Regional Information Report 3A.16-06

Feasibility of estimating salmon abundance in the Kuskokwim River using sonar, 2014 and 2015

by

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May 2016

Alaska Department of Fish and Game **Division of Commercial Fisheries**

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Weights and measures (metric)	
centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm
Weights and measures (English)	
cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd
Time and temperature	
day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s
Physics and chemistry	
all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

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

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

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May 2016

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This document should be cited as follows:
Brodersen, N. B., B. C. McIntosh, and C. T. Pfisterer. 2016 . Feasibility of estimating salmon abundance in the Kuskokwim River using sonar, 2014 and 2015. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A.16-06, Anchorage.

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ABSTRACT

A study was initiated in 2014 to assess the feasibility of using sonar, in combination with drift gillnetting, to estimate salmon abundance in the Kuskokwim River. Ten areas in the lower river were surveyed, bottom profiles were analyzed for suitability of sonar operation, and two sites were selected for further study in 2015, one located near the upper confluence of the Kuskokwim River and Church Slough, and the other approximately 5 km downriver from the community of Akiak. Each site had both a gradual and a steep-sloping bank, and different sonar technology was tested on each bank in 2015: split-beam sonar on the gradual-sloping bank and imaging sonar on the steep-sloping bank. The feasibility of using drift gillnets for species apportionment was also assessed in 2015. A range of drift gillnet mesh sizes were fished on both banks at each site. The sonars were found to provide effective horizontal coverage, with 90% of fish passing within 14 m of the transducer on the left bank and within 140 m on the right bank at Akiak, and 90% of fish passing within 110 m of the transducer on the left bank and within 18 m on the right bank at Church Slough. Fish were found to be distributed throughout the vertical water column, and a spreader lens should be tested for the imaging sonar to provide effective vertical coverage on the steep-sloping bank. Drift gillnetting proved to be an effective fishing method at both sites. Advantages and disadvantages were found at both the Akiak and Church Slough sites, and the sonar research team concluded that the project would probably be successful at either site. The Kuskokwim research team and managers selected the site near Church Slough for 2016 operations, so that Kwethluk River fish would be included in the estimates.

Key words: hydroacoustics, sonar, split-beam, dual-frequency identification sonar DIDSON, adaptive resolution imaging sonar ARIS, gillnet, apportionment, Pacific salmon *Oncorhynchus* spp., Chinook *Oncorhynchus tshawytscha*, chum *O. keta*, sockeye *O. nerka*, Kuskokwim River, Alaska.

INTRODUCTION

The Kuskokwim River produces substantial runs of Chinook salmon *Oncorhynchus tshawytscha*, chum salmon *O. keta*, sockeye salmon *O. nerka*, and coho salmon *O. kisutch*, and supports large subsistence and commercial fisheries (Tiernan and Poetter 2015). The majority of the harvest occurs in the first 200 km of the Kuskokwim River and harvest opportunity is managed inseason (Tiernan and Poetter 2015). Currently, the only sources of timely inseason data available for managing the salmon fisheries comes from a test fishery operated near Bethel (Lipka and Poetter 2016), qualitative subsistence harvest reports (Shelden and Chavez 2016) and commercial harvest statistics. The available data provide only an index of salmon abundance. Timely and accurate abundance estimates for each salmon species passing through the lower river harvest areas are needed to improve the effectiveness of inseason management of the salmon fisheries.

Sonar has been used successfully in several large, turbid rivers in Alaska to provide salmon abundance estimates.[1] The Alaska Department of Fish and Game (ADF&G) operates projects on the Yukon River near the villages of Pilot Station (Lozori and McIntosh 2014) and Eagle (Lozori and Borden 2015), on the Kenai River (Key et al. 2016), and on the Copper River (Malherek et al. 2015), among others. The U.S. Fish and Wildlife Service (USFWS) operates a sonar project on the Chandalar River (Melegari 2015). The project on the Yukon River near Pilot Station operates under similar conditions to those found on the Kuskokwim River, and thus the Kuskokwim River feasibility work was initially patterned after that project.

The Kuskokwim River has had an irregular history of sonar projects operating in the lower river. In 1980 and 1981, a feasibility study was conducted at a site 8 km upstream from Bethel, but results were inconclusive and a full-scale project was not developed (Nickerson and Gaudet 1983). From 1988 through 1990, a feasibility project was operated near the same location, and

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[1] ADF&G (Alaska Department of Fish and Game). 2016. Alaska fisheries sonar. http://www.adfg.alaska.gov/index.cfm?adfg=sonar.main (Accessed April 2016).

from 1991 through 1995 the project produced daily passage estimates (Vaught and Molyneaux 1995). The project did not operate from 1996 through 1998 because of staffing shortages (Carl Pfisterer, Commercial Fisheries Biologist, ADF&G, Fairbanks; personal communication). A 3 year feasibility study was initiated in 1999 at a new site, 26 km upstream from Bethel, but only operated for a single season again because of staffing shortages .[2] Improvements in sonar technology over the last two decades, and the continuing need for additional inseason management tools, prompted renewed interest in using sonar to estimate salmon abundance in the lower Kuskokwim River.

OBJECTIVES

The purpose of this project was to assess the feasibility of using sonar and drift gillnets to estimate fish passage, by species, in the lower portion of the Kuskokwim River. Objectives included:

1) Identify a location on the lower Kuskokwim River with a substrate structure suitable for operating sonar and drift gillnets on both banks.
2) Deploy split-beam and imaging sonar on both banks of the river, determine optimal settings for fish detection, and assess effectiveness of fish detection.
3) Use drift gillnets to catch fish species detected by the sonar on both banks and assess the effectiveness of this method for species apportionment.

METHODS

Feasibility work began in 2014 when initial river bottom surveys were performed. Six sites near Bethel, where the river formed a single channel (Figure 1), were examined with a Humminbird[3] 998C SI fathometer with GPS and side-scan sonar to identify locations suitable for sonar where the river bottom had a consistent downward slope on both banks. In 2015, additional river bottom surveys were performed at seven sites, three that had been surveyed in 2014 and four additional sites. Two sites had acceptable profiles (Figure 2), and were selected for further investigation. One was located near the upper confluence of the Kuskokwim River and Church Slough, and the other was located approximately 5 km downriver from the community of Akiak. Both sites had a gradual-sloping bank and a steep-sloping bank. The gradual-sloping bank was located on the left bank at Church Slough and on the right bank at Akiak.

After the acceptable sites had been determined, water velocity was measured across the river channel at both Akiak and Church Slough at low, incoming, and high tidal stages, to assess any differences in tidal influence on water velocity, which could potentially affect fish behavior. Water velocity profile data were collected using a SonTek River Surveyor model M9 Doppler profiler. In addition, to identify areas with fewer snags for drift gillnetting, the Humminbird fathometer was towed along both banks at each site, utilizing the side-scan capabilities.

Sonar was deployed at the site near Church Slough from June 18 through June 26, and again from July 11 through July 17 (Table 1). Sonar was deployed at the site near Akiak from June 27 through July 10. Based on the river bottom profiles and experience at other sonar sites, split-beam sonar, with its narrow beam and greater range, was chosen for the gradual-sloping banks at

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[2] Vania, T. Unpublished. Kuskokwim River sonar operational plan. Alaska Department of Fish and Game, Anchorage.
[3] Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

each site. Imaging sonar was best suited for the shorter, wide-angled profiles of the steep-sloping banks. At both sites, two types of split-beam sonar were used on the gradual-sloping bank to determine the optimal system based on fish distribution and sonar coverage, a Hydroacoustic Technologies, Inc. (HTI) model 241-2 digital echosounder system, and a Simrad model EK60 digital echosounder system. A Sound Metrics Corp. Adaptive Resolution Imaging Sonar (ARIS) Explorer 1200 model was used on the steep-sloping banks. On both left and right banks, sonar data were collected using varying ranges (strata definitions) to identify optimal configurations for future operation. In addition, the ARIS was used to collect vertical distribution data to a range of approximately 40 m on both banks to assess whether the vertical sonar beam angles were sufficient to cover the majority of fish passage. The ARIS was also deployed beside the split-beam sonars for a count comparison to assess the performance of the split-beam sonars in the nearshore 40 m range.

To determine whether gillnets would be suitable for species apportionment, drift gillnet fishing was performed at Church Slough from June 23 through June 25 and July 12 through July 16, and at Akiak from June 28 through July 9. Nets with a length of 25 fathoms, depths of approximately 26 ft and 13 ft deep, and stretch mesh sizes of 2.75 in, 5.25 in, 6.5 in, and 7.5 in were used. Nets were fished in three zones to cover areas with high fish passage, and to allow for effective fishing based on depth: a nearshore and an offshore zone on the gradual-sloping bank, and a nearshore zone on the steep-sloping bank. Healthy fish were released back into the river, and mortalities were given to the communities of Kwethluk and Akiak.

