Regional Operational Plan SF.2A.2020.11

Operational Plan: Kenai River Chinook Salmon Sonar Assessment at River Mile 13.7, 2020–2022

by

Brandon Key

James Miller

and

Jiaqi Huang

June 2020

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

REGIONAL OPERATIONAL PLAN SF.2A.2020.11

OPERATIONAL PLAN: KENAI RIVER CHINOOK SALMON SONAR ASSESSMENT AT RIVER MILE 13.7, 2020–2022

by
Brandon Key
Alaska Department of Fish and Game, Division of Sport Fish, Soldotna
James Miller
Alaska Department of Fish and Game, Division of Sport Fish, Anchorage
and
Jiaqi Huang
Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services, Anchorage

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

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Brandon Key,
Alaska Department of Fish and Game, Division of Sport Fish,
43961 Kalifornsky Beach Road, Suite B, Soldotna, AK 99669-8276

James Miller,
Alaska Department of Fish and Game, Division of Sport Fish,
333 Raspberry Road, Anchorage, AK 99518-1599

Jiaqi Huang,
Alaska Department of Fish and Game, Division of Sport Fish,
333 Raspberry Road, Anchorage, AK 99518-1599

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Title	Name	Signature	Date
Project leader	Brandon Key		
Biometrician	Jiaqi Huang		
Research Coordinator	Tim McKinley		
Regional Supervisor	Tom Vania		

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ABSTRACT

Alaska Department of Fish and Game (ADF&G) has monitored Chinook salmon (*Oncorhynchus tshawytscha*) passage in the Kenai River using side-looking sonar technology from 1987 to present. The historical site at RM 8.6 used dual-beam (1987–1994), split-beam (1995–2011), and dual-frequency identification sonar or "DIDSON" (2012–2014) technology. Starting in 2013, ADF&G began operating adaptive resolution imaging sonar or "ARIS" at a new site located at RM 13.7. The RM 8.6 site was discontinued following the 2014 season in favor of data collection at the RM 13.7 site. This plan covers RM 13.7 project operations for the 2020–2022 seasons.

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

INTRODUCTION

Chinook salmon (*Oncorhynchus tshawytscha*) returning to the Kenai River (Figure 1) are managed as 2 distinct runs (Burger et al. 1985): early (mid-May–30 June) and late (1 July–mid-August). Early-run Chinook salmon are harvested primarily by sport anglers, and late-run Chinook salmon are harvested by commercial, sport, subsistence, and personal use fisheries. These fisheries may be restricted or liberalized if the projected escapement falls below or above goals adopted by the Alaska Board of Fisheries (BOF). These goals are defined by Alaska Administrative Codes 5 AAC 56.070 (*Kenai River and Kasilof River Early-Run King Salmon Conservation Management Plan*) and 5 AAC 21.359 (*Kenai River Late-Run King Salmon Management Plan*) and are intended to ensure sustainable Chinook salmon stocks. Sonar estimates of inriver Chinook salmon passage provide the basis for estimating spawning escapement and implementing management plans that regulate harvest in the competing fisheries for this stock.

From 1987 through 2011, the Alaska Department of Fish and Game (ADF&G) used dual-beam (1987–1994) and split-beam (1995–2011) side-looking sonar technology to estimate Chinook salmon passage in the Kenai River at RM 8.6. These technologies relied on target strength (loudness of returning echoes) and range (distance from shore) thresholds to differentiate between sockeye (*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, subsequent studies showed that these criteria can lead to inaccurate estimates (Burwen et al. 1998; Hammarstrom and Hasbrouck 1999). Extensive research was conducted at the Kenai RM 8.6 Chinook salmon sonar site toward improving our ability to identify species from split-beam sonar data (Burwen and Fleischman 1998; Burwen et al. 2003; Miller et al. 2010). Beginning in 2002, ADF&G evaluated whether dual-frequency identification sonar (DIDSON) could 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). Split-beam estimates were found to be inaccurate (Miller et al. 2013), and they were discontinued following the 2011 season (Miller et al. 2015). DIDSON-based estimates continued to be produced at the RM 8.6 site through 2014.

The RM 8.6 site was originally selected in 1985, based primarily on its suitability for operating a dual-beam (and subsequently a split-beam) sonar system, which required a near-perfect linear bottom profile over the entire insonified zone or, in this case, from the nearshore region to the thalweg[1]. However, the RM 8.6 site had many disadvantages, primarily related to its location within tidal influence: 1) incomplete coverage of the river during high tides that flood the region

[1] See Key et al (2016a) for a comprehensive history of sonar research and development at the Kenai River RM 8.6 site.

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 bank. It became evident that relocating the site farther upriver could improve the estimates of Chinook salmon passage by minimizing or eliminating these negative factors. In 1999, ADF&G evaluated a second sonar site at RM 13.2 for use of 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).

Because DIDSON multibeam technology was better able to insonify irregular bottom profiles, the search for a site above tidal influence was resumed in 2011. A potential new site at RM 13.7 (Figure 1) was identified and evaluated during a 2-week period in 2012 using the newest generation of DIDSON technology, referred to as Adaptive Resolution Imaging Sonar (ARIS). One of the main advantages of the RM 13.7 site is the potential to achieve bank-to-bank coverage of the river with sonar, which was not possible at the RM 8.6 site (Figure 2). ADF&G operated a full-scale experimental project at the RM 13.7 site using ARIS during 17 May–17 August 2013 (Miller et al. 2016a) and again during 16 May–15 August 2014 while also continuing to operate the DIDSON at the RM 8.6 site.

Estimates of Chinook salmon abundance require information on Chinook salmon size, which has been obtained historically from an inriver gillnetting program operated at RM 8.6 (Perschbacher 2012a-d, 2014, 2015, 2018, *In prep*; Perschbacher and Eskelin 2016). Netting at RM 8.6 was restricted to a midriver corridor in order to approximately match the cross-sectional area insonified by the DIDSON. In 2012, Chinook salmon sampled at the RM 8.6 netting project and at tributary weirs upstream differed in size, raising the possibility that Chinook salmon sampled midriver at RM 8.6 were not representative of the entire run. Auxiliary nearshore sonar deployments at RM 8.6 in 2011 and 2012 confirmed that some Chinook salmon were migrating between the DIDSON transducers and shore (Miller et al. 2014, 2015). In response, the netting program at RM 8.6 was expanded in 2013 to include nearshore drifts (Perschbacher 2015).

In addition, following the 2012 season, a state space model (SSM) was fitted to sonar, netting, catch rate, and capture–recapture data; historical abundance was reconstructed; and sustainable escapement goals (3,800–8,500 fish for the early run[2] and 15,000–30,000 fish for the late run) were recommended in preparation for the 2013 season (Fleischman and McKinley 2013; McKinley and Fleischman 2013). This modeling exercise, which synthesized information from all applicable data, estimated that the proportion of Chinook salmon migrating midriver (pMR) and detected by sonar and nets at RM 8.6 was 0.65 during the early run and 0.78 during the late run. In 2013 and 2014, to account for incomplete detection at RM 8.6, DIDSON estimates of inriver abundance were expanded by 1.55 (1/0.65) during the early run and 1.28 (1/0.78) during the late run, and used inseason to assess achievement of the new escapement goals. Sonar operations were discontinued at the RM 8.6 site following the 2014 season in favor of abundance estimates produced at the RM 13.7 site where near bank-to-bank coverage eliminates uncertainty resulting from spatial expansions of passage estimates.

From 2010 to 2016, estimates of small Chinook salmon based on DIDSON and ARIS counts were produced by mixture model analysis that required fish size data from nets drifted at the RM 8.6 site. Such estimates, however, were sensitive to how the netting data were used (Miller et al.

[2] For the early run, an optimal escapement goal of 5,300–9,000 was later adopted by the Alaska Board of Fisheries, superseding the sustainable escapement goal.

2016b). In 2015, for example, inseason estimates used for managing the fishery required substantial postseason revisions, largely because inseason procedures adopted to accommodate sparse netting data proved biased under some circumstances (Key et al. 2017).

Beginning in 2017, Chinook salmon stock assessment and management have been based on direct sonar counts of fish 75 cm or longer as measured by ARIS (AL) at the RM 13.7 site. Fish 75 cm AL or longer (equivalent to 75 cm mid eye to tail fork [METF] or longer) are composed almost entirely of Chinook salmon. Based on a spawner-recruit analysis conducted by Fleischman and Reimer (2017), ADF&G established sustainable escapement goals (SEGs) of 2,800–5,600 early-run and 13,500–27,000 late-run Kenai River Chinook salmon 75 cm METF or longer. The early- and late-run SEGs were later superseded by optimal escapement goals of 3,900–6,600 and 15,000–30,000 Chinook salmon 75 cm METF or longer, as established by the Alaska Board of Fisheries.

The 2020–2022 RM 13.7 project will operate from 16 May to approximately 20 August each year. In addition to producing inseason estimates of Chinook salmon 75 cm METF or longer, abundance estimates of all Chinook salmon (regardless of size) will be generated postseason using mixture model analyses that combine RM 13.7 sonar data and RM 8.6 netting data. Postseason estimates of all sizes of Chinook salmon are used for historical comparison and to be able to provide an all-fish estimate for data requests.

OBJECTIVES

PRIMARY OBJECTIVE

Produce daily inseason net upstream passage estimates of fish 75 cm or longer (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. These estimates will be based solely on ARIS fish-length measurements.

SECONDARY OBJECTIVE

Produce postseason net upstream passage estimates of Chinook salmon, regardless of size, at RM 13.7 of the Kenai River such that early- and late-run estimates are within 15% of the true value 95% of the time. These estimates 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).

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 (Miller et al. 2015) and was selected for its location above tidal influence, 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. The main channel on the west side of the river is approximately 94 m wide, and the minor channel located along the east side is approximately 30 m wide (Figure 2). The minor channel has enough water for fish passage at higher water levels from approximately mid-June through August. Tidal fluctuation at this site is minimal (less than 1 ft) and is observable only during the large spring tide sequence. The substrate in both the main channel and the minor channel is composed of small cobble, rocks, and gravel.

Land use permits are obtained from the Department of Natural Resources Division of Parks and Outdoor Recreation. A more detailed description of the RM 13.7 site along with details and diagrams required for permit applications can be found in Appendices A1–A15).

ACOUSTIC SAMPLING

Adaptive Resolution Imaging Sonar (ARIS) technology, developed by the manufacturers of DIDSON (Sound Metrics Corporation[3]), will be used at the RM 13.7 site. Components of the ARIS system are listed in Table 1. ARIS multibeam technology is a similar but updated version of the DIDSON technology and is summarized in Appendix B1 along with a discussion of the features of the ARIS models used in this study. One spare ARIS 1200 system and 2 DIDSON LR systems will be available as backups should any of the active 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 2). 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 94 m in width, a second sonar will be deployed on each bank to insonify the nearshore zone and the first 3–8 m in front of the offshore sonars (Figures 2 and 3). 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 (Figures 2 and 4).

Two different ARIS models will be used to provide optimal coverage of the mainstem cross-section (Figures 2 and 3, 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 level or low water temperature 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 (about 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 (Figures 3 and 5). 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 8–10 m from the bank at ordinary high water, allowing it to cover the area behind the offshore sonar as well as approximately the first 3–5 m in front of the offshore sonar (Figures 3 and 5). 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

[3] Product names used in this publication are presented for completeness and do not constitute product endorsement.

1800 without the HRL (14° × 28° versus 4° × 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 6). 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; the nearshore and channel sonars may be deployed on "H" or "goal post" mounts rather than a tripod mount if water levels are too low for an individual sonar (Figure 7). 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 3). 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 8). 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 8 and 9, Appendices C1 and C2). Two battery banks, charged daily using generators, will provide power to the right-bank sonar electronics and wireless bridges.

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 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). Table 2 lists the schedule and parameters used to sample the 11 individual range strata on 10 July 2019. Table 3 shows an example from 2015 of range changes that year; water levels were fairly stable after June 29, and only minor changes were made to the positions of the sonars through the end of the season on 20 August. Figure 10 also shows example images for each of the 8 range strata insonified by the mainstem sonars. Table 3 provides an example of changes in sonar parameters throughout the season as the water level rises and aims are refined.

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.

Expected Precision

The relative precisions of early- and late-run Chinook salmon passage estimates from 2013 to 2019 using the systematic sample design described above and achieved at a significance level of $\alpha = 0.05$ range from 3% to 15% (Table 4). With the same amount of sampling effort scheduled for 2020–2022, the precision criteria in the primary and secondary objectives are likely to be achieved.

DATA COLLECTION

Data Collection Parameters

In designing ARIS, the manufacturers separated the data collection (ARIScope) and data processing (ARISFish) software. ARIScope has several data collection parameters that are user selectable including window length, transmit pulse width, and downrange resolution (Table 5, Appendices B6 and B7). ARIS downrange resolution (i.e., window length per number of samples) is particularly improved over its predecessor (DIDSON). Whereas DIDSON is 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 5 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.

Remote Access to Sonar Site

Because the RM 13.7 site will not be manned at all hours, a system to remotely access and determine the status of the data collection computers and sonars has been developed. Each data collection computer will have wireless internet service through a Cisco Meraki wireless access point connected to an AT&T Beam (providing 4G LTE service) and can be accessed remotely using a GoToMyPC account (Figure 8).

Manual ARIS Fish Length Measurements

Measurements of fish length will be obtained using ARISFish V2.6 (or latest version) software supplied by SMC. Detailed instructions for taking manual measurements and the software settings and parameters that will be used for this project are given in Appendix D1. Electronic echograms similar to those generated with the DIDSON software (Miller et al. 2015) will provide a system to manually count, track, and size individual fish (Figure 11).

Measured fish will be subjected to a "centerline rule" (Appendix D3). Only those fish that cross the longitudinal central axis of the ARIS video image will be candidates for measuring. Fish that do not cross the centerline will be ignored. This removes the opportunity for fish to be counted in multiple spatial strata, which would create a positive bias in passage estimates. Note that the 2010–2014 DIDSON-based abundance estimates at the RM 8.6 site (Miller et al. 2013-2015; Key et al. 2016a, 2016b) were not subjected to a centerline rule.

For the purpose of this study, fish size will be divided into 3 categories based on ARIS length (AL) measurements. Fish with AL measurements greater than or equal to 40 cm and less than 75 cm will be referred to as "small fish." Fish with AL measurements greater than or equal to 75 cm and less than 90 cm will be referred to as "medium fish." Fish with AL measurements greater than or equal to 90 cm will be referred to as "large fish."

Estimates of medium- and large-fish abundance will be produced by the sonar alone. Throughout the season, all medium and large fish will be counted and measured, and travel direction (upstream or downstream) will be recorded. The sampling protocol, where a sample is defined as a specific spatial stratum monitored for 10 minutes, is described below:

1) During samples without dense aggregations of fish, length and direction of travel will be recorded for all salmon-shaped fish greater than or equal to 40 cm AL that meet the centerline rule (Appendix D3).

2) During individual samples with dense aggregations of fish (Figure 12), length and direction of travel will be recorded for all fish greater than or equal to 75 cm AL. However, length will be recorded for only a subsample of fish with ARIS length greater than or equal to 40 cm and less than 75 cm. The first *F* fish in the sampled period will be measured, where choice of *F* depends on daily staff time constraints. For the remainder of the sample (after the first *F* fish), only fish appearing to be greater than or equal to 75 cm AL will be measured and only those fish that actually measure greater than or equal to 75 cm AL will be recorded. During these times, fish measuring less than 75 cm AL will not be recorded in any way, including fish chosen for measurement that turn out to be less than 75 cm.
3) Direction of travel will automatically be recorded for all measured targets.

