

Proportion Retained												
	Chinook	S Chum	F Chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others	Total
May	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.278	0.000	0.381
June	0.612	0.466	0.000	0.000	0.000	0.000	0.692	0.395	0.500	0.702	0.250	0.524
July	0.376	0.293	0.287	0.455	0.667	0.000	0.558	0.097	0.321	0.708	0.000	0.308
August	0.000	0.000	0.616	1.000	0.189	0.000	0.583	0.000	0.143	0.333	0.041	0.298
September	0.000	0.000	0.667	0.000	0.111	0.000	0.500	0.077	0.500	1.000	0.000	0.235
Total	0.578	0.411	0.543	0.615	0.180	0.000	0.579	0.094	0.273	0.654	0.040	0.402

[a] Includes 234 Chinook salmon caught in the "Period 0" sampling test fish period.

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

Table 7.–Cumulative fish passage estimates by zone and by species at Pilot Station sonar on the Yukon River, with standard errors (SE) and 90% confidence intervals (CI), 2009.

		Left Bank				90% CI	
Species	Right Bank	Nearshore	Offshore	Total Passage	SE	Lower	Upper
Large Chinook [a]	36,892	24,512	46,957	108,361	13,396	86,324	130,398
Small Chinook	9,009	15,452	11,227	35,688	5,468	26,693	44,683
Summer chum	388,955	602,541	430,150	1,421,646	44,701	1,348,113	1,495,179
Fall chum	29,304	25,087	178,916	233,307	24,065	193,720	272,894
Coho	76,070	38,213	92,337	206,620	18,886	175,552	237,688
Pink	6,406	14,655	2,618	23,679	6,565	12,880	34,478
Other	200,232	353,131	211,777	765,140	34,776	707,934	822,346
Total	746,868	1,073,591	973,982	2,794,441			

[a] Large Chinook are >655 mm METF, small Chinook ≤655 mm METF.

Table 8.–Reporting units of zones pooled for the 2009 season at the Pilot Station sonar site on the Yukon River.

Date	Right Bank (Zone 1)	Left Bank Nearshore (Zone 2)	Left Bank Offshore (Zone 3)	Reason for pooling [a]
6/01 6/02 6/03 6/04 6/05 6/06 6/07	1	2	3	I.C.
6/28 6/29	64	65	66	C.O.
6/30 7/01	70	71	72	C.O.
7/03 7/04	82	83	84	C.O.
7/06 7/07	91	92	93	C.O.
7/08 7/09	94	95	96	C.O.
7/13 7/14	112	113	114	C.O.
7/16 7/17	121	122	123	C.O
7/20 7/21	133	134	135	C.O.
7/26 7/27	148	149	150	C.O.
8/02 8/03	169	170	171	C.O
8/11 8/12		194		I.C
8/19 8/20		218	219	I.C.
8/21 8/22		224	225	I.C.

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Table 8.–Page 2 of 2.

Date	Right Bank (Zone 1)	Left Bank Nearshore (Zone 2)	Left Bank Offshore (Zone 3)	Reason for pooling [a]
8/23 8/24		230	231	I.C.
8/25 8/26 8/27		239	240	I.C.
8/31 9/1	251	252	253	I.C
9/3 9/4		258		I.C.

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

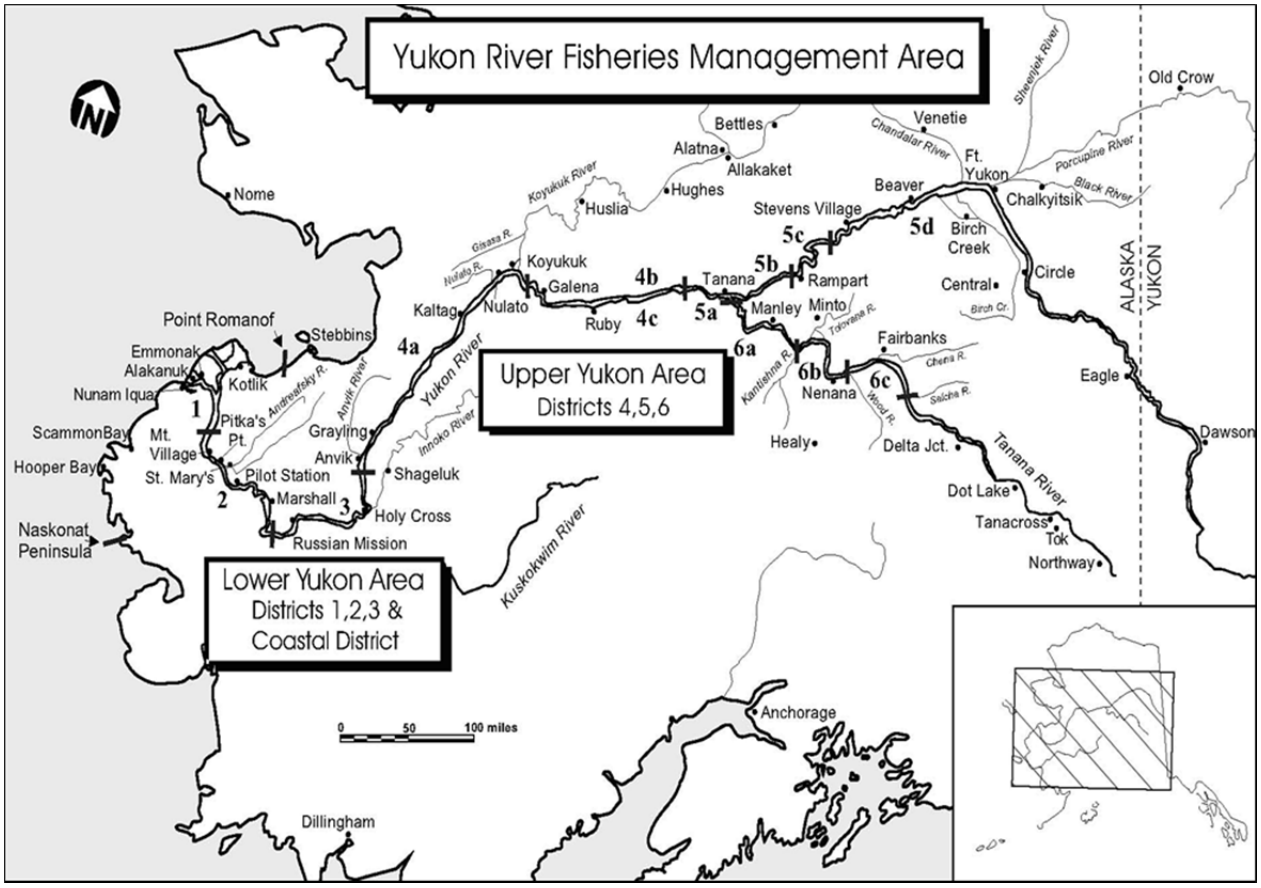


Figure 1.–Fishing districts and communities of the Yukon River watershed.

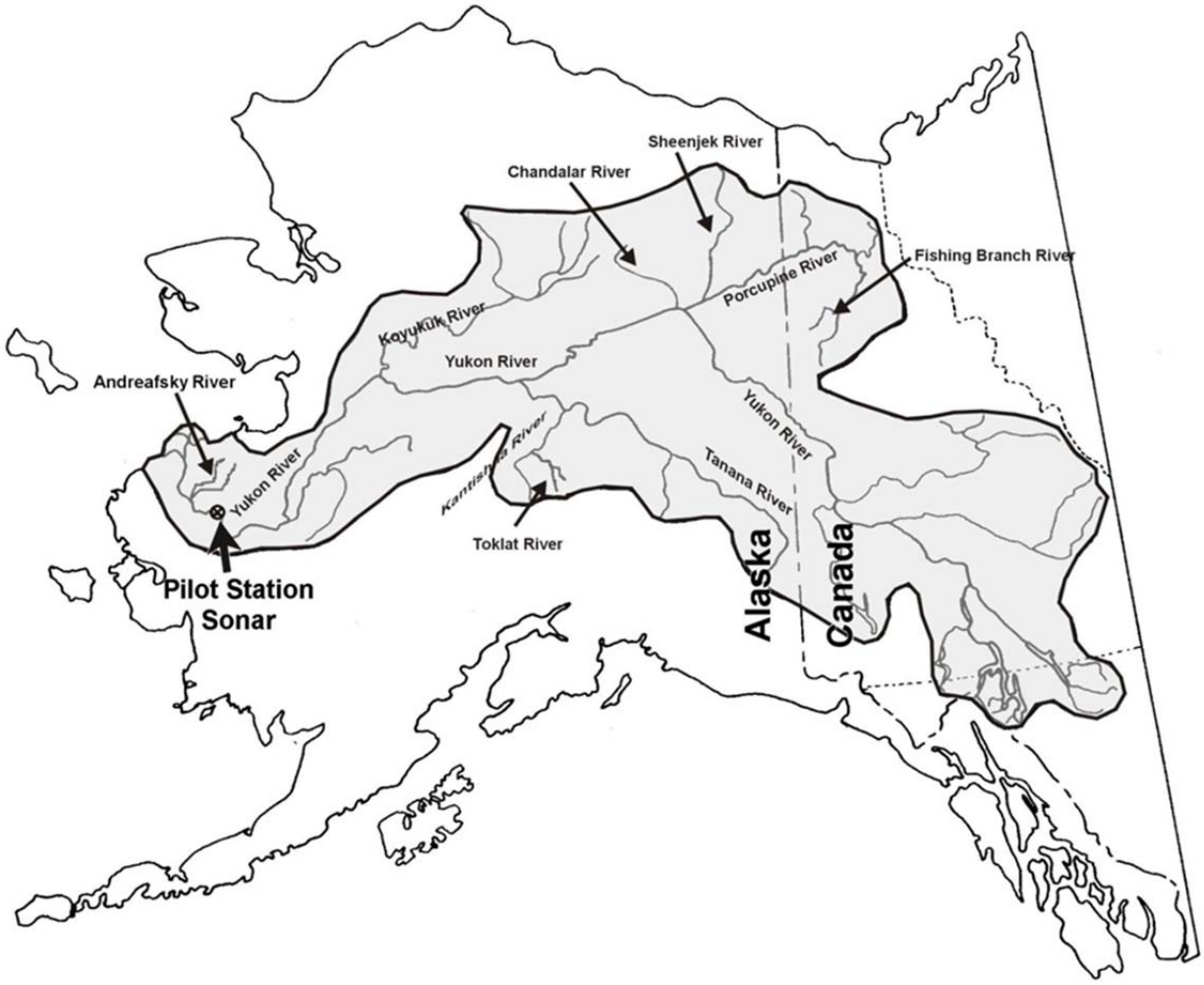


Figure 2.–Extent of Yukon River drainage.

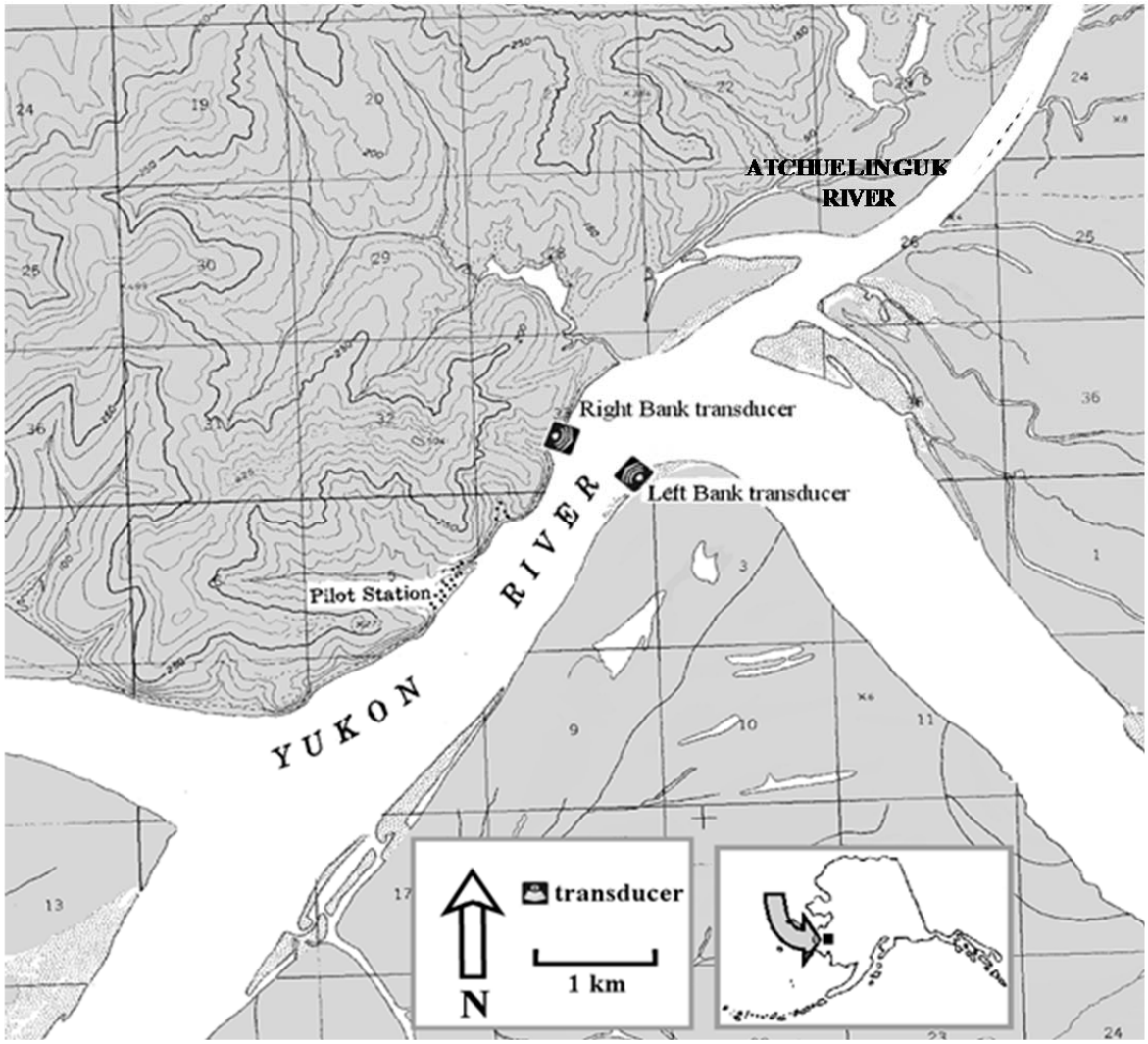
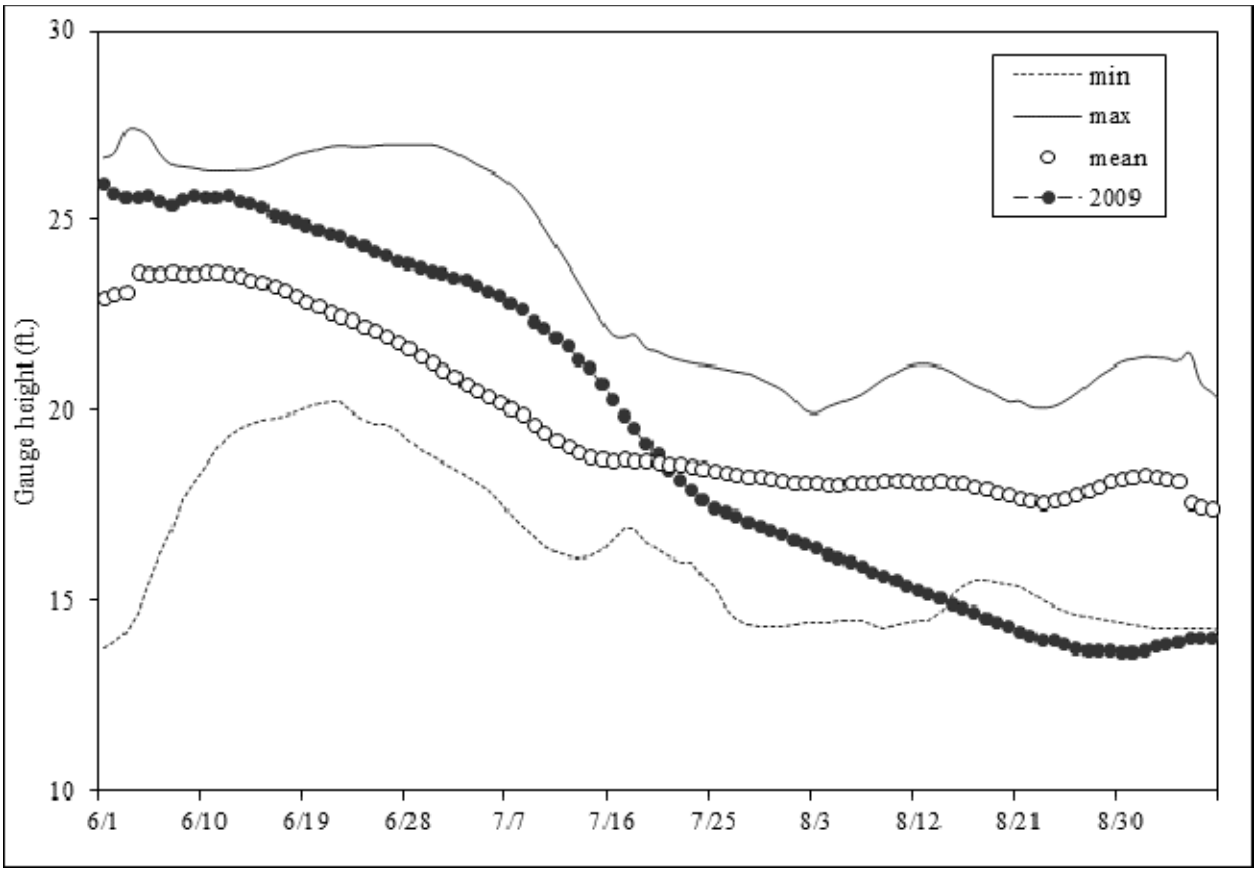


Figure 3.–Location of Pilot Station sonar project showing general transducer sites.