RESULTS

A range of factors were considered in comparing the two potential sonar sites (Table 2). Physically, the river was slightly wider, and the tide was substantially larger, at the site near Church Slough than at the site near Akiak. Doppler profile data showed that at Church Slough the water velocity was highest at low tide, and decreased as the tide came in (Table 3). At Akiak the water velocity was nearly the same throughout the low, incoming, and high tidal stages.

The snag-free fishing zone for the steep-sloping bank was slightly closer to the sonar at Church Slough than at Akiak and, due to the location of snags, the average drift time was longer at Church Slough. There was more subsistence fishing effort in front of the sonar at Akiak, which may have been due to more openings when the project was collecting data at that site.

At both sites, passage was higher on the right bank than the left bank (Table 4). At Akiak, 90% of fish passed within 14 m of the transducer on the left bank, and within 140 m on the right bank (Figure 3). At Church Slough, 90% of fish passed within 110 m of the transducer on the left bank, and within 18 m on the right bank (Figure 4). Approximately 5% of fish passed between 200 and 250 m from the transducers (Table 5). In some instances, as the tide height increased, fish distribution shifted offshore. There appeared to be a distinct relationship between horizontal distribution and tide height on the left bank at both sites (Figure 5). Although the data set was incomplete for the right bank at both sites, there was a slight relationship at Akiak and no relationship at Church Slough.

Overall, the proportion of downstream passage was just slightly higher (<1%) at Akiak than at Church Slough for the short time period observed (Table 6). There appeared to be a distinct relationship between the proportion of downstream traveling fish and tide height at both sites on the left bank (Figure 6), and a weak to non-existent relationship on the right bank, although again, the data set was incomplete for the right bank at both sites. Also, there appeared to be a relationship between upstream fish counts and tide height on the left bank at Akiak (Figure 7), but no obvious relationship on the right bank, or on either bank at Church Slough.

Fish were distributed throughout the water column at both sites (Figures 8 and 9). Fish were not observed as high in the water column on the left bank at the site near Akiak, however, these data were collected with a single vertical stratum that did not include the upper water column.

At both Church Slough and Akiak, the Simrad and ARIS each detected more fish than the HTI. At Church Slough the ARIS also detected more fish than the Simrad (Figure 10). There were no paired data for the Simrad and ARIS at Akiak. Examination of echograms showed that most missed fish were in the nearshore 20 m range. Comparisons of different sonar strata definitions showed that on the gradual-sloping bank, a nearshore stratum with a range of 0 to 50 m, a mid-shore stratum with a range of 50 to 150 m, and an offshore stratum with a range of 150 to 250 m, allowed for easily countable fish traces, and corresponded well with test fish zones. On the steep-sloping bank, a nearshore stratum with a range of 0 to 20 m, and an offshore stratum with a range of 20 to 40 m also worked well for these reasons. On both banks other strata definitions were found to be acceptable as well, however, and further experimentation with strata definitions could be performed in future seasons to identify the optimal configurations based on horizontal fish distribution over a complete season.

A total of 1,009 fish were captured in the test fishery. Species included Chinook, chum, sockeye, and pink *O. gorbuscha* salmon, as well as least cisco *Coregonus sardinella*, Bering cisco *C. laurettae*, humpback whitefish *C. pidschian*, broad whitefish *C. nasus*, sheefish *Stenodus leucichthys*, burbot *Lota lota*, and Dolly Varden *Salvelinus malma* (Table 7). The 2.75 in and 5.25 in mesh sizes were used for nearly equal amounts of time at both sites. Due to net damage caused by snags at Church Slough, the 7.5 in mesh net was used for less time than at Akiak (Table 8).

DISCUSSION

Near-complete sonar coverage of the river should be possible at either site, given the relatively narrow river width, consistent-sloping river bottom, and low suspended sediment levels. The horizontal distribution results indicate that the majority of fish travel close to shore within the range of the sonar at both sites. Relationships between the tide height and horizontal distribution, downstream passage, and upstream passage were present at both sites. In addition, vertical fish distribution was similar between the two sites. For future operation it will be important to have sonar beams that can cover the entire vertical water column on both banks of the river. A spreader lens should be tested for the ARIS in 2016 to improve vertical coverage on the steep-sloping bank.

The small discrepancies between the HTI and Simrad were probably because of differences in aim or perhaps vertical beam widths. If the HTI system is used in 2016, the height of the transducer relative to the river bottom should be tested, and special care should be taken to ensure an optimal aim. In 2015, a 2° x 10° (height x width) transducer was used for the HTI, in contrast to the 2.5° x 10° Simrad transducer. In 2016, a 2.5° x 10° transducer should be tested with the HTI system, if available, to see if fish detection improves. In addition, installation of the fish leads should improve fish detection in the immediate nearshore region of all sonars. The discrepancies between the ARIS and both split-beam sonars are probably because of the wider field of view of the ARIS, higher frequency and resolution, and the ability to use the video when counting. In 2016, it may be advantageous to deploy a Sound Metrics Corp. dual-frequency identification sonar (DIDSON) Long-Range (LR) model beside the split-beam sonar to cover the nearshore region (0 to 20 m) where the split-beam is narrow.

Species with a range of sizes were caught at both sites, which was encouraging for evaluation of the test fishery performance. During the last few days of test fishing at the site near Church Slough, large numbers of least cisco were caught on the right bank with the 2.75 in net, indicating that there are periods of concentrated whitefish migration on the Kuskokwim River. Anticipating these periods in future seasons will be important to ensure proper apportionment of daily estimates.

The shallow nets effectively caught fish in the nearshore drifts along the steep-sloping banks at both sites, and caught fewer snags than the deep nets. Further experimentation with net depth should be performed in 2016 to determine the optimal depth for each drift zone. Snags were primarily a problem on the steep-sloping banks at both sites, but could be avoided with shorter drifts. Longer drift times would be preferable during times of low fish passage, making the longer average drift time on the steep-sloping bank at Church Slough advantageous. Drift zones should be as close to the sonar as possible to reduce the possibility of fish changing banks between the fishing zone and the sonar location, and to support the assumption that the test fishery is catching a representative sample of the fish detected on the sonar. For this reason, the shorter distance between the drift zone on the steep-sloping bank and the sonar at Church Slough gave this site a slight advantage over Akiak.

The primary disadvantage of Church Slough was the larger tidal change, which made for a more difficult sonar deployment, and would require a substantially longer sonar fish lead to be built on the gradual-sloping left bank. However, the higher subsistence fishing traffic in front of the sonar at Akiak gave Church Slough an advantage. In addition, the close proximity to Bethel made the site near Church Slough more affordable in terms of fuel and travel time costs. An additional consideration identified by fishery managers was that Kwethluk River fish would be included in the sonar estimate if the project was located at Church Slough, which would be preferable. On the other hand, managers noted that because most subsistence fishing occurs downstream from Akiak, if the project was located at Akiak, the sonar estimates would be rough approximations of the escapement estimates, which could possibly be an advantage.

In spring 2016, the sonar research team, Kuskokwim research team, and Kuskokwim managers held a teleconference to discuss the findings from 2015, and decide which site to use for the 2016 feasibility study. In summary, the 2015 field work showed that there were advantages and disadvantages to both the Akiak and Church Slough sites, but there were no obvious factors that indicated one site would produce more accurate estimates. The sonar research team concluded that the project would likely be successful at either site. Given this information, the Kuskokwim research team and managers decided that the site near Church Slough would be preferable, so that Kwethluk River fish would be included in the estimates. After the teleconference, planning for the 2016 field season was directed to the site near Church Slough.

ACKNOWLEDGEMENTS

The authors would like to thank Malcolm McEwen for performing the initial site surveys in 2014, the Kwethluk Village Corporation and Akiak Village Corporation for providing land use permits, and the ADF&G Kuskokwim River research and management teams in Bethel for their information and support.

The authors would also like to thank the following people for their outstanding hard work and dedication to the project during the 2015 season: crew leader Keegan Birchfield, and technicians Brit Hayes and Chad Latham.

REFERENCES CITED

Key, B. H., J. D. Miller, D. L. Burwen, and S. J. Fleischman. 2016. Estimates of Chinook salmon passage in the Kenai River at river mile 8.6 using dual-frequency identification sonar, 2014. Alaska Department of Fish and Game, Fishery Data Series No. 16-14, Anchorage.