Additional detail on procedures and software settings that will be used to obtain manual fish length measurements can be found in Appendices B1–B12.

Netted Fish Length Measurements

An established test gillnetting project at RM 8.6 (Perschbacher *In prep*) will provide information on fish length by species, which is needed postseason to estimate abundance of Chinook salmon of all sizes. Fish length measurements from the netting project are one source of input data required for mixture model estimates of Chinook salmon abundance (see below). Chinook salmon abundance estimates will use all inriver gillnetting data, including midriver and nearshore.

DATA REDUCTION

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[4]. File size also increases with the downrange resolution level. We estimate that 10-minute file sizes will vary at maximum from approximately 300,000 kB to approximately 900,000 kB. Table 6 gives an example of 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 will be automatically generated by the ARIS software using the following selected identifiers: location, bank, year, month, day, and military time (hour, min, and sec). As an example, the file RO_2016-07-22-041000 refers to a file collected by the right bank offshore sonar, which started data collection on 22 July 2016 at 04:10 AM.

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 8). The hard drives will be swapped out at least once per day and transported back to the Soldotna ADF&G office.

Office Data Management and Archiving

In the Soldotna office, data will be uploaded from each external drive to a NetApp server that is connected to the statewide network and is accessible by 7 (or more) data processing computers via a 16-port 1 GB Ethernet switch (Figure 13). One of the data processing computers will be used to upload ARIS data from the external hard drives to the NetApp server using batch files that sort and store data files in the following directory hierarchy: 1) by year (e.g., Data20XX), 2) by day,

[4] 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, offshore range strata will require a slower ping rate and files will contain fewer frames.

3) by sonar (e.g., LeftFar), 4) by stratum, and 5) by set . Directory names are unique to each of the 5 sonars: Channel (for right bank minor channel), LeftFar (left bank offshore sonar), LeftNear (left bank nearshore sonar), RightNear (right bank nearshore sonar), and RightFar (Right bank offshore sonar). Following upload to the NetApp server, 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.

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 **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

$$\hat{y}_{iks} = \frac{24}{h_{iks}} \sum_j \hat{y}_{ijks} \tag{2}$$

where h_{iks} is the number of hours during which fish passage is 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 **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:

[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).

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

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

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

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.

Passage Estimates of Fish 75 cm AL or Longer

Passage estimates of fish 75 cm AL or longer will be produced inseason daily. The number of 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.

Passage Estimates of Chinook Salmon Regardless of Size

Upstream Chinook salmon passage, regardless of size, will be estimated postseason by fitting daily mixture models to ARIS lengths of all upstream bound fish and 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 netting data from RM 8.6, as described in Appendices G1–G5.

The variance estimate will follow Goodman (1960):

$$\widehat{var}(\hat{z}_i) = \hat{w}_i^2 \widehat{var}(\hat{\pi}_{Ci}) + \hat{\pi}_{Ci}^2 \widehat{var}(w_i) - \widehat{var}(\hat{\pi}_{Ci})\widehat{var}(w_i) \tag{7}$$

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

[6] During periods with dense aggregations of fish, w is germane only to those fish selected for measuring, not all fish greater than or equal to 40 cm AL.

data from RM 8.6 will be used so that the netting sample will best represent the length composition of all migrating Chinook salmon.

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.

Note that estimates of w_i and π_{Ci} are intermediate quantities only, in the sense that they are required in order to estimate z_i and N_i, but have no biological interpretation themselves because not all small fish (40–75 cm AL) are measured and counted. Estimates of z_i and N_i remain valid.

SCHEDULE AND DELIVERABLES

Dates	Activity
1 May–15 May	Group training on manual ARIS measures; review and update RM 13.7 ARIS office manual
	RM 13.7 project deployment
	Deploy main channel offshore ARIS
	Update batch files for RM 13.7 ARIS data as needed
15 May–1 June	Continue training sessions with crew as needed for measuring consistency
1 June or later	Deploy nearshore ARIS systems when water level justifies
	Deploy minor-channel weir and ARIS when water level justifies
20 August–25 August	Terminate data collection 20 August (or earlier 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 for a given sample year will be completed by 1 April of the following year. The final report will be completed by 1 September of the year following data collection (i.e., report for 2020 data collection will be completed by 1 September 2021).

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.

Jiaqi Huang, Biometrician III
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.

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.

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.

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.

Fish and Wildlife Technician II
Duties: Assist Crew Leader with all aspects of DIDSON and ARIS deployment, operation, and data processing. Approximate work dates: 16 June–20 August.

BUDGET SUMMARY

The total proposed budget for the Kenai River Chinook salmon sonar project (fiscal year 2020) is $218,631. Budget and personnel requirements are summarized below.

Budget summary for FY20.

Line item	Category	Budget ($K)
100	Personal Services	190.0
200	Travel	1.2
300	Contractual	16.2
400	Commodities	11.2
500	Equipment	0.0
Total		218.6

Funded personnel for FY20.

PCN	Name	Level	Funded person months
4166	Brandon Key	Fishery Biologist II	12.0
1793	Mike Hopp	Fish & Wildlife Technician III	4.0
4146	Vacant	Fish & Wildlife Technician II	3.5
5347	Vacant	Fish & Wildlife Technician II	2.6
4305	Nathan Plate	Fish & Wildlife Technician II	3.5
Total			25.6

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TABLES

Table 1.–ARIS system components to be used for data collection.

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° × 30° beam pattern
	4	High resolution lens for ARIS 1200 models with ~ 4° × 15° beam pattern
Data collection computer	5	Dell Latitude 7490 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 10 July 2019 for each range stratum sampled by 5 sonars at RM 13.7.

Location	ARIS serial no.	Range stratum	Time (min past hour)	Frame rate (f/sec)	Range (m) Start	Range (m) End	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	7.3	2.5	16	High	Max	23	23	3,454	10	1,827	7.95	−4.3	0.2	185
Left far	1064																
		1	00,30	10	3.5	8	High	Max	5	13	4,870	10	626	−8.66	−7.8	−5.7	55
		2	10,40	8	8	22	High	Max	12	20	11,141	10	1,950	−5.84	−5.3	−5.7	55
		3	20,50	6.7	22	33	High/Low	Max	21	33	30,629	10	1,530	−1.64	−1.2	−5.7	55
Right far	1063																
		1															
		2	00,20	8	8	22	High	Max	23	21	10,863	10	1,901	3.31	−3.0	0.2	305
		3	10,30	7.2	22	33	Low/High	Max	23	33	29,874	10	1,494	3.94	−3.0	0.2	305
Right near	1098																
		1	40	8	3.5	8	High	Max	16	13	4820	10	620	2.96	−4.0	0.2	264
		2	50	8	8	24	High	Max	16	24	11,018	10	2,203	2.64	−4.3	0.2	264
Channel	1095																
		1	00	8	2.8	6	High	Max	8	13	3,832	10	438	−5.77	−11.7	2	7
		2	10	8	6	12	High	Max	13	12	8,213	10	821	0.5	−6.0	1.9	6
		3	20	8	12	20	High	Max	13	20	16,426	10	1,095	5.47	−0.9	1.9	6

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

Sonar location	Stratum	Start times (min past hour)	12 May	21 May	26 May	1 Jun	3 Jun	4 Jun	5 Jun	9 Jun	29 Jun [a]
Left near											
	1	00,30	[b]	[b]	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	[c]	[c]	[c]	[c]	[c]	[c]
	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	[d]	[d]	[d]	3.5–8.1	3.5–8	3.5–8	3.5–8	3.5–8	3.5–8
	2	50	[d]	[d]	[d]	8.1–16.1	8–16	8–16	8–16	8–18.2	8–20
Channel											
	1	0	[e]	[e]	[e]	[e]	[e]	2.6–6.01	2.6–6.01	2.6–6.01	2–6
	2	10	[e]	[e]	[e]	[e]	[e]	6–12	6–12	6–12	6–12
	3	30	[e]	[e]	[e]	[e]	[e]	12–22	12–22	12–22	12–22

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

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

[c] 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.

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

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

Table 4.–Relative precisions (α = 0.05) of Chinook salmon net upstream passage estimates for ARIS-length (AL) ≥75 cm and ARIS-length mixture model (ALMM) for early and late run at RM 13.7 Kenai River, 2013–2019.

	Early		Late	
Year	AL ≥ 75 cm	ALMM (all sizes)	AL ≥ 75 cm	ALMM (all sizes)
2013	10.6%	15.3%	4.4%	5.9%
2014	10.8%	12.7%	5.2%	6.7%
2015	7.8%	8.3%	4.2%	4.8%
2016	6.0%	7.1%	4.5%	4.2%
2017	6.8%	7.5%	4.0%	3.4%
2018	10.1%	11.6%	4.7%	5.1%
2019	7.5%	9.3%	5.1%	5.9%

Table 5.–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 6.–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)	NA	NA	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

Note: NA means not applicable.

[a] ARIS 1800 files can be larger than ARIS 1200 files because ARIS 1800 has twice as many subbeams (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

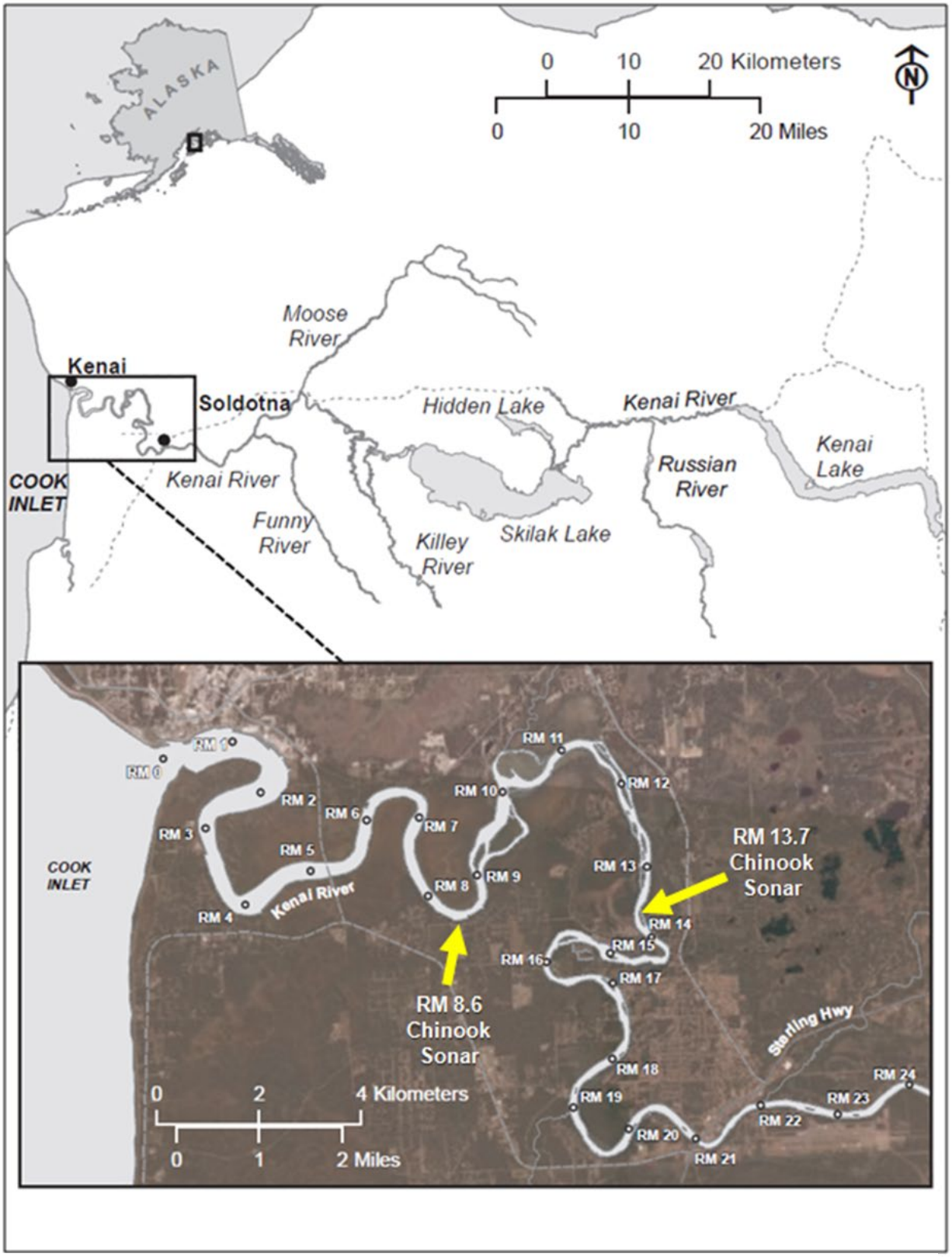


Figure 1.–Map of Kenai River showing location of historical Chinook salmon sonar site at river mile 8.6 and new sonar site at river mile 13.7.

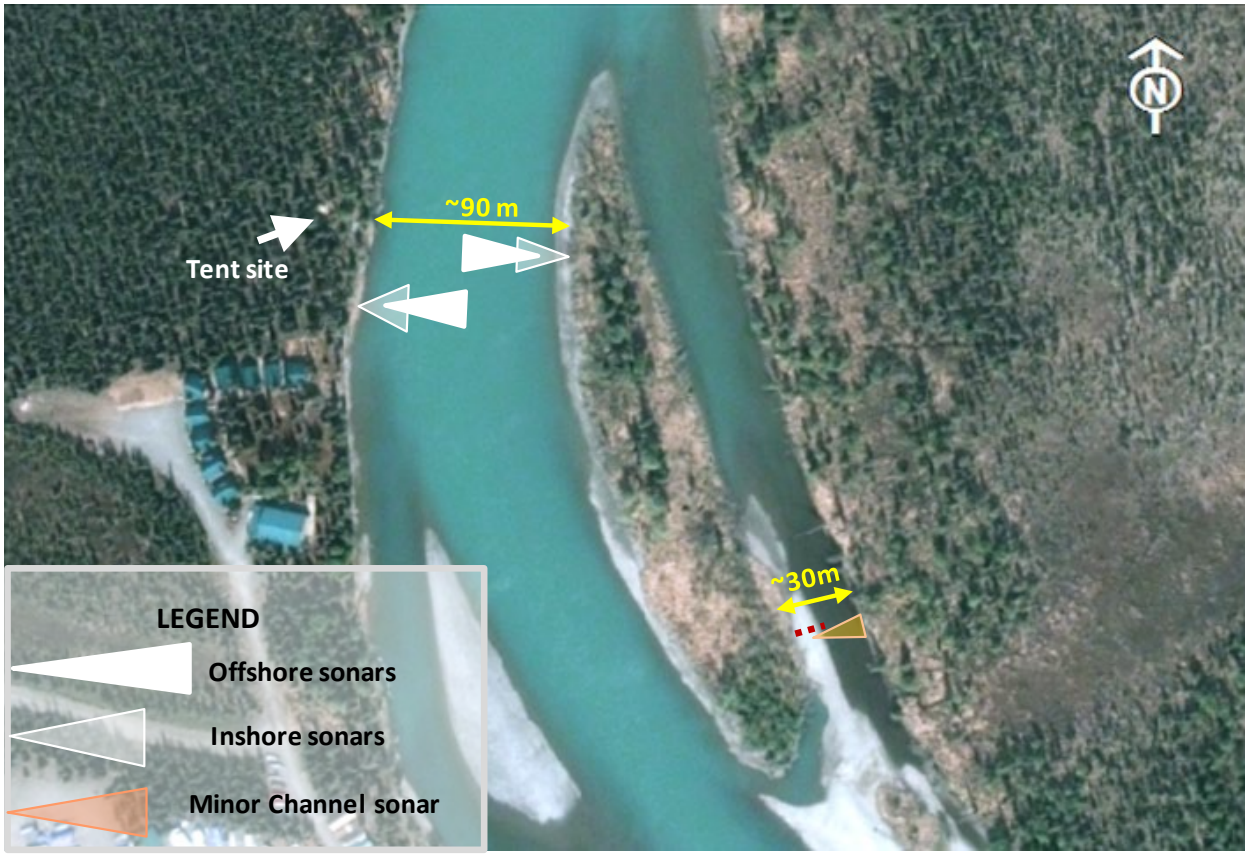


Figure 2.–Kenai River RM 13.7 sonar site showing approximate deployment locations and beam coverage of 5 ARIS units.

