Operational Plan: Kenai River Chinook Salmon Sonar Assessment at River Mile 13.7, 2016

by

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Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations

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

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ABSTRACT

Alaska Department of Fish and Game (ADF&G) has monitored Chinook salmon (*Oncorhynchus tshawytscha*) passage from 1987 to present in the Kenai River at river mile (RM) 8.6 using side-looking sonar technology. 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, only the RM 13.7 project was operated. This plan covers the RM 13.7 project operations for the 2016 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; Key et al. 2016b). 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 river mile (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). In 2011, 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).

Although the RM 8.6 site has been used historically, the transition to DIDSON multibeam technology has provided the opportunity of moving the sonar program upriver above tidal influence. The RM 8.6 site was originally 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 discontinued operations at the RM 8.6 site. In 2016, the RM 13.7 project will operate 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 RM 8.6 netting data (midriver and nearshore drifts; see Perschbacher 2015[1]). 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 are 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 multibeam sonar deployment (Figures 2 and 3). Land

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[1] This represents a change from 2015, when only midriver netting data were used to generate mixture model estimates during the season.

use permits are obtained from the Department of Natural Resources Division of Parks and Outdoor Recreation. Appendix A1 presents a more detailed description of the site RM 13.7 along with details and diagrams required for annual permit applications (Appendices A2–A15).

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 B1 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.

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 B1). 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 B1). 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 about 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 B4). Additionally, the wider beam dimensions of the ARIS 1800 without the HRL ($14° \times 28°$ versus $4° \times 15°$) 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, Appendices C1 and C2).

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 11 individual range strata on 14 July 2015. By 14 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 20 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 2016.

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. The

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

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 stratum[2]. 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 µs 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.

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 2016.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 Appendices D1–D2. Further information on the NAS configuration and instructions for mapping to the NAS can be found in Appendices E1–E3.

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., Data2016), 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

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[2] 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.

(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 backup hard drive are not sorted or stored according to any hierarchy. However, the naming convention for the data files naturally sorts them by sonar and then date and time.

Upgrades are tentatively planned for the Soldotna office network in 2016. The upgrades would provide offsite data storage. Procedures will be modified as needed to incorporate the new system.

Remote Access to Sonar Site

Because the RM 13.7 site will not be manned at all hours in 2016, 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 Appendices F1–F3. 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 criterion[3].
2) Direction of travel is automatically recorded for each measured fish, as determined from which end of the fish is clicked first during the measurement process[4].

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:

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[3] 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 F2–F3 for further detail on centerline criterion.

[4] If the first click is at the upstream end of the fish, direction of travel is recorded as upstream. Likewise, if the first click is at the downstream end, direction of travel is recorded as downstream. Therefore, accurate direction of travel data usually requires clicking on the snout of the fish first. However, if the fish is facing upstream but is being swept backward by the current, the tail of the fish must be clicked first in order to accurately record the downstream direction of travel.

1) Length will be measured for all large salmon-shaped fish greater than or equal to 75 cm AL that meet centerline criterion.
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) 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.
4) Medium-sized 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.
5) Direction of travel is automatically recorded for each measured fish (see Detail 2 under Standard Protocol above).
6) The ARIS software does not provide a way to record direction of travel for (unmeasured) marked fish. Also, under conditions when the FT protocol is being implemented, it is usually not practical to record direction of travel accurately for all marked fish. Therefore, no effort will be made to identify downstream bound 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-sized 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, but the remaining (unmeasured) shorter fish will not be recorded 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 the centerline criterion.
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 will be automatically recorded for each measured fish (see Detail 2 under Standard Protocol above).

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:

$$\hat{y}_i = \sum_k \sum_s \hat{y}_{iks} \tag{1}$$

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

$$\hat{y}_{iks} = \frac{24}{h_{iks}} \sum_{s=1}^{4} \hat{y}_{ijks} \tag{2}$$

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, which will be estimated as

$$\hat{y}_{ijks} = \frac{60}{m_{ijks}} c_{ijks} \tag{3}$$

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 model[5]; Wolter 1985) with adjustments for missing data as follows:

$$\hat{V}[\hat{y}_i] \cong 24^2(1-f)\frac{\sum\limits_{j=2}^{24} \phi_{ij}\phi_{i(j-1)}\left(\hat{y}_{ij} - \hat{y}_{i(j-1)}\right)^2}{2\sum\limits_{j=1}^{24}\phi_{ij}\sum\limits_{j=2}^{24}\phi_{ij}\phi_{i(j-1)}} \tag{4}$$

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

$$\hat{y}_{ij} = \sum_k \sum_s \hat{y}_{ijks} . \tag{5}$$

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[5] 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).

Other estimates of passage will be obtained by changing the criteria **X** for fish counts c_{ijks} in Equation 3. For example, for estimates of downstream large fish, **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 ARIS lengths of upstream bound fish and midriver RM 8.6 netting data. The estimate of upstream Chinook salmon passage on day i will be

$$\hat{z}_i = \hat{w}_i \hat{\pi}_{Ci} \tag{6}$$

where $\hat{w}_i$ is sampled[6] upstream fish passage on day i, obtained by applying Equations 1–3 for upstream bound 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 ARIS lengths for upstream bound fish from RM 13.7, and midriver netting data from RM 8.6, as described in Appendix G1.

The variance estimate will follow Goodman (1960):

$$\text{vâr}(\hat{z}_i) = \hat{y}_i^2 \, \text{vâr}(\hat{\pi}_{Ci}) + \hat{\pi}_{Ci}^2 \, \text{vâr}(\hat{w}_i) - \text{vâr}(\hat{\pi}_{Ci}) \text{vâr}(\hat{w}_i). \tag{7}$$

ARIS data for upstream bound fish will be used in the mixture model to be consistent with the drift gillnetting data, which presumably capture only upstream bound fish. Midriver and nearshore netting data from RM 8.6 will be used so that the netting sample will best represent the length composition of all migrating Chinook salmon[7].

Daily net upstream Chinook salmon passage will be approximated as

$$\hat{N}_i \approx \hat{z}_i \frac{u_i - d_i}{u_i} \tag{8}$$

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 (FT) 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. Direction of travel is available for these fish; however, accurate direction of travel is not available for marked but unmeasured fish that are 40 cm and up to 75 cm AL. These constraints require the following modifications to the abundance estimators:

---

[6] When the ALF protocol is being employed, w is germane only to those fish selected for measuring, not all fish greater than or equal to 40 cm AL.

[7] This represents a change from 2015, when only midriver netting data were used to generate mixture model estimates during the season.

1) Daily passage y_{FTi} will be defined as the number of all marked and measured salmon-shaped fish greater than or equal to 40 cm AL, except downstream bound fish greater than or equal to 75 cm AL. Equations 1–3 will be used to estimate daily passage except that c_{ijks} will equal the number of all salmon-shaped fish greater than or equal to 40 cm AL (excluding downstream bound 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 lengths from the subset of smaller fish (40 cm up to 75 cm) observed by ARIS, will be fit to the same subset of the data described above.

3) The daily proportion π_{FTi} of the FT protocol fish that are upstream bound 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 all 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 bound 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, but the rest will not be counted. 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 G5) 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} will equal 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

Dates	Activity
1 May–15 May 2016	- 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 - Collect river bottom profile data from each bank using vertically mounted DIDSON
15 May–1 June 2016	Continued training sessions with crew as needed for measuring consistency
1 June 2016 or later	- Deploy nearshore ARIS systems when water level justifies - Deploy minor-channel weir and ARIS when water level justifies
20 August–25 August 2016	Terminate data collection (based on less than 1% cumulative fish passage for 3 days), 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 2017. The final report will be completed by 1 September 2017.

RESPONSIBILITIES

Brandon Key, Fishery Biologist II, Project Leader

Duties: 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

Duties: Assist with conducting and supervising all aspects of the study. 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

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

Jiaqi Huang, Biometrician III

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

Mike Hopp, Fish and Wildlife Technician III, Crew Leader

Duties: 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 2016.

John Sigurdsson, Fish and Wildlife Technician II

Duties: Assist Crew Leader with all aspects of ARIS deployment, operation, and data processing. Approximate work dates: 1 May–20 August 2016.

Shaylee Rizzo, Fish and Wildlife Technician II

Duties: Assist Crew Leader with all aspects of ARIS deployment, operation, and data processing. Approximate work dates: 1 June–20 August 2016.

Nathan Plate, Fish and Wildlife Technician II

Duties: Assist Crew Leader with all aspects of DIDSON and ARIS deployment, operation, and data processing. Approximate work dates: 1 July–20 August 2016.

BUDGET SUMMARY

The total proposed budget for the Kenai River Chinook salmon sonar project (fiscal year 2017) is $209,000. Budget and personnel requirements are summarized below.

Budget summary for FY 17.

Line item	Category	Budget ($K)
100	Personal Services	161.8
200	Travel	4.6
300	Contractual	24.9
400	Commodities	10
500	Equipment	0.0
Total		201

Funded personnel for FY17.

PCN	Name	Level	Funded Man Months
4166	Brandon Key	Fishery Biologist II	12.0
1793	Mike Hopp	Fish & Wildlife Technician III	4.0
4146	John Sigurdsson	Fish & Wildlife Technician II	3.5
5347	Shaylee Rizzo	Fish & Wildlife Technician II	2.6
4305	Nathan Plate	Fish & Wildlife Technician II	2.6
Total			24.7

REFERENCE 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. John Wiley and Sons, New York.

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.

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.

REFERENCES CITED (Continued)

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.

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. 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.

Reynolds, J. H., C. A. Woody, N. E. Gove, and L. F. Fair. 2007. Efficiently estimating salmon escapement uncertainty using systematically sampled data. Pages 121-129 [In] C. A. Woody, editor. Sockeye salmon evolution, ecology, and management. American Fisheries Society, Symposium No. 54, Anchorage.

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.

Xie, Y., and F. J. Martens. 2014. An empirical approach for estimating the precision of hydroacoustic fish counts by systematic hourly sampling. North American Journal of Fisheries Management 34(3):535-545.

TABLES

Table 1.–ARIS system components to be used in 2016.

System component	Qty	Description
Sounders	4	ARIS 1200
		Left bank mainstem offshore
		Right bank mainstem offshore
		Right bank mainstem nearshore
		Right bank minor channel
	1	ARIS 1800
		Left bank mainstem nearshore
Lens assembly	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

Table 2.–Sampling schedule and parameter settings on 14 July 2015 for each range stratum sampled by 5 sonars at RM 13.7.

Location	ARIS serial no.	Range stratum	Time (min past hour)	Frame rate (frames /sec)	Start range (m)	End range (m)	Frequency	Tx Power	Receiver gain (dB)	Pulse length (μs)	Start delay (s)	Sample period (s)	Samples per beam	AR2 tilt	Pitch	Roll	Heading
Left near	1096																
		1	00,30	8.00	2.5	13.5	High	Max	16	20	3459	10	1520	9.22	−2.6	1.4	181
Left far	1064																
		1	00,30	10.00	3.5	8.0	High	Max	2	13	4836	10	621	3.37	−7.0	−8.6	85
		2	10,40	10.00	8	22.0	High	Max	10	20	11058	10	1934	6.43	−3.9	−8.6	85
		3	20,50	6.61	22	33.5	High	Max	16	33	30412	10	1589	8.72	−2.0	−8.5	85
Right far	1063																
		1															
		2	00,20	9.00	8	22.0	High	Max	17	20	11046	10	1933	0.98	−2.5	−1.0	22
		3	10,30	6.90	22	33.5	High	Max	17	31	30412	10	1590	1.43	−2.0	−1.0	21
Right near	1098																
		1	40	9.00	3.5	8.0	High	Max	6	13	4850	10	624	−6.07	−6.0	1.8	271
		2	50	9.00	8	20.0	High	Max	6	20	11086	10	1663	−4.34	−4.5	−1.9	269
Channel	1095																
		1	00	8.30	2	6.0	High	Max	2	13	2778	10	556	−0.24	−11.5	−1.9	25
		2	10	9.00	6	12.0	High	Max	8	13	8256	10	826	7.27	−5.1	−2.2	25
		3	20	9.00	12	22.0	High	Max	16	21	16494	10	1373	10.79	−1.7	−2.0	25
		Weir	50	9.00	1.5	4.0	High	Max	16	5	2064	10	344	−0.87	−12.9	1.0	14

Table 3.–Summary of sonar stratum ranges (in meters) by date at RM 13.7, 2015.

Sonar location	Stratum	Start time	12 May	21 May	26 May	1 Jun	3 Jun	4 Jun	5 Jun	9 Jun	29 Jun
Left near											
	1	00/30	N/A	N/A	2.5–10	2.5–10	2.5–10	2.5–10	2.5–12.5	2.5–13.5	2.5–13.5
Left far											
	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	3.5–8
	2	10/40	8–22	8–22	8–22	8–22	8–22	8–22	8–22	8–22	8–22
	3	20/50	22–35	22–33.5	22–33.5	22–33.5	22–33.5	22–33.5	22–33.5	22–33.5	22–33.5
Right far											
	1	00/30	3.5–8	3.5–8	3.5–8	N/A	N/A	N/A	N/A	N/A	N/A
	2	10	8–22	8–22	8–22	8–22	8–22	8–22	8–22	8–22	8–22
	3	20	22–35	24–33.5	24–33.5	24–33.5	24–33.5	24–35	24–35	24–35	24–35
Right near											
	1	40	N/A	N/A	N/A	3.5–8.1	3.5–8	3.5–8	3.5–8	3.5–8	3.5–8
	2	50	N/A	N/A	N/A	8.1–16.1	8–16	8–16	8–16	8–18.2	8–20
Channel											
	1	0	N/A	N/A	N/A	N/A	N/A	2.6–6.01	2.6–6.01	2.6–6.01	2–6
	2	10	N/A	N/A	N/A	N/A	N/A	6–12	6–12	6–12	6–12
	3	30	N/A	N/A	N/A	N/A	N/A	12–22	12–22	12–22	12–22
	Weir	10/50	N/A	N/A	N/A	N/A	N/A	1.5–4	1.5–4	1.5–4	1.5–4

[a]   The left bank near sonar was deployed on 26 May.

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

[c]   The right bank near sonar was deployed on 1 June.

[d]   The channel sonar was deployed on 4 June.

[e]   No changes were made to range after 29 June.

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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 µs to 100 µs	4 µs to 100 µs	7 µs, 13 µs, 27 µs, 54 µs (relative to window length)	4.5 µs, 9 µs, 18 µs, 36 µs (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 µPa at 1 m	~200–206 dB re 1 µPa 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

Table 5.–Data storage needs for data collected in 2015 from 5 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.
Total					
Hourly			4.725	7.5	
Daily (hourly × 24)			113.4	179.4[d]	
Season [b,c]			9,866	17,543	or ~17.5 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 20 August (102 days), inshore and channel sonars operate 1 June to 20 August (81 days).

[d] Amount of data generated daily will fluctuate based on sonars in operation and individual stratum settings.

FIGURES
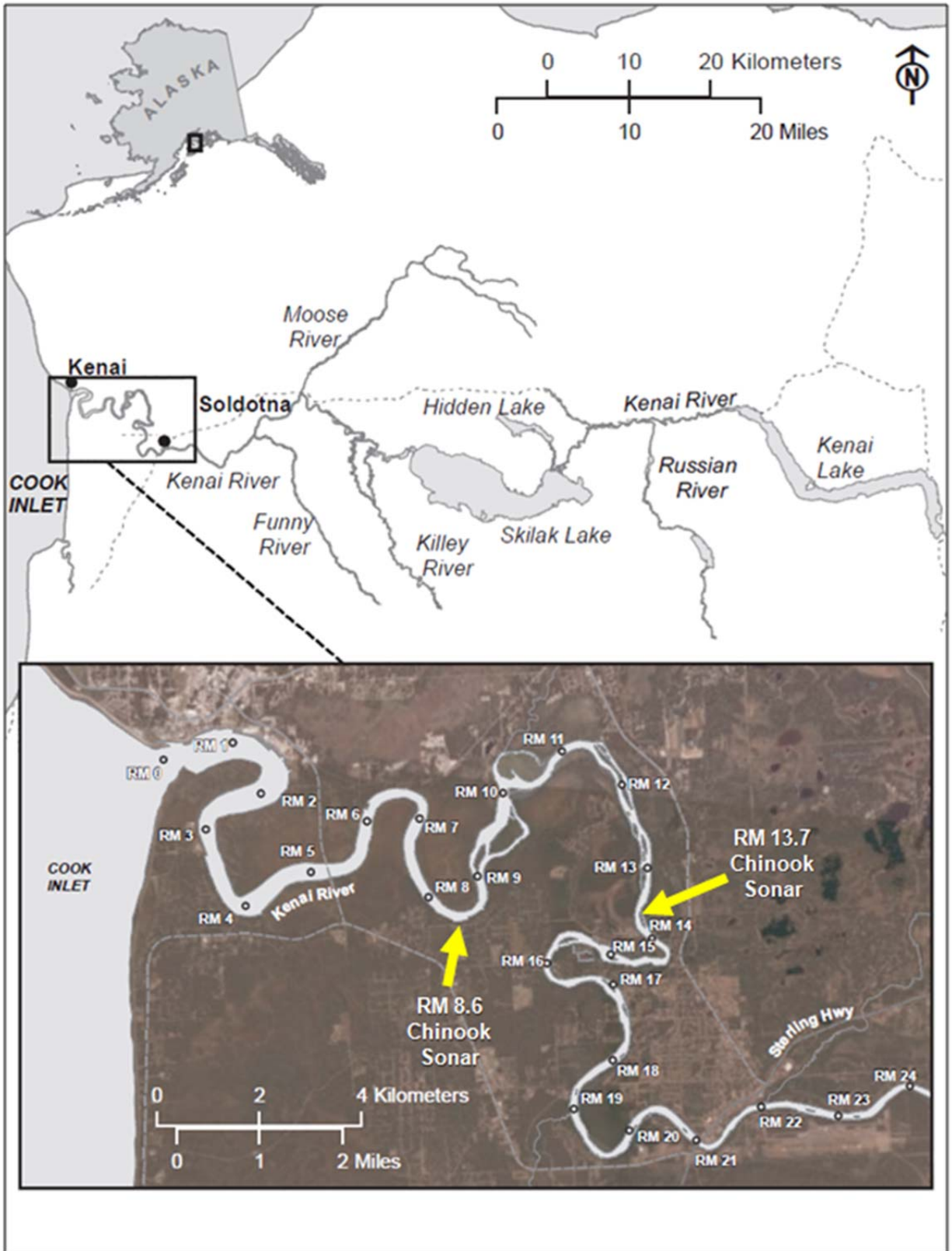
Figure 1.–Map of Kenai River showing location of historical Chinook salmon sonar site at river mile 8.6 and new sonar site at river mile 13.7.
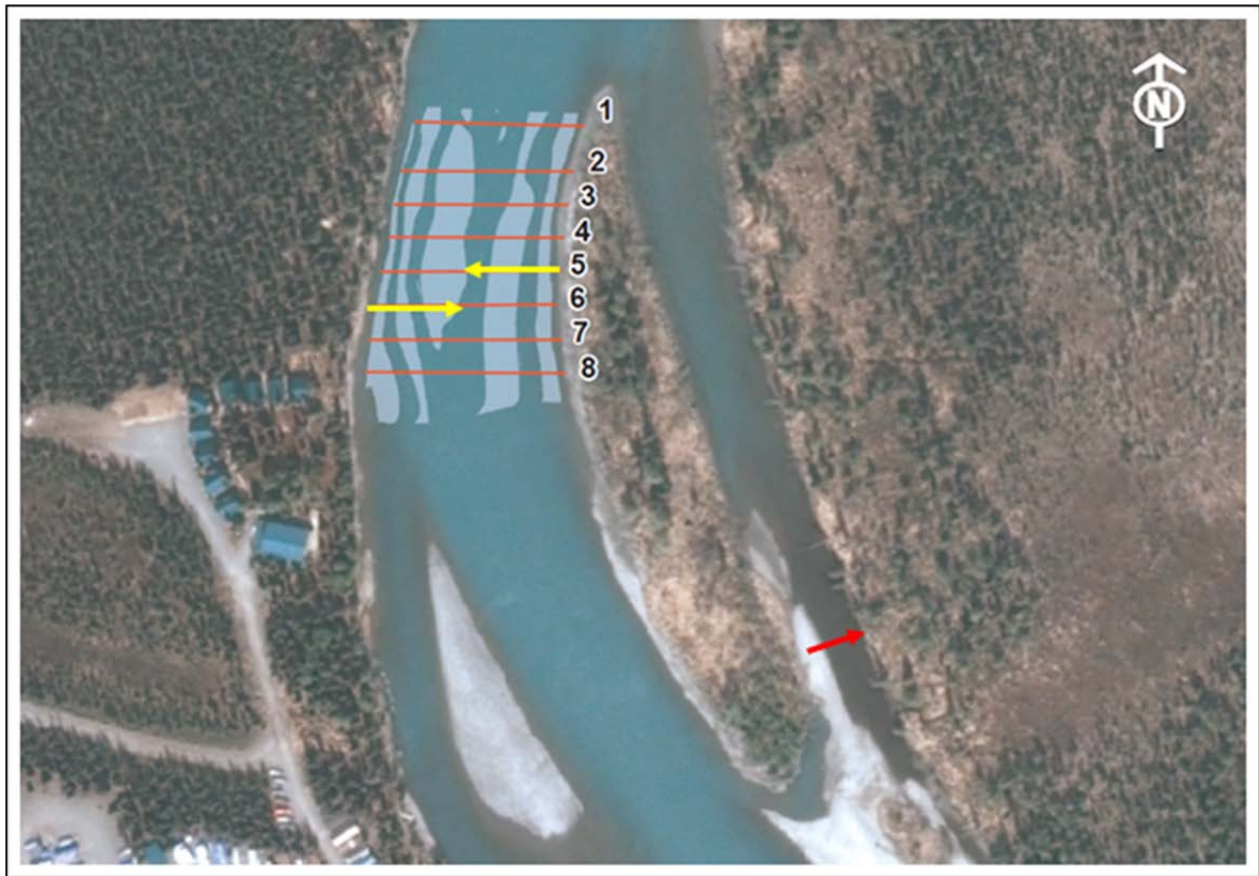
Figure 2.–Yellow arrows indicate preferred locations for sonars on each bank of the main channel.

Note: Red arrow indicates approximate location for sonar in the minor channel.
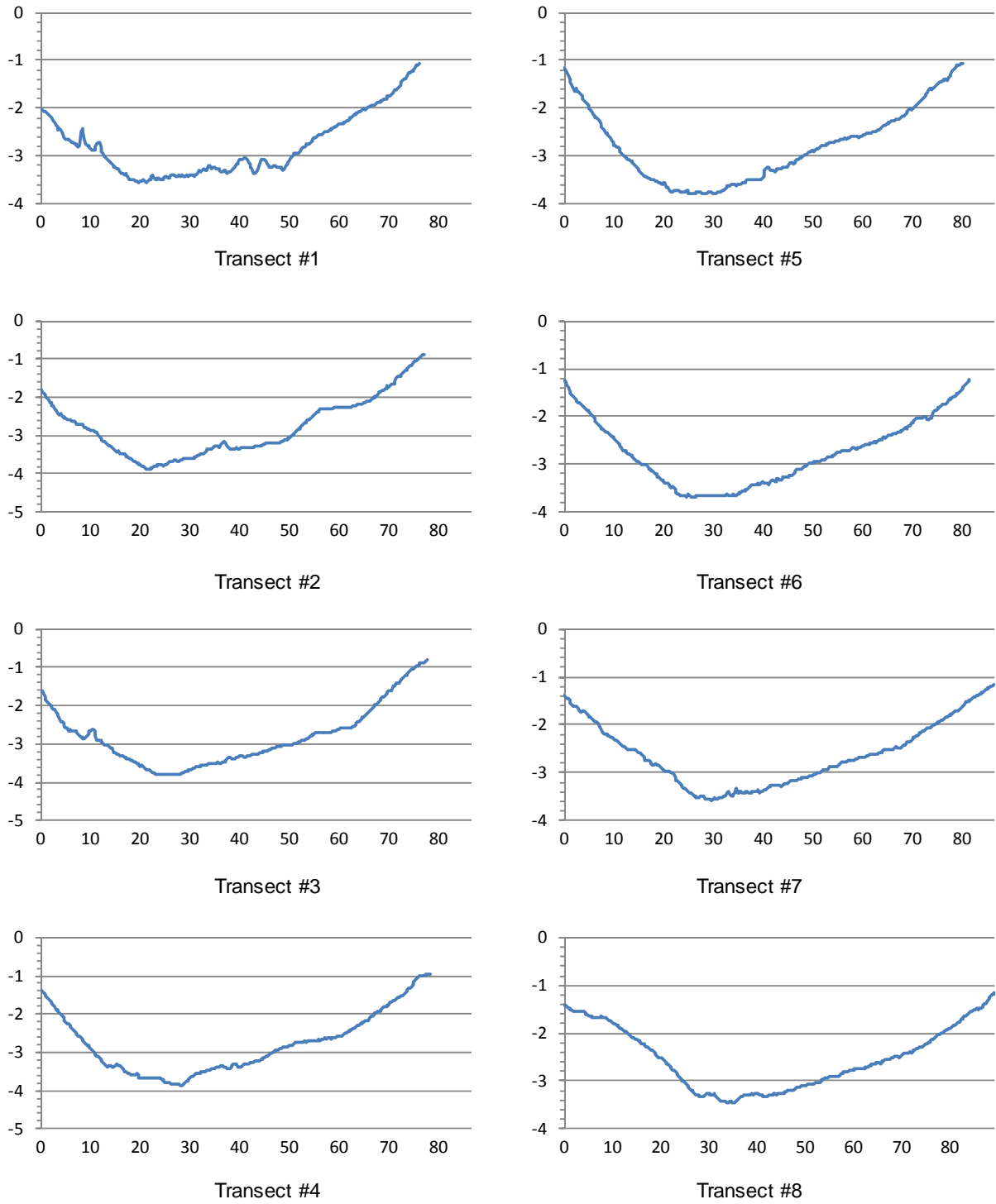
Figure 3.–Corresponding profiles for 8 of the 9 transects conducted near RM 13.7 of the Kenai River (see Figure 2).

