

Operational Plan: Kenai River Chinook Salmon Sonar Assessment at River Mile 13.7, 2015

by

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Weights and measures (metric)		General		Mathematics, statistics	
centimeter	cm	Alaska Administrative Code	AAC	all standard mathematical signs, symbols and abbreviations	
deciliter	dL	all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.	alternate hypothesis	H _A
gram	g	all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.	base of natural logarithm	e
hectare	ha			catch per unit effort	CPUE
kilogram	kg			coefficient of variation	CV
kilometer	km	at	@	common test statistics	(F, t, χ^2 , etc.)
liter	L			confidence interval	CI
meter	m	compass directions:		correlation coefficient	
milliliter	mL	east	E	(multiple)	R
millimeter	mm	north	N	correlation coefficient (simple)	r
Weights and measures (English)		south	S	covariance	cov
cubic feet per second	ft ³ /s	west	W	degree (angular)	°
foot	ft	copyright	©	degrees of freedom	df
gallon	gal	corporate suffixes:		expected value	E
inch	in	Company	Co.	greater than	>
mile	mi	Corporation	Corp.	greater than or equal to	≥
nautical mile	nmi	Incorporated	Inc.	harvest per unit effort	HPUE
ounce	oz	Limited	Ltd.	less than	<
pound	lb	District of Columbia	D.C.	less than or equal to	≤
quart	qt	et alii (and others)	et al.	logarithm (natural)	ln
yard	yd	et cetera (and so forth)	etc.	logarithm (base 10)	log
Time and temperature		exempli gratia		logarithm (specify base)	log ₂ , etc.
day	d	(for example)	e.g.	minute (angular)	'
degrees Celsius	°C	Federal Information Code	FIC	not significant	NS
degrees Fahrenheit	°F	id est (that is)	i.e.	null hypothesis	H ₀
degrees kelvin	K	latitude or longitude	lat or long	percent	%
hour	h	monetary symbols		probability	P
minute	min	(U.S.)	\$, ¢	probability of a type I error	
second	s	months (tables and figures): first three letters	Jan,...,Dec	(rejection of the null hypothesis when true)	α
Physics and chemistry		registered trademark	®	probability of a type II error	
all atomic symbols		trademark	™	(acceptance of the null hypothesis when false)	β
alternating current	AC	United States		second (angular)	"
ampere	A	(adjective)	U.S.	standard deviation	SD
calorie	cal	United States of America (noun)	USA	standard error	SE
direct current	DC	U.S.C.	United States Code	variance	
hertz	Hz			population sample	Var
horsepower	hp				var
hydrogen ion activity (negative log of)	pH				
parts per million	ppm	U.S. state	use two-letter abbreviations		
parts per thousand	ppt, ‰		(e.g., AK, WA)		
volts	V				
watts	W				

REGIONAL OPERATIONAL PLAN SF.2A.2015.18

**OPERATIONAL PLAN: KENAI RIVER CHINOOK SALMON SONAR
ASSESSMENT AT RIVER MILE 13.7, 2015**

by

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April 2016

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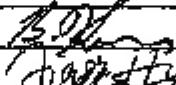

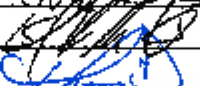

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TABLE OF CONTENTS

	Page
LIST OF TABLES.....	iii
LIST OF FIGURES.....	iii
LIST OF APPENDICES	iv
ABSTRACT	1
INTRODUCTION.....	1
OBJECTIVES.....	2
Primary Objective.....	2
Secondary Objective.....	2
METHODS.....	2
Site Description	2
Acoustic Sampling.....	3
Sampling Procedure.....	4
Data Collection Parameters	5
On-site Data Storage and Management	8
Office Data Management and Archiving.....	10
Remote Access to Sonar Site.....	10
Fish Length and Direction of Travel.....	10
Data Analysis.....	12
Fish Passage.....	12
Chinook Salmon Passage.....	13
Modifications under FT Protocol.....	14
Modifications under All-Large-Fish (ALF) Protocol	14
Large Fish Passage Estimates.....	15
SCHEDULE AND DELIVERABLES	15
RESPONSIBILITIES	15
BUDGET SUMMARY FY 16	16
REFERENCE CITED.....	17
FIGURES	21
APPENDIX A: COMPARISON OF DIDSON AND ARIS CONFIGURATIONS USED ON KENAI RIVER CHINOOK SALMON SONAR PROJECTS.....	39
APPENDIX B: ARIS LENGTH MIXTURE MODEL AND ASSOCIATED BUGS PROGRAM CODE	63
APPENDIX C: PROCEDURES FOR DAILY ARIS PROCESSING	77
APPENDIX D: INSTRUCTIONS AND SETTINGS USED FOR MANUAL FISH LENGTH MEASUREMENTS FROM ARIS IMAGES USING ARISFISH SOFTWARE VERSION 2.3.....	83
APPENDIX E: RM 13.7 SITE INVESTIGATION DOCUMENTATION.....	97
APPENDIX F: KENAI RIVER CHINOOK SALMON SONAR NETWORK CONFIGURATIONS.....	113
APPENDIX G: CISCO BRIDGE CONFIGURATION	119

LIST OF TABLES

Table	Page
1 ARIS system components to be used in 2015.	3
2 Sampling schedule and parameter settings on July 15, 2014 for each range stratum sampled by 5 sonars at RM 13.7.	6
3 Summary of sonar stratum ranges (in meters) by date at RM 13.7, 2014.	7
4 Select user configurable parameters in SMC ARIScope data collection software and their corresponding values in DIDSON (high frequency identification mode only).	8
5 Data storage needs for data collected in 2014 from 4 mainstem ARIS systems at the RM 13.7 site.	9
6 Proposed 2016 field season costs.	16
7 Funded personnel for 2016 field season.	17

LIST OF FIGURES

Figure	Page
1 Map of Kenai River showing location of historical Chinook salmon sonar site at river mile 8.6 and new sonar site at river mile 13.7.	22
2 Yellow arrows indicate preferred locations for sonars on each bank of the main channel.	23
3 Corresponding profiles for 8 of the 9 transects conducted near RM 13.7 of the Kenai River (see Figure 2).	24
4 Kenai River RM 13.7 sonar site showing approximate deployment locations and beam coverage of 5 ARIS units.	25
5 Deployment schematic for ARIS systems in 2015 on the main channel at RM 13.7.	26
6 Proposed coverage for the right bank (top; Transect 5 in Figure 2) and left bank (bottom; Transect 6 in Figure 2) at RM 13.7.	27
7 Sonar coverage of the minor channel at the Kenai River RM 13.7 sonar site is achieved using an ARIS 1200 deployed on a tripod mount combined with a fixed weir.	28
8 ARIS deployment schematic at RM 13.7 site on June 23, 2014, showing beam coverage on the main channel using 2 sonars (inshore and offshore) on each bank.	29
9 RM 13.7 tent housing data collection computers for all 5 ARIS units.	30
10 An ARIS 1200 with a high-resolution lens mounted on a steel tripod for offshore deployment (A) and on an aluminum H-mount for near shore deployment (B).	31
11 ARIS data collection schematic for the RM 13.7 site.	32
12 Diagram of components required on RM 13.7 right bank for wireless transmission of ARIS data back to the main camp on left bank.	33
13 Example images from each of the 4 left bank (top) and 4 right bank (bottom) range strata taken on July 15–18, 2014. Fish swimming through the beams are circled on each image.	34
14 Directory structure for the Network Attached Storage System in the Soldotna office showing the contents of the left bank offshore sonar for 17 May 2014.	35
15 An example of high density passage from 6 August 2014.	36
16 Example of a Chinook salmon about 99 cm (AL) at 11 m swimming past milling pink salmon on 5 August 2014.	37

LIST OF APPENDICES

Appendix	Page
A1	DIDSON and ARIS configurations used on Kenai River Chinook sonar projects at RM 8.6 and RM 13.7 in 2014, including an overview of features that affect resolution and range capabilities.40
A2	Manufacturer specifications for sonar models ARIS 1200, ARIS 1800, DIDSON SV, and DIDSON LR. ...47
A3	Diagram showing the horizontal plane of a DIDSON-LR or ARIS 1200 with a high resolution lens.50
A4	Relationships between focal length and lens position for ARIS.51
A5	An enlargement of a tethered Chinook salmon showing the individual pixels that comprise a DIDSON image (top) contrasted with an ARIS image of a free-swimming Chinook salmon (bottom).52
A6	Downrange resolution for ARIS images is set using the Detail slider under the expanded <i>Sonar Control Menu</i> or by setting the Sample Period under the <i>Advance Sonar Settings</i> dialogue.....53
A7	Summary of ARIScope data acquisition parameters that affect downrange resolution.....54
A8	An ARIS image of a tethered salmon at 29 m collected at a 4 μ s sample period and 4 m range window (top) yields poor results due to a poor downrange to crossrange pixel ratio. Better results are achieved using a 10 μ s sample period and 14 m range window (bottom).56
A9	Results from SMC’s test of the Auto-Pulse length setting with 1) auto-resolution, 2) fixed Sample Period of 12 μ s, and 3) fixed Sample Period of 10 μ s for range strata that approximate those used on the Kenai River mile 13.7 site.57
A10	Images from a close-range tethered fish at 2 different range windows demonstrate the advantage of a shorter range window and higher sample period for close range sampling.....58
A11	Images from a 68.5 cm sockeye salmon demonstrate a measurement bias at ranges less than 3.5 m, even with the short 5 m range window.....59
A12	Data collected from tethered fish (in this case, a 60 cm sockeye salmon) provided the opportunity to compare the effects and inter-relationship between 2 parameters affecting image resolution, transmitted pulse length, and sample period.60
A13	Images of a tethered fish taken at 2 different aims. Panel 1 shows a better defined bottom but fish measurement is more difficult against the bright background. Panel 2 shows the sonar pitch raised 2° and a better defined fish outline for easier measuring; there is still bottom structure showing at all ranges.61
B1	Mixture model for estimating species composition of migrating fish.64
B2	Hypothetical distributions of fish length measurements (black solid lines) from the Kenai River: (A, top) few small Chinook salmon, no measurement error and (B, bottom) 40% of Chinook salmon are small, measurement error standard deviation 10 cm.67
B3	Abridged tethered fish dataset (symbols) used to provide mildly informative prior information on regression parameters to the ARIS length mixture model. Lines show samples of 100 plausible linear relationships drawn from the resulting prior distribution.....68
B4	Flow chart of the ARIS length mixture model described in the text. The frequency distribution of ARIS length measurements (panel g) is modeled as a weighted mixture of species-specific distributions (b and e), which in turn are the products of species-specific size distributions (a and d) and the relationship between ARIS measured length and true length (c). The weights (species proportions, panel f) are the parameters of interest.69
B5	WinBUGS code for mixture model under “standard” and “all large fish” data processing protocols.70
B6	WinBUGS code for mixture model, under fast-track data processing protocol.71
B7	OpenBUGS code for daily abundance model, to be used when it is not possible to generate Chinook salmon passage estimates with AL mixture model.....73
B8	WinBUGS code for hierarchical age-composition model. Posteriors distributions from fitting this model provide prior distributions for AL mixture model.74
B9	Example WinBUGS data under Fast-Track sampling protocol.....75
C1	Steps for processing RM 13.7 daily ARIS data using batch files for Kenai River Chinook salmon sonar, 2015.78

LIST OF APPENDICES (Continued)

Appendix	Page
D1 Instructions and settings for manual length measurements from ARIS images in 2015 using SMC 2.3– Rev 6993.	84
D2 Illustration of the problem of double-counting.....	91
D3 Specific examples for applying the “Centerline Rule” when selecting fish for counting and measurements.	92
E1 Additional details regarding the RM 13.7 sonar site.	98
E2 Aerial map and parcel numbers for RM 13.7 sonar site.	99
E3 Aerial view of sonar deployment at the RM 13.7 sonar site.....	100
E4 Aerial view of main channel left bank camp and sonar deployment at the RM 13.7 sonar site.	101
E5 Side view of main channel left bank camp and walkway deployment at the RM 13.7 sonar site.	102
E6 Side view of main channel left bank sonar tripod deployment at the RM 13.7 sonar site.....	103
E7 Aerial view of main channel right bank battery bank and sonar deployment at the RM 13.7 sonar site.....	104
E8 Side view of main channel right bank battery bank and walkway deployment at the RM 13.7 sonar site..	105
E9 Side view of main channel right bank sonar tripod deployment at the RM 13.7 sonar site.	106
E10 Aerial view of minor channel battery bank, weir, and sonar deployment at the RM 13.7 sonar site.	107
E11 Side view of minor channel battery bank and walkway deployment at the RM 13.7 sonar site.	108
E12 Side view of minor channel battery weir and sonar tripod deployment at the RM 13.7 sonar site.	109
E13 Estimated power requirements for electronics based in the main camp on left bank.	110
E14 Proposed schematic for supplying DC power to the two right bank main channel ARIS systems at RM 13.7 via a battery bank charged by a 2000 W generator.....	111
E15 Proposed system schematic for the supplying DC power to the minor-channel ARIS system at RM 13.7 via a battery bank charged by a 1000 W generator.	112
F1 Soldotna sonar office IP addresses.	114
F2 RM 13.7 sonar site IP addresses (2014 configuration).....	116
F3 Mapping to the Network Attached Storage (NAS), Buffalo TeraStation 5800, in 2015.	117
G1 Wireless bridge diagram.....	120

ABSTRACT

Alaska Department of Fish and Game (ADF&G) has monitored Chinook salmon passage in the Kenai River at river mile (RM) 8.6 using side-looking sonar technology from 1987 to present. The original acoustic technology, dual-beam sonar (1987–1994), was replaced by split-beam sonar (1995–2011), and most recently by dual-frequency identification sonar or “DIDSON” (2011–present). Starting in 2013, ADF&G operated 2 sonar stations, one at the historical RM 8.6 site and a second experimental site at RM 13.7. Starting in 2015, ADF&G will discontinue the RM 8.6 project and will only operate the RM 13.7 project. This plan covers the RM 13.7 project operations for the 2015 season.

Key words: ARIS, DIDSON, Chinook salmon, *Oncorhynchus tshawytscha*, acoustic assessment, Kenai River, riverine sonar, fisheries sonar, multibeam sonar

INTRODUCTION

Fixed-location, side-looking sonar techniques are commonly used to obtain inseason estimates of run strength for anadromous fish stocks in rivers that are too wide or deep for installing weir structures or too occluded for visual observations (Cronkite et al. 2006; Holmes et al. 2006; Maxwell and Gove 2007; Maxwell et al. 2011; Dunbar 2013; Lozori and McIntosh 2014). In Alaska, sonar estimates of inriver passage often provide the basis for estimating spawning escapement and for regulating harvests of commercial fishermen and sport anglers of important salmon stocks (Westerman and Willette 2012; Miller et al. 2014). Acoustic assessment sites currently exist on at least 10 rivers in Alaska. One of the barriers to even wider use of sonar assessment has been the need to estimate not just the number of spawning salmon, but the number spawning by species. Apportioning sonar counts by species often requires separate intensive sampling such as netting programs (Bromaghin 2005; Carroll and McIntosh 2008) or fish wheel programs (Fair et al. 2009) that are costly to implement and subject to biases that can be difficult to resolve.

From 1987 through 2011, ADF&G used dual beam (1987–1994) and then split beam (1995–2011) side-looking sonar technology to estimate Chinook salmon (*Oncorhynchus tshawytscha*) passage in the Kenai River at RM 8.6. These technologies relied on acoustic size (average strength of returning echoes) and range (distance from shore) thresholds to differentiate between sockeye salmon (*O. nerka*) and Chinook salmon. These criteria were based on the premise that sockeye salmon are smaller and migrate primarily near shore, whereas Chinook salmon are larger and tend to migrate up the middle of the river. However, studies have shown that these criteria can lead to inaccurate estimates (Burwen et al. 1998; Hammarstrom and Hasbrouck 1999). Extensive research has been conducted at the Kenai RM 8.6 Chinook salmon sonar site toward improving the ability to identify species from acoustic data (Burwen and Fleischman 1998; Burwen et al. 2003; Miller et al. 2010). Recently, ADF&G evaluated the potential for dual-frequency identification sonar (DIDSON) to provide improved discrimination of larger Chinook salmon from smaller species of salmon based on size measurements taken directly from high-resolution images of migrating salmon (Burwen et al. 2007). Based on results of the DIDSON evaluations, and due to the inaccuracy of the split-beam estimates (Miller et al. 2012; Miller et al. 2013), production of split-beam estimates at the RM 8.6 site was discontinued following the 2011 season and replaced by DIDSON-based estimates in 2012 (Miller et al. 2014; Miller et al. 2015). Escapement goals based on DIDSON-generated estimates of passage were developed (Fleischman and McKinley 2013; McKinley and Fleischman 2013).

The transition to DIDSON multibeam technology provided the opportunity of moving the sonar program upriver above tidal influence. The RM 8.6 site used historically was selected in part because of its suitability for operating a dual-beam (and subsequently a split-beam) sonar system, which requires a near-perfect linear bottom profile over the entire insonified zone or, in this case, from the nearshore region to the thalweg. However, this site has many disadvantages primarily related to its location within tidal influence: 1) incomplete coverage of the river due to tidal activity flooding the region behind the transducers, 2) milling fish behavior related to tidal flux, 3) physical risk to gear by large debris carried by extreme tidal fluxes, and 4) lack of legal access to the property on one of the banks. Relocating the site farther upriver improves ADF&G's ability to more accurately estimate Chinook salmon passage by minimizing or eliminating these negative factors.

In 1999, ADF&G searched for and subsequently evaluated a second sonar site at RM 13.2 for using split-beam sonar to assess fish passage, but the bottom topography was less acoustically favorable and the fish were more difficult to detect due to increased background noise levels from bottom irregularities and boat traffic (Burwen et al. 2000). Multibeam technology is better able to insonify the near-bottom region despite irregularities in the river-bottom profile. During a 2-week period in 2012, a new sonar site located at RM 13.7 (Figure 1) was identified and evaluated using the newest generation of DIDSON technology referred to as Adaptive Resolution Imaging Sonar (ARIS). During 2013 and 2014, ADF&G operated a full-scale experimental project using ARIS at the RM 13.7 site, while continuing to operate the historical RM 8.6 site. Passage estimates from the RM 13.7 site were consistent with expectations based on previous analyses (Fleischman and McKinley 2013; McKinley and Fleischman 2013). In 2015, ADF&G will discontinue operations at the RM 8.6 site and produce daily and seasonal estimates using data from the RM 13.7 project, operating from 16 May to approximately 20 August.

OBJECTIVES

PRIMARY OBJECTIVE

Estimate upstream passage of Chinook salmon at RM 13.7 of the Kenai River such that early- and late-run estimates are within 10% of the true value 95% of the time. This estimate will be based on fitting a mixture model to ARIS fish-length measurements and midriver RM 8.6 netting data (Perschbacher 2014). The cumulative estimate will be updated twice weekly.

SECONDARY OBJECTIVE

Estimate upstream passage of fish greater than 75 cm (as measured by ARIS) at RM 13.7 of the Kenai River such that early- and late-run estimates within 10% of the true value 95% of the time. This estimate will be based solely on ARIS fish-length measurements.

METHODS

SITE DESCRIPTION

This study will be conducted at RM 13.7 on the Kenai River (Figure 1). This location was identified during surveys conducted in 2012 and was selected for its favorable physical characteristics for deploying ARIS multibeam technology, its accessibility via an adjacent boat launch facility, and legal access to property on either bank of the main channel. Bathymetric surveys conducted by Aquacoustics, Inc. on 9 July 2012 showed that the section of river at RM

13.7 has a nearly ideal bottom profile for sonar deployment (Figures 2 and 3). Land use permits are obtained from the Department of Natural Resources Division of Parks and Outdoor Recreation. Appendix E1 presents a more detailed description of the site RM 13.7 along with details and diagrams required for annual permit applications (Appendices E2–E15).

ACOUSTIC SAMPLING

Adaptive Resolution Imaging Sonar (ARIS) technology, developed by the manufacturers of DIDSON, will be used at the RM 13.7 site. Components of the ARIS system are listed in Table 1. The theory behind ARIS multibeam technology is similar to that of the DIDSON and is summarized in Appendix A1 along with a discussion of the features of the ARIS models used in this study. A DIDSON LR system will be available as a backup should any of the ARIS systems become inoperable for an extended period of time.

Table 1.—ARIS system components to be used in 2015.

System component	Qty	Description
Sounders	4	ARIS 1200
		Left bank mainstem offshore
		Right bank mainstem offshore
		Right bank mainstem nearshore
	1	Right bank minor channel
Lens assembly	1	ARIS 1800
		Left bank mainstem nearshore
	1	Standard lens for ARIS 1800 model with ~12°x30° beam pattern
	4	High resolution lens for ARIS 1200 models with ~4°x15° beam pattern
Data collection computer	5	Dell Latitude E6430 laptop computers (one for each sonar)
Wireless bridge	3	Wireless Bridge Radio sets (Cisco Aironet model 1310s)
Remote pan and tilt	5	Sound Metrics AR2 rotators—controlled via ARISCOPE software

Sonar System Configuration and River Coverage

Site characteristics at RM 13.7 allow for near complete sonar coverage of the river cross-section. A total of 5 sonars are required to provide coverage: a nearshore and offshore sonar on each bank of the mainstem and 1 sonar on the right bank minor or side channel (Figure 4). During the early part of the season when the water level is low (approximately mid-May to early June), 1 sonar on each bank is sufficient to insonify most of the mainstem river cross-section (approximately 60–70 m at low water). But later in the season, as water levels rise and the mainstem river increases to 90 m in width, a second sonar will be deployed on each bank to insonify the nearshore zone and the first 5–10 m in front of the offshore sonars (Figures 5 and 6). The original (now offshore) sonars cannot be moved closer to shore as water levels rise because they already insonify the maximum range recommended for operation in high-frequency mode (approximately 30–35 m, Appendix A1). The minor channel is dry when the project begins in mid-May, but has sufficient water for fish passage starting in early to mid-June. This channel is approximately 30 m wide at high water and can be covered by a single sonar combined with a fixed weir on either bank (Figure 7).

Two different ARIS models will be used to provide optimal coverage of the mainstem cross-section (Figures 5 and 6, Appendix A1). ARIS 1200 models operating at high frequency with high-resolution lenses (HRL) will be used as the offshore sonars because they have the longer range capabilities (up to ~33 m) needed to insonify most of the mainstem river at lower water levels as well as the offshore region of the mainstem during higher water levels. An ARIS model 1200 may be operated at low frequency early in the season during periods of low water in order to improve image quality at far range. An ARIS model 1200 with a high-resolution lens will also be used on the minor channel due to the longer (~25 m) range requirements. In 2013, we determined that an ARIS 1200 with HRL was also required to insonify the right bank nearshore area due to the longer range covered by the nearshore sonar on this bank (Figure 8). An ARIS 1800 with a standard lens will be deployed as the nearshore sonar on the left bank because the offshore sonar will be positioned only about 8 m from the bank at ordinary high water, allowing it to cover the area behind the offshore sonar as well as approximately the first 5 m in front of the offshore sonar (Figure 8). The ARIS 1800 is more advantageous for insonifying close-range targets and nearshore areas because it operates at a higher frequency yielding higher resolution, and the standard lens also has better focusing capabilities at closer ranges (Appendix A4). Additionally, the wider beam dimensions of the ARIS 1800 without the HRL ($14^{\circ} \times 28^{\circ}$ versus $4^{\circ} \times 15^{\circ}$) provide better coverage in both vertical and horizontal dimensions at short ranges. Finally, using sonars with different operating frequencies will allow nearshore and offshore strata to be sampled simultaneously without crosstalk interference if desired.

Sampling for both banks will be controlled by electronics housed in a tent located on the left (west) bank of the river (Figure 9). The ARIS units will be mounted on SMC AR2 pan-and-tilt units for remote aiming in the horizontal and vertical axes. The offshore sonar and rotator units will be deployed in the river using a tripod-style mount that can be deployed from a boat at higher water levels (Figure 10). The nearshore and channel sonars may be deployed on “H” or “goal post” mounts as shown in Figure 10. In the horizontal plane, the sonar will be aimed perpendicular to the flow of the river current to maximize the probability of insonifying migrating salmon from a lateral aspect. In the vertical plane, the sonar will be aimed to insonify the near-bottom region (Figure 6). Internal sensors in the ARIS will provide measurements of compass heading, pitch, and roll as well as water temperature.

Communication cables from the left bank ARIS units will feed directly into the left bank ARIS Command Module (similar to the DIDSON Top Side Box) and data collection computers (Figure 11). On the right bank, data from the 3 ARIS systems will be transmitted via 3 wireless bridges to 3 data collection computers on the left bank (Figures 11 and 12, Appendix G1).

Sampling Procedure

A systematic sample design (Cochran 1977) will be used to sequentially sample discrete range strata (“range windows”) for a total (minimum) of 10 minutes each per hour. The ARIS can be programmed to automatically sample each range stratum using the software interface “ARIScope.” Dividing the total range to be insonified into shorter range strata allows the aim of the sonar beam to be optimized for sampling a given river section (i.e., generally the aim must be raised in the vertical dimension as sections farther from shore are sampled). A sampling scheme was developed during the 2013 and 2014 seasons. Table 2 lists the schedule and parameters used to sample the 12 individual range strata on 15 July 2014. By 15 July, water levels were more or less stable and only minor changes were made to parameters or to the positions of the sonars through the end of the season on 15 August. Figure 13 also shows example images for each of

the 8 range strata insonified by the mainstem sonars. Table 3 summarizes the changes in sonar parameters throughout the season as the water level rose and aims were refined. We anticipate following a similar schedule in 2015.

Estimates of fish passage will be made from 16 May to 20 August or until less than 1% of the cumulative passage is estimated for 3 consecutive days.

Data Collection Parameters

In designing ARIS, the manufacturers separated the data collection (ARIScope) and data processing (ARISFish) software. Unlike the DIDSON Control and Display interface, ARIScope has several data collection parameters that are now user selectable rather than being fixed or limited to a few discrete values; these include window length, transmit pulse length, and downrange resolution (Table 4). ARIS downrange resolution (i.e., window length per number of samples) is particularly improved over the DIDSON software. Whereas DIDSON was limited to 512 samples to define the downrange resolution, ARIS can collect up to 4,000 samples per beam. The parameters that are now selectable and that will be optimized for each range interval are given in Table 4 along with the corresponding fixed values in the DIDSON system. A consultant from Sound Metrics Corporation will be on site during project deployment in May 2015 to ensure data collection parameters for each range interval have been optimized.

The autofocus feature will be enabled so that the sonar automatically sets the lens focus to the midrange of the selected range window.

Table 2.–Sampling schedule and parameter settings on July 15, 2014 for each range stratum sampled by 5 sonars at RM 13.7.

Sonar location	ARIS serial no.	Range stratum	Time	Frame rate	Start range	End range	Freq.	Tx power	Receiver gain	Pulse length	Start delay	Sample period	Samples per beam	AR2 tilt	Pitch	Roll	Heading
Left near	1096	1	00/30	7.7	2.4	12.1	High	Max	17	17	3495	6	2217	3.6	−3.6	−1.9	186
Left far	1064	1	00/30	9	3.5	7.96	High	Max	10	8	4850	5	1237	−2.5	−9.7	−4.4	57
		2	10/40	9	8	22	High	Max	16	21	11086	15	1292	0.75	−7.8	−4.5	60
Right far	1063	3	20/50	6.54	22	34.97	Low/high	Max	24	35	30487	11	1634	5	−4.6	−4.5	60
		1															
		2	00/10	8	8	21.97	High	Max	14	20	11046	12	1608	−3.03	−4.4	−1.2	301
		3	20/30	6.42	22	34.99	High/low	Max	21	24	30522	8	2225	−3.33	−3.7	−1.0	302
Right near	1098	1	40	12	3.5	9	High	Max	6	9	4844	4	19.3	−5.33	−5.9	0	2.63
		2	50	9	9	21	High	Max	6	20	12457	7	2372	−3.76	−4.4	0	263
Channel	1095	1	0	10	2.61	6.24	High	Max	5	5	3598	5	999	2.35	−11.4	−2.8	10
		2	10	10	6.19	11.24	High	Max	5	10	8557	4	1745	8.57	−5.6	−2.7	9
		3	20	8.85	11.2	20.64	High	Max	5	19	15579	8	1641	11.6	−2.1	−2.9	9
		Weir	50	10	1.61	4.33	High	Max	5	5	2222	4	939	−2.54	−16.1	2.7	353

Table 3.—Summary of sonar stratum ranges (in meters) by date at RM 13.7, 2014.

Stratum	Start time	16 May	19 May	28 May	2 Jun	11 Jun	23 Jun	15 Jul	22 Jul
1	00/30	N/A ^a	N/A ^a	2.5–9.5	2.5–9.5	2.5–9.5	2.4–12.1	2.4–12.1	2.4–12.1
1	00/30	3.5–8	3.5–8	3.5–8	3.5–8	3.5–8	3.5–8	3.5–8	3.5–8
2	10/40	8–22	8–22	8–22	8–22	8–22	8–22	8–22	8–22
3	20/50	22–36	22–35	22–35	22–35	22–35	22–35	22–35	22–35
1	00/30	3.5–8	3.5–8	3.5–8	N/A ^b	N/A ^b	N/A ^b	N/A ^b	N/A ^b
2	10	8–22	8–22	8–22	8–22	8–22	8–22	8–22	8–22
3	20	22–35	24–35	24–35	24–35	24–35	24–35	24–35	24–35
1	40	N/A ^c	N/A ^c	N/A ^c	3.5–8.7	3.5–8.7	3.5–9	3.5–9	3.5–9
2	50	N/A ^c	N/A ^c	N/A ^c	8.7–16	8.7–16	9–18	9–21	9–21
1	00	N/A ^d	N/A ^d	N/A ^d	N/A ^d	3.4–6.3	2.6–6.2	2.6–6.2	2.6–6.2
2	10	N/A ^d	N/A ^d	N/A ^d	N/A ^d	6.3–10.3	6.2–11.2	6.2–11.2	6.2–12
3	30	N/A ^d	N/A ^d	N/A ^d	N/A ^d	10.3–19.7	11.2–20.6	11.2–20.6	12–22
Weir	10/50	N/A ^d	N/A ^d	N/A ^d	N/A ^d	1.6–4.3	1.6–4.3	1.6–4.3	1.6–4.3

^a The left bank near sonar was deployed on 28 May.

^b Three strata were used on the right bank far sonar to begin the season, but Stratum 1 was eliminated on 2 June because this range was covered by the newly deployed right bank near sonar.

^c The right bank near sonar was deployed on 2 June.

^d The channel sonar was deployed on 11 June.

Table 4.–Select user configurable parameters in SMC ARIScope data collection software and their corresponding values in DIDSON (high frequency identification mode only).

Parameter	ARIS 1200	ARIS 1800	DIDSON LR (1200)	DIDSON SV (1800)
Transmit pulse length	4 μ s to 100 μ s	4 μ s to 100 μ s	7 μ s, 13 μ s, 27 μ s, 54 μ s (relative to window length)	4.5 μ s, 9 μ s, 18 μ s, 36 μ s (relative to window length)
Downrange resolution (window length/samples)	3 mm to 10 cm	3 mm to 100 mm	5 mm, 10 mm, 20 mm, 40 mm (relative to window length)	2.5 mm, 5 mm, 10 mm, 20 mm (relative to window length)
Source level	~206–212 dB re 1 μ Pa at 1 m	~200–206 dB re 1 μ Pa at 1 m		
Window length	Any	Any	2.5 m, 5 m, 10 m, 20 m	1.25 m, 2.5 m, 5 m, 10 m
Samples per beam	Up to 4,000	Up to 4,000	512	512

On-site Data Storage and Management

Individual files for each 10-minute sample will vary in size due to different ping rates for each range stratum¹. File size also increases with the downrange resolution level. A Sound Metrics consultant will assist with determining the optimal resolution value for individual range strata. We estimate that 10-minute file sizes will vary at maximum from approximately 300,000 KB to approximately 900,000 KB. Table 5 gives a worst case scenario for data storage needs at these sample rates.

Data from each sample will be stored to a uniquely named file. Filenames are automatically generated by the ARIS software using optional identifiers such as sonar serial number, location, bank, year, month, day, military time (hour, min, sec), transmitted pulse length, number of beams sampled, samples per beam, frequency, and range interval. For example, the file

SN 1064_Kenai13-7_LB_2014-07-17_004000_T24_B48_S2000_F12_R21-35.aris

refers to a file collected by sonar number 1064 at RM 13.7 on the left bank of the Kenai River, which started data collection on 17 July 2014 at 00:40 AM using a transmitted pulse length of 24 μ sec and using all 48 beams, with 2000 samples per beam at a frequency of 1.2 MHz, over the range interval 21–35 m.

Longer file names may be used initially, but pared back later if we determine that the long file names hinder file handling during file transfer, processing, and archiving. Initially, the additional information in the file name may help during the early phase of this project when different settings are being evaluated.

One laptop will be dedicated to collecting data from each sonar. Data will be written directly to 1 of 2 external hard drives assigned to that computer and sonar (Figure 11). The hard drives will be swapped out once per day and transported back to the Soldotna ADF&G office.

¹ Files from individual range strata will vary in size if the ping rate is optimized for each range strata. Because the return time for a ping increases with range, off-shore range strata will require a slower ping rate and files will contain fewer frames.

Table 5.—Data storage needs for data collected in 2014 from 4 mainstem ARIS systems at the RM 13.7 site.

Location	Sonar	Stratum (approx. range)	10-min file size (GB)	Hourly sample size (GB)	Comments
Left bank nearshore ^a	ARIS 1800—standard lens	Stratum 1 (2–15 m)	0.9	1.8	Collect data for 20 min out of each hour. See comment 1 below.
Left bank offshore	ARIS 1200—large lens	Stratum 1 (3–8 m)	0.3	0.6	Collect data for 20 min each hour.
	ARIS 1200—large lens	Stratum 2 (8–24 m)	0.5	1	Collect data for 20 min each hour.
	ARIS 1200—large lens	Stratum 3 (24–34 m)	0.3	0.6	Collect data for 20 min each hour.
Right bank nearshore	ARIS 1200—large lens	Stratum 1 (3–8 m)	0.45	0.45	Collect data for 10 min out of each hour.
	ARIS 1800—large lens	Stratum 2 (8–16 m)	0.55	0.55	Collect data for 10-min out of each hour.
Right bank offshore	ARIS 1200—large lens	Stratum 1 (3–8 m)	N/A	N/A	Right bank offshore Stratum 1 covered by right bank nearshore Stratum 2.
	ARIS 1200—large lens	Stratum 2 (8–23 m)	0.35	0.7	Collect data for 20 min each hour.
	ARIS 1200—large lens	Stratum 2 (23–35 m)	0.4	0.8	Collect data for 20 min each hour.
Minor channel	ARIS 1200—large lens	Stratum 1 (3–6 m)	0.275	0.275	Collect data for 10 min each hour.
	ARIS 1200—large lens	Stratum 2 (6–12 m)	0.35	0.35	Collect data for 10 min each hour.
	ARIS 1200—large lens	Stratum 3 (12–20 m)	0.35	0.35	Collect data for 10 min each hour.
<hr/>					
Total					
Hourly			4.725	7.5	
Daily (hourly × 24)			113.4	179.4	
Season ^{b,c}			9,866	15,608	or ~15 TB for season

^a ARIS 1800 files can be larger than ARIS 1200 files because the ARIS 1800 has twice as many sub-beams (96 versus 48 beams).

^b Although ARIS file sizes are usually larger than DIDSON files, ARIS strata may cover larger ranges and will not necessarily generate larger files depending on the selected **Samples/Beam** parameter.

^c Assumes offshore sonars operate 16 May to 15 August (97 days), inshore sonars operate 1 June to 15 August (76 days), and minor channel sonars operate 10 June to 15 August (67 days).

Office Data Management and Archiving

Procedures for processing the large volume of data generated daily by the ARIS systems were developed during the 2013 and 2014 seasons and may continue to be refined and expanded upon in 2015. In the Soldotna office, data will be uploaded from each external drive to a 16 TB Buffalo TeraStation Network Attached Storage (NAS) where it can be shared with up to 14 users through a 1 GB Ethernet network (i.e., through a 16 port 1 GB Ethernet switch connected to computers with 1 GB Ethernet cards; Figure 14). This process is facilitated through the use of batch files described in Appendix C1. Further information on the NAS configuration and instructions for mapping to the NAS can be found in Appendices F1–F3.

As shown in Figure 14, a separate computer will be used to upload ARIS data from the external hard drives to the NAS using batch files that sort and store files in the following directory hierarchy: 1) by year (e.g., Data2014), 2) by day, 3) by sonar (e.g., LeftFar), and 4) by stratum. The following folders were unique to each of the 5 sonars: Channel (for right bank minor channel), LeftFar (left bank offshore sonar), LeftNear (left bank nearshore sonar), RightNear (right bank nearshore sonar), and RightFar (Right bank offshore sonar). Two separate networks will be set up between the NAS and attached computers, 1 for data upload (connecting the upload computer) and 1 for data processing (connecting up to 14 data processing computers). This will allow simultaneous upload and data processing. Following upload to the NAS, data from each external hard drive will also be copied to a second “backup” external hard drive. Data transferred to the back-up hard drive are not sorted or stored according to any hierarchy. However the naming convention of the data files naturally sorts them by sonar and then data and time.

Remote Access to Sonar Site

Because the RM 13.7 site will not be manned at all hours in 2015, a system to remotely access and determine the status of the data collection computers and sonars will be implemented. Each data collection computer will be equipped with wireless internet service through AT&T Beams (providing 4G LTE service) and can be accessed remotely using GoToMyPC accounts (Figure 11).

Fish Length and Direction of Travel

Estimates of total length will be made from images using the ARISFish V2.3 (or a more recent version provided by the manufacturer). Detailed instructions for taking manual measurements and the software settings and parameters are given in Appendix D1. On a given day, depending on the factors given above, one of 3 sampling protocols (described below) will guide processing and analysis of the RM 13.7 data.

Standard (ST) Sampling Protocol

The standard sampling protocol, detailed below, will be followed during the early run to the extent possible:

- 1) ARIS length (AL) will be measured for all salmon-shaped fish greater than or equal to 40 cm that meet the centerline criteria².

² Only fish that cross the center axis of the video image will be measured. Fish that do not cross the center axis will be ignored. See Appendices D2–D3 for further detail on centerline criteria.

- 2) Direction of travel is automatically recorded for each measured fish. However, while measuring a fish, an accurate direction of travel requires clicking on the snout of the fish first.