Source: United States Geological Service.

Note: Missing values were estimated using linear interpolation.

Figure 4.–Yukon River daily water level during the 2009 season at Pilot Station water gage compared to minimum, maximum, and mean gage height 2001 to 2008.

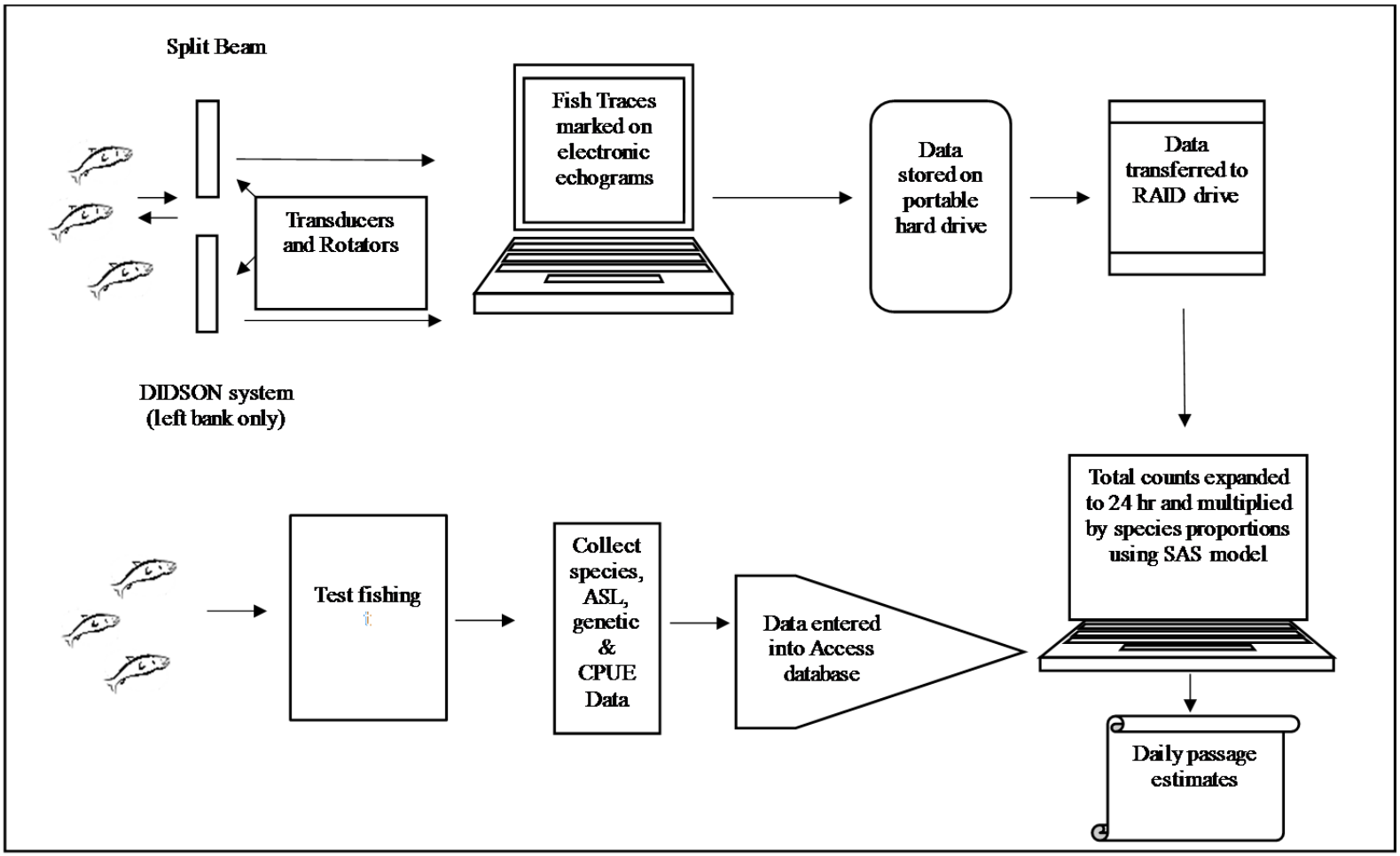


Figure 5.–Flow diagram of data collection and processing at the Pilot Station sonar site on the Yukon River, 2009.

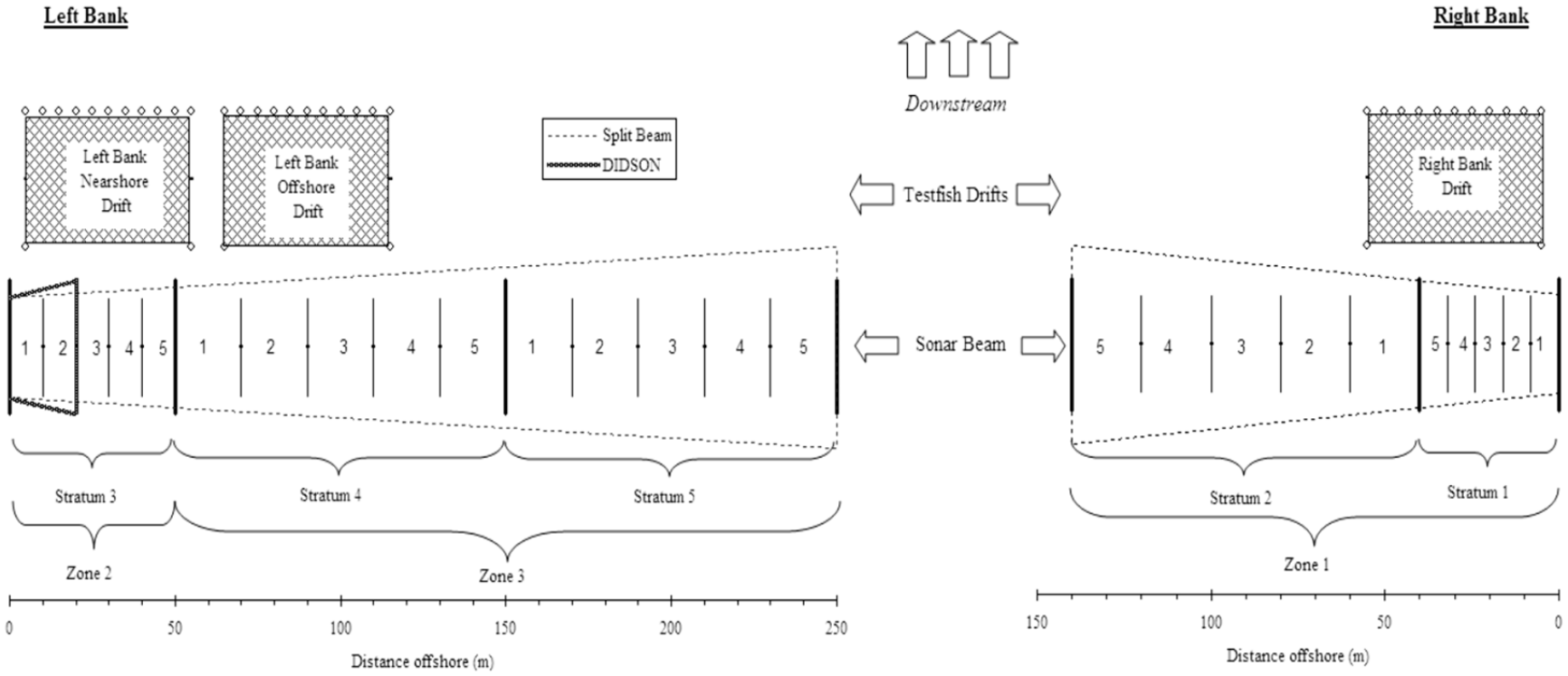


Figure 6.–Illustration of relationships between strata, sectors, zones, test fish drifts, and approximate sonar ranges (not to scale) at the Pilot Station sonar project, on the Yukon River 2009.

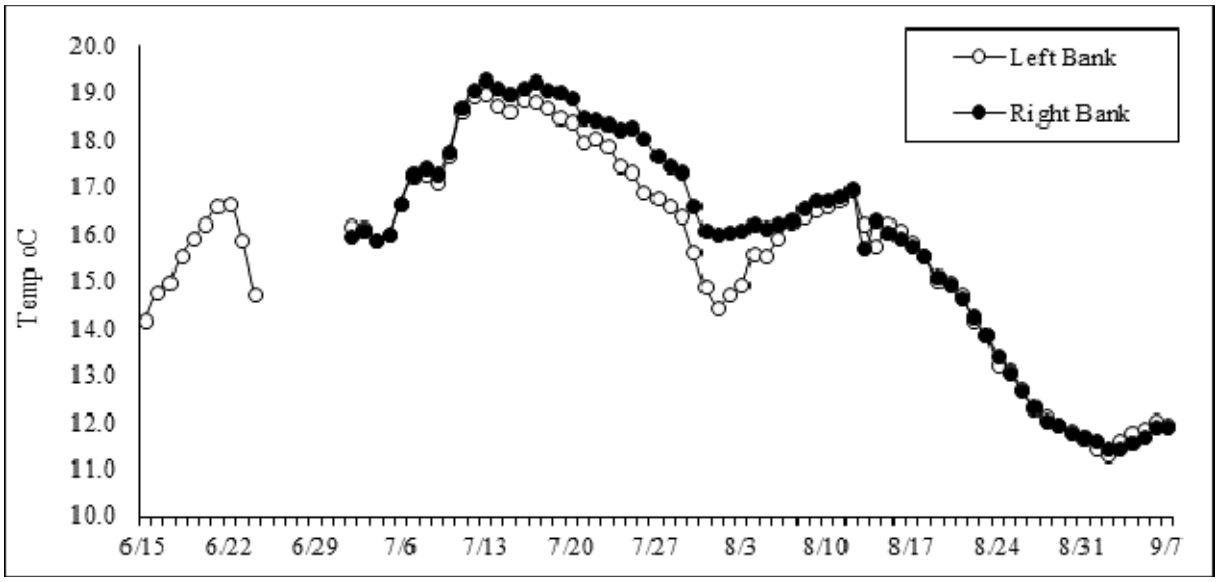


Figure 7.–Water temperatures recorded at the Pilot Station sonar project on the Yukon River with electronic data loggers by bank, 2009.

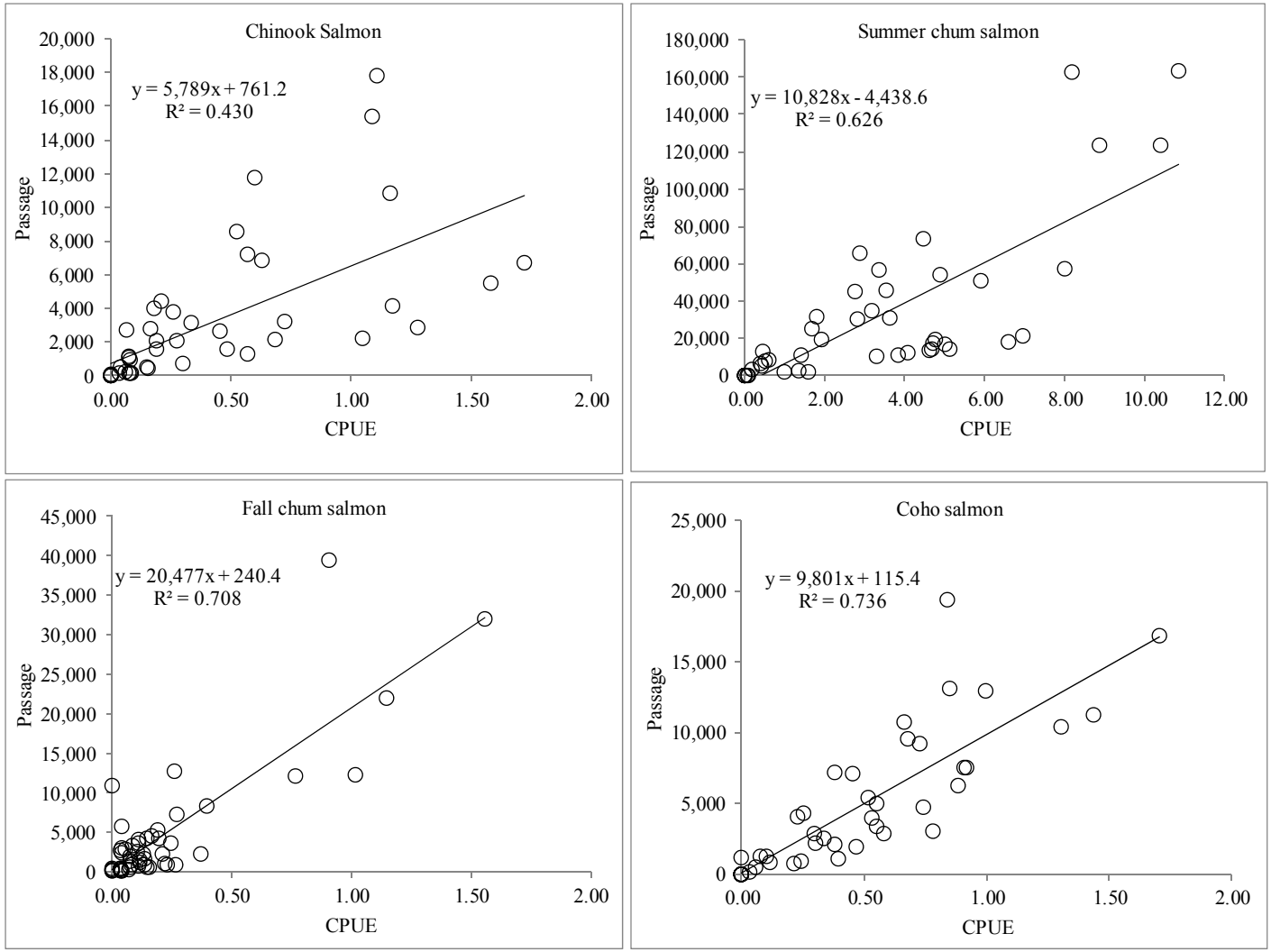


Figure 8.–Scatter plots of daily fish passage versus CPUE for Chinook, summer chum, fall chum, and coho salmon, at the Pilot Station sonar site on the Yukon River, 2009.