Lipka, C., and A. Poetter. 2016. Characterization of the 2014 salmon runs in the Kuskokwim River based on the test fishery at Bethel. Alaska Department of Fish and Game, Fishery Data Series No. 16-07, Anchorage.

Lozori, J. D., and L. K. Borden. 2015. Sonar estimation of Chinook and fall chum salmon passage in the Yukon River near Eagle, Alaska, 2014. Alaska Department of Fish and Game, Fishery Data Series No. 15-44, Anchorage.

Lozori, J. D., and B. C. McIntosh. 2014. Sonar estimation of salmon passage in the Yukon River near Pilot Station, 2012. Alaska Department of Fish and Game, Fishery Data Series No. 14-22, Anchorage.

Malherek, D., R. Johnson, and J. Bell. 2015. Using hydroacoustic methods to enumerate migrating salmon in the Copper River, Miles Lake sonar project, 2008-2010. Alaska Department of Fish and Game, Fishery Data Series No. 15-23, Anchorage.

Melegari, J. L. 2015. Abundance and run timing of adult fall chum salmon in the Chandalar River, Yukon Flats National Wildlife Refuge, Alaska, 2014. U.S. Fish and Wildlife Service, Alaska Fisheries Data Series Number 2015-9, Fairbanks.

Nickerson, R. B. and D. Gaudet. 1983. Sonar feasibility studies in the lower Kuskokwim and Yukon Rivers, 1980-1983. Alaska Department of Fish and Game, Division of Commercial Fisheries, Yukon Escapement Report 36, Anchorage.

Shelden, C. A., and R. Chavez. 2016. Inseason subsistence salmon harvest monitoring, Lower Kuskokwim River, 2014. Alaska Department of Fish and Game, Fishery Management Report No. 16-06, Anchorage.

Tiernan, A., and A. Poetter. 2015. 2013 Kuskokwim area management report. Alaska Department of Fish and Game, Fishery Management Report No. 15-46, Anchorage.

Vaught, K. D. and D. B. Molyneaux. 1995. Kuskokwim River sonar project abundance estimates of salmon species, 1994. Alaska Department of Fish and Game, Regional Information Report 3A95-18, Anchorage.

TABLES AND FIGURES

Table 1.–List of major activities with dates performed at the Kuskokwim River sonar assessment project, 2015.

Site	Activity	Dates
Church Slough	Left bank (HTI and Simrad split-beam) sonar operation	6/18–6/26 and 7/11–7/17
	Right bank (ARIS imaging) sonar operation	6/20–6/26 and 7/12–7/14
	Drift gillnet fishing	6/23–6/25 and 7/12–7/16
	Vertical distribution data collection (left bank)	7/16–7/17
	Vertical distribution data collection (right bank)	6/20, 6/22–6/24, and 7/14–7/15
	Sonar comparison data collection (left bank)	6/21–6/24 and 7/11–7/17
Akiak	Left bank (ARIS imaging) sonar operation	6/27–7/10
	Right bank (HTI and Simrad split-beam) sonar operation	6/27–7/10
	Drift gillnet fishing	6/28–7/09
	Vertical distribution data collection (left bank)	7/08–7/09
	Vertical distribution data collection (right bank)	7/09–7/10
	Sonar comparison data collection (right bank)	6/27–6/29 and 7/02–7/10

Table 2.–Additional factors taken into consideration for the Akiak and Church Slough sites, to aid with the sonar project site selection on the Kuskokwim River, 2015.

Item for consideration	Akiak	Church Slough
Approximate river width (m)	375	450
Approximate tide height (m)	0.23	0.76
Estimated fish lead length on gradual-sloping bank (m)	8	40
Downstream distance from sonar to test fish zone on steep-sloping bank (m)	282	214
Average length of drift on steep-sloping bank (min)	4.9	6.5
Subsistence fishing traffic (relative to other site)[a]	Higher	Lower
Distance from Bethel (km)	45	18

[a] There may not have been equal numbers of subsistence openings during the time periods that the project operated at each site.

Table 3.–Mean cross-channel water velocity at low, incoming, and high tidal stages at the Akiak and Church Slough sites on the Kuskokwim River, 2015.

	Mean velocity (m/s)	
Tidal stage	Akiak	Church Slough
Low	0.73	0.74
Incoming	0.74	0.60
High	0.74	0.50

Table 4.–Passage estimates and proportion by bank at the Akiak and Church Slough sites on the Kuskokwim River, 2015.

		Passage estimate			Proportion	
Site	Date	Left bank	Right bank	Total	Left bank	Right bank
Akiak	6/27	6,960	31,233	38,193	0.18	0.82
	6/28	8,372	16,632	25,004	0.33	0.67
	6/29	8,084	14,750	22,834	0.35	0.65
	6/30	10,134	10,878	21,012	0.48	0.52
	Total	33,550	73,493	107,043	0.31	0.69
Church Slough	6/20	5,335	16,752	22,087	0.24	0.76
	6/22	10,449	18,733	29,182	0.36	0.64
	6/23	17,541	23,856	41,397	0.42	0.58
	6/24	15,240	35,103	50,343	0.30	0.70
	6/25	11,265	13,502	24,767	0.45	0.55
	Total	59,830	107,946	167,776	0.36	0.64

Table 5.–Sonar counts and proportion of counts by strata at the Akiak site on the Kuskokwim River, 2015.

		Count				Proportion		
Date	Time	0–50 m[a]	50–200 m	200–250 m	Total	0–50 m	50–200 m	200–250 m
7/06	1300	267	349	17	633	0.422	0.551	0.027
	1500	277	325	16	618	0.448	0.526	0.026
	1700	202	338	23	563	0.359	0.600	0.041
	1900	215	373	16	604	0.356	0.618	0.026
	2100	278	405	39	722	0.385	0.561	0.054
	2300	260	400	32	692	0.376	0.578	0.046
7/07	0100	244	458	22	724	0.337	0.633	0.030
	0300	266	399	54	719	0.370	0.555	0.075
	0500	219	285	83	587	0.373	0.486	0.141
	0700	238	422	17	677	0.352	0.623	0.025
	0900	285	465	15	765	0.373	0.608	0.020
Total		2,751	4,219	334	7,304	0.377	0.578	0.046

[a] Counts in the 0–50 m and 50–200 m strata were from HTI sonar echograms; counts in the 200–250 m stratum were from Simrad echograms.

Table 6.–Number and proportion of upstream and downstream fish traces at the Akiak and Church Slough sites on the Kuskokwim River, 2015.

		Number of traces			Proportion	
Site	Date	Upstream	Downstream	Total	Upstream	Downstream
Akiak	6/27	5,180	100	5,280	0.981	0.019
	6/28	9,424	306	9,730	0.969	0.031
	6/29	7,534	457	7,991	0.943	0.057
	6/30	6,176	323	6,499	0.950	0.050
	Total	28,314	1,186	29,500	0.960	0.040
Church Slough	6/20	2,309	154	2,463	0.937	0.063
	6/22	6,518	411	6,929	0.941	0.059
	6/23	15,084	510	15,594	0.967	0.033
	6/24	8,046	80	8,126	0.990	0.010
	6/25	4,336	189	4,525	0.958	0.042
	Total	36,293	1,344	37,637	0.964	0.036

Table 7.–Fish caught in the test fishery at the Akiak and Church Slough sites on the Kuskokwim River, 2015.

	Number caught		
Species	Akiak	Church Slough	Total
Chinook	11	14	25
Sockeye	292	64	356
Pink	2	2	4
Chum	61	97	158
Cisco	61	327	388
Broad WF	0	2	2
Humpback WF	28	23	51
Burbot	3	6	9
Sheefish	0	2	2
Dolly Varden	0	14	14
Total	458	551	1,009

Note: WF = whitefish

Table 8.–Fishing effort (in hours) by stretch mesh size at the Akiak and Church Slough sites on the Kuskokwim River, 2015.

Mesh size (in)	Akiak	Church Slough	Total
2.75	4.0	4.1	8.1
5.25	3.9	3.5	7.5
6.50	0.0	1.1	1.1
7.50	3.9	1.5	5.4
Total	11.8	10.2	22.1

Note: This study primarily used 3 mesh sizes: 2.75 in, 5.25 in, and 7.5 in. At the end of the season at the Church Slough site, the 7.5 in mesh net was torn badly, so the 6.5 in mesh net was used in its place. The 6.5 in mesh net was not fished at the Akiak site.