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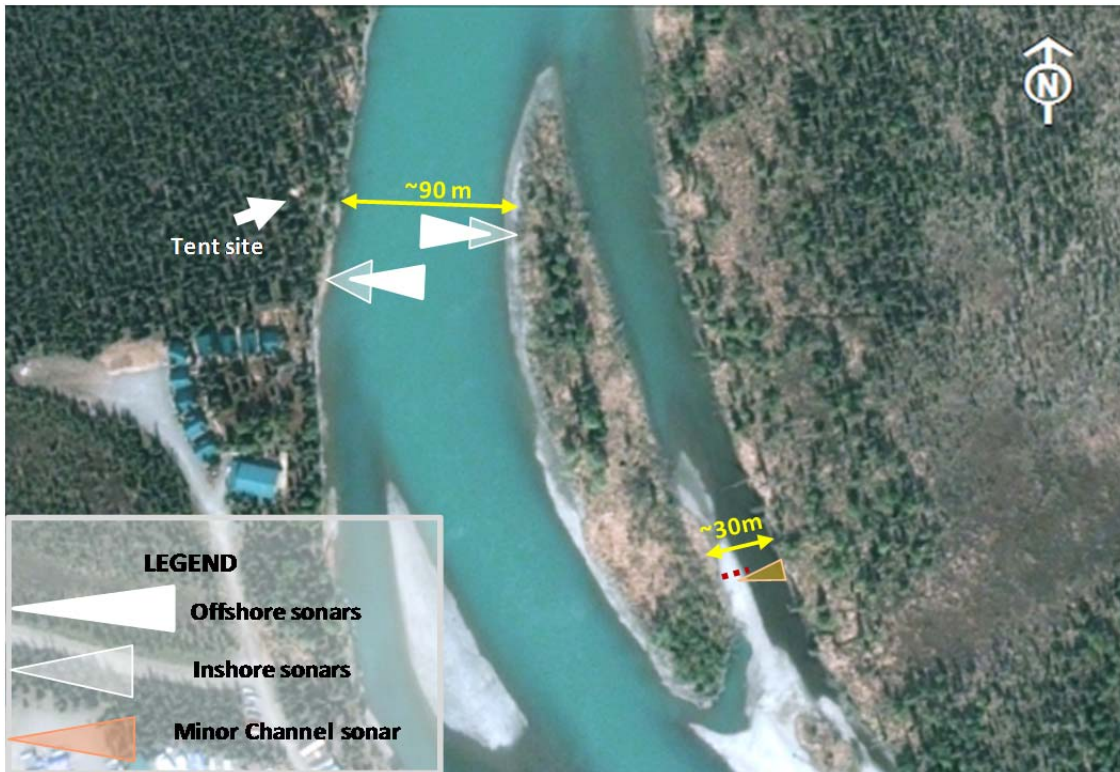
Figure 4.–Kenai River RM 13.7 sonar site showing approximate deployment locations and beam coverage of 5 ARIS units.
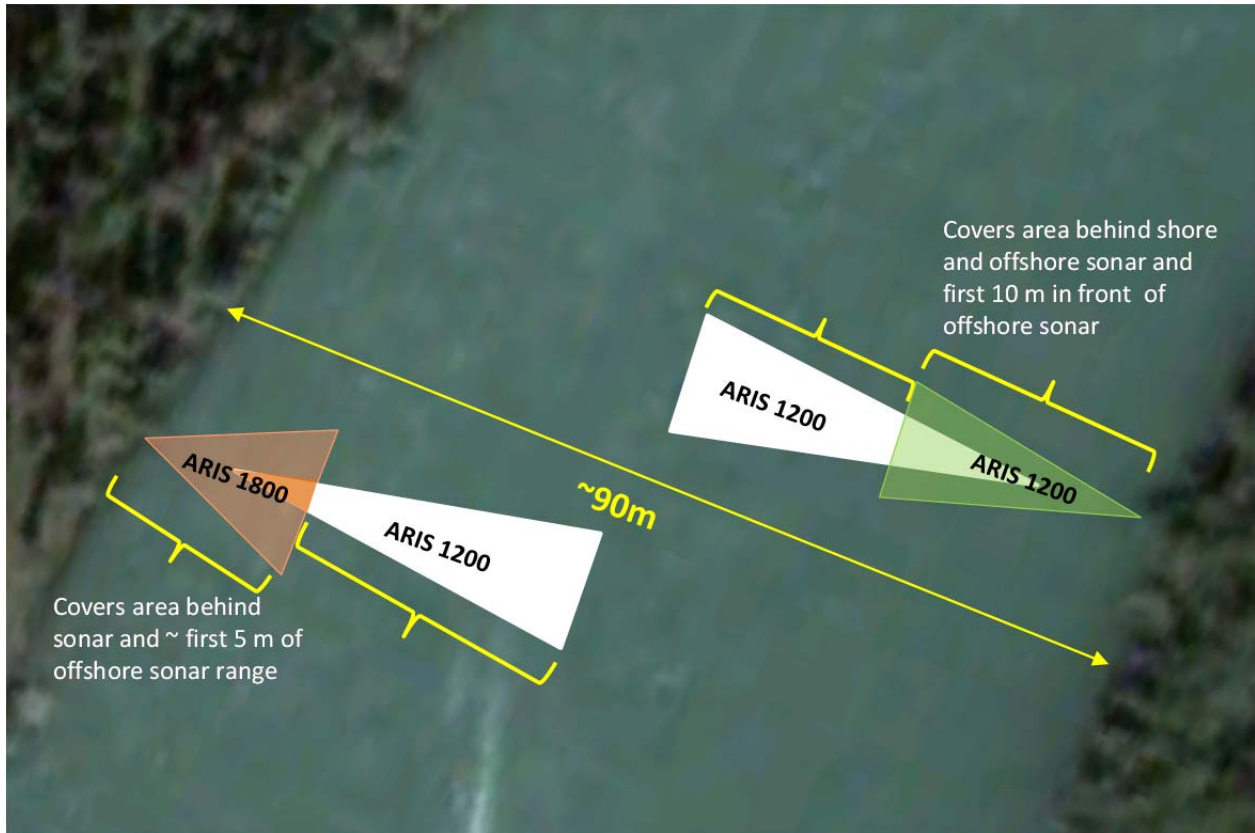
Figure 5.–Deployment schematic for ARIS systems in 2016 on the main channel at RM 13.7. Image taken from Google Maps © 2013.

	Left bank inshore	Left bank offshore	Right Bank inshore	Right Bank offshore
Effective Beam Size (deg)	14	4	4	4
Sample range (m)	15.1	33	20	35
Pitch angle (deg)	-6.6	-3.9	-4.9	-2.4
rotators				
Select which beams to use:	LB Inshore	LB offshore	RB Inshore	RB offshore

	Range	Depth	weir end
LB inshore	2.5	-0.6	
LB offshore	8.5	-1.7	
RB inshore	4.5	-0.6	max range 94.25
RB offshore	14.25	-1.6	
	80	-2.35	

	Left bank inshore	Left bank offshore	Right Bank inshore	Right Bank offshore
Effective Beam Size (deg)	14	4	4	4
Sample range (m)	15.1	33	20	35
Pitch angle (deg)	-6.6	-3.9	-4.9	-2.4
rotators				
Select which beams to use:	LB Inshore	LB offshore	RB Inshore	RB offshore

	Range	Depth	weir end
LB inshore	2.5	-0.6	
LB offshore	8.5	-1.7	
RB inshore	4.5	-0.6	max range 95.5
RB offshore	14.25	-1.6	
	80	-2.35	

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.

Showing extended nearshore range for RB nearshore and eliminating the first RO stratum

Left Bank

Distance LN to LO = 8.7 m
Distance LN to start of LO Stratum 1 = 8.7+3.5 = 12.2 m
Total distance covered by LN = 12.1 m
Overlap between end of LN and start of LO Stratum 1 = 12.1-12.2 = -0.1 m

Stratum 2   Stratum 1   8.0m

21.94m

34.6m

Right Bank

Stratum 2   Stratum 1   3.5m
9m
18m

Distance RN to RO = 10 m
Distance RN to start of RO Stratum 1 = 10+8.0 = 18 m
Total distance covered by RN = 18 m
Overlap between end of RN and start of RO Stratum 1 = 18-18 = 0 m

34.97m
22.0m
3.5m   8.0m
Stratum 1   Stratum 2   Stratum 3

single stratum
2.4-12.1m

2.4m Start range
8.7m Offshore sonar at 6.1m
12.1m End range

Flow

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

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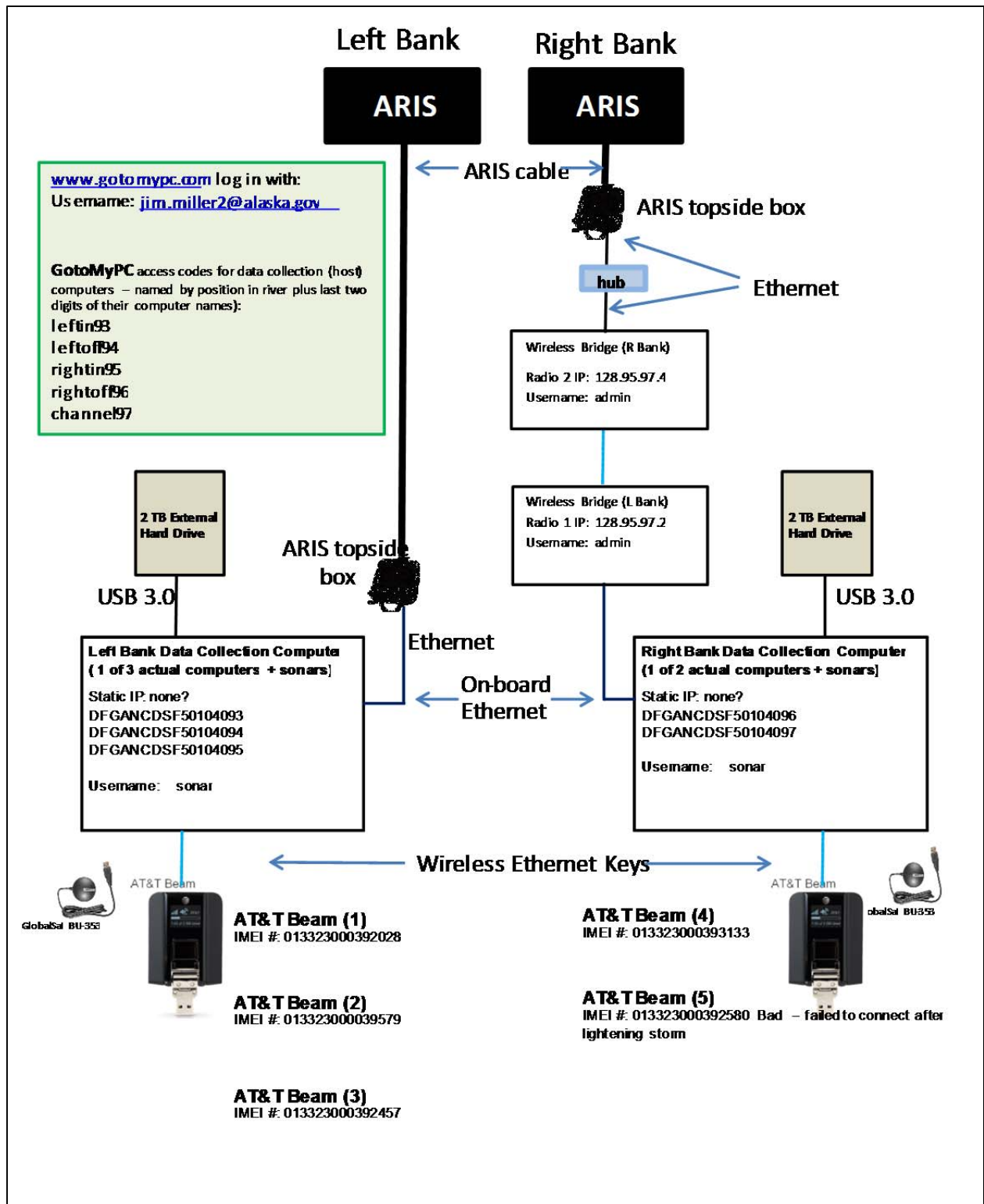
Figure 11.–ARIS data collection schematic for the RM 13.7 site.

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.

Power Strip

Power

Remote Switch

Power from Battery Bank

Power

Power

Power

Topside 24v AC adaptor

Hub

wireless bridge power injector

Ethernet

Ethernet

ARIS Topside Box

Ethernet or Coax to Bridge

300' ARIS cable

CISCO Wireless Bridge
Model AIR-BR1310G-A-K9-R
IP address: 128.95.97.2xx
Subnet Mask: 255.255.255.0
Gateway: XX-XX-XX-XX-XX-XX
128.95.97.227 (DIDSON IP)
Unit MAC Address: XX-XX-XX-XX-XX-XX
Radio A MAC Address: XX-XX-XX-XX-XX-XX

update

CISCO Wireless Bridge
Model AIR-BR1310G-A-K9-R
IP address: 128.95.97.X
Subnet Mask: 255.255.255.0
Gateway: XX-XX-XX-XX-XX-XX
128.95.97.227 (DIDSON IP)
Unit MAC Address: XX-XX-XX-XX-XX-XX
Radio A MAC Address: XX-XX-XX-XX-XX-XX

update

Ethernet or Coax to Bridge

wireless bridge power injector

Ethernet

Data Collection Laptop on Left bank

IP address: 128.95.97.2XX
Subnet Mask: 255.255.0.0

update

The Magnum Pure Sine Inverter kit (MMS1012–G1000 W/12V) combines the inverter and charger which are stored/mounted in the white container at the lower left corner of the fish tote. The controller (ME-RC50) is mounted on the top of the container. The system is powered by two AGM L16 6V batteries that are charged daily by 1000W Honda generator. Additional batteries can be added as required.

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)

Left bank Offshore (3 strata)

Stratum 1: 2.5-12.1 m
Pitch = -3.6°

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)

Stratum1:3.5-9.0 m
Pitch = -6.0°

Stratum 2:9.0-21.0 m
Pitch = -4.5°

Stratum 2: 8.0 to 22.0 m
Pitch = -4.0°
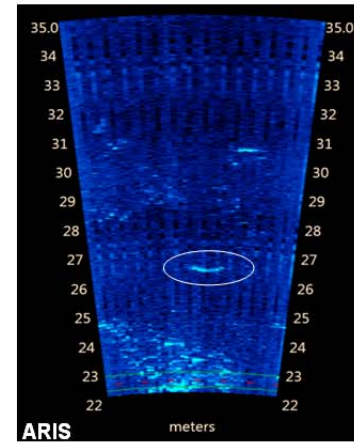
Stratum 3: 22.1-35.0 m
Pitch = -3.8°

Figure 13.–Example images from each of the 4 left bank (top) and 4 right bank (bottom) range strata taken on 15–18 July 2014.

Note: Fish swimming through the beams are circled on each image.
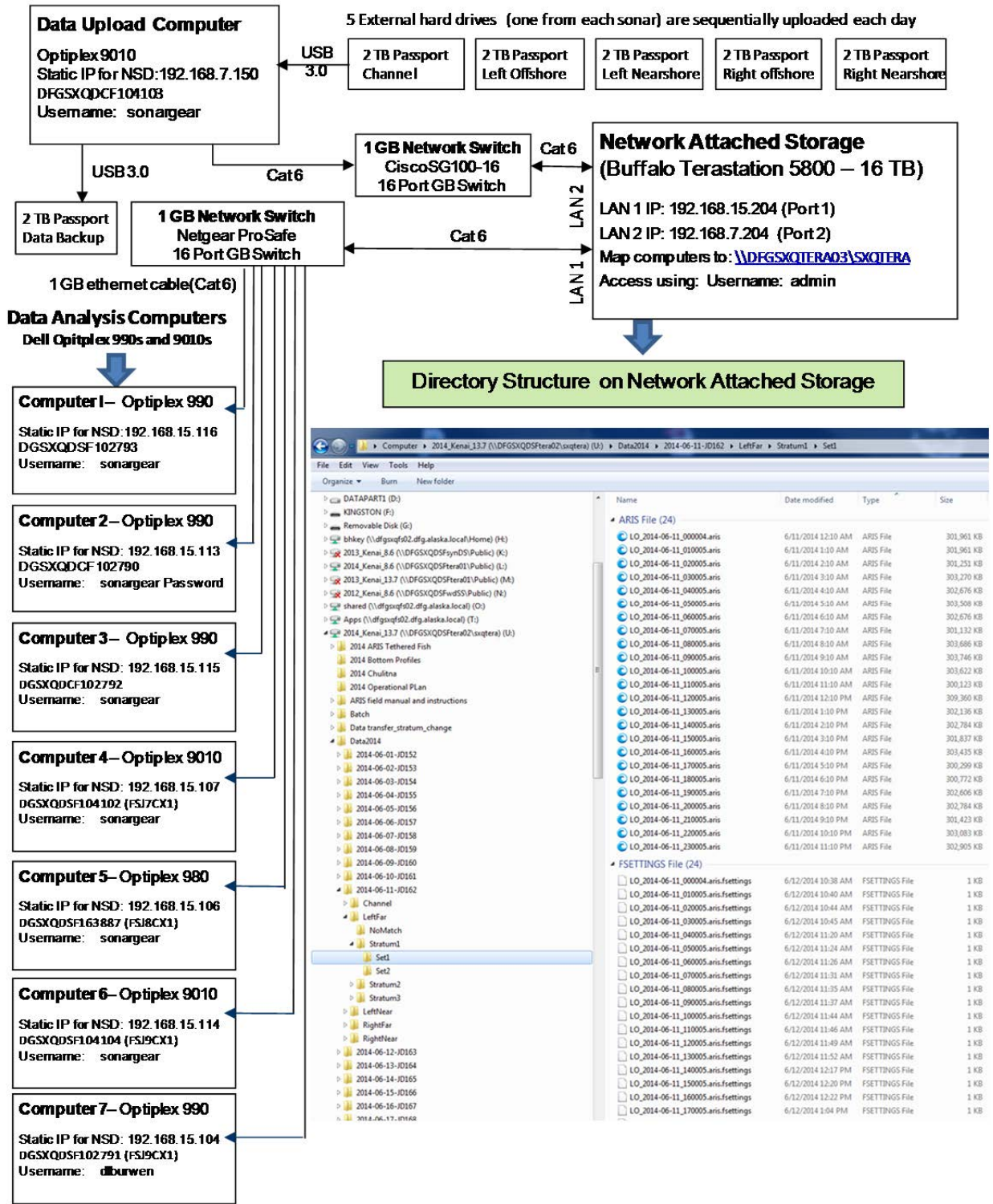
Figure 14.–Directory structure for the Network Attached Storage System in the Soldotna office showing the contents of the left bank offshore sonar for 17 May 2014.
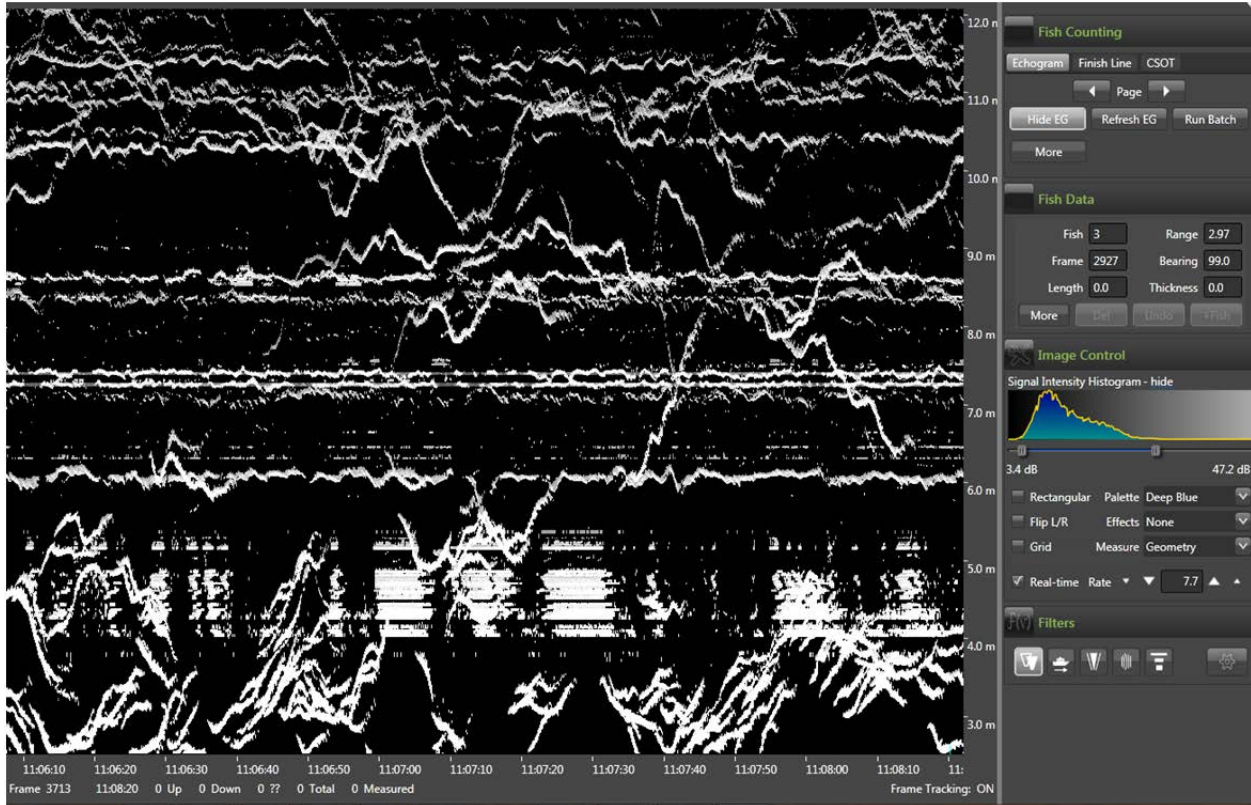
Figure 15.–An example of high density passage from 6 August 2014.

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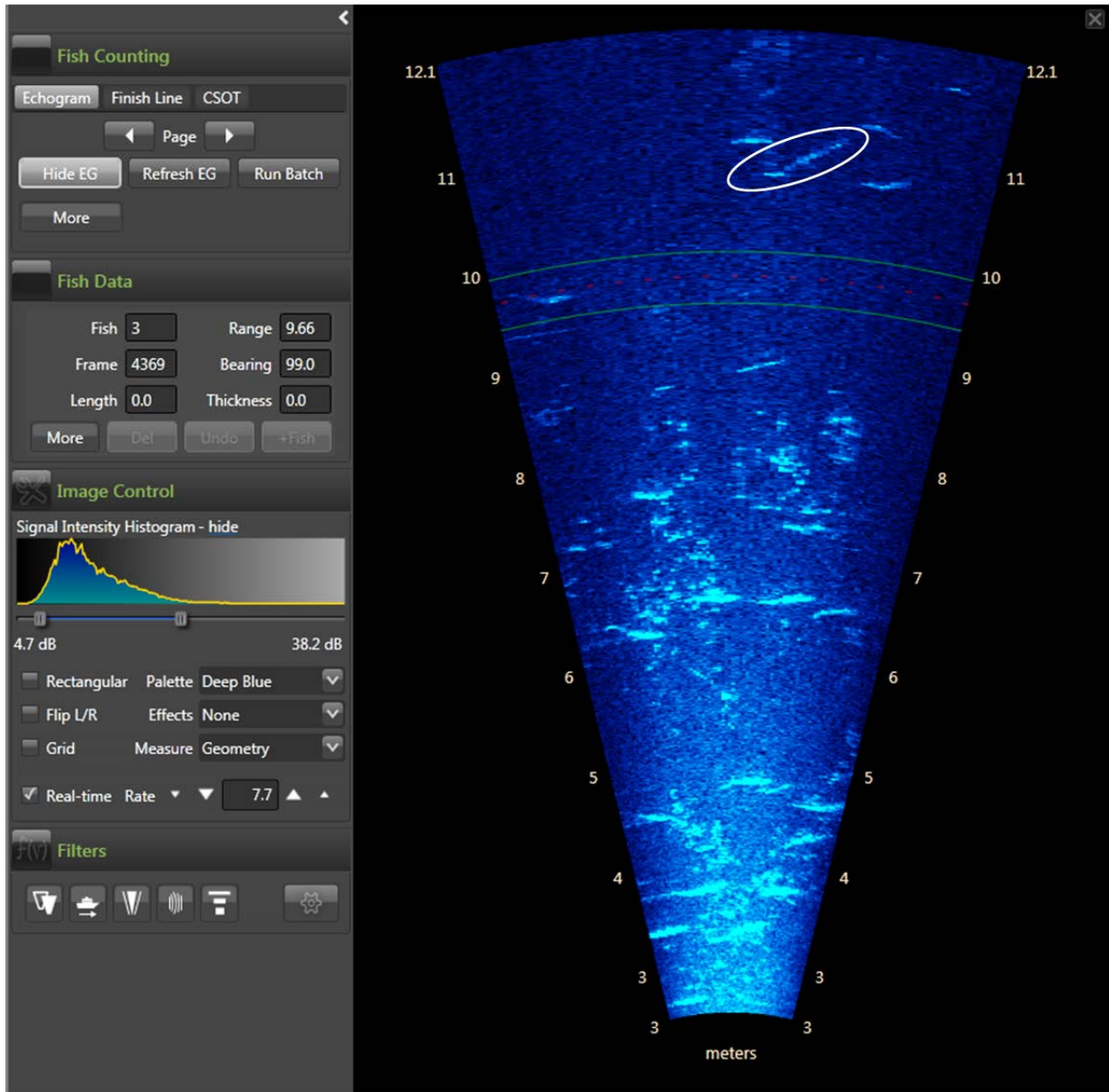
Figure 16.–Example of a Chinook salmon about 99 cm (AL) at 11 m swimming past milling pink salmon on 5 August 2014.

APPENDIX A: RM 13.7 SITE INVESTIGATION DOCUMENTATION

Benefits of using the RM 13.7 site to collect sonar data include the following: 1) the State of Alaska owns land on both sides of the river (Department of Natural Resources [DNR] land on the left[8] [KPB parcel 055-250-23] and right bank [KPB parcel 057-250-30]) (Appendix A2), 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 A3). 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.