Fast Track (FT) Sampling Protocol

When sockeye salmon are abundant, it can become too time-consuming to measure each individual fish, given staffing and time constraints. Additionally, during periods of peak passage, fish often swim in large tightly-compacted groups and measurements cannot always be uniquely associated with specific fish (Figure 15). The “Fast Track” sampling protocol, detailed below, will be reserved for use during the early run when sockeye salmon are especially abundant:

- 1) Length will be measured for all large salmon-shaped fish greater than or equal to 75 cm AL that meet centerline criteria.
- 2) Length will also be measured for a subset of medium salmon-shaped fish greater than or equal to 40 cm and less than 75 cm (AL). The first 5 salmon-shaped fish passing during a given sampled period will be measured.
- 3) Direction of travel is automatically recorded for each measured fish. For a measured fish, an accurate direction of travel requires clicking on the snout of the fish first.
- 4) The remaining medium-sized fish greater than or equal to 40 cm and less than 75 cm (AL) will be marked (tallied) but not measured. To mark fish, staff will watch a short section of the ARIS video associated with the chart, count the number of fish in a group that (as best as can be determined) cross the centerline, and then make the counted number of marks on the chart.
- 5) Medium-size fish that are mistaken for large fish and are measured but then turn out to be less than 75 cm, will be marked (tallied) but length will not be recorded.
- 6) For marked fish, an accurate direction of travel requires using [shift] click when marking downstream fish. However, under conditions when fast tracking is being implemented, it will usually not be practical to record direction of travel accurately for all marked fish. Therefore, no effort will be made to identify downstream fish when marking.

All Large Fish (ALF) Sampling Protocol

During the late run, staffing and time constraints often come into play. Also, tightly compacted groups are common, and milling or holding pink salmon can make it difficult to reliably assess direction of travel for small and medium fish. Staff are able to easily discern larger Chinook salmon swimming directly through the smaller holding or milling salmon (Figure 16). The “All Large Fish” (ALF) sampling protocol will be the default protocol during the late run. Fish larger than 75 cm, along with a subset of shorter fish, will be measured, and the remaining shorter fish will be ignored as follows:

- 1) Length will be measured for the first 5 salmon-shaped fish greater than or equal to 40 cm AL regardless of direction of travel.
- 2) Length will be measured for all large salmon-shaped fish greater than or equal to 75 cm AL that meet centerline criteria.

- 3) Remaining fish less than 75 cm AL will not be recorded in any way. Medium sized fish mistakenly chosen for measurement (after the first 5 fish), but that turn out to be less than 75 cm, will not be recorded.
- 4) Direction of travel is automatically recorded for each measured fish. However, while measuring a fish, an accurate direction of travel requires clicking on the snout of the fish first.

DATA ANALYSIS

Abundance estimates at RM 13.7 will apply to the entire river cross-section.

Fish Passage

The ARIS sonar system is composed of multiple individual transducers scheduled to operate 10 minutes per hour for each spatial stratum, 24 hours per day. There will be 1–3 spatial strata sampled per transducer and 2–5 transducers deployed in the river at any given time. The number of fish y that satisfy a set of criteria \mathbf{X} (e.g., fish with ARIS length equal to or greater than 75 cm and that migrated in an upstream direction) during day i will be estimated as follows:

$$\hat{y}_i = \sum_k \sum_s \hat{y}_{iks} \quad (1)$$

where \hat{y}_{iks} is net fish passage in stratum s of transducer k during day i , and estimated as

$$\hat{y}_{iks} = \frac{24}{h_{iks}} \sum_{j=1}^4 \hat{y}_{ijks} \quad (2)$$

where h_{iks} is the number of hours during which fish passage was estimated for stratum s of transducer k during day i , and \hat{y}_{ijks} is hourly fish passage for stratum s of transducer k during hour j of day i , and is estimated as

$$\hat{y}_{ijks} = \frac{60}{m_{ijks}} c_{ijks} \quad (3)$$

where

m_{ijks} = number of minutes (usually 10) sampled for stratum s of transducer k during hour j of day i , and

c_{ijks} = number of fish satisfying criteria \mathbf{X} (e.g., upstream direction of travel; ARIS length greater than or equal to 75 cm) in stratum s of transducer k during hour j of day i .

The variance of the daily estimates of y , due to systematic sampling in time, will be approximated (successive difference model³; Wolter 1985) with adjustments for missing data as follows:

³ This is an assessment of the uncertainty due to subsampling (counting fish for 10 minutes per hour and expanding). The formulation in Equation 4 is conservative in the sense that it has been shown to overestimate the true uncertainty when applied to salmon passage data (Reynolds et al. 2007; Xie and Martens 2014).

$$\hat{V}[\hat{y}_i] \cong 24^2(1-f) \frac{\sum_{j=2}^{24} \phi_{ij} \phi_{i(j-1)} (\hat{y}_{ij} - \hat{y}_{i(j-1)})^2}{2 \sum_{j=1}^{24} \phi_{ij} \sum_{j=2}^{24} \phi_{ij} \phi_{i(j-1)}} \quad (4)$$

where f is the sampling fraction (temporal sampling fraction, usually 0.17), ϕ_{ij} is 1 if \hat{y}_{ij} exists for hour j of day i , or 0 if not, and

$$\hat{y}_{ij} = \sum_k \sum_s \hat{y}_{ijks} \cdot \quad (5)$$

Other estimates of passage will be obtained by changing the criteria \mathbf{X} for fish counts c_{ijks} in Equation 3. For example, for estimates of downstream large fish, \mathbf{X} would be “downstream direction of travel; ARIS length greater than or equal to 75 cm.” Estimates of daily net upstream passage will be obtained by calculating separate estimates of upstream and downstream passage (Equations 1–3) and subtracting the downstream estimate from the upstream estimate. The estimated variance of net upstream daily passage will be the sum of the upstream and downstream variances.

Chinook Salmon Passage

Upstream Chinook salmon passage, regardless of size, will be estimated by fitting a mixture model to upstream ARIS length and midriver RM 8.6 netting data. The estimate of upstream Chinook salmon passage on day i will be

$$\hat{z}_i = \hat{w}_i \hat{\pi}_{Ci}, \quad (6)$$

where \hat{w}_i is upstream fish passage on day i , obtained by applying Equations 1–3 for upstream fish greater than or equal to 40 cm ARIS length, and $\hat{\pi}_{Ci}$ is the proportion of sampled fish that are Chinook salmon on day i , estimated by fitting an ARIS length mixture model to upstream ARIS lengths from RM 13.7, and midriver netting data from RM 8.6, as described in Appendix B1.

The variance estimate will follow Goodman (1960):

$$\text{var}(\hat{z}_i) = \hat{y}_i^2 \text{var}(\hat{\pi}_{Ci}) + \hat{\pi}_{Ci}^2 \text{var}(\hat{w}_i) - \text{var}(\hat{\pi}_{Ci}) \text{var}(\hat{w}_i) \quad (7)$$

Upstream ARIS data will be used in the mixture model to be consistent with the drift gillnetting data, which presumably capture only upstream bound fish. Midriver (as opposed to nearshore) netting data from RM 8.6 will be used to preserve comparability with the escapement goals currently in effect.

Daily net upstream Chinook salmon passage will be approximated as

$$\hat{N}_i \approx \hat{z}_i \frac{u_i - d_i}{u_i}, \quad (8)$$

where u_i and d_i are daily estimates of upstream and downstream passage of fish greater than or equal to 75 cm AL, respectively, obtained using Equations 1–3.

Modifications under FT Protocol

Under the Fast-Track protocol, length measurements will be available for all fish greater than or equal to 75 cm AL and a subset of fish equal to or greater than 40 cm and up to 75 cm (AL). These constraints require the following modifications to the abundance estimators:

- 1) Daily passage y_{FTi} will be defined as the number of salmon-shaped fish greater than or equal to 40 cm AL, except downstream fish greater than or equal to 75 cm AL. Equations 1–3 will be used to estimate daily passage except that c_{ijks} equals the number of salmon-shaped fish greater than or equal to 40 cm AL, excluding downstream fish greater than or equal to 75 cm AL, in stratum s for hour j and day i .
- 2) The AL mixture model, modified to accommodate censored lengths from small fish (Appendix B6), will be fit to the same subset of the data described above.
- 3) The daily proportion π_{FTi} of these specified fish that are upstream Chinook salmon (output from AL mixture model) will be multiplied by the estimate of y_{FT} above to estimate z_i , number of Chinook salmon migrating upstream (Equations 6 and 7).
- 4) Under the FT protocol, because accurate direction of travel information is not available for fish greater than or equal to 40 cm and less than 75 cm (AL), it will not be possible to obtain an unbiased estimate of y_i , daily upstream passage of salmon-shaped fish greater than or equal to 40 cm AL. Quantity y_{FT} can be substituted, however it will be biased and overestimate the quantity by an unknown small amount because it includes some downstream fish greater than or equal to 40 cm and less than 75 cm (AL).

Modifications under All-Large-Fish (ALF) Protocol

Under the All-Large-Fish (ALF) protocol, all fish greater than or equal to 75 cm AL will be counted and measured, and a subset of fish greater than or equal to 40 and less than 75 cm (AL) will also be measured. Under the ALF protocol, the fraction of measured fish that are Chinook salmon is multiplied by the temporally expanded number of measured fish. This constraint requires no modifications to the usual (ST protocol) estimators; however, interpretations of the quantities differ as follows:

- 1) Daily quantity y_{ALFi} is defined as the number of salmon-shaped fish greater than or equal to 40 cm AL that are measured under the ALF protocol. Despite having a different interpretation than y_i , it will be estimated exactly as specified for the ST protocol in Equations 1–4, including the definitions of c_{ijks} and m_{ijks} .
- 2) The unmodified AL mixture model for the ST protocol (Appendix B5) will be fit to the AL measurements obtained under the ALF protocol.
- 3) Under the ALF protocol, it is not possible to obtain an unbiased estimate of y_i , daily upstream passage of salmon-shaped fish. Daily passage y_{ALFi} is an arbitrary quantity estimated solely to obtain Chinook salmon passage z_i , and it has no biological interpretation.
- 4) Because the ALF protocol sacrifices the ability to monitor salmon passage, it will be adopted only during the late run when fish behaviour precludes the ability to count fish or to determine direction of travel, or when timeliness of data processing becomes an important management consideration.

Large Fish Passage Estimates

The number of large fish x , equal to or exceeding 75 cm AL, during day i that migrate upstream will be estimated using Equations 1–3, except that c_{iksj} equals the number of upstream bound fish in the insonified zone equal to or exceeding 75 cm in length as measured by ARIS in stratum s during hour j of day i .

SCHEDULE AND DELIVERABLES

Project activities are scheduled as follows:

Dates	Activity
1 May–15 May 2015	<ul style="list-style-type: none">• Review and update measurement protocol• Group training on manual ARIS measures; review and update RM13.7 ARIS office manual• RM 13.7 project deployment• Deploy main channel offshore ARIS• Update batch files for RM 13.7 ARIS data if needed
11 May–15 May 2015	<ul style="list-style-type: none">• Bill Hanot (SMC consultant) on site to assist with sonar testing and configuration• Collect river bottom profile data from each bank using vertically mounted DIDSON
15 May–1 June 2015	<ul style="list-style-type: none">• Continued training sessions with crew as needed for measuring consistency
1 June 2015 or later	<ul style="list-style-type: none">• Deploy nearshore ARIS systems when water level justifies• Deploy minor-channel weir and ARIS when water level justifies
1 August–10 August 2015	<ul style="list-style-type: none">• If deemed necessary, deploy vertical mounted standard DIDSON with large lens on right bank main channel to collect vertical distribution data.
20 August–25 August 2015	<ul style="list-style-type: none">• Terminate data collection, dismantle and store gear

A report meeting the requirements of ADF&G's Fishery Data Series will be published. This report will provide an overview of the implemented methodology for generating ARIS-based Chinook salmon estimates. A draft version will be completed by 1 April 2016. The final report will be completed by 1 September 2016.

RESPONSIBILITIES

Brandon Key, Fishery Biologist II, ADF&G

Duties: Project Leader. General supervision of all aspects of the study. Set up and configure DIDSON and ARIS sonar systems. Assist with inseason data collection and postseason data analysis. Share responsibility for postseason report.

James Miller, Fishery Biologist III, ADF&G

Duties: Assist with conducting and supervising all aspects of the study. Work with Bill Hanot and other SMC personnel to develop and update data-processing software. Set up and configure DIDSON and ARIS sonar systems. Assist with inseason data collection and postseason data analysis. Assist with testing and evaluating evolving DIDSON and ARIS hardware and software. Share responsibility for postseason report.

Steve Fleischman, Fisheries Scientist I, ADF&G

Duties: Provide guidance on sample design and estimation procedures. Assist with inseason and postseason data analysis. Review project operational plan. Share responsibility for postseason report.

Jiaqi Huang, Biometrician III, ADF&G

Duties: Provide guidance on sample design and estimation procedures. Assist with postseason data analysis. Coauthor project operational plan and report.

Bill Hanot, Senior Engineer, Sound Metrics

Duties: Provide training in the operation of a new DIDSON prototype (ARIS) and ensure that all hardware and software features are working correctly. Develop software features required to collect or analyze DIDSON and ARIS data. Planned visit is 11–15 May 2015.

Mike Hopp, Fish and Wildlife Technician III, ADF&G

Duties: Crew Leader. Assist Project Leader with all aspects of ARIS deployment, operation, and data analysis. Assist with developing protocol and a comprehensive user manual for processing ARIS data for the purpose of generating daily estimates of Chinook salmon passage. Work dates: 15 April–31 August 2015.

John Sigurdsson, Fish and Wildlife Technician II, ADF&G

Duties: Assist Crew Leader with all aspects of ARIS deployment, operation, and data processing. Approximate work dates: 1 May–20 August 2015.

Shaylee Rizzo, Fish and Wildlife Technician II, ADF&G

Duties: Assist Crew Leader with all aspects of ARIS deployment, operation, and data processing. Approximate work dates: 1 June–20 August 2015.

Nathan Plate, Fish and Wildlife Technician II, ADF&G

Duties: Assist Crew Leader with all aspects of DIDSON and ARIS deployment, operation, and data processing. Approximate work dates: 1 July–20 August 2015.

Alex Pettey, Fish and Wildlife Technician II, ADF&G

Duties: Assist Crew Leader with all aspects ARIS deployment, operation, and data processing. Approximate work dates: 1 July–20 August 2015.

BUDGET SUMMARY FY 16

The total proposed budget for the Kenai River Chinook salmon sonar project (fiscal year, 2016) is \$194,000. Budget and personnel requirements are summarized in Table 6 and Table 7.

Table 6.—Proposed 2016 field season costs.

Line item	Category	Budget (\$K)
100	Personal Services	163.2
200	Travel	0.6
300	Contractual	23.7
400	Commodities	6.6
500	Equipment	0.0
Total		194.0

Table 7.–Funded personnel for 2016 field season.

PCN	Name	Level	Funded Man Months
4166	Brandon Key	Fishery Biologist II	12.0
1793	Mike Hopp	Fish & Wildlife Technician III	4.5
4146	John Sigurdsson	Fish & Wildlife Technician II	4.0
5347	Shaylee Rizzo	Fish & Wildlife Technician II	3.5
4305	Nathan Plate	Fish & Wildlife Technician II	3.5
1045	Alex Pettey	Fish & Wildlife Technician II	1.5
Total			29.0

REFERENCES CITED

- Bromaghin, J. 2005. A versatile net selectivity model, with application to Pacific salmon and freshwater species of the Yukon River, Alaska. *Fisheries Research* 74(1-3):157-168.
- Burwen, D. L., D. E. Bosch, and S. J. Fleischman. 1998. Evaluation of hydroacoustic assessment techniques for Chinook salmon on the Kenai River, 1995. Alaska Department of Fish and Game, Fishery Data Series No. 98-3., Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/fds98-03.pdf>.
- Burwen, D. L., and S. J. Fleischman. 1998. Evaluation of side-aspect target strength and pulse width as hydroacoustic discriminators of fish species in rivers. *Canadian Journal of Fisheries and Aquatic Sciences* 55(11):2492-2502.
- Burwen, D. L., S. J. Fleischman, and J. D. Miller. 2007. Evaluation of a dual-frequency imaging sonar for estimating fish size in the Kenai River. Alaska Department of Fish and Game, Fishery Data Series No. 07 44, Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/fds07-44.pdf>.
- Burwen, D. L., S. J. Fleischman, and J. D. Miller. 2010. Accuracy and precision of manual fish length measurements from DIDSON sonar images. *Transactions of the American Fisheries Society*, 139:1306-1314.
- Burwen, D. L., S. J. Fleischman, J. D. Miller, and M. E. Jensen. 2003. Time-based signal characteristics as predictors of fish size and species for a side-looking hydroacoustic application in a river. *ICES Journal of Marine Science* 60:662-668.
- Burwen, D., J. Hasbrouck, and D. Bosch. 2000. Investigations of alternate sites for Chinook salmon sonar on the Kenai River. Alaska Department of Fish and Game, Fishery Data Series No. 00-43., Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/fds00-43.pdf>.
- Carroll, H. C., and B. C. McIntosh. 2008. Sonar estimation of salmon passage in the Yukon River near Pilot Station, 2006. Alaska Department of Fish and Game, Fishery Data Series No. 08-65, Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/fds08-65.pdf>.
- Cochran, W. G. 1977. Sampling techniques. 3rd edition. New York., John Wiley and Sons.
- Cronkite, G. M. W., H. J. Enzenhofer, T. Ridley, J. Homes, J. Lilja, and K. Benner. 2006. Use of high-frequency imaging sonar to estimate adult sockeye salmon escapement in the Horsefly River, British Columbia. *Canadian Technical Report of Fisheries and Aquatic Sciences* No. 2647.

REFERENCES CITED (Continued)

- Dunbar, R. D. 2013. Sonar estimation of fall chum salmon abundance in the Sheenjek River, 2012. Alaska Department of Fish and Game, Fishery Data Series No. 13-36, Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FDS13-36.pdf>.
- Fair, L. F., T. M. Willette, and J. Erickson. 2009. Escapement goal review for Susitna River sockeye salmon, 2009. Alaska Department of Fish and Game, Fishery Manuscript Series No. 09-01, Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/fms09-01.pdf>.
- Fleischman, S. J., and D. L. Burwen. 2003. Mixture models for the species apportionment of hydroacoustic data, with echo-envelope length as the discriminatory variable. *ICES Journal of Marine Science* 60:592-598.
- Fleischman, S. J., and T. R. McKinley. 2013. Run reconstruction, spawner–recruit analysis, and escapement goal recommendation for late-run Chinook salmon in the Kenai River. Alaska Department of Fish and Game, Fishery Manuscript Series No. 13-02, Anchorage. <http://www.adfg.alaska.gov/FedAidpdfs/FMS13-02>.
- Goodman, L. A. 1960. On the exact variance of products. *Journal of the American Statistical Association* 55:708-713.
- Hammarstrom, S. L., and J. J. Hasbrouck. 1999. Estimation of the abundance of late-run Chinook salmon in the Kenai River based on exploitation rate and harvest, 1997. Alaska Department of Fish and Game, Fishery Data Series No. 99-8., Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/fds99-08.pdf>.
- Holmes, J. A., G. M. Cronkite, H. J. Enzenhofer, and T. J. Mulligan. 2006. Accuracy and precision of fish-count data from a “dual-frequency identification sonar” (DIDSON) imaging system. *ICES Journal of Marine Sciences* 63:543-555.
- 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. <http://www.adfg.alaska.gov/FedAidPDFs/FDS14-22.pdf>.
- Maxwell, S. L., A. V. Faulkner, L. Fair, and X. Zhang. 2011. A comparison of estimates from 2 hydroacoustic systems used to assess sockeye salmon escapement in 5 Alaska Rivers. Alaska Department of Fish and Game, Fishery Manuscript Series No. 11-02, Anchorage. <http://www.adfg.alaska.gov/FEDAIDpdfs/FMS11-02.pdf>.
- Maxwell, S. L., and N. E. Gove. 2007. Assessing a dual-frequency identification sonar’s fish-counting accuracy, precision, and turbid river range capability. *Journal of the Acoustical Society of America* 122:3364-3377.
- McKinley, T. R., and S. J. Fleischman. 2013. Run reconstruction, spawner–recruit analysis, and escapement goal recommendation for early-run Chinook salmon in the Kenai River. Alaska Department of Fish and Game, Fishery Manuscript Series No. 13-03, Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FMS13-03.pdf>.
- Miller, J. D., D. L. Burwen, and S. J. Fleischman. 2010. Estimates of Chinook salmon passage in the Kenai River using split-beam sonar, 2006. Alaska Department of Fish and Game, Fishery Data Series No. 10-40, Anchorage. <http://www.adfg.alaska.gov/FedAidpdfs/FDS10-40.pdf>.
- Miller, J. D., D. L. Burwen, and S. J. Fleischman. 2012. Estimates of Chinook salmon passage in the Kenai River using split-beam sonar, 2008-2009. Alaska Department of Fish and Game, Fishery Data Series No. 12-73, Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FDS12-73.pdf>.
- Miller, J. D., D. L. Burwen, and S. J. Fleischman. 2013. Estimates of Chinook salmon passage in the Kenai River using split-beam and dual-frequency identification sonars, 2010. Alaska Department of Fish and Game, Fishery Data Series No. 13-58, Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FDS13-58.pdf>.
- Miller, J. D., D. L. Burwen, and S. J. Fleischman. 2014. Estimates of Chinook salmon passage in the Kenai River using split-beam and dual-frequency identification sonars, 2011. Alaska Department of Fish and Game, Fishery Data Series No. 14-18, Anchorage. <http://www.adfg.alaska.gov/FedAidpdfs/FDS14-18.pdf>.
- Miller, J. D., D. L. Burwen, and S. J. Fleischman. 2015. Estimates of Chinook salmon passage in the Kenai River at river mile 8.6 using dual-frequency identification sonar, 2012. Alaska Department of Fish and Game, Fishery Data Series No. 15-09, Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FDS15-09.pdf>.
- Perschbacher, J. 2014. Chinook salmon creel survey and inriver gillnetting study, Lower Kenai River, Alaska, 2012. Alaska Department of Fish and Game, Fishery Data Series No. 14-37, Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FDS14-37.pdf>.
- Perschbacher, J. 2015. Chinook salmon creel survey and inriver gillnetting study, lower Kenai River, Alaska, 2013. Alaska Department of Fish and Game, Fishery Data Series No. 15-46, Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FDS15-46.pdf>.

REFERENCES CITED (Continued)

Westerman, D. L., and T. M. Willette. 2012. Upper Cook Inlet salmon escapement studies, 2011. Alaska Department of Fish and Game, Fishery Data Series No. 12-83, Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FDS12-83.pdf>.

Wolter, K. M. 1985. Introduction to variance estimation. Springer-Verlag, New York.

FIGURES

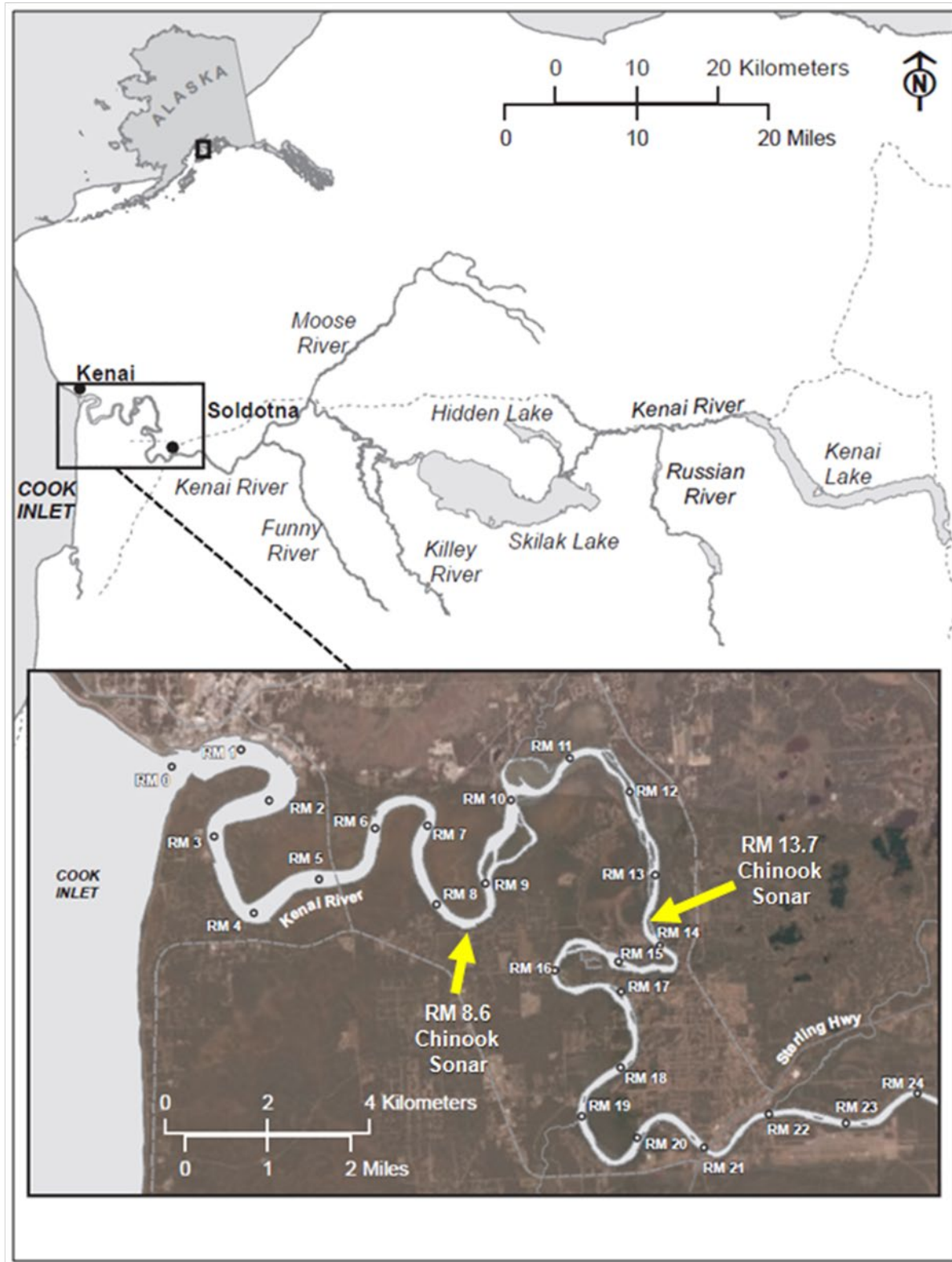


Figure 1.—Map of Kenai River showing location of historical Chinook salmon sonar site at river mile 8.6 and new sonar site at river mile 13.7.



Figure 2.—Yellow arrows indicate preferred locations for sonars on each bank of the main channel.
Note: Red arrow indicates approximate location for sonar in the minor channel.

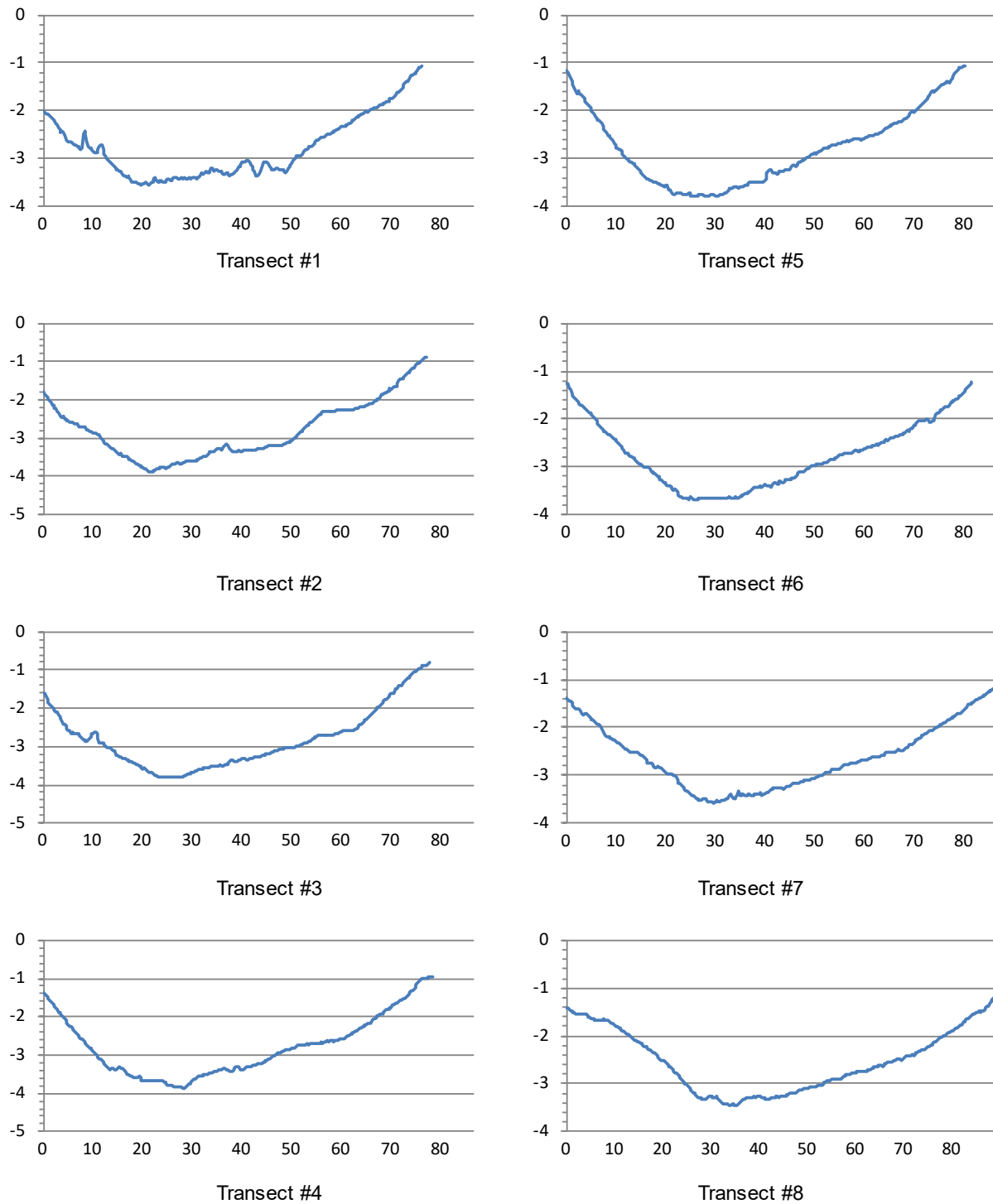


Figure 3.—Corresponding profiles for 8 of the 9 transects conducted near RM 13.7 of the Kenai River (see Figure 2).

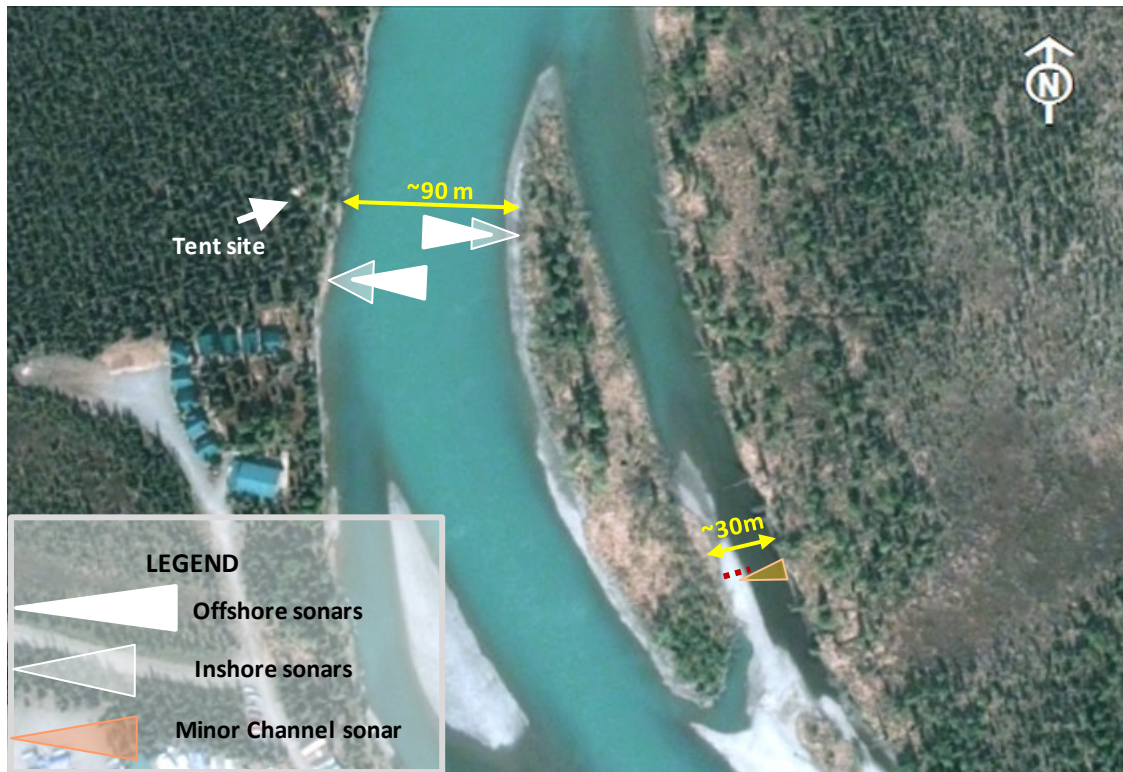


Figure 4.–Kenai River RM 13.7 sonar site showing approximate deployment locations and beam coverage of 5 ARIS units.

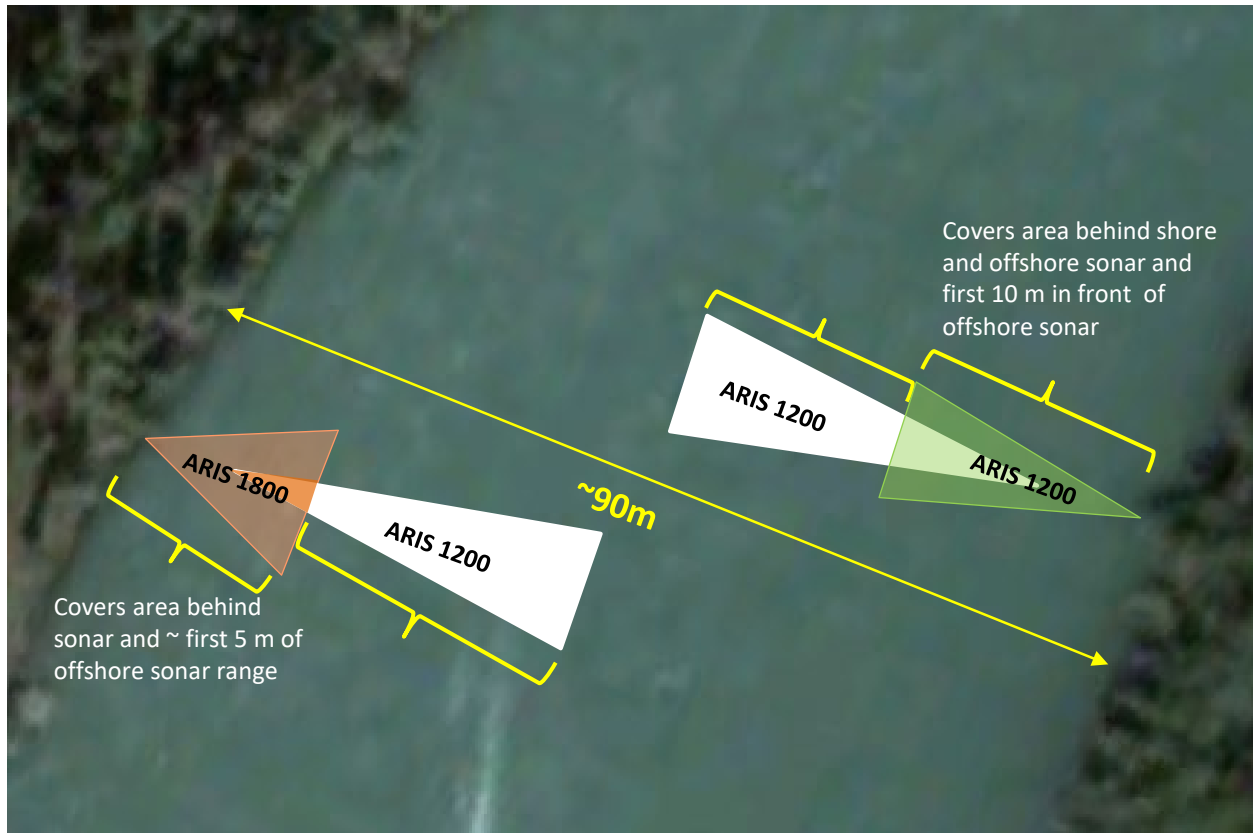


Figure 5.—Deployment schematic for ARIS systems in 2015 on the main channel at RM 13.7.