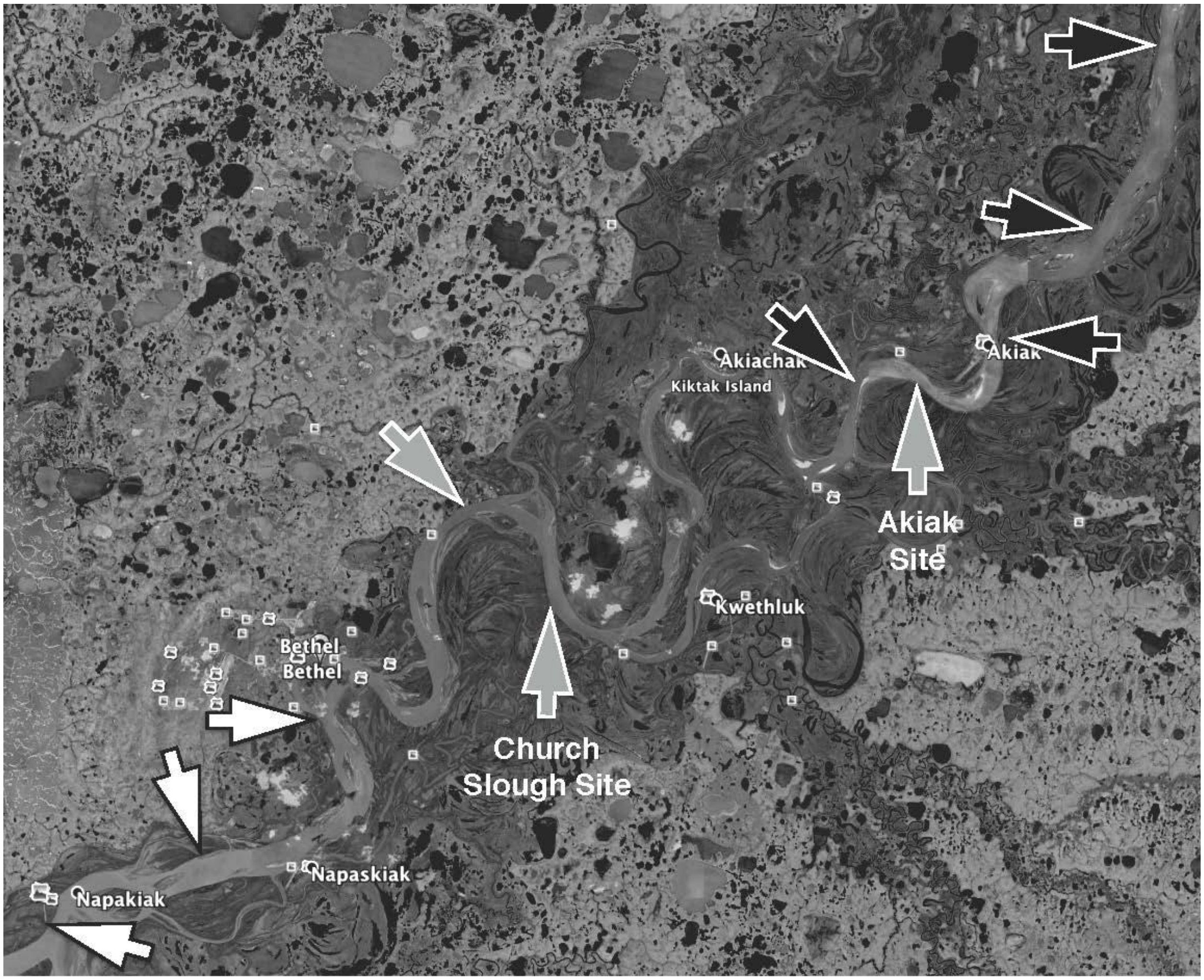
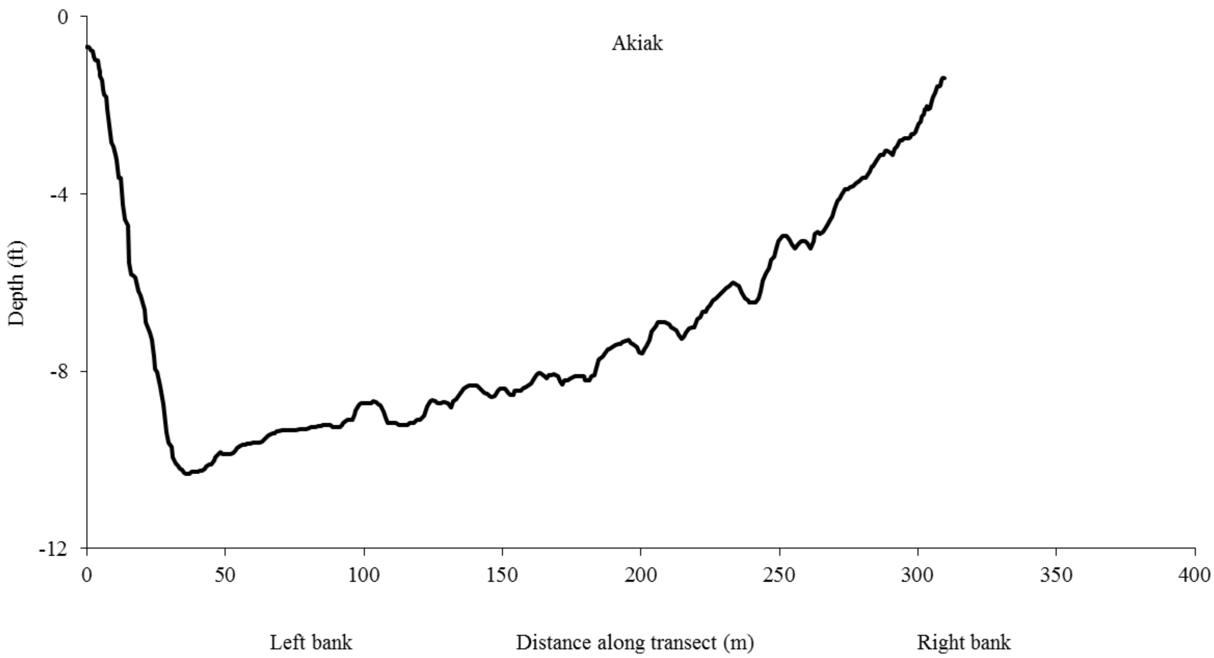


Figure 1.–Sites surveyed during the initial investigation on the Kuskokwim River.

Note: White arrows mark sites that were surveyed in 2014, black arrows mark sites that were surveyed in 2015, and grey arrows mark sites that were surveyed in both 2014 and 2015. Image courtesy of Google Earth.