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[8] Looking downstream.
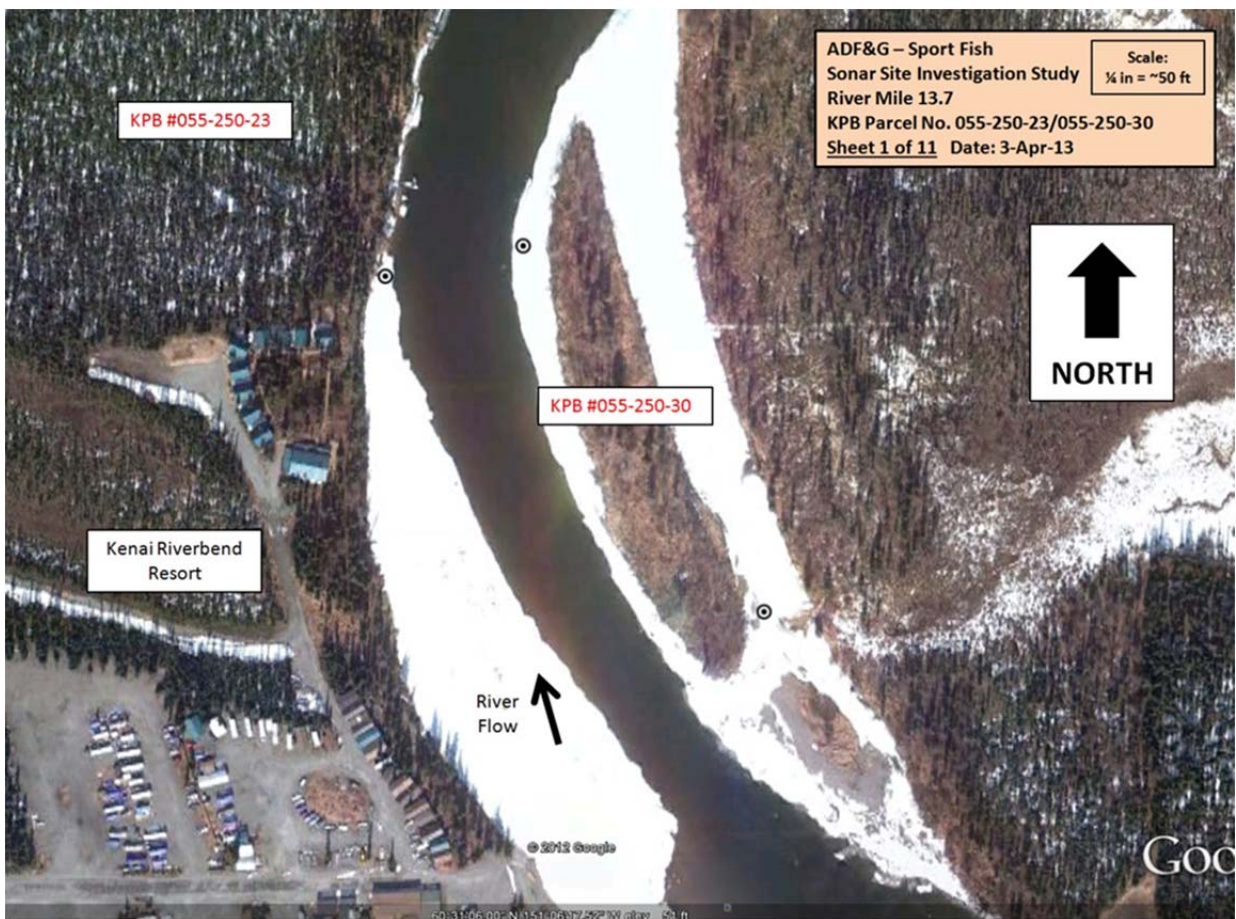
Appendix A2.–Aerial map and parcel numbers for RM 13.7 sonar site. Image taken from Google Maps © 2013.
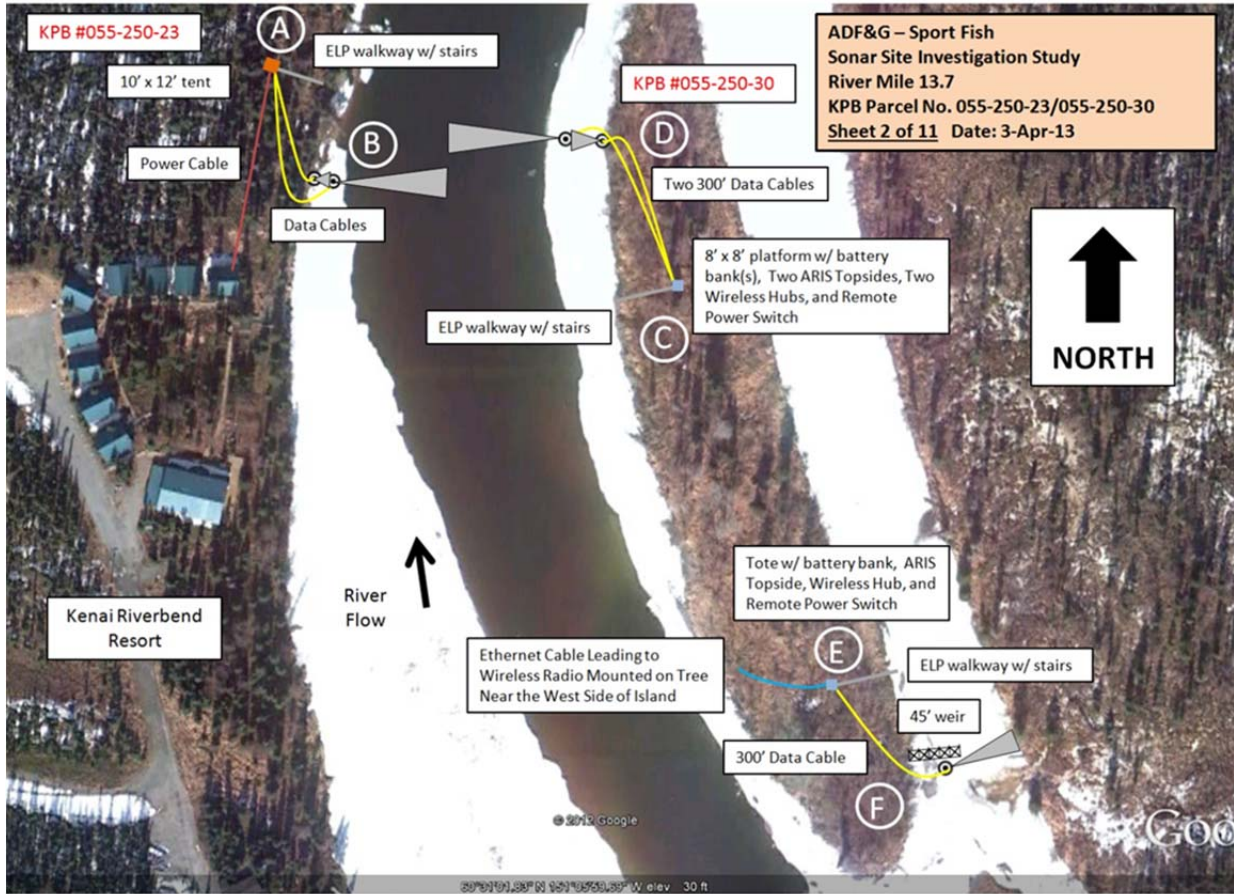
Appendix A3.–Aerial view of sonar deployment at the RM 13.7 sonar site. Image taken from Google Maps © 2013.

Note: Letters A–F show locations of diagrams in Appendices A4–A12.

Top View – Main Channel Left Bank (looking downstream)

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

(A) (B)

Scale:
1 in = ~14ft

Ordinary High Water

NORTH

Tent located >50 ft inland from ordinary high water

Removable elevated light penetrating walkway (3 ft wide), platform (12 ft x 8 ft), and steps (3 ft x 8 ft).

10 ft x 12 ft WeatherPort supported by elevated temporary wooden plywood platform - located in open area so no vegetation removal will be required

River Flow

Electronic control cables leading from tent to sonar units in the river

Submerged steel tripods (~6 ft and 24 ft from OHW) with ARIS units attached – location will be identified by a marker float on the water's surface

Power cable (250 ft) running from Riverbend Resort cabin to sonar tent

Appendix A4.–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

10 ft x 12 ft
WeatherPort supported
by elevated temporary
wooden plywood
platform - located in
open area so no
vegetation removal will
be required

Tent located 50 ft inland from ordinary high water

12 ft x 8 ft
removable ELP
platform

Removable
elevated light
penetrating steps
(3 ft x 11 ft)

Removable ELP walkway (3 ft wide)

8 ft

Electronic control cables leading from tent to sonar units in the river

Ordinary
High
Water

Appendix A5.–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

ADF&G – Sport Fish
Sonar Site Investigation Study
River Mile 13.7
KPB Parcel No. 055-250-23
Sheet 5 of 11   Date: 3-Apr-13

Scale:
1 in = ~4 ft

Ⓑ

Submerged steel tripods 6 ft and 24 ft from OHW with ARIS units attached – location will be identified by a marker float on the water's surface

Electronic control cables leading from tent to sonar unit in the river

Ordinary High Water

~ 6 ft

~ 24 ft

Appendix A6.–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

ADF&G – Sport Fish
Sonar Site Investigation Study
River Mile 13.7
KPB Parcel No. 055-250-30
Sheet 6 of 11   Date: 3-Apr-13

C   D

Scale:
1 in = ~12 ft

NORTH

50 ft from OHW

8 ft x 8 ft ELP platform located in open area so no vegetation removal will be required

Electronic control cables leading from totes to sonar units in the river

Submerged steel tripods (~6 ft and 45 ft from OHW) with ARIS units attached – location will be identified by a marker float on the water's surface

Battery bank and sonar topside equipment housed in two 4 ft x 3 ft plastic container tote

Small 2000 watt generator housed in a 3 ft x 2 ft wooden box lined with plastic for spill containment

Ordinary High Water

Removable elevated light penetrating walkway and steps.

River Flow

Two wireless radio antennas strapped to tree to transmit data to tent located across the river

Tree

Appendix A7.–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**

ADF&G – Sport Fish
Sonar Site Investigation Study
River Mile 13.7
KPB Parcel No. 055-250-30
Sheet 7 of 11   Date: 3-Apr-13

Ⓒ

Scale:
1 in = ~8 ft

Two wireless radio antennas strapped to tree to transmit data to tent located across the river

Small 2000 watt generator housed in a 3 ft x 2 ft wooden box lined with plastic for spill containment

Removable elevated light penetrating walkway (3 ft wide) and steps (3 ft x 11 ft).

Battery bank and sonar topside equipment housed in two 4 ft x 3 ft plastic container totes

Ordinary High Water

Wooden platform located 50 ft inland from OHW

Electronic control cables will lead from totes to sonar units in the river

8 ft x 8 ft ELP platform located in open area so no vegetation removal will be required

Appendix A8.–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**

ADF&G – Sport Fish
Sonar Site Investigation Study
River Mile 13.7
KPB Parcel No. 055-250-30
Sheet 8 of 11   Date: 3-Apr-13

Scale:
1 in = ~6 ft

Ⓓ

Submerged steel tripods
(~6 ft and 45 ft from OHW)
with ARIS units attached –
location will be identified
by a marker float on the
water's surface

Electronic control cables
leading from topside totes
to sonar units in the river

Ordinary
High
Water

~ 6 ft

~ 45 ft

Appendix A9.–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

8 ft x 8 ft ELP platform located in open area so no vegetation removal will be required

ADF&G – Sport Fish
Sonar Site Investigation Study
River Mile 13.7
KPB Parcel No. 055-250-30
Sheet 9 of 11   Date: 3-Apr-13
E   F
Scale: 1 in = ~ 14 ft

50 ft from OHW

Removable elevated light penetrating walkway and steps.

River Flow

NORTH

Battery bank and sonar topside equipment housed in a 4 ft x 3 ft plastic container tote

Small 1000 watt generator housed in a 3 ft x 2 ft wooden box lined with plastic for spill containment

Large warning buoys suspended from weir tripod supports

~ 45 ft rigid tripod-style weir to deflect fish in front of sonar transducer

Ethernet cable will lead from the platform to a wireless radio mounted on a tree located on the west side of the island

Ordinary High Water

Electronic control cable leading from topside tote to sonar unit in the river

Submerged steel tripod (~40 ft from OHW) with ARIS unit attached

Appendix A10.–Aerial view of minor channel battery bank, weir, and sonar deployment at the RM 13.7 sonar site.

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

Wireless radio antennae strapped to tree near west side of island to transmit data to tent located across the river (up to 100 ft of Ethernet cable running from tote to wireless radio).

Small 1000 watt generator housed in a 3 ft x 2 ft wooden box lined with plastic for spill containment

Battery bank and sonar topside equipment housed in a 4 ft x 3 ft plastic container tote

ADF&G – Sport Fish
Sonar Site Investigation Study
River Mile 13.7
KPB Parcel No. 055-250-30
Sheet 10 of 11 Date: 3-Apr-13

Ⓔ

Scale:
1 in = ~ 8 ft

Removable elevated light penetrating walkway (3 ft wide) and steps (3 ft x 11 ft).

Ordinary High Water

ELP platform located 50 ft inland from OHW

8 ft x 8 ft ELP platform located in open area so no vegetation removal will be required

Electronic control cable will lead from tote to sonar unit in the river

Appendix A11.–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

ADF&G – Sport Fish
Sonar Site Investigation Study
River Mile 13.7
KPB Parcel No. 055-250-30
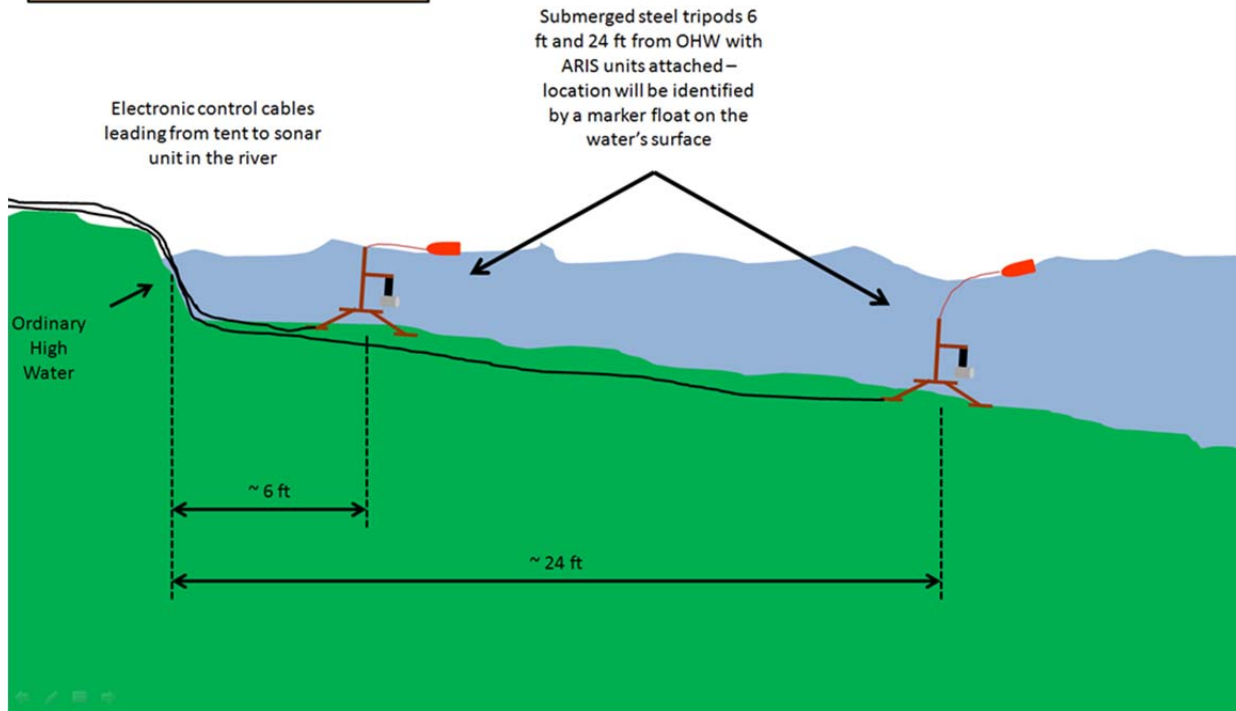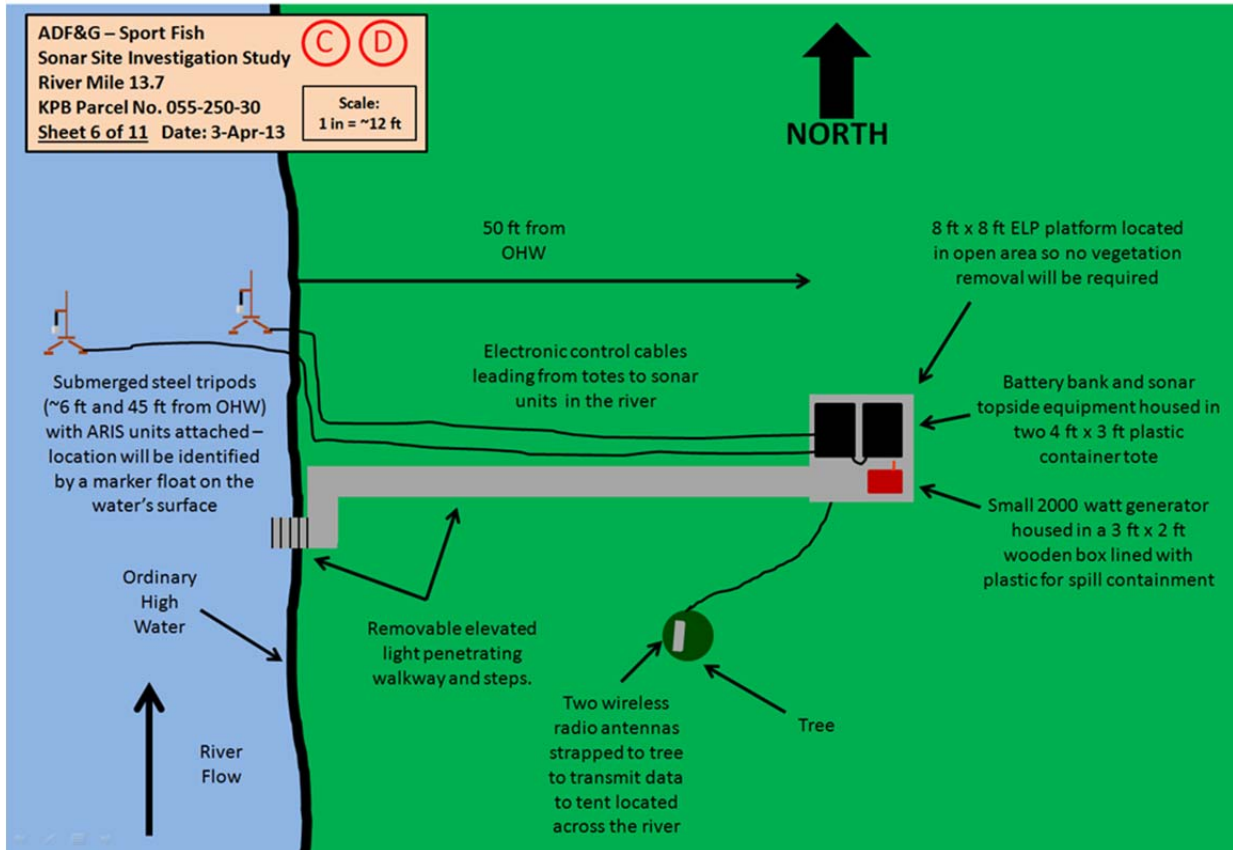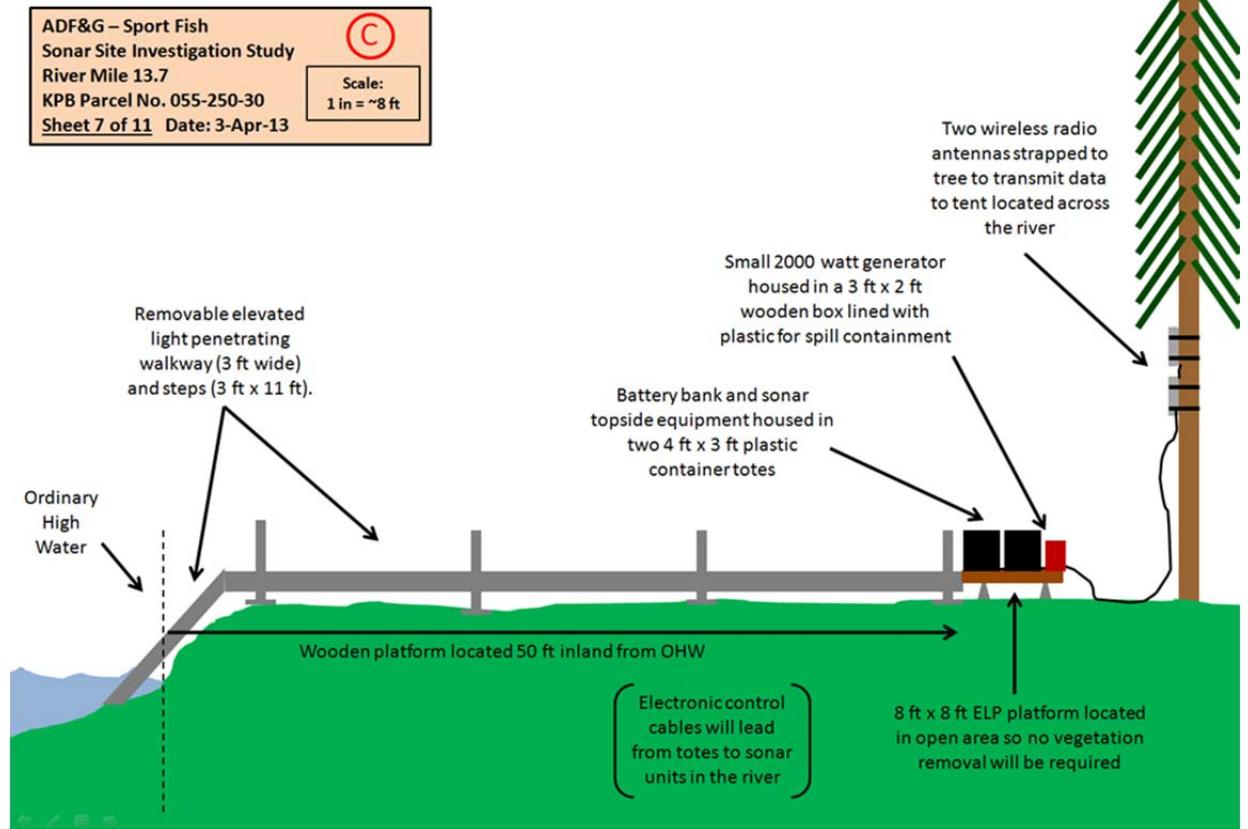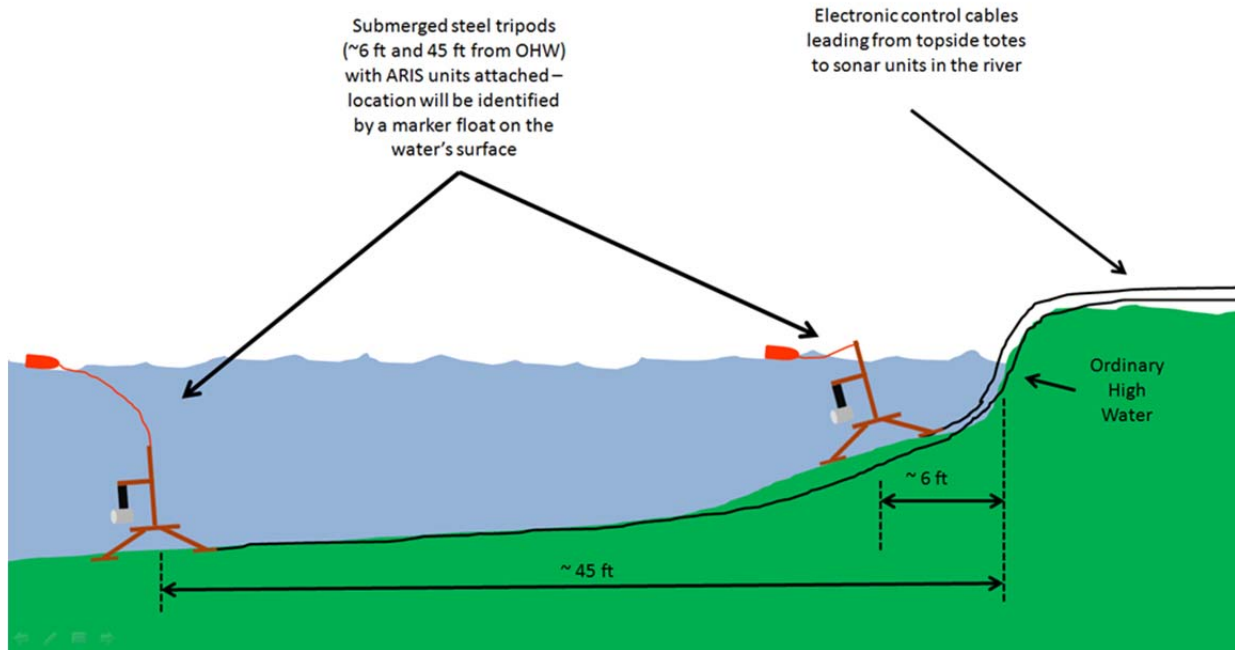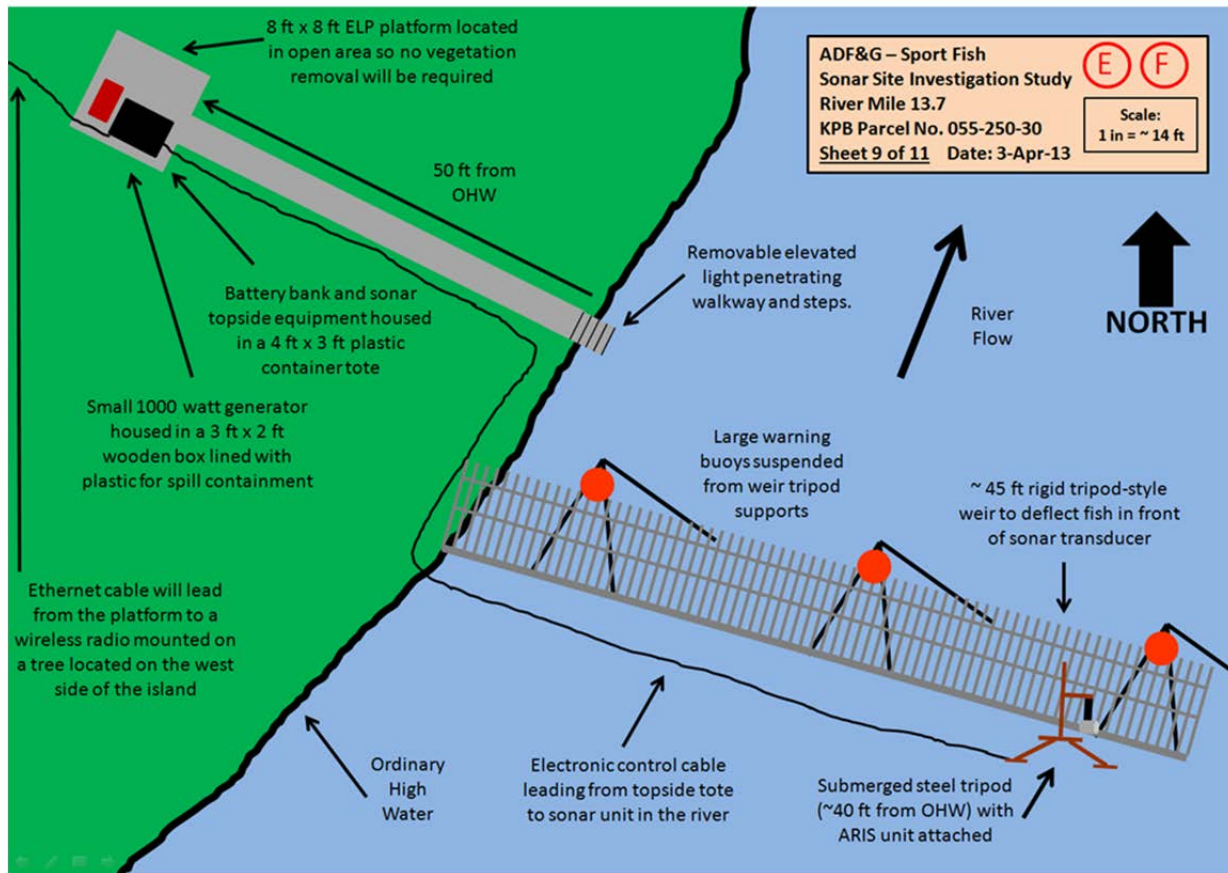Sheet 11 of 11 Date: 3-Apr-13

Scale:
1 in = ~6 ft

F

~ 45 ft rigid tripod-style
picket weir to deflect fish
to pass in front of sonar
transducer

Large warning
buoys suspended
from weir tripod
supports

Submerged steel tripods
~40 ft from OHW with ARIS
units attached – location
will be identified by a
marker float on the water's
surface

Ordinary
High
Water

Electronic control cable
lead from topside tote to
sonar unit in the river

~ 40 ft

~ 45 ft

Appendix A12.–Side view of minor channel battery weir and sonar tripod deployment at the RM 13.7 sonar site.

RM 13.7 Tent Electronics Schematics

16.5 amps max

Multi Plug Adapter

Multi Plug Adapter

AC power from cabin

Battery Backup #1

Battery Backup #2

Power	Device
0.5 amp	ARIS Topside (LB Nearshore)
2.5 amp	Laptop #1 (LB Nearshore)
0.5 amp	ARIS Topside (LB Offshore)
2.5 amp	Laptop #2 (LB Offshore)
0.5 amp	Wireless Power Injector #1 (RB Nearshore)
2.5 amp	Laptop #3 (RB Nearshore)
0.5 amp	Wireless Power Injector #2 (RB Offshore)
2.5 amp	Laptop #4 (RB Offshore)
0.5 amp	Wireless Power Injector #3 (Minor Channel)
2.5 amp	Laptop #5 (Minor Channel)

0.5 amp

0.45 amp

Appendix A13.–Estimated power requirements for electronics based in the main camp on left bank.