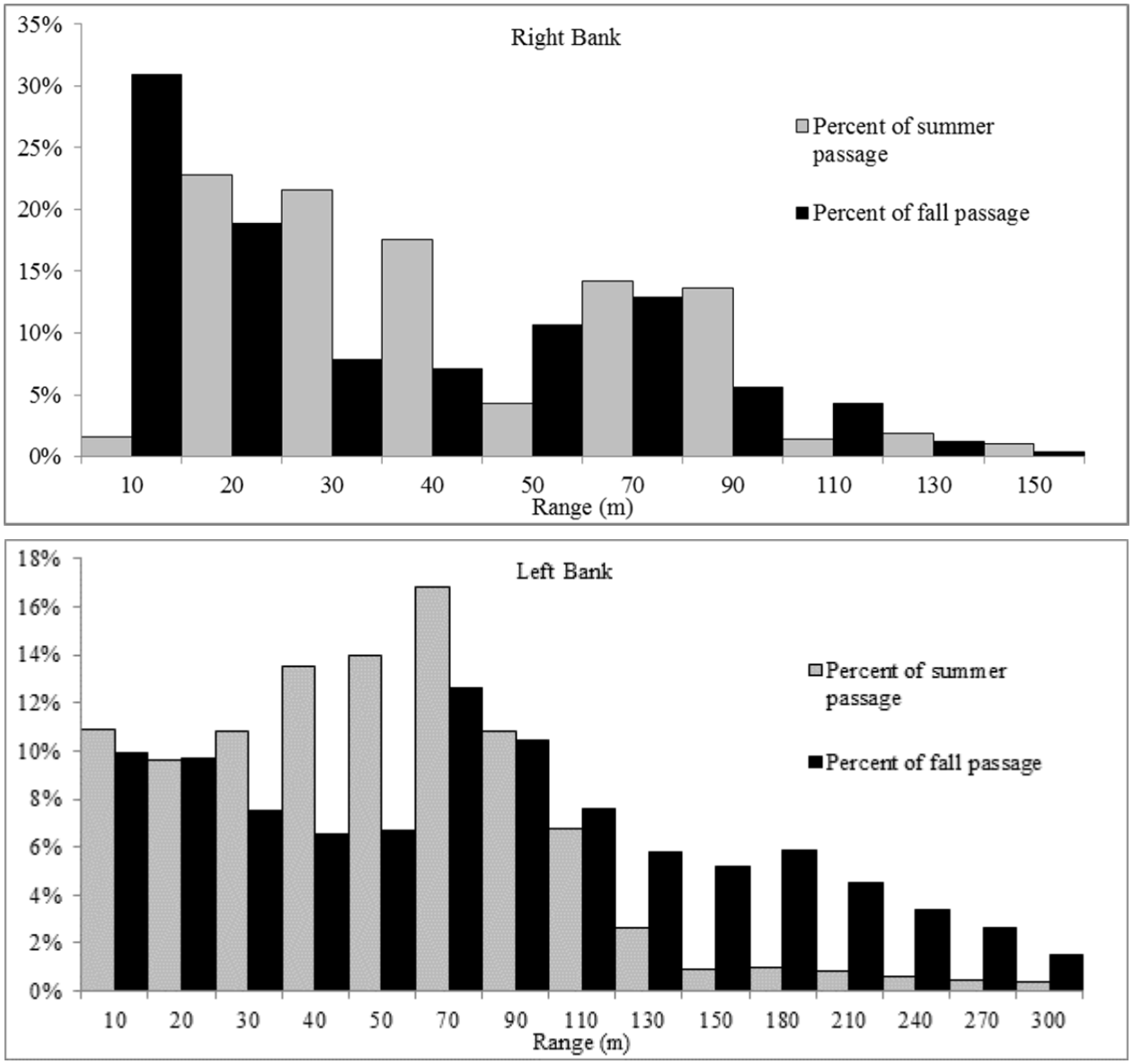


Figure 9.–Horizontal fish distribution (distance from transducer) by bank and season, at the Pilot Station sonar site on the Yukon River, 2009.

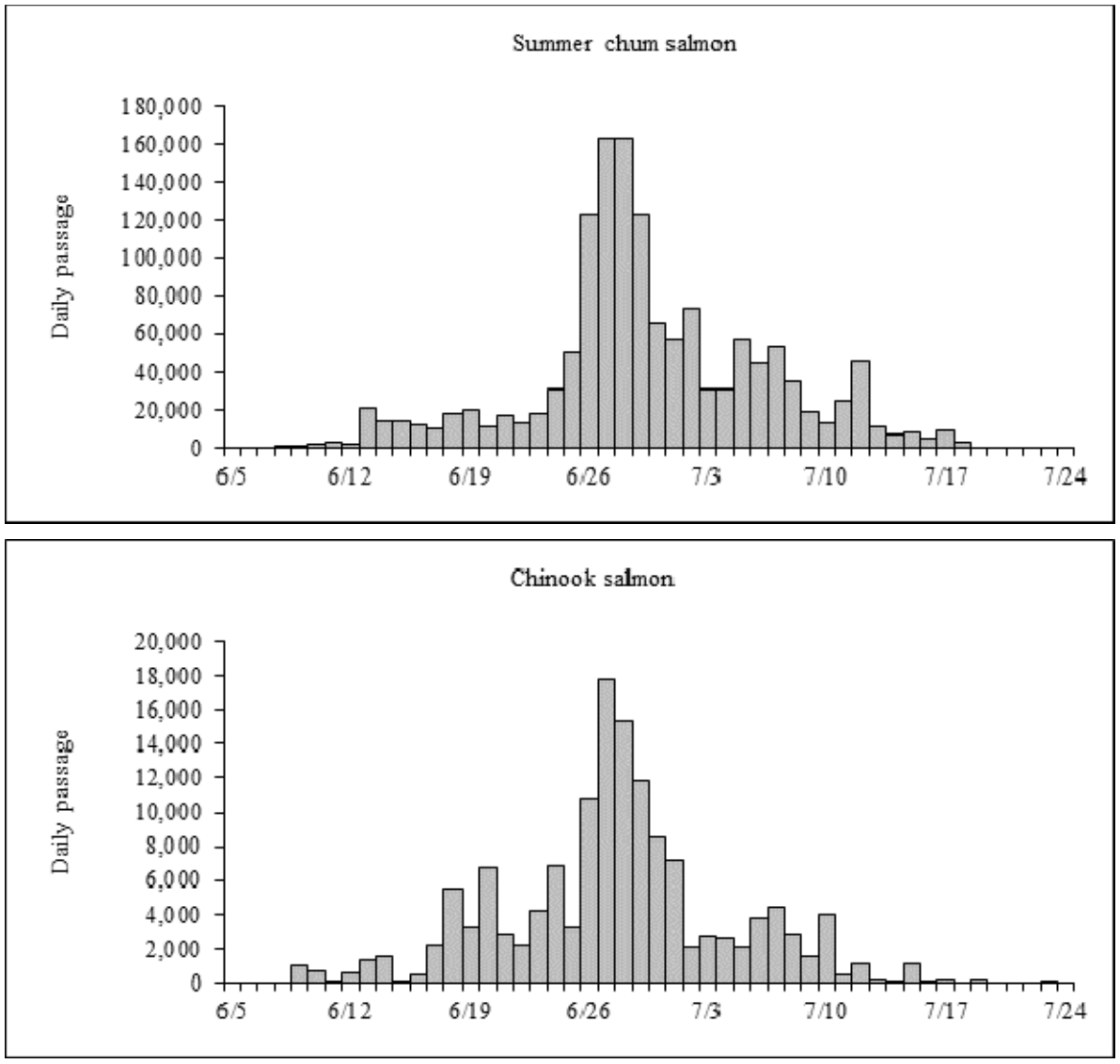


Figure 10.–Summer chum and Chinook salmon daily passage estimates, at the Pilot Station sonar site on the Yukon River, 2009.

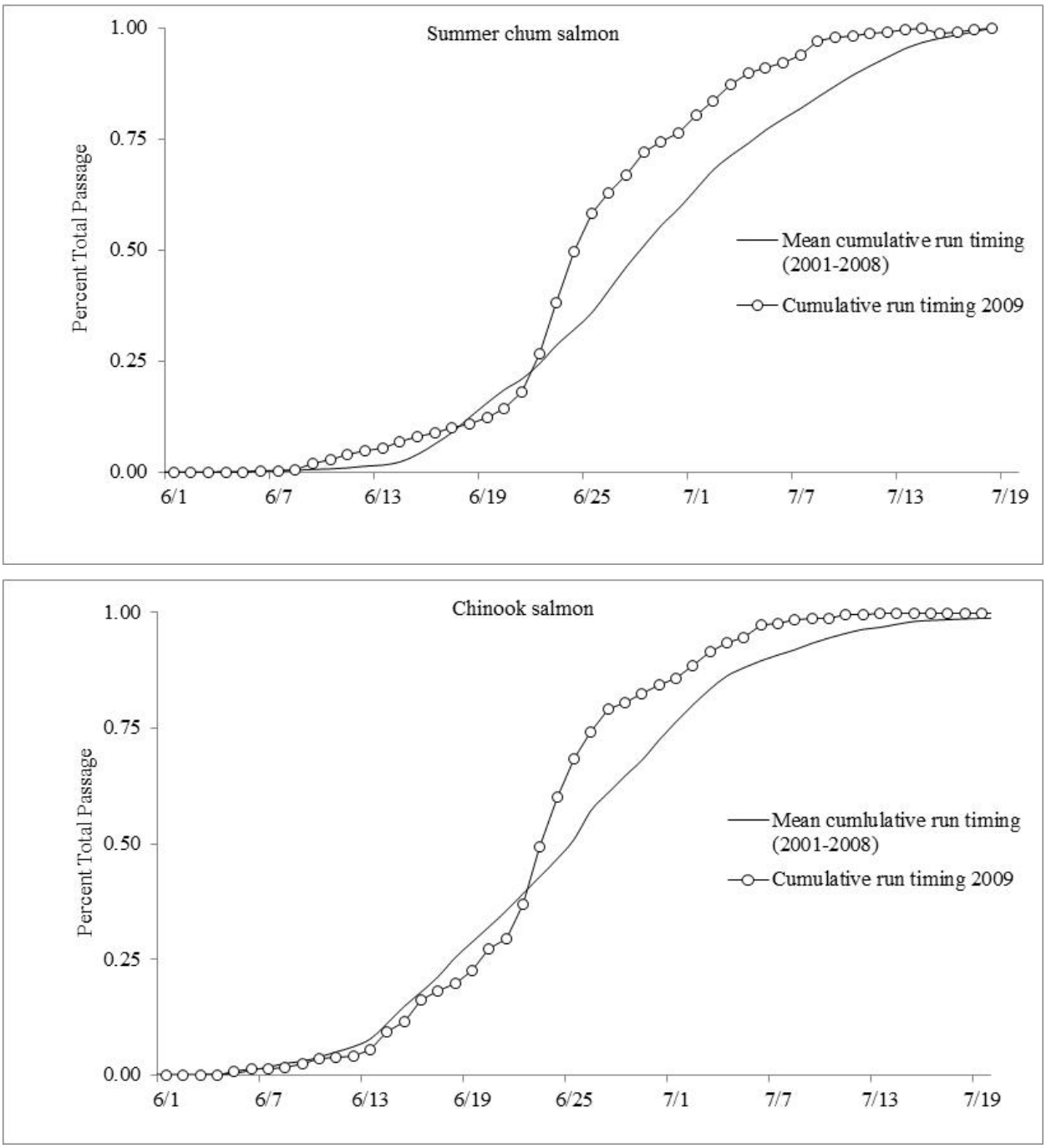


Figure 11.–2009 Chinook and summer chum salmon daily cumulative passage timing compared to the 2001–2008 mean passage timing at the Pilot Station sonar site, on the Yukon River.

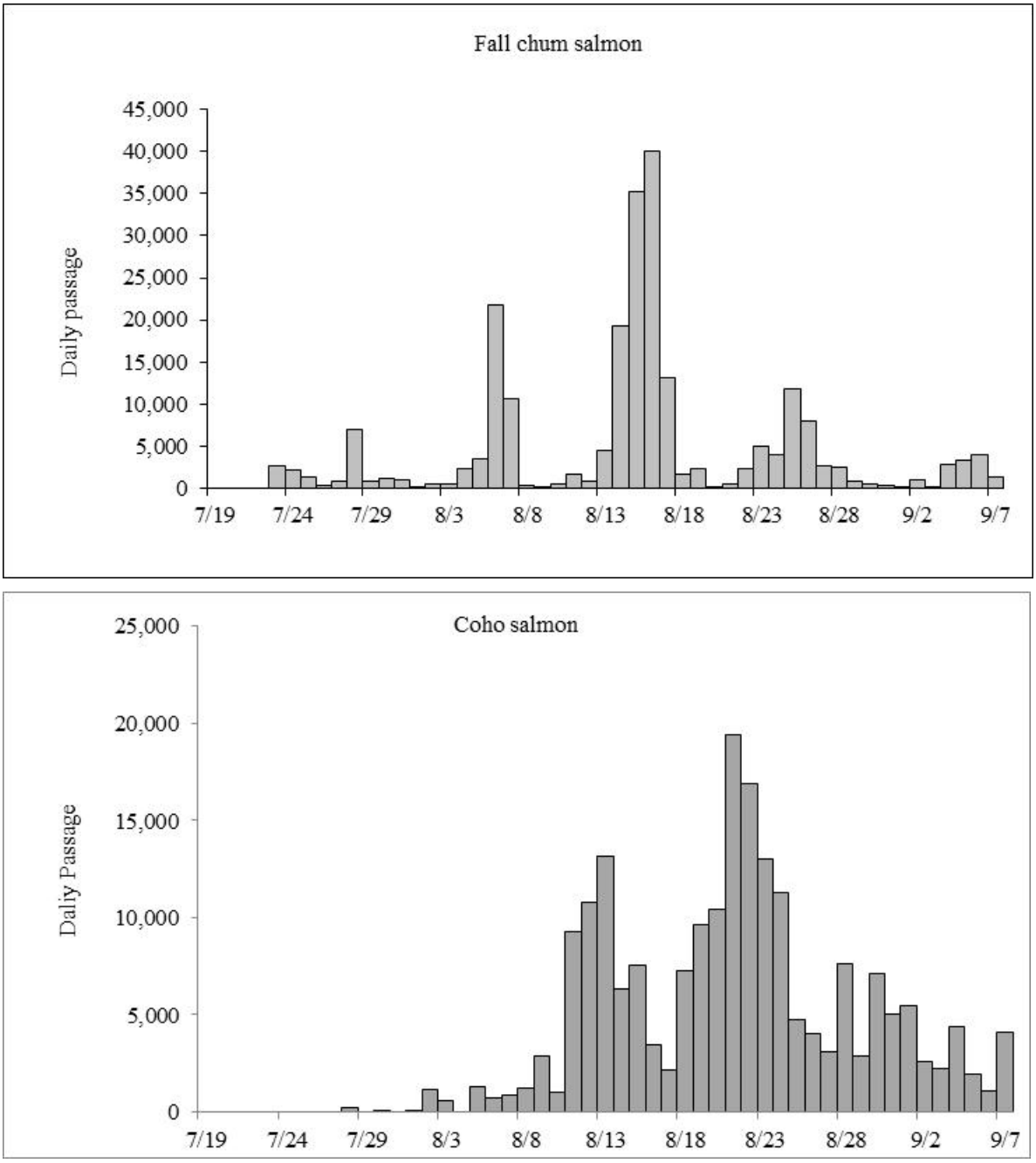


Figure 12.–Fall chum and coho salmon daily passage estimates, at the Pilot Station sonar site on the Yukon River, 2009.