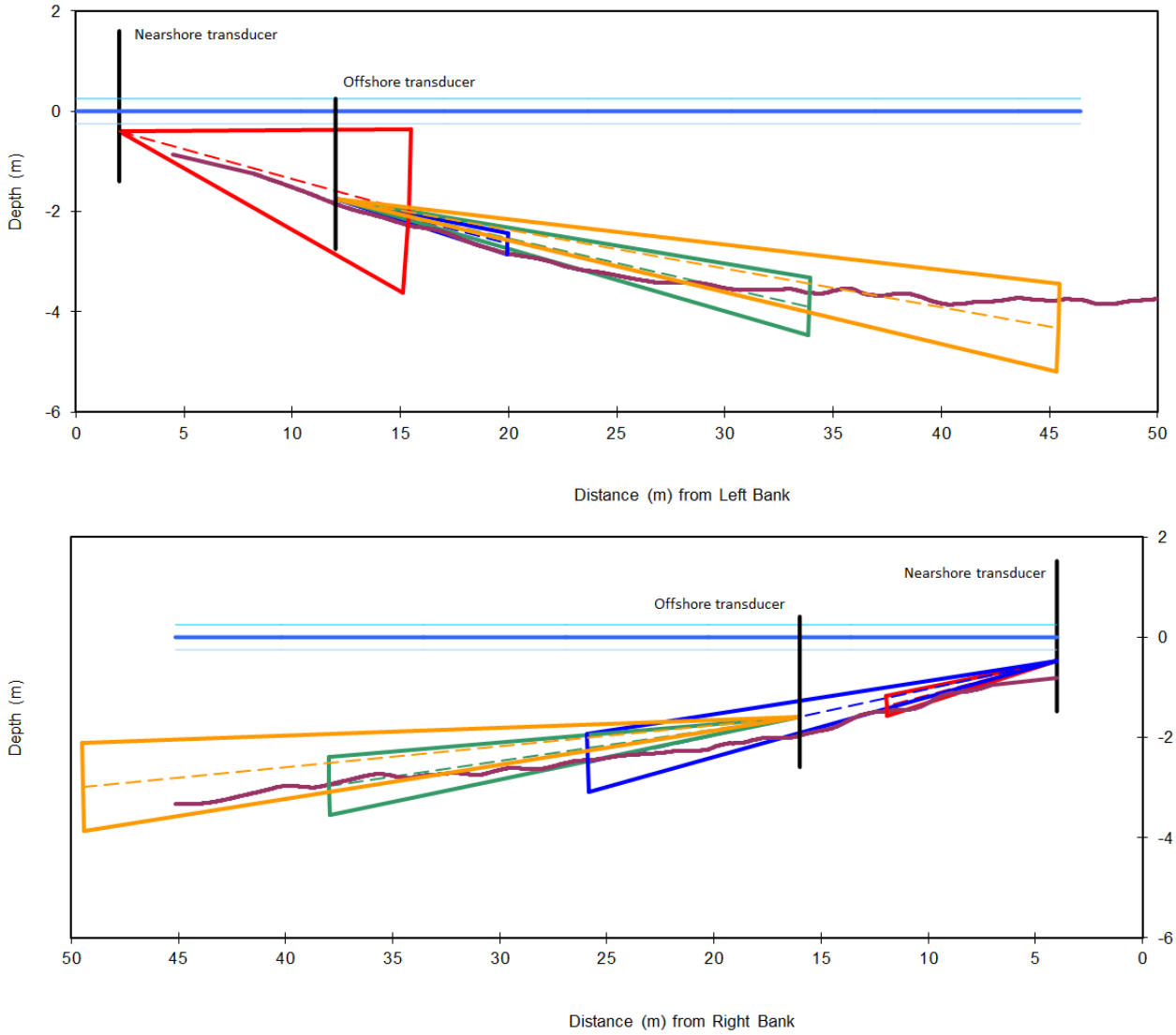


Figure 3.–Kenai River mile 13.7 main channel left and right bank bottom profiles collected on 8 July 2015 with nearshore and offshore sonar beams superimposed.

Note: On the left bank, an ARIS 1800 with a standard lens and a 14º vertical field of view was deployed nearshore (red beam) and an ARIS 1200 with a high-resolution lens and a 3º vertical field of view was deployed offshore (blue, green, and yellow beams). On the right bank, an ARIS 1200 with a high-resolution lens and a 3º vertical field of view was deployed both nearshore (red and blue beams) and offshore (green and yellow beams).

Figure 4.–Sonar coverage of the minor channel at the Kenai River RM 13.7 sonar site is achieved using an ARIS 1200 deployed on a tripod mount combined with a fixed weir.

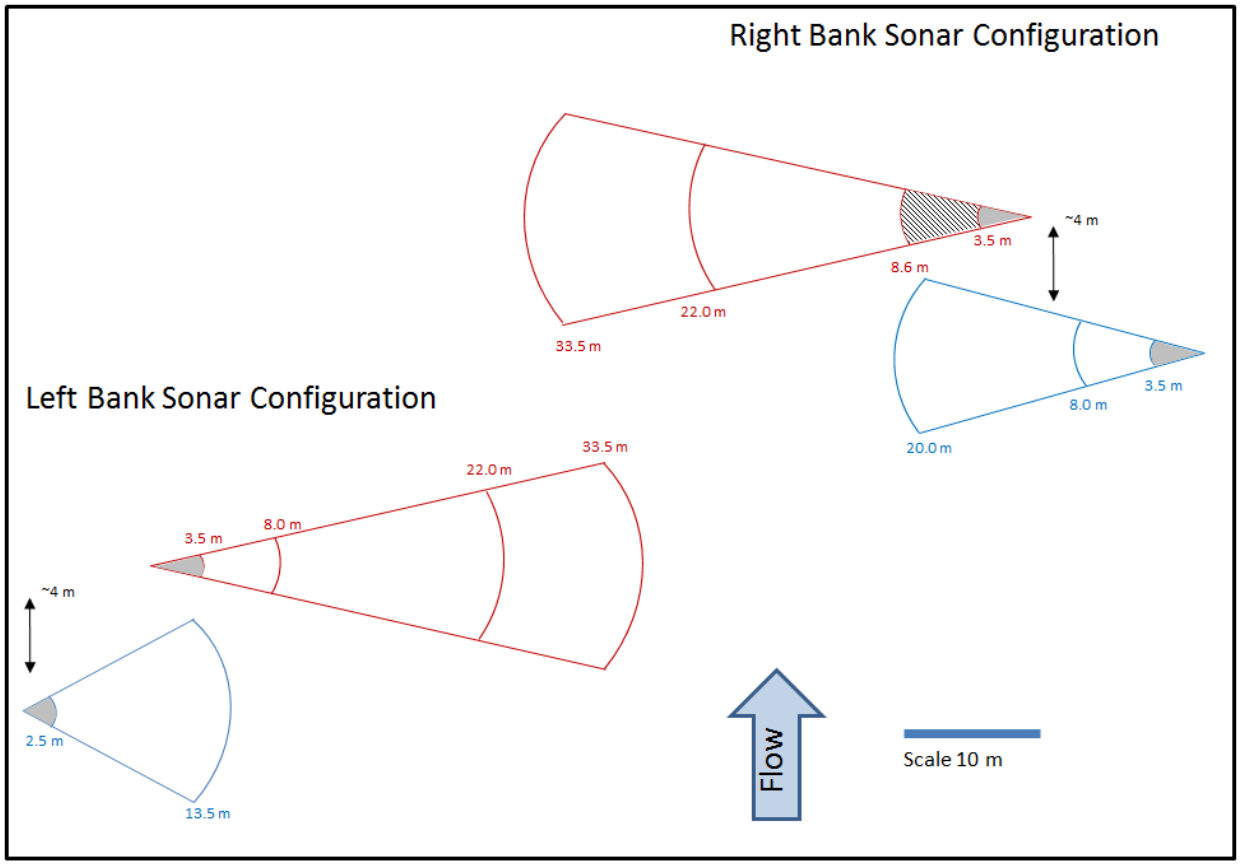


Figure 5.–Schematic for 4 left-bank (1 nearshore range [blue], 3 offshore ranges [red]) and 5 right-bank (2 nearshore ranges [blue], 3 offshore ranges [red]) range strata on the main channel of the Kenai River at RM 13.7.

Note: No data are collected between the face of the transducer and the start of the first range stratum in order to avoid range-related size bias caused by poor focal resolution at such close ranges (see Appendix A1). Data will be collected in the right bank offshore 3.5–8.0 m stratum early in the season. Increased water levels will allow the right bank inshore sonar to be deployed near the beginning of June and from that date forward, the area formerly covered by the right bank offshore 3.5–8.0 stratum will be covered by the right bank inshore 8.0–20.0 m stratum.

Figure 6.–RM 13.7 tent housing data collection computers for all 5 ARIS units.

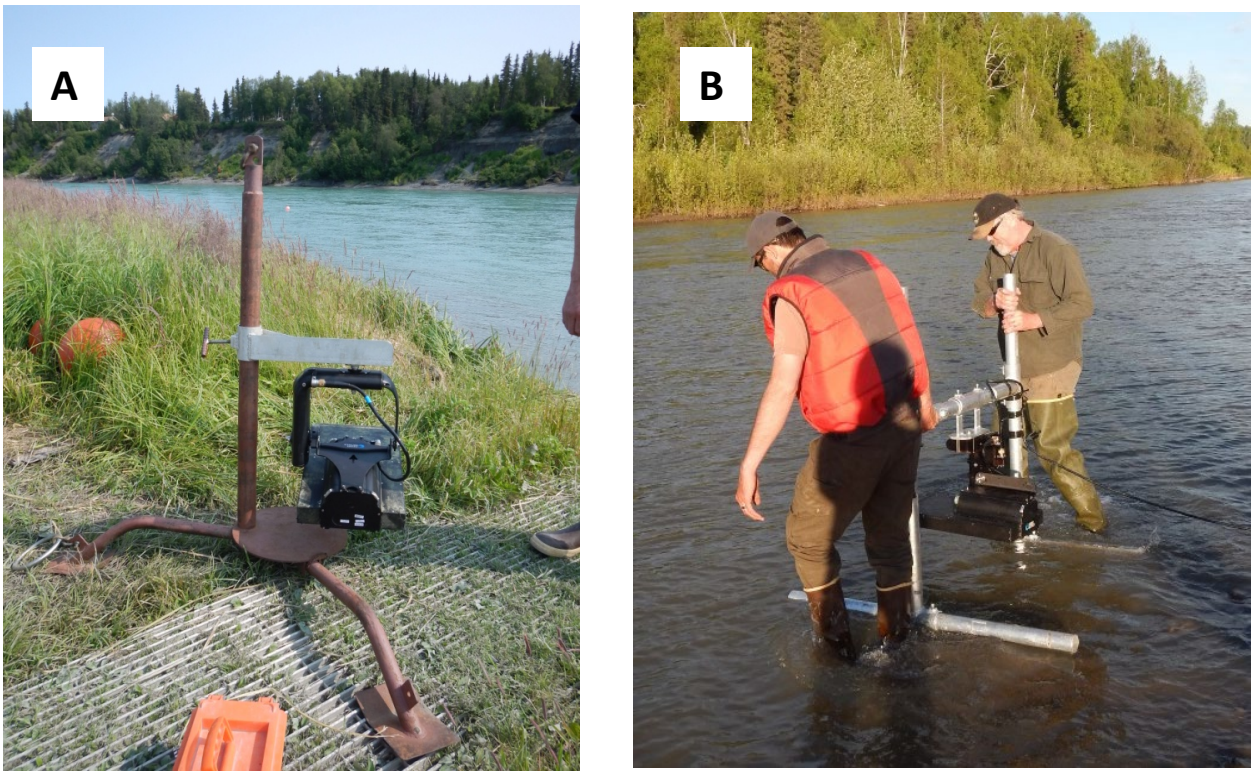


Figure 7.–An ARIS 1200 with a high-resolution lens mounted on a steel tripod for offshore deployment (A) and on an aluminum H-mount for nearshore deployment (B).