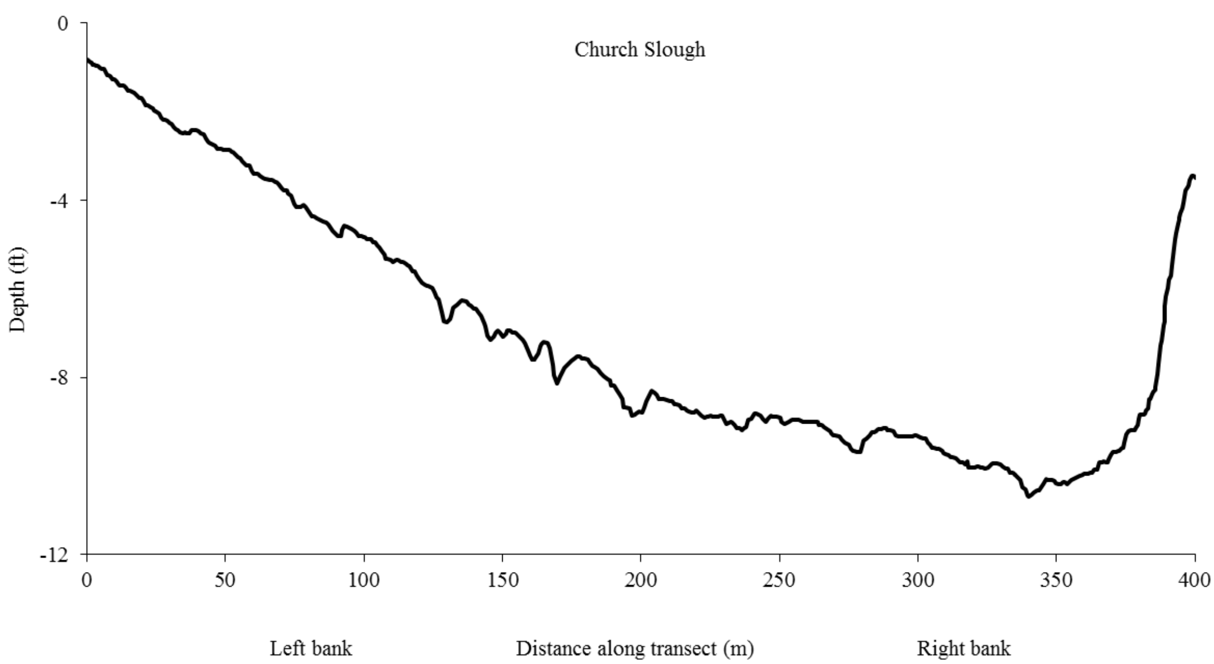
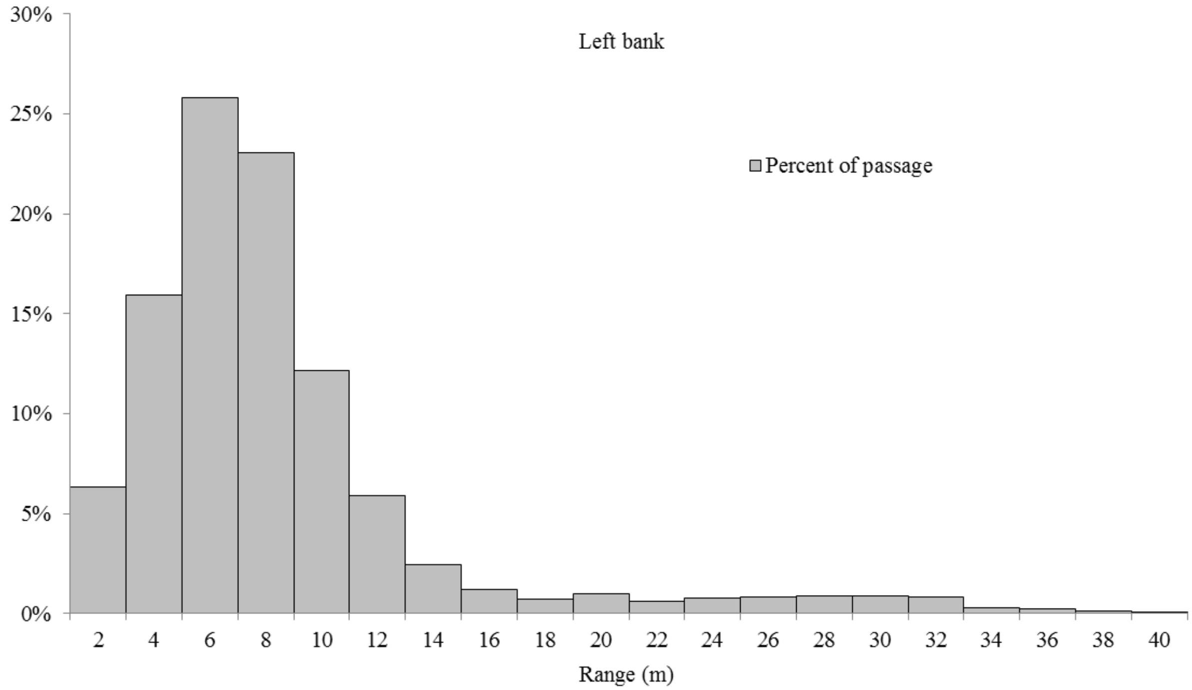


Figure 2.–River bottom profiles, looking downstream, at the Akiak and Church Slough sites on the Kuskokwim River, 2015.



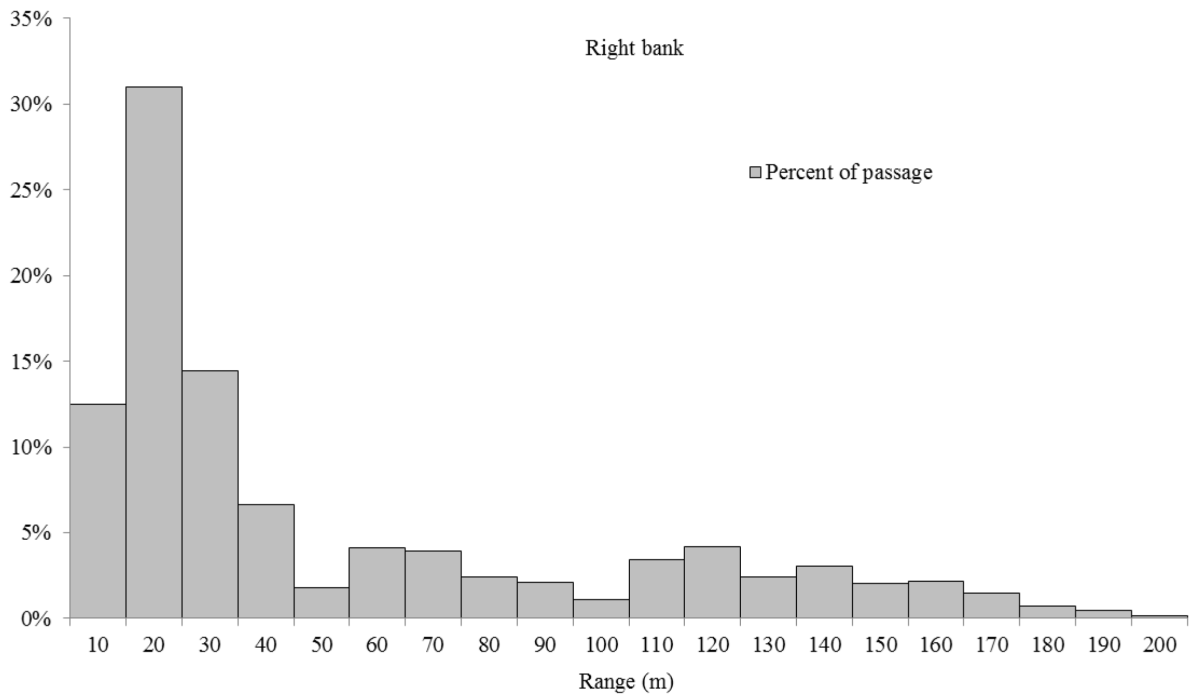
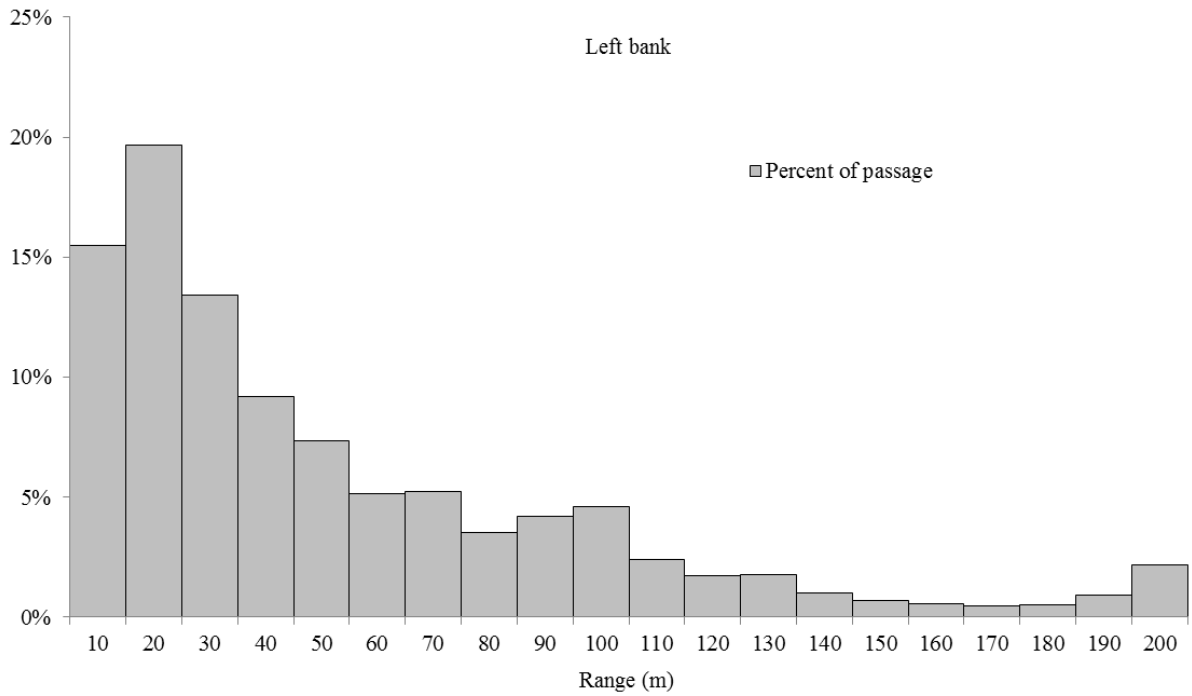


Figure 3.–Horizontal fish distribution (distance from transducer) by bank at the Akiak site on the Kuskokwim River, 2015.