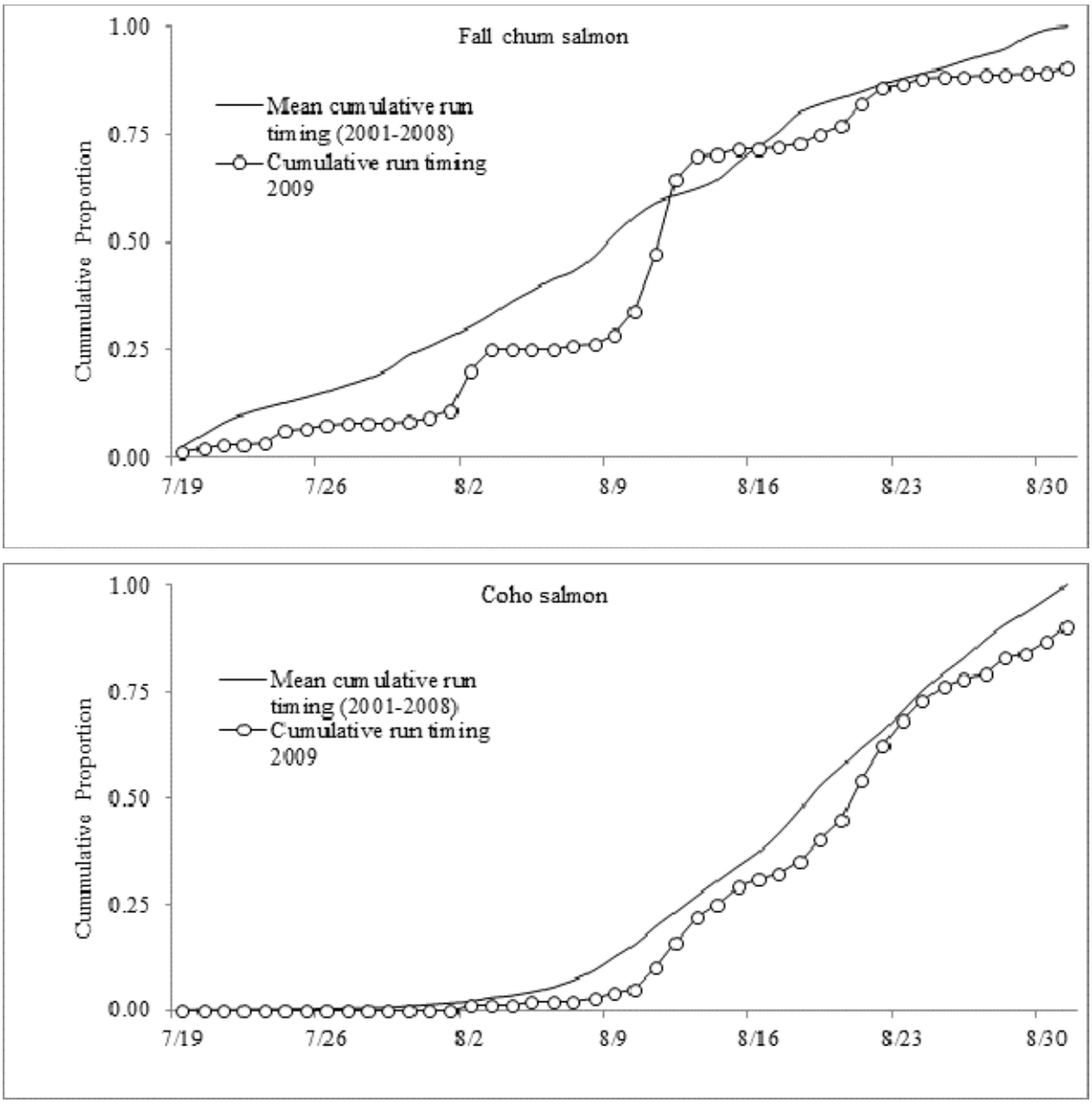


Figure 13.–Fall chum and coho salmon daily cumulative mean 2001–2008 passage timing compared to 2009 passage at the Pilot Station sonar site, on the Yukon River.

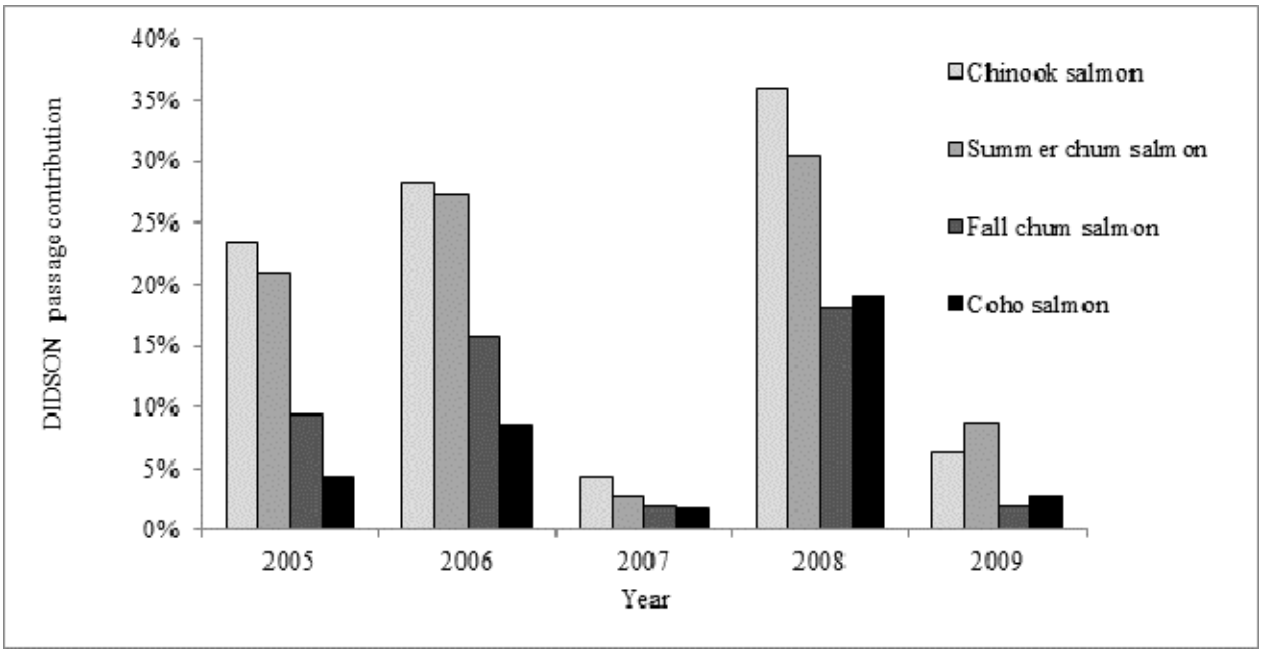


Figure 14.–Percent of additional passage contributed by the DIDSON 2005–2009 at the Pilot Station sonar site, on the Yukon river, relative to split beam in the same area (zone 2, sectors 1 and 2 in stratum 3).

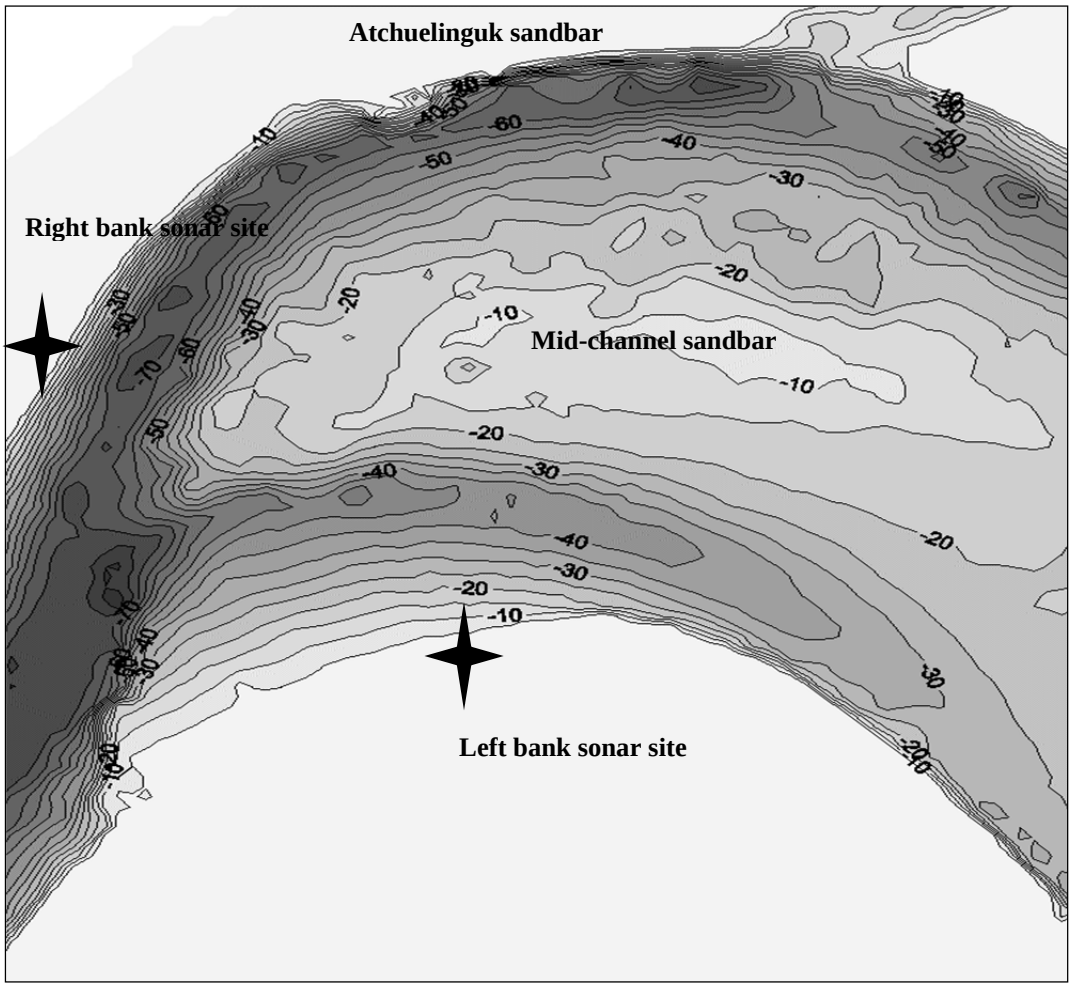


Figure 15.–2004 Bathymetric chart showing the location of the Atchuelinguk and Midchannel sandbars in the Yukon River.

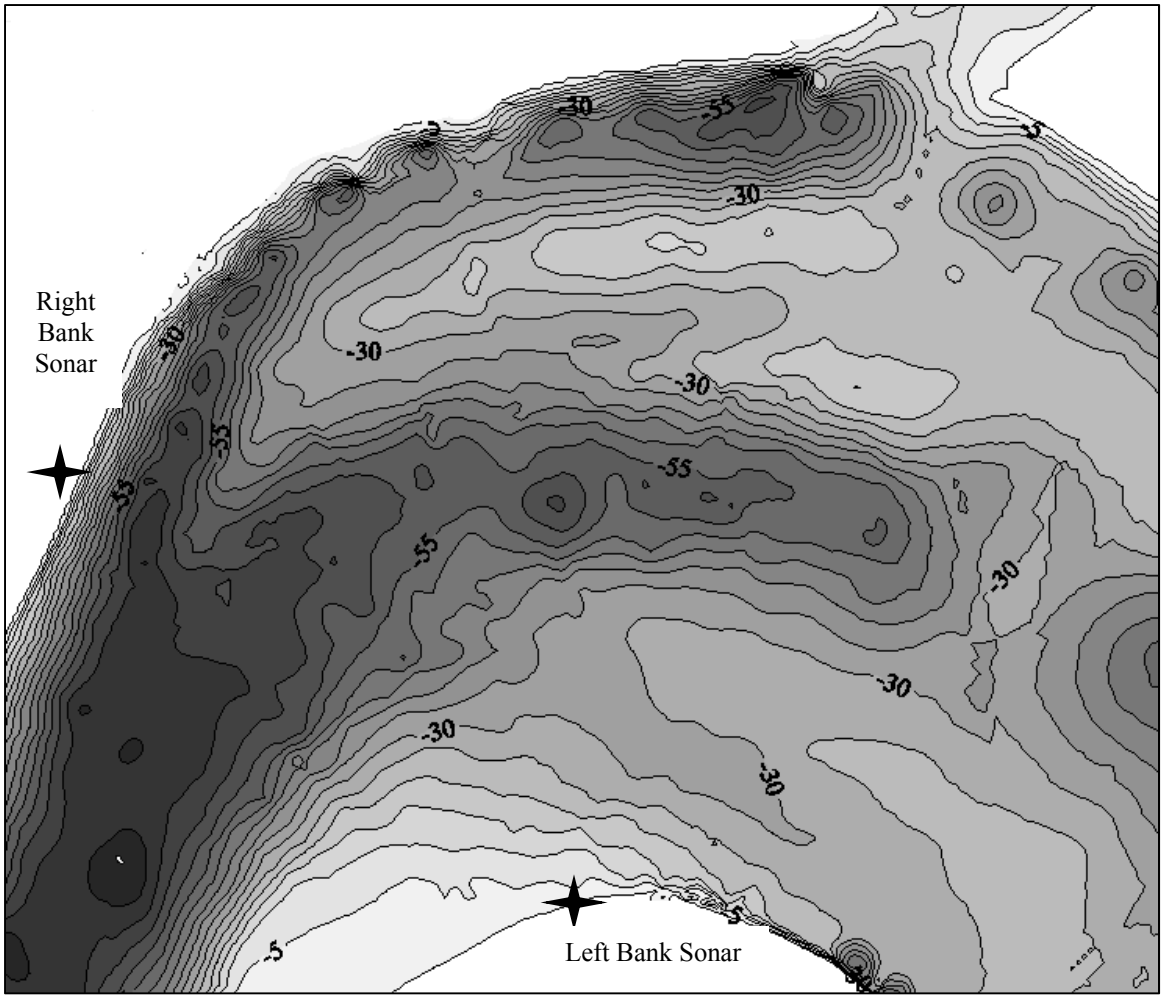


Figure 16.–2009 Bathymetric chart showing the regression of the Midchannel sandbar and shallowing of the left bank profile in the Yukon River.

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

Appendix A1.–Net selectivity parameters used in fish species apportionment at Pilot Station sonar, on the Yukon River 2009.

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 CPUE BY DAY AND BANK

Appendix B1.–Left bank CPUE by day and salmon species at the Pilot Station sonar site on the Yukon River, 2009.