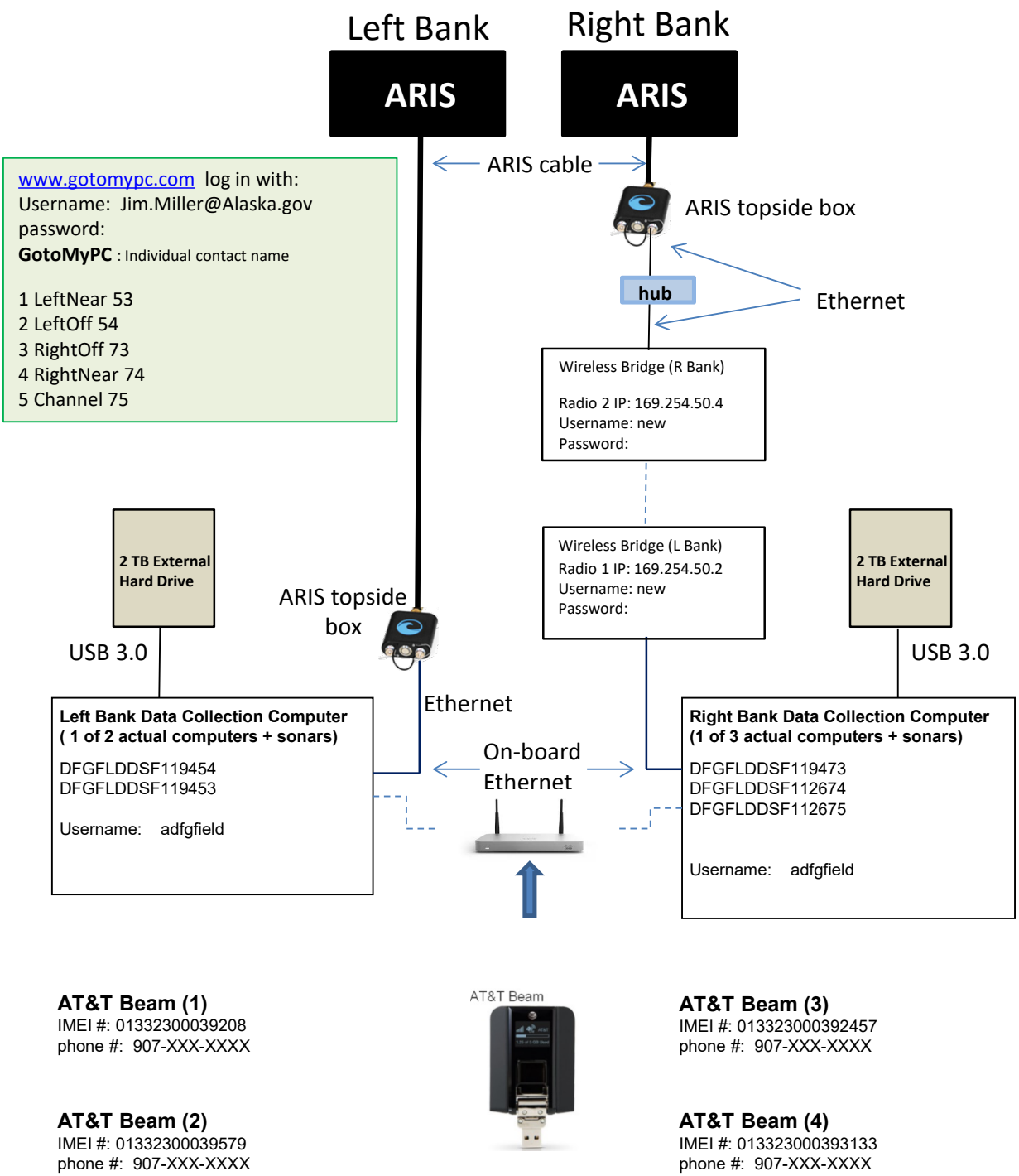
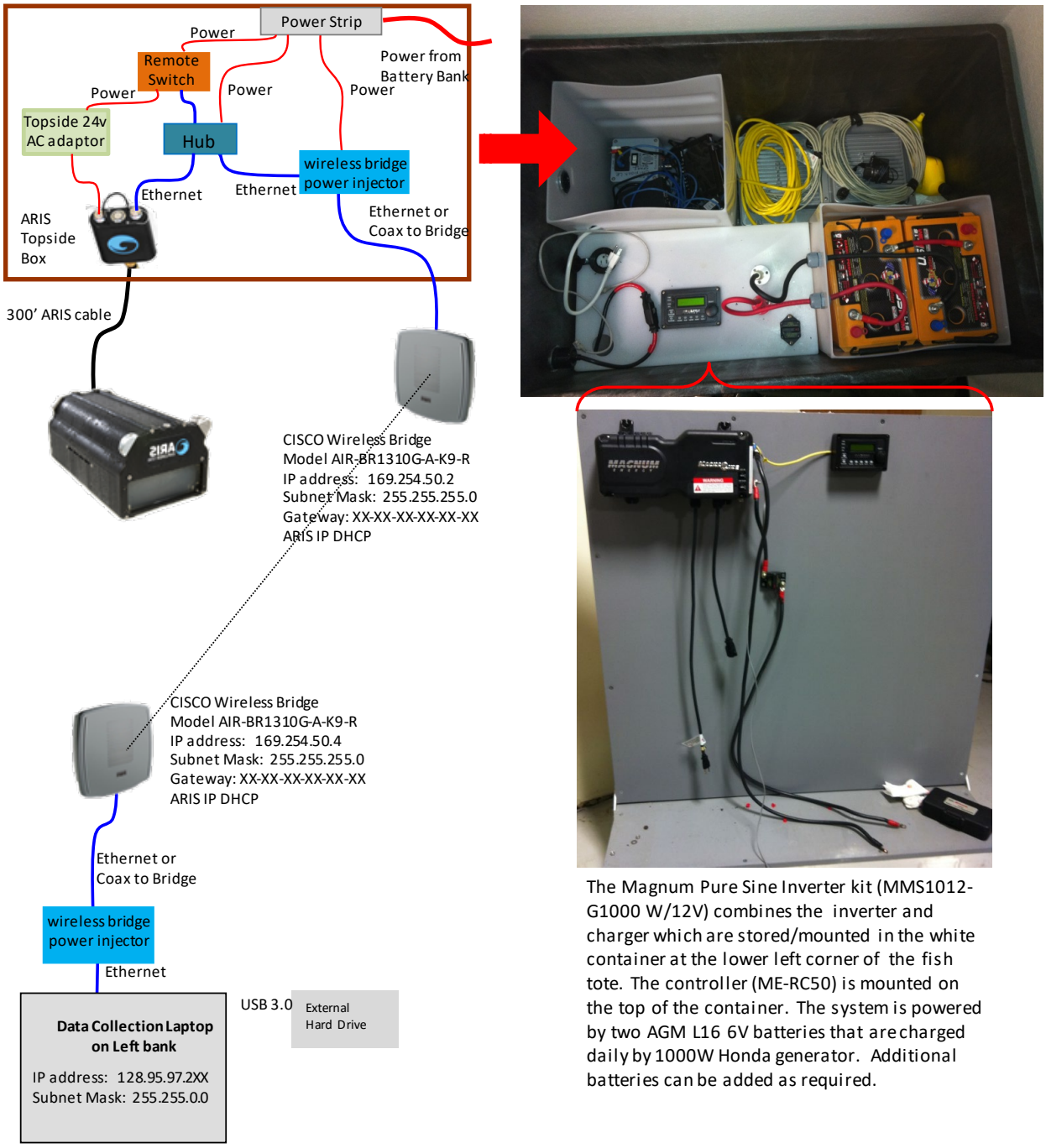


Figure 8.–ARIS data collection schematic for the RM 13.7 site.

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 wirelessly connected to the Meraki device equipped with an AT&T Beam (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.

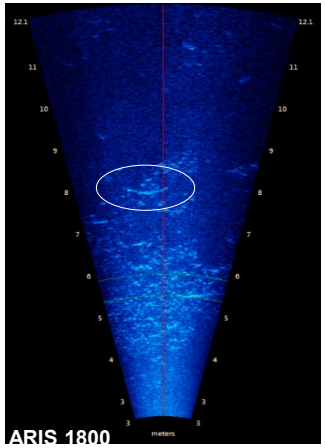


The Magnum Pure Sine Inverter kit (MMS1012-G1000 W/12V) combines the inverter and charger which are stored/mounted in the white container at the lower left corner of the fish tote. The controller (ME-RC50) is mounted on the top of the container. The system is powered by two AGM L16 6V batteries that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

Figure 9.–Diagram of components required on RM 13.7 right bank for wireless transmission of ARIS data back to the main camp on left bank.

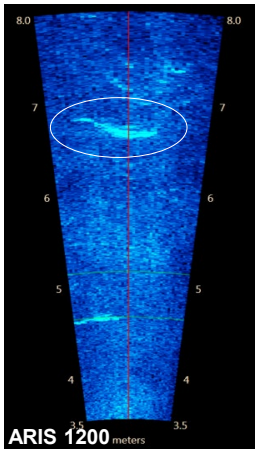
Note: A wireless bridge transmits data to a data collection computer on the left bank for storage and subsequent transport to the Soldotna office.

Left bank Nearshore (1 stratum)

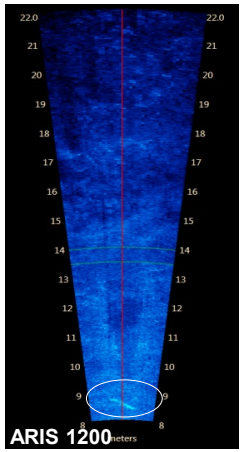


Stratum 1: 2.5-12.1 m
Pitch = -3.6º

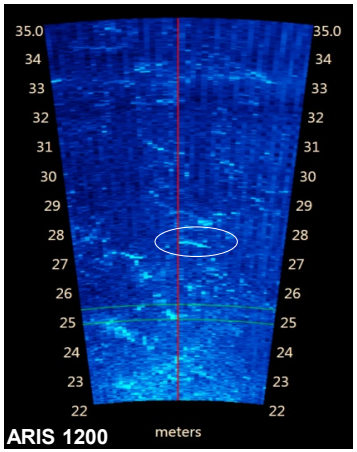
Left bank Offshore (3 strata)



Stratum 1: 3.5-8.0 m
Pitch = -7.2º

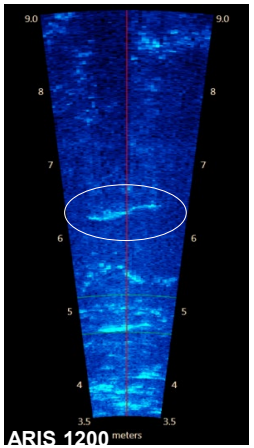


Stratum 2: 8.0-22.0 m
Pitch = -6.8

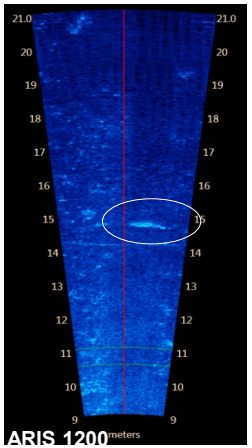


Stratum 3: 22.0-35.0 m
Pitch = -5.5º

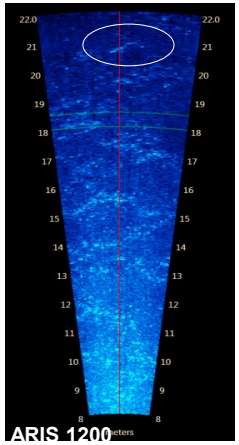
Right bank Nearshore (2 strata)



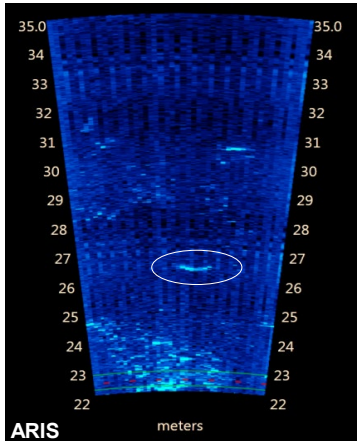
Stratum1:3.5-9.0 m
Pitch = -6.0º



Stratum 2:9.0-21.0 m
Pitch = -4.5º



Stratum 2: 8.0 to 22.0 m
Pitch = -4.0º



Stratum 3: 22.1-35.0 m
Pitch = -3.8º

Figure 10.–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.

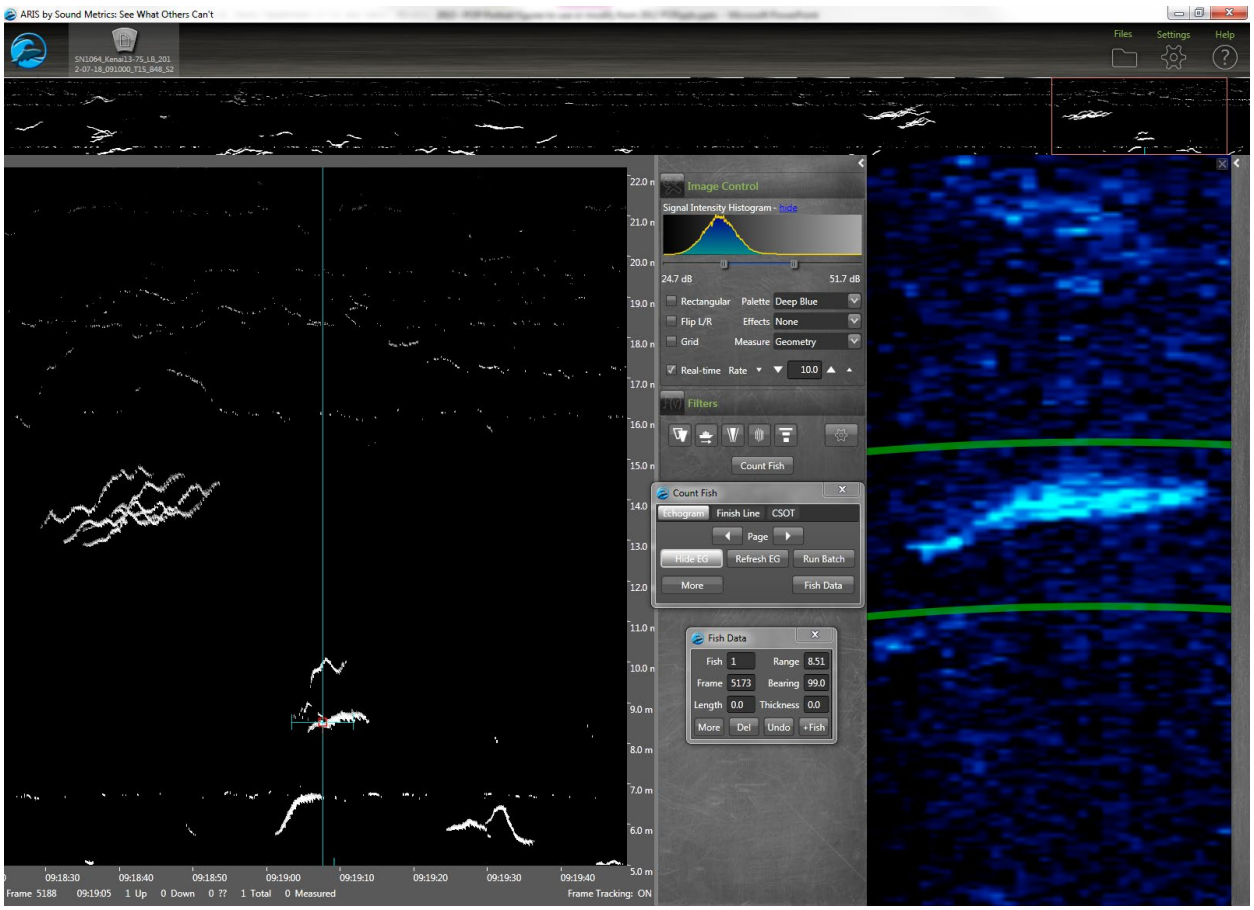


Figure 11.–ARISFish display window showing an echogram (at left) with traces of migrating fish that can be simultaneously displayed in video mode (at right) where fish images can be enlarged and measured.

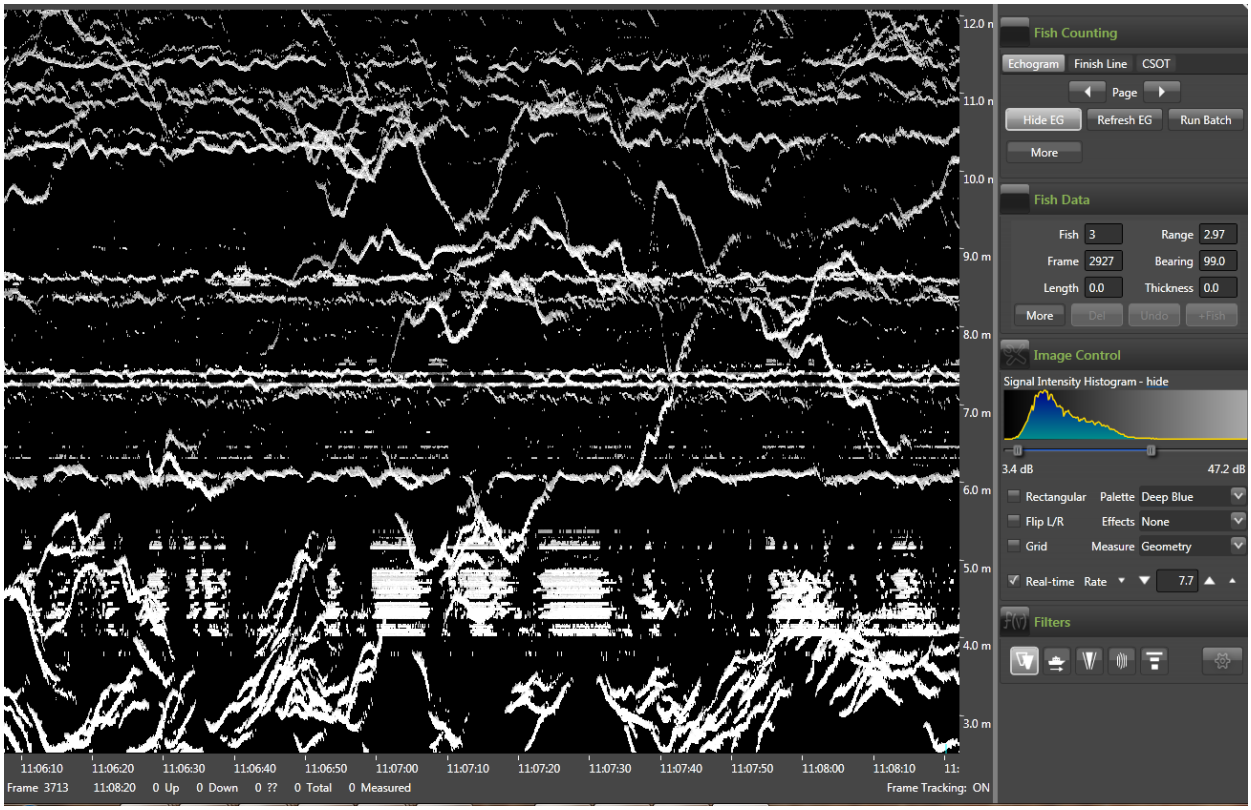


Figure 12.–An example of high-density passage from 6 August 2014.