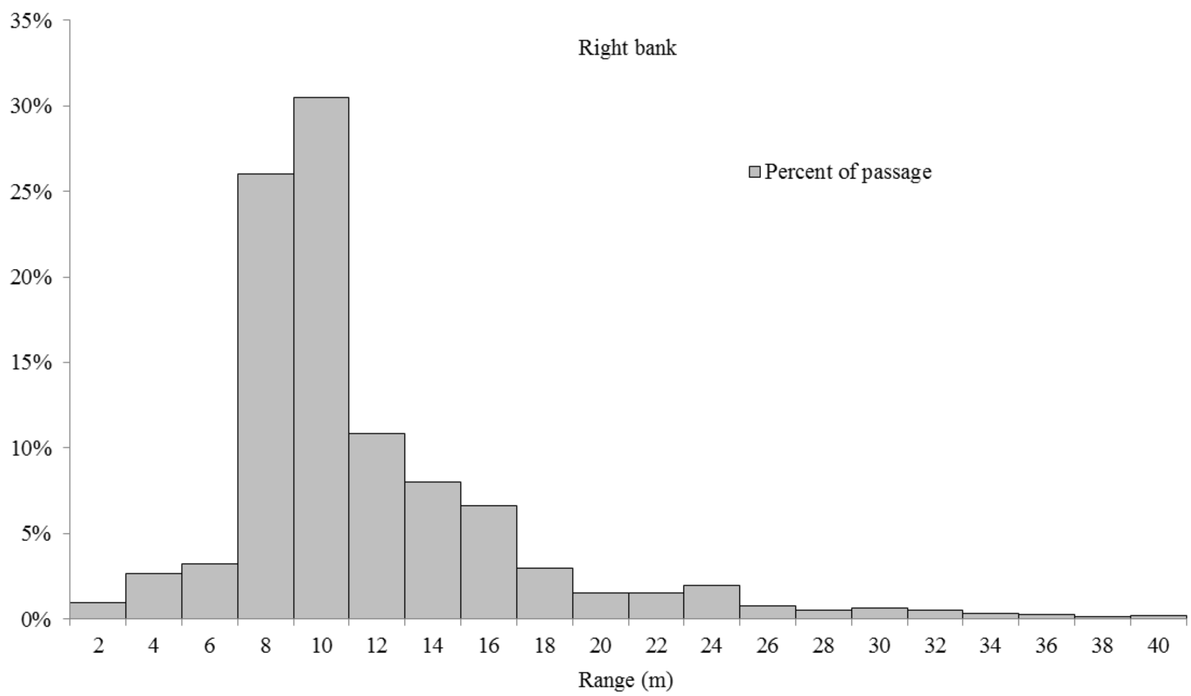


Figure 4.–Horizontal fish distribution (distance from transducer) by bank at the Church Slough site on the Kuskokwim River, 2015.

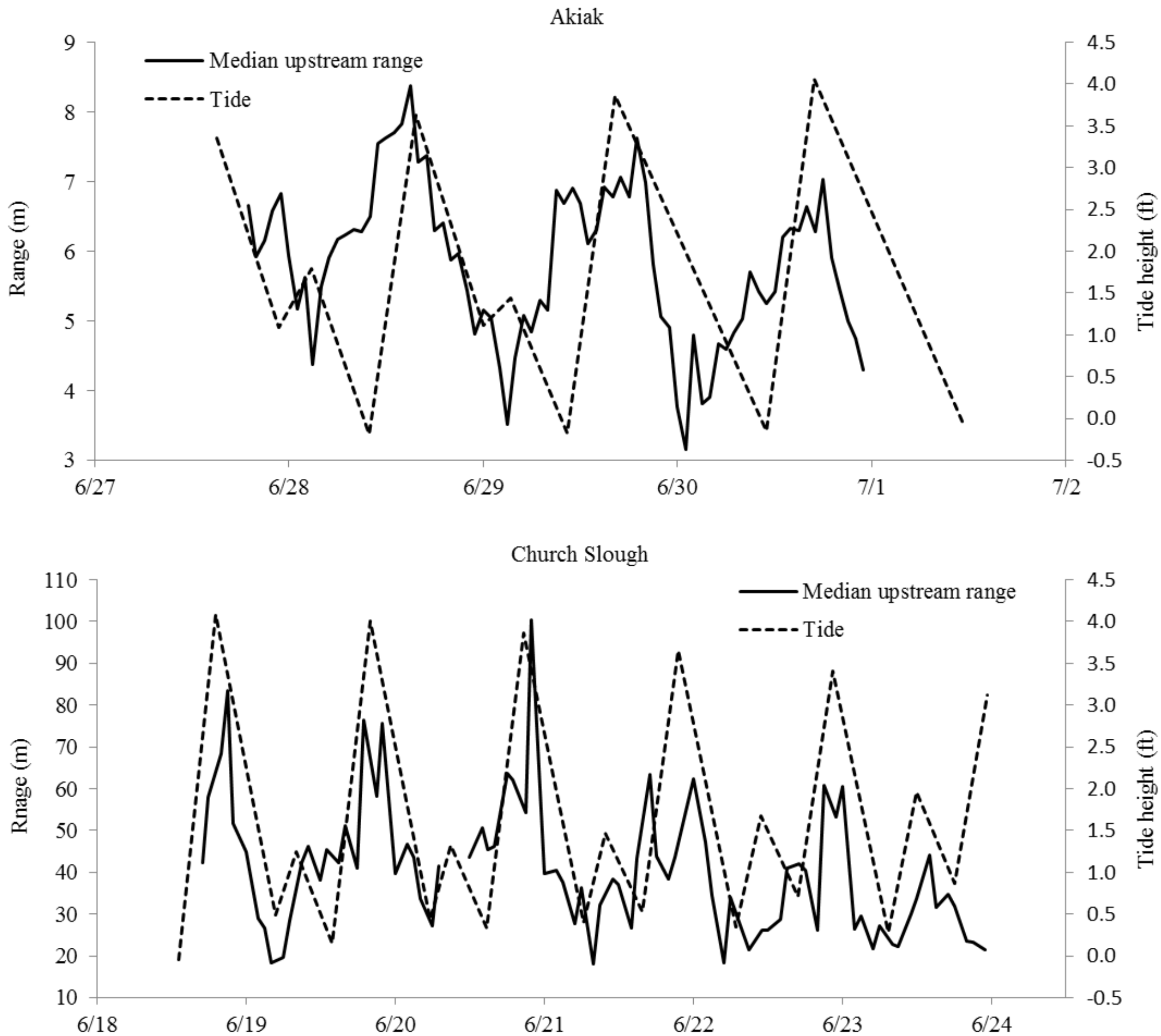


Figure 5.–Median range (distance from transducer) of upstream traveling fish with tide height on the left bank at the Akiak and Church Slough sites, 2015.

Note: Gaps in the median upstream range data series represent times when no sonar data were collected.

Source of tide data: National Oceanic and Atmospheric Administration.