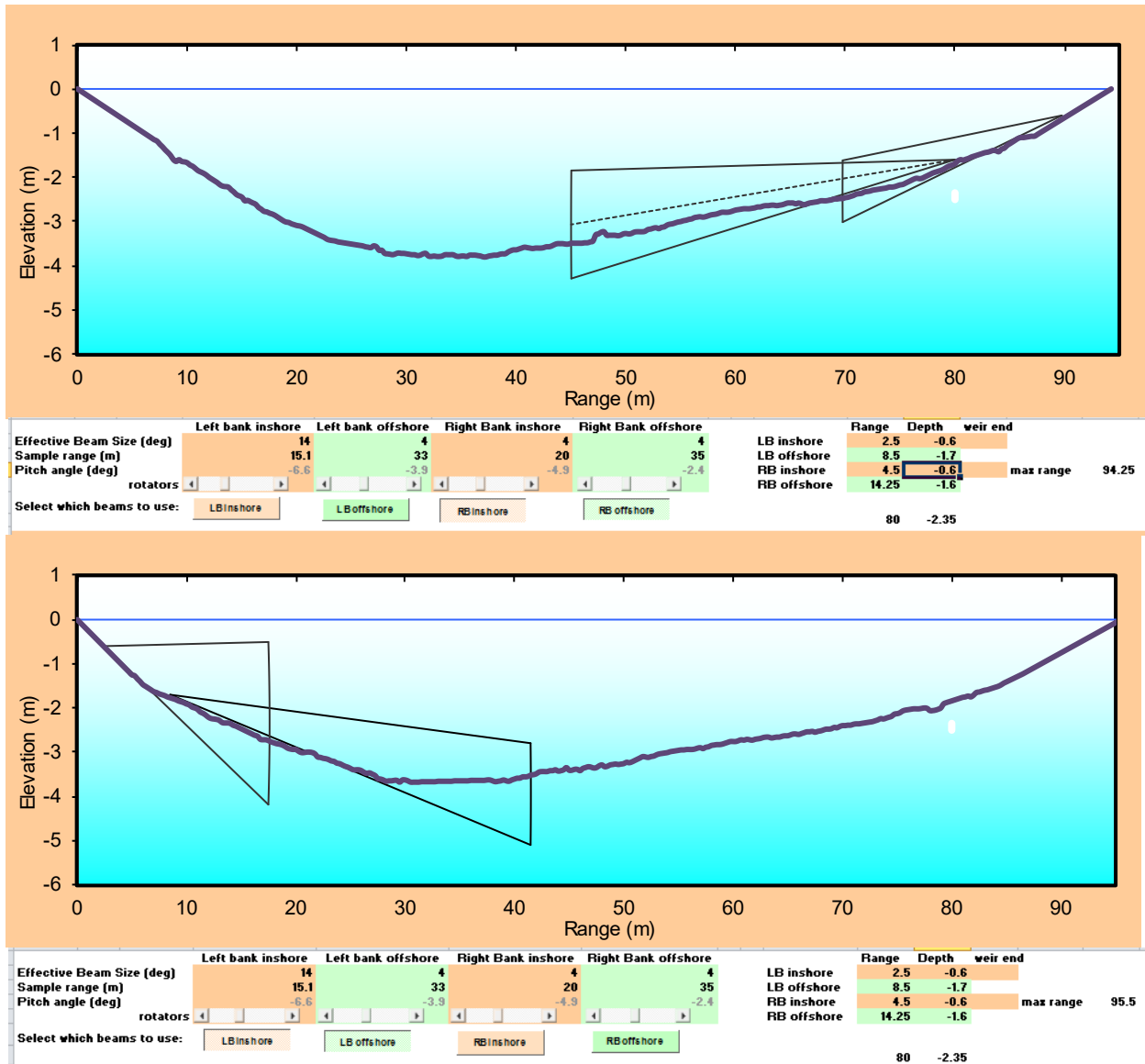


Figure 6.—Proposed coverage for the right bank (top; Transect 5 in Figure 2) and left bank (bottom; Transect 6 in Figure 2) at RM 13.7.

Note: Proposed parameters are given for vertical beam width, total insonified range, sonar depth, and pitch angle.



Figure 7.—Sonar coverage of the minor channel at the Kenai River RM 13.7 sonar site is achieved using an ARIS 1200 deployed on a tripod mount combined with a fixed weir.

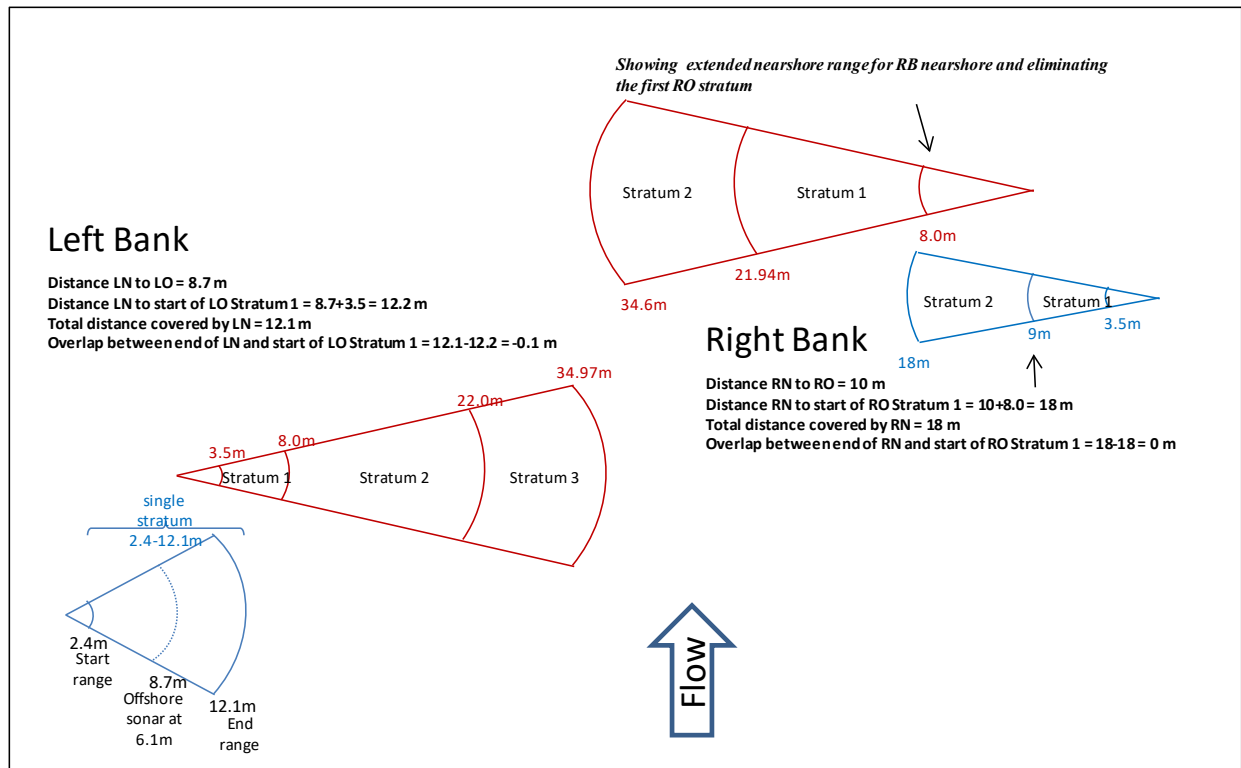


Figure 8.—ARIS deployment schematic at RM 13.7 site on June 23, 2014, showing beam coverage on the main channel using 2 sonars (inshore and offshore) on each bank.



Figure 9.—RM 13.7 tent housing data collection computers for all 5 ARIS units.



Figure 10.—An ARIS 1200 with a high-resolution lens mounted on a steel tripod for offshore deployment (A) and on an aluminum H-mount for near shore deployment (B).

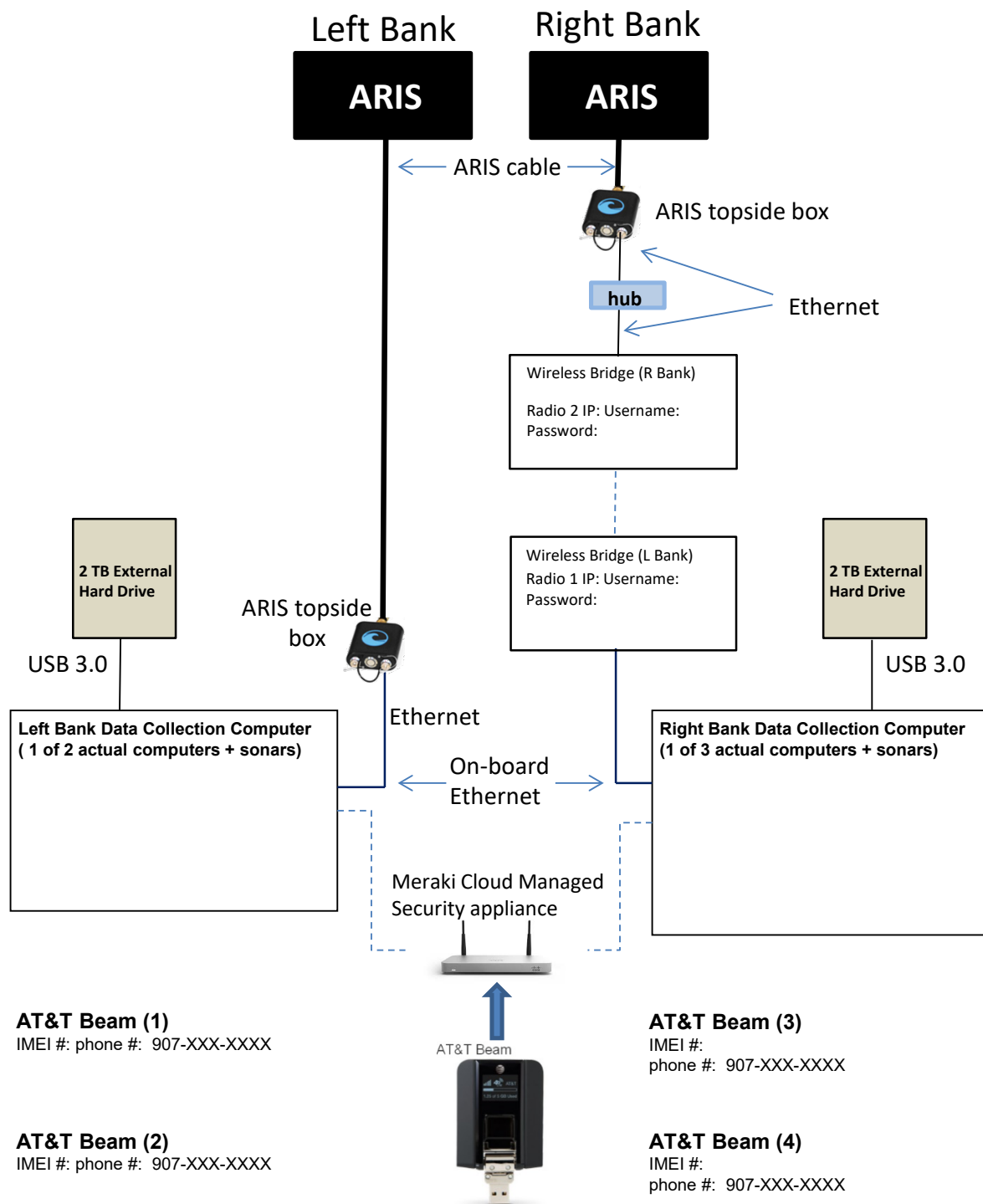


Figure 11.—ARIS data collection schematic for the RM 13.7 site.

Note: For simplicity, this diagram shows only 1 of 3 right bank data-collection computer+sonar pairs and 1 of 2 left bank data collection computer+sonar pairs. Each computer is equipped with wireless ethernet through AT&T Beams (providing 4g LTE service) and can be accessed remotely using Gotomypc accounts.

The components shown in the diagram below are housed in the small white container in the upper left corner of the fish tote (42"x29"x28"). The batteries are stored in a separate container in the lower right corner of the fish tote. The combined charger/inverter are mounted in the third container in the lower left corner.

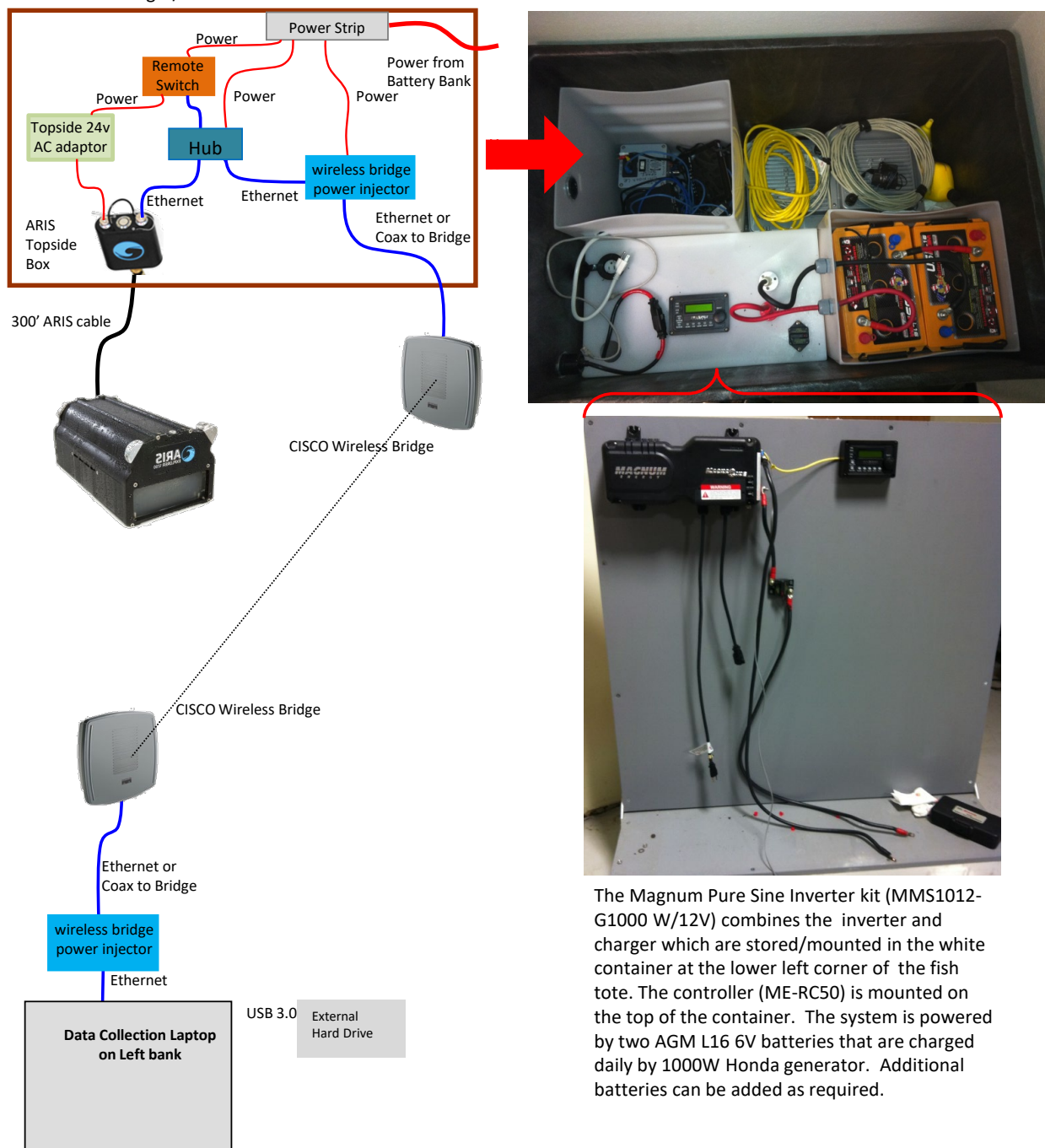
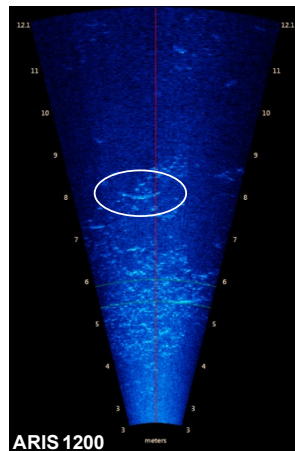


Figure 12.—Diagram of components required on RM 13.7 right bank for wireless transmission of ARIS data back to the main camp on left bank.

Note: A wireless bridge transmits data to a data collection computer on the left bank for storage and subsequent transport to the Soldotna office.

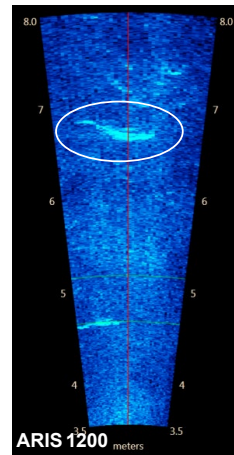
Left bank Nearshore (1 stratum)



Stratum 1: 2.5-12.1 m

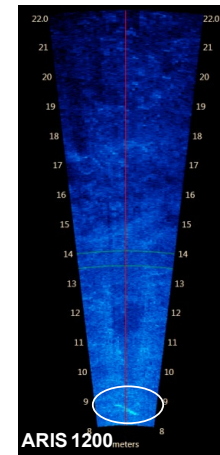
Pitch = -3.6°

Left bank Offshore (3 strata)



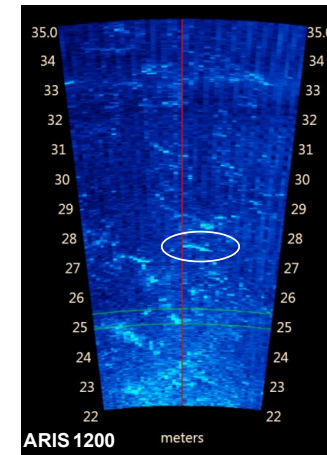
Stratum 1: 3.5-8.0 m

Pitch = -7.2°



Stratum 2: 8.0-22.0 m

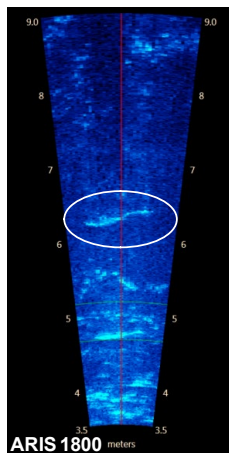
Pitch = -6.8°



Stratum 3: 22.0-35.0 m

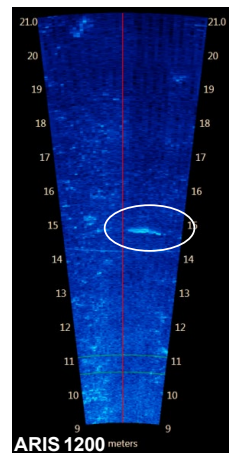
Pitch = -5.5°

Right bank Nearshore (2 strata)



Stratum 1: 3.5-9.0 m

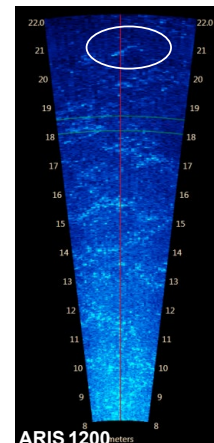
Pitch = -6.0°



Stratum 2: 9.0-21.0 m

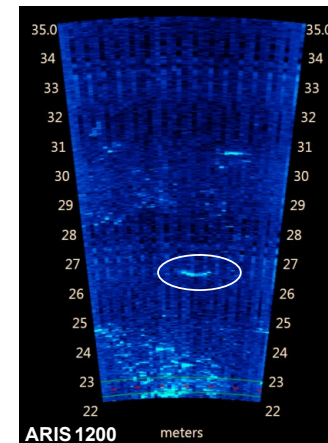
Pitch = -4.5°

Right bank Offshore (2 strata)



Stratum 2: 8.0 to 22.0 m

Pitch = -4.0°



Stratum 3: 22.1-35.0 m

Pitch = -3.8°

Figure 13.—Example images from each of the 4 left bank (top) and 4 right bank (bottom) range strata taken on July 15–18, 2014. Fish swimming through the beams are circled on each image.

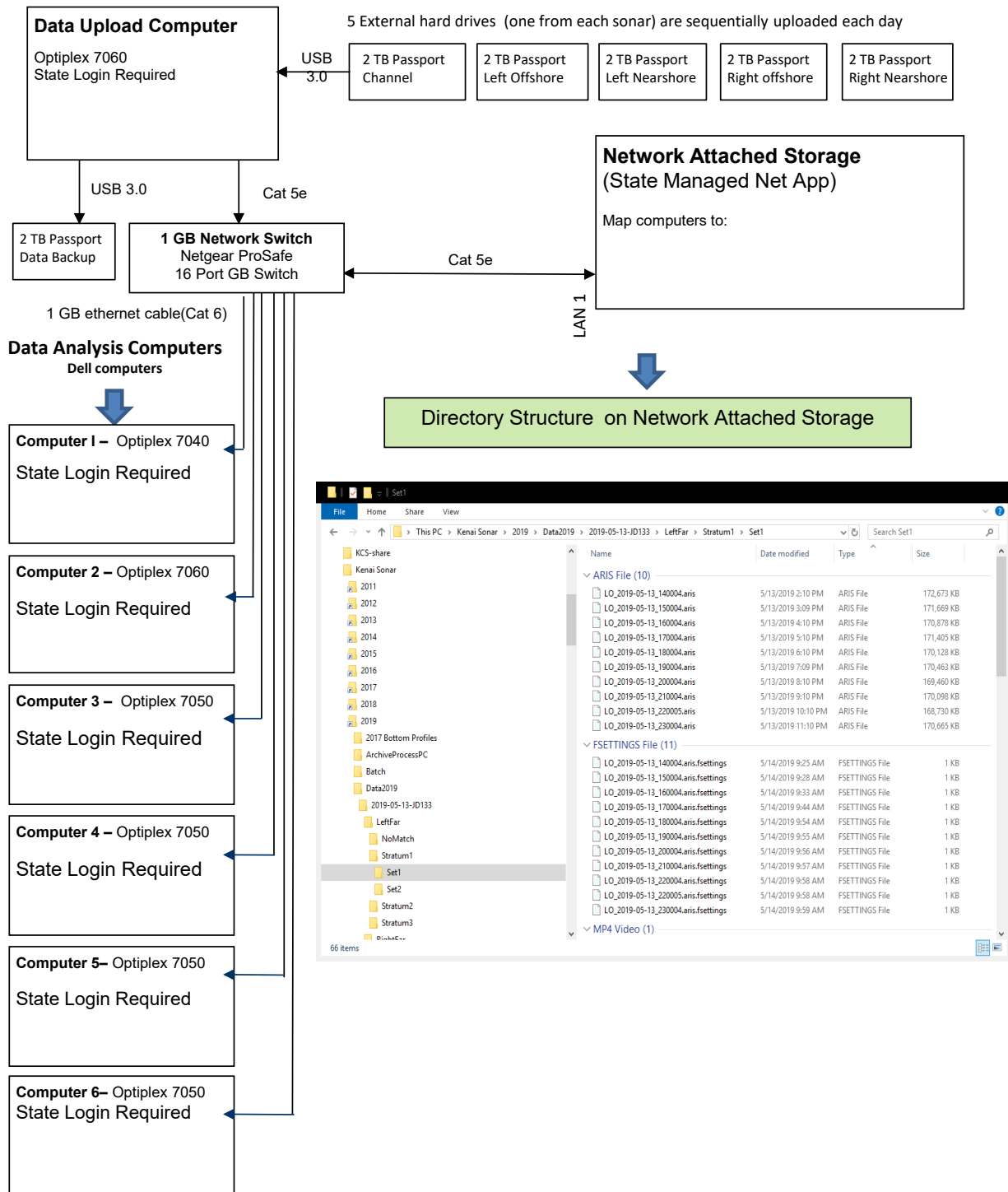


Figure 14.—Directory structure for the Network Attached Storage System in the Soldotna office showing the contents of the left bank offshore sonar for 17 May 2014.

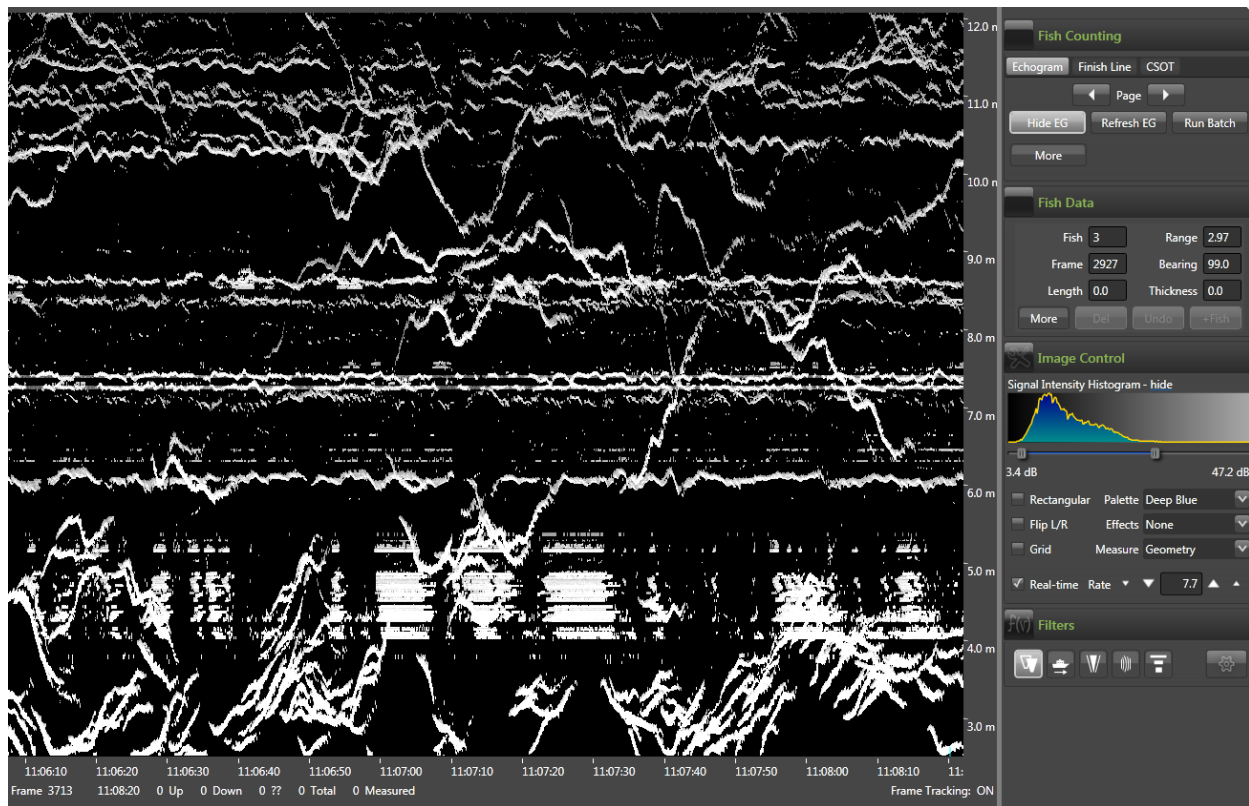


Figure 15.—An example of high density passage from 6 August 2014.

Note: There are approximately 170 fish in this 2-minute chart recording. A 10-minute sample with such high density can take several hours to process if each individual fish must be measured.

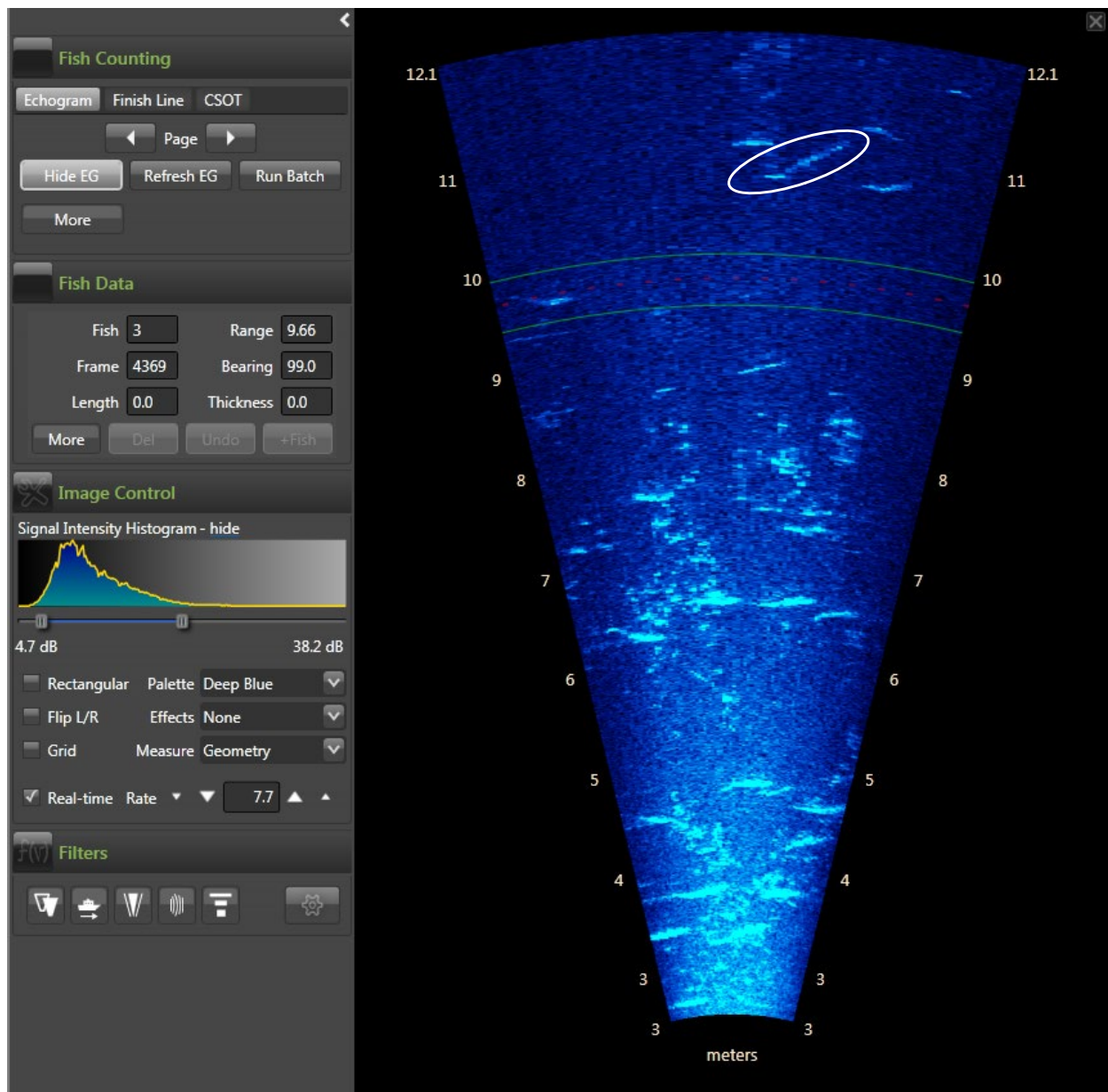


Figure 16.—Example of a Chinook salmon about 99 cm (AL) at 11 m swimming past milling pink salmon on 5 August 2014.

**APPENDIX A: COMPARISON OF DIDSON AND ARIS
CONFIGURATIONS USED ON KENAI RIVER CHINOOK
SALMON SONAR PROJECTS**

Appendix A1.—DIDSON and ARIS configurations used on Kenai River Chinook sonar projects at RM 8.6 and RM 13.7 in 2014, including an overview of features that affect resolution and range capabilities.

Frequency

DIDSONs operate at 2 frequencies: a high frequency that produces higher resolution images and a low frequency that detects targets at farther ranges but at a reduced image resolution. Two DIDSON models are currently available based on different operating frequencies (Table A1-1). The short-range or standard model (DIDSON SV) operates at 1.8 MHz to approximately 15 m in range and at 1.1 MHz to approximately 30 m and produces higher resolution images than the long-range model. The long-range model (DIDSON LR) operates at 1.2 MHz to approximately 30 m in range and at 0.7 MHz to ranges exceeding 100 m, but produces images with approximately half the resolution of the DIDSON-SV (see explanation below). The two DIDSON LRs used in this study were operated in high frequency mode to achieve maximum image resolution.

Table A1-1.—Summary of manufacturer specifications for maximum range, individual beam dimensions, and beam spacing for DIDSON SV, DIDSON LR, ARIS 1800, and ARIS 1200 systems at 2 frequencies, with and without the addition of a high resolution lens (specifications from Sound Metrics Corporation). A more complete summary is given in Appendix A2.

System	Maximum range (m) ^a	Horizontal beam width	Vertical beam width	Number of beams	Individual beam width ^{b,c}	Individual beam spacing ^{b,c}
DIDSON SV or ARIS 1800 at 1.8 MHz	15	28°	14°	96	0.30°	0.30°
DIDSON SV or ARIS 1800 at 1.1 MHz ^d	35	28°	14°	48	0.50°	0.60°
DIDSON SV or ARIS 1800 at 1.8 MHz + high-resolution lens	20	15°	3°	96	0.17°	0.15°
DIDSON SV or ARIS 1800 at 1.1 MHz + high-resolution lens	40+	15°	3°	48	0.22°	0.30°
DIDSON LR or ARIS 1200 at 1.2 MHz	25	28°	14°	48	0.50°	0.60°
DIDSON LR or ARIS 1200 at 0.7 MHz	80	28°	14°	48	0.80°	0.60°
DIDSON LR or ARIS 1200 at 1.2 MHz + high-resolution lens	30	15°	3°	48	0.27°	0.30°
DIDSON LR or ARIS 1200 at 0.7 MHz + high-resolution lens	100	15°	3°	48	0.33°	0.30°

^a Actual range will vary depending on site and water characteristics.

^b Beam width values are for 2-way transmission at the -3 dB points.

^c Values for beam spacing and beam width are approximate. Beam widths are slightly wider near the edges of the beam and the beam spacing is slightly narrower. Conversely, beams are slightly narrower near the center of the beam, and the beam spacing is slightly wider (e.g., the center beam spacing is closer to 0.34°, and the beam width is 0.27° for a DIDSON SV at 1.8 MHz, Bill Hanot, Sound Metrics Corporation, personal communication). Nonlinear corrections are applied by the manufacturer in software to correct for these effects in the DIDSON standard—but not the high-resolution—lens. Nonlinear corrections are applied in software to correct for these effects in both the ARIS standard and high-resolution lens.

^d ARIS 1800 uses 96 beams at low frequency by default, whereas DIDSON is hard-wired for 48 beams at low frequency. If ARIS 1800 is set for 96 beams, then beam spacing is 0.3° at low frequency or high frequency. If ARIS 1800 is set for 48 beams, then beam spacing is 0.6° at low frequency or high frequency.

-continued-

Similar to DIDSON, Adaptive Resolution Imaging Sonar (ARIS) systems operate at 2 frequencies analogous to the DIDSON frequencies (Appendix A2). The two ARIS models used on this project, ARIS 1800 and ARIS 1200, are essentially updated versions of the DIDSON SV and DIDSON LR models (Table A1-1 and Appendix A2). Both ARIS models used in this study were operated in high frequency mode when possible to achieve maximum image resolution. One difference between ARIS and DIDSON with respect to low frequency data collection is that the ARIS 1800 uses 96 beams at low frequency by default, whereas the equivalent DIDSON SV is hard-wired for 48 beams at low frequency.

Beam Dimensions and Lens selection

The DIDSON-LRs and ARIS 1200s used in this study are fitted with high-resolution lenses to increase the image resolution to the level achieved by the DIDSON-SV and ARIS 1800 (Table A1-1, referred to as DIDSON-LR+HRL, ARIS 1200+HRL). The high-resolution lens has a larger aperture that increases the image resolution over the standard lens by approximately a factor of 2 by reducing the width of the individual beams and spreading them across a narrower field of view (Table A1-1). Overall nominal beam dimensions for a DIDSON-LR or an ARIS 1200 with a standard lens are approximately 29° in the horizontal axis and 14° in the vertical axis. Operating at 1.2 MHz, the 29° horizontal axis is a radial array of 48 beams that are nominally 0.54° wide and spaced across the array at approximately 0.60° intervals. With the addition of the high-resolution lens, the overall nominal beam dimensions of the DIDSON-LR and ARIS 1200 are reduced to approximately 15° in the horizontal axis and 3° in the vertical axis and the 48 individual beams are reduced to approximately 0.3° wide and spaced across the array at approximately 0.3° intervals (Appendix A3). The combined concentration of horizontal and vertical beam widths also increases the returned signal from a given target by 10 dB, an effect that increases the maximum range of the sonar over the standard lens.

A standard lens will be used with the ARIS 1800 deployed near shore at the RM 13.7 site because the wider beam dimensions are preferred for increasing the beam coverage at close range and reducing biases associated with focal resolution at close range (see below).

Focal resolution of DIDSON–ARIS lenses—considerations for measurement accuracy

When sizing fish from DIDSON or ARIS images, there can be a bias factor beyond the geometric beam spreading issue, depending on the start range and end range of the image window. Depth of field is reduced at closer focusing ranges, with the effect that defocused targets will appear smeared in the azimuthal direction. The degree of bias is dependent on both the set focus range and the distance of the target from that set focus range. It is also dependent on the lens set. In general, if the focus is set to 4 m or longer for a standard lens, or 7 m or longer for a large lens, targets will be in good focus from there out to infinity. Inside of that range, focus will degrade significantly (Bill Hanot, Sound Metrics Corporation, Seattle Washington, personal communication). One way to minimize out-of-focus images is to create a smaller range window for insonifying targets at close range. For example, we often use a 5 m range window from approximately 3 to 8 m for the first range stratum when using a large (telephoto) lens.

-continued-

For DIDSON, focus counts of 0–255 represent the total range of travel of the middle (focus) lens. For the ARIS 1200 or 1800, which uses the same lens set and has the same focus curves, focus counts of 0–1000 represent the total range of travel (0.1% per unit). Appendix A4 shows the ARIS lens position (indicated by the numbers in the range 0–1000) versus focus range for the ARIS High Resolution (large or telephoto) lens. There is a non-linear relationship between lens position and focus range, with short range focus requiring large movements for small increments in focus range, and long range focus having small changes in lens position for several meters of change in focus range. Also, beyond a certain range, images are generally in focus. Based on the focus curves in Appendix A4, images are at least 75% in focus starting at 4 m for the standard lens and starting at 7 m for the large lens.

Image Resolution Basics

The resolution of a DIDSON or ARIS image is defined in terms of downrange and crossrange resolution where crossrange resolution refers to the width and downrange resolution refers to the height of the individual pixels that make up the image (Appendix A5). Each image pixel in a DIDSON or ARIS frame has (x, y) rectangular coordinates that are mapped back to a beam and sample number defined by polar coordinates. The pixel height defines the downrange resolution and the pixel width defines the crossrange resolution of the image. Appendix A5 shows that image pixels are sometimes broken down into smaller screen pixels (e.g., pixels immediately to the right of the enlarged pixels), which is an artifact of conversions between rectangular and polar coordinates.

Crossrange resolution

The crossrange resolution is primarily determined by the individual beam spacing and beam width, both of which are approximately 0.3° for all the sonar configurations used in this study (i.e., DIDSON LR at 1.8 MHz with large lens, ARIS 1800 at 1.8 MHz with standard lens, and ARIS 1200 at 1.2 MHz with large lens; Table A1-1). Targets at closer range are better resolved because the individual beam widths and corresponding image pixels increase with range following the formula below:

$$X = 2R \tan(\theta/2) \quad (A1)$$

where

X = width of the individual beam or “image pixel” in meters,

R = range of interest in meters, and

θ = individual beam angle in degrees (approximately 0.3°).

Downrange resolution

The sonar input parameter “**Window Length**,” i.e., the range interval sampled by the sonar, controls the downrange resolution of the DIDSON image and is calculated using the following formula:

$$Y = W/N \quad (A2)$$

-continued-

where

W = **Window Length** (cm)

N = number of range samples (or pixels).