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.

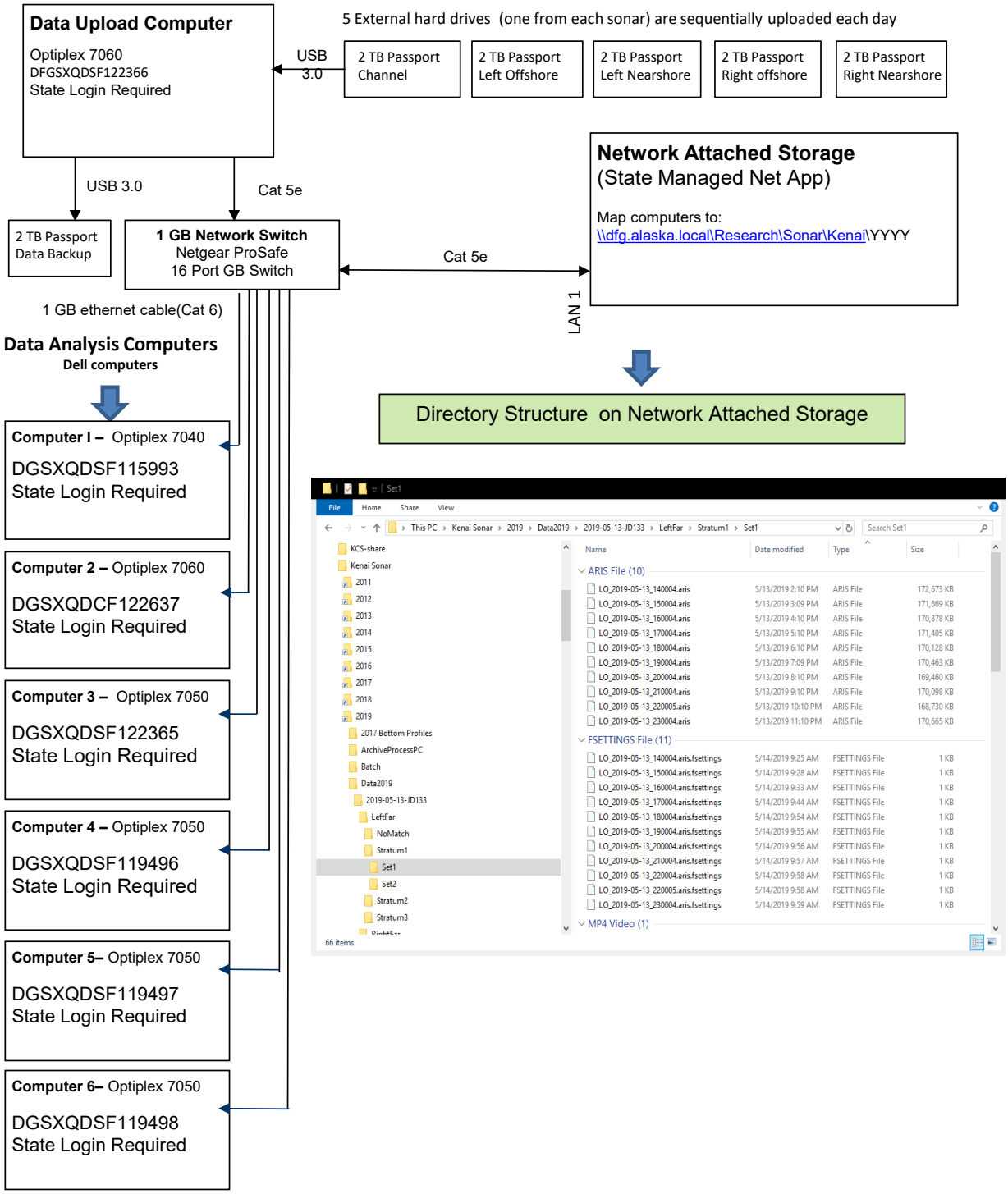


Figure 13.–Directory structure for the Network Attached Storage System in the Soldotna office showing the contents of the 2019 season folder.

APPENDIX A: RM 13.7 SITE INVESTIGATION DOCUMENTATION

Three benefits of using the Kenai River 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 bank[7] [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 near-full (bank-to-bank) coverage requires a total of 5 sonars: 4 sonars on the main channel and a fifth sonar to monitor the minor channel on right bank (Appendix A3). Site diagrams for the left bank can be found in Appendices A4–A6. Site diagrams for the right bank main river channel can be found in Appendices A7–A9. Site diagrams for the minor river channel can be found in Appendices A10–A12.

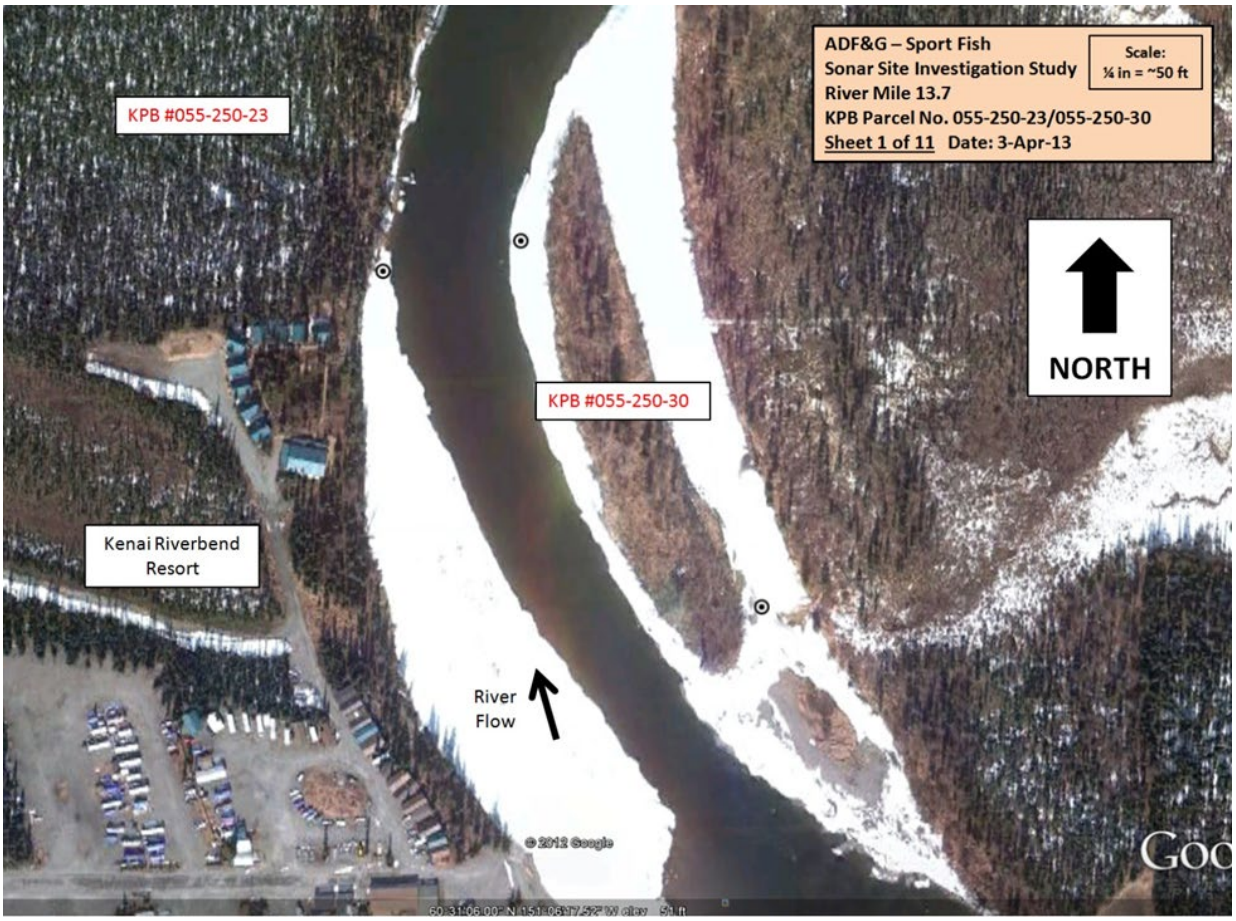
A 10 ft × 12 ft tent will be assembled on the left bank at least 50 ft from ordinary high-water levels (OHW; Appendices A4–A5). The tent will be located in a clearing to alleviate the need to remove trees and other vegetation. The tent electronics schematics are shown in Appendix A13. Power will be supplied to the tent via 2 power cords running from external outlets on a cabin located approximately 60 m upstream of the tent (Appendices A3–A4). Electronic control cables will lead from the tent into the river and attach to each of 2 ARIS units (nearshore and offshore sonars) mounted to removable steel tripods (Appendices A4 and A6). The sonars will be positioned on the river bottom approximately 6 ft and 24 ft from OWH (Appendix A6).

On the right bank main-channel site, 2 waterproof totes (about 3 ft × 4 ft) will house a battery bank (Appendix A14) and the topside sonar electronics (Appendices A7–A8 and A14). A plywood box (about 3 ft × 3 ft) lined with plastic (for spill containment) located near the totes will house a small generator (Appendices A7–A8). 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 offshore sonars) mounted to removable steel tripods (Appendices A7 and A9). The sonars will be positioned on the river bottom approximately 6 ft and 45 ft from OWH (Appendix A9).

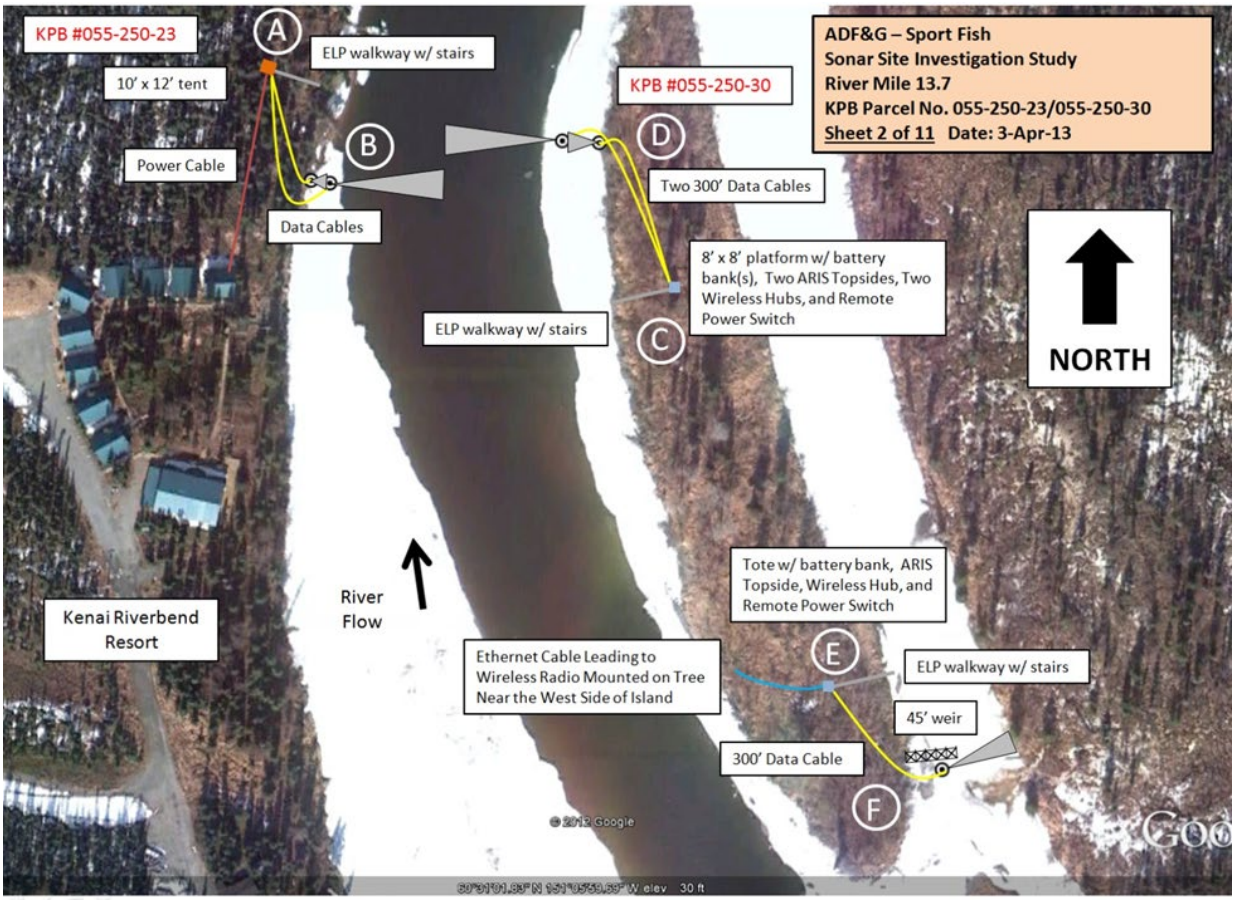
On the right bank minor-channel site, a single waterproof tote (about 3 ft × 4 ft) will house the battery bank (Appendix A15) and topside sonar electronics (Appendices A10–A11). Electronic control cables will lead from the topside electronics tote into the river and attach to a single ARIS unit mounted 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 A10 and A12).

Submerged steel tripods will be marked with a marker float on the water's surface (Appendices A6 and A9). 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.

[7] Looking downstream.