52
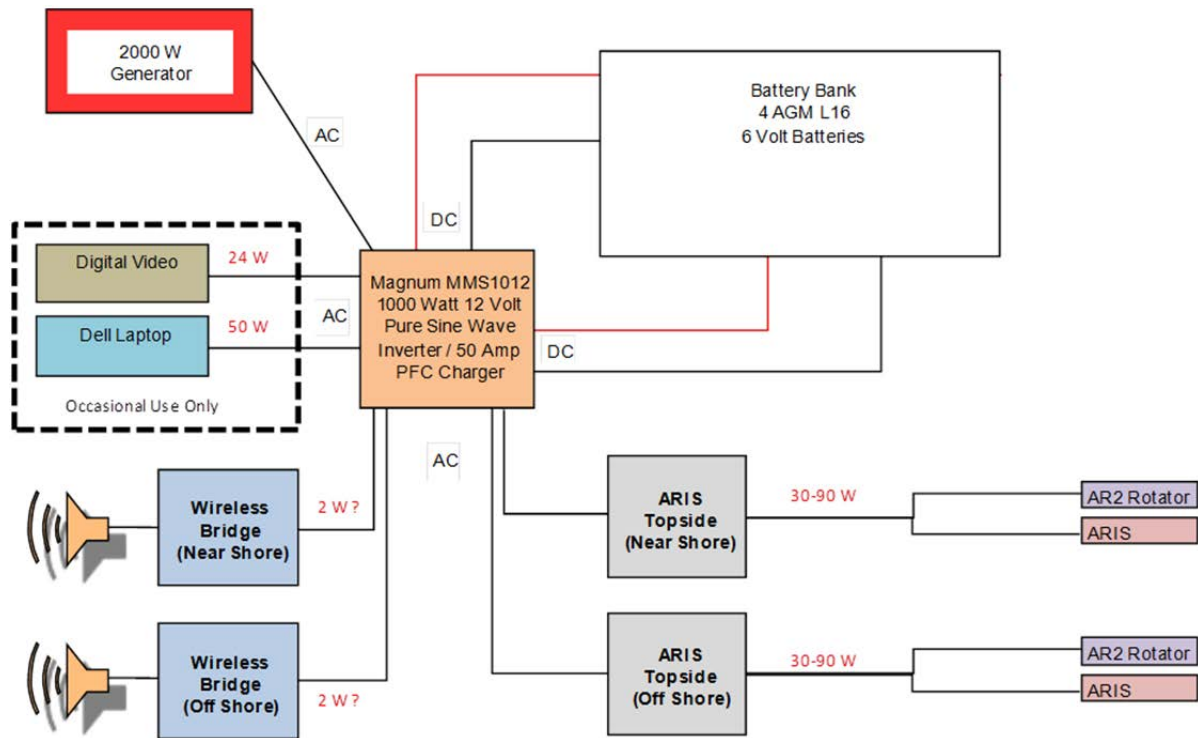
Appendix A14.–Proposed schematic for supplying DC power to the 2 right bank main channel ARIS systems at RM 13.7 via a battery bank charged by a 2000 W generator.
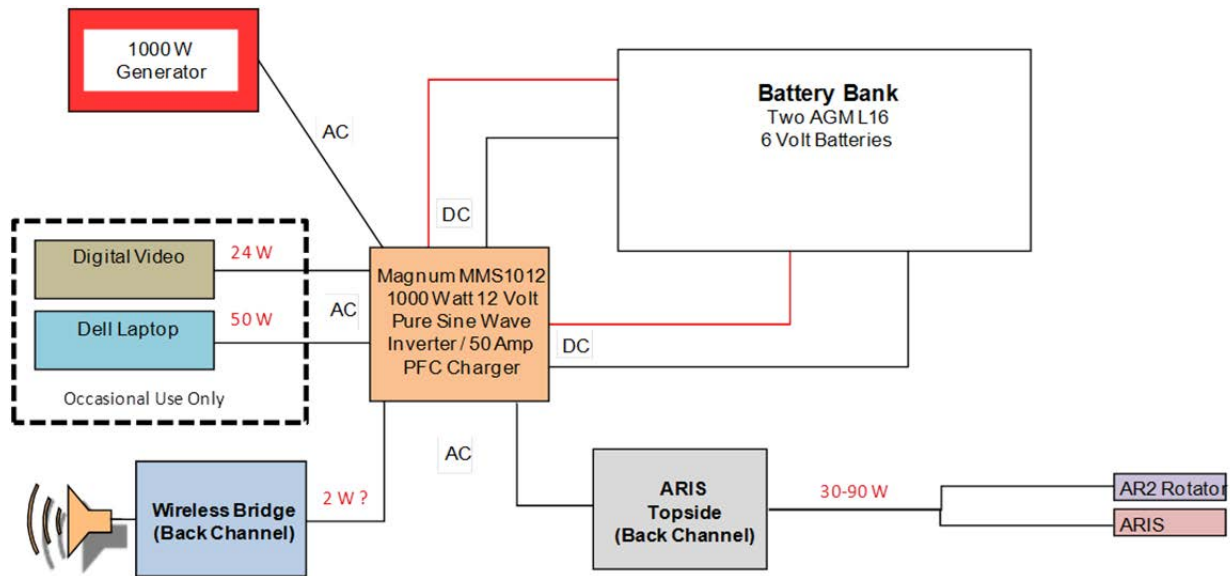
Appendix A15.–Proposed system schematic for the supplying DC power to the minor-channel ARIS system at RM 13.7 via a battery bank charged by a 1000 W generator.

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

Appendix B1.–DIDSON and ARIS configurations used on Kenai River Chinook salmon sonar projects at RM 8.6 and RM 13.7 in 2015, including an overview of features that affect resolution and range capabilities.

Frequency

A DIDSON operates 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 B1-1). 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 B1-1.–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 (HRL). Specifications are from Sound Metrics Corporation. A more complete summary is given in Appendix B2.

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 + HRL	20	15°	3°	96	0.17°	0.15°
DIDSON SV or ARIS 1800 at 1.1 MHz + HRL	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 + HRL	30	15°	3°	48	0.27°	0.30°
DIDSON LR or ARIS 1200 at 0.7 MHz + HRL	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 B2). 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 B1-1 and Appendix B2). 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 (HRL) to increase the image resolution to the level achieved by the DIDSON SV and ARIS 1800 (Table B1-1, referred to as DIDSON LR+HRL, ARIS 12000+HRL). The HRL 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 B1-1). 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 HRL, 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 B3). 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.

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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 B4 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 nonlinear 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 B4, 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 B5). 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 B1-1). Targets at closer range are better resolved because the individual beam widths and corresponding image pixels increase with range following the formula below:

$$X = 2R\tan(\theta/2) \tag{B1}$$

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:

$$Y = W/N \tag{B2}$$

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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 that 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 B5 contrasts images from a DIDSON LR+HRL with an ARIS 1200+HRL. The ARIS image in Appendix B5 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 µs) in the Advanced Sonar Settings menu (Appendix B6). 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 B7.

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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 the accuracy of fish length measurements. 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 B7.

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 B8 (top) was collected at maximum resolution (4 µs) at a range of 29 m with a 4 m range window, but presents a poor image for measurement purposes. The lesser resolution (10 µs) image in Appendix B8 (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 WPF[9] 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.

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[9]There 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 B9 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 farther 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 B8 (top) and produces a "blockier pixel" that is easier for making "beam-edge to beam-edge" length measurements as in Appendix B8 (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 B1-1). 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.

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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 B4), use a shorter range window for the first range stratum to minimize the effect of poor focal resolution at close range (Appendix B10). 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 B11).

Unpublished tethered fish studies (Name, position, affiliation, personal communication) show that a 10 µs 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 equal to 10 µs at 20 m, use PW of about 20 µs; at 30 m, use PW of about 30 µs). 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 µs). Poor images can result when the sample period is equal to or greater than the transmit pulse (see Appendix B12, 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 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 image quality (Appendix B13). 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 B2.–Manufactuer 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

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

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## 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
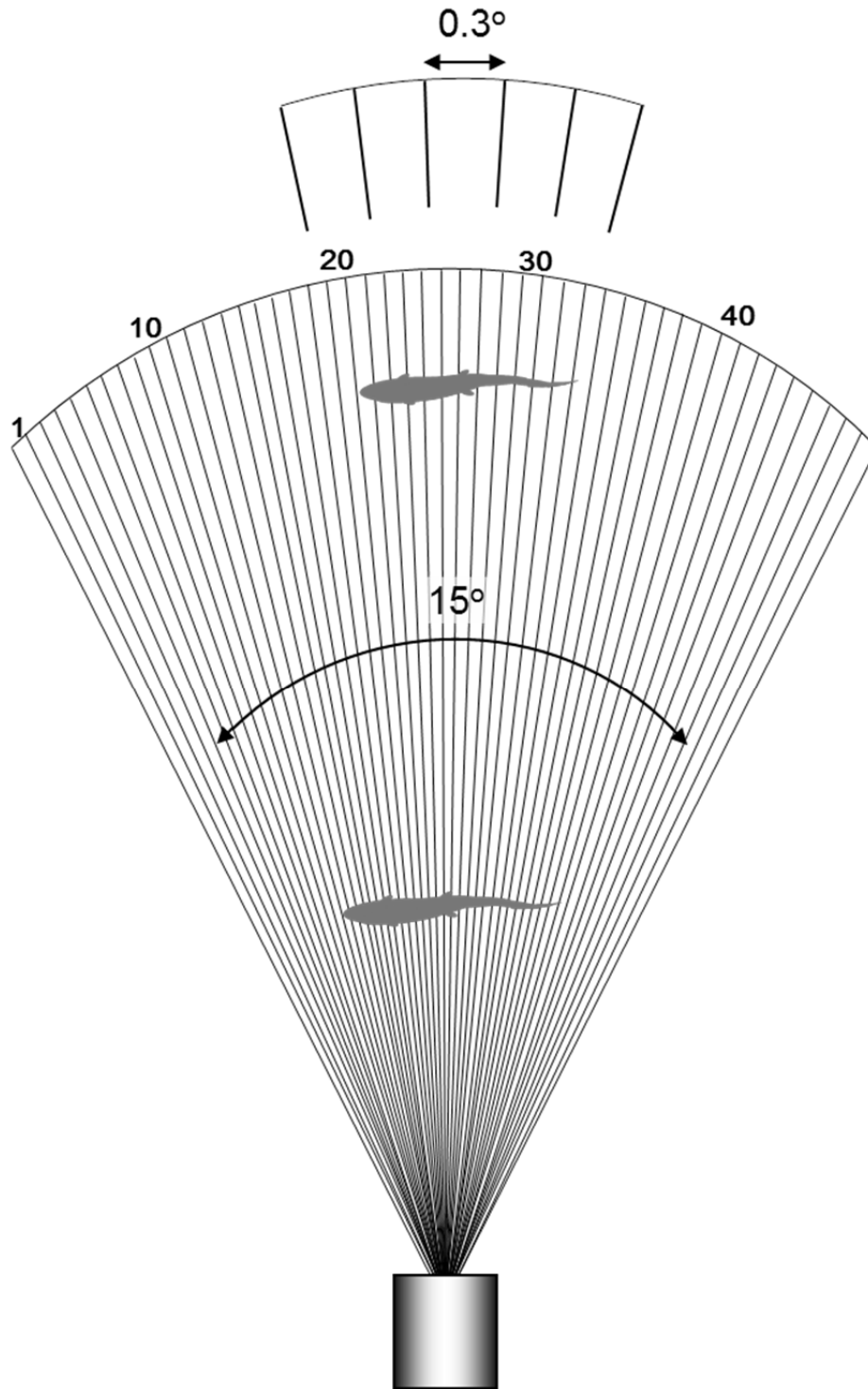
Appendix B3.–Diagram showing the horizontal plane of a DIDSON-LR or ARIS 1200 with a high resolution lens.

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.
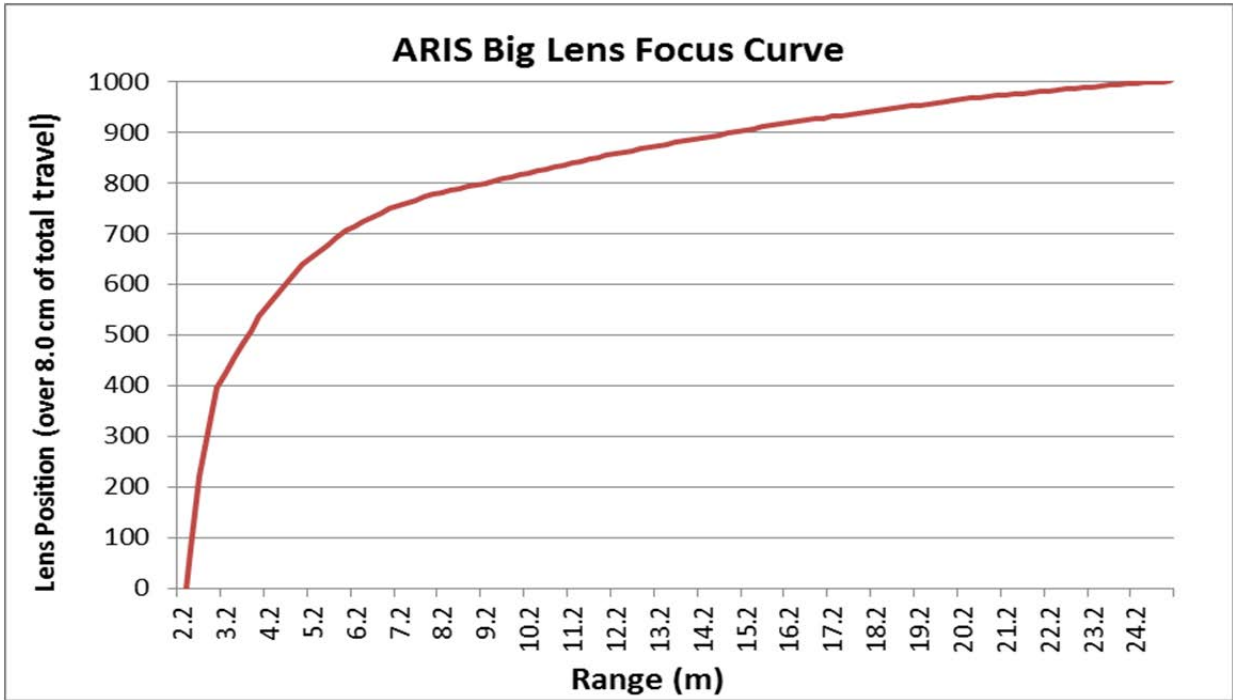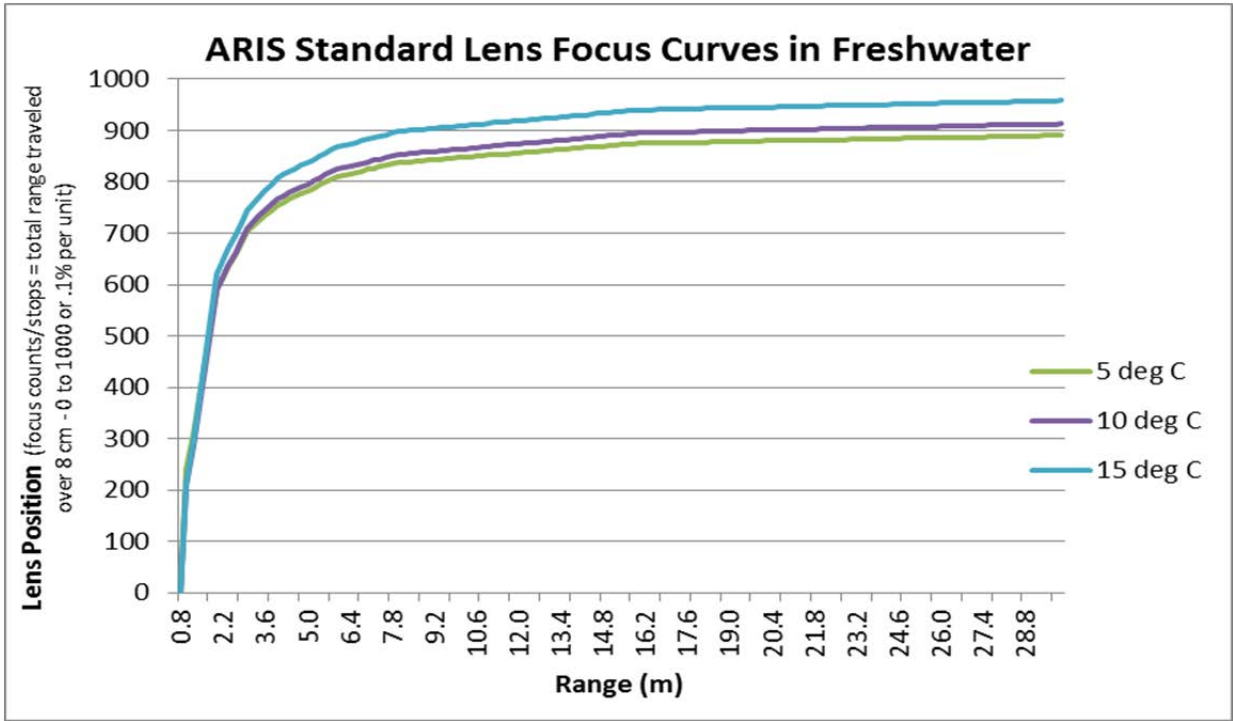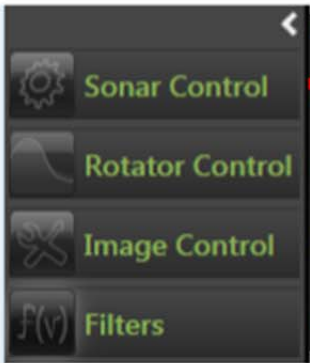
Appendix B4.–Relationships between focal length and lens position for ARIS.
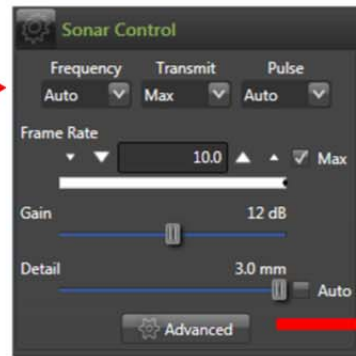
Pixel Height

Pixel width
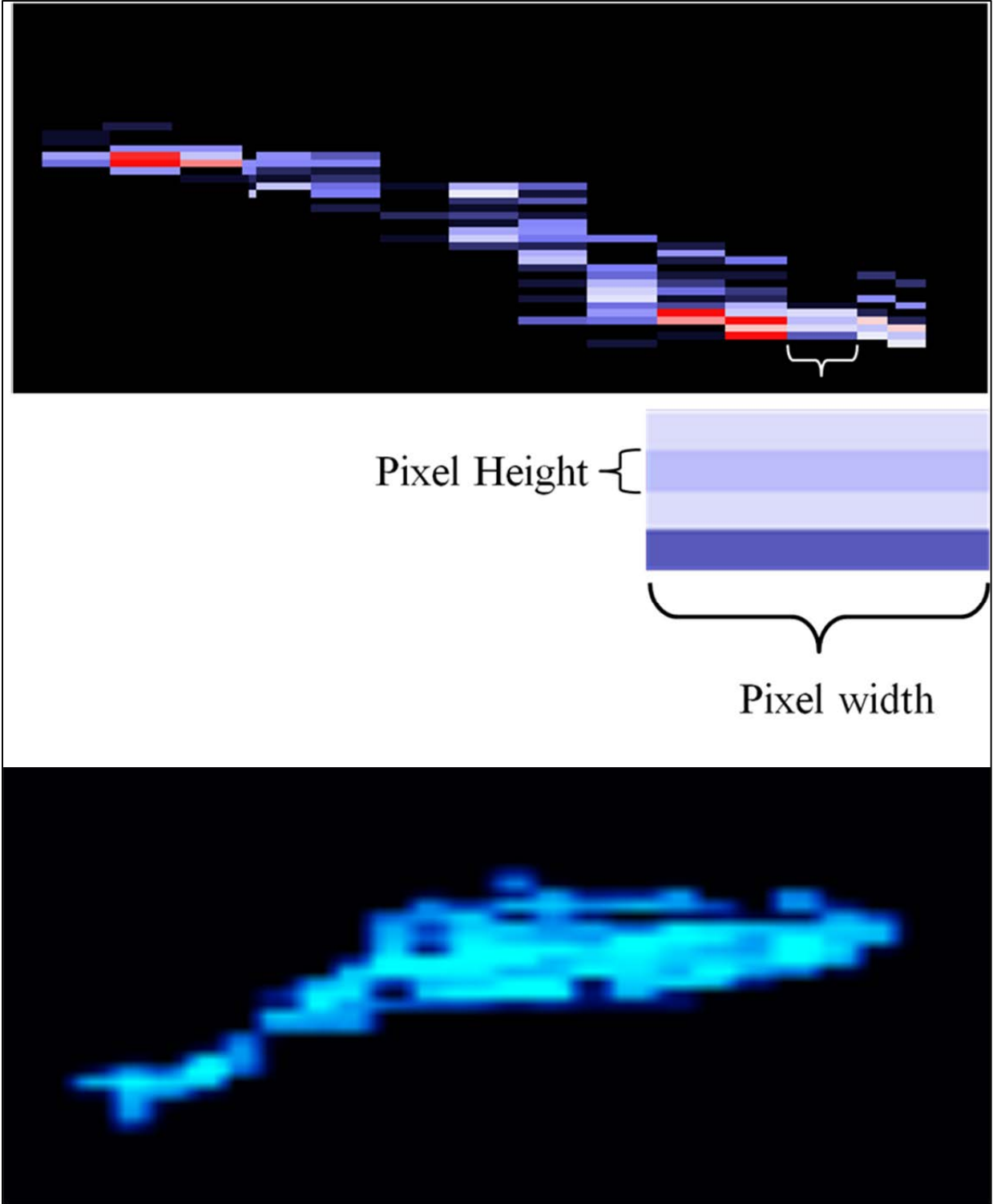
Appendix B5.–An enlargement of a tethered Chinook salmon showing the individual pixels that compose a DIDSON image (top) contrasted with an ARIS image of a free-swimming Chinook salmon (bottom).
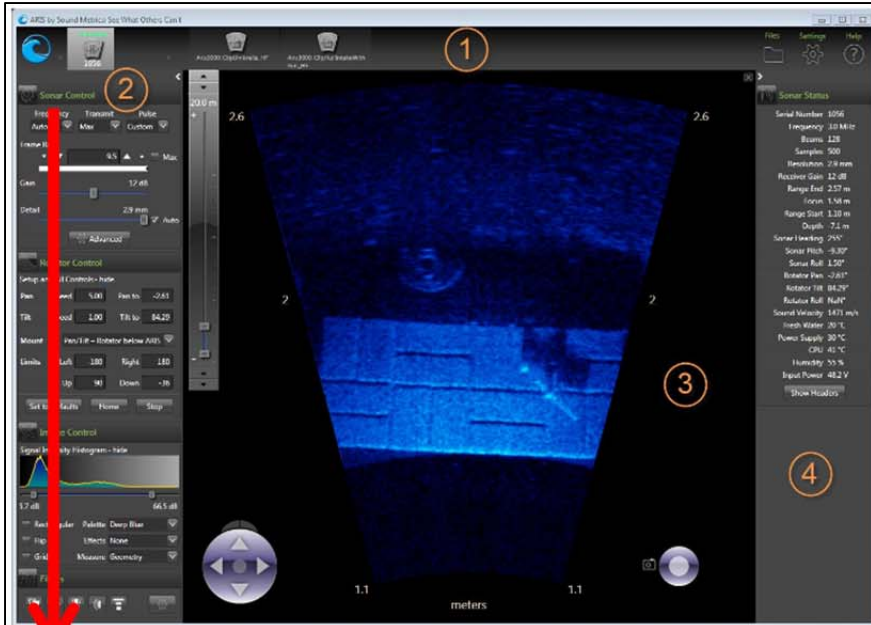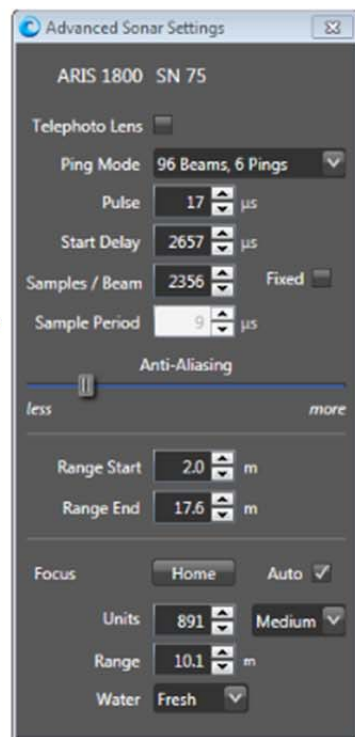
Control Panel Menu

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 B6.–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 B7.–Summary of ARISCope data acquisition parameters that affect downrange resolution.

Parameter	Description
Detail (mm)	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 *Sonar Control* dialog under ECHOScope's *Control Panel* (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 *Advanced Sonar Settings* dialog box (Appendix A6). These parameters, in combination with the transmit pulse width, control downrange resolution. 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). **Using Auto Detail:** 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. 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 *Advanced Settings.*
Pulse (µs)	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 *Advanced Setting Dialog* (Appendix A6). **Pulse** width settings: • 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 *Advanced Settings Dialog* (Appendix A6).

Appendix B7.–Page 2 of 2.