With DIDSON, N is fixed at 512 samples (pixels), and images with shorter window lengths are always better resolved. The DIDSON **Window Length** parameter can only be set at the discrete values 2.5, 5.0, 10.0, or 20.0 m for the DIDSON-LR+HRL at 1.2 MHz. Although using shorter window lengths increases resolution, it also requires more individual strata to cover the desired range. Dividing the total range coverage into too many discrete strata increases the data-processing time. For this study, a window length of 5 m was used for the first 2 range strata to minimize the bias associated with close range targets. A window length of 10 m was used for each of the 2 subsequent range strata, a compromise which allows a relatively high resolution while allowing a reasonable distance to be covered by each stratum. The downrange resolution (or pixel height) for a 5 m range window is 1 cm (500 cm/512) and for a 10 m window length, downrange resolution is 2 cm (1,000 cm/512).

ARIS images can attain a finer downrange resolution than DIDSON. With ARIS, N can vary from 128 to a maximum of 4,000 samples (pixels) and **Window Length** is user selectable. This allows the user to collect data over a longer window length but increases the number of samples per beam to compensate. Appendix A5 contrasts images from a DIDSON LR+HRL with an ARIS 1200+HRL. The ARIS image in Appendix A5 has twice the downrange resolution of the DIDSON image because it was collected at 2,000 samples (pixels) per beam with a 20 m range window yielding a downrange resolution of 1 cm (2,000 cm/2,000 pixels) compared to a downrange resolution of 2 cm for the DIDSON image that was collected at 512 samples with a 10 m range window (1,000 cm/512).

Note that the pixels composing the ARIS image appear less well defined because a smoothing algorithm has been applied.

Setting the downrange resolution in ARIS

Data acquisition parameters affecting downrange resolution, or image pixel height, can be selected using the “**Detail**” parameter (measured in mm) from the ARIScope Sonar Control menu or by fixing the “**Sample Period**” parameter (measured in μ s) in the Advanced Sonar Settings menu (Appendix A6). Decreasing the **Detail** parameter or sample period (or increasing resolution) will automatically increase the number of samples per beam. Additionally, if the **Window Length** parameter is changed, the number of samples per beam will automatically increase or decrease to maintain the selected parameters values for **Sample Period** or **Detail** settings. These parameters are described in Appendix A7.

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Achieving optimal resolution with ARIS—the trade-offs

Optimizing crossrange resolution is primarily achieved through selecting the appropriate hardware (sonar model and lens set). But optimizing downrange resolution is achieved by user-selected parameters.

Optimizing downrange resolution

Higher downrange resolution settings will result in larger file sizes, but may be worth the trade-off to improve accuracy of fish length measurements when measuring fish. In practice, the selected resolution may be limited by factors such as wireless transmission bandwidth and data storage capacity. Higher resolution files also increase processing time because they take longer to load into data processing software. Descriptions of all data acquisition parameters that affect downrange resolution are given in Appendix A7.

Tethered fish studies have shown that increasing resolution beyond a certain level does not necessarily result in improved image quality or measurement accuracy. For example, the tethered fish image in Appendix A8 (top) was collected at maximum resolution (4 μ s) at a range of 29 m with a 4 m range window, but presents a poor image for measurement purposes. The lesser resolution (10 μ s) image in Appendix A8 (bottom) is actually preferable for measuring purposes. Part of the reason for this difference is due to the fact that each beam gets wider in crossrange with range from the sonar and the downrange resolution becomes “out of proportion” to the crossrange resolution if the sample period is too short. For a given downrange resolution (or sample period), a single sample gets effectively wider and skinnier with increasing range. Furthermore, this data passes through a WPF⁴ smoothing function even when “**Enable smoothing**” is off, making the individual beams somewhat blurred and hard to distinguish. For high-resolution samples, this effectively makes the data look “wide and stringy.”

According to the manufacturer (Personal Communication, Bill Hanot, Sound Metrics Corporation, Seattle WA), there is a trade-off to be considered when collecting data at longer ranges. If the resolution is lowered (i.e., a longer sample period) such that the ratio of crossrange to downrange resolution is reduced, the individual beams can be seen much more clearly when **Enable smoothing** is unchecked. The potential drawback is that there are fewer samples across a fish, though in this case, the recorded resolution of about 3 mm is probably much higher than is really necessary.

-continued-

⁴There are 2 smoothing functions involved in displaying the image data. One is a software function that is coded by the manufacturer to interpolate beam data to create virtual beams when “Enable smoothing” in *Settings* is on (it can be turned off to disable the function). This function is very similar to the DIDSON software “Smooth” function. The second smoothing algorithm, called Windows Presentation Foundation (WPF), is included in the Windows graphics functions used to put the (raw or interpolated) image on the screen, and it cannot be turned off. The data can only be viewed without the WPF smoothing in Rectangular mode, which is a different type of display function.

The appearance of WPF smoothing depends greatly on the image data and looks much different for “wide stringy” samples compared to “narrow blocky” samples. If the primary concern is to distinguish the individual beams clearly when **Enable smoothing** is turned off for “beam-edge to beam-edge” length measurements, then the resolution (**Sample Period**) will have to be set for this purpose. This means the transmit pulse must be long enough to get a minimum of 2 samples. For example, at 30 m range the appropriate sample period might be 16 μs (rather than 4 μs) for a well-defined “unsmoothed” beam, and then the transmit pulse should be a minimum of 32 μs .

After reviewing tethered fish data collected at different parameter settings affecting downrange resolution and consulting with the manufacturer, the manufacturer recommended the settings in Appendix A9 for the range strata used on the Kenai River. These settings strike a balance between image quality and file size. A fixed sample period of 10 μs was recommended for all strata, with the transmit pulse width varied to ensure a sufficient number of samples. Note that at shorter ranges where the beams are narrow and crossrange resolution is high, a transmit pulse width and sample period are used that ensure at least 1 sample occurs within the transmit pulse. At further ranges, where the beams are wider, a longer transmit pulse width is recommended that is long enough to get a minimum of 2 samples within the transmit pulse. This maintains a better downrange to crossrange ratio and avoids the “wide stringy” effect seen in Appendix A8 (top) and produces a “blockier pixel” that is easier for making “beam-edge to beam-edge” length measurements as in Appendix A8 (bottom).

Optimizing crossrange resolution

Achieving the highest crossrange resolution is important when taking fish length measurements from images. Collecting data at high frequency with a telephoto lens produces the highest crossrange resolution for each ARIS or DIDSON model. However, the large lens is not always used because it also decreases the vertical beam width dimension from about 14° to about 3° and the field of view from about 30° to about 15° (Table A1-1). Also, reduced focal resolution at close range must be considered as discussed above. The large lens is used in this study on long range DIDSON and ARIS models to both extend the range at which high frequency data can be collected (~35 m) and to double the crossrange resolution. The standard lens is used on the ARIS 1800 to achieve better water column coverage over the short range coverage.

ARIS 1800 images can attain a finer crossrange resolution than the equivalent DIDSON SV at low frequency because, as mentioned previously, ARIS 1800 can use 96 beams at low frequency whereas DIDSON is hard-wired for 48 beams at low frequency. This means the ARIS 1800 can achieve twice the resolution that a DIDSON SV can achieve at ranges requiring low frequency mode (i.e., ranges exceeding approximately 15–20 m). However, using all 96 beams will cut the maximum frame rate by half, which can be an issue when insonifying farther ranges.

Some general rules for better measurements

When sampling at close range (less than about 8 m with a long range lens or less than about 4 m with standard lens; Appendix A4), use a shorter range window for the first range stratum to minimize the effect of poor focal resolution at close range (Appendix A10). We find that a 5 m range window is adequate for sampling a 3.5–8.5 m stratum using a large lens, and we do not generally sample at less than 3.5 m when using a large lens to avoid range-related size bias due to poor focal resolution (Appendix A11).

Unpublished tethered fish studies (Name, position, affiliation, personal communication) show that a 10 μ s sample period is a good compromise, yielding high-resolution images at manageable file sizes.

SMC recommends using a transmit pulse width (PW) that is long enough to get a minimum of 2 samples within the transmit pulse sample period (SP) at farther ranges (e.g., for a constant SP = 10 μ s at 20 m, use PW \approx 20 μ s; at 30 m, use PW \approx 30 μ s). This maintains a better downrange to crossrange ratio and should provide a better image for “beam-edge-to-beam-edge” measurements. At closer ranges greater than about 10 m, a pulse that is long enough to get 1 sample within the transmit pulse is acceptable (e.g., PW = 10–15 μ s). Poor images can result when the sample period is equal to or greater than the transmit pulse (see Appendix A12, Panel 3).

Avoid aiming the sonar too far into the bottom. It’s a common mistake to optimize the image of the bottom, using the logic that the fish should be optimally insonified too. However, aiming the sonar further into the bottom than required to cover the near-bottom region can cause unnecessary loss of vertical beam width and water column coverage and degrade the image quality (Appendix A13). This can be a problem especially when using a Large Lens accessory because the beam width has been reduced from about 12° to about 3°, and unless the river is extremely shallow, losing more vertical beam width than necessary is undesirable.

Appendix A2.—Manufacturer specifications for sonar models ARIS 1200, ARIS 1800, DIDSON SV, and DIDSON LR.

ARIS 1800 Specifications:

Detection Mode

Operating Frequency 1.1 MHz
Beamwidth (two-way) 0.5° H by 14° V
Source Level (average) ~200-206 dB re 1 µPa at 1 m (*TBD*)
Nominal Effective Range 35 m

Identification Mode

Operating Frequency 1.8 MHz
Beamwidth (two-way) 0.3° H by 14° V
Source Level (average) ~200–206 dB re 1 µPa at 1 m (*TBD*)
Nominal Effective Range 15 m

Both Modes

Number of beams 96 or 48
Beam Spacing 0.3° nominal
Horizontal Field-of-View 28°
Max frame rate (96 beams) 3-15 frames/s (6-15 frames/sec w/48 beams)
Minimum Range Start 0.7 m
Downrange Resolution 3 mm to 10 cm
Transmit Pulse Length 4 µs to 100 µs
Remote Focus 0.7 m to max range
Power Consumption 15 Watts typical
Weight in Air 5.5 kg (12.1 lb)
Weight in Water *TBD*, ~1.4 kg (3 lb)
Dimensions 31cm × 17cm × 14cm
Depth rating 300 m
Data Comm Link 100BaseT Ethernet
Maximum cable length (Ethernet) 90 m (300 feet)

ARIS 1200 Specifications:

Detection Mode

Operating Frequency 0.7 MHz
Beamwidth (two-way) 0.8° H by 14° V
Source Level (average) ~206-212 dB re 1 µPa at 1 m (*TBD*)
Nominal Effective Range 80 m

Identification Mode

Operating Frequency 1.2 MHz
Beamwidth (two-way) 0.5° H by 14° V
Source Level (average) ~206-212 dB re 1 µPa at 1 m (*TBD*)
Nominal Effective Range 25 m

Both Modes

Number of beams 48
Beam Spacing 0.6° nominal
Horizontal Field-of-View 28°
Max frame rate (range dependent) 2.5-15 frames/s
Minimum Range Start 0.7 m
Downrange Resolution 3 mm to 10 cm
Transmit Pulse Length 4 µs to 100 µs
Remote Focus 0.7 m to max range

-continued-

ARIS 1200 Specifications (continued):

Both Modes

Power Consumption 15 Watts typical
Weight in Air 5.5 kg (12.1 lb)
Weight in Water *TBD*, ~1.4 kg (3 lb)
Dimensions 31 cm × 17 cm × 14cm
Depth rating 300 m
Data Comm Link 100BaseT Ethernet
Maximum cable length (Ethernet) 90 m (300 feet)

DIDSON SV Specifications

Detection Mode

Operating Frequency 1.1 MHz
Beamwidth (two-way) 0.4° H by 14° V
Number of Beams 48
Beam Spacing 0.6°
(Extended) Window Start 0.83 m to 52.3 m in 0.83 m steps
(Extended) Window Length 5 m, 10 m, 20 m, 40 m
Range Bin Size (relative to window length) 10 mm, 20 mm, 40 mm, 80 mm
Pulse Length (relative to window length) 18 µs, 36 µs, 72 µs, 144 µs

Identification Mode

Operating Frequency 1.8 MHz
Beamwidth (two-way) 0.3° H by 14 ° V
Number of Beams 96
Beam Spacing 0.3°
(Extended) Window Start 0.42 m to 26.1 m in 0.42 m steps
(Extended) Window Length 1.25 m, 2.5 m, 5 m, 10 m
Range Bin Size (relative to window length) 2.5 mm, 5 mm, 10 mm, 20 mm
Pulse Length (relative to window length) 4.5 µs, 9 µs, 18 µs, 36 µs

Both Modes

Max Frame Rate (range dependent) 4–21 frames/s
Field-of-view 29°
Remote Focus 1 m to infinity
Control & Data Interface UDP Ethernet
Aux Display NTSC Video
Max cable length (100/10BaseT) 61 m/152 m (200 ft/500 ft)
Max cable length (twisted pair, Patton Extender) 1220 m (4000 ft)
Max cable length (fiber optics) kilometers
Power Consumption 25 Watts typical
Weight in Air 7.9 kg (17.4 lb)
Weight in Sea Water 1.0 kg (2.2 lb)
Dimensions 31.0 cm × 20.6 cm × 17.1 cm
Topside PC Requirements Windows (XP, Vista, 7), Ethernet
Optional NTSC video monitor

-continued-

DIDSON LR Specifications

Detection Mode

Operating Frequency 0.7 MHz

Beamwidth (two-way) 0.8° H by 14° V

Number of Beams 48

Beam Spacing 0.6°

Extended Range Settings

(Extended) Window Start 0.83 m to 52.3 m in 0.83 m steps

(Extended) Window Length 10 m, 20 m, 40 m, 80 m

Range Bin Size (relative to window length) 20 mm, 40 mm, 80 mm, 160 mm

Pulse Length (relative to window length) 23 µs, 46 µs, 92 µs, 184 µs

Identification Mode

Operating Frequency 1.2 MHz

Beamwidth (two-way) 0.5° H by 14 ° V

Number of Beams 48

Beam Spacing 0.3° nominal

Extended Range Settings

(Extended) Window Start 0.42 m to 26.1 m in 0.42 m steps

(Extended) Window Length 2.5 m, 5 m, 10 m, 20 m

Range Bin Size (relative to window length) 5 mm, 10 mm, 20 mm, 40 mm

Pulse Length (relative to window length) 7 µs, 13 µs, 27 µs, 54 µs

Both Modes

Max Frame Rate (range dependent) 2–21 frames/s

Field-of-view 29°

Remote Focus 1 m to infinity

Control & Data Interface UDP Ethernet

Aux Display NTSC Video

Max cable length (100/10BaseT) 61 m/152 m (200 ft/500 ft)

Max cable length (twisted pair, Patton Extender) 1220 m (4000 ft)

Max cable length (fiber optics) kilometers

Power Consumption 25 Watts typical

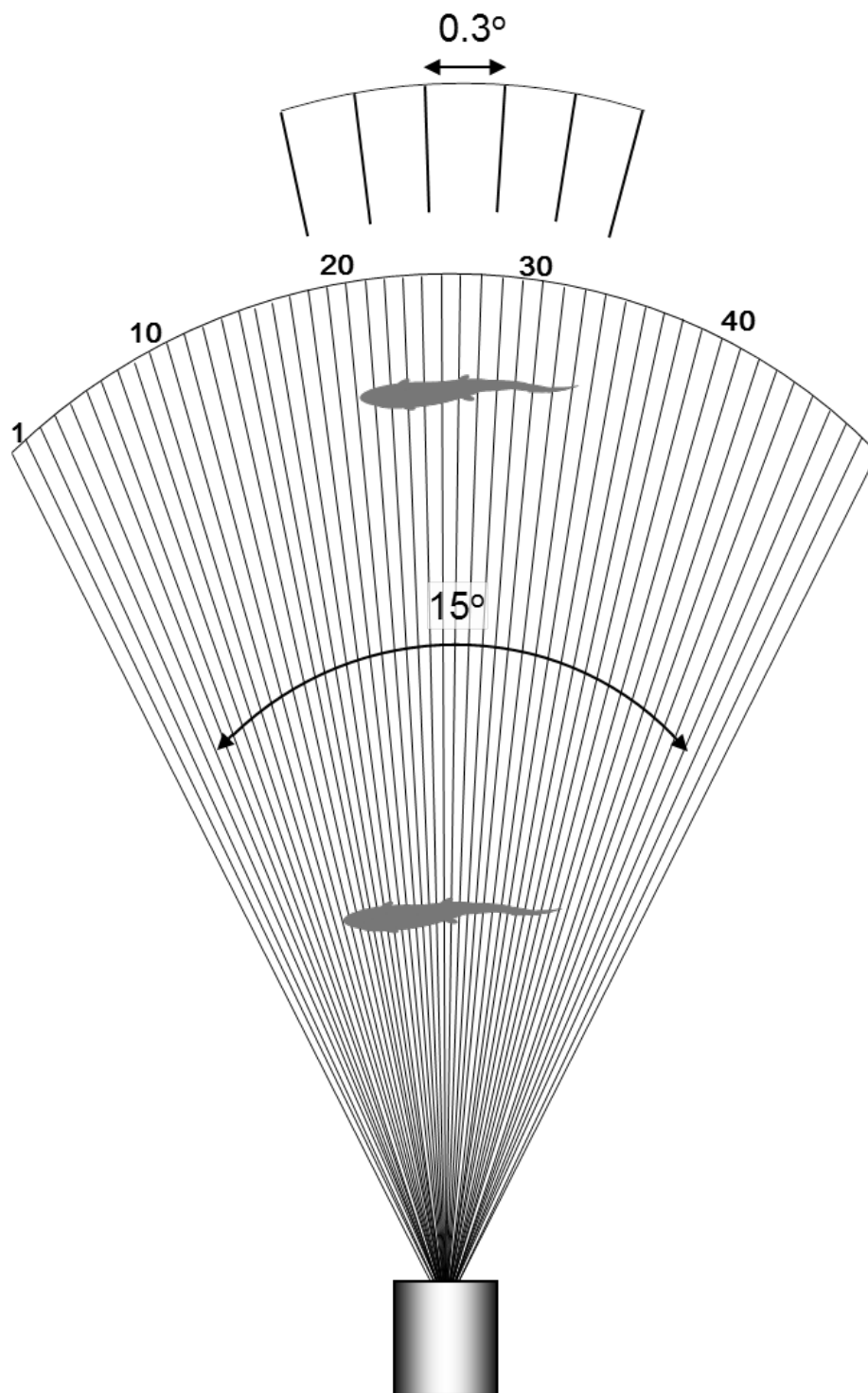
Weight in Air 7.9 kg (17.4 lb)

Weight in Sea Water 1.0 kg (2.2 lb)

Dimensions 31.0 cm × 20.6 cm × 17.1 cm

Topside PC Requirements Windows (XP, Vista, 7), Ethernet

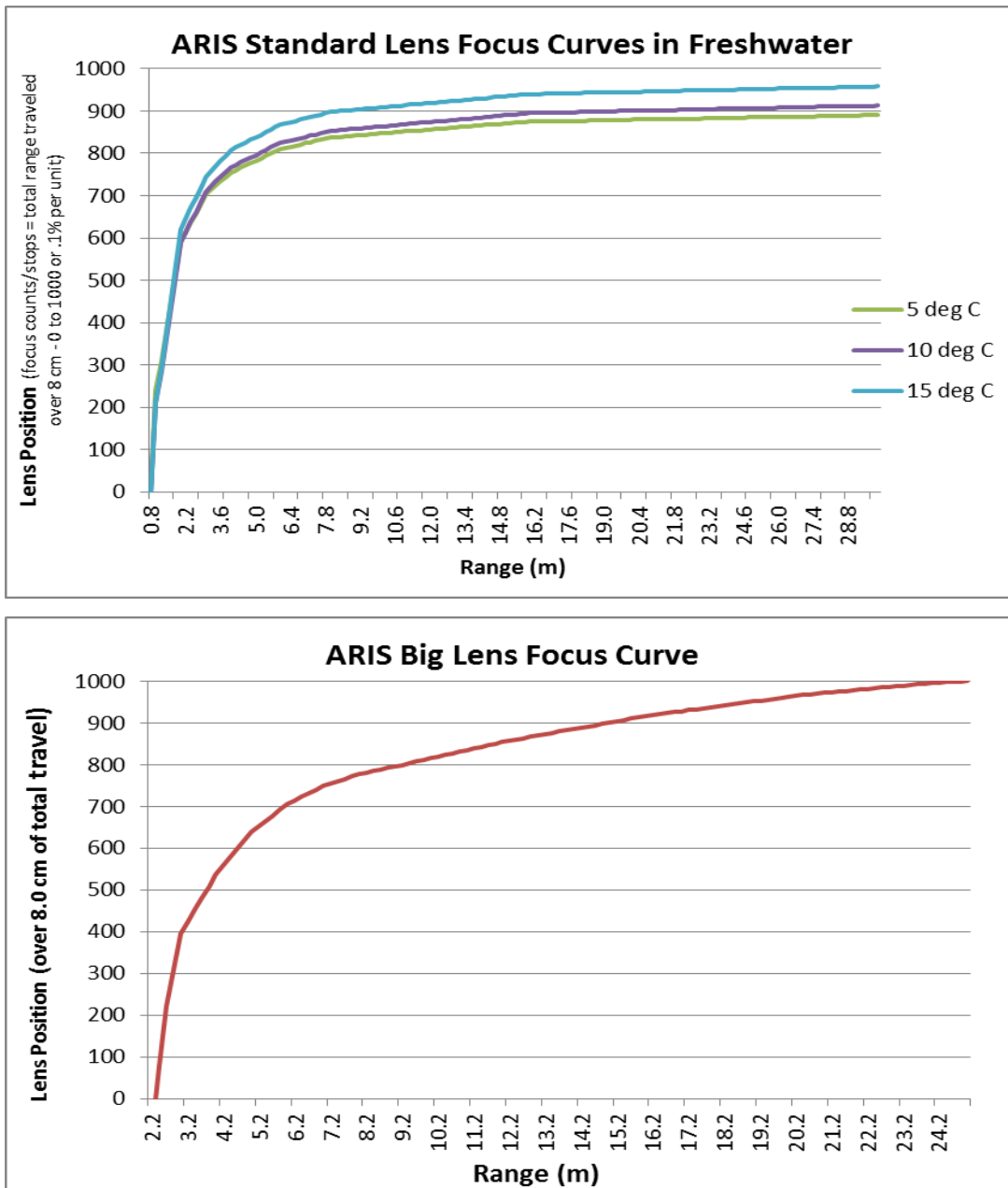
Optional NTSC video monitor



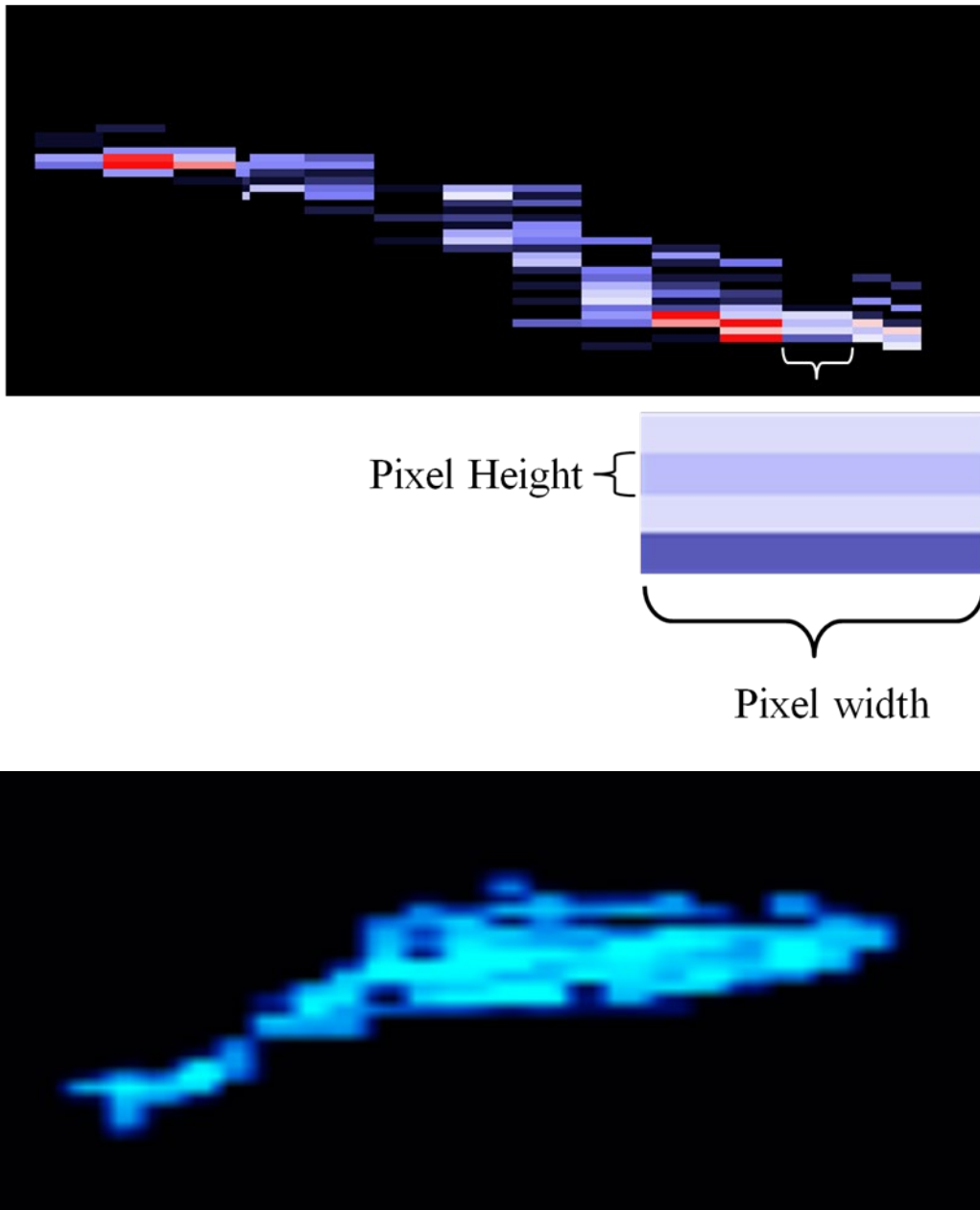
Appendix A3.—Diagram showing the horizontal plane of a DIDSON-LR or ARIS 1200 with a high resolution lens.

Source: Burwen et al. 2007.

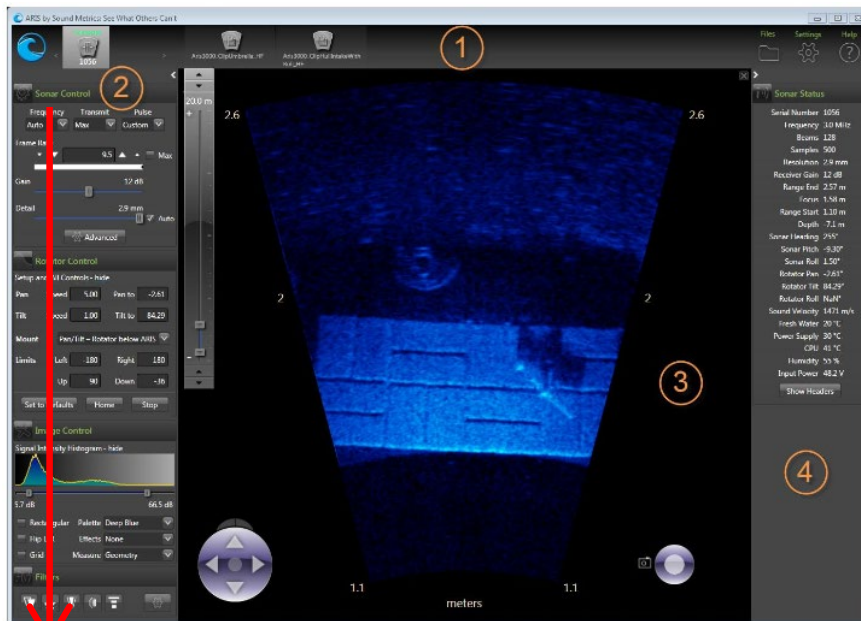
Note: The overall horizontal beam width of 15° is comprised of 48 sub-beams with approximately 0.3° beam widths. Because sub-beams grow wider with range, fish at close range are better resolved than fish at far range.



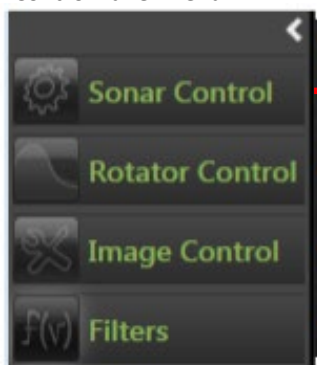
Appendix A4.—Relationships between focal length and lens position for ARIS.



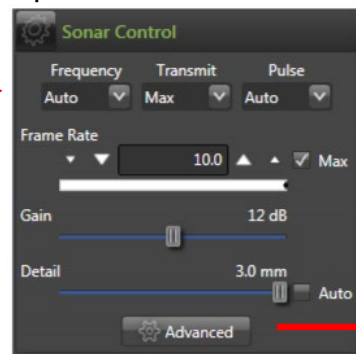
Appendix A5.—An enlargement of a tethered Chinook salmon showing the individual pixels that comprise a DIDSON image (top) contrasted with an ARIS image of a free-swimming Chinook salmon (bottom).



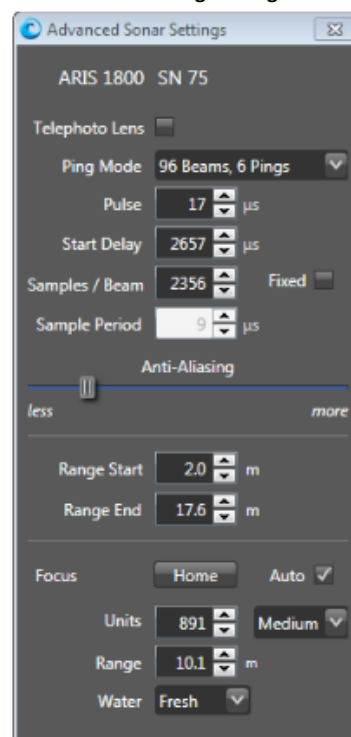
Control Panel Menu



Expanded Sonar Control Window



Advanced Settings dialog



The *Advance Settings* dialog allows direct access to all sonar data acquisition parameters, sample start and end range, and fine manual focus control.

In practice, we have found it easiest to set certain parameters in the *Advance Settings* dialog rather than using the sliders in other control windows (e.g. Sample Period versus Detail). The sliders are useful for exploring the best parameters during initial sonar set up. Once the approximate range and resolution have been selected using sliders, more exact values can be set in the *Advance Settings* dialog.

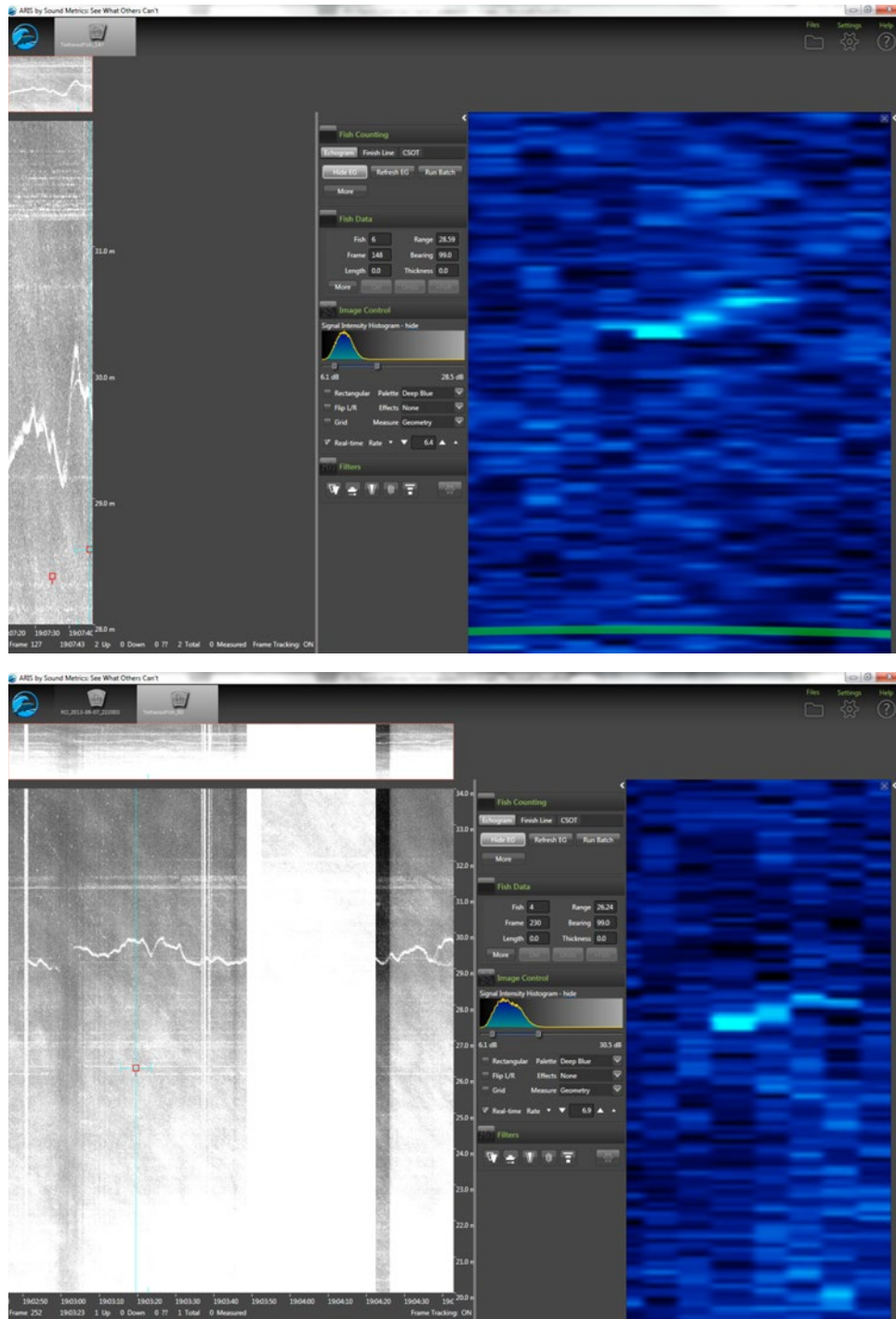
Appendix A6.—Downrange resolution for ARIS images is set using the **Detail** slider under the expanded *Sonar Control Menu* or by setting the **Sample Period** under the *Advance Sonar Settings* dialogue.

Appendix A7.—Summary of ARIScope data acquisition parameters that affect downrange resolution.

Parameter	Description
Detail (mm)	<p>Downrange resolution refers to the “height” of the ARIS image pixel and can be set in ARIScope using the “Detail” or “Sample Period” parameters. Setting the Detail parameter, measured in millimeters, in turn sets the data “Sample Period” which is the equivalent parameter in microseconds. The downrange resolution can be set using the Detail slider in the <i>Sonar Control</i> dialog under ECHOScope’s <i>Control Panel</i> (Appendix A6), which then automatically sets the Sample Period. Downrange resolution can also be set more exactly and directly by entering a value for Sample Period in the <i>Advanced Sonar Settings</i> dialog box (Appendix A6). These parameters, in combination with the transmit pulse width, control downrange resolution.</p> <p>Slide the control to the left for less Detail (longer sample period), or to the right for more Detail (shorter sample period). Images with greater Detail have more Samples/Beam, leading to larger frame sizes. As a consequence file sizes will be larger and frame rates may need to be reduced to handle the data throughput. This may also be a consideration when transmitting data via wireless radio where bandwidth may limit frame size and frame rate. There is a limit of 4,096 Samples/Beam, so at maximum Detail, these is about a 12 m (39 ft) maximum range (2.9 mm maximum downrange resolution × 4,096 samples is approximately 12 m).</p> <p>Using Auto Detail:</p> <p>Checking the Auto box (default) will attempt to provide a good balance between Detail and file size per frame rate. For our purposes, we find that using auto detail does not provide the level of resolution we prefer, particularly at farther ranges.</p> <p>Also note that when the Auto box is checked, the number of Samples/Beam is automatically fixed at the current number when starting to record a file. Checking the Auto box automatically unchecks the Fixed (Samples/Beam) box in <i>Advanced Settings</i>.</p>
Pulse (μs)	<p>Transmit Pulse width determines the downrange resolution and brightness of the image. Shorter pulses make for better resolution but put less energy into the water, reducing the brightness of the image and the maximum effective range. Longer pulses will reduce downrange resolution but make the image brighter with a longer maximum effective range. In general, choosing between Narrow, Medium and Wide settings will give sufficient control over the tradeoff between maximum range and resolution. Transmit Pulse width can be manually set in the <i>Advanced Setting Dialog</i> (Appendix A6).</p> <p>Pulse width settings:</p> <ul style="list-style-type: none"> • Narrow (default) transmit Pulse width is set to ~1.2× the Sample Period. • Medium transmit Pulse width is set to ~2.0× the Sample Period. • Wide transmit Pulse width is set to ~3.3× the Sample Period. • Auto transmit Pulse width is set to approximately the end range in μs. • Custom Settings in μs can be selected in the <i>Advanced Settings Dialog</i> (Appendix A6).

-continued-

Parameter	Description
Sample Period (μ s)	The image data sample period within a beam in microseconds. Shorter values provide higher downrange resolution, at the expense of larger frame sizes and potentially restricted frame rates. Normally set with the <i>Sonar Control Menu</i> Detail slider or Auto checkbox.
Samples/Beam	<p>Number of data samples in a sonar beam from 128 to 4,096. Changing this value manually to a larger number will increase the image window end range and decrease the end range for a smaller number. Check the Fixed box to force a fixed number of Samples/Beam. This allows changing the range start and range end of the image window while recording without starting a new output file. Checking the Fixed box automatically unchecks the Auto (Detail) box in the <i>Sonar Settings</i> panel; if the Auto (Detail) box is checked when Fixed is unchecked, then the number of Samples/Beam is automatically fixed at the current number while recording a file.</p> <p>Avoid setting the resolution using the Samples/Beam parameter because increasing the number of Samples/Beam will automatically increase the window end range rather than increase the Sample Period or Detail parameters.</p>



Appendix A8.—An ARIS image of a tethered salmon at 29 m collected at a 4 μ s sample period and 4 m range window (top) yields poor results due to a poor downrange to crossrange pixel ratio. Better results are achieved using a 10 μ s sample period and 14 m range window (bottom).