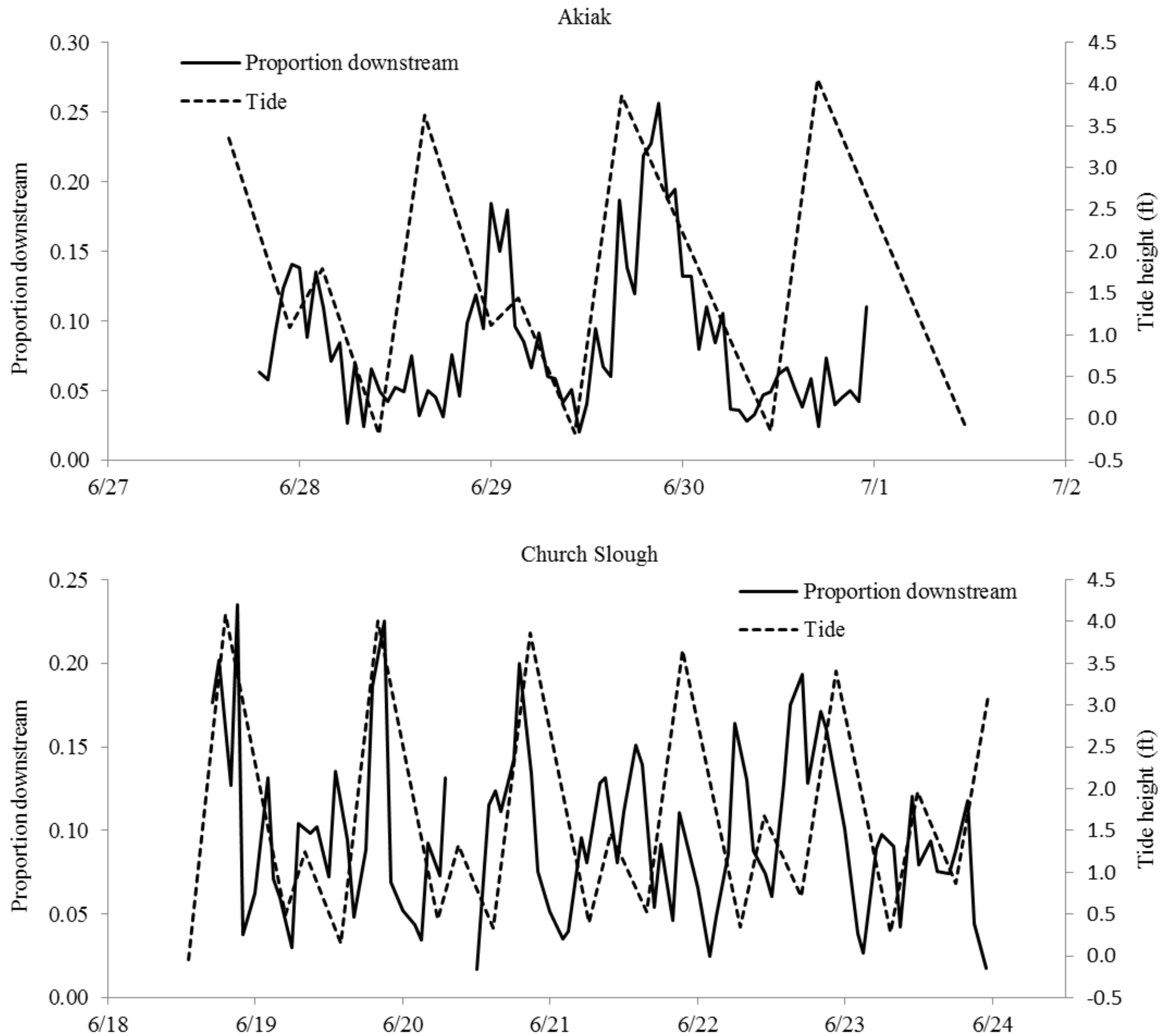


Figure 6.–Proportion of downstream traveling fish with tide height on the left bank at the Akiak and Church Slough sites, 2015.

Note: Gaps in the proportion downstream data series represent times when no sonar data were collected.

Source of tide data: National Oceanic and Atmospheric Administration.

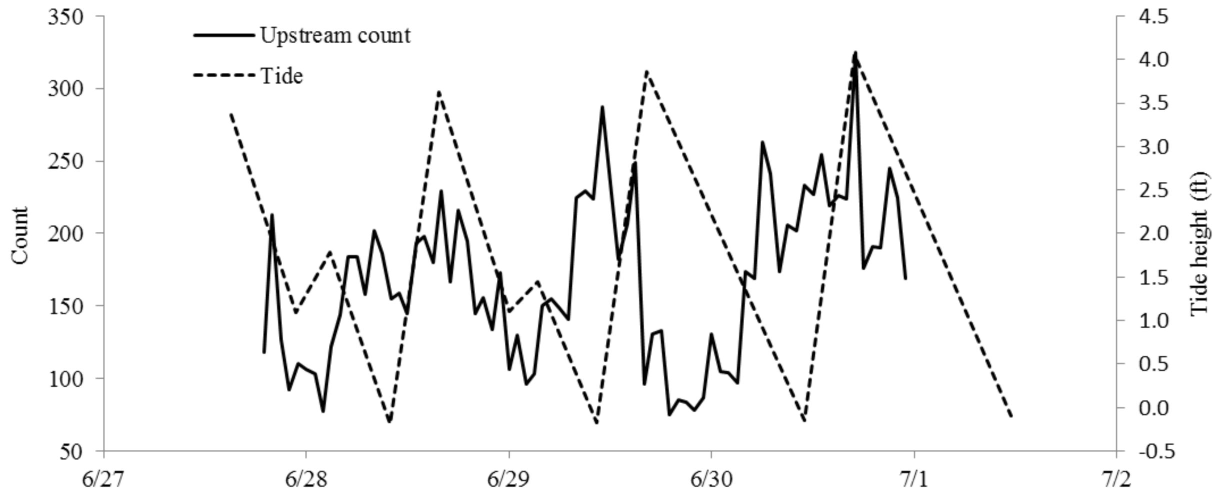


Figure 7.–Upstream traveling fish count with tide height on the left bank at the Akiak site on the Kuskokwim River, 2015.

Source of tide data: National Oceanic and Atmospheric Administration.

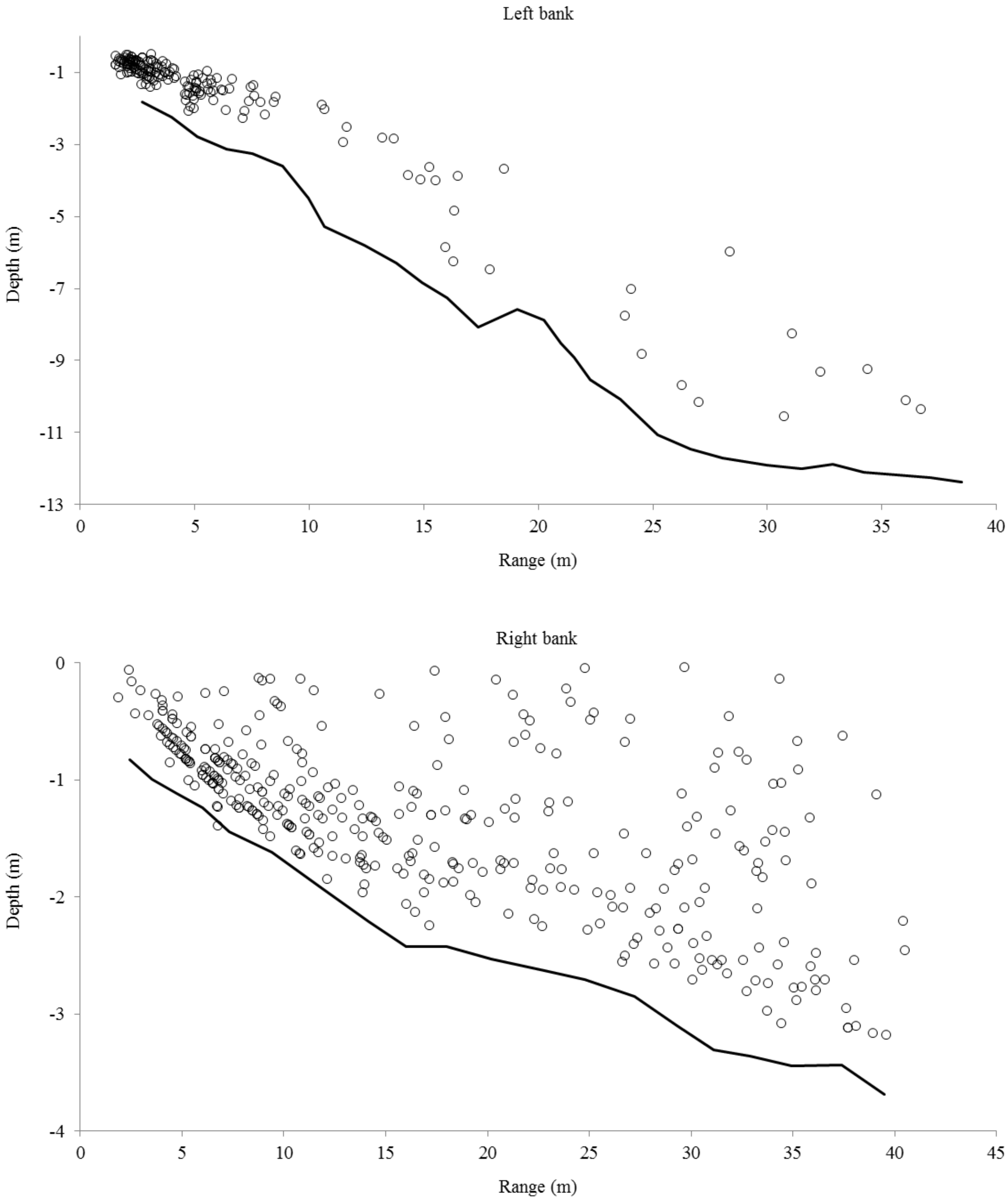


Figure 8.–Vertical and horizontal distribution of sonar targets by bank at the Akiak site on the Kuskokwim River, 2015.