Parameter	Description
Sample Period (µs)	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 *Sonar Control Menu* **Detail** slider or Auto checkbox.
Samples/Beam	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 *Sonar Settings* 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. 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.
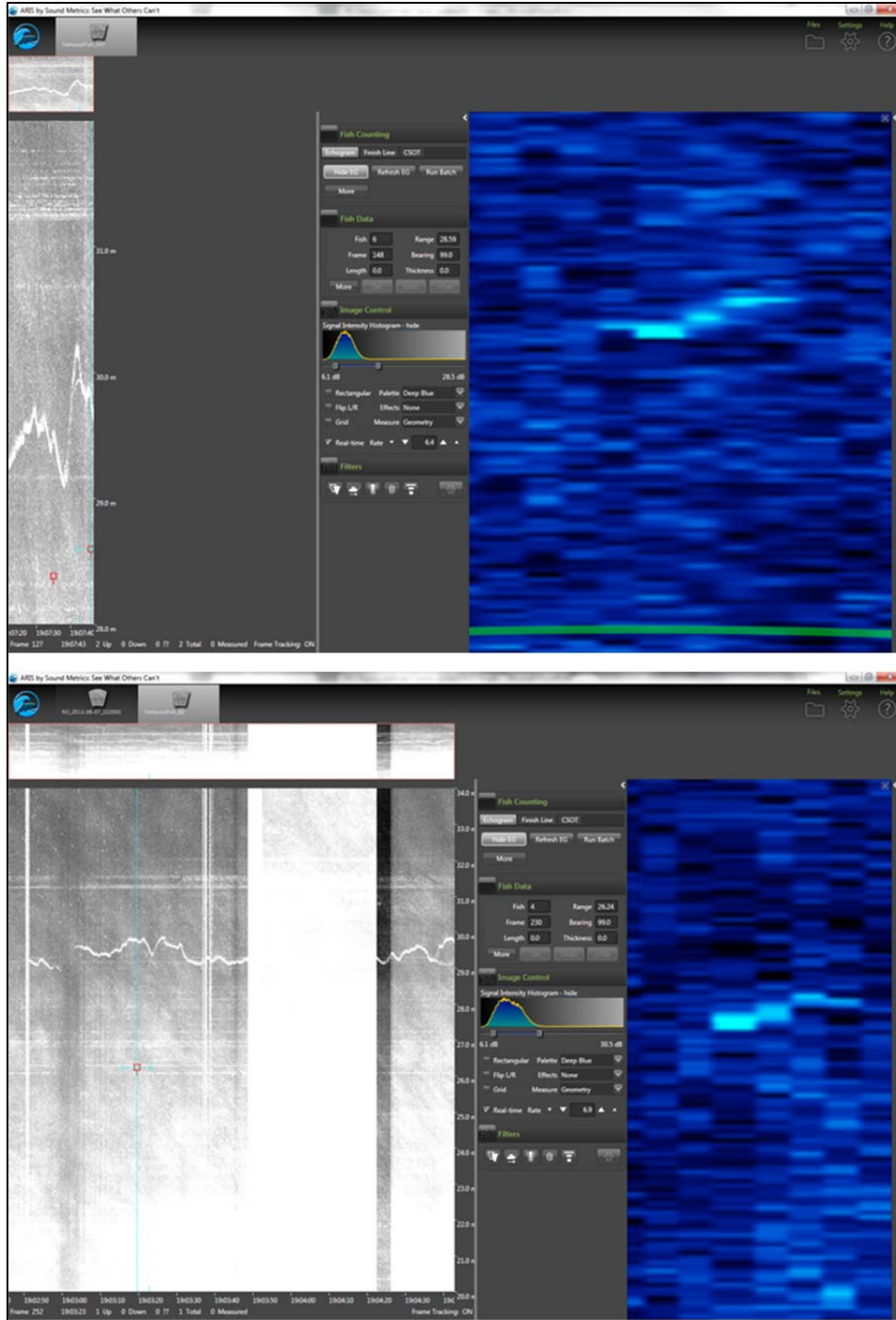
Appendix B8.–An ARIS image of a tethered salmon at 29 m collected at a 4 µs sample period and 4 m range window (top) yields poor results due to a poor downrange to crossrange pixel ratio. Better results are achieved using a 10 µs sample period and 14 m range window (bottom).
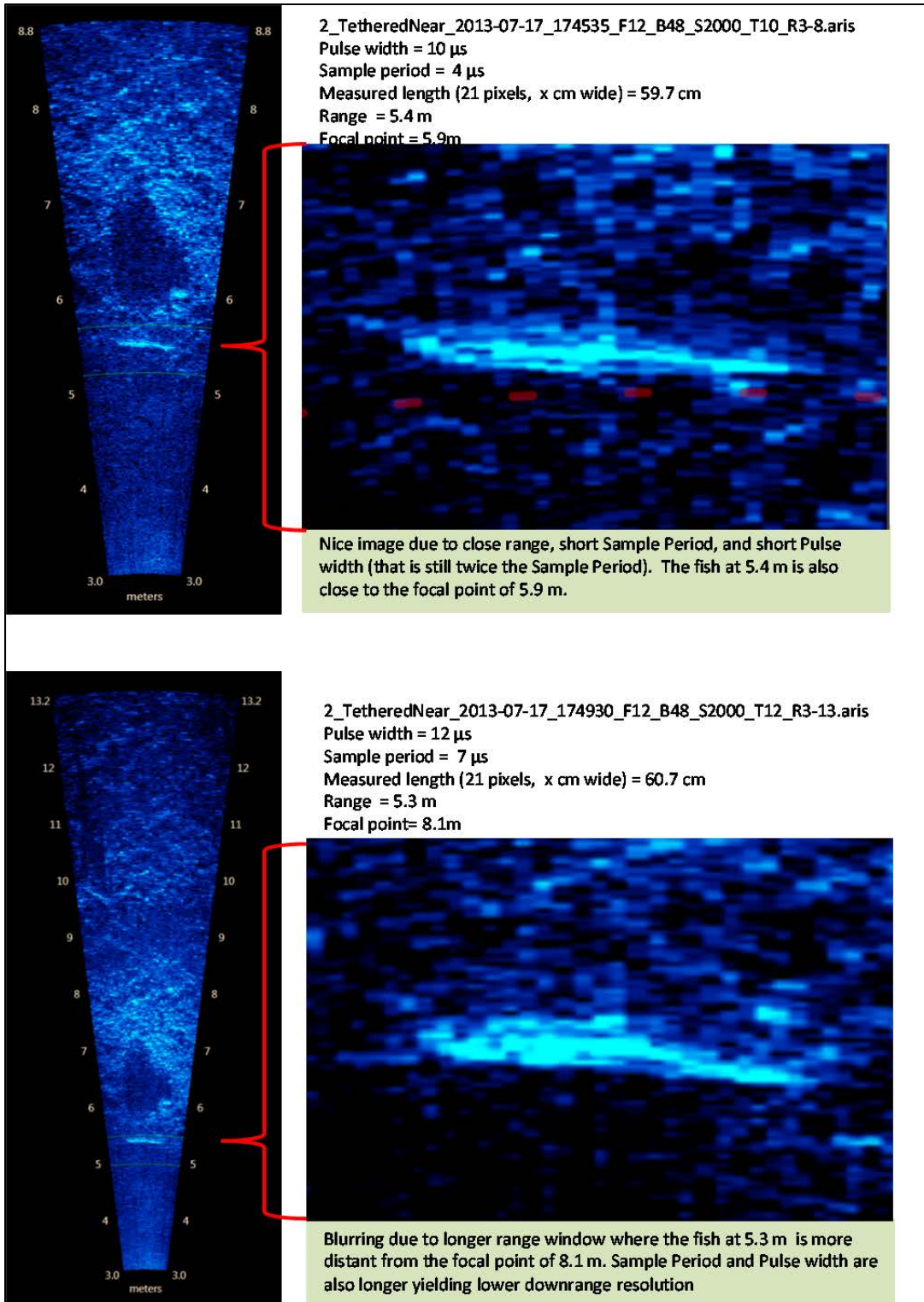
Source: files 2014-07-21_190721_F12_B48_S1378_T29_R27-31 (top) and 2014-07-21_190245_F12_B48_S1931_T33_R19-34_HF (bottom).

Appendix B9.–Results from SMC's test of the Auto-Pulse length setting with items (1) auto-resolution, (2) fixed **Sample Period** of 12 µs, (3) fixed **Sample Period** of 10 µs for range strata that approximate those used on the Kenai River mile 13.7 site, and (4) fixed **Sample Period** of 10 µs with longer pulse lengths than (3).

| Item	Range	Sample period (auto resolution)	Samples/beam	Pulse length (auto)
(1)				
	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)				
	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)				
	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]				
	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 µs
Sample period = 4 µs
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 µs
Sample period = 7 µs
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 B10.–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.
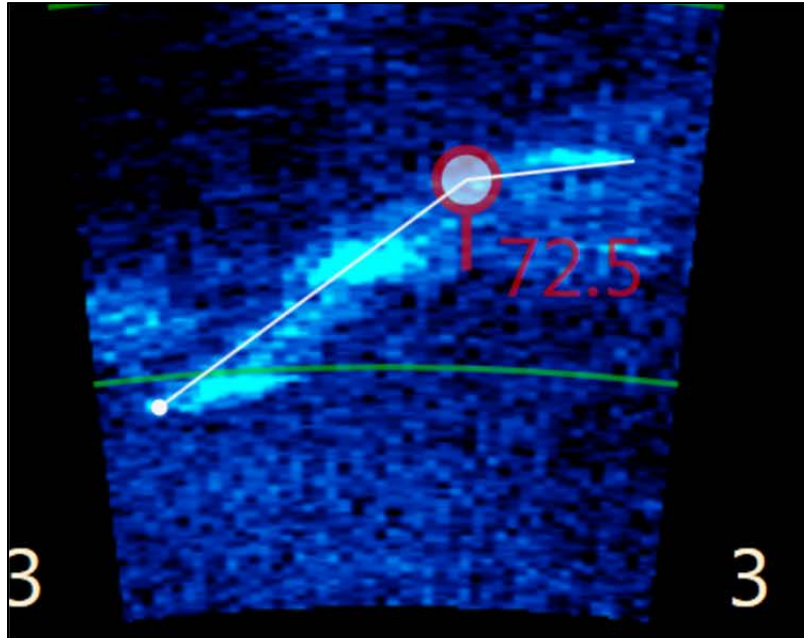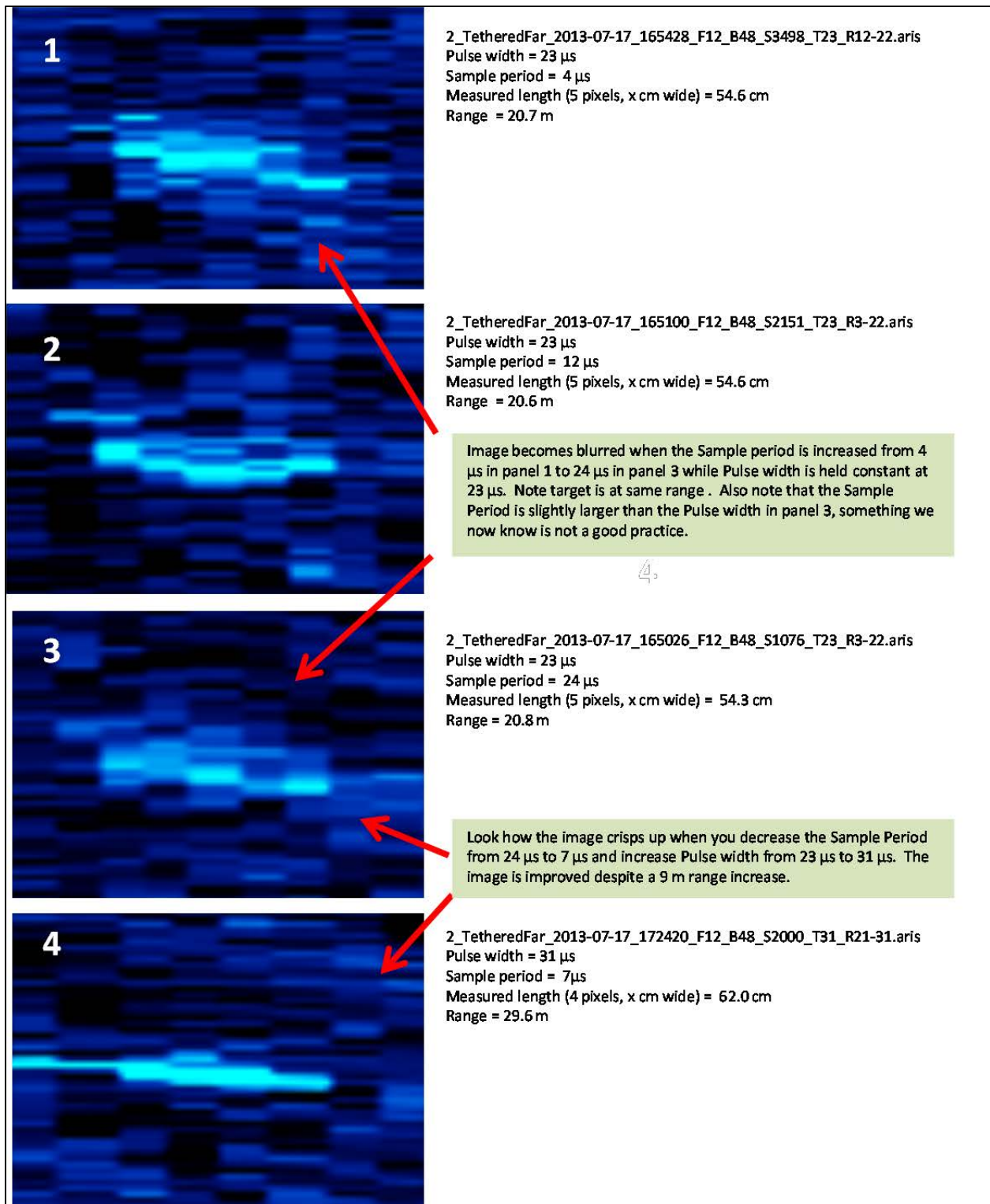
3_TetheredNear_2013-07-17_182746_F12_B48_S1724_T08_R3-8.aris
Fish Range: 3.35 m
Frame 2498
Fish size 72.5 cm
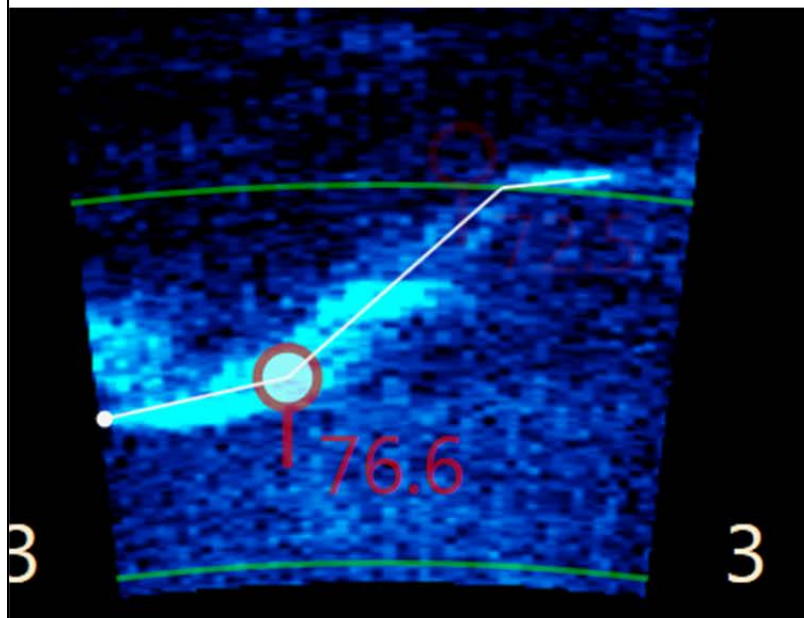
3_TetheredNear_2013-07-17_182746_F12_B48_S1724_T08_R3-8.aris
Fish Range: 3.17 m
Frame 1896
Fish size 76.6 cm

Appendix B11.–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.

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2_TetheredFar_2013-07-17_165428_F12_B48_S3498_T23_R12-22.aris
Pulse width = 23 µs
Sample period = 4 µs
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 µs
Sample period = 12 µs
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 µs in panel 1 to 24 µs in panel 3 while Pulse width is held constant at 23 µs. 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 µs
Sample period = 24 µs
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 µs to 7 µs and increase Pulse width from 23 µs to 31 µs. 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 µs
Sample period = 7µs
Measured length (4 pixels, x cm wide) = 62.0 cm
Range = 29.6 m

Appendix B12.–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.
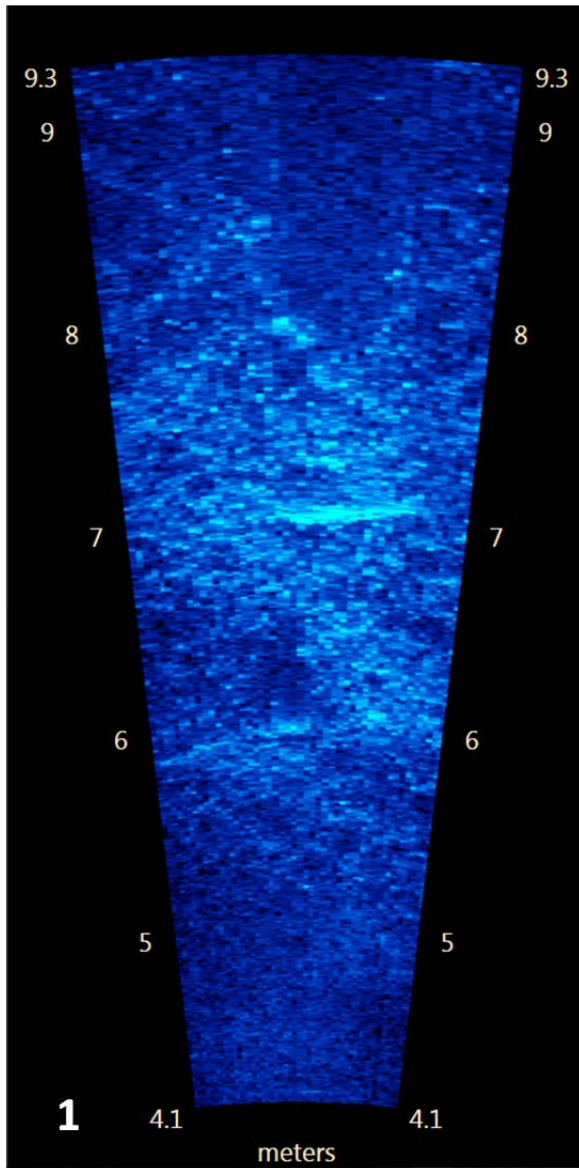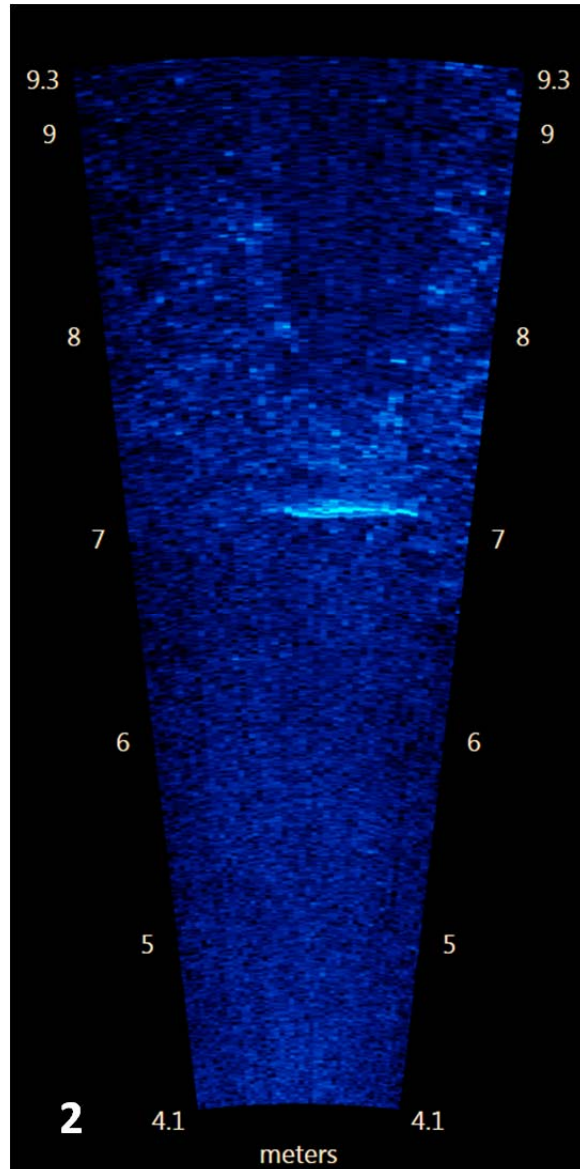
Appendix B13.–Images of a tethered fish taken at 2 different aims. Panel 1 shows a better defined bottom but fish measurement is more difficult against the bright background. Panel 2 shows the sonar pitch raised 2° and a better defined fish outline for easier measuring; there is still bottom structure 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 C: CISCO BRIDGE CONFIGURATION AND SETUP INSTRUCTIONS

Model No.: AIR-BR1310G-A-K9
IP Address: [static, assigned below]   **Default IP Address:** NONE
Username: admin   **Default Username:** Cisco

(The example below assumes a Didson network. See the IP notes about an Aris network.)
Computer used to collect data
IP Address: 128.95.97.203   [for Didson network. Aris sonar uses 169.254.xxx.xxx network.]

Right_Bank (tent side of the river)   **Left_Bank (bluff)**
SSID: RightBank   SSID: LeftBank
IP Address: 128.95.97.2   IP Address: 128.95.97.4
Subnet Mask: 255.255.255.0   Subnet Mask: 255.255.255.0
Gateway: None   Gateway: None
Wired MAC Address: 50-3D-E5-D9-6B-7A   Unit MAC Address: 00-07-7D-4D-18-16
Radio MAC Address: 00-3A-99-D0-97-C0   Radio MAC Address: 00-3A-99-DE-CB-10

Required Connections:
The access point provides an RS-232 serial port that enables a connection to a PC for monitoring and configuration. Attach the PC to the access point (Cisco Bridge), using the serial console cable (DB9 to RJ45 adaptor cable) provided with this package.

After initial Console setup, you will then connect to the web interface using the Ethernet network interface. Connect an Ethernet cable between the PC and the Cisco Bridge's power injector. (The PC must be set to a static IP address on the same subnet as the Cisco Bridge.)

To connect to the console port, complete the following steps:
1. Connect the DB-9 end of the console cable to the serial port on the PC and connect the RJ45 end to the Console port on the access point's power injector.

2. Start your terminal program. Set the terminal emulation software is set as follows:
- Select the appropriate serial port (COM port 1 or 2).
- Set the data rate to 9600 baud (if this fails*, try 38400 – found on one unit)
- Set the data format to 8 data bits, 1 stop bit, and no parity.
- Set flow control to none.
- When using HyperTerminal, select Terminal keys, not Windows keys.

3. Power up the Cisco Bridge, and observe the boot process in the terminal program. You should be able to observe readable text. If not, try the other baud rate noted above*. After it is done booting, press the [Enter] key to initiate the console connection. The console login screen will be displayed. Enter the default username and password to access the console.

4. Set the Cisco Bridge IP Address.   Enter Ethernet configuration mode by typing the following commands: (prompt is in bold and what you type is not bolded)

-continued-

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```
ap>enable
Password:(enter password) [Cisco is default password]
ap#configure terminal
Enter configuration commands, one per line.
End with CNTL/Z.
ap(config)#interface bvi1 [last letter is a 'one', not an 'el']
ap(config-if)#ip address 128.95.97.xxx 255.255.255.0
ap(config-if)#exit
ap(config)#exit
ap#
*Mar  1 00:02:44.209: %SYS-5-CONFIG_I: Configured from console
by console [press enter]
Ap#write
Building configuration...
[OK]
ap#write memory
Building configuration...
[OK]
ap#
```

Command-line notes – IP Address:
On the `ip address` line, the 'xxx' entry means you must enter a unique static ip address; usually 2 for the Camp-side Bridge, and 4 for the remote Bridge (Example: 128.95.97.2). The subnet mask in this example is 255.255.255.0

The subnet must be set up to match the sonar units and the PC/laptop. Didson sonar uses 128.95.97.xxx Class C subnet, and Aris sonar uses 169.254.xxx.xxx Class B subnet.

Example `ip address` commands:

```
                IP:             Subnet mask:
ip address 128.95.97.2 255.255.255.0      [Didson Camp Bridge]
ip address 128.95.97.4 255.255.255.0      [Didson remote Bridge]