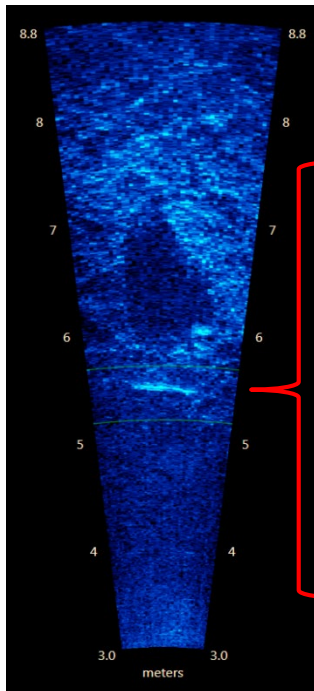
Source: files 2014-07-21_190721_F12_B48_S1378_T29_R27-31 (top) and 2014-07-21_190245_F12_B48_S1931_T33_R19-34_HF (bottom).

Appendix A9.—Results from SMC’s test of the Auto-Pulse length setting with 1) auto-resolution, 2) fixed **Sample Period** of 12 μs , and 3) fixed **Sample Period** of 10 μs for range strata that approximate those used on the Kenai River mile 13.7 site.

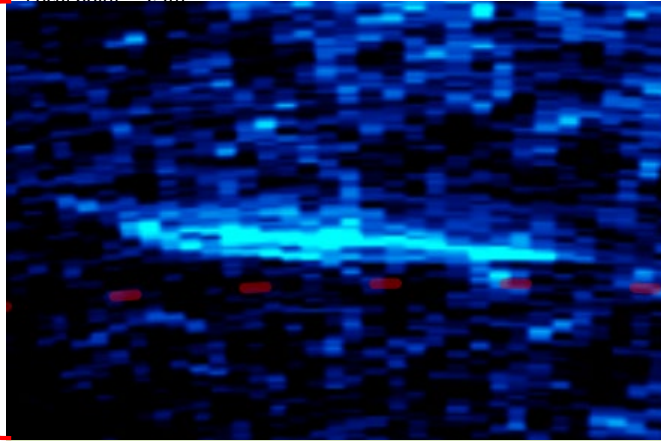
(1)			
Range	Sample Period (auto resolution)	Samples/Beam	Pulse Length (auto)
3 m–8 m	11 μs (8.0 mm)	613	7
8 m–20 m	28 μs (20.3 mm)	577	19
20 m–35 m	40 μs (29.0 mm)	504	33
(2)			
Range	Sample Period (auto resolution)	Samples/Beam	Pulse Length (auto)
3 m–8 m	12 μs (8.7 mm)	560	7
8 m–20 m	12 μs (8.7 mm)	1,345	19
20 m–35 m	12 μs (8.7 mm)	1,682	33
(3)			
Range	Sample Period (auto resolution)	Samples/Beam	Pulse Length (auto)
3 m–8 m	10 μs (7.3 mm)	684	7
8 m–20 m	10 μs (7.3 mm)	1,611	19
20 m–35 m	10 μs (7.3 mm)	2,016	33
(4) ^a			
Range	Sample Period (auto resolution)	Samples/Beam	Pulse Length (auto)
3 m–8 m	10 μs (7.3 mm)	684	12
8 m–20 m	10 μs (7.3 mm)	1,611	20
20 m–35 m	10 μs (7.3 mm)	2,016	35

^a Bill Hanot recommends a fixed **Sample Period** (i.e., constant downrange resolution) using a longer pulse length

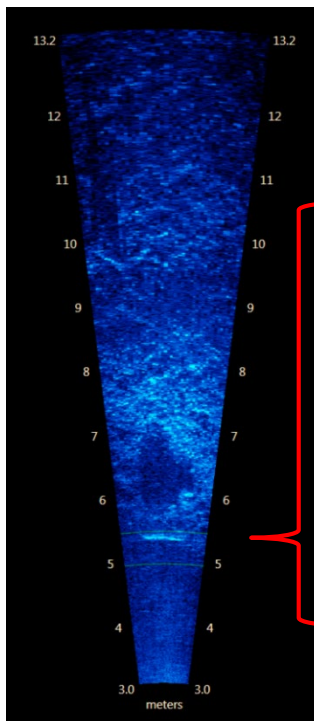
Note: Based on these tests, SMC now recommends using example settings in item (4) where the **Sample Period** is fixed at 10 μs and the transmit pulse is set to the **Sample Period** + 2 μs for the 3 m–8 m stratum in order to ensure that at least one sample is within the shortest possible returned pulse. For farther range strata, SMC recommends a transmit pulse that ensures at least 2 samples are within the transmit Pulse.



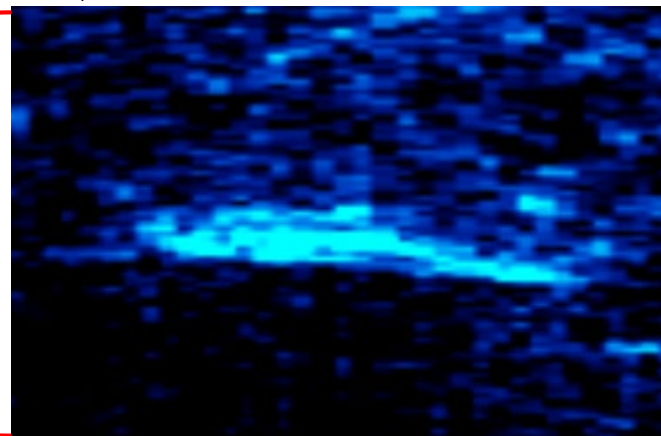
2_TetheredNear_2013-07-17_174535_F12_B48_S2000_T10_R3-8.aris
Pulse width = 10 μ s
Sample period = 4 μ s
Measured length (21 pixels, x cm wide) = 59.7 cm
Range = 5.4 m
Focal point = 5.9m



Nice image due to close range, short Sample Period, and short Pulse width (that is still twice the Sample Period). The fish at 5.4 m is also close to the focal point of 5.9 m.



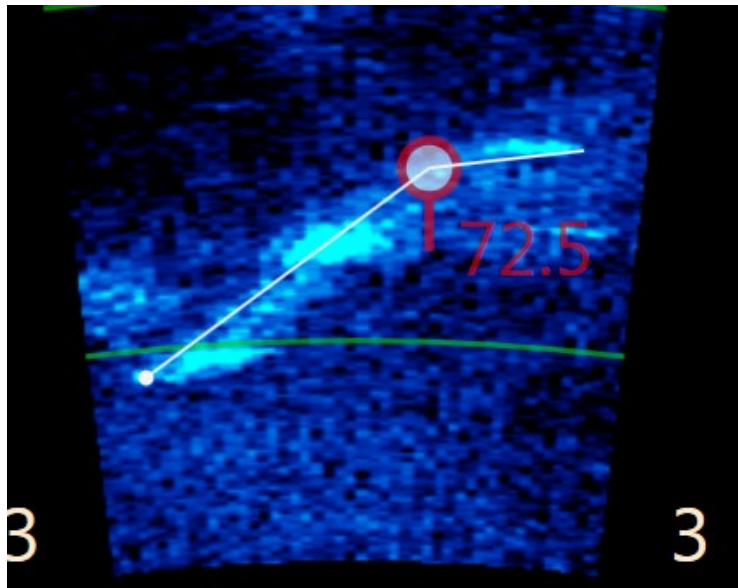
2_TetheredNear_2013-07-17_174930_F12_B48_S2000_T12_R3-13.aris
Pulse width = 12 μ s
Sample period = 7 μ s
Measured length (21 pixels, x cm wide) = 60.7 cm
Range = 5.3 m
Focal point = 8.1m



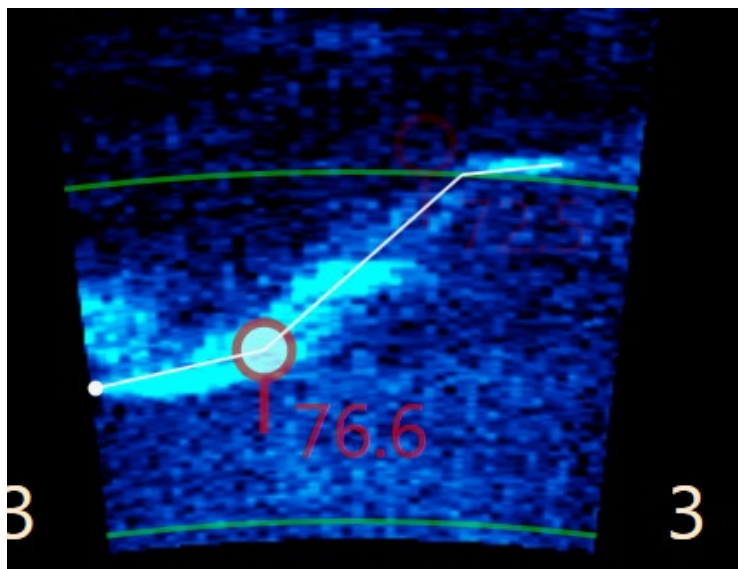
Blurring due to longer range window where the fish at 5.3 m is more distant from the focal point of 8.1 m. Sample Period and Pulse width are also longer yielding lower downrange resolution

Appendix A10.–Images from a close-range tethered fish at 2 different range windows demonstrate the advantage of a shorter range window and higher sample period for close range sampling.

Note: The top image has better resolution because of the shorter range window with better focal resolution and a higher sample period than the bottom image.

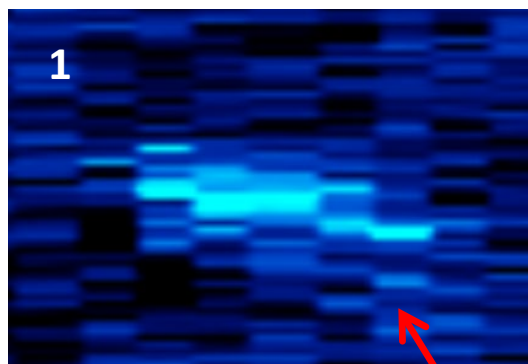


3_TetheredNear_2013-07-17_182746_F12_B48_S1724_T08_R3-8.aris
 Fish Range: 3.35 m
 Frame 2498
 Fish size 72.5 cm

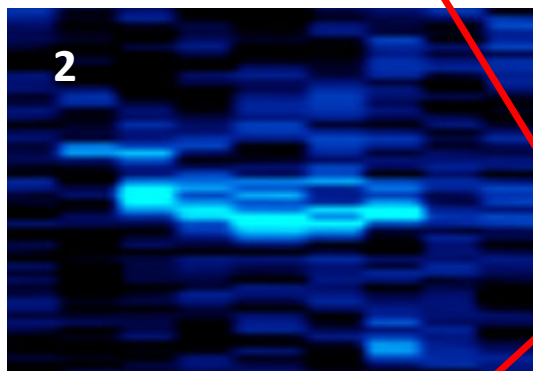


3_TetheredNear_2013-07-17_182746_F12_B48_S1724_T08_R3-8.aris
 Fish Range: 3.17 m
 Frame 1896
 Fish size 76.6 cm

Appendix A11.–Images from a 68.5 cm sockeye salmon demonstrate a measurement bias at ranges less than 3.5 m, even with the short 5 m range window.

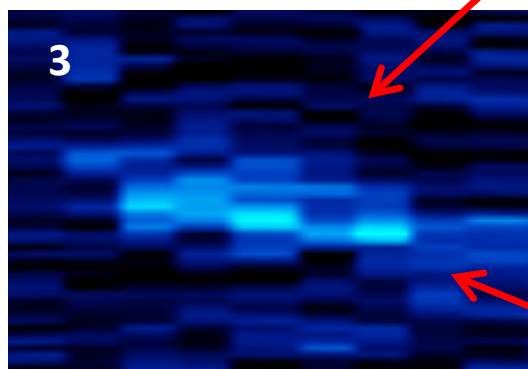


2_TetheredFar_2013-07-17_165428_F12_B48_S3498_T23_R12-22.aris
Pulse width = 23 μ s
Sample period = 4 μ s
Measured length (5 pixels, x cm wide) = 54.6 cm
Range = 20.7 m



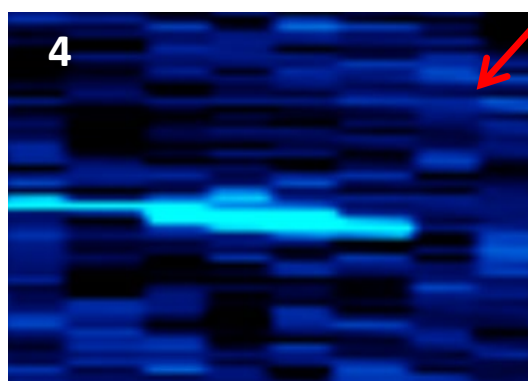
2_TetheredFar_2013-07-17_165100_F12_B48_S2151_T23_R3-22.aris
Pulse width = 23 μ s
Sample period = 12 μ s
Measured length (5 pixels, x cm wide) = 54.6 cm
Range = 20.6 m

Image becomes blurred when the Sample period is increased from 4 μ s in panel 1 to 24 μ s in panel 3 while Pulse width is held constant at 23 μ s. Note target is at same range. Also note that the Sample Period is slightly larger than the Pulse width in panel 3, something we now know is not a good practice.



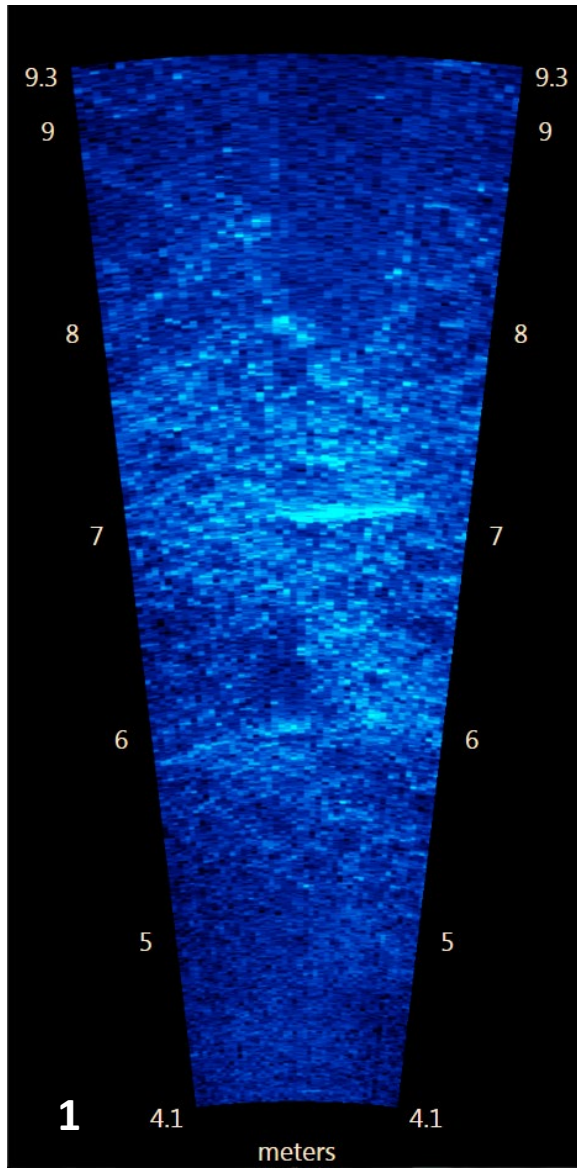
2_TetheredFar_2013-07-17_165026_F12_B48_S1076_T23_R3-22.aris
Pulse width = 23 μ s
Sample period = 24 μ s
Measured length (5 pixels, x cm wide) = 54.3 cm
Range = 20.8 m

Look how the image crisps up when you decrease the Sample Period from 24 μ s to 7 μ s and increase Pulse width from 23 μ s to 31 μ s. The image is improved despite a 9 m range increase.

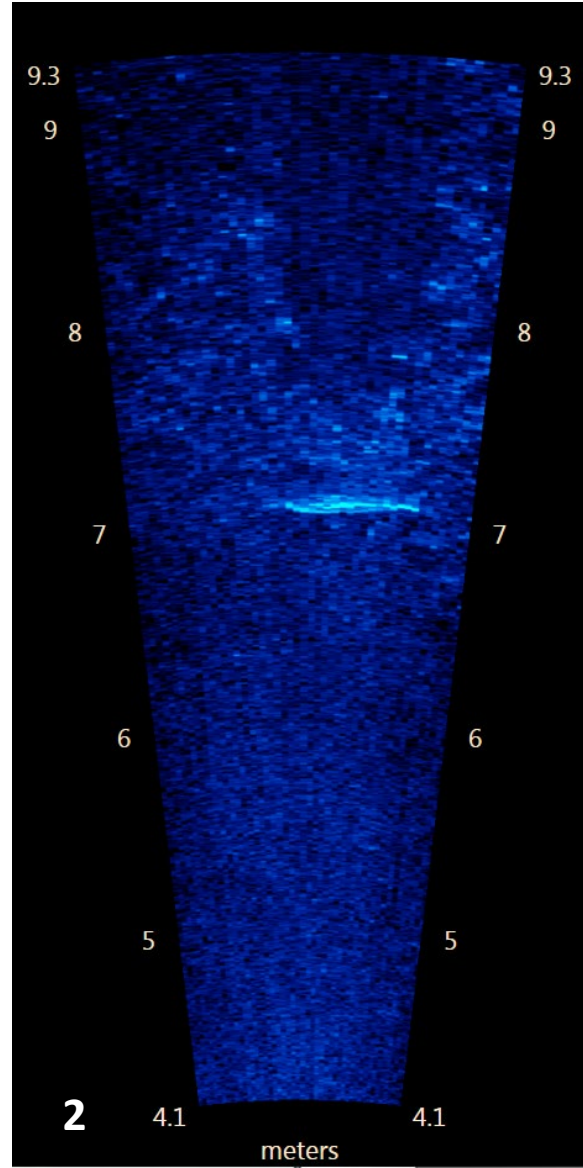


2_TetheredFar_2013-07-17_172420_F12_B48_S2000_T31_R21-31.aris
Pulse width = 31 μ s
Sample period = 7 μ s
Measured length (4 pixels, x cm wide) = 62.0 cm
Range = 29.6 m

Appendix A12.—Data collected from tethered fish (in this case, a 60 cm sockeye salmon) provided the opportunity to compare the effects and inter-relationship between 2 parameters affecting image resolution, transmitted pulse length, and sample period.



Pitch = -4.40°



Pitch = -2.30°

Appendix A13.—Images of a tethered fish taken at 2 different aims. Panel 1 shows a better defined bottom but fish measurement is more difficult against the bright background. Panel 2 shows the sonar pitch raised 2° and a better defined fish outline for easier measuring; there is still bottom structure showing at all ranges.

Source: File: 3_TetheredNear_2013-07-17_181104_F12_B48_S1771_T08_R4-9.aris Frames 2893 and 3224

Note: Aiming the sonar farther into the bottom than required to cover the near-bottom region can cause unnecessary loss of vertical beam width and water column coverage and degrade the fish image.

APPENDIX B: ARIS LENGTH MIXTURE MODEL AND ASSOCIATED BUGS PROGRAM CODE

Appendix B1.–Mixture model for estimating species composition of migrating fish.

Mixture models are useful for extracting information from the observed frequency distribution of a carefully selected measurement. If one were able to observe the exact length, but not the species, of every fish passing the sonar in the Kenai River, the distribution of such measurements might look something like that in Appendix B2. Given additional knowledge about the size of sockeye and Chinook salmon, the shape of the overall distribution can reveal much about the relative abundance of each species. For instance, if it is known that sockeye salmon do not exceed 70 cm in length, and that small Chinook salmon are very rare, one can conclude that the left hand mode of the distribution is composed almost entirely of sockeye salmon and that the species composition is perhaps 50–50 sockeye to Chinook salmon. Mixture model analysis is merely a quantitative version of this assessment in which the shape of the overall frequency distribution is modeled and “fitted” until it best approximates the data. Uncertainty is assessed by providing a range of plausible species compositions that could have resulted in the observed frequency distribution.

As another example, imagine that there are substantial numbers of small Chinook salmon and that there is error in the length measurements. The effect of the measurement error is to cause the modes to begin to overlap, reducing the ability to detect detail in the length distribution and reducing the precision of the estimates. Under this scenario it is still possible to make subjective assessments about the true species composition, but to quantify the uncertainty is more difficult. Mixture models provide an objective way to accomplish this.

Such a model can be conducted on any quantity related to length, including length as measured from ARIS images (“AL”). Given knowledge of the relationship between length and the observed quantity (e.g., Burwen et al. 2010), it is straightforward to convert from length units to the new units by including the slope, intercept, and mean squared error of the relationship in the mixture model (Equation B1-2 below). The more closely related the surrogate measurement is to the one of interest, the more the two distributions will resemble each other and the better the resulting estimate will be. AL is a good predictor of fish length⁵; similar to DIDSON length (Appendix B3; see also Burwen et al. 2010). Thus the observed frequency distribution of AL supplies valuable information about species composition, even though there is overlap of AL measurements between species.

The AL mixture model is described below. See also Fleischman and Burwen (2003) and Miller et al. (2012) for a similar model using split-beam echo length as the hydroacoustic variable.

The probability density function (pdf) of hydroacoustic variable y (= AL) is modeled as a weighted mixture of 2 component distributions arising from sockeye and Chinook salmon (Appendix B4),

$$f(y) = \pi_s f_s(y) + \pi_c f_c(y) \quad (\text{B1-1})$$

where $f_s(y)$ and $f_c(y)$ are the pdfs of the sockeye and Chinook salmon component distributions, and the weights π_s and π_c are the proportions of sockeye and Chinook salmon in the population.

Individual observations of y are modeled as normal random variates whose mean is a linear function of fish length x :

⁵ Preliminary analysis of ARIS tethered fish data were collected at RM 8.6 in 2014.

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i \quad (\text{B1-2})$$

where β_0 is the intercept; β_1 the slope; and ε_i is normally distributed with mean 0 and variance σ^2 . Thus the component distributions $f_S(y)$ and $f_C(y)$ are functions of the length distributions $f_S(x)$ and $f_C(x)$ and the linear model parameters β_0 , β_1 , and σ^2 (Appendix B4). The species proportions π_S and π_C are the parameters of interest.

Length measurements are obtained from fish captured by gillnets (e.g., Perschbacher 2015) downstream of the sonar site. Length data are paired with hydroacoustic data from the same time periods. In this version of the analysis, we assume no gillnet size selectivity.

Sockeye and Chinook salmon return from the sea to spawn at several discrete ages. We modeled sockeye and Chinook length distributions as three-component normal age mixtures.

$$f_S(x) = \theta_{S1} f_{S1}(x) + \theta_{S2} f_{S2}(x) + \theta_{S3} f_{S3}(x) \quad (\text{B1.3})$$

$$f_C(x) = \theta_{C1} f_{C1}(x) + \theta_{C2} f_{C2}(x) + \theta_{C3} f_{C3}(x) \quad (\text{B1.4})$$

where θ_{Ca} and θ_{Sa} are the proportions of Chinook and sockeye salmon belonging to age component a ,

$$f_{Sa}(x) \sim N(\mu_{Sa}, \tau^2_{Sa}), \text{ and} \quad (\text{B1.5})$$

$$f_{Ca}(x) \sim N(\mu_{Ca}, \tau^2_{Ca}). \quad (\text{B1.6})$$

The overall design is therefore a mixture of (transformed) mixtures. That is, the observed hydroacoustic data are modeled as a two-component mixture of y , each component of which is transformed from a three-component normal mixture of x .

Bayesian statistical methods will be employed because they provide realistic estimates of uncertainty and the ability to incorporate auxiliary information. We will implement the Bayesian mixture model in WinBUGS (Bayes Using Gibbs Sampler; Gilks et al. 1994). Bayesian methods require that prior probability distributions be formulated for all unknowns in the model. Species proportions π_S and π_C are assigned an uninformative Dirichlet(1,1) prior. Age proportions $\{\theta_{Sa}\}$ and $\{\theta_{Ca}\}$ are assigned informative Dirichlet priors based on a hierarchical analysis of historical data (Appendix B5). Likewise, informative normal priors based on historical data are used for the length-at-age means μ and standard deviations τ . Prior information about regression parameters β_0 , β_1 , and σ^2 is supplied by embedding an analysis of a subset⁶ of tethered fish data in the mixture model (Figure B1-2).

WinBUGS uses Markov chain Monte Carlo methods to sample from the joint posterior distribution of all unknown quantities in the model. We will start at least two Markov chains for each run and monitor Gelman-Rubin statistics to assess convergence. Burn-in periods of 10,000 or more samples will be used. Samples will be thinned 10 to 1, and at least 10,000 samples per chain will be retained.

The end product of a Bayesian analysis is the joint posterior probability distribution of all unknowns in the model. For point estimates, the posterior mean will be used. The posterior

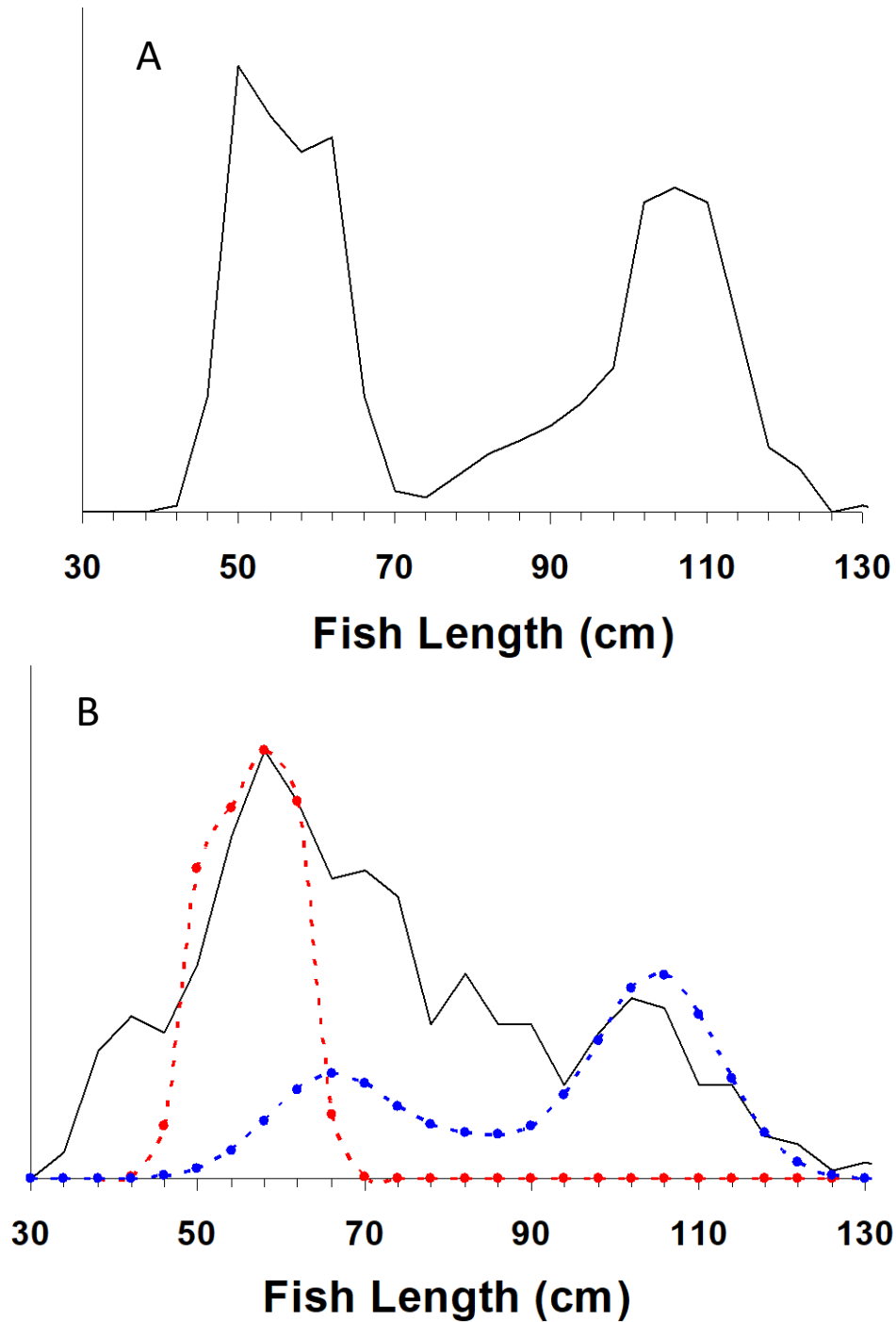
⁶ Preliminary work has shown that DIDSON/ARIS length measurements of tethered fish data are not necessarily representative of measurements from free-swimming fish. Therefore, inclusion of the entire tethered fish data set can bias mixture model results. Fortunately, only weak prior information about the regression parameters is required in order to estimate species composition with the mixture model, and this can be supplied by using only a small subset ($n=5$) of tethered fish data, which does not cause substantial bias in the species composition estimates.

standard deviation will be presented as an analogue to the standard error of an estimate from a frequentist (non-Bayesian) statistical analysis.

The mixture model will be fit to daily ARIS length data but will utilize 7 days of netting data ending on the date of the current ARIS lengths.

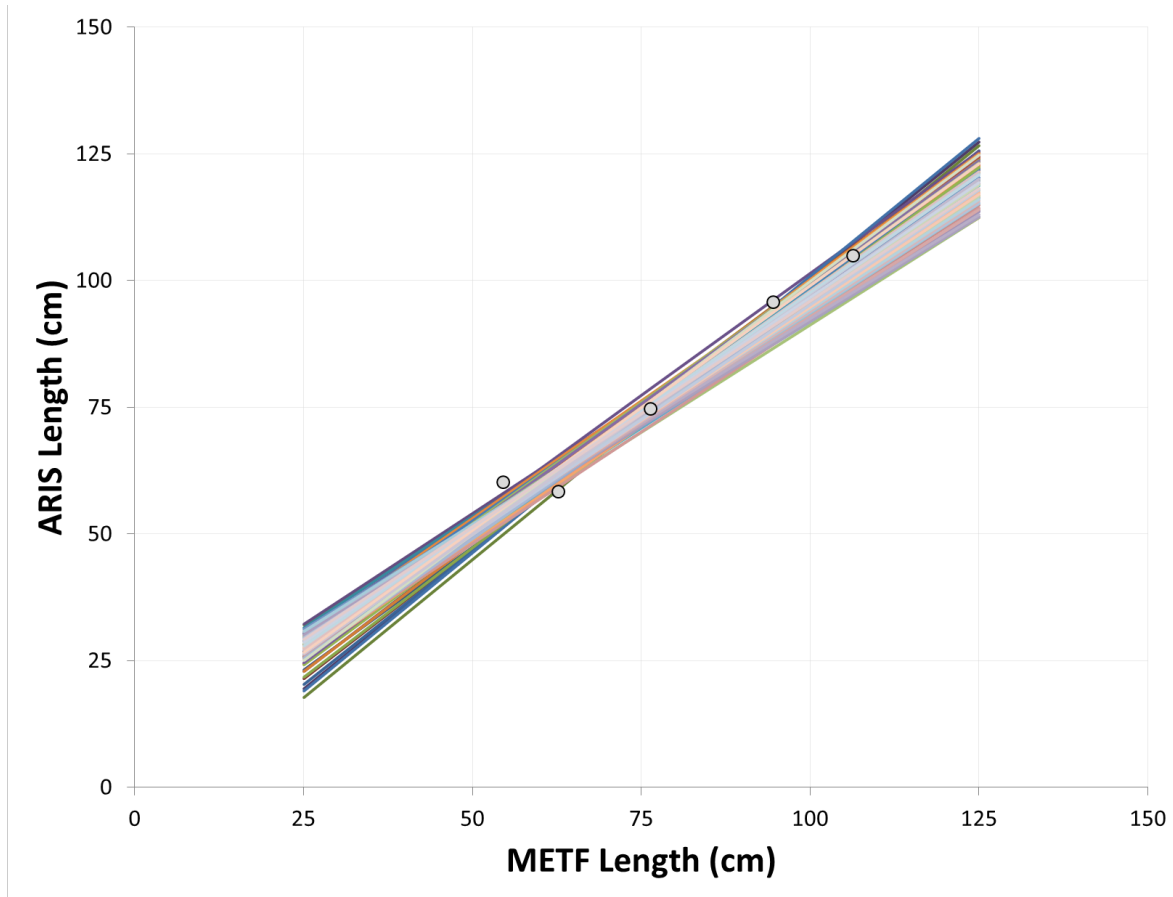
During times when it is impractical to measure every fish recorded by the ARIS, a “Fast-Track” sampling protocol will be adopted, and fish measuring less than 75 cm (AL) will be counted but not measured. These fish will be modeled accordingly, as having come from a left-censored sample. The model for censored observations is specified in the last paragraph of WinBUGS code in Appendix B3.

By default, data will be stratified by day, i.e., daily data from different spatial/temporal strata will be pooled and the above model fit to the pooled data (Equation 5). Sample size limitations may occasionally necessitate pooling the data across more than one day. Changes will not be made to stratification structure during the season. Situations that would warrant a (post-season) revision to the estimates include (1) sampling fraction differing greatly among spatial/temporal strata, or (2) evidence that the slope and intercept parameters differ by stratum. In such cases, the data will be divided into appropriate groups before analysis, and spatial and temporal expansions will be specific to each group.

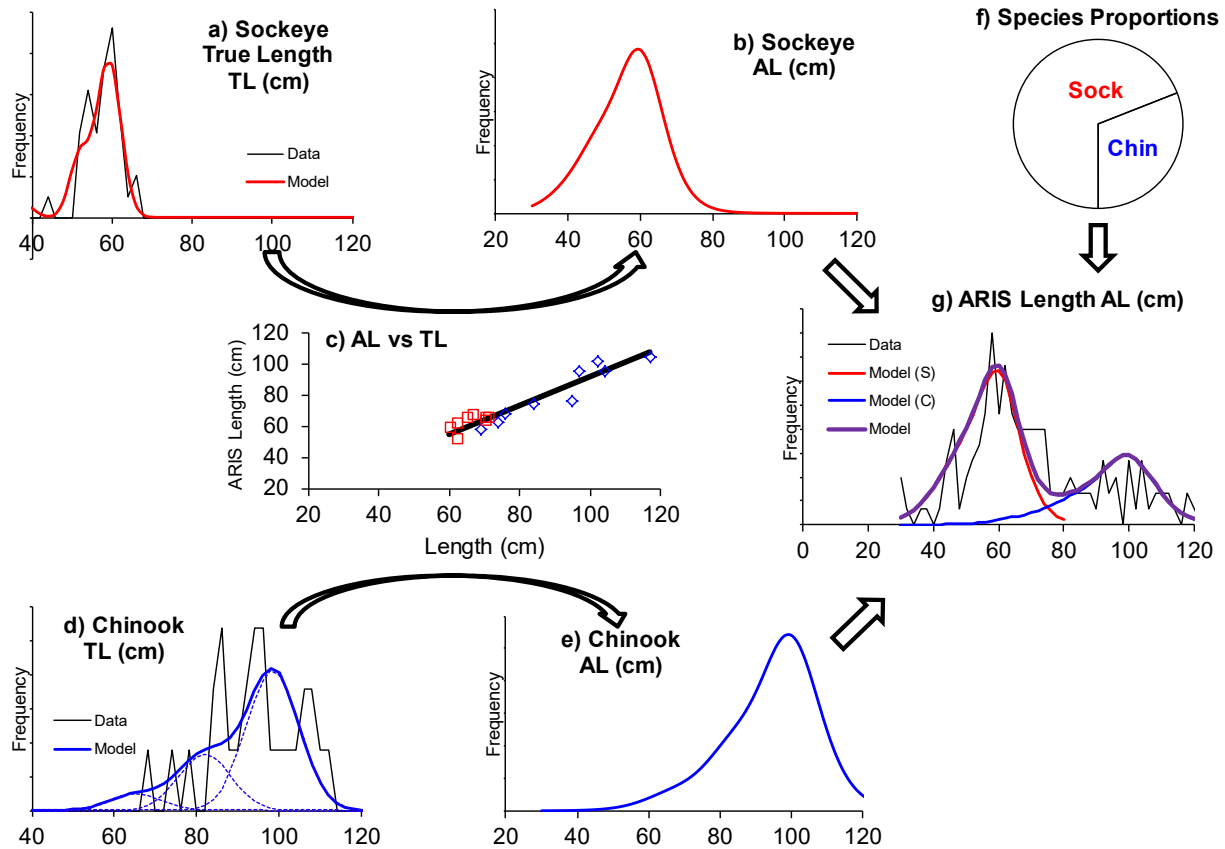


Appendix B2.—Hypothetical distributions of fish length measurements (black solid lines) from the Kenai River: (A, top) few small Chinook salmon, no measurement error and (B, bottom) 40% of Chinook salmon are small, measurement error standard deviation 10 cm.

Note: Distributions of sockeye (red dashed line) and Chinook (blue dashed line) salmon true length are shown in Case B. In both cases, the true species composition is 50% sockeye and 50% Chinook salmon.



Appendix B3.—Abridged tethered fish dataset (symbols) used to provide mildly informative prior information on regression parameters to the ARIS length mixture model. Lines show samples of 100 plausible linear relationships drawn from the resulting prior distribution.



Appendix B4.—Flow chart of the ARIS length mixture model described in the text. The frequency distribution of ARIS length measurements (panel g) is modeled as a weighted mixture of species-specific distributions (b and e), which in turn are the products of species-specific size distributions (a and d) and the relationship between ARIS measured length and true length (c). The weights (species proportions, panel f) are the parameters of interest.