	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	9.77	0	0.00	6.08	0	0.00	0	0.00	0	0.00
6/02	15.12	0	0.00	17.01	0	0.00	0	0.00	0	0.00
6/03	17.03	0	0.00	16.80	0	0.00	0	0.00	0	0.00
6/04	18.99	0	0.00	17.09	0	0.00	0	0.00	0	0.00
6/05	16.85	0	0.00	18.34	0	0.00	0	0.00	0	0.00
6/06	17.34	0	0.00	18.39	0	0.00	0	0.00	0	0.00
6/07	18.79	0	0.00	17.78	0	0.00	0	0.00	0	0.00
6/08	20.56	0	0.00	19.79	2	0.10	0	0.00	0	0.00
6/09	17.03	1	0.06	17.74	2	0.11	0	0.00	0	0.00
6/10	17.55	6	0.34	15.49	22	1.42	0	0.00	0	0.00
6/11	16.76	2	0.12	18.01	36	2.00	0	0.00	0	0.00
6/12	18.07	4	0.22	13.05	32	2.45	0	0.00	0	0.00
6/13	15.69	9	0.57	8.31	79	9.51	0	0.00	0	0.00
6/14	15.56	7	0.45	11.07	65	5.87	0	0.00	0	0.00
6/15	16.47	2	0.12	13.72	64	4.67	0	0.00	0	0.00
6/16	18.84	4	0.21	10.04	48	4.78	0	0.00	0	0.00
6/17	14.73	21	1.43	9.46	23	2.43	0	0.00	0	0.00
6/18	15.38	23	1.50	7.62	56	7.35	0	0.00	0	0.00
6/19	15.42	10	0.65	10.92	56	5.13	0	0.00	0	0.00
6/20	13.74	21	1.53	6.61	31	4.69	0	0.00	0	0.00
6/21	14.73	19	1.29	8.10	37	4.57	0	0.00	0	0.00
6/22	13.65	9	0.66	8.66	42	4.85	0	0.00	0	0.00
6/23	11.62	19	1.63	8.49	45	5.30	0	0.00	0	0.00
6/24	15.97	11	0.69	8.44	28	3.32	0	0.00	0	0.00
6/25	17.02	5	0.29	7.03	46	6.55	0	0.00	0	0.00
6/26	11.45	17	1.48	7.75	85	10.96	0	0.00	0	0.00
6/27	13.57	20	1.47	5.60	67	11.96	0	0.00	0	0.00
6/28	11.12	11	0.99	6.00	81	13.51	0	0.00	0	0.00
6/29	9.56	3	0.31	5.39	51	9.46	0	0.00	0	0.00
6/30	19.23	6	0.31	7.83	30	3.83	0	0.00	0	0.00
7/01	8.49	5	0.59	3.95	34	8.61	0	0.00	0	0.00
7/02	14.52	6	0.41	8.46	43	5.08	0	0.00	0	0.00
7/03	10.25	1	0.10	11.74	38	3.24	0	0.00	0	0.00
7/04	16.51	10	0.61	12.72	30	2.36	0	0.00	0	0.00
7/05	19.01	3	0.16	12.11	42	3.47	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	10.69	4	0.37	8.13	18	2.21	0	0.00	0	0.00
7/07	16.28	3	0.18	8.82	64	7.26	0	0.00	0	0.00
7/08	16.84	3	0.18	11.59	40	3.45	0	0.00	0	0.00
7/09	10.61	1	0.09	9.84	21	2.13	0	0.00	0	0.00
7/10	19.43	5	0.26	12.99	9	0.69	0	0.00	0	0.00
7/11	15.89	1	0.06	14.06	35	2.49	0	0.00	0	0.00
7/12	18.65	0	0.00	9.05	30	3.32	0	0.00	0	0.00
7/13	11.08	0	0.00	11.36	13	1.14	0	0.00	0	0.00
7/14	18.42	2	0.11	19.57	6	0.31	0	0.00	0	0.00
7/15	17.33	2	0.12	17.60	8	0.45	0	0.00	0	0.00
7/16	13.02	0	0.00	12.57	3	0.24	0	0.00	0	0.00
7/17	17.79	1	0.06	17.89	11	0.61	0	0.00	0	0.00
7/18	18.34	0	0.00	14.37	2	0.14	0	0.00	0	0.00
7/19	11.65	0	0.00	13.08	0	0.00	0	0.00	0	0.00
7/20	5.43	0	0.00	10.31	0	0.00	0	0.00	0	0.00
7/21	6.84	0	0.00	18.34	0	0.00	2	0.11	0	0.00
7/22	7.17	0	0.00	18.64	0	0.00	0	0.00	0	0.00
7/23	6.58	1	0.15	20.51	0	0.00	1	0.05	0	0.00
7/24	6.13	0	0.00	17.13	0	0.00	4	0.23	0	0.00
7/25	6.40	0	0.00	17.81	0	0.00	1	0.06	0	0.00
7/26	5.80	0	0.00	17.95	0	0.00	2	0.11	0	0.00
7/27	6.57	0	0.00	11.84	0	0.00	2	0.17	0	0.00
7/28	7.14	0	0.00	20.15	0	0.00	0	0.00	1	0.05
7/29	6.36	0	0.00	18.95	0	0.00	1	0.05	0	0.00
7/30	6.13	0	0.00	17.12	0	0.00	1	0.06	0	0.00
7/31	5.89	0	0.00	17.77	0	0.00	3	0.17	0	0.00
8/01	6.62	0	0.00	19.03	0	0.00	4	0.21	0	0.00
8/02	6.05	0	0.00	13.38	0	0.00	16	1.20	0	0.00
8/03	6.09	0	0.00	12.76	0	0.00	0	0.00	0	0.00
8/04	6.97	0	0.00	19.76	0	0.00	0	0.00	0	0.00
8/05	5.78	0	0.00	17.96	0	0.00	0	0.00	1	0.06
8/06	6.25	0	0.00	19.19	0	0.00	1	0.05	2	0.10
8/07	5.85	0	0.00	17.81	0	0.00	2	0.11	0	0.00
8/08	6.97	0	0.00	20.78	0	0.00	1	0.05	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	6.59	0	0.00	21.10	0	0.00	5	0.24	0	0.00
8/10	7.20	0	0.00	20.08	0	0.00	14	0.70	1	0.05
8/11	6.67	0	0.00	19.69	0	0.00	17	0.86	6	0.30
8/12	7.60	0	0.00	19.03	0	0.00	9	0.47	2	0.11
8/13	5.78	0	0.00	18.69	0	0.00	5	0.27	5	0.27
8/14	6.43	0	0.00	19.48	0	0.00	3	0.15	5	0.26
8/15	5.94	0	0.00	19.21	0	0.00	1	0.05	2	0.10
8/16	6.35	0	0.00	19.20	0	0.00	0	0.00	0	0.00
8/17	7.07	0	0.00	19.53	0	0.00	1	0.05	3	0.15
8/18	6.81	0	0.00	19.02	0	0.00	1	0.05	2	0.11
8/19	6.23	0	0.00	18.44	0	0.00	3	0.16	4	0.22
8/20	0.00	0	0.00	11.41	0	0.00	1	0.09	1	0.09
8/21	5.62	0	0.00	18.86	0	0.00	7	0.37	4	0.21
8/22	5.64	0	0.00	6.55	0	0.00	1	0.15	2	0.31
8/23	5.50	0	0.00	19.43	0	0.00	1	0.05	4	0.21
8/24	0.00	0	0.00	10.94	0	0.00	0	0.00	0	0.00
8/25	6.74	0	0.00	18.40	0	0.00	0	0.00	0	0.00
8/26	6.36	0	0.00	18.19	0	0.00	2	0.11	4	0.22
8/27	6.47	0	0.00	16.55	0	0.00	0	0.00	3	0.18
8/28	6.45	0	0.00	18.77	0	0.00	0	0.00	2	0.11
8/29	6.60	0	0.00	18.24	0	0.00	1	0.05	2	0.11
8/30	6.08	0	0.00	19.64	0	0.00	0	0.00	4	0.20
8/31	5.11	0	0.00	16.31	0	0.00	0	0.00	1	0.06
9/01	0.00	0	0.00	25.24	0	0.00	3	0.12	2	0.08
9/02	6.58	0	0.00	17.83	0	0.00	1	0.06	0	0.00
9/03	5.33	0	0.00	17.82	0	0.00	1	0.06	1	0.06
9/04	6.37	0	0.00	16.21	0	0.00	0	0.00	1	0.06
9/05	6.18	0	0.00	17.02	0	0.00	3	0.18	0	0.00
9/06	5.64	0	0.00	17.68	0	0.00	1	0.06	0	0.00
9/07	5.64	0	0.00	18.44	0	0.00	0	0.00	1	0.05
Total	1,048.41	278	19.77	1,460.70	1,475	172.02	122	6.93	66	3.73

Appendix B2.–Right bank CPUE by day and salmon species at the Pilot Station sonar site on the Yukon River, 2009.

	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	5.47	0	0.00	2.23	0	0.00	0	0.00	0	0.00
6/02	7.20	0	0.00	7.58	0	0.00	0	0.00	0	0.00
6/03	7.58	0	0.00	9.00	0	0.00	0	0.00	0	0.00
6/04	7.03	0	0.00	7.17	0	0.00	0	0.00	0	0.00
6/05	8.61	0	0.00	7.68	0	0.00	0	0.00	0	0.00
6/06	8.28	0	0.00	9.67	0	0.00	0	0.00	0	0.00
6/07	7.98	0	0.00	7.84	0	0.00	0	0.00	0	0.00
6/08	7.25	0	0.00	8.04	0	0.00	0	0.00	0	0.00
6/09	7.08	1	0.14	5.83	0	0.00	0	0.00	0	0.00
6/10	5.88	1	0.17	7.50	1	0.13	0	0.00	0	0.00
6/11	8.24	0	0.00	8.84	0	0.00	0	0.00	0	0.00
6/12	8.02	0	0.00	6.99	0	0.00	0	0.00	0	0.00
6/13	7.13	4	0.56	4.77	12	2.52	0	0.00	0	0.00
6/14	7.05	4	0.57	3.54	10	2.82	0	0.00	0	0.00
6/15	6.92	0	0.00	3.16	15	4.75	0	0.00	0	0.00
6/16	6.85	0	0.00	4.64	12	2.59	0	0.00	0	0.00
6/17	6.30	1	0.16	2.92	18	6.16	0	0.00	0	0.00
6/18	6.76	12	1.78	2.24	9	4.02	0	0.00	0	0.00
6/19	6.73	6	0.89	5.43	22	4.05	0	0.00	0	0.00
6/20	7.75	16	2.06	3.01	6	2.00	0	0.00	0	0.00
6/21	5.65	7	1.24	3.26	20	6.13	0	0.00	0	0.00
6/22	6.74	5	0.74	3.91	16	4.09	0	0.00	0	0.00
6/23	7.96	4	0.50	3.61	12	3.32	0	0.00	0	0.00
6/24	4.69	2	0.43	3.15	14	4.45	0	0.00	0	0.00
6/25	6.95	3	0.43	3.99	19	4.76	0	0.00	0	0.00
6/26	6.65	4	0.60	3.29	30	9.11	0	0.00	0	0.00
6/27	5.39	1	0.19	3.56	8	2.25	0	0.00	0	0.00
6/28	4.52	6	1.33	2.20	8	3.64	0	0.00	0	0.00
6/29	3.82	5	1.31	1.48	10	6.78	0	0.00	0	0.00
6/30	7.40	8	1.08	3.96	4	1.01	0	0.00	0	0.00
7/01	3.75	2	0.53	1.55	10	6.47	0	0.00	0	0.00
7/02	7.43	0	0.00	4.32	14	3.24	0	0.00	0	0.00
7/03	4.37	0	0.00	3.88	6	1.55	0	0.00	0	0.00
7/04	7.77	1	0.13	6.24	4	0.64	0	0.00	0	0.00
7/05	6.98	2	0.29	5.40	17	3.15	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	4.59	0	0.00	3.43	14	4.08	0	0.00	0	0.00
7/07	7.70	2	0.26	5.48	6	1.10	0	0.00	0	0.00
7/08	7.21	1	0.14	5.77	15	2.60	0	0.00	0	0.00
7/09	5.04	2	0.40	4.17	6	1.44	0	0.00	0	0.00
7/10	8.18	0	0.00	6.31	0	0.00	0	0.00	0	0.00
7/11	7.65	0	0.00	9.20	4	0.43	0	0.00	0	0.00
7/12	7.60	2	0.26	4.85	19	3.92	0	0.00	0	0.00
7/13	5.72	1	0.17	6.40	12	1.88	0	0.00	0	0.00
7/14	8.19	0	0.00	7.39	5	0.68	0	0.00	0	0.00
7/15	8.14	0	0.00	9.54	6	0.63	0	0.00	0	0.00
7/16	6.83	0	0.00	6.00	5	0.83	0	0.00	0	0.00
7/17	8.66	0	0.00	8.67	5	0.58	0	0.00	0	0.00
7/18	8.36	0	0.00	7.17	2	0.28	0	0.00	0	0.00
7/19	5.95	0	0.00	5.82	0	0.00	1	0.17	0	0.00
7/20	2.66	0	0.00	5.38	0	0.00	2	0.37	0	0.00
7/21	2.87	0	0.00	7.52	0	0.00	1	0.13	0	0.00
7/22	2.84	0	0.00	8.84	0	0.00	0	0.00	0	0.00
7/23	3.06	0	0.00	9.62	0	0.00	3	0.31	0	0.00
7/24	2.63	0	0.00	8.88	0	0.00	3	0.34	0	0.00
7/25	3.02	0	0.00	8.13	0	0.00	5	0.62	0	0.00
7/26	2.89	0	0.00	7.86	0	0.00	1	0.13	0	0.00
7/27	2.95	0	0.00	6.22	0	0.00	2	0.32	0	0.00
7/28	3.69	0	0.00	9.08	0	0.00	1	0.11	0	0.00
7/29	2.93	0	0.00	8.81	0	0.00	3	0.34	0	0.00
7/30	3.10	0	0.00	8.76	0	0.00	3	0.34	0	0.00
7/31	3.25	1	0.31	9.11	0	0.00	7	0.77	0	0.00
8/01	3.01	0	0.00	9.40	0	0.00	3	0.32	0	0.00
8/02	2.87	0	0.00	8.40	0	0.00	9	1.07	0	0.00
8/03	2.57	0	0.00	5.32	0	0.00	0	0.00	1	0.19
8/04	3.33	0	0.00	8.32	0	0.00	2	0.24	0	0.00
8/05	2.92	0	0.00	8.14	0	0.00	0	0.00	1	0.12
8/06	3.17	0	0.00	8.92	0	0.00	0	0.00	4	0.45
8/07	0.94	0	0.00	8.57	0	0.00	0	0.00	3	0.35
8/08	3.21	0	0.00	9.28	0	0.00	7	0.75	3	0.32

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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	2.62	0	0.00	9.42	0	0.00	0	0.00	9	0.96
8/10	3.13	0	0.00	8.54	0	0.00	15	1.76	6	0.70
8/11	3.18	0	0.00	7.91	0	0.00	26	3.29	14	1.77
8/12	2.75	0	0.00	9.64	0	0.00	17	1.76	17	1.76
8/13	2.76	0	0.00	8.38	0	0.00	2	0.24	18	2.15
8/14	3.22	0	0.00	9.90	0	0.00	1	0.10	21	2.12
8/15	3.24	0	0.00	6.94	0	0.00	0	0.00	22	3.17
8/16	2.97	0	0.00	8.03	0	0.00	0	0.00	15	1.87
8/17	2.76	0	0.00	9.28	0	0.00	0	0.00	8	0.86
8/18	3.17	0	0.00	9.90	0	0.00	5	0.50	9	0.91
8/19	3.23	0	0.00	8.11	0	0.00	2	0.25	14	1.73
8/20	4.11	0	0.00	9.30	0	0.00	2	0.22	26	2.80
8/21	3.43	0	0.00	8.50	0	0.00	14	1.65	19	2.24
8/22	2.55	0	0.00	8.70	0	0.00	5	0.57	24	2.76
8/23	3.09	0	0.00	7.68	0	0.00	0	0.00	23	2.99
8/24	3.02	0	0.00	8.57	0	0.00	2	0.23	28	3.27
8/25	2.53	0	0.00	8.65	0	0.00	3	0.35	20	2.31
8/26	2.46	0	0.00	8.17	0	0.00	0	0.00	10	1.22
8/27	2.68	0	0.00	7.75	0	0.00	0	0.00	16	2.07
8/28	2.03	0	0.00	8.72	0	0.00	1	0.11	23	2.64
8/29	3.51	0	0.00	7.72	0	0.00	1	0.13	13	1.68
8/30	3.05	0	0.00	6.86	0	0.00	1	0.15	8	1.17
8/31	2.61	0	0.00	9.06	0	0.00	1	0.11	13	1.44
9/01	0.00	0	0.00	11.51	0	0.00	1	0.09	17	1.48
9/02	2.85	0	0.00	9.16	0	0.00	2	0.22	9	0.98
9/03	2.63	0	0.00	8.79	0	0.00	1	0.11	7	0.80
9/04	2.99	0	0.00	7.63	0	0.00	2	0.26	5	0.66
9/05	2.63	0	0.00	8.57	0	0.00	2	0.23	12	1.40
9/06	2.77	0	0.00	7.77	0	0.00	0	0.00	10	1.29
9/07	2.78	0	0.00	7.78	0	0.00	1	0.13	5	0.64
Total	476.66	104	16.67	683.58	396	108.08	160	18.79	453	53.27

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

Appendix C1.–Daily fish passage estimates by zone with standard errors (SE), Yukon River Pilot Station sonar site, 2009.