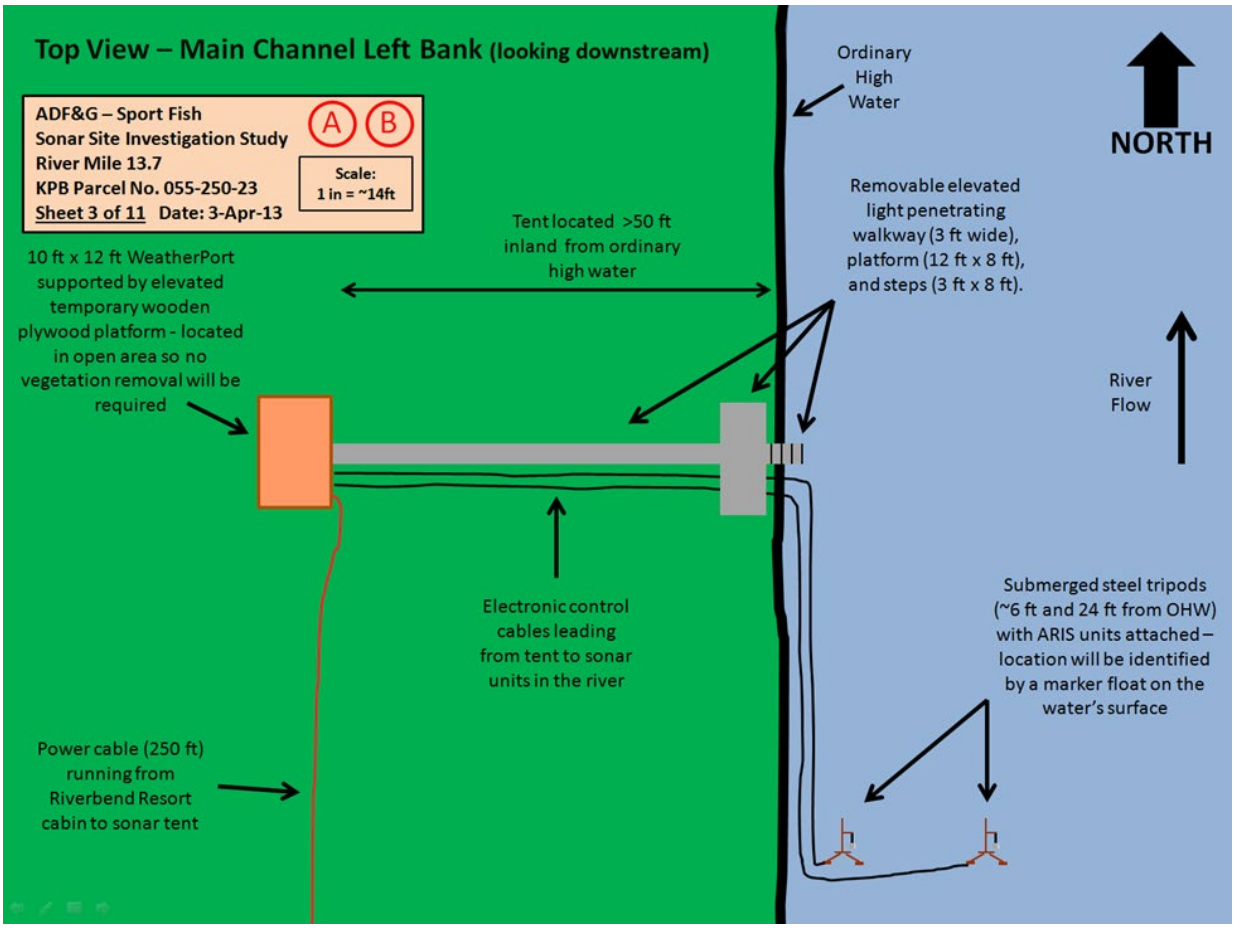


Appendix A2.–Aerial map and parcel numbers for RM 13.7 sonar site. Image taken from Google Maps © 2013.

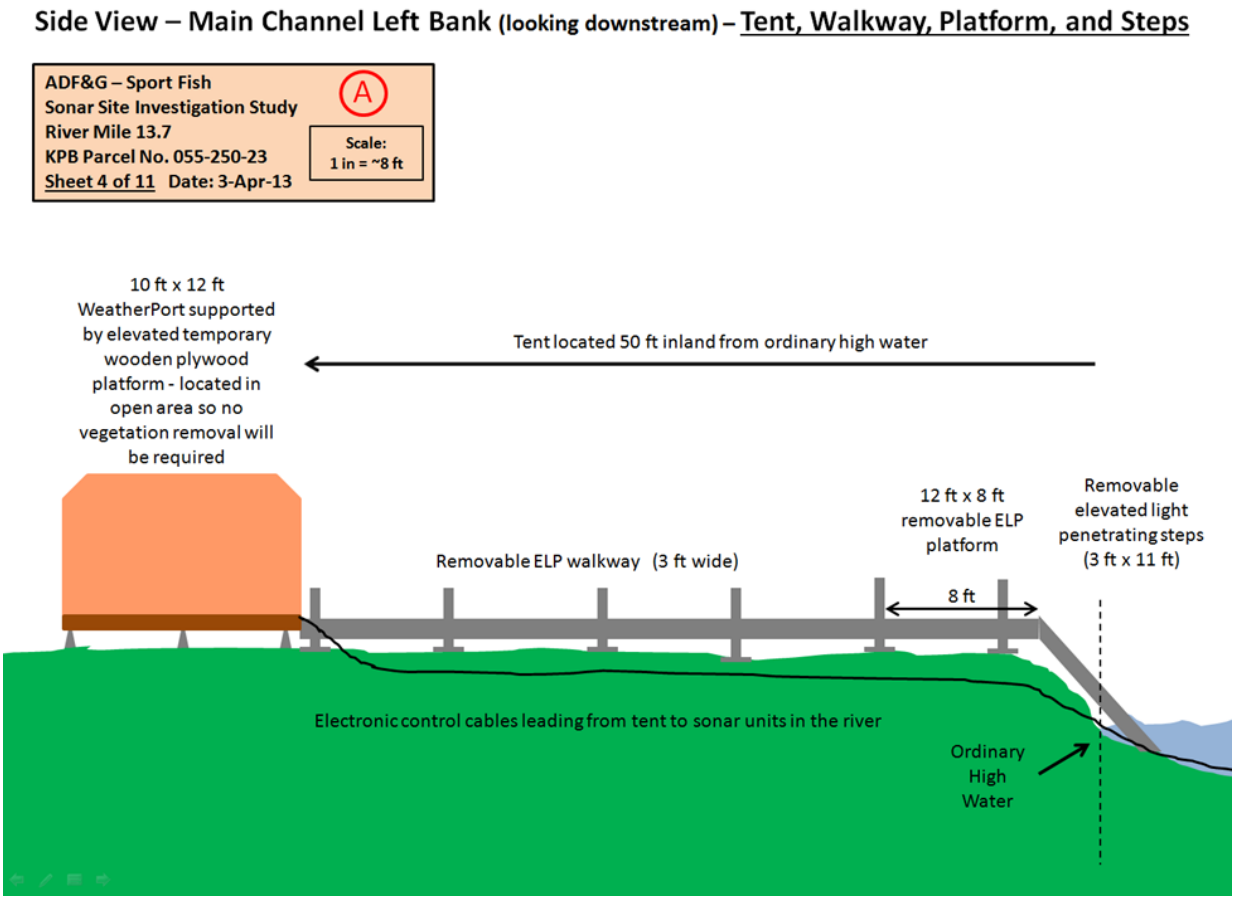


Appendix A3.–Aerial view of sonar deployment at the RM 13.7 sonar site. Image taken from Google Maps © 2013.

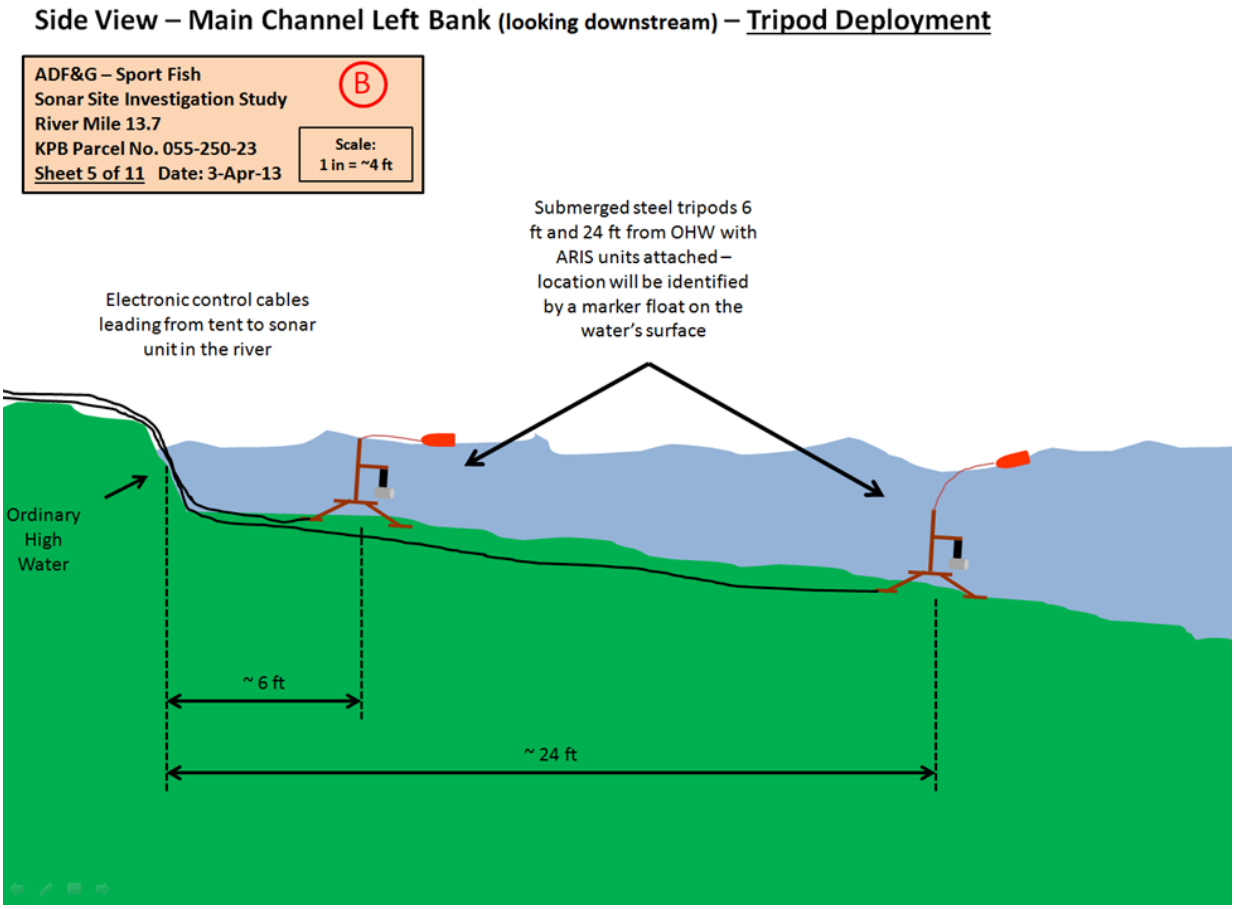
Note: Letters A–F show locations of diagrams in Appendices A4–A12.



Appendix A4.–Aerial view of main channel left bank camp and sonar deployment at the RM 13.7 sonar site.

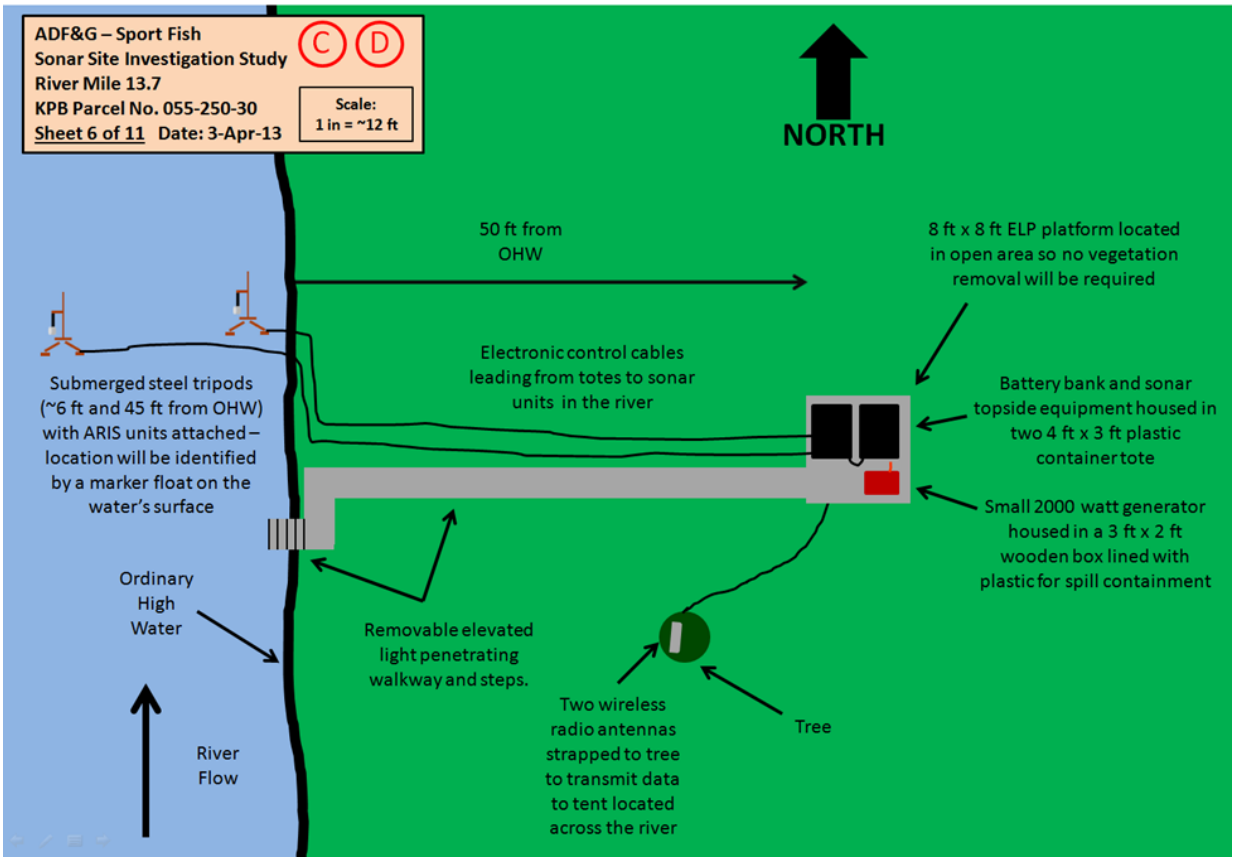


Appendix A5.–Side view of main channel left bank camp and walkway deployment at the RM 13.7 sonar site.