Appendix B5.—WinBUGS code for mixture model under “standard” and “all large fish” data processing protocols.

```

model{
  beta0 ~ dnorm(75,0.0025)  #subjective prior sd=20cm
  beta1 ~ dnorm(1,25)       #subjective prior sd=0.2
  sigma.AL ~ dunif(0,20)
  tau.AL <- 1 / sigma.AL / sigma.AL
  ps[1:2] ~ ddirch(D.species[])
  pa[1,1] ~ dbeta(B1,B2)
  theta1 ~ dbeta(B3,B4)
  pa[1,2] <- theta1 * (1 - pa[1,1])
  pa[1,3] <- 1 - pa[1,1] - pa[1,2]
  pa[2,1] ~ dbeta(0.5,0.5)
  theta2 ~ dbeta(0.5,0.5)
  pa[2,2] <- theta2 * (1 - pa[2,1])
  pa[2,3] <- 1 - pa[2,1] - pa[2,2]

  n.chin <- ps[1] * ntgts
  p.large <- ps[1] * (1 - pa[1,1])
  n.large <- p.large * ntgts

  Lsig[1,1] <- 78
  Lsig[1,2] <- 70
  Lsig[1,3] <- 74
  Lsig[2,1] <- 25
  Lsig[2,2] <- 25
  Lsig[2,3] <- 25
  for (s in 1:2) {for (a in 1:3) {Ltau[s,a] <- 1 / Lsig[s,a] / Lsig[s,a] }}
  mu[1,1] ~ dnorm(621,0.0076)
  mu[1,2] ~ dnorm(825,0.0021)
  mu[1,3] ~ dnorm(1020,0.0047)
  mu[2,1] ~ dnorm(380,0.0004)
  mu[2,2] ~ dnorm(500,0.0004)
  mu[2,3] ~ dnorm(580,0.0004)
  for (a in 1:3) {
    pa.effective[1,a] <- pa[1,a] * q1.a[a] / inprod(pa[1,],q1.a[])
    pa.effective[2,a] <- pa[2,a]
  }
  for (k in 1:5) {
    TL.cm.75[k] <- TL.cm[k] - 75
    mu.AL1[k] <- beta0 + beta1 * TL.cm.75[k]
    AL1[k] ~ dnorm(mu.AL1[k],tau.AL)
  }
  for (i in 1:nfish) {
    age[i] ~ dcat(pa.effective[species[i],1:3])
    mefl.mm[i] ~ dnorm(mu[species[i],age[i]],Ltau[species[i],age[i]])
  }
  for (j in 1:ntgts) {
    species2[j] ~ dcat(ps[])
    age2[j] ~ dcat(pa[species2[j],1:3])
    mefl.mm.2[j] ~ dnorm(mu[species2[j],age2[j]],Ltau[species2[j],age2[j]])
    TL2.cm.75[j] <- (1.1*mefl.mm.2[j] + 2) / 10 - 75  # CONVERSION TO TL
    mu.AL2[j] <- beta0 + beta1 * TL2.cm.75[j]
    AL2[j] ~ dnorm(mu.AL2[j],tau.AL)
  }
}

```

Note: Prior distributions are in green font, likelihoods in blue.


```

model{
  beta0 ~ dnorm(75,0.0025)  #subjective prior sd=20cm
  beta1 ~ dnorm(1,25)       #subjective prior sd=0.2
  sigma.AL ~ dunif(0,20)
  tau.AL <- 1 / sigma.AL / sigma.AL
  ps[1:2] ~ ddirch(D.species[])
  pa[1,1] ~ dbeta(B1,B2)
  theta1 ~ dbeta(B3,B4)
  pa[1,2] <- theta1 * (1 - pa[1,1])
  pa[1,3] <- 1 - pa[1,1] - pa[1,2]
  pa[2,1] ~ dbeta(0.5,0.5)
  theta2 ~ dbeta(0.5,0.5)
  pa[2,2] <- theta2 * (1 - pa[2,1])
  pa[2,3] <- 1 - pa[2,1] - pa[2,2]

  n.upstr <- n_meas + n_small
  n.chin <- ps[1] * n.upstr
  p.large <- ps[1] * (1 - pa[1,1])
  n.large <- p.large * n.upstr

  Lsig[1,1] <- 78
  Lsig[1,2] <- 70
  Lsig[1,3] <- 74
  Lsig[2,1] <- 25
  Lsig[2,2] <- 25
  Lsig[2,3] <- 25
  for (s in 1:2) {for (a in 1:3) {Ltau[s,a] <- 1 / Lsig[s,a] / Lsig[s,a] }}
  mu[1,1] ~ dnorm(621,0.0076)
  mu[1,2] ~ dnorm(825,0.0021)
  mu[1,3] ~ dnorm(1020,0.0047)
  mu[2,1] ~ dnorm(380,0.0004)
  mu[2,2] ~ dnorm(500,0.0004)
  mu[2,3] ~ dnorm(580,0.0004)
  for (a in 1:3) {
    pa.effective[1,a] <- pa[1,a] * q1.a[a] / inprod(pa[1,],q1.a[])
    pa.effective[2,a] <- pa[2,a]
  }
  for (k in 1:5) {
    TL.cm.75[k] <- TL.cm[k] - 75
    mu.AL1[k] <- beta0 + beta1 * TL.cm.75[k]
    AL1[k] ~ dnorm(mu.AL1[k],tau.AL)
  }
  for (i in 1:n_fish) {
    age[i] ~ dcat(pa.effective[species[i],1:3])
    mefl.mm[i] ~ dnorm(mu[species[i],age[i]],Ltau[species[i],age[i]])
  }
}

```

-continued-

```

for (j in 1:n_meas) {
  species2[j] ~ dcat(ps[])
  age2[j] ~ dcat(pa[species2[j], 1:3])
  mefl.mm.2[j] ~ dnorm(mu[species2[j], age2[j]], Ltau[species2[j], age2[j]])
  TL2.cm.75[j] <- (1.1*mefl.mm.2[j] + 2) / 10 - 75 # CONVERSION TO TL BASED ON NUSHAGAK
2001 DATA
  mu.AL2[j] <- beta0 + beta1 * TL2.cm.75[j]
  AL2[j] ~ dnorm(mu.AL2[j], tau.AL)
}
for (k in 1:n_small) {
  species3[k] ~ dcat(ps[])
  age3[k] ~ dcat(pa[species3[k], 1:3])
  mefl.mm.3[k] ~ dnorm(mu[species3[k], age3[k]], Ltau[species3[k], age3[k]])
  TL3.cm.75[k] <- (1.1*mefl.mm.3[k] + 2) / 10 - 75
  mu.AL3[k] <- beta0 + beta1 * TL3.cm.75[k]
  AL3[k] ~ dnorm(mu.AL3[k], tau.AL)(, 70)
}
}

```

Note: Prior distributions are in green font, likelihoods in blue.

Appendix B7.—OpenBUGS code for daily abundance model, to be used when it is not possible to generate Chinook salmon passage estimates with AL mixture model.

```

model{
q.gt80 ~ dnorm(0,1.0E-6)I(0,10)
tau.log.gt80 ~ dgamma(0.001,0.001)
phi.gt80 ~ dnorm(0,1.0E-4)I(-.8,.8)
log.resid.gt80.0 ~ dnorm(0,4)I(-3,3)
sigma.gt80 <- 1 / sqrt(tau.log.gt80)

q.ncpu ~ dnorm(0,1.0E-6)I(0,1)
tau.log.ncpu ~ dgamma(0.001,0.001)
phi.ncpu ~ dnorm(0,1.0E-4)I(-.8,.8)
log.resid.ncpu.0 ~ dnorm(0,4)I(-3,3)
sigma.ncpu <- 1 / sqrt(tau.log.ncpu)

mean.log.N ~ dnorm(0,1.0E-12)
tau.log.N ~ dgamma(0.01,0.01)
N.early <- sum(N[1:46])
N.late <- sum(N[47:87])

for (d in 1:D) {
  log.N[d] ~ dnorm(0,1.0E-12)I(0,.)
  ARIS[d] ~ dlnorm(log.N[d],tau.log.DID[d])
  gt80[d] ~ dlnorm(log.q1Nmean2[d],tau.log.gt80)
  ncpu[d] ~ dlnorm(log.q2Nmean2[d],tau.log.ncpu)
  N[d] <- exp(log.N[d])
  tau.log.DID[d] <- 1 / log(cv.DID[d]*cv.DID[d] + 1)
  log.q1Nmean1[d] <- log(q.gt80 * N[d])
  log.resid.gt80[d] <- log(gt80[d]) - log.q1Nmean1[d]
  log.q2Nmean1[d] <- log(q.ncpu * N[d])
  log.resid.ncpu[d] <- log(ncpu[d]) - log.q2Nmean1[d]
}
log.q1Nmean2[1] <- log.q1Nmean1[1] + phi.gt80 * log.resid.gt80.0
log.q2Nmean2[1] <- log.q2Nmean1[1] + phi.ncpu * log.resid.ncpu.0
for (d in 2:D) {
  log.q1Nmean2[d] <- log.q1Nmean1[d] + phi.gt80 * log.resid.gt80[d-1]
  log.q2Nmean2[d] <- log.q2Nmean1[d] + phi.ncpu * log.resid.ncpu[d-1]
}
}

```

Note: Prior distributions are in green font, likelihoods in blue.

Appendix B8.–WinBUGS code for hierarchical age-composition model. Posteriors distributions from fitting this model provide prior distributions for AL mixture model.

Age Mixture.odc version 6a:

```
model {
  #Overall means and std deviations
  for (a in 1:A) {
    sigma[a] ~ dnorm(0,1.0E-4)I(0,)
    tau[a] <- 1 / sigma[a] / sigma[a]
    mu[a] ~ dnorm(0,1.0E-12)I(0,)
  }
  #Dirichlet distributed age proportions across years within weeks
  D.scale ~ dunif(0,1)
  D.sum <- 1 / (D.scale * D.scale)
  for (w in 1:W){
    pi[w,1] ~ dbeta(0.2,0.4)
    pi.2p[w] ~ dbeta(0.2,0.2)
    pi[w,2] <- pi.2p[w] * (1 - pi[w,1])
    pi[w,3] <- 1 - pi[w,1] - pi[w,2]
    for (y in 1:Y) {
      for (a in 1:A) {
        D[w,y,a] <- D.sum * pi[w,a]
        g[w,y,a] ~ dgamma(D[w,y,a],1)
        pi.wy[w,y,a] <- g[w,y,a]/sum(g[w,y,])
      }
    }
  }
  for (i in 1:nfish) {
    age[i] ~ dcat(pi.wy[week[i],year[i],1:A])
    length[i] ~ dnorm(mu[age[i]],tau[age[i]])
  }
}
```

Note: Prior distributions are in green font, likelihoods in blue.

APPENDIX C: PROCEDURES FOR DAILY ARIS PROCESSING

Raw Data Transfer and Storage

Ensure the “UpperRiver” Ethernet cable is plugged into the dedicated upload computer

First drive backup (first day of data)

1. Make sure drive X: is plugged in (backup drive) and that it has enough room to back up data (about 150 GB)
2. Plug in first field hard drive-**Note the DRIVE LETTER ex. E:**
3. Edit TheMenu.bat
 - a. Change DRIVE LETTER if necessary
 - b. Change dates to the first day if necessary- There are two calendar dates and one Julian Date (normally you do not have to change the date first time through)
 - c. Save and exit
4. RUN batch file
 - a. Follow prompts to select correct sonar for downloading
5. Proceed through redundancy prompts-there are many
6. DRIVE should download with tones indicating progression
7. Eject DRIVE when done

Second DRIVE backup

1. Make sure that the new DRIVE has the same DRIVE LETTER as the original (its best to edit all drives pre-season to default to the same DRIVE LETTER)
2. RUN batch and proceed through the same steps as above

Proceed through the remaining drives until all of the first day is complete

Second pass

1. Edit TheMenu.bat for the **following** data day (Change the Julian date and two calendar dates)
2. Proceed through the same steps above (First Drive backup)

The original data day is now backed up to X: and ready for processing (U:\Data2015) and the following partial day is ready for the next day's upload.

-continued-

⁷ Last updated by Brandon Key (April 2, 2014) and Michael Hopp (August 28, 2013). Note that filenames and directory structures highlighted in yellow will need to be updated annually.

Reconnect Ethernet Cable to the processing network

Manual Target Measurement

1. Use ARIS FISH Application to process *.aris files for manual measurement of targets.
2. Open file, select parameters, create echogram and measure fish according to specified protocols ie. Normal, Fast Track, Large Fish only. See Methods section for a description of tracking protocols.

Editing Asamples.txt for missing data

Edit the Asamples.txt file located in U:\upload. This file is best modified in the file **2015 ARIS daily summary of data quality.xls** (U:\spreadsheets), then copied into the Asamples.txt file in notepad using a copy/paste command (needs to be a “tab” delimited file). Copy Asamples.txt to the data directory for that day (e.g. to **U:\Data2014\2014-08-02_JD214**)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1														
2	JD	Hour	LN1	LF1	LF2	LF3	RF3	RF2	RF1	RN2	RN1	C1	C2	C3
3	136	0	0	0	0	0	0	0	0	0	0	0	0	0
4	136	1	0	0	0	0	0	0	0	0	0	0	0	0
5	136	2	0	0	0	0	0	0	0	0	0	0	0	0
6	136	3	0	0	0	0	0	0	0	0	0	0	0	0
7	136	4	0	0	0	0	0	0	0	0	0	0	0	0
8	136	5	0	0	0	0	0	0	0	0	0	0	0	0
9	136	6	0	0	0	0	0	0	0	0	0	0	0	0
10	136	7	0	0	0	0	0	0	0	0	0	0	0	0
11	136	8	0	0	0	0	0	0	0	0	0	0	0	0
12	136	9	0	0	0	0	0	0	0	0	0	0	0	0
13	136	10	0	0	0	0	0	0	0	0	0	0	0	0
14	136	11	0	0	0	0	0	0	0	0	0	0	0	0
15	136	12	0	0	0	0	0	0	0	0	0	0	0	0
16	136	13	0	0	0	0	0	0	0	0	0	0	0	0

-continued-

ARIS Packaging and Upload

As prepared by Michael A. Hopp, 8-28-2013

Checklist:

1. Complete the ARIS measurements for a day
2. Copy the day's completed files table into the "*Asamples2015.txt*" and save it in *U:\Data2015*
3. Edit & save the "*Package ArisMH.bat*" file found in *U:\Batch* for the selected DataDate and JD
4. Run it and observe the package process in the *U:\Data2015\RM13-Packaged* folder
5. Verify that the new zip file is created, like: "*Aris_JD229_YYYY-08-17_TxtData.Zip*"
6. Review the logfile like: "*Package-2014-08-17-JD229.txt*" and locate & fix any missing files.
7. If necessary, delete the zip file and re-pack after the missing files are tracked.
8. Edit & save the "*duploadMH.bat*" file found in *U:\Batch* for the selected DataDate and JD
9. Run it and then verify a new file is created like: *Aris_JD229_YYYY-08-17_SentToAnc.dat*
10. Check the progress report on the desktop in *ArisTxtDataSentToAnc.txt*

Details - Using the Packaging batch file: [Can be run on any data computer – with U: drive connection.]

First of all, the ARIS data for that date must be measured and finished according to rules and procedures explained in Appendix D. Then update the table in "*U:\Spreadsheets\2015ARIS daily summary of data quality - update 7-11-15.xlsx*". Then copy the JD day's table from the spreadsheet into "*Asamples2015.txt*" according to the example found in *U:\DataProc15\Manual*. This file has a table in it that identifies which ARIS files have been finished.

Then edit the "*Package ArisMH.bat*" file found in *U:\Batch* to set the DataDate and JD variables. The DataDate variable must precisely match the existing example, like: 2015-08-07

Finally, save the batch file with his changes and then double-click it to run it.

Follow the progress of this batch file by watching the *U:\Data2015\RM13-Packaged* folder. After the batch process finishes, verify that there is a new zip file in this directory named according to this example: "*Aris_JD229_2015-08-17_TxtData.Zip*". Open it to read the count of files & compare it to the expected value.

At the end, the batch file will open in Notepad the progress file log like: "*Package-2015-08-17-JD229.txt*". Review it to locate any missing files. If necessary, fix this error by tracking those files, deleting the zip package and then re-pack the day's data.

-continued-

Using the Upload batch file: [This must be run on the upload computer only – with ANC drive connection.]

First complete the packaging step (above) for the selected DataDate and JD.

Then edit “*duploadMH.bat*” file found in **U:\Batch** to set the DataDate and JD variables. The DataDate variable must precisely match the existing example, like: 2015-08-07

Then save the batch file with his changes and double-click it to run it.

Normally, this batch file will take just a couple of seconds to complete

Details of Packaging:

The ARIS Data is stored at Drive **U:\Data2015** at the Sonar Office in sub-folders named by the Aris unit location at RM 13.7. Each sub-folder contains folders named by date stamps like 2015-08-18-JD230 and each of those sub-folders have sub-folders according to Stratum and then by Set. So a common path =

“U:\Data2015\2014-08-18-JD230\LeftNear\StratumI\SetI”.

The packaging batch file does these things (after a tech sets the appropriate DataDate and JD variables at the top of the batch file):

1. Logs progress to **U:\BATCH\LOGS\Package-%DataDate%-JD%JD%.txt**
2. Selects which ARIS unit, stratum and set to copy, according to variables set in the batch file.
3. Looks for “**Asamples2015.txt**” in **U:\Data2015** as a sentinel to proceed. If this file is not found, the batch file will stop and not package anything.
4. Looks for any *.txt files left over in **U:\Data2015\RM13-Packaged** and zips them up into **TxtFoundInPackFolder-%JD%.ZIP** located in the same folder.
5. Moves the sentinel file “**Asamples2015.txt**” to **U:\Data2015\RM13-Packaged** , renaming it: **Asamples%DataDate%.txt**
6. Copies into **U:\Data2015\RM13-Packaged** all the *.txt files located in all the specified subfolders for the specified DataDate & JD. (These are measurement data files made as a technician measures fish.)
7. Packages (zips) all these files (now copied to **U:\Data2014\RM13-Packaged**) into a zip file named according to this example: **Aris_JD229_2014-08-17_TxtData.Zip** - and stored in the same folder.
8. Finishes the progress log - **U:\BATCH\LOGS\Package-%DataDate%-JD%JD%.txt**
9. Opens into Notepad the progress log file - **U:\BATCH\LOGS\Package-%DataDate%-JD%JD%.txt**

-continued-

Details of Upload:

The upload batch file does these things (after a tech sets the appropriate DataDate and JD variables at the top of the batch file):

1. Creates a new “*AncUpload-ArisTxtDaily.txt*” located in *U:\Batch\LOGS* , overwriting any existing one. Progress is logged into this file.
2. Looks for *Aris_JD%JD%_%DataDate%_TxtData.Zip* located in *U:\Data2015\RM13-Packaged*
3. If it finds this file, it will copy (upload) it to *J:\Soldotna\ARIS*
4. Creates a new *Aris_JD%JD%_%DataDate%_SentToAnc.dat* file in the *U:\Data2015\RM13-Packaged* folder as a convenient reference of files already uploaded. This is a simple one-line text file containing:
Aris_JD%JD%_%DataDate%_TxtData.Zip copied to Anc on %DATE% AT %TIME%
5. Completes the log file.
6. Appends the log file to *C:\Users\sxqkenaisonar\Desktop\ArisTxtDataSentToAnc.txt* ...and to *U:\Batch\LOGS\AncUpload-ArisTxtAll.txt*. (This makes a running log, appending the current upload progress log to previous ones.)

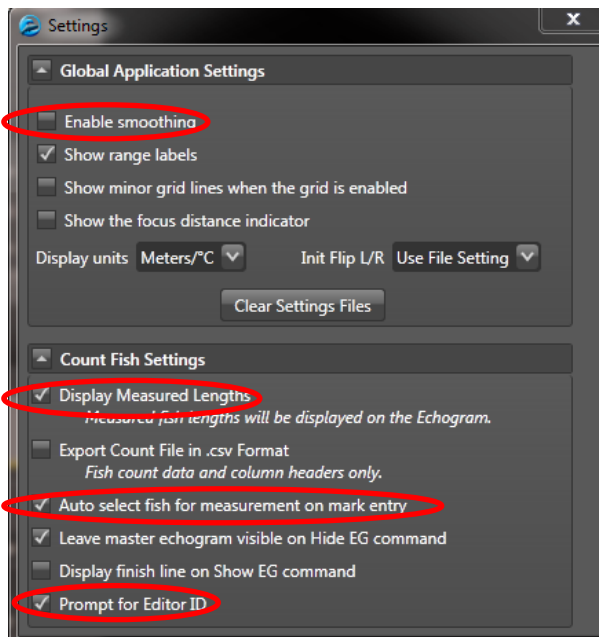
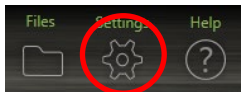
RM 13.7 Batch files

TheMenu.bat	Opens program for data download from individual sonars. Makes backup copies of files and renames them according to organization scheme
xxSonarUL.bat	Allows easy changes to be made to Sonar designations and sample times without interrupting other programs
Package ArisMH.bat	Collects ARIS tracking files for processing and upload
duploadMH.bat	Uploads data to anchorage.

**APPENDIX D: INSTRUCTIONS AND SETTINGS USED FOR
MANUAL FISH LENGTH MEASUREMENTS FROM ARIS
IMAGES USING ARISFISH SOFTWARE VERSION 2.3**

1) Set Global Settings after a **NEW** installation of ARISFish

- a) Open ARISFish global settings and ensure you have the following settings if you are measuring fish:



- b) Enable smoothing is *off*
c) Display Measured Lengths is *on*
d) Auto select fish for measurement on mark entry is *on*
e) Prompt for Editor ID is *on*

2) Set processing parameters for a new set of files for a new day or stratum:

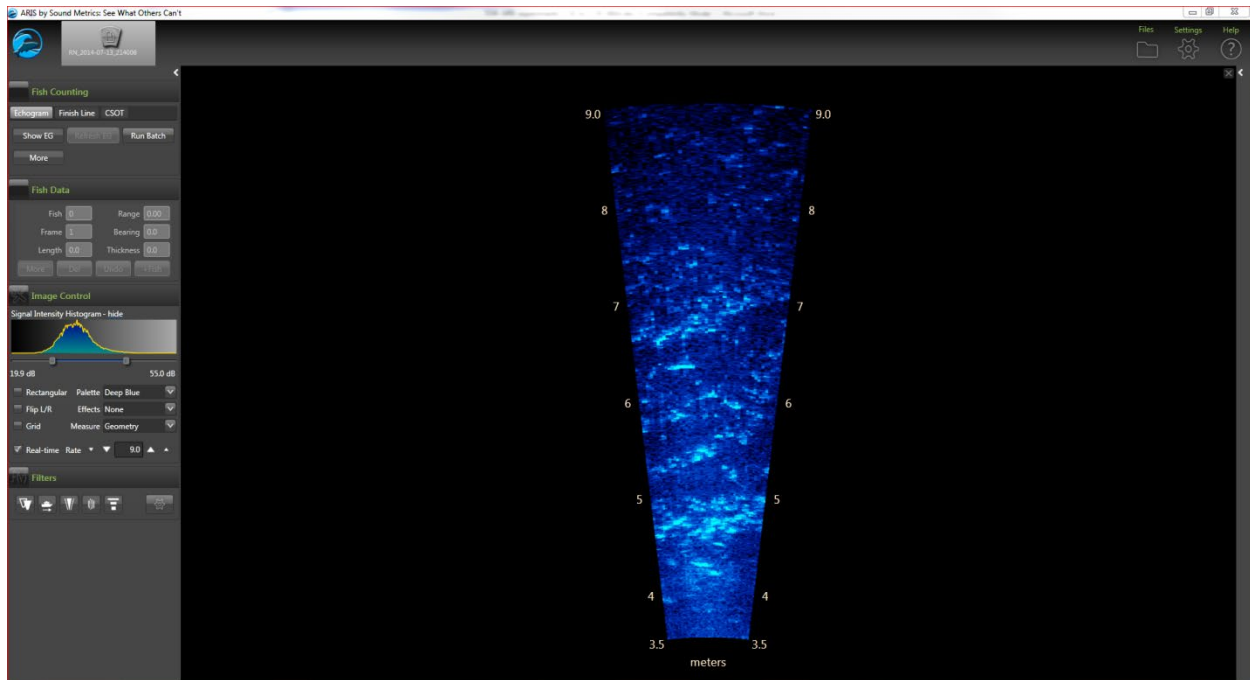
- a) Select <Files> <Open Recently Viewed>



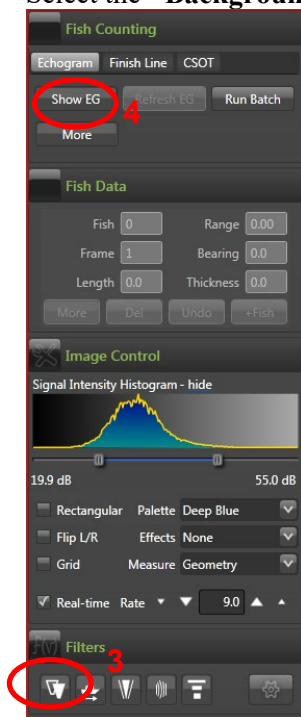
- b) Navigate to the appropriate directory and open a file (or simply double click on the file of interest)

-continued-

At this point, the ARISFish display should look similar to the image below:



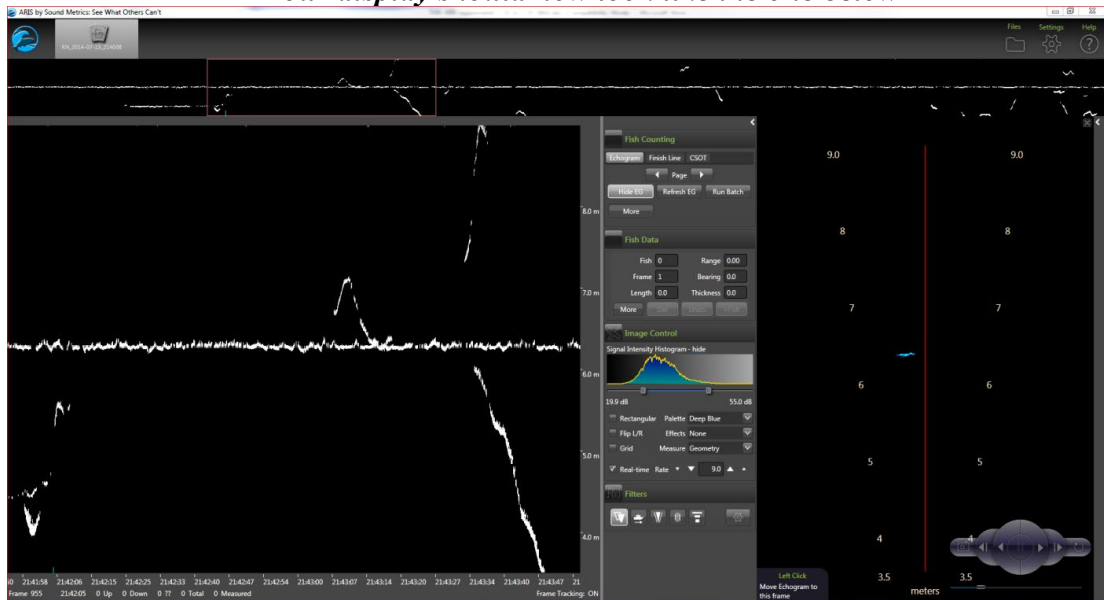
- c) Select the **<Background Subtraction>** icon and wait 30 seconds or so for background to subtract



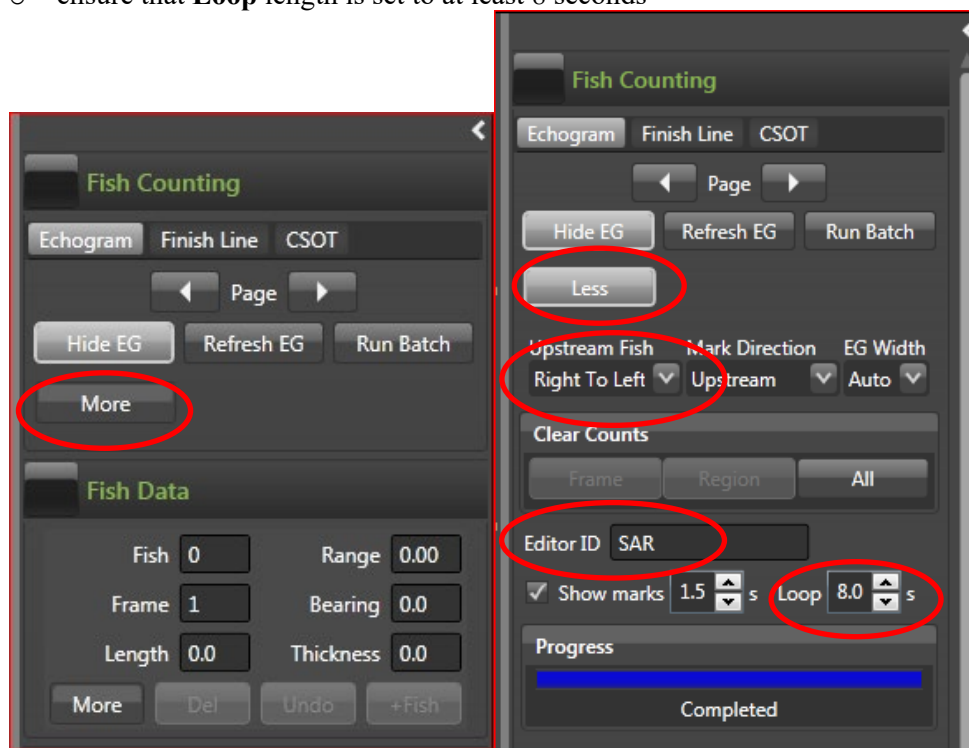
- d) Then select **<Show EG>** to display the Echogram
e) You will be prompted to enter your Editor ID. Press OK.

-continued-

Your display should now look like the one below



- f) Select **<More>** from the Fish Counting window to get the extended window where you can:
- enter your **Editor ID** initials
 - set the **Upstream Fish** direction
 - ensure that **Loop** length is set to at least 8 seconds



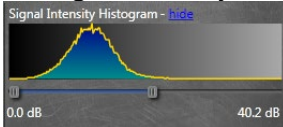
- then select **Less** to unexpand Fish Counting window (you'll be able to access other controls like BS easier if you do this)

-continued-

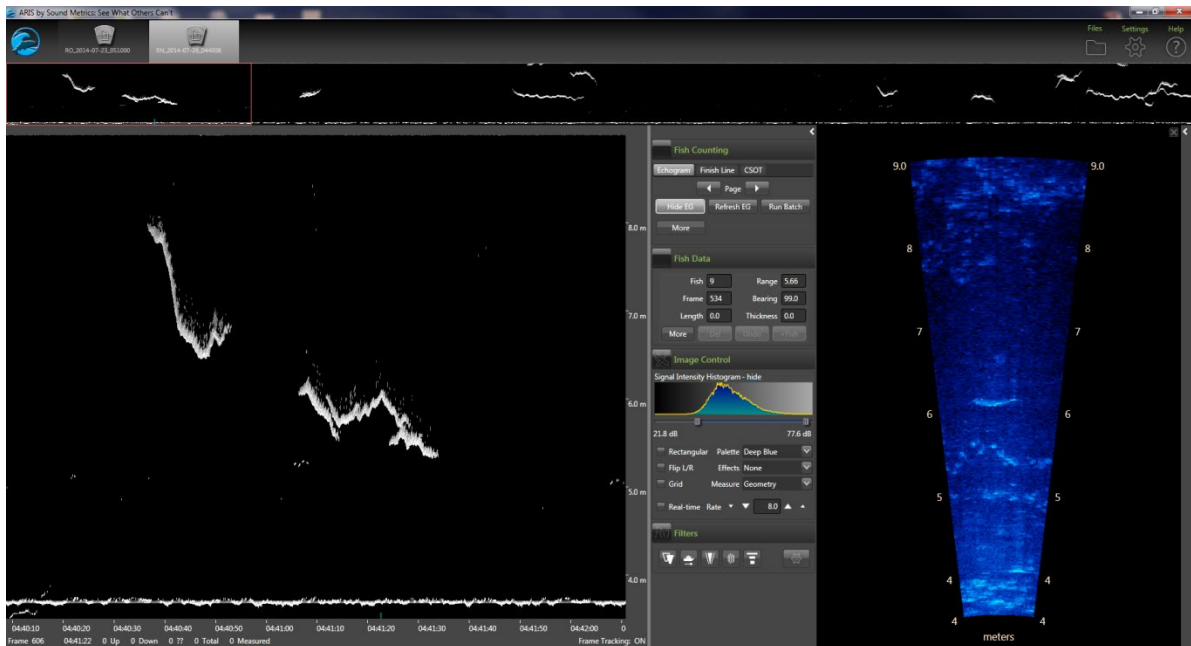
- g) Select <**Background Subtraction**> icon on Filters Menu (Toggle) – this will now turn background subtraction off on the video image. **Failing to turn background subtraction off prior to measuring fish image length may result in an underestimate of actual fish length.**⁸



- h) Set Signal Intensity sliders to optimize video image for measuring fish.



- i) Your overall display should look similar to:



- j) Now you are ready to start measuring (or marking) individual fish
k) Once finished measure/markng all fish in the file, turn <**Background Subtraction**> on prior to advancing to the next file.

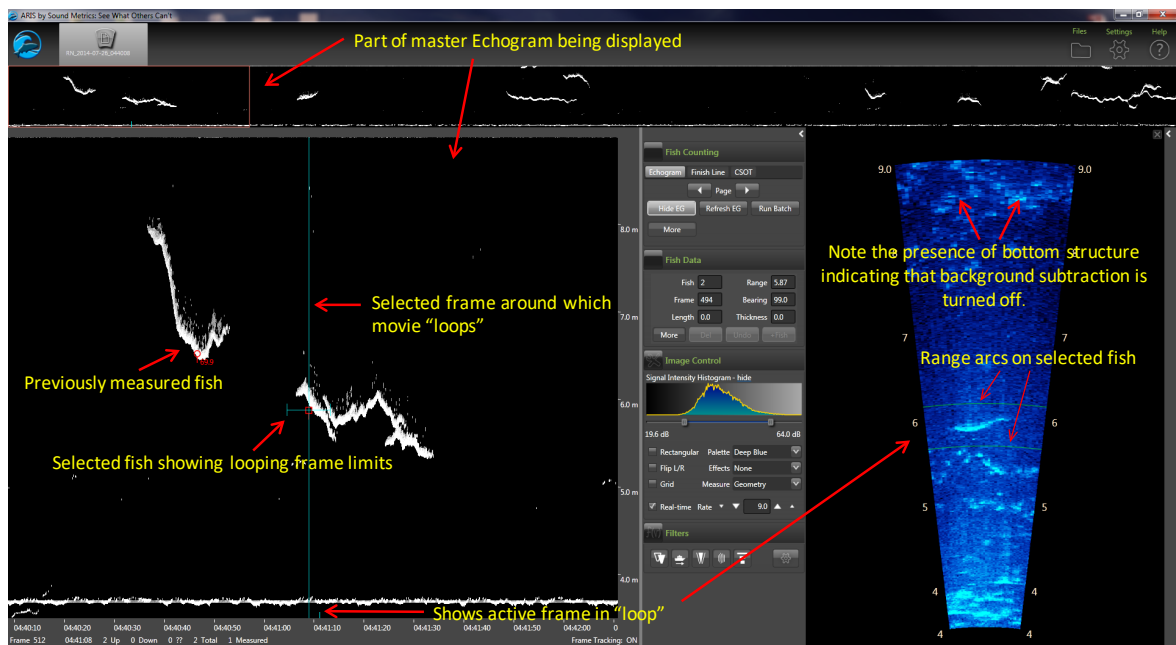
-continued-

⁸ Unlike with DIDSON data, we no longer use the background selection option while measuring fish image length most of the time. The new ARIS background selection algorithm is more aggressive than the DIDSON and unless one is very careful in selecting a frame, it is easy to underestimate fish length. Toggling between background selection mode and the raw image can sometimes be helpful in determining the end of the tail or snout. If we do use background selection, we generally take background selection off before finalizing measurement. A well selected frame will give the same length measurement with or without background selection.

- l) Select <Alt><right arrow> to advance to the next file.
- m) Once the new file opens, turn <Background Subtraction> off before beginning to measure fish (all other parameter settings and display configuration settings should be preserved from the previous file)
- n) When you switch banks, you will need to reset the direction of travel parameter in step 5
- o) Now you are ready to start measuring/markings fish in the new file.

3) Instructions for manual fish length measurements using SMC ARISFish software version 2.3 - Rev 6993 in 2015.

- a) Ensure <Background Subtraction> is toggled *off* as described in step 6 above.
- b) <Left Click> on the Echogram fish to be measured (Puts red marker on fish and automatically activates the movie showing the fish bounded by range arcs.



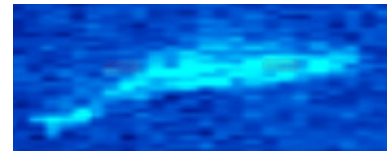
- o Press <space bar> to start or stop the video playback
- c) Use <right arrow> and <left arrow> to step through movie one frame at a time to find a frame that displays the entire fish length well
 - o Measurements should be taken from frames where contrast between the fish image and background are high and where the fish displays its full length
 - o In general, the best images are obtained when the fish is sinusoidal in shape (rather than straight and/or perfectly perpendicular to the sonar beam)
 - o Watching the behavior of the head and especially the tail over several frames, and taking several measurement, is often helpful in distinguishing the best frame
- d) <Right Click Drag> on movie image to zoom in for measurement
- e) <Left Click Drag> if necessary to center movie window prior to measuring

-continued-

- f) <left click> on the fish snout and continue to <left click> along the midline of the fish to create a “segmented measurement.” The segments should follow the midline of the body of the fish – ending with the tail.



- o Toggling between BS mode and the raw image can sometimes be helpful in determining the actual end of the tail or snout.



- g) Select <f> key to add measurement to the .txt file (fish it!) – you will see measurement in red (<Left Click> on echogram inside mark, if you want to delete measurement and start over)
- h) Select <v> key to unzoom movie window (not necessary if you have another fish nearby you want to measure)
- i) Next fish...repeat steps 1-8, or
- j) Occasionally press <E> to save your work on each sequence when complete (or before you divert to another task).
- k) <Left Click> on Master Echogram to advance to new echogram section, or
- l) <Alt><Right Arrow> to advance to next file

4) To mark (count) fish in SMC ARISFish software version 2.3 - Rev 6993 in 2015.

- a) <Left Click> on the fish trace in the echogram if upstream
- b) <Ctrl> <Left Click> on the fish trace in the echogram if downstream

-continued-

5) Hot keys used in measuring and counting fish in SMC ARISFish software.