		Left Bank				Percent by bank	
Date	Right Bank	Nearshore	Offshore	Total	SE	Right	Left
6/01	990	0	0	990	112	100	0
6/02	1,197	0	0	1,197	123	100	0
6/03	1,534	2,255	173	3,962	624	39	61
6/04	1,909	734	0	2,643	377	72	28
6/05	1,469	1,302	0	2,771	477	53	47
6/06	1,787	1,624	241	3,652	542	49	51
6/07	1,270	2,893	269	4,432	701	29	71
6/08	1,015	1,961	64	3,040	1,629	33	67
6/09	1,473	1,554	281	3,308	961	45	55
6/10	1,764	3,493	361	5,618	2,161	31	69
6/11	2,260	4,226	444	6,930	1,718	33	67
6/12	2,611	3,086	248	5,945	2,205	44	56
6/13	8,911	13,569	3,765	26,245	2,845	34	66
6/14	10,657	6,665	1,194	18,516	1,681	58	42
6/15	8,566	6,219	969	15,754	3,371	54	46
6/16	9,364	3,976	72	13,412	1,983	70	30
6/17	8,030	4,507	2,213	14,750	2,421	54	46
6/18	11,337	10,219	2,322	23,878	3,141	47	53
6/19	12,790	7,224	2,788	22,802	2,491	56	44
6/20	13,695	6,810	1,081	21,586	1,887	63	37
6/21	11,251	6,992	1,537	19,780	2,623	57	43
6/22	8,978	7,124	1,272	17,374	1,712	52	48
6/23	11,276	7,655	2,667	21,598	4,464	52	48
6/24	17,632	9,502	11,303	38,437	5,533	46	54
6/25	9,731	19,710	25,251	54,692	3,708	18	82
6/26	29,605	64,975	40,669	135,249	13,045	22	78
6/27	42,763	86,224	51,790	180,777	15,203	24	76
6/28	52,142	77,596	51,225	180,963	21,521	29	71
6/29	29,632	56,838	50,364	136,834	18,380	22	78
6/30	18,812	26,948	29,715	75,475	11,023	25	75
7/01	19,346	23,718	22,397	65,461	10,648	30	70
7/02	18,552	37,005	26,294	81,851	5,823	23	77
7/03	13,609	16,525	16,898	47,032	7,665	29	71
7/04	9,986	19,860	17,818	47,664	7,621	21	79
7/05	17,118	26,179	16,937	60,234	4,316	28	72
7/06	20,697	18,382	21,280	60,359	11,882	34	66
7/07	13,942	30,281	27,515	71,738	14,302	19	81
7/08	12,914	19,488	17,305	49,707	6,418	26	74
7/09	7,875	9,569	10,586	28,030	4,953	28	72
7/10	5,153	11,113	6,735	23,001	10,803	22	78
7/11	6,461	20,775	13,789	41,025	6,217	16	84
7/12	8,271	29,422	18,747	56,440	4,640	15	85
7/13	4,880	14,853	10,813	30,546	12,236	16	84
7/14	4,235	10,956	5,445	20,636	9,987	21	79
7/15	4,310	11,005	3,691	19,006	1,778	23	77
7/16	4,179	9,157	5,487	18,823	6,827	22	78
7/17	4,120	14,083	13,357	31,560	9,324	13	87
7/18	3,752	15,637	6,647	26,036	5,115	14	86
7/19	2,871	16,524	4,533	23,928	4,176	12	88
7/20	3,024	8,718	2,555	14,297	2,726	21	79

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Appendix C1.–Page 2 of 2.

Date	Right Bank	Left Bank		Total	SE	Percent by bank	
		Nearshore	Offshore			Right	Left
7/21	2,297	3,775	1,985	8,057	1,987	29	71
7/22	1,919	5,789	3,423	11,131	1,033	17	83
7/23	2,180	8,808	3,836	14,824	3,455	15	85
7/24	2,451	7,301	5,014	14,766	5,142	17	83
7/25	2,274	7,143	4,647	14,064	4,656	16	84
7/26	2,222	7,059	3,419	12,700	1,778	18	83
7/27	2,259	6,512	2,662	11,433	1,668	20	80
7/28	2,007	6,572	2,291	10,870	3,790	18	82
7/29	1,664	7,220	2,140	11,024	2,935	15	85
7/30	2,805	11,748	2,972	17,525	3,479	16	84
7/31	3,280	5,692	2,563	11,535	2,246	28	72
8/01	2,530	5,965	6,677	15,172	4,253	17	83
8/02	4,005	8,404	25,093	37,502	10,205	11	89
8/03	3,759	5,866	11,505	21,130	7,074	18	82
8/04	2,660	6,602	7,192	16,454	6,943	16	84
8/05	2,906	7,449	5,130	15,485	1,764	19	81
8/06	2,991	7,227	4,756	14,974	1,282	20	80
8/07	2,607	5,797	3,772	12,176	2,678	21	79
8/08	3,486	4,946	3,836	12,268	4,567	28	72
8/09	5,069	5,141	4,413	14,623	4,861	35	65
8/10	8,657	11,392	12,596	32,645	11,044	27	73
8/11	11,596	12,698	50,313	74,607	15,557	16	84
8/12	14,256	12,461	36,894	63,611	9,198	22	78
8/13	12,125	8,587	6,817	37,529	3,505	32	68
8/14	7,879	6,556	9,167	23,602	8,291	33	67
8/15	7,235	6,499	6,771	20,505	7,320	35	65
8/16	6,870	5,393	5,309	17,572	2,343	39	61
8/17	5,884	6,221	9,013	21,118	3,342	28	72
8/18	7,019	4,878	9,699	21,596	7,750	33	68
8/19	6,867	5,051	13,863	25,781	8,210	27	73
8/20	7,575	4,128	12,527	24,230	7,745	31	69
8/21	7,999	5,633	23,333	36,965	9,429	22	78
8/22	7,035	4,061	17,897	28,993	8,258	24	76
8/23	6,708	3,201	9,791	19,700	4,397	34	66
8/24	5,935	2,283	9,273	17,491	4,558	34	66
8/25	5,089	2,257	8,305	15,651	5,349	33	67
8/26	4,201	2,557	9,689	16,447	5,720	26	74
8/27	4,313	2,172	5,351	11,836	4,751	36	64
8/28	4,053	1,981	4,557	10,591	3,605	38	62
8/29	3,135	2,084	5,293	10,512	4,783	30	70
8/30	3,141	2,540	4,725	10,406	1,853	30	70
8/31	3,169	1,964	4,188	9,321	4,896	34	66
9/01	2,965	2,305	4,913	10,183	5,269	29	71
9/02	3,209	2,171	5,021	10,401	4,354	31	69
9/03	3,507	2,253	4,773	10,533	4,982	33	67
9/04	2,934	1,960	4,821	9,715	3,830	30	70
9/05	2,707	1,906	3,880	8,493	1,429	32	68
9/06	2,639	1,991	3,775	8,405	3,039	31	69
9/07	3,049	2,261	2,995	8,305	1,757	37	63
Total	746,868	1,073,591	973,982	2,794,441			

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 2009

	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
6/01	0	0	0	0	0	0	0	990	990
6/02	0	0	0	0	0	0	0	1,197	1,197
6/03	0	0	0	0	0	0	0	3,962	3,962
6/04	0	0	0	0	0	0	0	2,643	2,643
6/05	0	0	0	0	0	0	0	2,771	2,771
6/06	0	0	0	0	0	0	0	3,652	3,652
6/07	0	0	0	0	0	0	0	4,432	4,432
6/08	0	0	0	64	0	0	0	2,976	3,040
6/09	976	0	976	148	0	0	0	2,184	3,308
6/10	682	20	702	2,057	0	0	0	2,859	5,618
6/11	77	66	143	2,533	0	0	0	4,254	6,930
6/12	494	9	503	1,826	0	0	0	3,616	5,945
6/13	831	454	1,285	21,110	0	0	0	3,850	26,245
6/14	1,303	244	1,547	14,328	0	0	0	2,641	18,516
6/15	28	122	150	14,028	0	0	0	1,576	15,754
6/16	131	283	414	11,990	0	0	0	1,008	13,412
6/17	1,632	564	2,196	10,381	0	0	0	2,173	14,750
6/18	4,230	1,300	5,530	17,946	0	0	0	402	23,878
6/19	1,909	1,336	3,245	19,411	0	0	0	146	22,802
6/20	5,726	962	6,688	10,709	0	0	0	4,189	21,586
6/21	1,894	943	2,837	16,666	0	0	0	277	19,780
6/22	1,743	416	2,159	13,416	0	0	0	1,799	17,374
6/23	3,307	844	4,151	17,447	0	0	0	0	21,598
6/24	4,291	2,541	6,832	31,100	0	0	0	505	38,437
6/25	1,691	1,472	3,163	50,740	0	0	0	789	54,692
6/26	8,277	2,537	10,814	123,534	0	0	0	901	135,249
6/27	13,583	4,215	17,798	162,979	0	0	0	0	180,777
6/28	13,082	2,290	15,372	163,276	0	0	0	2,315	180,963
6/29	9,836	1,960	11,796	123,342	0	0	0	1,696	136,834
6/30	5,602	2,940	8,542	65,830	0	0	0	1,103	75,475
7/01	4,834	2,404	7,238	57,146	0	0	0	1,077	65,461
7/02	1,661	397	2,058	73,137	0	0	0	6,656	81,851
7/03	1,939	787	2,726	30,473	0	0	0	13,833	47,032
7/04	1,904	754	2,658	31,245	0	0	0	13,761	47,664
7/05	1,717	387	2,104	56,352	0	0	0	1,778	60,234
7/06	3,065	710	3,775	45,057	0	299	0	11,228	60,359
7/07	3,638	769	4,407	53,901	0	201	0	13,229	71,738
7/08	2,024	802	2,826	34,577	0	569	0	11,735	49,707
7/09	1,148	449	1,597	19,125	0	347	0	6,961	28,030
7/10	2,273	1,750	4,023	12,908	0	0	0	6,070	23,001
7/11	0	493	493	25,208	0	573	0	14,751	41,025
7/12	1,104	0	1,104	45,501	0	256	0	9,579	56,440
7/13	240	0	240	10,742	0	611	0	18,953	30,546
7/14	162	0	162	6,660	0	321	0	13,493	20,636
7/15	872	284	1,156	7,477	0	0	0	10,373	19,006
7/16	68	0	68	5,283	0	507	0	12,965	18,823

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	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
7/17	165	0	165	8,525	0	500	0	22,370	31,560
7/18	0	0	0	3,468	0	0	0	22,568	26,036
7/19	104	74	178	0	2,911	1,001	0	19,838	23,928
7/20	0	0	0	0	2,228	765	0	11,304	14,297
7/21	0	0	0	0	1,473	585	0	5,999	8,057
7/22	0	0	0	0	422	111	0	10,598	11,131
7/23	43	110	153	0	940	2,511	0	11,220	14,824
7/24	0	0	0	0	7,320	206	0	7,240	14,766
7/25	0	0	0	0	863	505	0	12,696	14,064
7/26	0	0	0	0	1,213	952	0	10,535	12,700
7/27	0	0	0	0	1,053	902	0	9,478	11,433
7/28	0	0	0	0	106	3,755	181	6,828	10,870
7/29	0	0	0	0	568	1,050	0	9,406	11,024
7/30	0	0	0	0	546	0	49	16,930	17,525
7/31	75	0	75	0	2,289	101	0	9,070	11,535
8/01	0	0	0	0	3,654	730	43	10,745	15,172
8/02	0	0	0	0	21,923	276	1,158	14,145	37,502
8/03	0	0	0	0	10,887	259	559	9,425	21,130
8/04	0	0	0	0	262	98	0	16,094	16,454
8/05	0	0	0	0	72	0	1,280	14,133	15,485
8/06	0	0	0	0	430	0	737	13,807	14,974
8/07	0	0	0	0	1,890	0	868	9,418	12,176
8/08	0	0	0	0	892	1,814	1,243	8,319	12,268
8/09	0	0	0	0	4,536	94	2,870	7,123	14,623
8/10	0	0	0	0	12,320	0	982	19,343	32,645
8/11	0	0	0	0	31,926	1,762	9,268	31,651	74,607
8/12	0	0	0	0	39,448	0	10,752	13,411	63,611
8/13	0	0	0	0	12,724	0	13,149	11,656	37,529
8/14	0	0	0	0	1,668	1,858	6,300	13,776	23,602
8/15	0	0	0	0	2,353	0	7,511	10,641	20,505
8/16	0	0	0	0	133	0	3,443	13,996	17,572
8/17	0	0	0	0	479	160	2,163	18,316	21,118
8/18	0	0	0	0	2,297	0	7,230	12,069	21,596
8/19	0	0	0	0	5,220	0	9,595	10,966	25,781
8/20	0	0	0	0	4,220	0	10,403	9,607	24,230
8/21	0	0	0	0	12,136	0	19,397	5,432	36,965
8/22	0	0	0	0	8,388	0	16,897	3,708	28,993
8/23	0	0	0	0	2,769	0	13,015	3,916	19,700
8/24	0	0	0	0	2,577	0	11,260	3,654	17,491
8/25	0	0	0	0	795	0	4,729	10,127	15,651
8/26	0	0	0	0	545	0	4,003	11,899	16,447
8/27	0	0	0	0	301	0	3,094	8,441	11,836
8/28	0	0	0	0	208	0	7,589	2,794	10,591
8/29	0	0	0	0	919	0	2,881	6,712	10,512
8/30	0	0	0	0	61	0	7,134	3,211	10,406
8/31	0	0	0	0	3,036	0	5,030	1,255	9,321

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	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
9/01	0	0	0	0	3,547	0	5,462	1,174	10,183
9/02	0	0	0	0	4,048	0	2,593	3,760	10,401
9/03	0	0	0	0	1,338	0	2,213	6,982	10,533
9/04	0	0	0	0	3,298	0	4,375	2,042	9,715
9/05	0	0	0	0	4,171	0	1,959	2,363	8,493
9/06	0	0	0	0	5,766	0	1,104	1,535	8,405
9/07	0	0	0	0	138	0	4,101	4,066	8,305
Total	108,361	35,688	144,049	1,421,646	233,307	23,679	206,620	765,140	2,794,441

[a] Chinook salmon > 655 mm.

[b] Chinook salmon ≤ 655mm.

APPENDIX E: PILOT STATION SONAR FISH PASSAGE ESTIMATES BY SPECIES, 1999–2009

Appendix E1.–Pilot Station sonar project total fish passage estimates by species, 1999–2009.

Species	2009[a]	2008	2007	2006	2005[b]	2004	2003	2002	2001[a]	2000	1999
Lg. Chinook[c]	108,361	106,708	90,184	145,553	142,007	110,236	245,037	92,584	85,511	39,233	127,809
Sm. Chinook	35,688	23,935	35,369	23,850	17,434	46,370	23,500	30,629	13,892	5,195	16,914
Chinook Total	144,049	130,643	125,553	169,403	159,441	156,606	268,537	123,213	99,403	44,428	144,723
Summer Chum	1,421,646	1,665,667	1,726,885	3,767,044	2,439,616	1,357,826	1,168,518	1,088,463	441,450	456,271	973,708
Fall Chum[d]	233,307	615,127	684,011	790,563	1,813,589	594,060	889,778	326,858	376,182	247,935	379,493
Chum Total	1,654,953	2,280,794	2,410,896	4,557,607	4,253,205	1,951,886	2,058,296	1,415,321	817,632	704,206	1,353,201
Coho[d]	206,620	135,570	173,289	131,919	184,718	188,350	269,081	122,566	137,769	175,421	62,521
Pink	23,679	558,050	71,699	115,624	37,932	243,375	4,656	64,891	665	35,501	1,801
Other Species[e]	765,140	585,303	1,085,316	875,899	593,248	637,257	502,878	557,779	353,431	361,222	465,515
Season Total	2,794,441	3,690,360	3,866,753	5,850,452	5,228,544	3,177,474	3,103,448	2,283,770	1,408,900	1,320,778	2,027,761

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, 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, however in 2008, operations were extended to September 7, instead of the usual end date of August 31.

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

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

Appendix F1.–DIDSON generated component of the left bank nearshore daily fish passage estimates at the Pilot Station sonar site, on the Yukon River 2009.