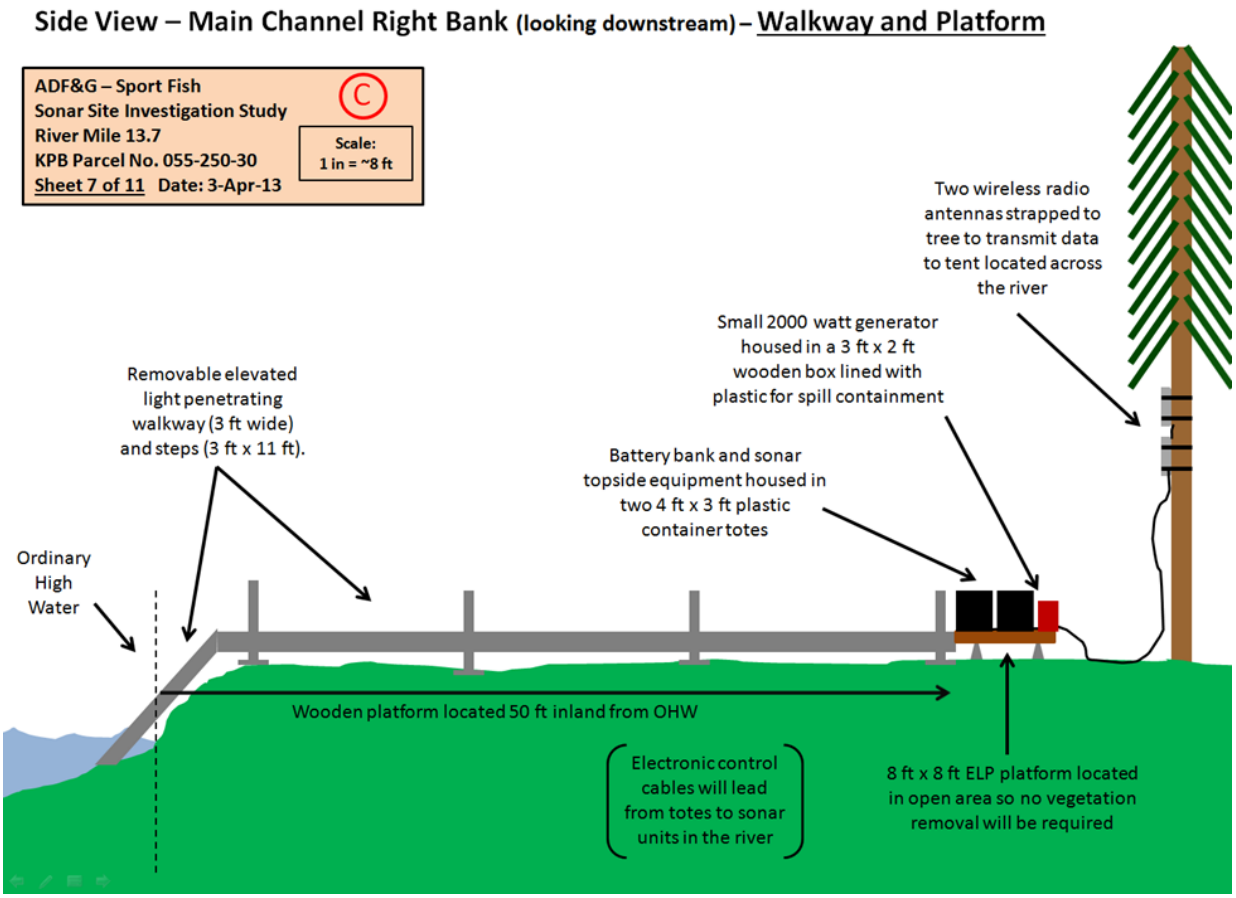


Appendix A6.–Side view of main channel left bank sonar tripod deployment at the RM 13.7 sonar site.

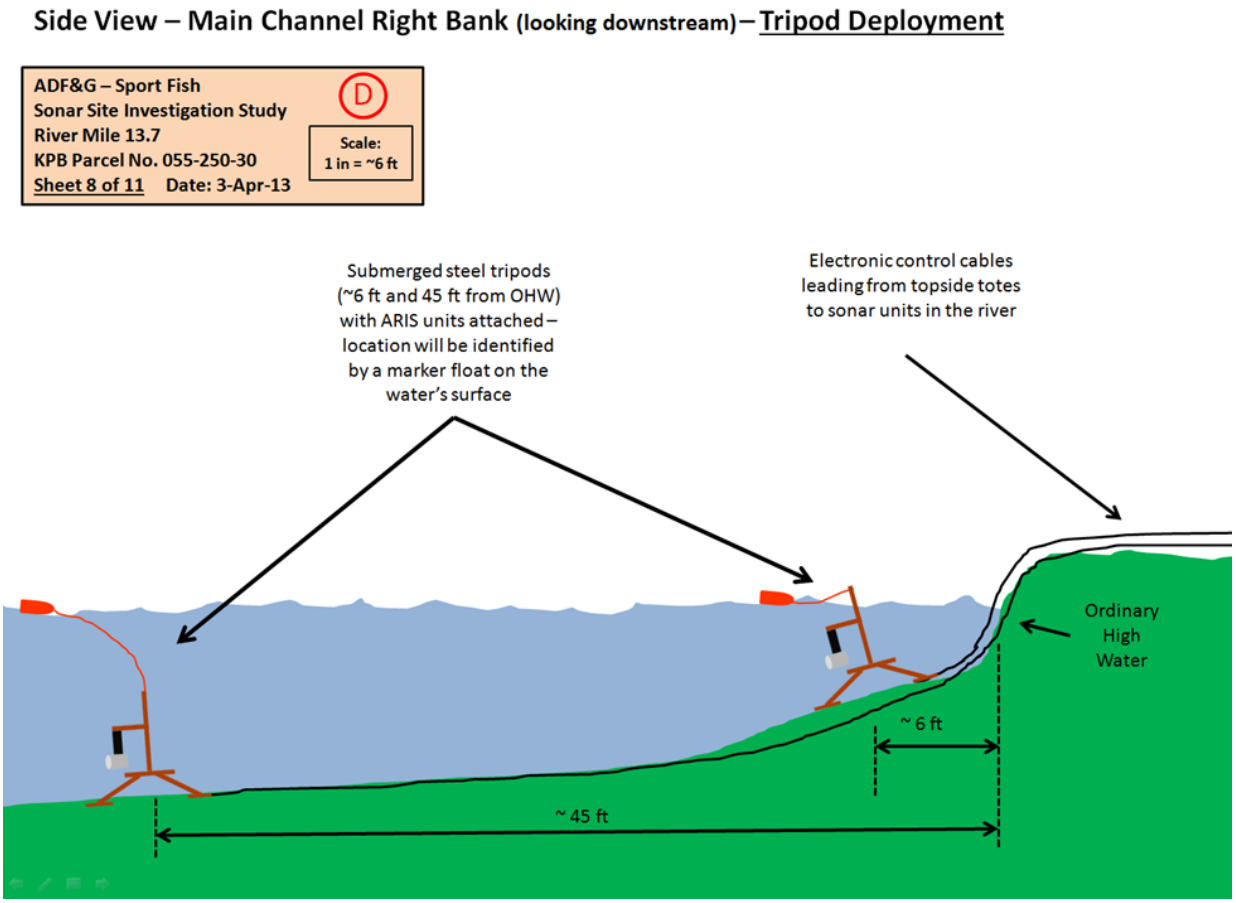
Top View – Main Channel Right Bank (looking downstream) – Walkway, Platform, Tripod Deployment



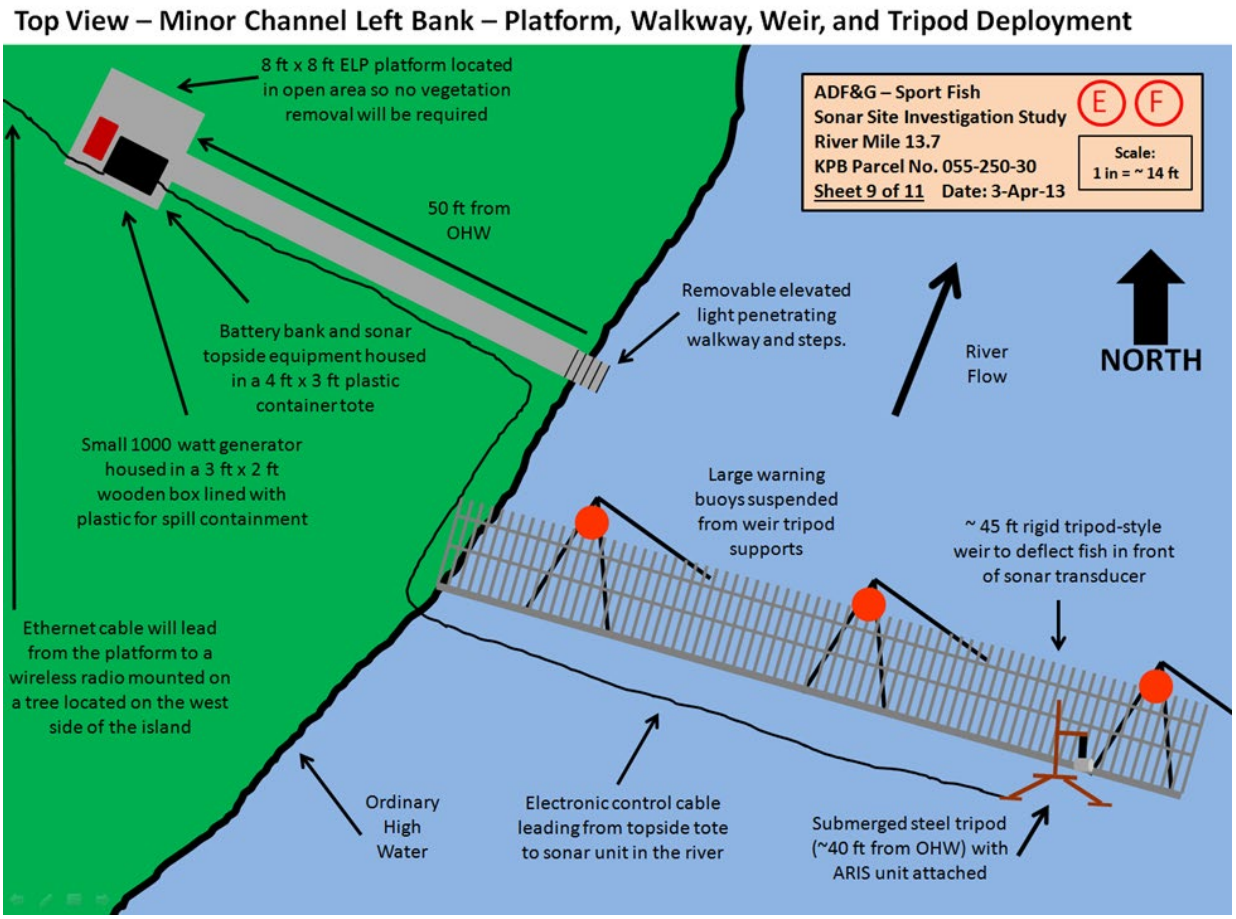
Appendix A7.–Aerial view of main channel right bank battery bank and sonar deployment at the RM 13.7 sonar site.



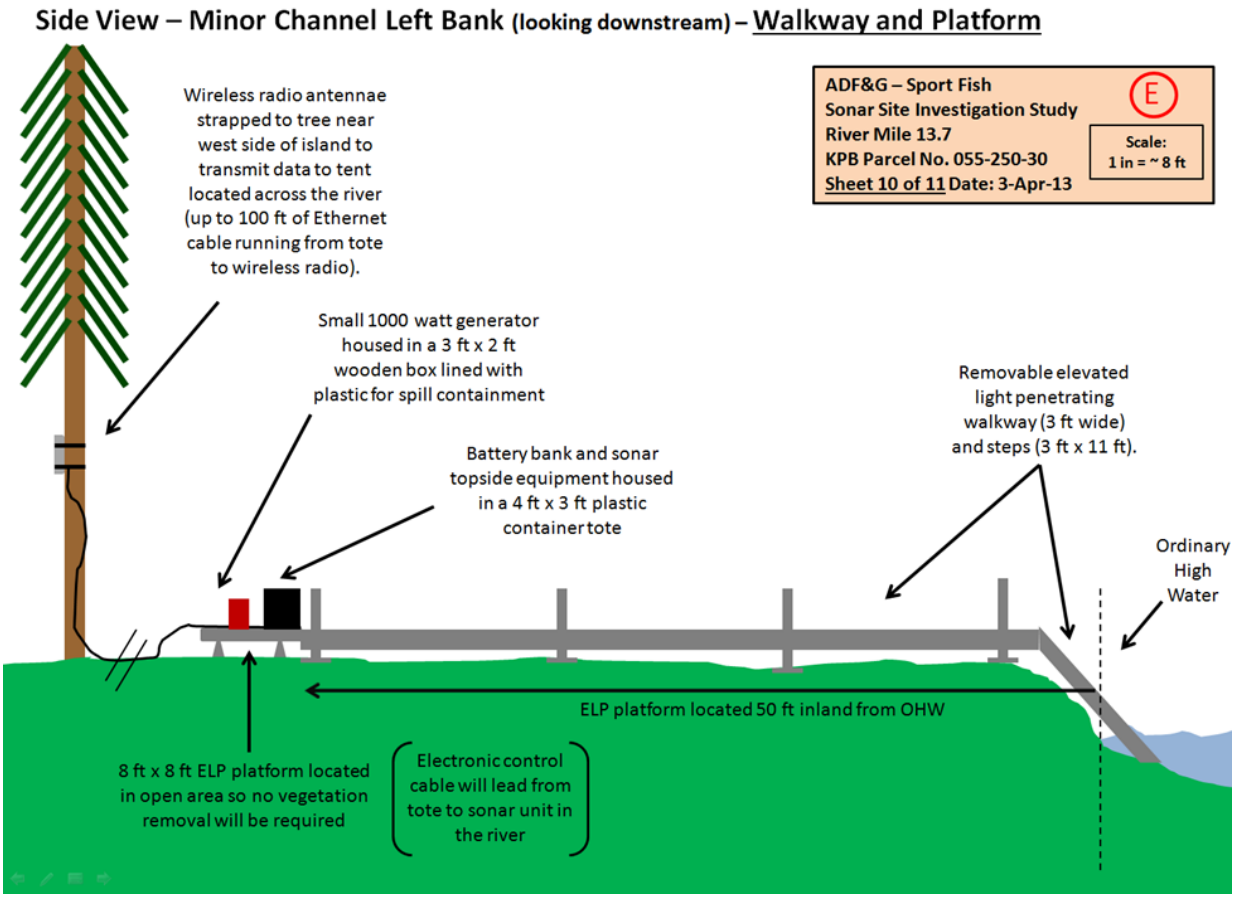
Appendix A8.–Side view of main channel right bank battery bank and walkway deployment at the RM 13.7 sonar site.