<e> to “save” all echogram measurements to file

<f> to “fish it” (to accept the measurement and display it on the echogram)

<u> to “undo” the last segment

<d> to “delete” all segments

<space bar> to pause in movie mode

<right arrow> forward direction when you play movie or advances frame one at a time if the movie is paused

<left arrow> opposite of above

Left Click Drag to show movie over the selected time

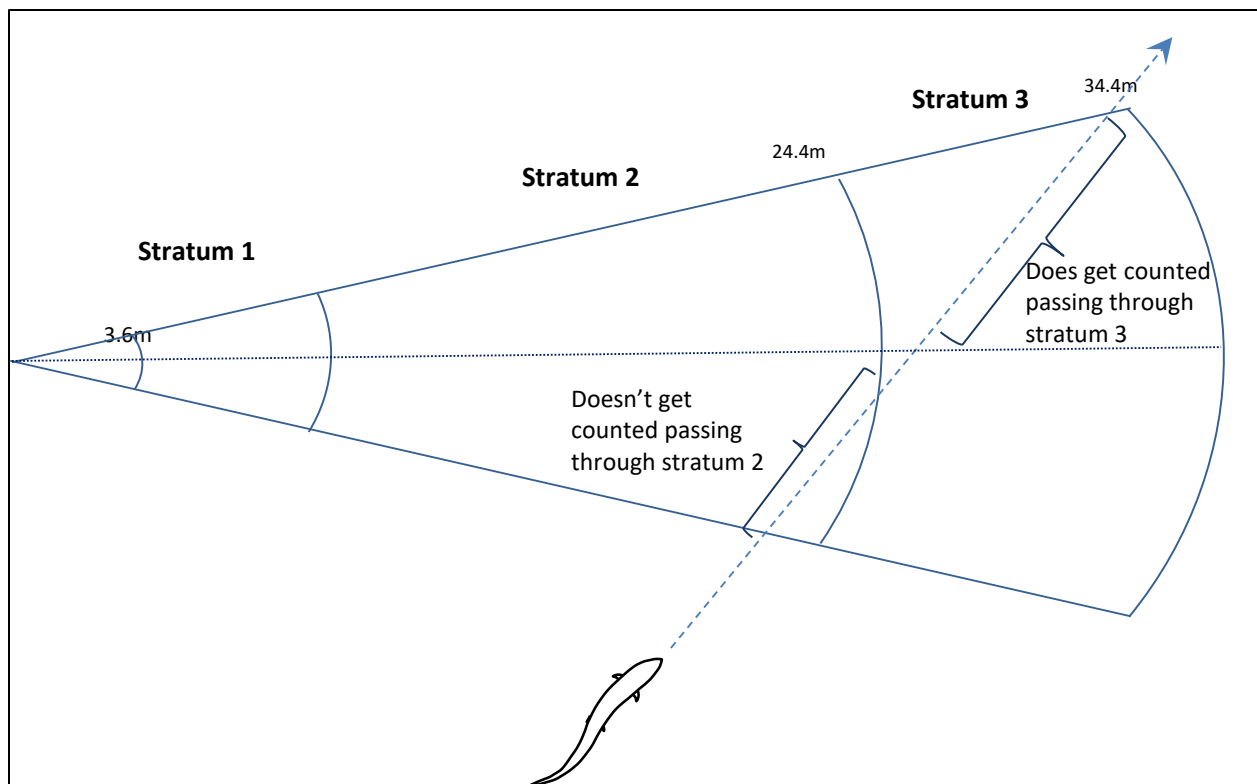
Right Click Drag zooms the selected area in the video image when an echogram fish is selected

6) Instructions for including or excluding fish to be counted and/or measured

In order to optimize the aim of the sonar beams relative to the bottom of the river, the insonified zone is often divided into individual range strata that are sampled separately. In order to avoid over counting fish as they cross stratum boundaries, we apply the “centerline rule” where a fish is not counted unless it crosses the centerline of the sonar beam. Appendix D2 demonstrates the potential for over counting without applying this criterion. Additional examples are given in Appendix D3.

Summary of fish measurement rules

- a) For a fish to be considered valid for measurement, it must cross the centerline.
 - If a fish enters or exits the beam on the near- or far-range boundary (beginning or end range), the snout of the fish must cross the centerline before it can be considered a valid fish to measure.
 - If the snout of the fish enters the near- or far-range boundary right on the centerline, the fish should be considered valid for measurement.
- b) Exclude fish that hold throughout the length of the sample.
- c) Exclude fish that are holding at either the beginning or the end of the sample.
 - Fish that are actively migrating (not holding) as the sample begins or ends should be considered valid targets for measurement as long as they cross the centerline.
- d) Exclude fish that enter the beam from upstream, then exit the beam upstream (do not measure even if they cross the centerline).
- e) Exclude fish that enter the beam from downstream and then exit the beam downstream (do not measure even if they cross the centerline).
- f) Exclude fish that enter the beam from either upstream or downstream and then disappear from the image (unless there is evidence to suggest direction of travel).
- g) Use the video image to identify actively migrating fish when several holding fish are present. If you have several fish holding throughout the sample, use the video mode or run your cursor across the echogram while watching the ARIS image to observe fish that are actively transiting the image. Measure fish that are actively transiting the image and that meet all criteria listed above.
- h) Consult with others if you come across a questionable trace (fish) or are unclear of the rules listed above.

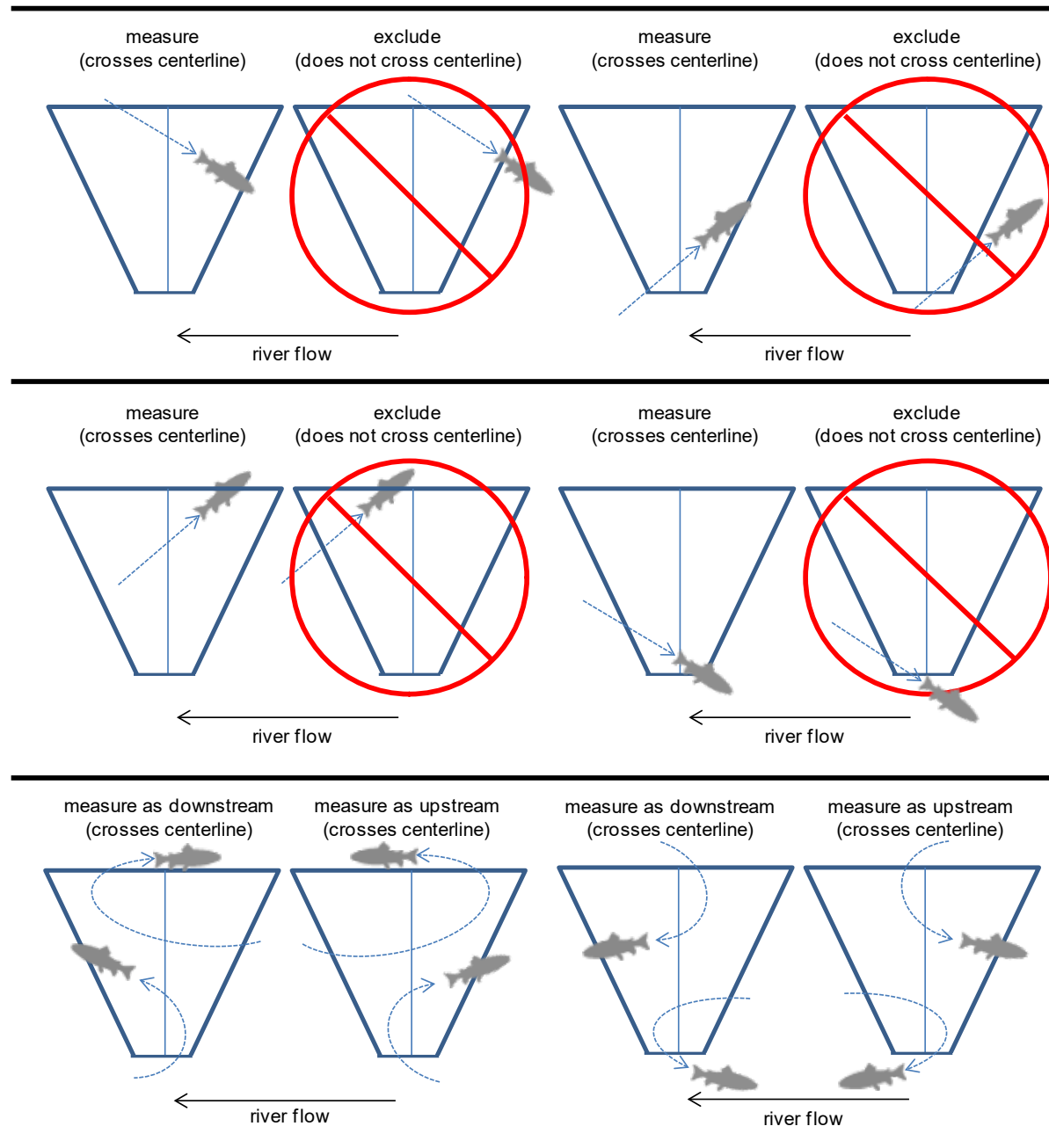


Appendix D2.—Illustration of the problem of double-counting.

Note: To avoid counting this fish in both stratum 2 and stratum 3, the fish will only be counted in stratum 3 where it crosses the centerline of the beam.

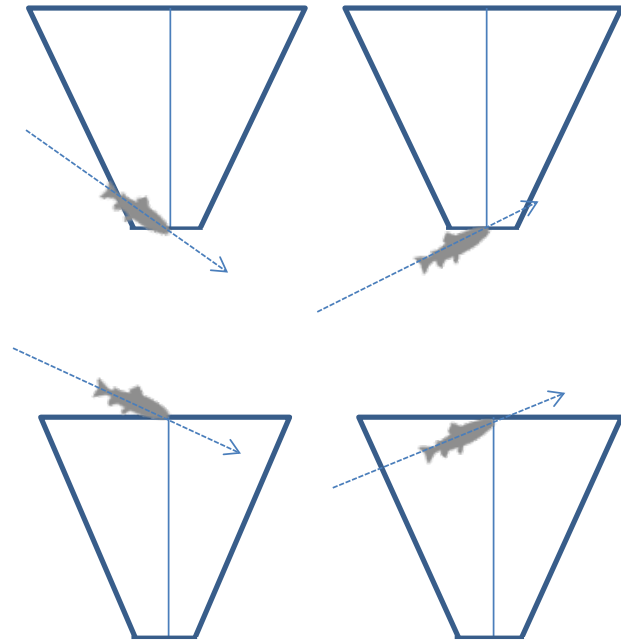
Appendix D3.—Specific examples for applying the “Centerline Rule” when selecting fish for counting and measurements.

For a fish to be considered valid for measurement (either upstream or downstream), the snout must cross the centerline.

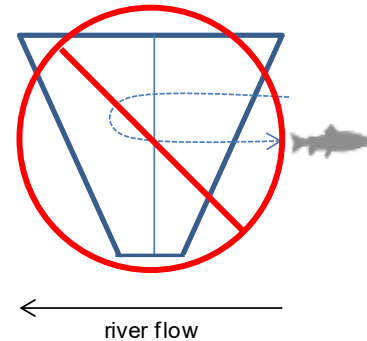


-continued-

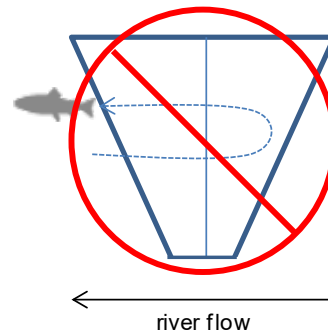
If the snout of the fish enters the near- or far-range boundary right on the centerline, the fish should be considered valid for measurement.



Exclude fish that enter the beam from upstream, then exit the beam upstream (do not measure even if they cross the centerline).

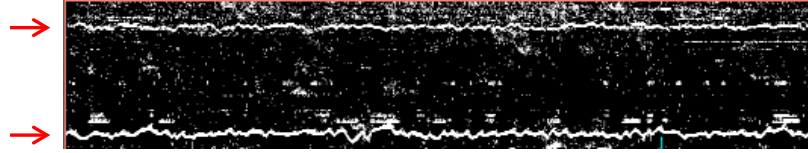


Exclude fish that enter the beam from downstream, then exit the beam downstream (do not measure even if they cross the centerline).



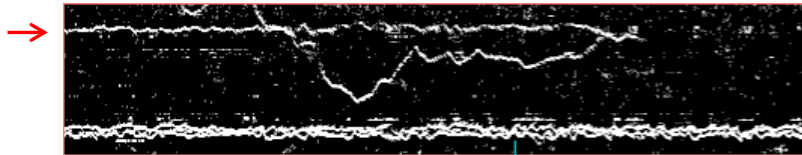
-continued-

Exclude fish that hold throughout the length of the sample.

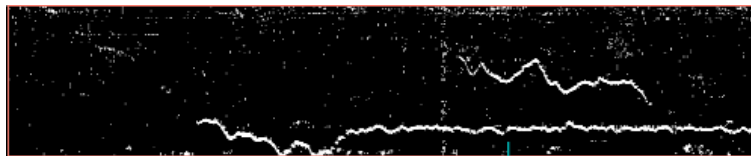


Two fish hold throughout the entire file.
Exclude both fish.

Exclude fish that hold at either the beginning or end of the sample.



Fish holding as sample begins, then exits the beam about $\frac{3}{4}$ of the way through the sample. Exclude this fish.



Fish enters the beam mid sample, then holds through the end of the sample. Exclude this fish

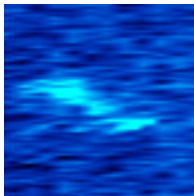
Fish that are actively migrating (not holding) as the sample begins or ends should be considered valid targets for measurement as long as they cross the centerline.



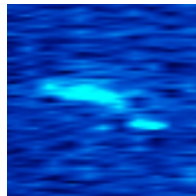
Fish is actively migrating through the beam as the sample starts. It crosses the center line and exits upstream so should be measured.

-continued-

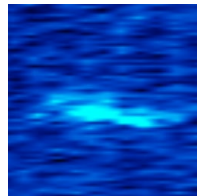
A fish passing through the beam that turns perpendicular to the axis and disappears should be excluded unless there is other evidence to indicate direction of travel.



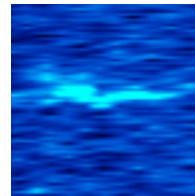
Frame #2353



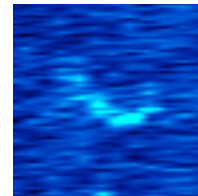
Frame #2354



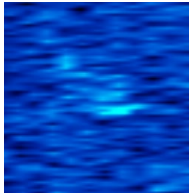
Frame #2355



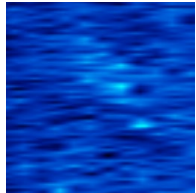
Frame #2356



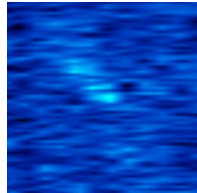
Frame #2357



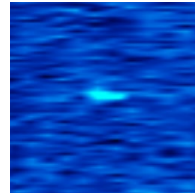
Frame #2358



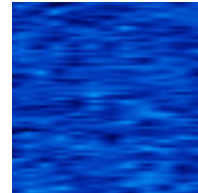
Frame #2359



Frame #2360



Frame #2361



Frame #2362

APPENDIX E: RM 13.7 SITE INVESTIGATION DOCUMENTATION

Appendix E1.—Additional details regarding the RM 13.7 sonar site.

Benefits of using the RM 13.7 site to collect sonar data include the following: 1) the State owns land on both sides of the river (Department of Natural Resources [DNR] land on the left⁹ [KPB parcel 055-250-23] and right bank [KPB parcel 057-250-30]) (Appendix E2), 2) the location is above major tidal influence, and 3) the river channel is relatively narrow at this location. The upland on both banks is composed of trees and shrubs. The main tent housing sonar electronics will be located on the left bank (Appendix E3). Data from the right bank will be transmitted to the tent on the left bank using wireless technology.

Providing full (bank-to-bank) coverage will require a total of 5 sonars: 4 sonars on the main channel and a fifth sonar to monitor the minor channel on right bank (Appendix E3). Site diagrams for the left bank can be found in Appendices E4–E6. Site diagrams for the right bank main river channel can be found in Figures Appendices E7–E9. Site diagrams for the minor river channel can be found in Appendices E10–E12.

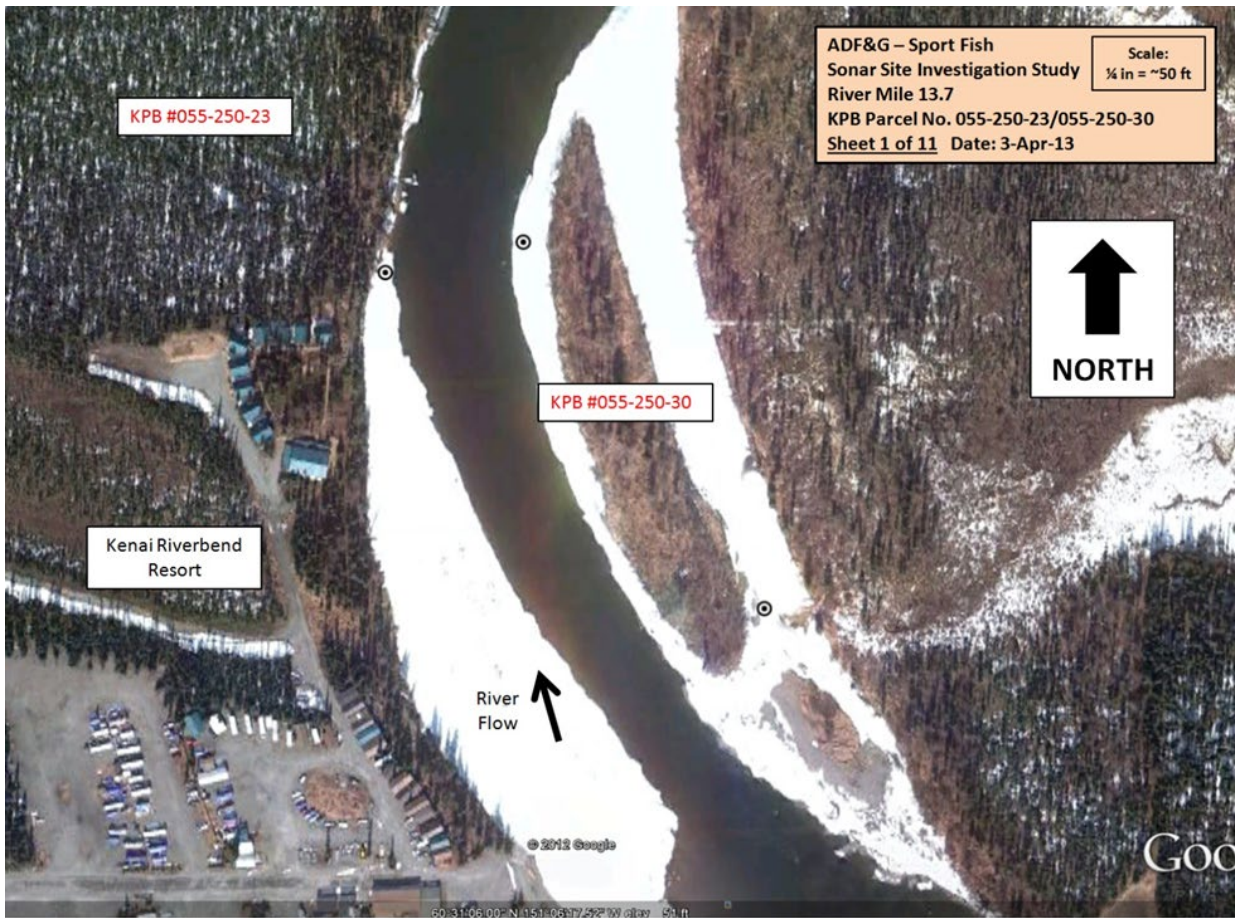
A 10 ft × 12 ft tent will be assembled on the left bank at least 50 ft from ordinary high water levels (OHW) (Appendices E4–E5). The tent will be located in a clearing to alleviate the need to remove trees and other vegetation. The tent electronics schematics are shown in Appendix E13). Power will be supplied to the tent via 2 power cords running from external outlets on a cabin located approximately 60 m upstream of the tent (Appendices E3–E4). Electronic control cables will lead from the tent into the river and attach to each of 2 ARIS units (nearshore and farshore sonars) mounted to removable steel tripods (Appendices E4 and E6). The sonars will be positioned on the river bottom approximately 6 ft and 24 ft from OWH (Appendix E6).

On the right bank main-channel site, 2 waterproof totes (~ 3 ft × 4 ft) will house a battery bank (Appendix E14) and the topside sonar electronics (Appendices E7–E8 and E14). A plywood box (~ 3 ft × 3 ft) lined with plastic (for spill containment) located near the totes will house a small generator (Appendices E7–E8). A power cable will lead from the batteries to the tote housing the ARIS electronics. Electronic control cables will lead from the topside electronics tote into the river and attach to each of 2 ARIS units (nearshore and farshore sonars) mounted to removable steel tripods (Appendices E7 and E9). The sonars will be positioned on the river bottom approximately 6 ft and 45 ft from OWH (Appendix E9).

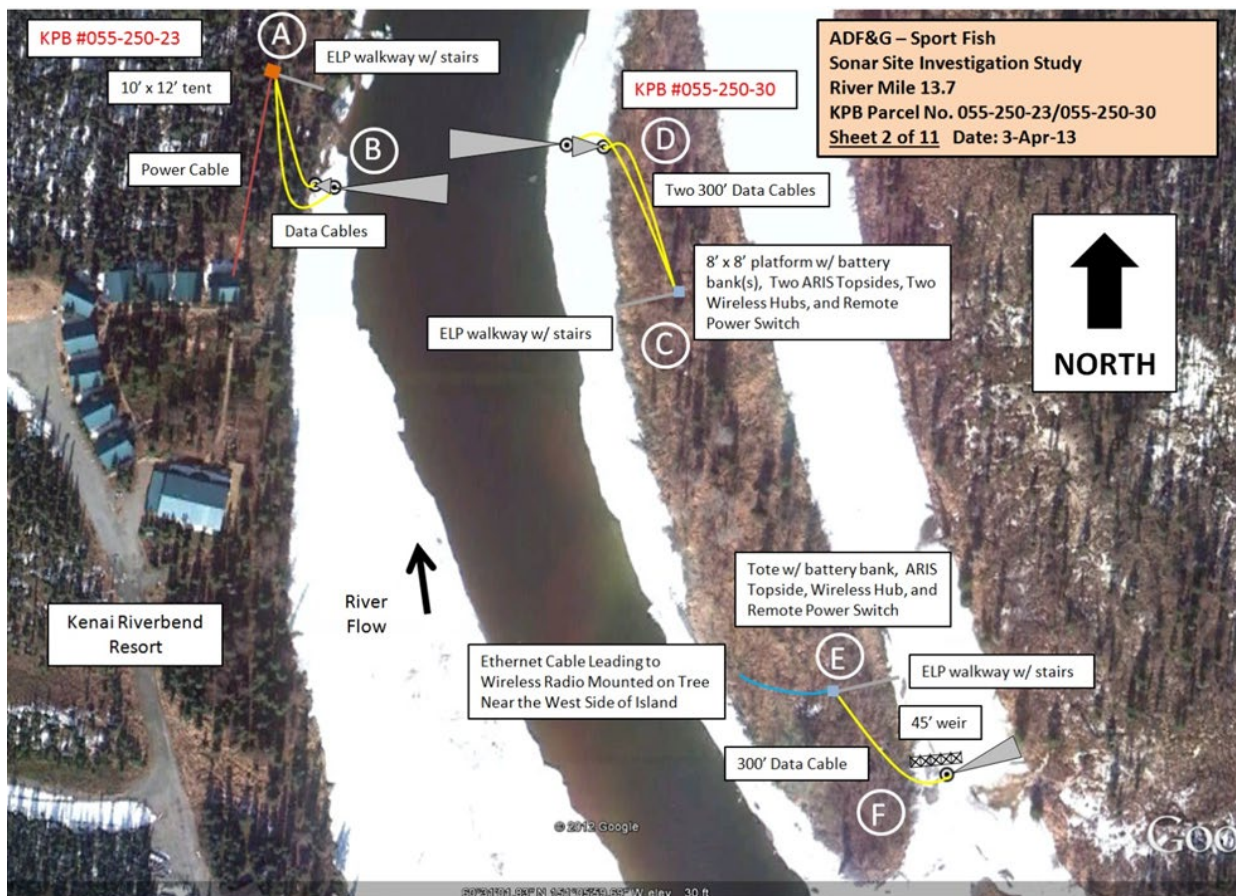
On the right bank minor-channel site, a single waterproof tote (~ 3 ft × 4 ft) will house the battery bank (Appendix E15) and topside sonar electronics (Appendices E10–E11). Electronic control cables will lead from the topside electronics tote into the river and attach to a single ARIS unit mounted on a steel tripod approximately 40 ft from OHW; a picket weir will extend approximately 45 ft from OHW to force fish in front of the sonar (Appendices E10 and E12).

Submerged steel tripods will be marked with a marker float on the water's surface (Appendices E6 and E9). Additional large red “warning” buoys will be placed near the offshore sonar tripods on each bank. Signage warning boaters to stay offshore of the warning buoys will be posted at all boat launches and signage identifying the location of the new sonar project will be placed approximately 300 ft upriver and downriver of the site.

⁹ Looking downstream.

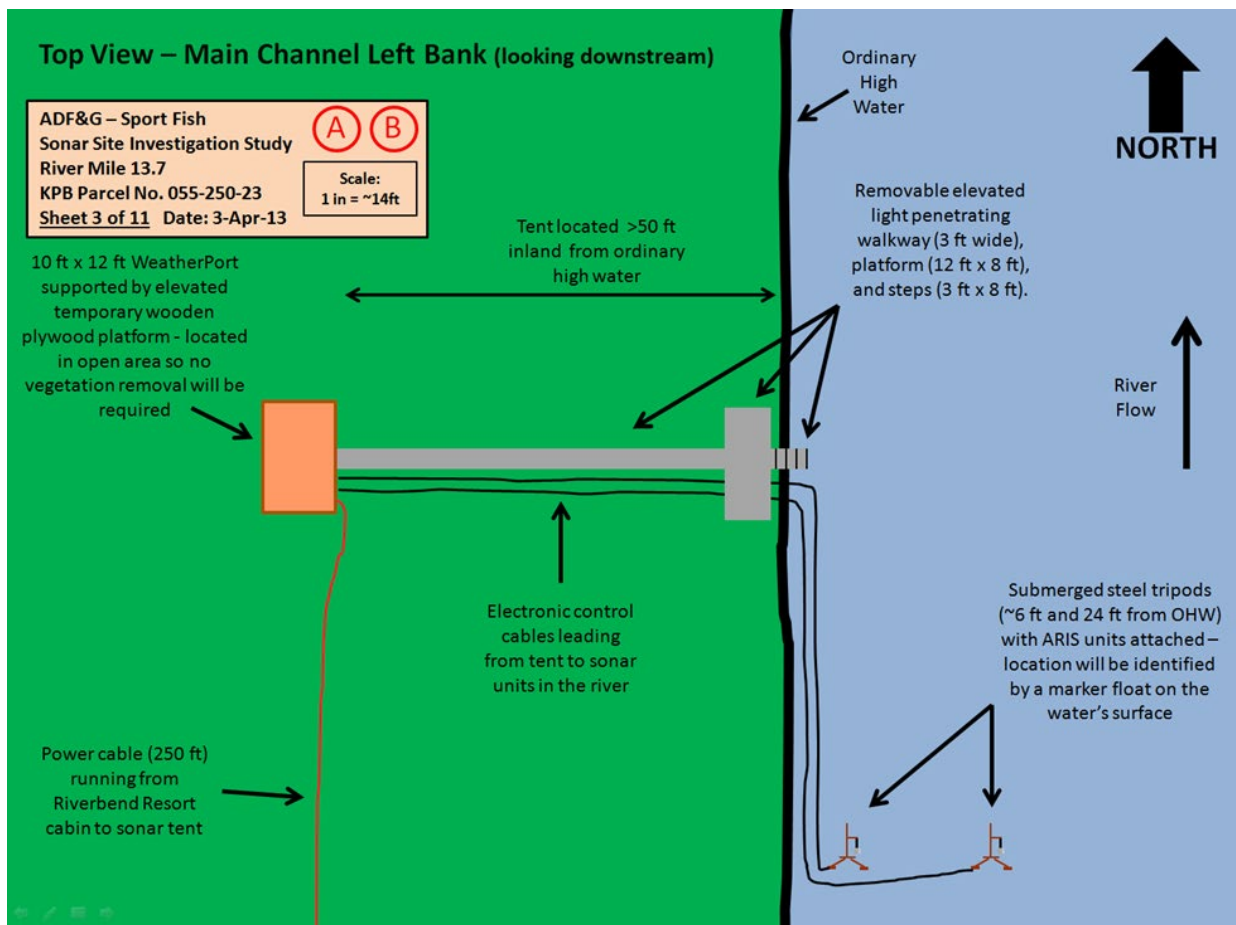


Appendix E2.—Aerial map and parcel numbers for RM 13.7 sonar site.



Appendix E3.—Aerial view of sonar deployment at the RM 13.7 sonar site.

Note: Letters A–F show locations of diagrams in Appendices E4–E12.



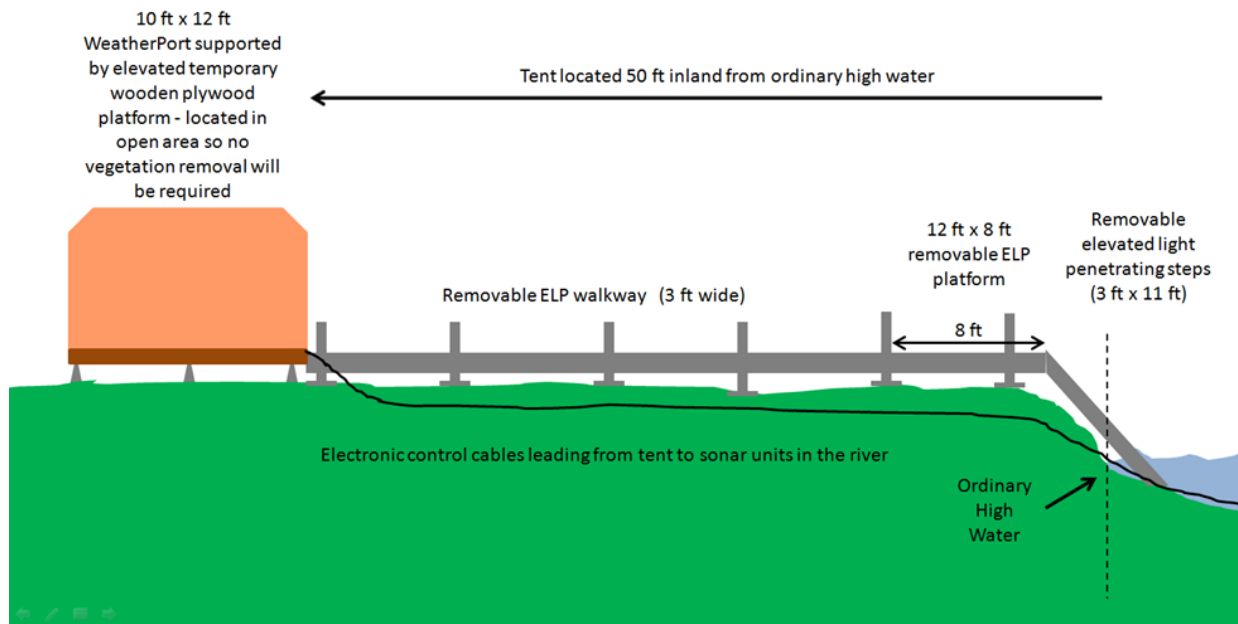
Appendix E4.—Aerial view of main channel left bank camp and sonar deployment at the RM 13.7 sonar site.

Side View – Main Channel Left Bank (looking downstream) – Tent, Walkway, Platform, and Steps

ADF&G – Sport Fish
Sonar Site Investigation Study
River Mile 13.7
KPB Parcel No. 055-250-23
Sheet 4 of 11 Date: 3-Apr-13

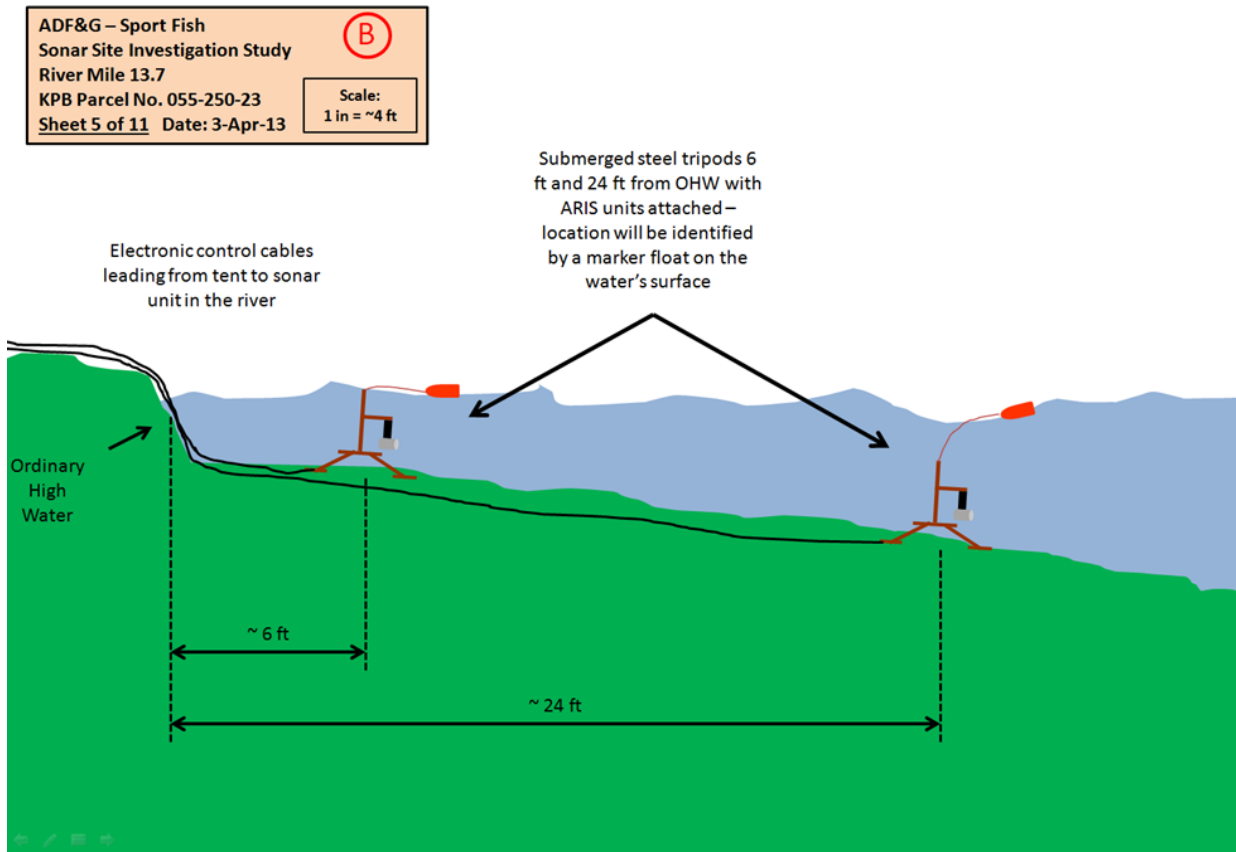
A

Scale:
1 in = ~8 ft



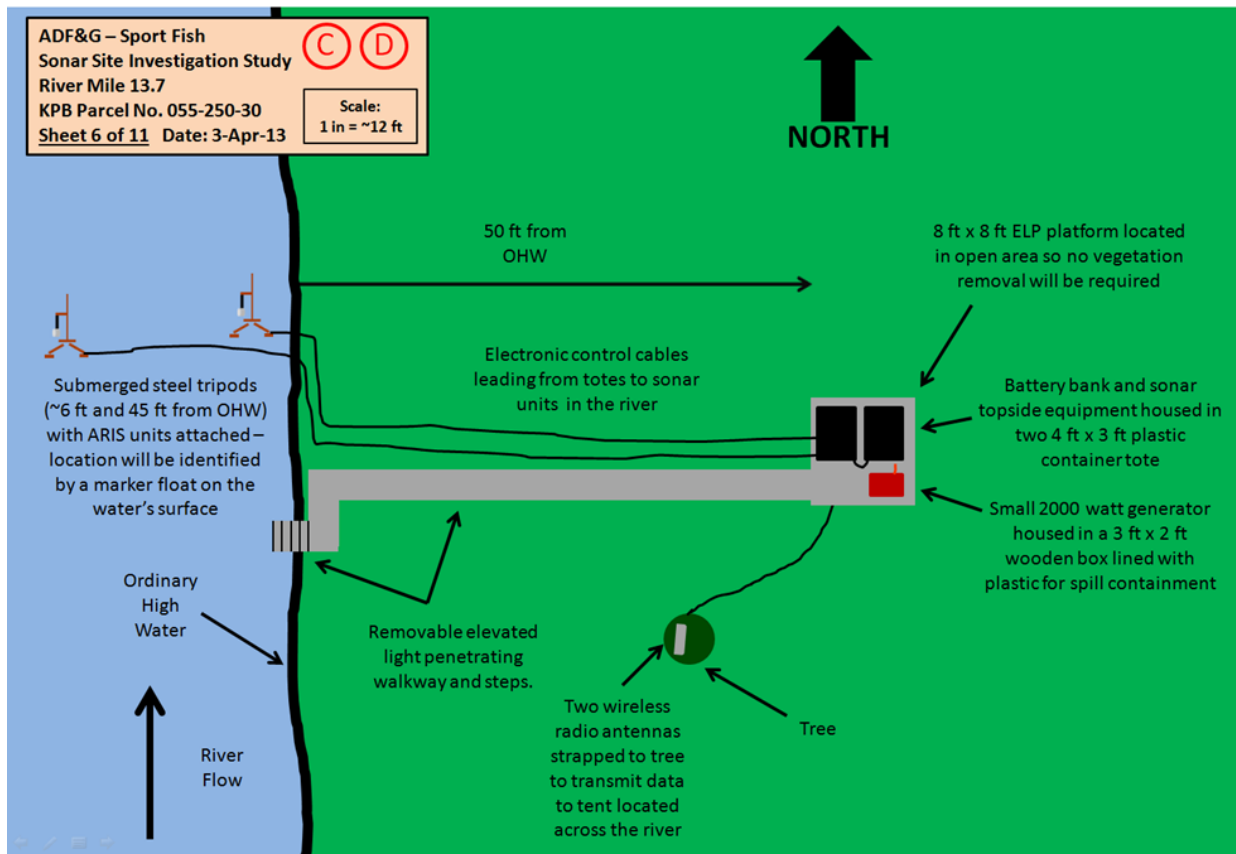
Appendix E5.—Side view of main channel left bank camp and walkway deployment at the RM 13.7 sonar site.