	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
6/01	0	0	0	0	0	0	0	0	0
6/02	0	0	0	0	0	0	0	0	0
6/03	0	0	0	0	0	0	0	1,342	1,342
6/04	0	0	0	0	0	0	0	741	741
6/05	0	0	0	0	0	0	0	1,209	1,209
6/06	0	0	0	0	0	0	0	1,097	1,097
6/07	0	0	0	0	0	0	0	1,880	1,880
6/08	0	0	0	0	0	0	0	1,481	1,481
6/09	0	0	0	0	0	0	0	704	704
6/10	0	0	0	335	0	0	0	1,470	1,805
6/11	24	28	52	907	0	0	0	819	1,778
6/12	10	0	10	438	0	0	0	390	838
6/13	8	11	19	358	0	0	0	17	393
6/14	81	0	81	1,246	0	0	0	554	1,881
6/15	0	18	18	851	0	0	0	295	1,163
6/16	53	0	53	1,148	0	0	0	408	1,609
6/17	267	106	373	1,093	0	0	0	129	1,596
6/18	559	574	1,134	4,897	0	0	0	148	6,179
6/19	215	58	273	2,902	0	0	0	65	3,240
6/20	440	280	720	2,359	0	0	0	277	3,356
6/21	293	213	506	3,962	0	0	0	76	4,544
6/22	127	37	164	829	0	0	0	181	1,174
6/23	106	36	142	409	0	0	0	0	551
6/24	18	41	59	720	0	0	0	44	822
6/25	7	40	48	975	0	0	0	15	1,038
6/26	635	164	799	9,809	0	0	0	63	10,671
6/27	483	448	932	13,645	0	0	0	0	14,576
6/28	546	215	761	13,144	0	0	0	428	14,333
6/29	366	144	510	8,804	0	0	0	286	9,600
6/30	111	162	273	3,666	0	0	0	57	3,996
7/01	152	222	374	5,025	0	0	0	79	5,478
7/02	152	82	234	7,427	0	0	0	0	7,661
7/03	78	33	111	2,173	0	0	0	1,264	3,548
7/04	69	29	99	1,922	0	0	0	1,119	3,139
7/05	147	0	147	7,168	0	0	0	0	7,316
7/06	22	28	50	3,749	0	0	0	1,021	4,820
7/07	38	50	88	6,610	0	0	0	1,800	8,498
7/08	162	75	237	3,640	0	0	0	378	4,255
7/09	129	59	188	2,889	0	0	0	300	3,376
7/10	249	179	428	2,597	0	0	0	0	3,025
7/11	0	73	73	1,466	0	85	0	1,462	3,086
7/12	0	0	0	3,396	0	0	0	1,489	4,886
7/13	11	0	11	216	0	14	0	3,421	3,661
7/14	9	0	9	184	0	12	0	2,912	3,116
7/15	0	81	81	930	0	0	0	2,146	3,157
7/16	0	0	0	555	0	0	0	2,123	2,677

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	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
7/17	0	0	0	687	0	0	0	2,628	3,315
7/18	0	0	0	494	0	0	0	3,951	4,445
7/19	0	0	0	0	537	257	0	4,938	5,732
7/20	0	0	0	0	224	0	0	2,533	2,757
7/21	0	0	0	0	75	0	0	851	926
7/22	0	0	0	0	0	0	0	1,133	1,133
7/23	0	0	0	0	0	787	0	2,061	2,848
7/24	0	0	0	0	494	0	0	951	1,444
7/25	0	0	0	0	74	106	0	1,578	1,759
7/26	0	0	0	0	18	147	0	1,326	1,491
7/27	0	0	0	0	15	122	0	1,102	1,239
7/28	0	0	0	0	0	606	0	477	1,084
7/29	0	0	0	0	58	146	0	800	1,004
7/30	0	0	0	0	0	0	0	2,284	2,284
7/31	0	0	0	0	97	0	0	819	916
8/01	0	0	0	0	63	87	0	655	805
8/02	0	0	0	0	163	0	0	750	913
8/03	0	0	0	0	137	0	0	632	769
8/04	0	0	0	0	0	0	0	1,178	1,178
8/05	0	0	0	0	0	0	0	1,553	1,553
8/06	0	0	0	0	0	0	0	1,467	1,467
8/07	0	0	0	0	101	0	0	510	611
8/08	0	0	0	0	0	476	287	535	1,299
8/09	0	0	0	0	0	0	670	999	1,670
8/10	0	0	0	0	543	0	0	997	1,540
8/11	0	0	0	0	323	0	180	1,245	1,748
8/12	0	0	0	0	587	0	327	2,261	3,174
8/13	0	0	0	0	0	0	400	587	987
8/14	0	0	0	0	0	328	320	508	1,156
8/15	0	0	0	0	0	0	139	1,072	1,211
8/16	0	0	0	0	0	0	0	1,201	1,201
8/17	0	0	0	0	0	0	31	932	963
8/18	0	0	0	0	0	0	322	171	494
8/19	0	0	0	0	126	0	239	254	619
8/20	0	0	0	0	61	0	115	122	298
8/21	0	0	0	0	76	0	247	239	562
8/22	0	0	0	0	54	0	174	169	397
8/23	0	0	0	0	0	0	673	0	673
8/24	0	0	0	0	0	0	232	0	232
8/25	0	0	0	0	0	0	13	27	40
8/26	0	0	0	0	0	0	163	337	501
8/27	0	0	0	0	0	0	89	184	273
8/28	0	0	0	0	0	0	56	173	229
8/29	0	0	0	0	0	0	0	204	204
8/30	0	0	0	0	0	0	276	0	276
8/31	0	0	0	0	51	0	250	0	301

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	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
9/01	0	0	0	0	54	0	267	0	321
9/02	0	0	0	0	0	0	0	422	422
9/03	0	0	0	0	0	0	91	330	421
9/04	0	0	0	0	0	0	86	314	401
9/05	0	0	0	0	0	0	0	369	369
9/06	0	0	0	0	295	0	0	0	295
9/07	0	0	0	0	0	0	0	365	365
Total	5,567	3,486	9,057	123,625	4,226	3,173	5,647	81,884	227,611

Note: See Appendix C for daily fish passage estimates by zone.

[a] Chinook salmon > 655 mm.

[b] Chinook salmon ≤ 655mm.

Appendix F2.– Proportions by species, of daily total passage (both banks combined) for sectors 1 and 2 of Strata 3 of the left bank nearshore region generated by the DIDSON, at the Pilot Station sonar project on the Yukon River, 2009.

	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
6/01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.34
6/04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.28
6/05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.44
6/06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.30
6/07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.42
6/08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.49
6/09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.21
6/10	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.51	0.32
6/11	0.31	0.42	0.36	0.36	0.00	0.00	0.00	0.19	0.26
6/12	0.02	0.00	0.02	0.24	0.00	0.00	0.00	0.11	0.14
6/13	0.01	0.02	0.01	0.02	0.00	0.00	0.00	0.00	0.01
6/14	0.06	0.00	0.05	0.09	0.00	0.00	0.00	0.21	0.10
6/15	0.00	0.15	0.12	0.06	0.00	0.00	0.00	0.19	0.07
6/16	0.40	0.00	0.13	0.10	0.00	0.00	0.00	0.40	0.12
6/17	0.16	0.19	0.17	0.11	0.00	0.00	0.00	0.06	0.11
6/18	0.13	0.44	0.21	0.27	0.00	0.00	0.00	0.37	0.26
6/19	0.11	0.04	0.08	0.15	0.00	0.00	0.00	0.45	0.14
6/20	0.08	0.29	0.11	0.22	0.00	0.00	0.00	0.07	0.16
6/21	0.15	0.23	0.18	0.24	0.00	0.00	0.00	0.27	0.23
6/22	0.07	0.09	0.08	0.06	0.00	0.00	0.00	0.10	0.07
6/23	0.03	0.04	0.03	0.02	0.00	0.00	0.00	0.00	0.03
6/24	0.00	0.02	0.01	0.02	0.00	0.00	0.00	0.09	0.02
6/25	0.00	0.03	0.02	0.02	0.00	0.00	0.00	0.02	0.02
6/26	0.08	0.06	0.07	0.08	0.00	0.00	0.00	0.07	0.08
6/27	0.04	0.11	0.05	0.08	0.00	0.00	0.00	0.00	0.08
6/28	0.04	0.09	0.05	0.08	0.00	0.00	0.00	0.18	0.08
6/29	0.04	0.07	0.04	0.07	0.00	0.00	0.00	0.17	0.07
6/30	0.02	0.06	0.03	0.06	0.00	0.00	0.00	0.05	0.05
7/01	0.03	0.09	0.05	0.09	0.00	0.00	0.00	0.07	0.08
7/02	0.09	0.21	0.11	0.10	0.00	0.00	0.00	0.00	0.09
7/03	0.04	0.04	0.04	0.07	0.00	0.00	0.00	0.09	0.08
7/04	0.04	0.04	0.04	0.06	0.00	0.00	0.00	0.08	0.07
7/05	0.09	0.00	0.07	0.13	0.00	0.00	0.00	0.00	0.12
7/06	0.01	0.04	0.01	0.08	0.00	0.00	0.00	0.09	0.08
7/07	0.01	0.07	0.02	0.12	0.00	0.00	0.00	0.14	0.12
7/08	0.08	0.09	0.08	0.11	0.00	0.00	0.00	0.03	0.09
7/09	0.11	0.13	0.12	0.15	0.00	0.00	0.00	0.04	0.12
7/10	0.11	0.10	0.11	0.20	0.00	0.00	0.00	0.00	0.13
7/11	0.00	0.15	0.15	0.06	0.00	0.15	0.00	0.10	0.08
7/12	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.16	0.09
7/13	0.05	0.00	0.05	0.02	0.00	0.02	0.00	0.18	0.12
7/14	0.06	0.00	0.06	0.03	0.00	0.04	0.00	0.22	0.15
7/15	0.00	0.29	0.07	0.12	0.00	0.00	0.00	0.21	0.17
7/16	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.16	0.14

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	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
7/17	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.12	0.11
7/18	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.18	0.17
7/19	0.00	0.00	0.00	0.00	0.18	0.26	0.00	0.25	0.24
7/20	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.22	0.19
7/21	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.14	0.11
7/22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.10
7/23	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.18	0.19
7/24	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.13	0.10
7/25	0.00	0.00	0.00	0.00	0.09	0.21	0.00	0.12	0.13
7/26	0.00	0.00	0.00	0.00	0.01	0.15	0.00	0.13	0.12
7/27	0.00	0.00	0.00	0.00	0.01	0.14	0.00	0.12	0.11
7/28	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.07	0.10
7/29	0.00	0.00	0.00	0.00	0.10	0.14	0.00	0.09	0.09
7/30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13
7/31	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.09	0.08
8/01	0.00	0.00	0.00	0.00	0.02	0.12	0.00	0.06	0.05
8/02	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.05	0.02
8/03	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.07	0.04
8/04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07
8/05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.10
8/06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.10
8/07	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.05
8/08	0.00	0.00	0.00	0.00	0.00	0.26	0.23	0.06	0.11
8/09	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.14	0.11
8/10	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.05	0.05
8/11	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.04	0.02
8/12	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.17	0.05
8/13	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.03
8/14	0.00	0.00	0.00	0.00	0.00	0.18	0.05	0.04	0.05
8/15	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.06
8/16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.07
8/17	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.05
8/18	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.02
8/19	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.02	0.02
8/20	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01
8/21	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.04	0.02
8/22	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.05	0.01
8/23	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.03
8/24	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01
8/25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8/26	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.03
8/27	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.02
8/28	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.02
8/29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02
8/30	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.03
8/31	0.00	0.00	0.00	0.00	0.02	0.00	0.05	0.00	0.03

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	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
9/01	0.00	0.00	0.00	0.00	0.02	0.00	0.05	0.00	0.03
9/02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.04
9/03	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.05	0.04
9/04	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.15	0.04
9/05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.04
9/06	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.04
9/07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.04
Season Total	0.05	0.10	0.06	0.09	0.02	0.13	0.03	0.11	0.08

[a] Chinook salmon > 655 mm.

[b] Chinook salmon ≤ 655mm.

APPENDIX G: DAILY CUMULATIVE FISH PASSAGE ESTIMATES, PROPORTIONS, AND TIMING BY SPECIES

Appendix G1.–Daily cumulative fish passage estimates by species, at the Pilot Station sonar project on the Yukon River, 2009.

	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
6/01	0	0	0	0	0	0	0	990	990
6/02	0	0	0	0	0	0	0	2,187	2,187
6/03	0	0	0	0	0	0	0	6,149	6,149
6/04	0	0	0	0	0	0	0	8,792	8,792
6/05	0	0	0	0	0	0	0	11,563	11,563
6/06	0	0	0	0	0	0	0	15,215	15,215
6/07	0	0	0	0	0	0	0	19,647	19,647
6/08	0	0	0	64	0	0	0	22,623	22,687
6/09	976	0	976	212	0	0	0	24,807	25,995
6/10	1,658	20	1,678	2,269	0	0	0	27,666	31,613
6/11	1,735	86	1,821	4,802	0	0	0	31,920	38,543
6/12	2,229	95	2,324	6,628	0	0	0	35,536	44,488
6/13	3,060	549	3,609	27,738	0	0	0	39,386	70,733
6/14	4,363	793	5,156	42,066	0	0	0	42,027	89,249
6/15	4,391	915	5,306	56,094	0	0	0	43,603	105,003
6/16	4,522	1,198	5,720	68,084	0	0	0	44,611	118,415
6/17	6,154	1,762	7,916	78,465	0	0	0	46,784	133,165
6/18	10,384	3,062	13,446	96,411	0	0	0	47,186	157,043
6/19	12,293	4,398	16,691	115,822	0	0	0	47,332	179,845
6/20	18,019	5,360	23,379	126,531	0	0	0	51,521	201,431
6/21	19,913	6,303	26,216	143,197	0	0	0	51,798	221,211
6/22	21,656	6,719	28,375	156,613	0	0	0	53,597	238,585
6/23	24,963	7,563	32,526	174,060	0	0	0	53,597	260,183
6/24	29,254	10,104	39,358	205,160	0	0	0	54,102	298,620
6/25	30,945	11,576	42,521	255,900	0	0	0	54,891	353,312
6/26	39,222	14,113	53,335	379,434	0	0	0	55,792	488,561
6/27	52,805	18,328	71,133	542,413	0	0	0	55,792	669,338
6/28	65,887	20,618	86,505	705,689	0	0	0	58,107	850,301
6/29	75,723	22,578	98,301	829,031	0	0	0	59,803	987,135
6/30	81,325	25,518	106,843	894,861	0	0	0	60,906	1,062,610
7/01	86,159	27,922	114,081	952,007	0	0	0	61,983	1,128,071
7/02	87,820	28,319	116,139	1,025,144	0	0	0	68,639	1,209,922
7/03	89,759	29,106	118,865	1,055,617	0	0	0	82,472	1,256,954
7/04	91,663	29,860	121,523	1,086,862	0	0	0	96,233	1,304,618
7/05	93,380	30,247	123,627	1,143,214	0	0	0	98,011	1,364,852
7/06	96,445	30,957	127,402	1,188,271	0	299	0	109,239	1,425,211
7/07	100,083	31,726	131,809	1,242,172	0	500	0	122,468	1,496,949
7/08	102,107	32,528	134,635	1,276,749	0	1,069	0	134,203	1,546,656
7/09	103,255	32,977	136,232	1,295,874	0	1,416	0	141,164	1,574,686
7/10	105,528	34,727	140,255	1,308,782	0	1,416	0	147,234	1,597,687
7/11	105,528	35,220	140,748	1,333,990	0	1,989	0	161,985	1,638,712
7/12	106,632	35,220	141,852	1,379,491	0	2,245	0	171,564	1,695,152
7/13	106,872	35,220	142,092	1,390,233	0	2,856	0	190,517	1,725,698
7/14	107,034	35,220	142,254	1,396,893	0	3,177	0	204,010	1,746,334
7/15	107,906	35,504	143,410	1,404,370	0	3,177	0	214,383	1,765,340
7/16	107,974	35,504	143,478	1,409,653	0	3,684	0	227,348	1,784,163