ip address 169.254.50.2 255.255.0.0       [Aris Camp Bridge]
ip address 169.254.50.4 255.255.0.0       [Aris remote Bridge]
```

[Note that the subnet mask for Didson is 'Class C' but for the Aris, it is 'Class B']

5. You can now connect to the unit using the web browser. In the Browser URL address line (top text-entry line), enter the Cisco Bridge IP address (example: 128.95.97.2)

6. Logon and then go to the Security/SSID Manager. In the SSID Properties section, add the SSID and check the Interface Box. Just one is needed, but it must be exactly the same SSID for both Cisco Bridges of a **bridge-pair**. This must be a unique SSID: other **bridge-pairs** operating nearby cannot have the same SSID. (If they did, different **bridge-pairs** would try to connect together – and that would be bad!)

7. Scroll to the bottom of the Security/SSID Manager page and on the very last line, Set Infrastructure SSID: to the same SSID as the Cisco Bridge on the opposite bank and then check the Force Infrastructure Devices to associate only to this SSID Box, and click Apply.

8. Go to the Express Set-Up Page and configure as shown below. Be sure to click Apply before leaving the page:

Host Name is Right_Bank or Left_Bank
Configuration Server Protocol is Static IP
Role in Radio Network for Right Bank is Root Bridge and Left Bank is Non-Root Bridge.
Leave everything else default.
Click Apply

Multiple Near-By Bridge-Pairs:
The examples shown here assumed a single bridge-pair as it was set up at the Lower River Sonar Site. The Upper River site uses 3 nearby bridge-pairs for 3 across-river Aris sonar units. Here is a suggested naming convention for them:

Bridge Pair	SSID	Laptop Bridge	Aris Bridge	Sonar Location
1	River1	Camp1	ArisUnit1	RightFar
2	River2	Camp2	ArisUnit2	RightNear
3	River3	Camp3	ArisUnit3	Channel

Because these are all separate networks, the IP addresses can be set up identically (like the examples); but the SSIDs **must** be different because these bridge-pairs are operated in proximity to each other.

Express Set-Up

Host Name:	Left_Bank
MAC Address:	0007.7d4d.1816
Configuration Server Protocol:	○ DHCP ⊙ Static IP
IP Address:	128.95.97.4
IP Subnet Mask:	255.255.255.0
Default Gateway:	0.0.0.0
SNMP Community:	defaultCommunity
	⊙ Read-Only ○ Read-Write

Radio0-802.11G

Role in Radio Network:	○ Access Point ○ Repeater
	○ Root Bridge ⊙ Non-Root Bridge ☐ Install-Mode
	○ Workgroup Bridge ○ Scanner
Optimize Radio Network for:	○ Throughput ○ Range ⊙ Default ○ Custom
Aironet Extensions:	⊙ Enable ○ Disable

Test the units by connecting a computer to the Right Bank unit.
> Connect a crossover cable to the RJ-45 port of the computer and plug it into the Ethernet port on the access points power injector unit, then connect both the ports on the Bridge to both of the ports on the injector. Power everything on and wait for the bridges to connect you should now be able to ping both ends of the bridge.

-continued-

Connect the Didson to the Left Bank unit.

      Connect a patch cord to the RJ-45 port on the Didson topside box and plug it into an open port on a 10Mb hub then connect a patch cord from the hub to the Ethernet port on the access points power injector unit, then connect both of the Bridges ports to both of the ports on the injector. This is outlined in greater detail on the next page.

CISCO AERONET WIRELESS SYSTEM TO DIDSON

Important differences between SMC and CISCO wireless setups!

Use crossover cable from PC to CISCO power injector module

Use BOTH of the coax cables between radios and power injectors

Setup steps – better not deviate for now:

Topside box is attached to DIDSON

Video monitor is attached to Topside box (to monitor DIDSON boot etc)

Connect transmit and receive coax cables to power injectors and radios – taped coax cable ends go to remote bank (outside) radio connectors (there are two coax cables per radio to connect)

Mount radios and aim faces toward each other

Hook computer to hub using straight through patch cable, boot the computer

Hook hub to topside box using straight through patch cable

Power up the hub

Power up the DIDSON

When DIDSON says "waiting" you can ping via command window (ping 128.95.97.227)

If you can ping DIDSON, disconnect straight through from computer and connect that end to the CISCO power injector (take computer out of the equation)

Power up the remote side power injector

Power up equipment side power injector

Connect the PC to the equipment side power injector using a CROSSOVER cable

Before you ping the bridges\radios, you must wait for a LONG boot up (up to 4 minutes)

Ping right bank bridge (ping 128.95.97.2)

Ping left bank bridge (ping 128.95.97.4) – if you can't ping left bank, but you can ping right bank, there is probably noise interference (shut down SMC to verify)

You should now be able to ping the DIDSON if everything has gone well to this point

If you can ping the DIDSON start the DIDSON software on the computer (make sure DIDSON hasn't timed out though, if it has you must power down the DIDSON topside box and restart it.)
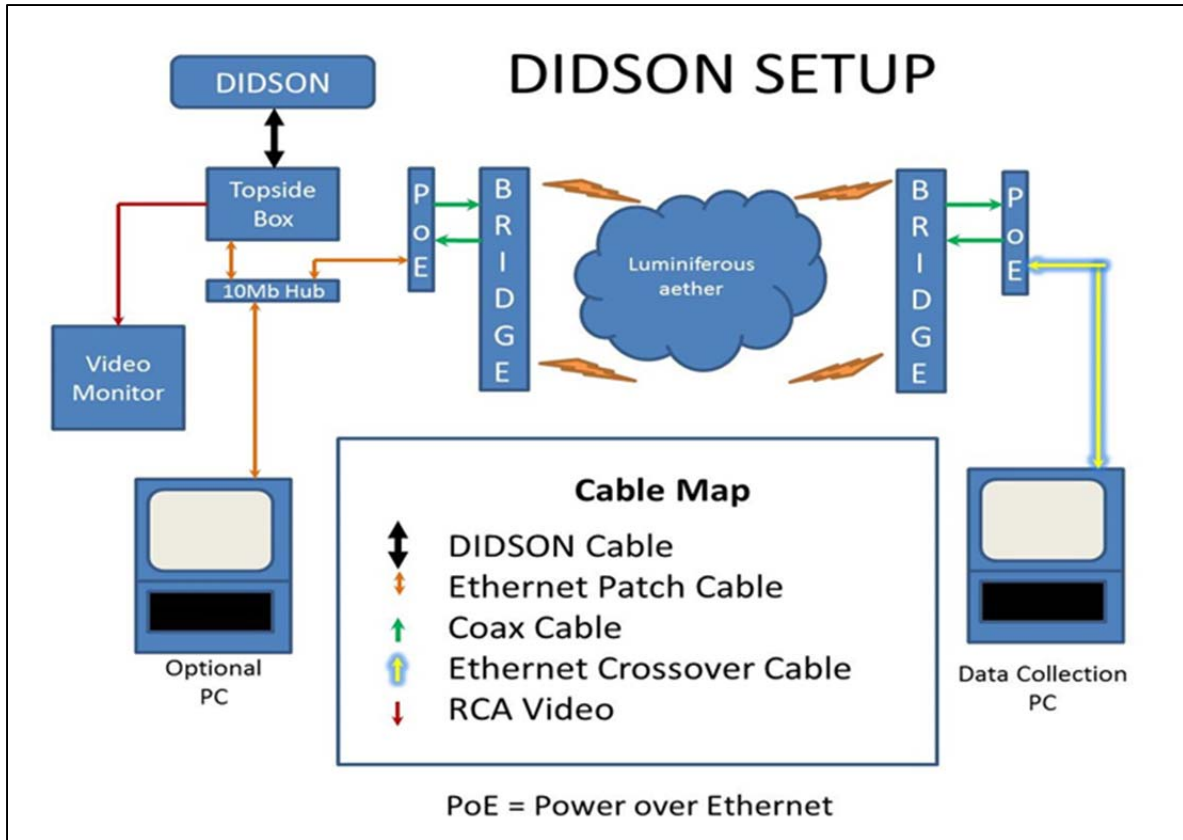
Appendix C2.–Wireless bridge diagram.

APPENDIX D: PROCEDURES FOR DAILY ARIS PROCESSING

The following was updated June 2015 by Mike Hopp, Fish and Wildlife Technician III, and Jim Miller, Fishery Biologist III, ADF&G, and was alsoupdated 18 May 2016 by Mike Hopp.

Note that dates highlighted in yellow in filenames, directory structures, and batch files need to be updated annually.

- Raw Data Transfer and Storage

Field data hard drives are brought in to the office daily around 8 AM. These drives have data from the previous day ~0800 – 2359 and from the current day 0000 – 0759. Two separate-day uploads are required for each drive.

1. Make sure that backup drive **X:** is present and has enough room to back up data (about 150 GB)
2. Plug in the first field hard drive – Note the DRIVE LETTER should be **E:** [If it isn't, a) make sure no other drives or jump drives are attached to the PC, or b) edit the drive letter in Drive Management, or c) edit the UploadMenu.bat to match the drive letter.]
3. RUN the *UploadMenu* batch file and follow prompts to select correct **Date** and **Sonar** for uploading
4. Verify file & folder prompts (there are many)
5. The batch process should upload to the backup drive **X:** and TeraStation **U:** with tones indicating progression
6. Change the **Date** and pick the same **Sonar** for the next day set-of-data on this drive
7. Eject this DRIVE when done
8. Repeat for each of the 5 **Sonar** field hard drives

The day's data for 5 ARIS Sonar is now backed up to X: and ready for processing (on *U:\Data2016*).

- Manual Target Measurement

1. Use the ***ARISFish*** Application to process all Set1 **.aris* files for manual measurement of targets.
2. Open each *.aris* file, select parameters, create echogram and measure fish according to specified protocols ie. Normal, Fast Track, Large Fish only (ALF – All Large Fish).
3. If Set1 data is missing or corrupt, use corresponding Set2 data if available.

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- Processing Data (**To be done from the data processing computer only**)

  1. **Open the desktop folder "NewProcess Data2016".**

   This opens the process folder with icons listed in proper sequence for processing data

  2. **Double-click the "One Ring to Rule Them All…" icon**
     a. This starts the master batch file that opens batch or other files in the proper sequence for processing.
     b. (Using the "One Ring…" helps to reduce human error in repetitive-sequential processing.)
     c. [Alternatively, the technician can process the data in sequence using the remaining icons, as long as the "Set Date" batch file is run before any subsequent batch file in the sequence.]
     d. The following steps are called in sequence by the "One Ring…" batch file, or you can execute them separately as indicated above.

     [**Reminder: <u>These next steps are called automatically</u> by the "One Ring…" batch file, which must be left open and running throughout processing (until <u>it closes itself at the end</u>). In using the "One Ring…" batch, click back into it and "Press any key to continue…" after each step is done.**]

  3. **Double-click the "Update Missed Samples" icon**
     a. This opens "*2016 Aris daily summary of data quality*" Excel workbook, located in *U:\Spreadsheets*
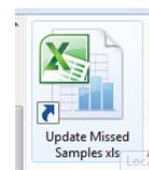
-continued-

b. Click on "missed hours for SAS" tab at the bottom of the sheet

166	3
166	4
166	5
166	6

missed hours for SAS / Strata Totals / Daily summary
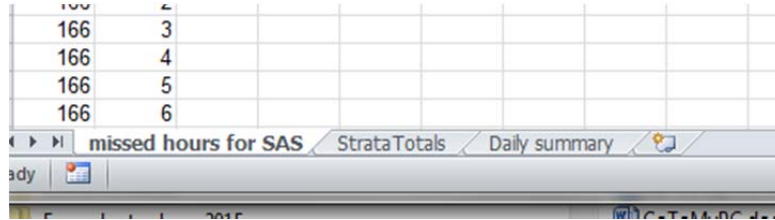
c. Copy the previous day's cells down through the current day's cells by selecting the last hour (23) set and then drag-down-fill for the current day.

d. Enter zeros for missing data, "1"s for measured data and "x" for nonexistent strata

JD	Hour	LN1	LF1	LF2	LF3	RF3	RF2	RF1	RN2	RN1	C1	C2	C3
170	19	1	1	1	1	0	0	x	1	1	1	1	1
170	20	1	1	1	1	0	0	x	1	1	1	1	1
170	21	1	1	1	1	0	0	x	1	1	1	1	1
170	22	1	1	1	1	1	1	x	1	1	1	1	1
170	23	1	1	1	1	1	1	x	1	1	1	1	1

e. Click on the "*Daily summary*" tab and then fill in the documentation row for that day

f. Click on "*missed hours for SAS*" tab

g. Save (but leave open for now)

4. **Double-click the "Update Asamples2016" icon**

a. This opens "*Asamples2016.txt*" file, located in *U:\DataProc16\SAS\SASinput*

Update
Asamples2015 an...

b. Copy current day's data (all 24 hours) from the "*2016 Aris daily summary of data quality*" workbook, "*missed hours for SAS*" tab

c. Paste these data (0–23, for the current day) at the bottom of the "*Asamples2016.txt*" text file (**Make sure there are no extra carriage returns at end of file; they would interfere with SAS processing**).

172	19	1	1	1	1	1	1	x	1	1	1	1	1
172	20	1	1	1	1	1	1	x	1	1	1	1	1
172	21	1	1	1	1	1	1	x	1	1	1	1	1
172	22	1	1	1	1	1	1	x	1	1	1	1	1
172	23	1	1	1	1	1	1	x	1	1	1	1	1
173	0	1	1	1	1	1	1	x	1	1	1	1	1
173	1	1	1	1	1	1	1	x	1	1	1	1	1
173	2	1	1	1	1	1	1	x	1	1	1	1	1
173	3	1	1	1	1	1	1	x	1	1	1	1	1
173	4	1	1	1	1	1	1	x	1	1	1	1	1
173	5	1	1	1	1	1	1	x	1	1	1	1	1
173	6	1	1	1	1	1	1	x	1	1	1	1	1
173	7	1	1	1	1	1	1	x	1	1	1	1	1
173	8	1	1	1	1	1	1	x	1	1	1	1	1
173	9	1	1	1	1	1	1	x	1	1	1	1	1

d. On the menu bar at the top, click on "File" then "Save"

-continued-

e. *[Skip e. if you are using the "One Ring…" batch. It does this for you.]* On the menu bar at the top, click on "File" then "Save as". Save in the following directory: *U:\Data2016\[current JD folder]*

f. Close "*Asamples2016.txt*"

g. Close "*2016 ARIS daily summary of data quality.xls*"

5. **Double-click the "Update pod data date and locations" icon**

a. This opens "*ADaily2016*.tx"t file, located in *U:\DataProc16\SAS\SASinput*

b. Copy previous day's row down, then update columns as necessary (**be sure to update dates**). Only the dates will typically change, unless a pod was reset. If a pod was reset the new pod location is always a distance from the OHW on left bank.

JD	MON	DAY	LN	LF	RF	RN	CH	MAXLN	MAXRN	OLAP	ENDLO	ENDRO
136	5	16	5.0	11.3	78.3	87.5	94.0	3.4	8.7	0.0	33.5	33.5
137	5	17	5.0	11.3	78.3	87.5	94.0	3.4	8.7	0.0	33.5	33.5
138	5	18	5.0	11.3	78.3	87.5	94.0	3.4	8.7	0.0	33.5	33.5
139	5	19	5.0	11.3	78.3	87.5	94.0	3.4	8.7	0.0	33.5	33.5
140	5	20	5.0	11.3	78.3	87.5	94.0	3.4	8.7	0.0	33.5	33.5
141	5	21	5.0	11.3	78.3	87.5	94.0	3.4	8.7	0.0	33.5	33.5

c. On the menu bar at the top, click on "File" then "Save" (saves a master copy)

d. *[Skip d. if you are using the "One Ring…" batch. It does this for you.]* On the menu bar at the top, click on "File" then "Save as" Save in the following directory: *U:\Data2015\[current JD folder]*

e. Close "*ADaily2016.txt*"

6. **Double-click the "2016 ARISfish list" icon**

a. This opens "*2016 ARIS Fish List v17.xls*", located in *U:\Spreadsheets*

b. Click on Enable Content tab at top in yellow bar, if it appears.

-continued-

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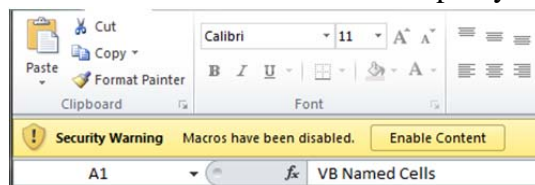
c. Click "*SelectFiles*" tab , located in the bottom left hand corner.
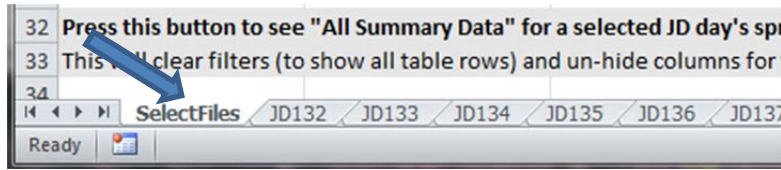
d. Update month and day (cells E2 and F2)

e. (Optional: Click on "*SetJD*" button (cell A3). "*Get Fish List*" does this for you.) (updates Julian Date)

f. Click "*Get Fish List*" button (cell C1, shown above). Click OK on the pop-up warning.

g. Click the hyperlink or spreadsheet tab for the current Julian Date (*JDxxx* worksheet)
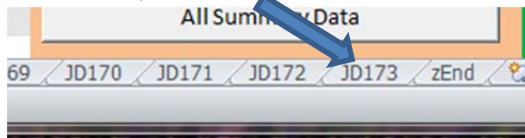
   i. Scan the "*Aris File Summary*" data table (on this *JDxxx* sheet) for any yellow cells

   ii. If yellow cells are found, make corrections to corresponding text files if necessary (text files found in *U:\Data2016\[current JD folder]*

   iii. If corrections are made, follow steps **c** through **g** again.

   iv. Verify total file count at bottom of the table

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v. Write down "LeftFar" temperature (both °C and °F – orange cells), [to be used later].

ArisUnit	Temperature °C
LeftNear	11.5
LeftFar	11.8
RightFar	12.3
RightNear	11.4
Channel	12.1

ArisUnit	Temperature °F
LeftNear	52.6
LeftFar	53.3
RightFar	54.1
RightNear	52.6
Channel	53.7

h. Click File on menu bar, then Save

i. Close "*2016 ARIS Fish List v17.xls*"

7. **Double-click the "Set Date" icon** (This is already done in Step 2 if using "*One Ring…*")

a. This opens "*MonthDayMenu.bat*" file, located in "*U:\Batch\AutoDated*"

b. Follow instructions to set the 2-digit month and 2-digit date. This is used in all subsequent batch files.

c. Change dates (JULDATE and YEAR) in the *.sas* text file that opens. **Be sure to <u>not</u> delete the semicolon following the data** (it must be there for the SAS program).

d. The batch file will close automatically.

8. **Double-click the "PackageARISforSAS" icon**

a. Opens "*PackageArisForSAS-2.bat*" batch file, located in "*U:\Batch\AutoDated*"

b. Follow instructions

    i. It packages files for the day. You will hear several beeps as it does so…

    ii. Then it automatically opens the "*Package-[DataDate]-JDxxx.txt*" log file. Use it to double-check that there are 24 files per stratum (unless we have missing samples).

    iii. After review, close the "*Package-[DataDate]-JDxxx.txt*" log file.

    iv. Continue following the batch file instructions.

    v. The batch file automatically opens **SAS** software.

    vi. At this point, you can drag batch file window to the other monitor to move it out of the way.

-continued-

vii. Ensure **SAS** is set to the proper directory (*U:\DataProc16\SAS\SASinput*) by looking in the lower right hand side of the SAS window. If not set to proper directory, double-click to browse to correct folder.
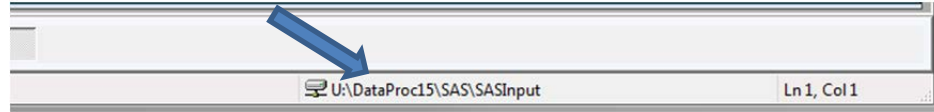
viii. Click on "File Shortcuts" on left side of screen in the Explorer tab on the bottom left to open the folder containing all SAS programs.
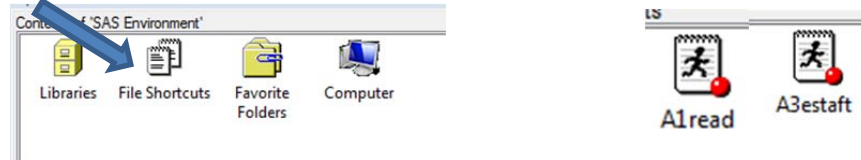
ix. Open the **1ˢᵗ SAS** program by clicking on "**A0config**" (the SAS program window will open).

1. Click the little running man on the menu bar at the top of the screen (this will run the program)

2. Watch the log window as program runs
3. No output from this program – proceed to next step once it stops running

x. Open **2ⁿᵈ SAS** program by clicking on "**A1Read**"

1. Click the little running man to run program (this one takes a while)
2. Watch the log window as program runs
3. No output from this program – proceed to next step once it stops running

xi. Open **3ʳᵈ SAS** program by clicking on either "**A3estast**" or "**A3estaft**" depending on whether the data was measured using the standard (ast) or fast track (aft) method.

1. Click the little running man to run program
2. Watch the log window as program runs
3. Produces output tables in "Results Viewer" window
4. From the "All Upstream Salmon Shaped Fish >=40" table write down the number of fish >= 40 cm for the current day (found in the "dayPassage1" column)

-continued-

        5. From the "<u>Net Upstream Salmon Shaped Fish >=75</u>" table write down the number of upstream fish >= 75 cm for the current day

        6. From the "<u>Net Upstream Salmon Shaped Fish >=90</u>" table write down the number of upstream fish >= 90 cm for the current day

        7. While in the Results Viewer window, click on "File" on the menu bar at the top, then "Save as"

        8. Click on "FileName" dropdown arrow to find "*SAS-OFFICE-JDxxx.mht*" in \ *Desktop*

        9. Change Julian Date to current day

        10. Click "Save" (saves output to desktop)

    xii. Open **4th SAS** program by clicking on "**A4Graph**"

        1. Click the little running man to run program

        2. Watch the log window as program runs

        3. Produces output graphs in "*GRAPH\ WORK…* " window

        4. Click on the graph for the current Julian Date