Note: On the left bank, data were collected with a single vertical stratum that did not cover the upper water column.

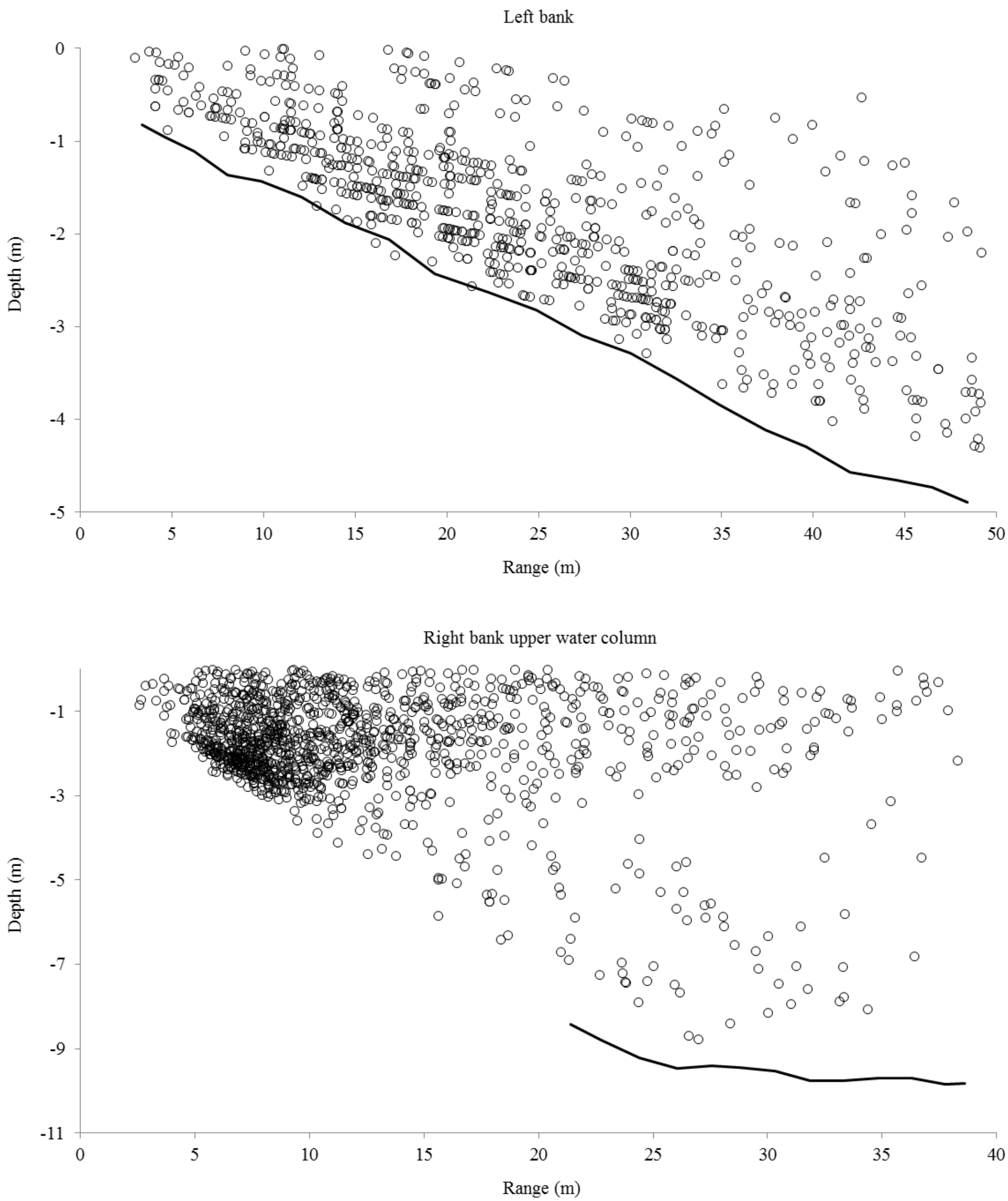


Figure 9.–Vertical and horizontal distribution of sonar targets by bank at the Church Slough site on the Kuskokwim River, 2015.

Note: On the right bank, data were collected with three vertical strata. Only data from the uppermost stratum are displayed in this figure.

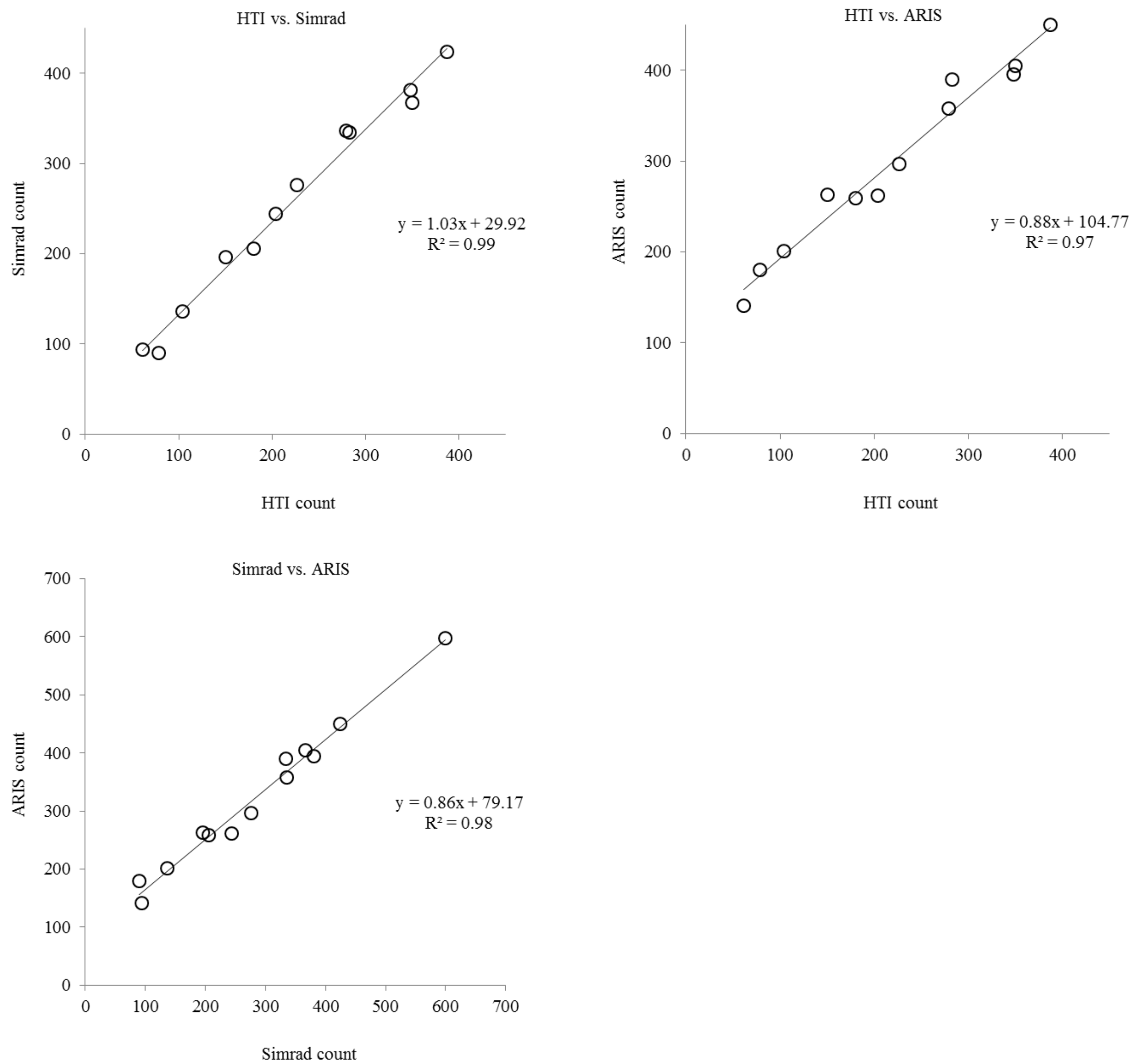


Figure 10.–Relationship among HTI, Simrad, and ARIS sonar counts from 0 m to 40 m when the sonars were operated side-by-side on the left bank at the Church Slough site on the Kuskokwim River, 2015.