Side View – Main Channel Left Bank (looking downstream) – Tripod Deployment



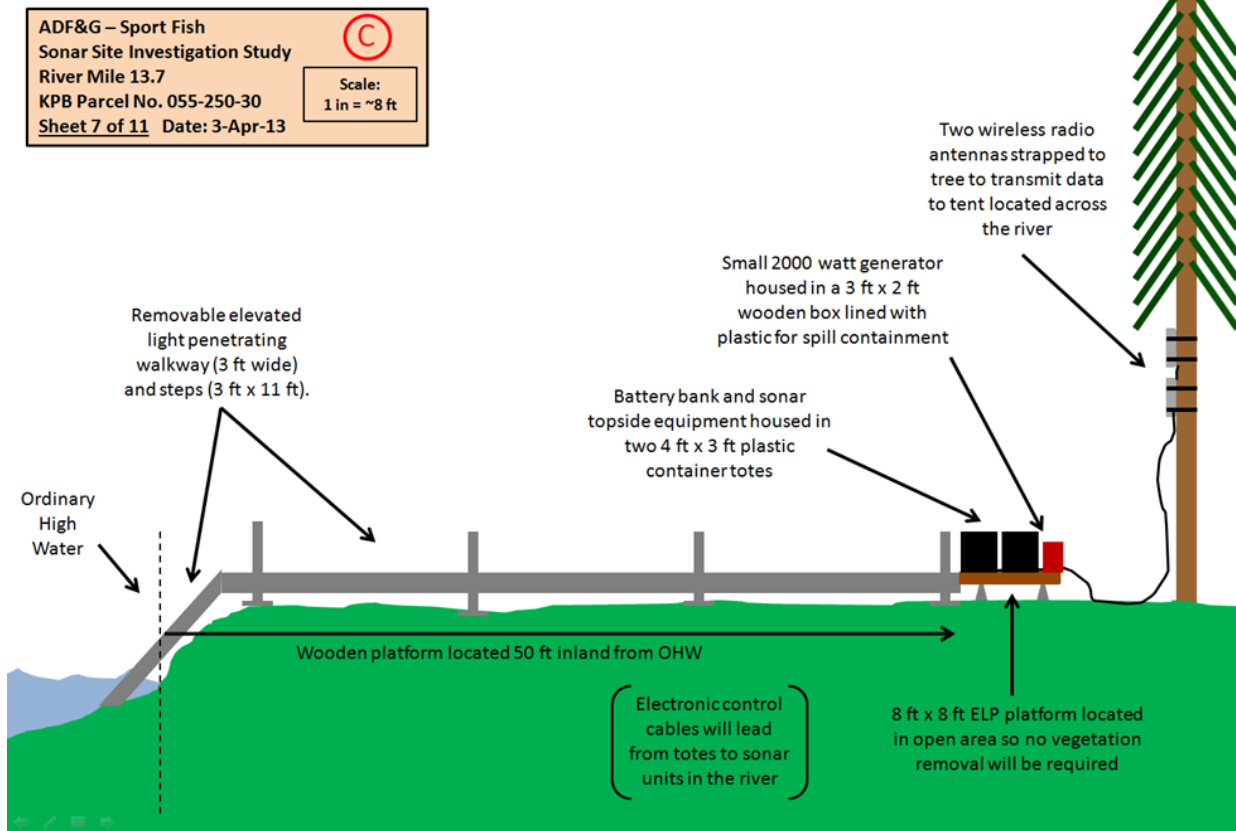
Appendix E6.–Side view of main channel left bank sonar tripod deployment at the RM 13.7 sonar site.

Top View – Main Channel Right Bank (looking downstream) – Walkway, Platform, Tripod Deployment



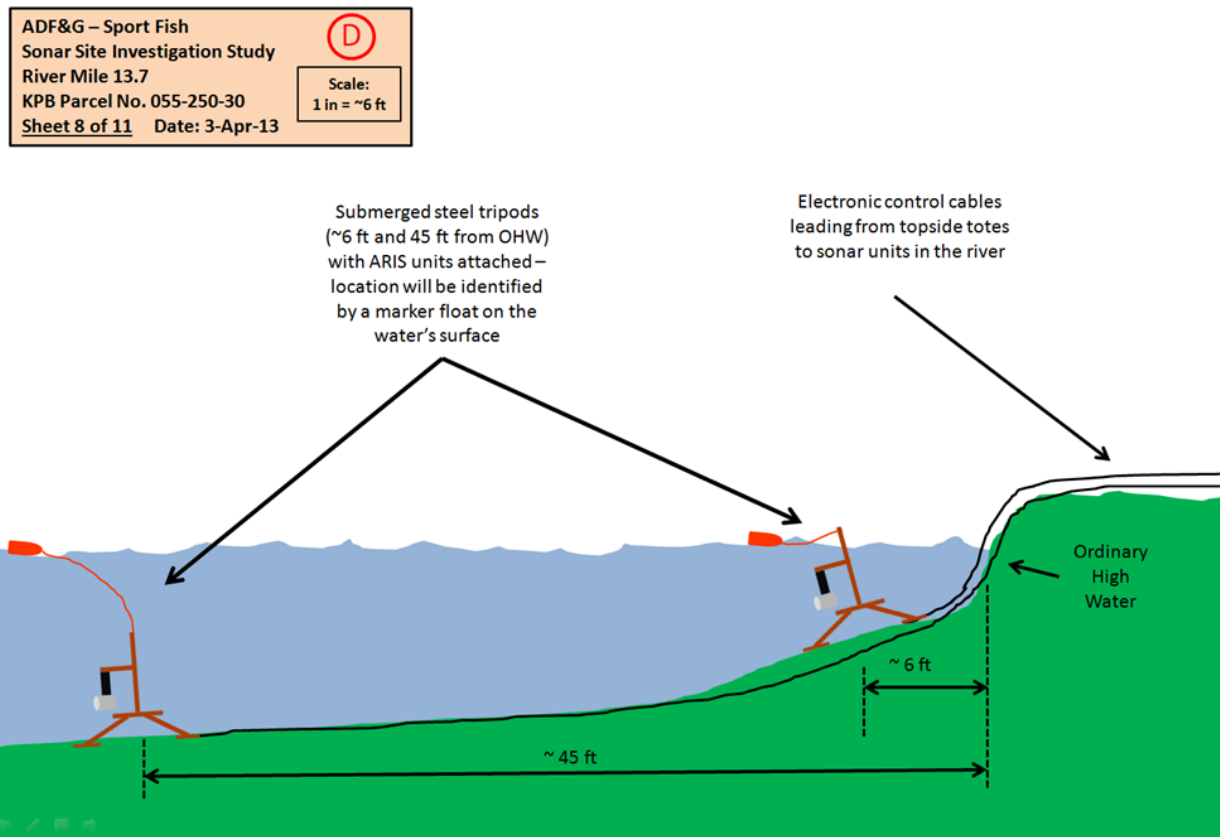
Appendix E7.—Aerial view of main channel right bank battery bank and sonar deployment at the RM 13.7 sonar site.

Side View – Main Channel Right Bank (looking downstream) – Walkway and Platform



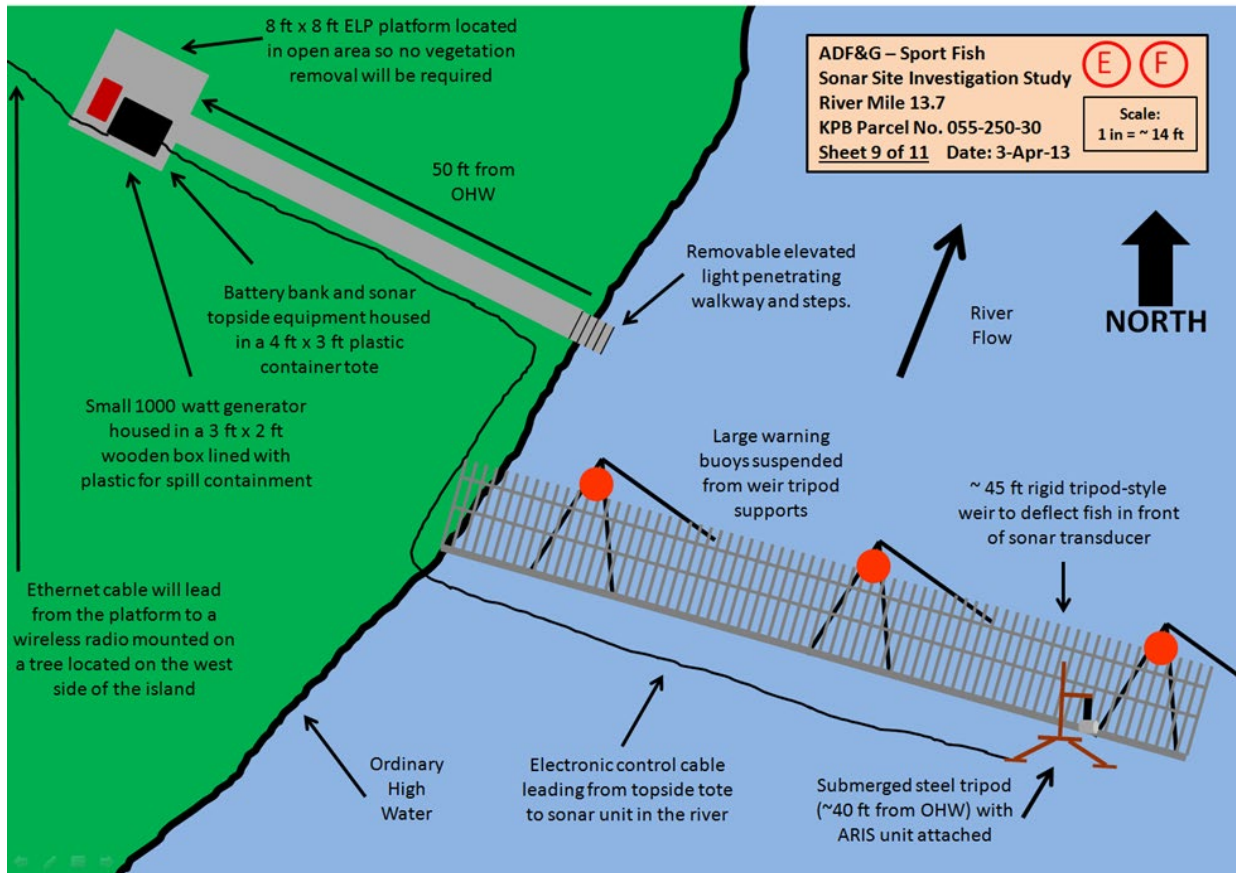
Appendix E8.—Side view of main channel right bank battery bank and walkway deployment at the RM 13.7 sonar site.

Side View – Main Channel Right Bank (looking downstream) – Tripod Deployment



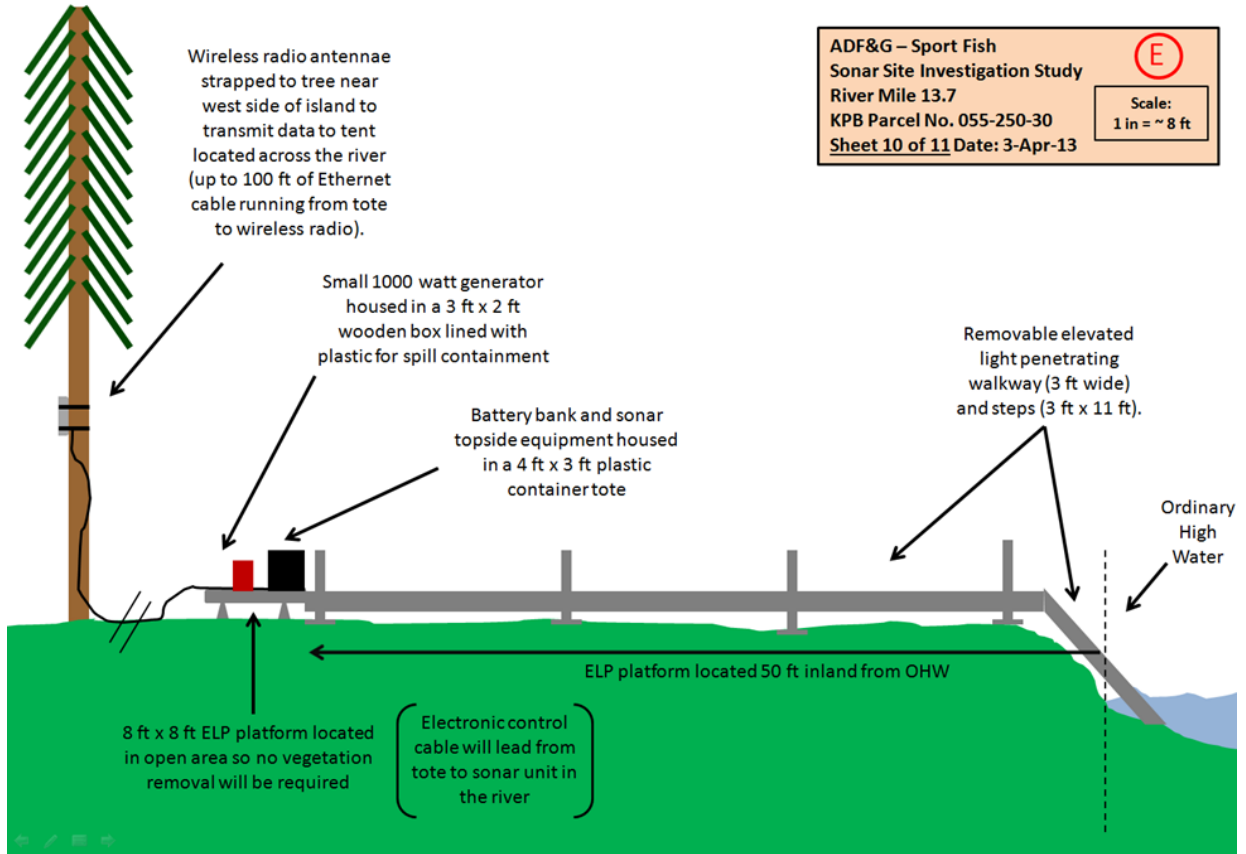
Appendix E9.—Side view of main channel right bank sonar tripod deployment at the RM 13.7 sonar site.

Top View – Minor Channel Left Bank – Platform, Walkway, Weir, and Tripod Deployment



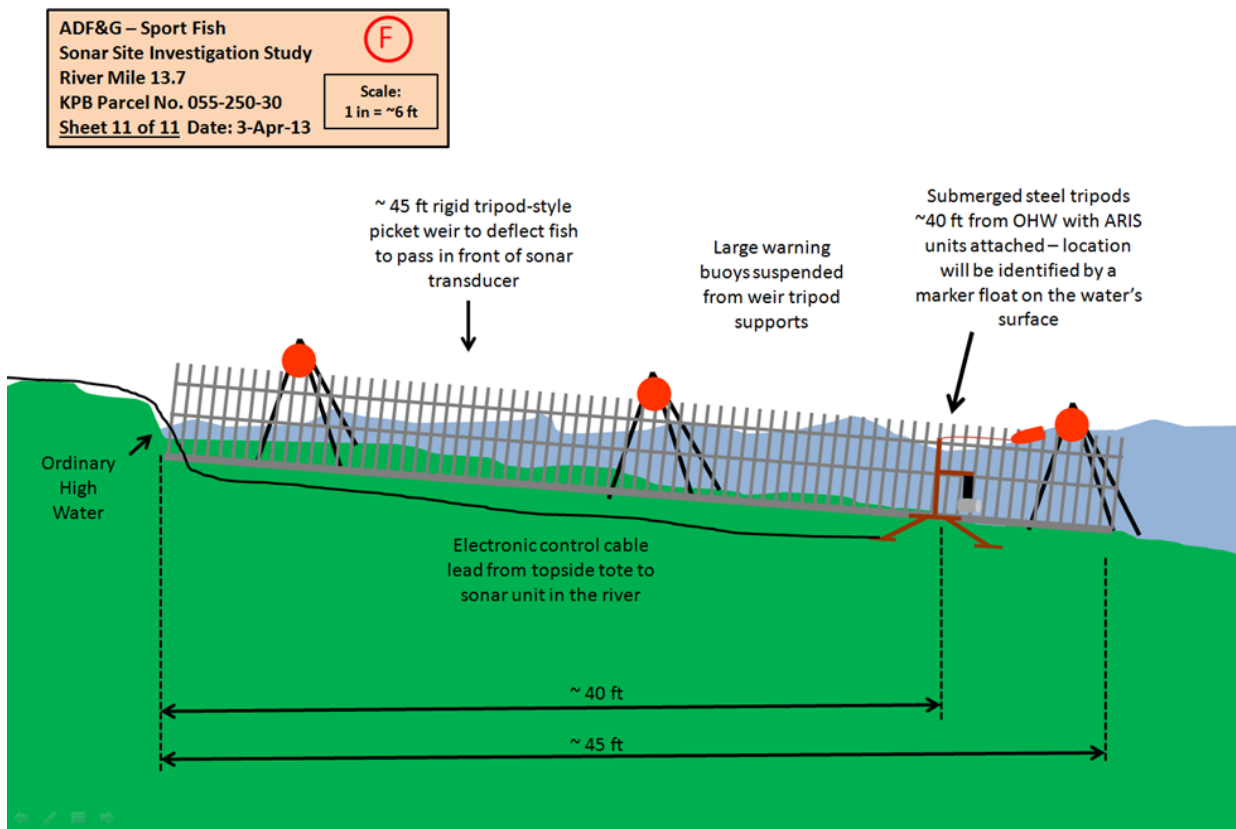
Appendix E10.–Aerial view of minor channel battery bank, weir, and sonar deployment at the RM 13.7 sonar site.

Side View – Minor Channel Left Bank (looking downstream) – Walkway and Platform



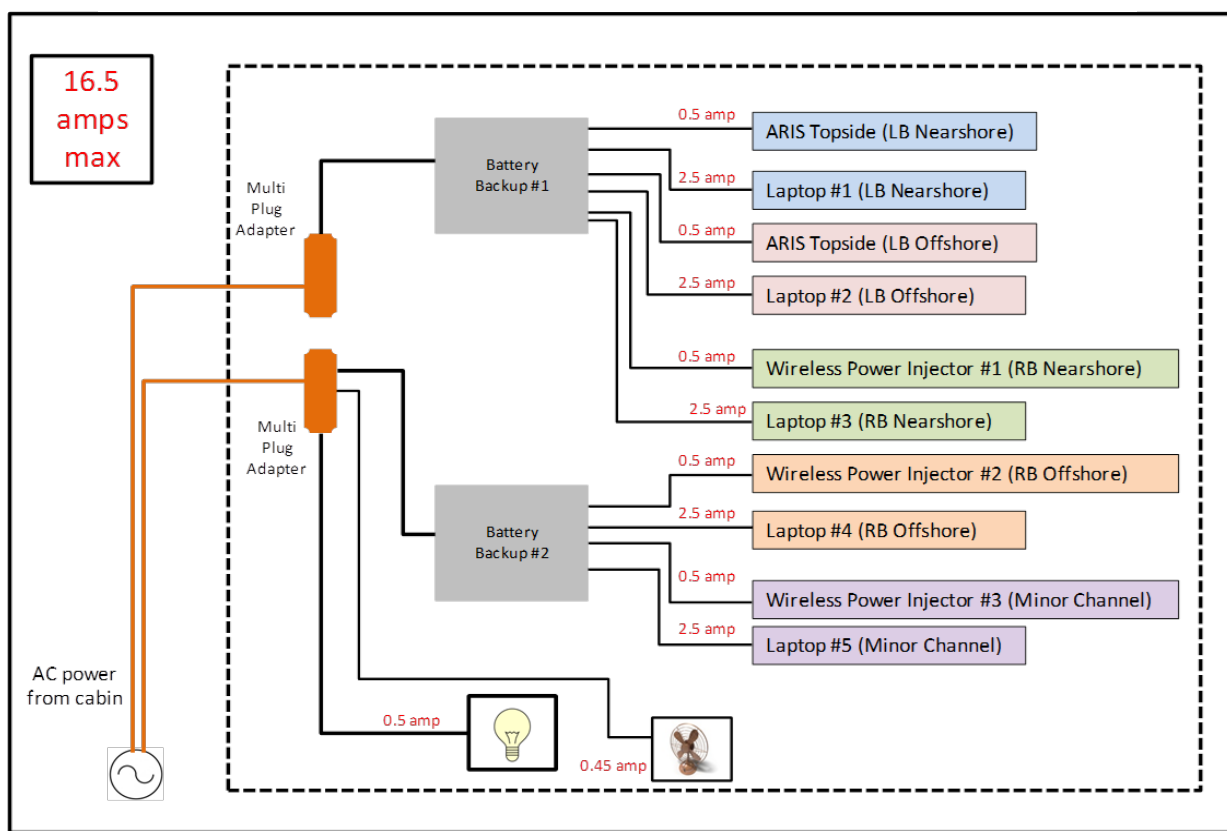
Appendix E11.–Side view of minor channel battery bank and walkway deployment at the RM 13.7 sonar site.

Side View – Minor Channel Left Bank (looking downstream) – Weir and Tripod Deployment

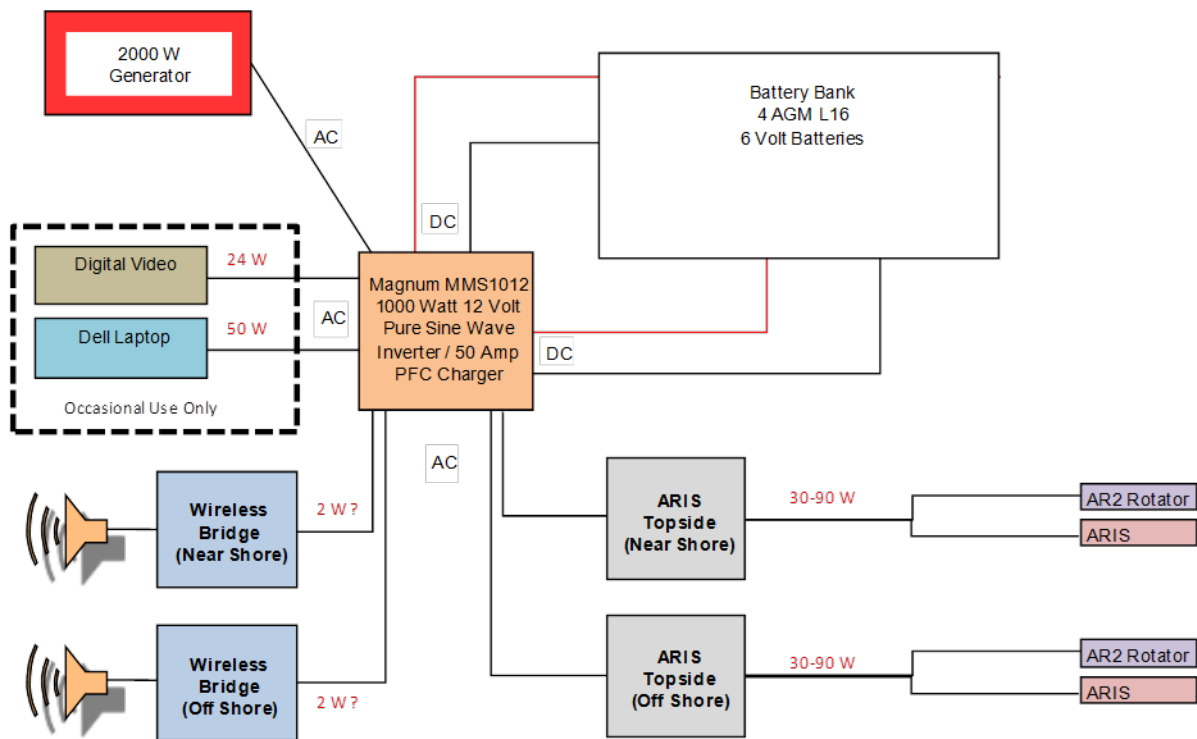


Appendix E12.–Side view of minor channel battery weir and sonar tripod deployment at the RM 13.7 sonar site.

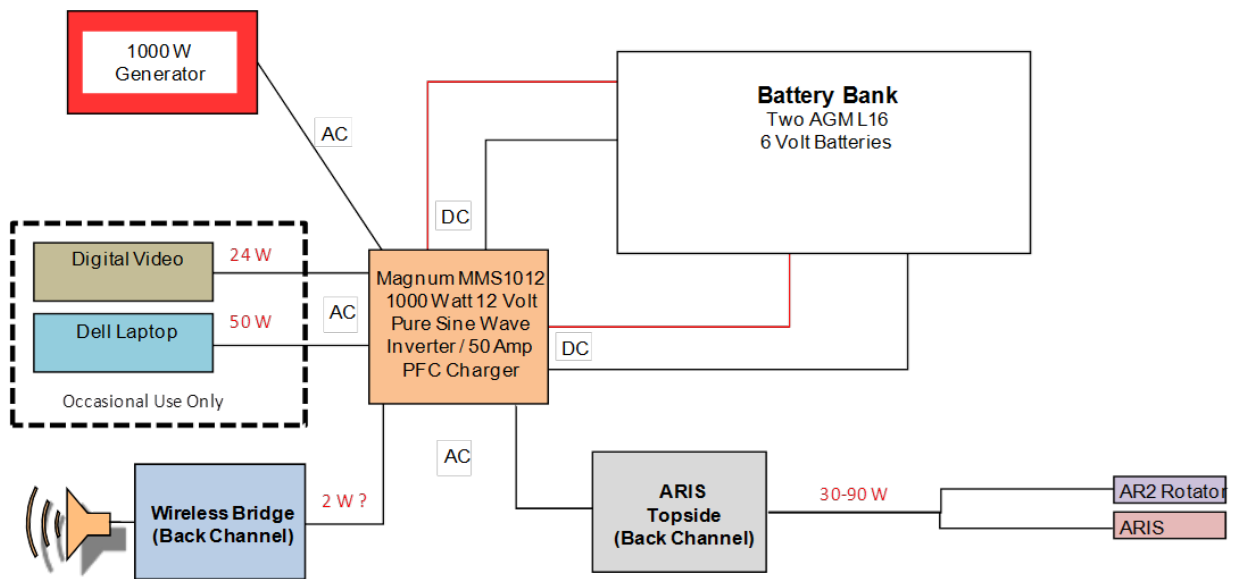
RM 13.7 Tent Electronics Schematics



Appendix E13.—Estimated power requirements for electronics based in the main camp on left bank.



Appendix E14.–Proposed schematic for supplying DC power to the two right bank main channel ARIS systems at RM 13.7 via a battery bank charged by a 2000 W generator.



Appendix E15.—Proposed system schematic for the supplying DC power to the minor-channel ARIS system at RM 13.7 via a battery bank charged by a 1000 W generator.

APPENDIX F: KENAI RIVER CHINOOK SALMON SONAR NETWORK CONFIGURATIONS

Appendix F1.—Soldotna sonar office IP addresses.

SONAR Office	IP address	Location	Serial #	Username	Device name or purpose
Network Attached Storage					
Western Digital Sharespace 4 GB	192.168.1.101	Sonar office	none	Admin	DFGANCDSDSSHR3 2011 data
Western Digital Sharespace 4 GB	192.168.1.103	Sonar office	none	Admin	2012 data
Synology DiskStation 1512 10 TB	192.168.1.165	Sonar office	none	Admin	2012 ARIS data + 2013 RM 8.5 DIDSON
Buffalo TeraStation Pro 8 24 TB	192.168.1.165	Sonar office	none	Admin	2013 RM 13.7 ARIS DFGSXQTERA01
Buffalo TeraStation Pro 8 24 TB	192.168.1.165	Sonar office	none	Admin	2014 RM 13.7 ARIS DFGSXQTERA02
Computers					
Dell Workstation Laptop (LAN 2)	192.168.1.205	Sonar office SOA network		dlburwen	DFGANCDSF185749
Dell Workstation Laptop (LAN 1)	146.63.15.200				
Dell Optiplex 980	192.168.15.106	Sonar Office SOA network	B414BP1	sxqkenaisonar	Main data-processing computer DFGSXQDSF163887
	146.63.158.86				
Dell Optiplex 9010	192.168.15.107	Sonar Office network	FSJ7CX1	Jim's state domain login	Backup data-processing computer (Jim's) DFGSXQDSF104102
	146.63.158.86	SOA network			
Dell Optiplex 990 mini tower	192.168.1.110	Sonar Office SOA network	BSQ86V1	sonargear	ARIS/DIDSON data processing (LBF) DFGSXQDSF102790
	146.63.15.xxx				DGSXQDCF102790
Dell Optiplex 990 mini tower	192.168.15.113	Sonar Office SOA network	BSS66V1	Michaels login	ARIS/DIDSON data processing (Michael's) DFGSXQDSF102793
	146.63.158.86				
Dell Optiplex 990 mini tower	192.168.15.115	Sonar Office SOA network	BSR96V1	sonargear	ARIS/DIDSON data processing (CLJ's) DFGSXQDSF102792
					DGSXQDCF102792

-continued-

SONAR Office	IP address	Location	Serial #	Username	Device name or purpose
Computers (cont.)					
Dell Optiplex 9010	192.168.15.150	Sonar Office SOA network	FSJ8CX1	sonargear	Upload computer DFGSXQDSF104103
Dell Optiplex 9010	192.168.15.114 146.63.158.86	Sonar Office SOA network	FSJ9CX1	Brandons Login	ARIS/DIDSON data processing Brandons DFGSXQDSF104104
Dell Latitude Laptop	192.168.1.222	Sonar Office SOA network		dlburwen	Deb's personal laptop DFGANCDSF164927
Dell Optiplex 990 mini tower	192.168.15.108	Sonar Office SOA network	BSR56V1		Debs processing comp DFGSXQDSF102791
Backups for sonar field sites, sometimes in office					
Dell Latitude Laptop E6500			J8XM4M 1	FISHSONAR2	Trevor's former laptop DFGANCDSF160898
Dell Latitude Laptop E6500			5L3Z8K1	FISHSONAR	Kara's former laptop DFGANCDSF158144
Dell Latitude Laptop E6500				FISHSONAR	Brandon's former laptop

Note: To attach to NAS devices, map drives to local address [\\192.168.1.165\](#) however there cannot be two NAS with that IP address on the Network at the same time or it will cause a conflict.

Appendix F2.–RM 13.7 sonar site IP addresses (2014 configuration).

River Mile 13.75 SONAR Site	IP address	Location	Serial #	Username	Device name or purpose
L-Bank Nearshore ARIS SubNet					
ARIS sonar	169.254.xx.xx				New
Dell Latitude Laptop E6430				sonar	New
L-Bank Offshore ARIS SubNet					
ARIS sonar	169.254.xx.xx				
Dell Latitude Laptop E6400				sonar	New
R-Bank Nearshore ARIS SubNet					
ARIS sonar	169.254.xx.xx				New
Dell Latitude Laptop E6430				sonar	New
NetBooter	128.95.97.150			admin	
CISCO Radio for ARIS					
Left bank radio	128.95.97.4				New
Right bank radio	128.95.97.2				New
R-Bank Offshore ARIS SubNet					
ARIS sonar	169.254.xx.xx				
Dell Latitude Laptop E6430				sonar	New
NetBooter	128.95.97.150			admin	
CISCO Radio for ARIS					
Left bank radio	128.95.97.4				
Right bank radio	128.95.97.2				
R-Bank Side-Channel SubNet					
ARIS sonar	169.254.xx.xx				New
Dell Latitude Laptop E6430	169.254.50.50 255.255.0.0			sonar	New
NetBooter	169.254.50.75 255.255.0.0			admin	·Hold down reset button for 1 second (really) with power on Default address is 192.168.1.100
CISCO Radio for ARIS					
Left bank radio	128.95.97.4 128.95.97.2				
Backup Computers (from 2012)					
Dell Latitude Laptop E6500	128.95.97.151	FISHSONAR	Chinook1		Brandon's former laptop
Dell Latitude Laptop E6500	128.95.97.153	FISHSONAR	Chinook1		Kara's former laptop

Note: The DIDSON networks for right and left banks are NEVER connected together. Therefore, the separate laptops or the underwater units, respectively, can have the same IP address (although no device can have the same IP address on the same network). The local and DIDSON networks are not bridged together in any way.

Appendix F3.–Mapping to the Network Attached Storage (NAS), Buffalo TeraStation 5800, in 2015.

The 2015 Buffalo TeraStation NAS device will be configured with two separate networks (one for the upload computer and one for the data processing computers) allowing simultaneous data upload and data processing. Each of the two Ethernet ports on the TeraStation will be connected to separate switches via separate networks:

- Port 1 will be set for the 192.168.15.x subnet and will be connected to the Netgear Switch
- Port 2 will be set for the 192.168.7.x subnet and will be connected to the Cisco Switch.

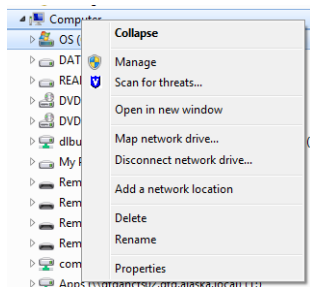
The IP addresses and device names for the 2015 TeraStation and storage devices from previous years are listed below:

Port	IP	Device	Data	Mapped Drive
1	192.168.15.204	DFGSXQDSFtera02	2015 RM 13.7	Q
2	192.168.7.204	DFGSXQDSFtera02	2015 RM 13.7	Q
1	192.168.15.203	DFGSXQDSFtera02	2014 RM 13.7	U
2	192.168.7.203	DFGSXQDSFtera02	2014 RM 13.7	U
1	192.168.15.201	DFGSXQDSFtera01	2014 RM 8.6	L*
2	192.168.7.201	DFGSXQDSFtera01	2014 RM 8.6	L*
1	192.168.15.200	DFGSXQDSFsynDS	2013 RM 8.6	K
2	192.168.7.200	DFGSXQDSFsynDS	2013 RM 8.6	K
1	192.168.15.202	DFGSXQDSFwdSS	SonarData2012	N
1	192.168.7.150	The Upload Computer	For Uploads.	-

*Mapped Drive letter M is used to access 2013 Upper River Data.

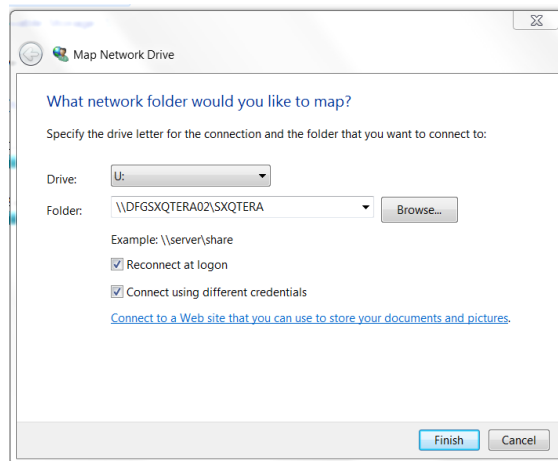
Batch files will be used to map to the different drives automatically, or the user can manually map to the different storage devices as follows:

- 1) **<Right click>** on Computer
Select **Map network drive.....**

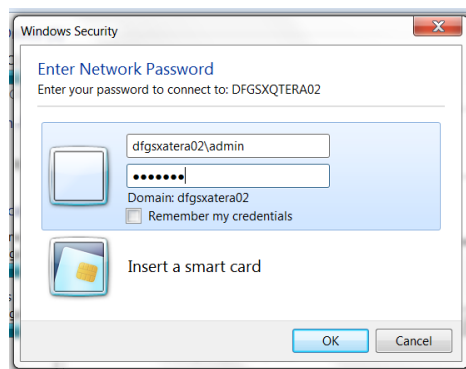


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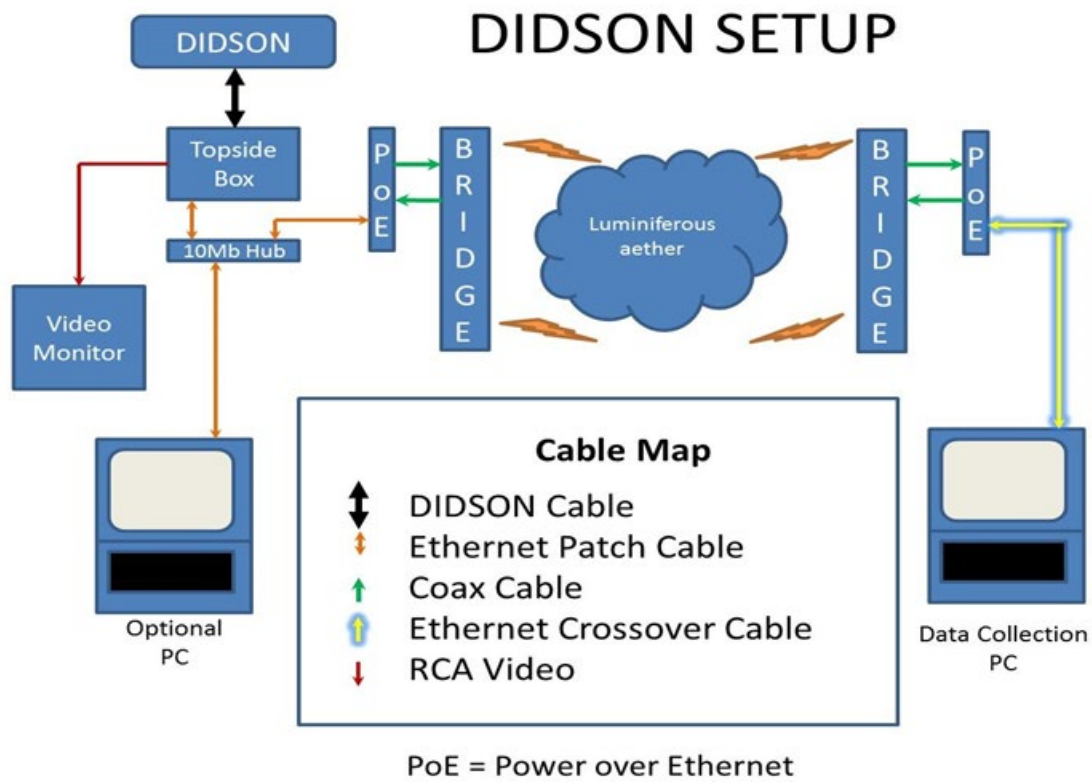
- 2) Select **Drive U:** from drop down menu
Enter Folder : [\\DFGSXQTERA02\SXQTERA](#)
Select/check **Connect using different credentials**
Select **Finish**



- 3) When prompted enter credentials:
Username: **dfgsxqtera02\admin**



APPENDIX G: CISCO BRIDGE CONFIGURATION



Appendix G1.–Wireless bridge diagram.