        5. Click File on the menu bar and then Export As Image

        6. Save as Type: PNG

        7. Change filename for the current Julian Date to save as *JDxxx.PNG* on the *Desktop*

        8. Click "Save" (saves graph to desktop)

    xiii. Close SAS

  c. Continue with batch file (closes automatically)

9. **Double-click the "UploadPackage" icon**
   a. Opens "*UploadPackage.bat*" , located in "*U:\Batch\AutoDated*"
   b. Follow instructions
   c. Batch file closes automatically

10. **Double-click the "Estimate Summary" icon**
    a. Opens "*Estimates.bat*" , located in "*U:\Batch*"
    b. Follow instructions
    c. Automatically opens Estimate_Summary2016.xls workbook (located in *U:\DataProc16\Spreadsheets*)
    d. Click on the Estimates By Day tab
    e. Enter estimates (that you wrote down earlier from SAS output) into the Estimates By Day table

-continued-

f. Write down Cumulative Totals (>=40, >=75, >=90) from the table.

g. Print table by clicking on "File" in the menu bar at top of window, then "Print"

h. Click on 2016 Plot (Print Me) tab to review the graph

i. Print graph by clicking on "File" in the menu bar at top of window, then "Print"

j. Click on Daily Estimates (Email Me) tab

k. Enter your name where designated in the Early Run Estimate Summary box

l. Open Outlook (Email) by clicking on Outlook icon at bottom of computer screen

m. In Outlook, on top left side of window, click on "New E-mail" (opens a blank email)

n. Copy and paste EARLY RUN ESTIMATE SUMMARY box from Daily Estimates (Email Me) tab to the body of the email (**be sure to use "Paste Options" and "Picture" when pasting to email**)

o. Copy and paste the title of the table (EARLY RUN ESTIMATE SUMMARY) from the Daily Estimate (Email Me) tab to the subject line of the email.

p. Click on the Estimate By Day tab so this is the tab in view when Excel is closed

q. Click the "X" in the upper right hand corner of the Excel window to close Excel

r. When prompted, click "Save" to save your work

s. Continue with batch file – follow instructions

t. The batch file will close automatically.

11. **Double-click the "Office Log" icon**

a. Opens "*OfficeLog.bat*", located in "*U:\Batch\AutoDated*"

b. Follow instructions

c. Automatically opens OFFICE_LOG.dotx template (located in *U:\DataProc16\OfficeLog*)

d. Fill in the log

e. Click "File" on the toolbar and then "Save As"

f. Click the "File name" dropdown arrow and click on previous day's filename

g. Change Julian Date to current day's date and save as JDxxx.docx

h. Click on "Save as type" and in the resulting dropdown window click on PDF (*.pdf)

i. Click "Save"

j. Click on "File" on menu toolbar, then "Print" to print one copy of the office log

k. Click on the "X" at the upper right of the window to close the office log template (do not save it)

l. Continue with batch file – follow instruction (Press any key to continue…)

m. The batch file will close automatically.

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12. **Complete and send email**
    a. Drag *Estimate Summary.xls*, *JDXXX.pdf* (office log), *SAS-Office-JDXXX.mht,* and the *JDxxx.PNG* SAS graph from computer desktop to the body of email.
    b. Click inside the "To" box in the email and then type "s"
    c. Click on "SSestimate"
    d. Click "Send" to send email

13. **Double-click the "Docushare Upload" icon** (Not currently in the "One Ring…" batch process)
    a. Opens "*Doc_U_share.bat*", located in "*U:\Batch*"
    b. Follow instructions
    c. Automatically opens Docushare window
    d. Login to Docushare
    e. Update Estimate Summary (EstimateSummary.xls) from desktop (use red arrow)
    f. Upload Office Log (*JDXXX.pdf*) from desktop – copy previous day's title first & change JD
    g. Upload Range/Time Graph (*JDXXX.png*) from desktop – copy previous day's title first & change JD
    h. Minimize Docushare
    i. Continue with batch file – follow instruction
    j. The batch file will close automatically

14. **Double-click the "Archive Batch Files" icon** (Not currently in the "One Ring…" batch process)
    a. Opens "*ArcBats.bat*". located in "*U:\Batch\AutoDated*"
    b. Follow instructions – cleans up desktop
    c. The batch file will close automatically

15. **Click into the "One Ring…" batch command window**
    a. (This window has been open and running throughout the 10 steps of processing. The technician clicks into it to "**Press any key to continue …**" after each step.)
    b. "**Press any key to continue …**" one final time, to let it finish. The window will close automatically.
16. **Put printouts of the *Office Log* and the *Daily Estimates* in the 3-ring binders.**

Appendix D2.–Primer on batch (.bat) files used on the Chinook salmon sonar project.

Updated 18 May 2016 by Mike Hopp for the Upper River Chinook ARIS Sonar Project.

Batch files are text files containing a series of commands intended to be executed by a command interpreter. When a batch file is run, the shell program (usually COMMAND.COM or cmd.exe) reads the file and executes its commands. Batch files are useful for running a sequence of "executables" automatically and are often used to automate tedious processes.

Several batch files have hard-coded filenames, pathnames, and year values as environment variables written near the top of the file. These must be edited and saved at the start of each season (use right mouse click, <**Edit**> or <**Edit with Notepad**++>). Some batch files have hard-coded dates (JD, Day, Month): these must be edited and saved before each use.

Most batch files using dates *now* use a Date Menu system that sets the date in text files, which are then read by the batch files. These batch files do not have to be edited daily.

Batch files used on this project are organized into folders according to their purpose and dependency (some batch files depend upon or call on other batch or text files). These are described in Table D2-1. Batch files, executables, and text files are given in Table D2-2.

Table D2-1.–Overview of batch file and folder locations and the purpose of the batch file for ARIS data processing

Location	Function	Dependencies
U:\Batch	Processing data after tracking and measuring fish is done	None. These are daily data processing batch files that are not dependent on AutoDated files. *Estimates.bat* and *Doc_U_share.bat* do not use dates.
U:\Batch\TxtCounter	Handy tool to list and count all ARIS measurement text files in a day's tracking folders	This uses 7 related .exe, .txt and .bat files. *DaterMenu.bat* executes *SetJDtxt.exe* (which writes *dateJD.txt*), then reads *dateJD.txt* and then calls *CountStrats.bat*. *CountStrats.bat* repeatedly calls *CountThisDir.bat*. *CountThisDir.bat* executes *TxtCount.exe* (which writes *txtCounted.txt*) and then reads *txtCounted.txt*.
U:\Batch\UploadDailyData	Uploads camp data from portable 2-Terabyte drives to a backup Passport HD and to organized sub-folders on the NAS	This uses 9 related .exe, .txt and .bat files. *UploadMenu.bat* executes *SetJDtxt.exe* (which writes *dateJD.txt*), then reads *dateJD.txt* and then calls *SonarUpload.bat*. *SonarUpload.bat* repeatedly calls *UploadStrataXX.bat* (where XX=LN, LO, RO, RN or CH –identifying a sonar unit).

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Location	Function	Dependencies
U:\Batch\Autodated	[New, using Date Menu] - processing data after tracking and measuring fish is done	This uses 13 related .exe, .txt and .bat files. *OneRing.bat* calls *MonthDayMenu.bat* and then reads *dateJD.txt*, *DataDay.txt* and *DataMonth.txt*. *OneRing.bat* executes 10 different steps by starting programs or calling batch files in the proper sequence. *MonthDayMenu.bat* executes *SetJDtxt.exe* (which writes *dateJD.txt*), then reads *dateJD.txt*, then writes *DataMonth.txt* and *DataDay.txt* and then opens notepad & *A0_Configure 2016v1.sas* (to edit date). *PackageArisForSAS-2.bat* reads *dateJD.txt*, *DataDay.txt* and *DataMonth.txt*. Then it repeatedly calls *LogStrataYN.bat* (for each of about 20 strata). Then it repeatedly calls *CopyStrata.bat* (for each strata). *UploadPackage.bat* reads *dateJD.txt*, *DataDay.txt* and *DataMonth.txt*. *OfficeLog.bat* reads *dateJD.txt.* ArcBats.bat reads *dateJD.txt.* *AsamplesReset.bat* reads *dateJD.txt*, *DataDay.txt* and *DataMonth.txt*.
U:\Batch\ManualDated	[Old method] - processing data after tracking and measuring fish is done	None. These are old batch files that were in use before the Date Menu system. Before use, each batch file must first be edited and saved to change the Date and JD (if used).
U:\Batch\LOGS	Stores log files generated by batch processing of data	This folder must exist, since it is referenced in several batch files as the location to store log files.
U:\DataProc16\SAS\SASPrograms	Controls SAS processing of data	These are SAS program files, similar to –but not the same as– batch files. Sequence numbers in the filename indicate the order to be run.
U:\Batch\Archive	Stores currently unused batch programs and icons	n/a
U:\Batch\Archive\Set2Mover	Was used in 2015 to move some Set2 data from the nearly-full TeraStation to another, to free up space.	This uses 4 related .exe, .txt and .bat files. *Menu2Mover.bat* executes *SetJDtxt.exe* (which writes *dateJD.txt*), then reads *dateJD.txt* and then repeatedly calls *Set2Mover.bat*.

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Appendix D2.–Page 3 of 7.

Table D2-2.–List of batch files, executables, and text files currently used in ARIS data processing.

File Name [a]	Location [b]	Type and function
*	*UploadDailyData*	For transferring Field data to Office NAS and Backup drive…
UploadMenu.bat	*UploadDailyData*	Initial batch file that provides a menu to select the *DataMonth & DataDay* and ARIS Sonar pod data (*PodxFolder*) to upload. It then calls *SonarUpload.bat* with *PodxFolder* as a parameter.
		[Environment variables set here are used by all the *UploadDailyData* batch files without necessarily being passed as parameters in a CALL command line. *DataYear* is hard coded and must be edited each season for a new year.]
SetJDtxt.exe	*UploadDailyData*	Executable used in *UploadMenu.bat* to calculate (based on *DataYear*, *DataMonth & DataDay* parameters) and write the data JD (Julian Date) in *dateJD.txt*.
dateJD.txt	*UploadDailyData*	Text file written by *SetJDtxt.exe* and read by *UploadMenu.bat* and stored in the JD environment variable. It is then used throughout the *UploadDailyData* set of batch files.
SonarUpload.bat	*UploadDailyData*	Batch file called by *UploadMenu.bat* with *PodxFolder* passed as a parameter into the *DestFolder* environment variable.
		This is the main processing batch file used to upload daily ARIS sonar data from field hard drives to the NAS and to the backup portable "My Passport" hard drive. It creates several subfolders on the NAS, determined by the *DestFolder*.
		Using a FOR LOOP with a *StratCount* counter, it repeatedly calls *UploadStrataXX.bat* to selectively copy the *.aris* files into subfolders based on the 10-minute time stamp in the filename.
		Additionally, this batch process uses extensive error-checking and logs its progress and then finally deletes the field-source files and folders (so that those drives can be re-used daily for data collection in the field).
UploadStrataLN.bat *UploadStrataLO.bat* *UploadStrataRO.bat* *UploadStrataRN.bat* *UploadStrataCH.bat*	*UploadDailyData*	Five batch files, each uniquely identifying a sonar unit. These are called repeatedly by *SonarUpload.bat* to copy the *MINS*-selected files (by 10-minute filemask) into the proper subfolder on the NAS.
		Five different batch files are needed to conveniently deal with the different 10-minute strata definitions for each of the 5 different sonar pod locations.

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File Name [a]	Location [b]	Type and function
*	*TxtCounter*	For checking progress & completion of ARIS measurement files for a data day…
DaterMenu.bat	*TxtCounter*	Initial batch file that provides a menu to select the *DataMonth* & *DataDay*. [*DataYear* is hard coded and must be edited each season for a new year.] After setting date and *DatedFolder* environment variables, it calls *CountStrats.bat*.
SetJDtxt.exe	*TxtCounter*	Executable used in *DaterMenu.bat* to calculate (based on *DataYear*, *DataMonth* & *DataDay* parameters) and write the data JD (Julian Date) in *dateJD.txt*.
dateJD.txt	*TxtCounter*	Text file written by *SetJDtxt.exe* and read by *DaterMenu.bat* and stored in the JD environment variable. It is then used throughout the *TxtCounter* set of batch files.
CountStrats.bat	*TxtCounter*	Batch file called by *DaterMenu.bat*. It repeatedly sets *StratXSetX* (as a sub-folder path environment variable) and calls *CountThisDir.bat*, which fills a text file with a count and list of .txt files for each sub-folder. This is the main processing batch file used to count and list all the ARIS fish-measurement .txt files in each of the sub-folders for an entire data-day. This is recorded in a *txtCounted.txt* file, located at the root of the *DateFolder*, which is then opened for the technician to review. This is a handy tool to help technicians determine fish-measurement progress during the day.
CountThisDir.bat	*TxtCounter*	Batch file repeatedly called by *CountStrats.bat*. It executes *TxtCount.exe* to count the .txt files in the selected folder and then writes that count in *txtCounted.txt*. It then reads *txtCounted.txt* into the *TxtFiles* environment variable and uses that to record the text count as well as a Directory list of .txt files into a *DirStrats.txt* file located at the root of the *DateFolder*.
TxtCount.exe	*TxtCounter*	Executable used in *CountThisDir.bat* to count the .txt files in the folder path (received as a command line parameter. It then writes that count in *txtCounted.txt*.
txtCounted.txt	*TxtCounter*	Text file written by *TxtCount.exe* and used in *CountThisDir.bat*. It stores a text representing a count of .txt files found in the folder path.

<center>-continued-</center>

File Name [a]	Location [b]	Type and function
*	*AutoDated*	For end-of-day processing of ARIS measurement files for an entire data-day…
OneRing.bat	*AutoDated*	Master batch file used to call other processes and batch files in the proper sequence of 10 steps in the Chinook ARIS Sonar post-measurement processing of a day's data.
		Files in the *AutoDated* folder use 13 related*** .exe, .txt and .bat files. *OneRing.bat* first calls *MonthDayMenu.bat* to set the *dateJD.txt*, *DataDay.txt* and *DataMonth.txt*. These files are then read by each of the .bat files in the *AutoDated* folder.
		In proper sequence, *OneRing.bat* gives instructions and CALLS *MonthDayMenu.bat*, STARTS the *2016 ARIS daily summary of data quality.xlsx*, OPENS *Asamples2016.txt*, OPENS *Adaily2016.txt*, OPENS *2016 ARIS Fish List v17.xlsm*, CALLS *PackageArisForSAS-2.bat*, CALLS *UploadPackage.bat*, CALLS *Estimates.bat,* CALLS *OfficeLog.bat*, CALLS *Doc_U_share.bat*, CALLS *ArcBats.bat.*
		***[It is not mandatory to use *OneRing.bat*, but it is otherwise necessary to run *MonthDayMenu.bat* before using other .bat files in the AutoDated folder since they depend on correct dates recorded in *dateJD.txt*, *DataDay.txt* and *DataMonth.txt*.]
MonthDayMenu.bat	*AutoDated*	Batch file that provides a menu to select the *DataMonth* & *DataDay* for data processing
		MonthDayMenu.bat executes *SetJDtxt.exe* (which writes *dateJD.txt*), then reads *dateJD.txt*, then writes *DataMonth.txt* and *DataDay.txt* and then opens notepad & *A0_Configure 2016v1.sas* (to edit the date).
		[*DataYear* is hard coded and must be edited each season for a new year.]
SetJDtxt.exe	*AutoDated*	Executable used in *MonthDayMenu.bat* to calculate (based on *DataYear*, *DataMonth* & *DataDay* parameters) and write the data JD (Julian Date) in *dateJD.txt*.

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File Name [a]	Location [b]	Type and function
dateJD.txt	*AutoDated*	Text file written by *SetJDtxt.exe* and read by several *.bat* files in the *AutoDated* folder. It is stored in the JD environment variable, which is then used throughout the batch file.
DataDay.txt	*AutoDated*	Text file recorded by *MonthDayMenu.bat* and used by several *.bat* files in the *AutoDated* folder.
DataMonth.txt	*AutoDated*	Text file recorded by *MonthDayMenu.bat* and used by several *.bat* files in the *AutoDated* folder.
PackageArisForSAS-2.bat	*AutoDated*	Batch file used to copy and also zip up a complete set of ARIS measurement .txt files for a particular data day.
		This is the main data processing batch file used copy .txt files from each of 20 different strata subfolders and gathers these copies into one pack folder. Then it zips up a copy of these .txt files; and then it moves them into a processing folder. Then it runs opens SAS to analyze and process this data.