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	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
7/17	108,139	35,504	143,643	1,418,178	0	4,184	0	249,718	1,815,723
7/18	108,139	35,504	143,643	1,421,646	0	4,184	0	272,286	1,841,759
7/19	108,243	35,578	143,821	1,421,646	2,911	5,185	0	292,124	1,865,687
7/20	108,243	35,578	143,821	1,421,646	5,139	5,950	0	303,428	1,879,984
7/21	108,243	35,578	143,821	1,421,646	6,612	6,535	0	309,427	1,888,041
7/22	108,243	35,578	143,821	1,421,646	7,034	6,646	0	320,025	1,899,172
7/23	108,286	35,688	143,974	1,421,646	7,974	9,157	0	331,245	1,913,996
7/24	108,286	35,688	143,974	1,421,646	15,294	9,363	0	338,485	1,928,762
7/25	108,286	35,688	143,974	1,421,646	16,157	9,868	0	351,181	1,942,826
7/26	108,286	35,688	143,974	1,421,646	17,370	10,820	0	361,716	1,955,526
7/27	108,286	35,688	143,974	1,421,646	18,423	11,722	0	371,194	1,966,959
7/28	108,286	35,688	143,974	1,421,646	18,529	15,477	181	378,022	1,977,829
7/29	108,286	35,688	143,974	1,421,646	19,097	16,527	181	387,428	1,988,853
7/30	108,286	35,688	143,974	1,421,646	19,643	16,527	230	404,358	2,006,378
7/31	108,361	35,688	144,049	1,421,646	21,932	16,628	230	413,428	2,017,913
8/01	108,361	35,688	144,049	1,421,646	25,586	17,358	273	424,173	2,033,085
8/02	108,361	35,688	144,049	1,421,646	47,509	17,634	1,431	438,318	2,070,587
8/03	108,361	35,688	144,049	1,421,646	58,396	17,893	1,990	447,743	2,091,717
8/04	108,361	35,688	144,049	1,421,646	58,658	17,991	1,990	463,837	2,108,171
8/05	108,361	35,688	144,049	1,421,646	58,730	17,991	3,270	477,970	2,123,656
8/06	108,361	35,688	144,049	1,421,646	59,160	17,991	4,007	491,777	2,138,630
8/07	108,361	35,688	144,049	1,421,646	61,050	17,991	4,875	501,195	2,150,806
8/08	108,361	35,688	144,049	1,421,646	61,942	19,805	6,118	509,514	2,163,074
8/09	108,361	35,688	144,049	1,421,646	66,478	19,899	8,988	516,637	2,177,697
8/10	108,361	35,688	144,049	1,421,646	78,798	19,899	9,970	535,980	2,210,342
8/11	108,361	35,688	144,049	1,421,646	110,724	21,661	19,238	567,631	2,284,949
8/12	108,361	35,688	144,049	1,421,646	150,172	21,661	29,990	581,042	2,348,560
8/13	108,361	35,688	144,049	1,421,646	162,896	21,661	43,139	592,698	2,386,089
8/14	108,361	35,688	144,049	1,421,646	164,564	23,519	49,439	606,474	2,409,691
8/15	108,361	35,688	144,049	1,421,646	166,917	23,519	56,950	617,115	2,430,196
8/16	108,361	35,688	144,049	1,421,646	167,050	23,519	60,393	631,111	2,447,768
8/17	108,361	35,688	144,049	1,421,646	167,529	23,679	62,556	649,427	2,468,886
8/18	108,361	35,688	144,049	1,421,646	169,826	23,679	69,786	661,496	2,490,482
8/19	108,361	35,688	144,049	1,421,646	175,046	23,679	79,381	672,462	2,516,263
8/20	108,361	35,688	144,049	1,421,646	179,266	23,679	89,784	682,069	2,540,493
8/21	108,361	35,688	144,049	1,421,646	191,402	23,679	109,181	687,501	2,577,458
8/22	108,361	35,688	144,049	1,421,646	199,790	23,679	126,078	691,209	2,606,451
8/23	108,361	35,688	144,049	1,421,646	202,559	23,679	139,093	695,125	2,626,151
8/24	108,361	35,688	144,049	1,421,646	205,136	23,679	150,353	698,779	2,643,642
8/25	108,361	35,688	144,049	1,421,646	205,931	23,679	155,082	708,906	2,659,293
8/26	108,361	35,688	144,049	1,421,646	206,476	23,679	159,085	720,805	2,675,740
8/27	108,361	35,688	144,049	1,421,646	206,777	23,679	162,179	729,246	2,687,576
8/28	108,361	35,688	144,049	1,421,646	206,985	23,679	169,768	732,040	2,698,167
8/29	108,361	35,688	144,049	1,421,646	207,904	23,679	172,649	738,752	2,708,679
8/30	108,361	35,688	144,049	1,421,646	207,965	23,679	179,783	741,963	2,719,085
8/31	108,361	35,688	144,049	1,421,646	211,001	23,679	184,813	743,218	2,728,406

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	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other	Total
9/01	108,361	35,688	144,049	1,421,646	214,548	23,679	190,275	744,392	2,738,589
9/02	108,361	35,688	144,049	1,421,646	218,596	23,679	192,868	748,152	2,748,990
9/03	108,361	35,688	144,049	1,421,646	219,934	23,679	195,081	755,134	2,759,523
9/04	108,361	35,688	144,049	1,421,646	223,232	23,679	199,456	757,176	2,769,238
9/05	108,361	35,688	144,049	1,421,646	227,403	23,679	201,415	759,539	2,777,731
9/06	108,361	35,688	144,049	1,421,646	233,169	23,679	202,519	761,074	2,786,136
9/07	108,361	35,688	144,049	1,421,646	233,307	23,679	206,620	765,140	2,794,441

[a] Chinook salmon > 655 mm.

[b] Chinook salmon ≤ 655mm.

Appendix G2.–Daily cumulative fish passage proportions and timing by species, at the Pilot Station sonar project on the Yukon River, 2009.

	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	0.00
6/02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
6/04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
6/05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
6/06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
6/07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
6/08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
6/09	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.03
6/10	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.04
6/11	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.04
6/12	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.05
6/13	0.03	0.02	0.03	0.02	0.00	0.00	0.00	0.05
6/14	0.04	0.02	0.04	0.03	0.00	0.00	0.00	0.05
6/15	0.04	0.03	0.04	0.04	0.00	0.00	0.00	0.06
6/16	0.04	0.03	0.04	0.05	0.00	0.00	0.00	0.06
6/17	0.06	0.05	0.05	0.06	0.00	0.00	0.00	0.06
6/18	0.10	0.09	0.09	0.07	0.00	0.00	0.00	0.06
6/19	0.11	0.12	0.12	0.08	0.00	0.00	0.00	0.06
6/20	0.17	0.15	0.16	0.09	0.00	0.00	0.00	0.07
6/21	0.18	0.18	0.18	0.10	0.00	0.00	0.00	0.07
6/22	0.20	0.19	0.20	0.11	0.00	0.00	0.00	0.07
6/23	0.23	0.21	0.23	0.12	0.00	0.00	0.00	0.07
6/24	**0.27**	**0.28**	**0.27**	0.14	0.00	0.00	0.00	0.07
6/25	0.29	0.32	0.30	0.18	0.00	0.00	0.00	0.07
6/26	0.36	0.40	0.37	**0.27**	0.00	0.00	0.00	0.07
6/27	0.49	**0.51**	0.49	0.38	0.00	0.00	0.00	0.07
6/28	**0.61**	0.58	**0.60**	**0.50**	0.00	0.00	0.00	0.08
6/29	0.70	0.63	0.68	0.58	0.00	0.00	0.00	0.08
6/30	**0.75**	0.72	0.74	0.63	0.00	0.00	0.00	0.08
7/01	0.80	**0.78**	**0.79**	0.67	0.00	0.00	0.00	0.08
7/02	0.81	0.79	0.81	0.72	0.00	0.00	0.00	0.09
7/03	0.83	0.82	0.83	0.74	0.00	0.00	0.00	0.11
7/04	0.85	0.84	0.84	**0.76**	0.00	0.00	0.00	0.13
7/05	0.86	0.85	0.86	0.80	0.00	0.00	0.00	0.13
7/06	0.89	0.87	0.88	0.84	0.00	0.01	0.00	0.14
7/07	0.92	0.89	0.92	0.87	0.00	0.02	0.00	0.16
7/08	0.94	0.91	0.93	0.90	0.00	0.05	0.00	0.18
7/09	0.95	0.92	0.95	0.91	0.00	0.06	0.00	0.18
7/10	0.97	0.97	0.97	0.92	0.00	0.06	0.00	0.19
7/11	0.97	0.99	0.98	0.94	0.00	0.08	0.00	0.21
7/12	0.98	0.99	0.98	0.97	0.00	0.09	0.00	0.22
7/13	0.99	0.99	0.99	0.98	0.00	0.12	0.00	**0.25**
7/14	0.99	0.99	0.99	0.98	0.00	0.13	0.00	0.27
7/15	1.00	0.99	1.00	0.99	0.00	0.13	0.00	0.28
7/16	1.00	0.99	1.00	0.99	0.00	0.16	0.00	0.30

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	Chinook			Chum				
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other
7/17	1.00	0.99	1.00	1.00	0.00	0.18	0.00	0.33
7/18	1.00	0.99	1.00	1.00	0.00	0.18	0.00	0.36
7/19	1.00	1.00	1.00	1.00	0.01	0.22	0.00	0.38
7/20	1.00	1.00	1.00	1.00	0.02	**0.25**	0.00	0.40
7/21	1.00	1.00	1.00	1.00	0.03	0.28	0.00	0.40
7/22	1.00	1.00	1.00	1.00	0.03	0.28	0.00	0.42
7/23	1.00	1.00	1.00	1.00	0.03	0.39	0.00	0.43
7/24	1.00	1.00	1.00	1.00	0.07	0.40	0.00	0.44
7/25	1.00	1.00	1.00	1.00	0.07	0.42	0.00	0.46
7/26	1.00	1.00	1.00	1.00	0.07	0.46	0.00	0.47
7/27	1.00	1.00	1.00	1.00	0.08	**0.50**	0.00	0.49
7/28	1.00	1.00	1.00	1.00	0.08	0.65	0.00	0.49
7/29	1.00	1.00	1.00	1.00	0.08	0.70	0.00	**0.51**
7/30	1.00	1.00	1.00	1.00	0.08	0.70	0.00	0.53
7/31	1.00	1.00	1.00	1.00	0.09	0.70	0.00	0.54
8/01	1.00	1.00	1.00	1.00	0.11	0.73	0.00	0.55
8/02	1.00	1.00	1.00	1.00	0.20	0.74	0.01	0.57
8/03	1.00	1.00	1.00	1.00	**0.25**	**0.76**	0.01	0.59
8/04	1.00	1.00	1.00	1.00	0.25	0.76	0.01	0.61
8/05	1.00	1.00	1.00	1.00	0.25	0.76	0.02	0.62
8/06	1.00	1.00	1.00	1.00	0.25	0.76	0.02	0.64
8/07	1.00	1.00	1.00	1.00	0.26	0.76	0.02	0.66
8/08	1.00	1.00	1.00	1.00	0.27	0.84	0.03	0.67
8/09	1.00	1.00	1.00	1.00	0.28	0.84	0.04	0.68
8/10	1.00	1.00	1.00	1.00	0.34	0.84	0.05	0.70
8/11	1.00	1.00	1.00	1.00	0.47	0.91	0.09	0.74
8/12	1.00	1.00	1.00	1.00	**0.64**	0.91	0.15	**0.76**
8/13	1.00	1.00	1.00	1.00	0.70	0.91	0.21	0.77
8/14	1.00	1.00	1.00	1.00	0.71	0.99	0.24	0.79
8/15	1.00	1.00	1.00	1.00	0.72	0.99	**0.28**	0.81
8/16	1.00	1.00	1.00	1.00	0.72	0.99	0.29	0.82
8/17	1.00	1.00	1.00	1.00	0.72	1.00	0.30	0.85
8/18	1.00	1.00	1.00	1.00	0.73	1.00	0.34	0.86
8/19	1.00	1.00	1.00	1.00	**0.75**	1.00	0.38	0.88
8/20	1.00	1.00	1.00	1.00	0.77	1.00	0.43	0.89
8/21	1.00	1.00	1.00	1.00	0.82	1.00	**0.53**	0.90
8/22	1.00	1.00	1.00	1.00	0.86	1.00	0.61	0.90
8/23	1.00	1.00	1.00	1.00	0.87	1.00	0.67	0.91
8/24	1.00	1.00	1.00	1.00	0.88	1.00	0.73	0.91
8/25	1.00	1.00	1.00	1.00	0.88	1.00	**0.75**	0.93
8/26	1.00	1.00	1.00	1.00	0.88	1.00	0.77	0.94
8/27	1.00	1.00	1.00	1.00	0.89	1.00	0.78	0.95
8/28	1.00	1.00	1.00	1.00	0.89	1.00	0.82	0.96
8/29	1.00	1.00	1.00	1.00	0.89	1.00	0.84	0.97
8/30	1.00	1.00	1.00	1.00	0.89	1.00	0.87	0.97
8/31	1.00	1.00	1.00	1.00	0.90	1.00	0.89	0.97

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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	0.92	1.00	0.92	0.97
9/02	1.00	1.00	1.00	1.00	0.94	1.00	0.93	0.98
9/03	1.00	1.00	1.00	1.00	0.94	1.00	0.94	0.99
9/04	1.00	1.00	1.00	1.00	0.96	1.00	0.97	0.99
9/05	1.00	1.00	1.00	1.00	0.97	1.00	0.97	0.99
9/06	1.00	1.00	1.00	1.00	1.00	1.00	0.98	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 H: PROPORTION OF AGREEMENT OF FISH PASSAGE ESTIMATES

Appendix H1.–Proportion of agreement of fish passage estimates produced using the standard three 3-h sampling method with those produced during continuous 24 hour sonar periods by zone from 1998 to 2007, at the Pilot Station sonar project on the Yukon River.

		Left Bank		
Date	Right Bank	Nearshore	Offshore	Total
6/18/98	0.146	-0.030	0.111	0.049
7/02/98	0.056	-0.056	-0.018	-0.007
7/04/98	0.012	-0.059	-0.075	-0.030
7/05/98	-0.118	-0.042	0.171	-0.048
7/06/98	-0.150	-0.041	-0.221	-0.114
7/16/98	-0.053	0.052	-0.109	-0.008
7/17/98	-0.053	0.052	-0.109	-0.008
8/10/98	0.062	0.125	0.000	0.065
8/24/98	-0.085	0.283	-0.013	0.132
6/26/99	-0.169	0.129	-0.175	-0.040
7/11/99	-0.123	0.024	0.110	0.031
7/24/99	-0.028	0.088	-0.062	0.012
8/08/99	-0.028	0.088	-0.062	0.012
8/21/99	0.059	0.300	0.075	0.170
6/28/00	-0.091	0.176	-0.007	-0.014
6/29/00	-0.040	0.110	0.015	0.040
7/12/00	-0.258	0.105	0.003	-0.015
7/26/00	-0.258	0.105	0.003	-0.015
8/16/00	0.091	0.165	0.143	0.143
8/30/00	-0.007	0.083	-0.092	0.030
7/03/01	-0.026	0.143	-0.136	0.024
7/20/01	-0.042	0.156	0.048	0.084
8/06/01	-0.037	-0.068	-0.050	-0.054
8/19/01	-0.062	0.022	-0.052	-0.040
6/17/02	0.165	-0.001	-0.049	0.016
7/02/02	-0.140	0.016	-0.025	-0.038
7/17/02	-0.099	0.109	0.039	0.005
7/31/02	-0.046	0.004	-0.176	-0.103
8/16/02	-0.050	0.090	0.095	0.047
6/22/03	-0.148	0.337	-0.087	0.030
7/06/03	-0.066	0.060	0.065	0.043
7/21/03	-0.005	0.182	-0.039	0.053
8/05/03	-0.011	0.475	0.261	0.279
8/18/03	-0.204	0.085	0.358	0.244
6/14/04	-0.232	0.198	0.114	-0.019
6/26/04	-0.039	0.234	-0.120	0.064
7/11/04	-0.066	0.072	-0.030	-0.010
7/25/04	-0.084	0.054	-0.005	0.013
8/08/04	-0.087	0.088	0.079	0.041
8/22/04	-0.195	0.092	0.323	0.155
6/18/05	0.006	0.184	0.003	0.053
6/30/05	0.041	0.058	-0.121	0.000
7/13/05	-0.001	0.002	-0.003	-0.001
7/27/05	-0.056	-0.002	-0.128	-0.052
8/09/05	-0.017	0.073	0.637	0.475
6/19/07	0.055	-0.003	-0.090	-0.032
8/05/07	-0.050	0.132	0.120	0.084

Note: Proportion of agreement is derived as follows: (three-3 h estimate/ 24 h estimate)-1. Therefore, a positive percentage indicates that the 3-3h estimate was higher than the estimate obtained during the 24 hour sonar period. There were no 24 hour sonar period conducted in 2006.