		It uses 20 environment variables to determine which of 20 strata are copied to a *PackFolder* (*U:\DataProc16\Manual*). It calls *LogStrataYN.bat* (for each strata) to log selections. Then it calls *CopyStrata.bat* (for each strata) to copy the .txt files.
		Then it copies this set into a compressed zip folder. Then it moves the .txt files into the *SASInputFolder* (*U:\DataProc16\SAS\SASInput*), where they will be processed by SAS. It uses extensive error-checking throughout and it logs its progress.
LogStrataYN.bat	*AutoDated*	Batch file called by *PackageArisForSAS-2.bat* for each of 20 strata. This records strata selection choices for subsequent copying of .txt files.
CopyStrata.bat	*AutoDated*	Batch file called by *PackageArisForSAS-2.bat* for each of 20 strata. This copies the .txt files from each strata folder to the *PackFolder*.
UploadPackage.bat	*AutoDated*	Batch file used to copy the *Aris_JDxx_2016-mm-dd_TxtData.Zip* from the *U:\Data2016\RM13-Packaged* folder to the Anchorage *J:\KNCHISNR\Soldotna\ARIS* folder. It uses extensive error-checking throughout and it logs its progress.

File Name [a]	Location [b]	Type and function
Estimates.bat	*Batch*	Batch file used to open *Estimate_Summary2016.xls* (located in *U:\DataProc2016\ Spreadsheets*) and also copy it to the desktop as *EstimateSummary.xls*.
OfficeLog.bat	*AutoDated*	Batch file used to open the *OFFICE_LOG.dotx* template (located in *U:\DataProc2016\ OfficeLog*). Then it copies *JDxxx.docx* and *JDxxx.pdf* from the local *MYDOCS* folder to the *ProcLogFolder* (*U:\DataProc2016\OfficeLog*) after user-editing and saving files.
Doc_U_share.bat	*Batch*	Batch file used to open Docushare for daily updates.
ArcBats.bat	*AutoDated*	Batch file used to archive the processing batch files & to delete temporary desktop files
AsamplesReset.bat	*AutoDated*	Batch file used to rename *JDxxx-Asamples2016.txt* back to *Asamples2016.txt*, located in the dated *U:\Data2016\2016-mm-dd-JDxxx* folder – in order to re-run *PackageArisForSAS-2.bat* (presumably after changes to data files were made). [*PackageArisForSAS-2.bat* looks for *Asamples2016.txt* and then renames it *JDxxx-Asamples2016.txt*. This file is used as a sentinel file to verify that the day's processing is done and ready to be packaged for SAS processing.]
*.sas	*SASPrograms*	For programming SAS to analyze and report on ARIS measurement raw data…
A0_Configure 2016v1	*SASPrograms*	Configures SAS environment (paths, dates, etc…) for current SAS program
A1_ReadData_2016v1	*SASPrograms*	Reads ARIS fish measurement data and data-recording time-stamps into SAS tables
A3_Estimate- Passage_2016v1	*SASPrograms*	Estimates passage of fish of different lengths (>= 40, 75, 90)
A4_RangeTime 2016v1dt	*SASPrograms*	Produces range-time graphs
A5_FreqDistnNetAL 2016BHK	*SASPrograms*	Produces frequency-distribution graphs
EasyA4_RangeTime 2016v1	*SASPrograms*	Produces range-time graphs

[a]   Files are listed in general order of use in a typical day.

[b]   Location refers to folders or subfolders in *U:\Batch* or *U:\DataProc16\SAS\,* as indicated in Table D2-1.

APPENDIX E: KENAI RIVER CHINOOK SALMON SONAR NETWORK CONFIGURATIONS

Appendix E1.–Soldotna sonar office IP addresses.

SONAR Office	IP address	Location	Serial #	Username	Device name or purpose
Network Attached Storage					
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	2014/2016 RM 13.7 ARIS DFGSXQTERA01
Buffalo TeraStation Pro 8 16 TB	192.168.1.165	Sonar office	none	Admin	2015 RM 13.7 ARIS DFGSXQTERA01
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

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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			J8XM4M1	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

Appendix E2.–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 E3.– Mapping to the Network Attached Storage (NAS), Buffalo TeraStation 5800, in 2016.

The 2015 Buffalo TeraStation NAS device will be configured with 2 separate networks (1 for the upload computer and 1 for the data processing computers), allowing simultaneous data upload and data processing. Each of the 2 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	192.168.15.203	DFGSXQDSFtera04	2016 RM 13.7	U
2	192.168.7.203	DFGSXQDSFtera04	2016 RM 13.7	U
1	192.168.15.204	DFGSXQDSFtera02	2015 RM 13.7	W
2	192.168.7.204	DFGSXQDSFtera02	2015 RM 13.7	W
1	192.168.15.203	DFGSXQDSFtera04	2014 RM 13.7	R
2	192.168.7.203	DFGSXQDSFtera04	2014 RM 13.7	R
1	192.168.15.201	DFGSXQDSFtera01	2014 RM 8.6	L [a]
2	192.168.7.201	DFGSXQDSFtera01	2014 RM 8.6	L [a]
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.	-

[a] 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………..**
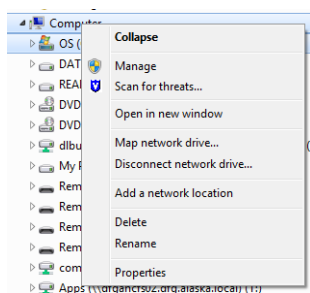
2) Select **Drive U:** from drop down menu
   Enter Folder : \\DFGSXQTERA02\SXQTERA

   Select\check **Connect using different credentials**

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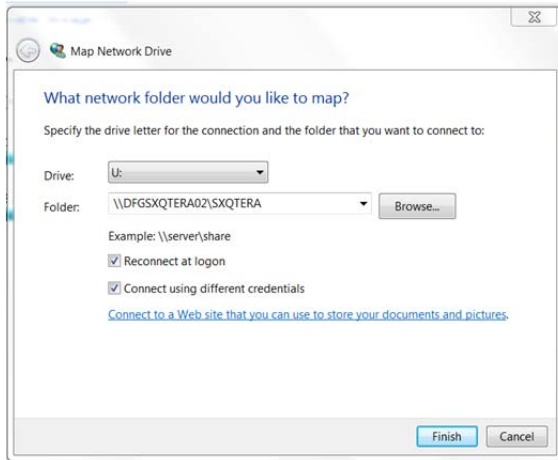
3) When prompted enter credentials:
   Username: **dfgsxqtera02\admin**

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

Appendix F1.–Instructions and settings for manual length measurements from ARIS images in 2016 using SMC 2.3–Rev 6993.

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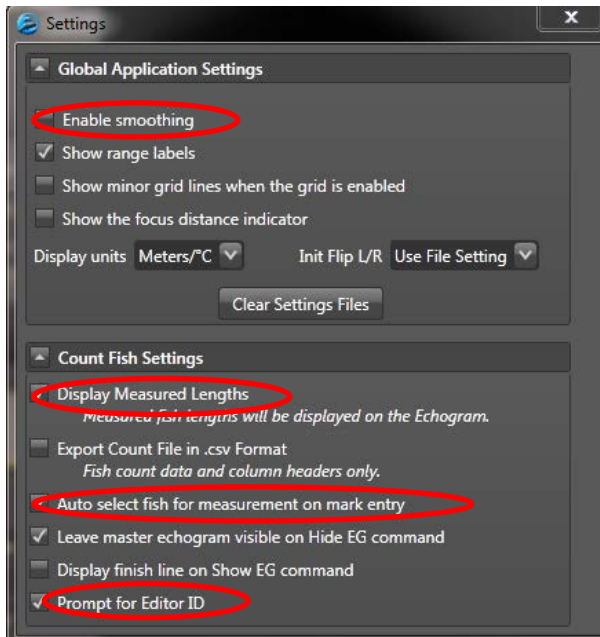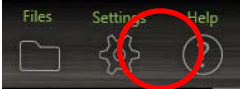
b) Enable smoothing is *off*.
c) Display Measured Lengths is *on*.
d) Auto select fish for measurement on mark entry is *on*.
e) Prompt for Editor ID is *on*.

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:
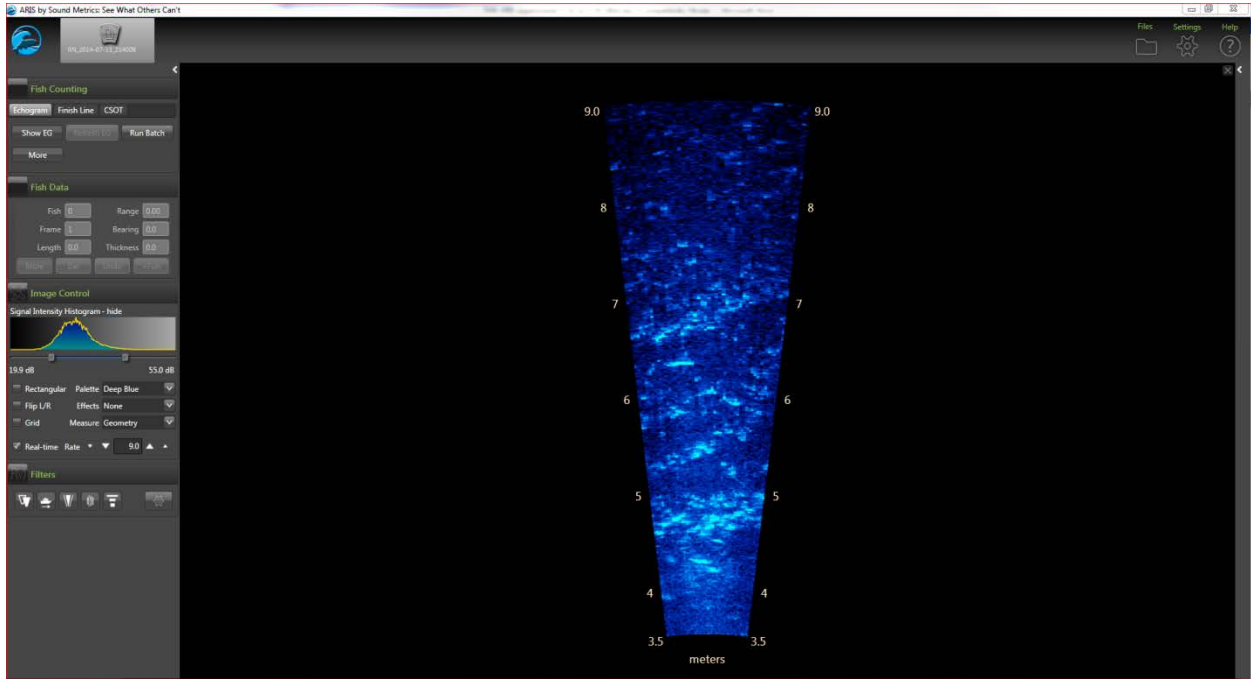
a) Select the **<Background Subtraction>** icon and wait 30 seconds or so for background to subtract
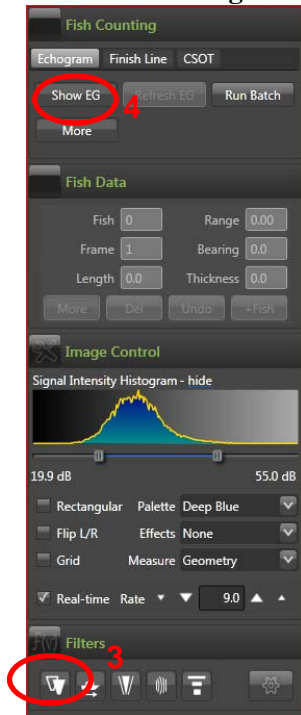
b) Then select **<Show EG>** to display the Echogram.
c) You will be prompted to enter your Editor ID. Press OK.

-continued-

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Your display should now look like the one below
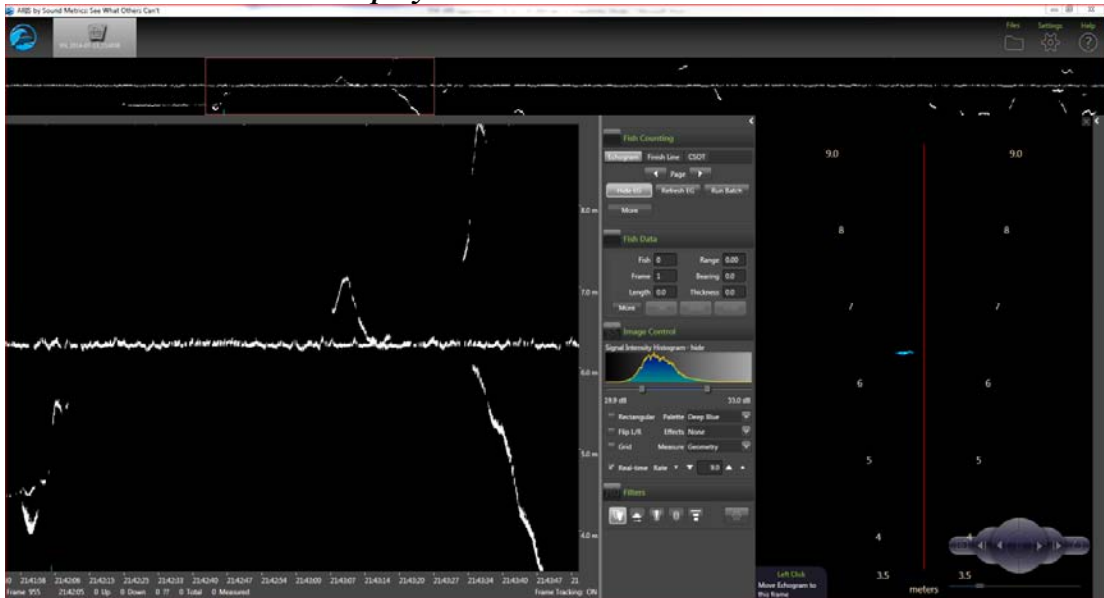
c) Select **<More>** from the Fish Counting window to get the extended window where you can
   o enter your **Editor ID** initials
   o set the **Upstream Fish** direction
   o ensure that **Loop** length is set to at least 8 seconds
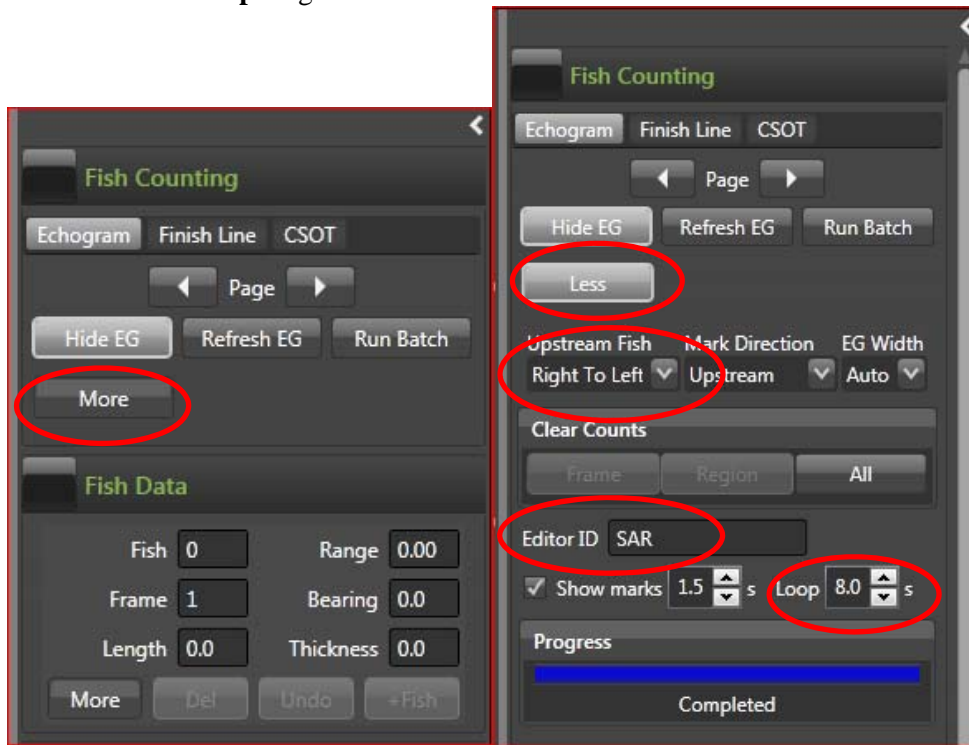
   o then select **Less** to unexpand Fish Counting window (you'll be able to access other controls like BS easier if you do this)

-continued-

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a) 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**[10]**.**

b) Set Signal Intensity sliders to optimize video image for measuring fish.
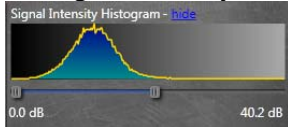
c) Your overall display should look similar to the following:
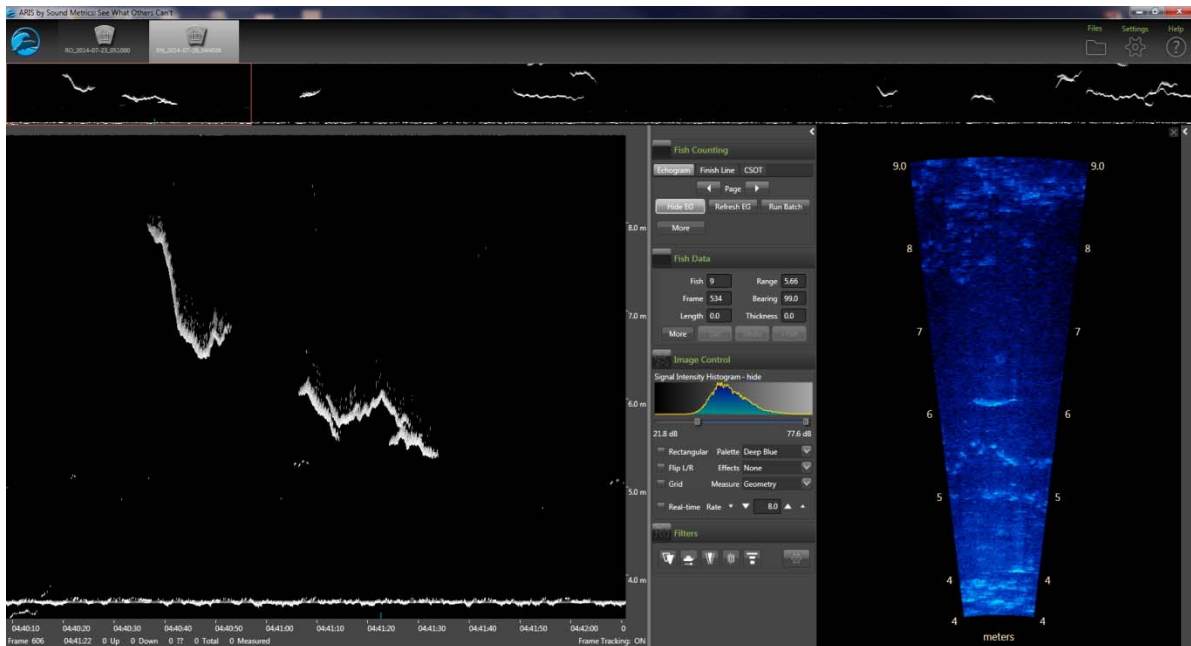
d) Now you are ready to start measuring (or marking) individual fish.
e) Once finished measure/marking all fish in the file, turn **<Background Subtraction>** on prior to advancing to the next file.

<div align="center">-continued-</div>

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[10] 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.

d) Select **<Alt><right arrow>** to advance to the next file.
e) 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).
f) When you switch banks, you will need to reset the direction of travel parameter in step 5.
g) Now you are ready to start measuring/marking fish in the new file.

3) Instructions for manual fish length measurements using SMC ARISFish software version 2.3 - Rev 6993 in 2016.

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.
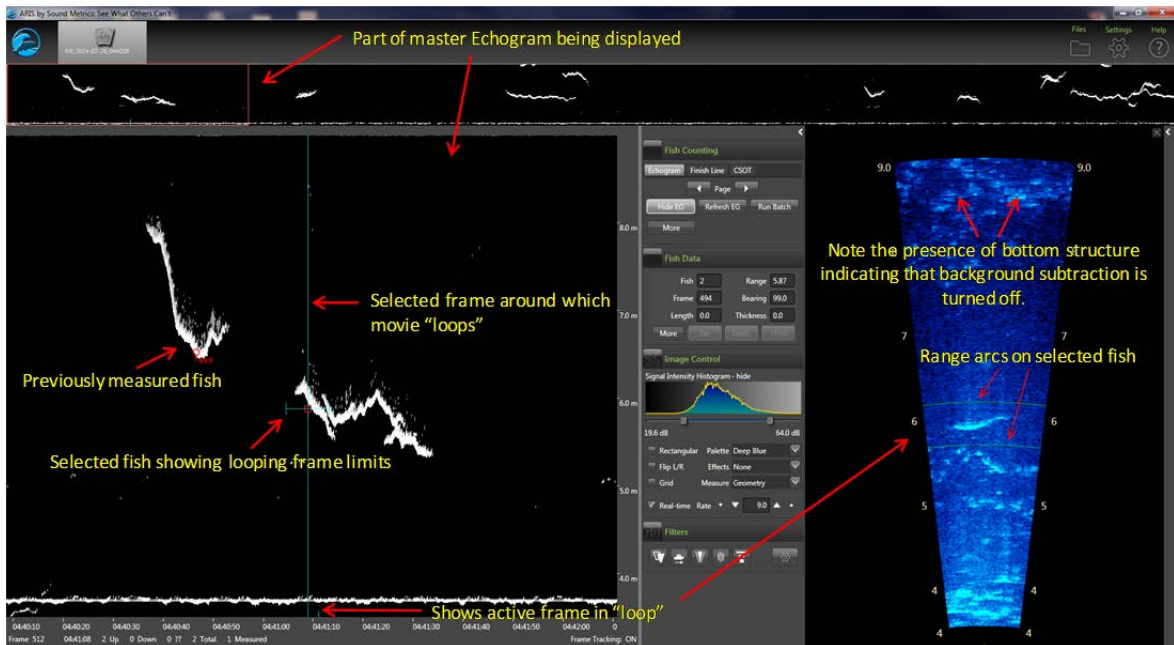
   o   Press **<space bar>** to start or stop the video playback.
c) Use **<right arrow>** and **<left arrow>** to step through movie one frame at a time to find a frame that displays the entire fish length well.
   o   Measurements should be taken from frames where contrast between the fish image and background 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 perfectuly 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)   Measure fish image:
- Fish traveling snout-first upstream or downstream - **<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.
- Fish backing downstream through the beam tail-first - **<left click>** on the fish tail 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 snout.
- 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 2016.

    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 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 F2 demonstrates the potential for overcounting without applying this criterion. Additional examples are given in Appendix F3.

Summary of fish measurement rules

a) For a fish to be considered valid for measurement, it must cross the centerline.
   - o 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.
   - o 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.
   - o 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.

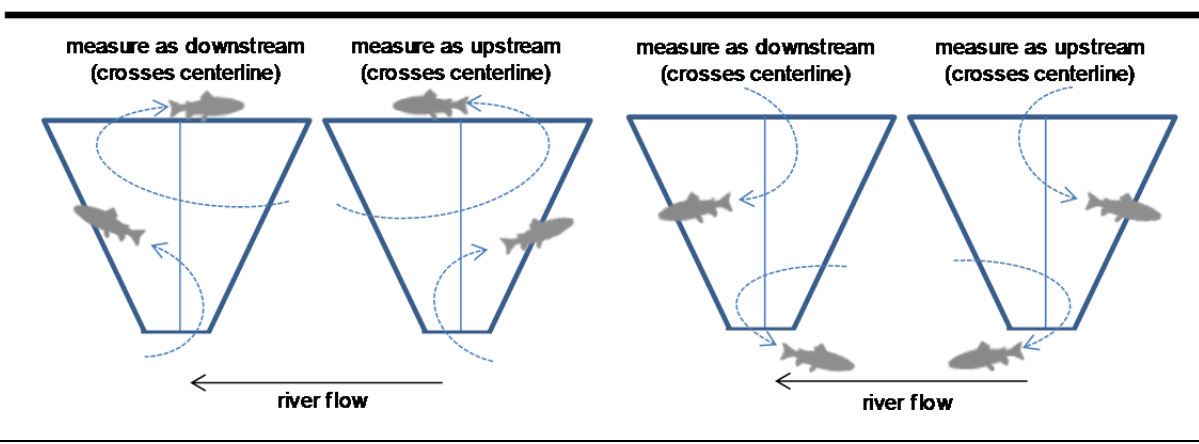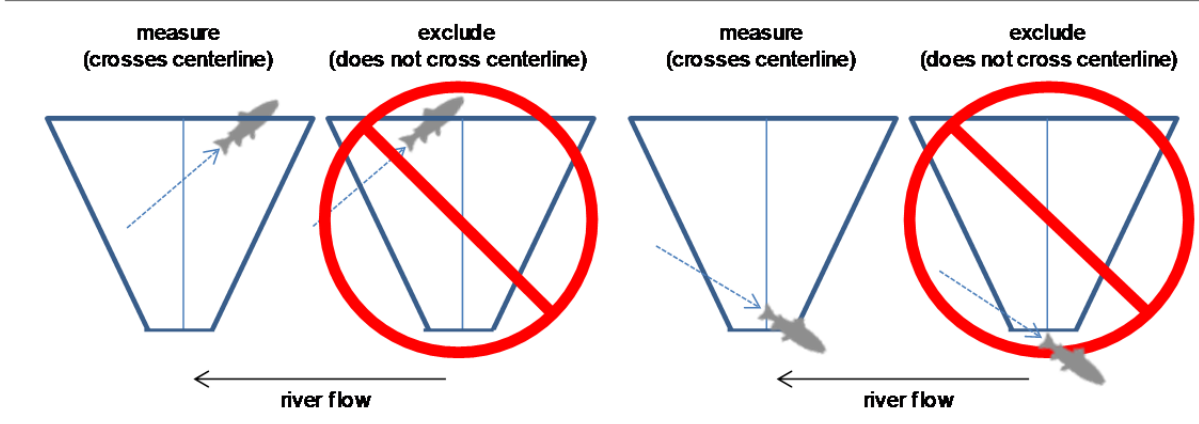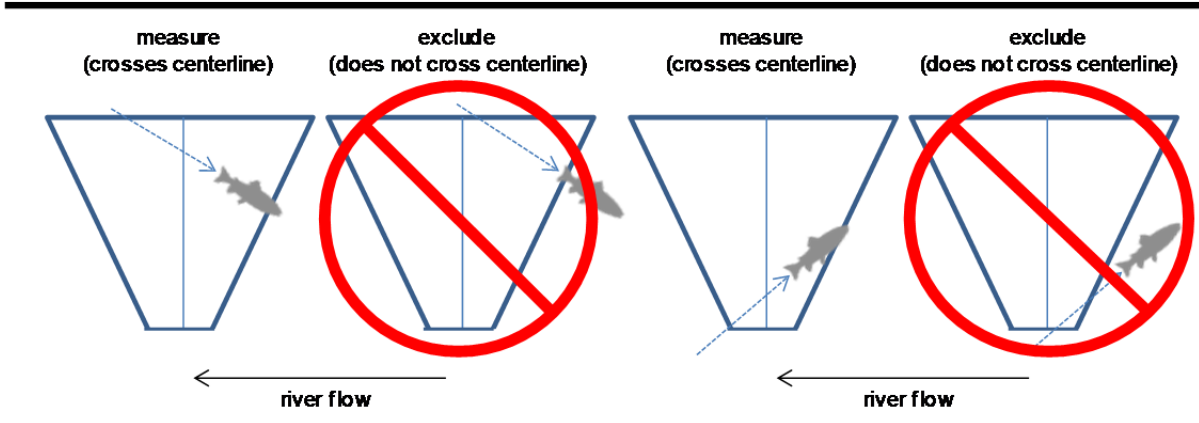h) Consult with others if you come across a questionable trace (fish) or are unclear of the rules listed above.
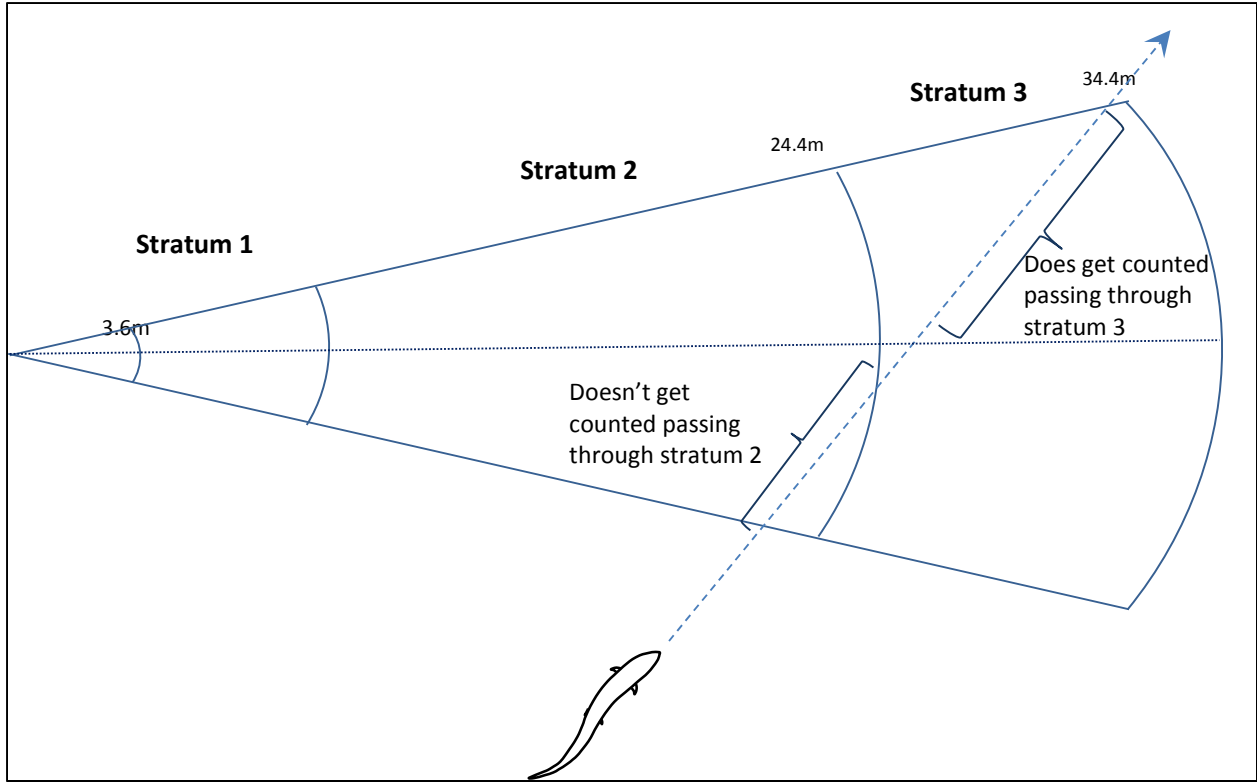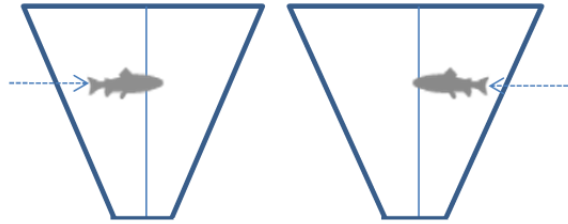
Appendix F2.–Illustration of the problem of double-counting.

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.
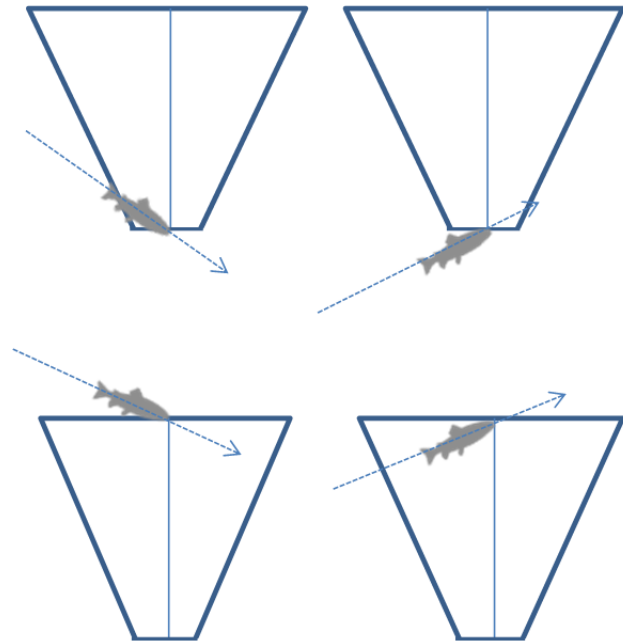
Appendix F3.–Specific examples for applying the "Centerline Rule" when selecting fish for counting and measurements.

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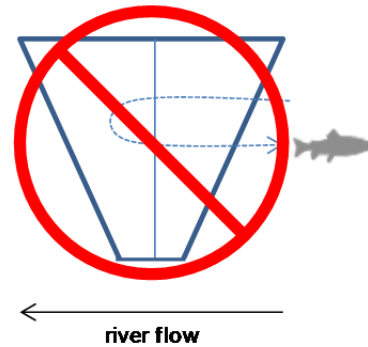
measure
(crosses centerline)

exclude
(does not cross centerline)

measure
(crosses centerline)

exclude
(does not cross centerline)

river flow

river flow

measure
(crosses centerline)

exclude
(does not cross centerline)

measure
(crosses centerline)

exclude
(does not cross centerline)

river flow

river flow

measure as downstream
(crosses centerline)

measure as upstream
(crosses centerline)

measure as downstream
(crosses centerline)

measure as upstream
(crosses centerline)

river flow

river flow

-continued-

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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).

river flow

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

river flow

-continued-

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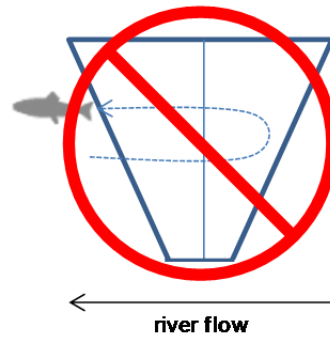
Exclude fish that hold throughout the length of the sample.
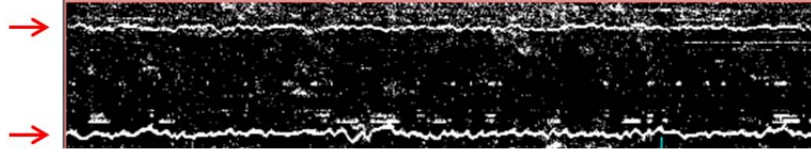
Two fish hold throughout the entire file.
Exclude both fish.

Exclude fish that hold at either the beginning or end of the sample.
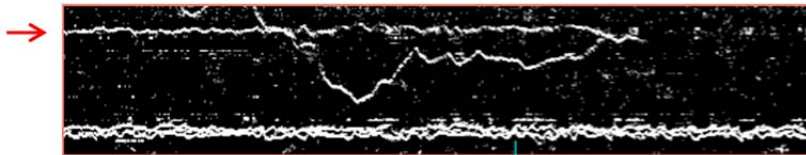
Fish holding as sample begins, then exits the beam about ¾ of the way through the sample. Exclude this fish.
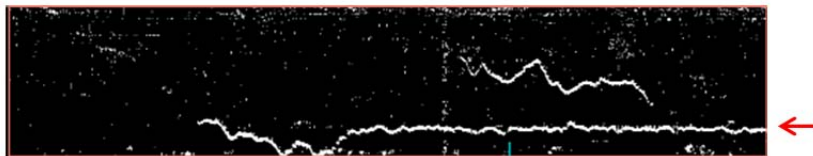
Fish enters the beam mid sample, then holds through the end of the sample. Exclude this fish

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.

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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.
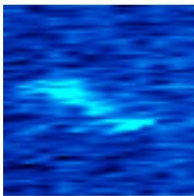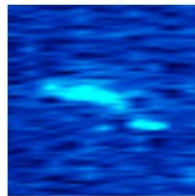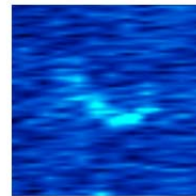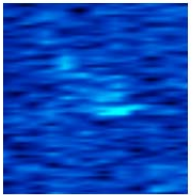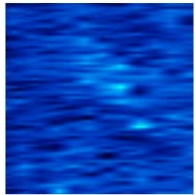

Frame #2353 Frame #2354 Frame #2355 Frame #2356 Frame #2357
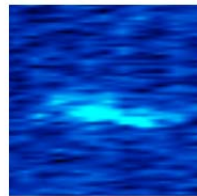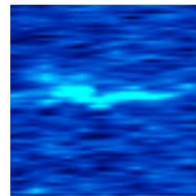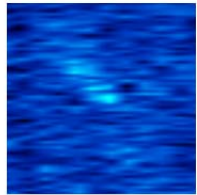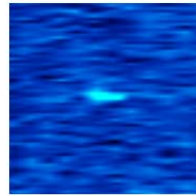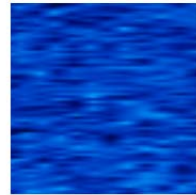
Frame #2358 Frame #2359 Frame #2360 Frame #2361 Frame #2362

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

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 G2. 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 there are substantial numbers of small Chinook salmon and 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.

Mixture models 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 G1.2 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 length[11]; similar to DIDSON length (Appendix G3; 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 G4),

$$f(y) = \pi_S f_S(y) + \pi_C f_C(y) \tag{G1.1}$$

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.

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[11] Preliminary analysis of ARIS tethered fish data were collected at RM 8.6 in 2014.

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

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i \tag{G1.2}$$

where β_0 is the intercept, β_1 is 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 G4). 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 from multiple days of netting are paired with a single day of hydroacoustic data. 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 salmon length distributions as 3-component normal age mixtures:

$$f_S(x) = \theta_{S1} f_{S1}(x) + \theta_{S2} f_{S2}(x) + \theta_{S3} f_{S3}(x) \text{ and} \tag{G1.3}$$

$$f_C(x) = \theta_{C1} f_{C1}(x) + \theta_{C2} f_{C2}(x) + \theta_{C3} f_{C3}(x) \tag{G1.4}$$

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

$$f_{Sa}(x) \approx N\left(\mu_{Sa}, \tau_{Sa}^2\right) \text{ and} \tag{G1.5}$$

$$f_{Ca}(x) \approx N\left(\mu_{Ca}, \tau_{Ca}^2\right). \tag{G1.6}$$

The overall design is therefore a mixture of (transformed) mixtures. That is, the observed hydroacoustic data are modeled as a 2-component mixture of *y*, each component of which is transformed from a 3-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 G5). 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 subset[12] of tethered fish data in the mixture model (Appendix G3).

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[12] Preliminary work has shown that DIDSON or 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.

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 2 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 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 G3.

By default, data will be stratified by day; i.e., daily data from different spatial and temporal strata will be pooled and the model given above will be fit to the pooled data (Equation 5 in Data Analysis section). Sample size limitations may occasionally necessitate pooling the data across more than 1 day. Changes will not be made to stratification structure during the season. Situations that would warrant a (postseason) revision to the estimates include the sampling fraction differing greatly among spatial and temporal strata, or 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.
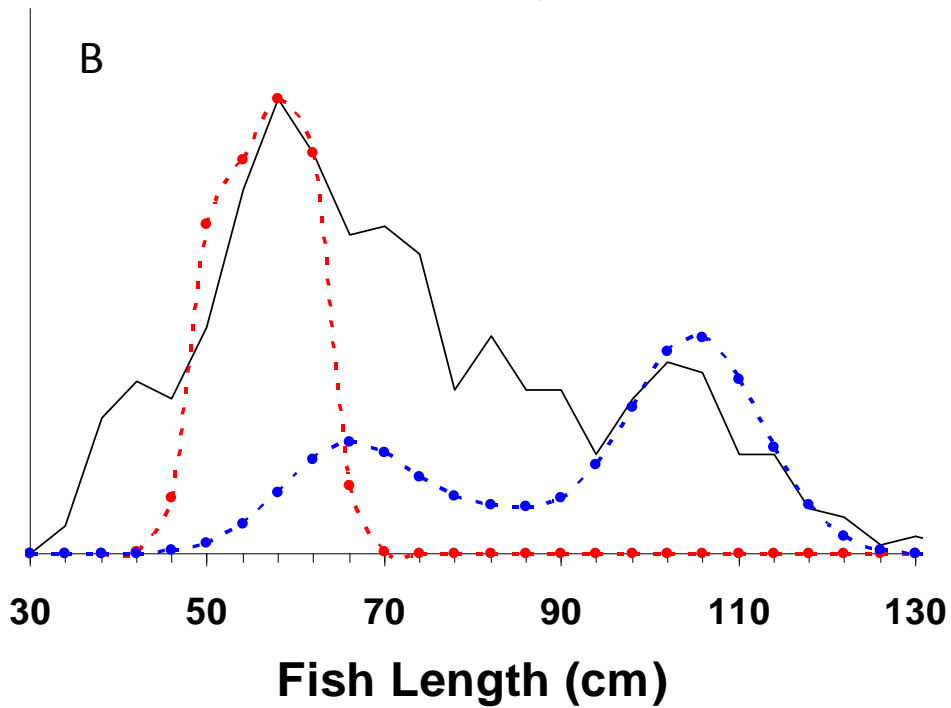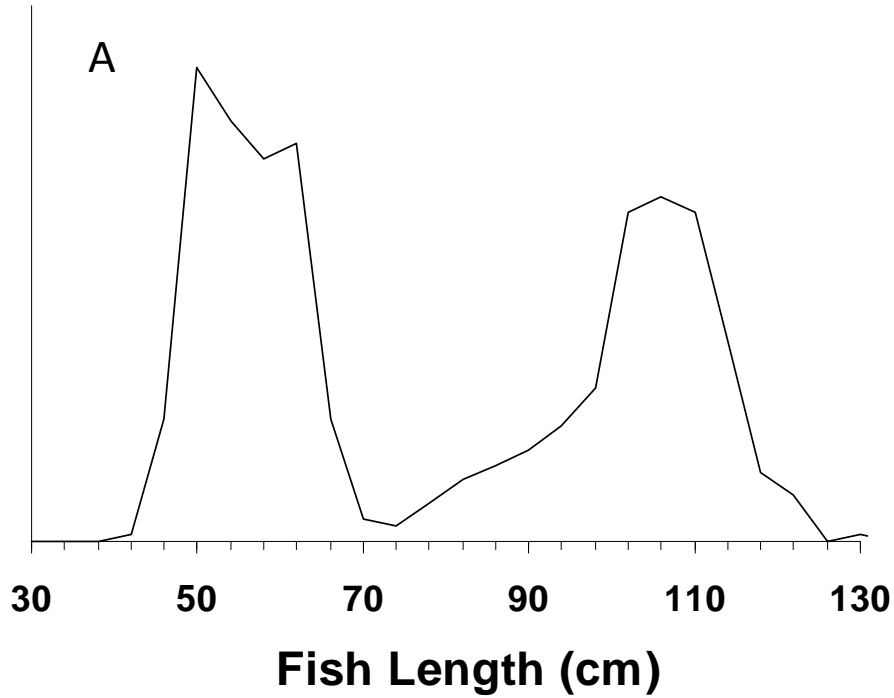
Appendix G2.–Hypothetical distributions of fish length measurements (black solid lines) from the Kenai River: (A, top) few small Chinook salmon with no measurement error and (B, bottom) 40% of Chinook salmon are small with measurement error standard deviation 10 cm.

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.
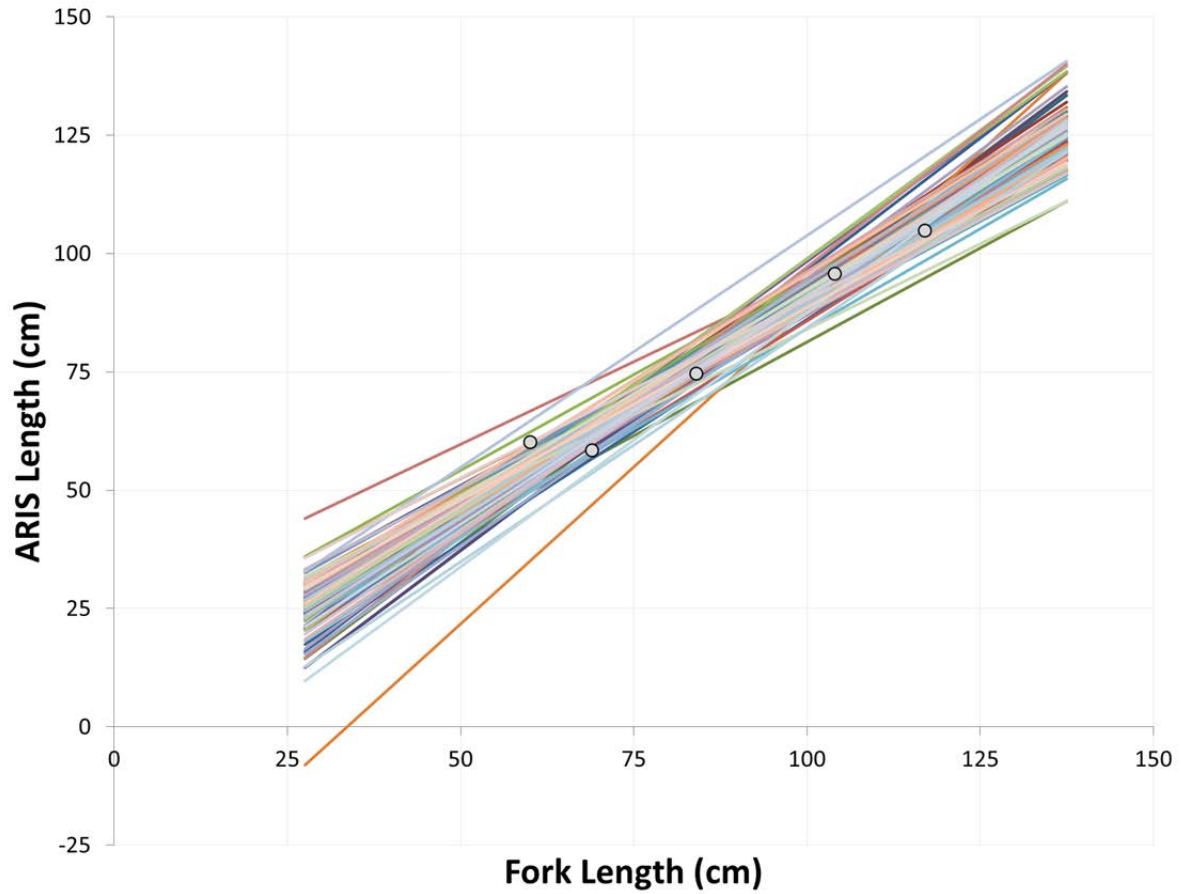
Appendix G3.–Abridged tethered fish dataset (symbols) used to provide mildly informative prior information on regression parameters to the ARIS length mixture model. Lines show samples of 100 plausible linear relationships drawn from the resulting prior distribution.

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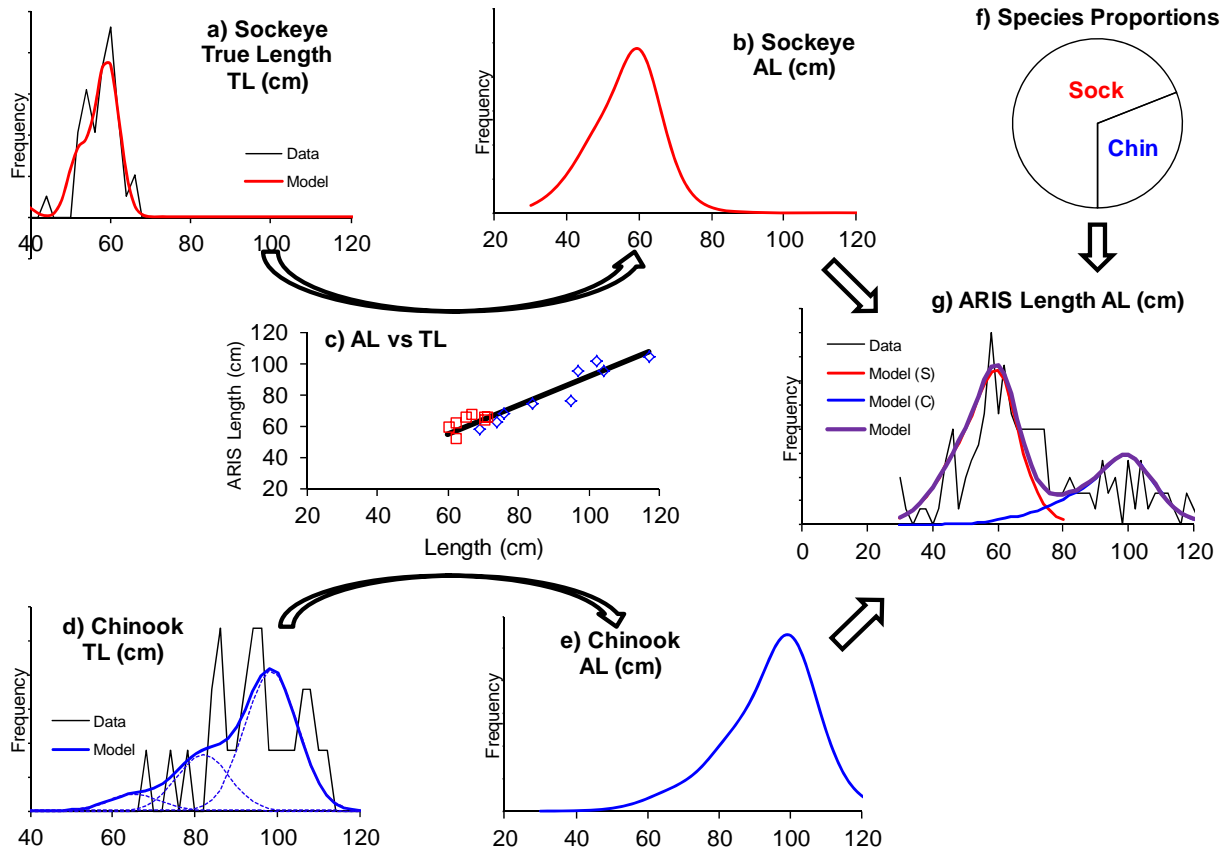
Appendix G4.–Flow chart of the ARIS length mixture model described in the text. The frequency distribution of ARIS length measurements (panel g) is modeled as a weighted mixture of species-specific distributions (b and e), which in turn are the products of species-specific size distributions (a and d) and the relationship between ARIS measured length and true length (c). The weights (species proportions, panel f) are the parameters of interest.

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Appendix G5.–WinBUGS code for mixture model under "standard" and "all large fish" data processing protocols.

```
model{
 beta0 ~ dnorm(75,0.0025)
 beta1 ~ dnorm(1,25)
 sigma.AL ~ dunif(0,20)
 tau.AL  <- 1 / sigma.AL / sigma.AL
 ps[1:2] ~ ddirch(D.species[])
 pa[1,1] ~ dbeta(0.5,0.5)
 theta1 ~ dbeta(0.5,0.5)
 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] * n_meas
 p.large <- ps[1] * (1 - pa[1,1] - pa[1,2])
 n.large <- p.large * n_meas

 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]
   DL1[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]])
   }
 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
   mu.AL2[j] <- beta0 + beta1 * TL2.cm.75[j]
   AL2[j] ~ dnorm(mu.AL2[j],tau.AL)I(40,)
   }
 }
```

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