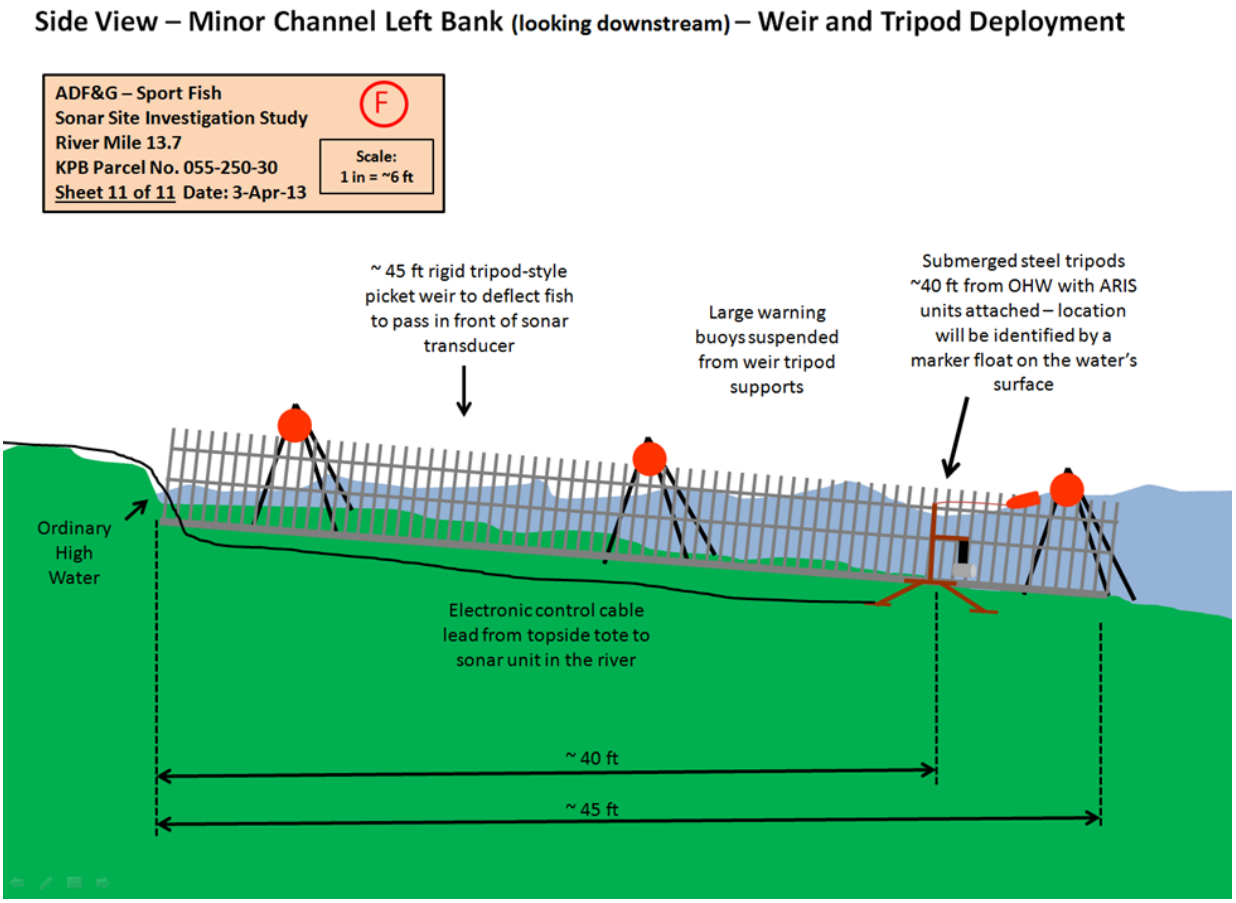
Appendix A9.–Side view of main channel right bank sonar tripod deployment at the RM 13.7 sonar site.



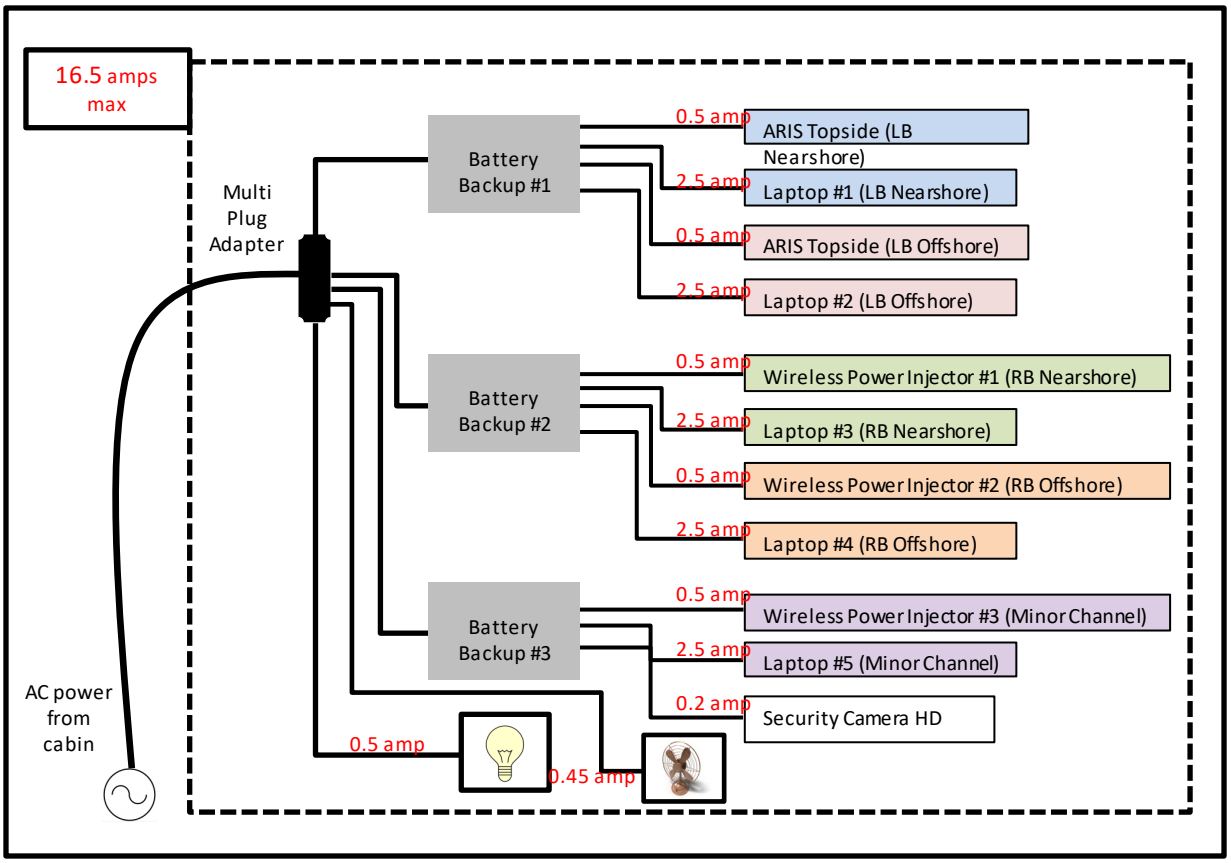
Appendix A10.–Aerial view of minor channel battery bank, weir, and sonar deployment at the RM 13.7 sonar site.



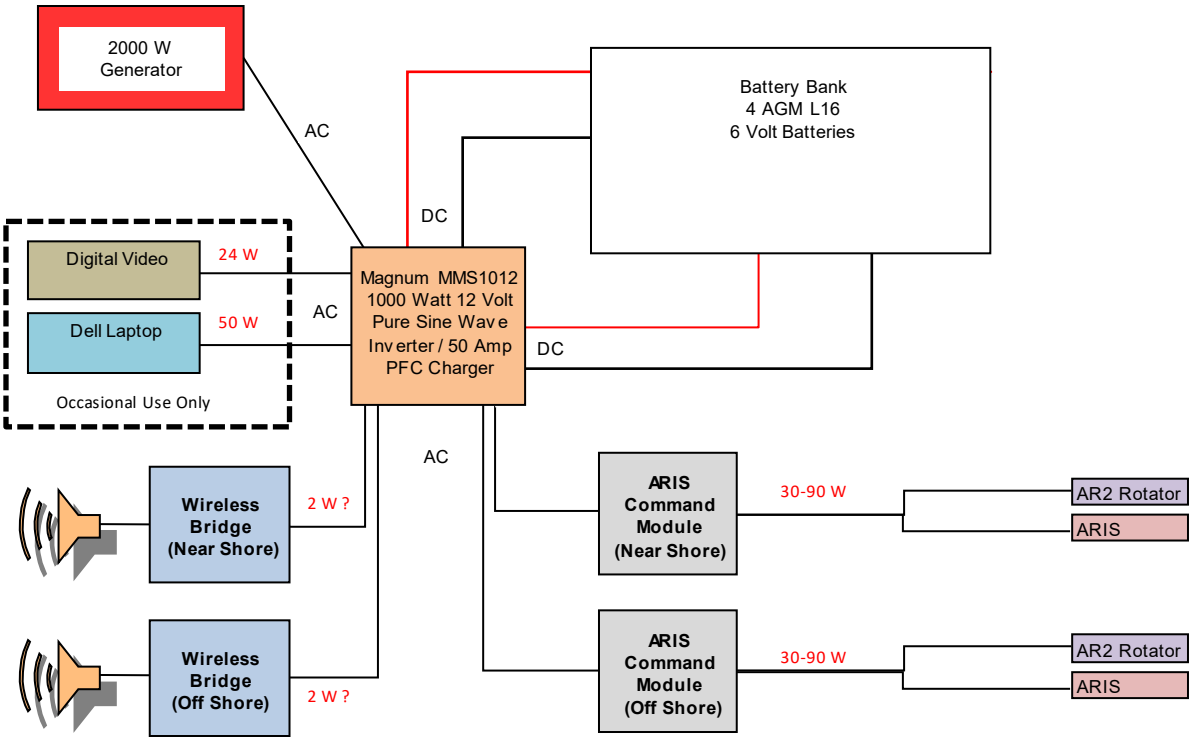
Appendix A11.–Side view of minor channel battery bank and walkway deployment at the RM 13.7 sonar site.



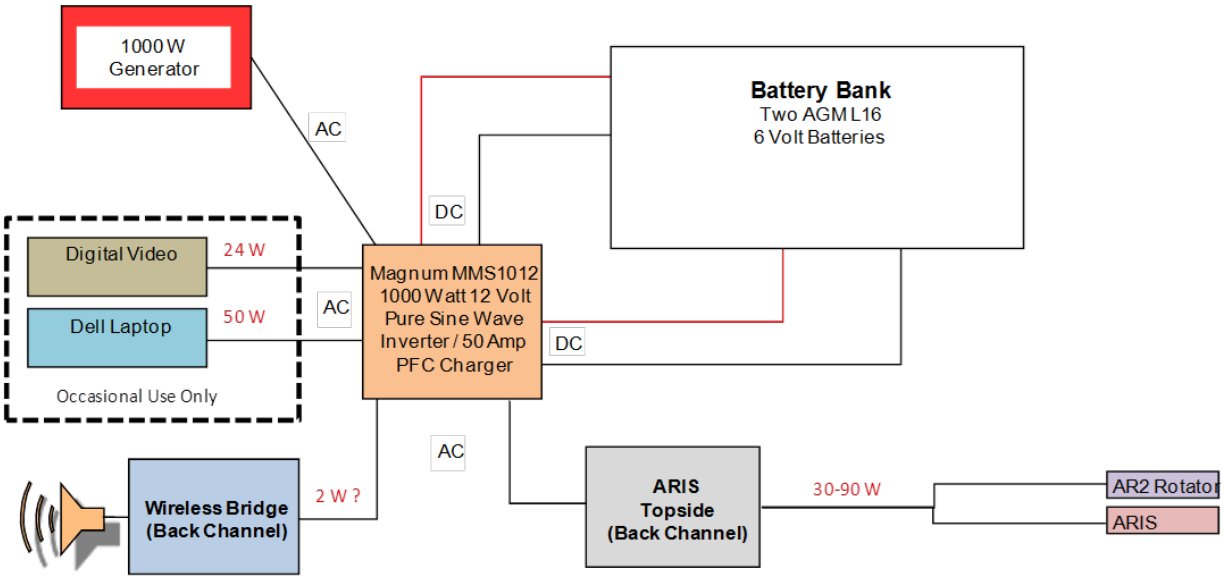
Appendix A12.–Side view of minor channel battery weir and sonar tripod deployment at the RM 13.7 sonar site.



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



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

Appendix B1.–DIDSON and ARIS configurations used on Kenai River Chinook salmon sonar project, including an overview of features that affect resolution and range capabilities.

Frequency

A dual-frequency identification sonar (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.

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Like the 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 B5 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:

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

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:

$$Y = W/N \qquad \text{(B2)}$$

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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 preferred for measuring. 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, these data pass through a WPF[8] 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 necessary.

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[8] 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 (about 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 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 is 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.–Manufacturer specifications for sonar models ARIS 1200, ARIS 1800, DIDSON SV, and DIDSON LR.

ARIS 1800 Specifications:

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

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

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

ARIS 1200 Specifications:

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

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

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

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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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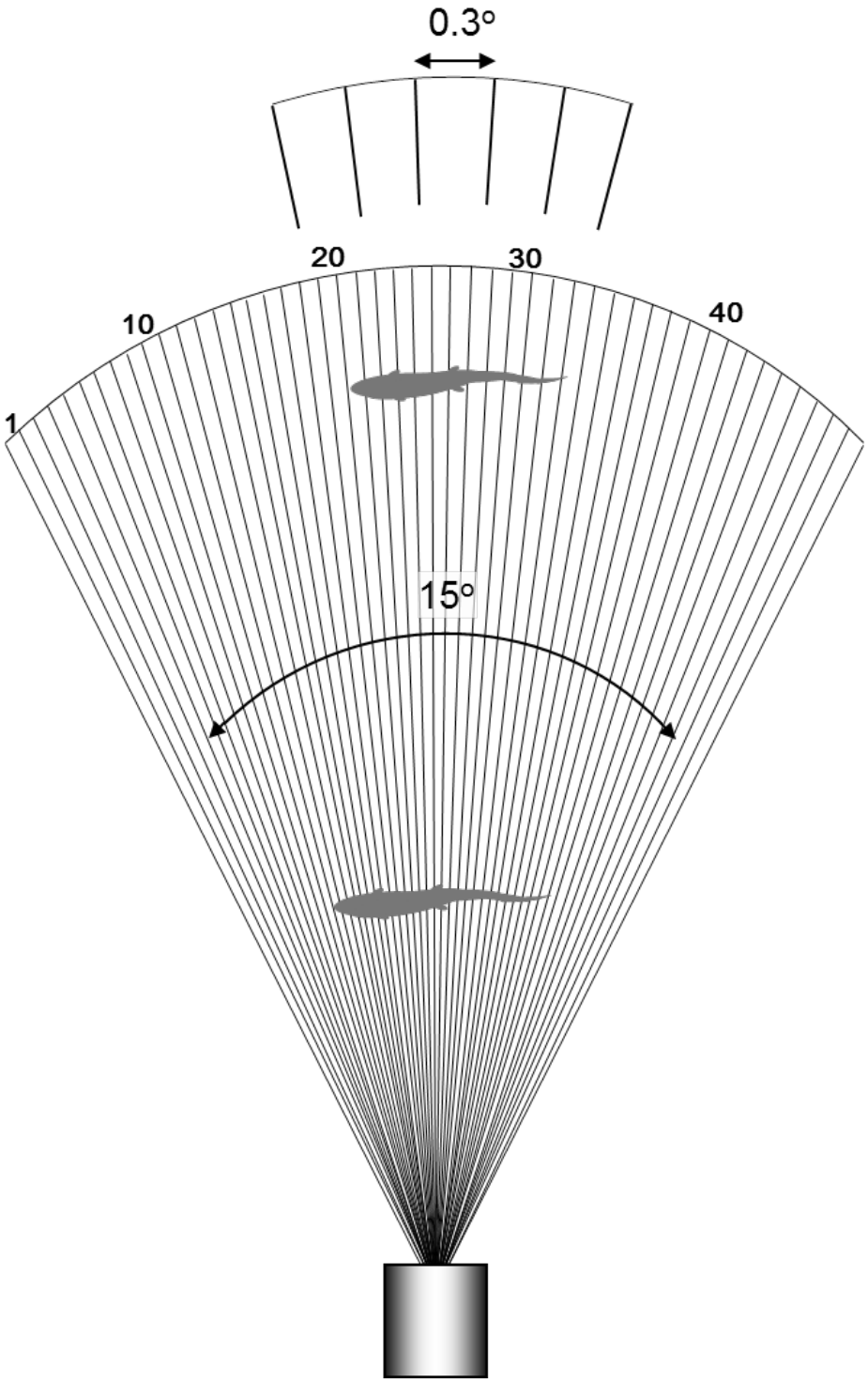
DIDSON LR Specifications

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

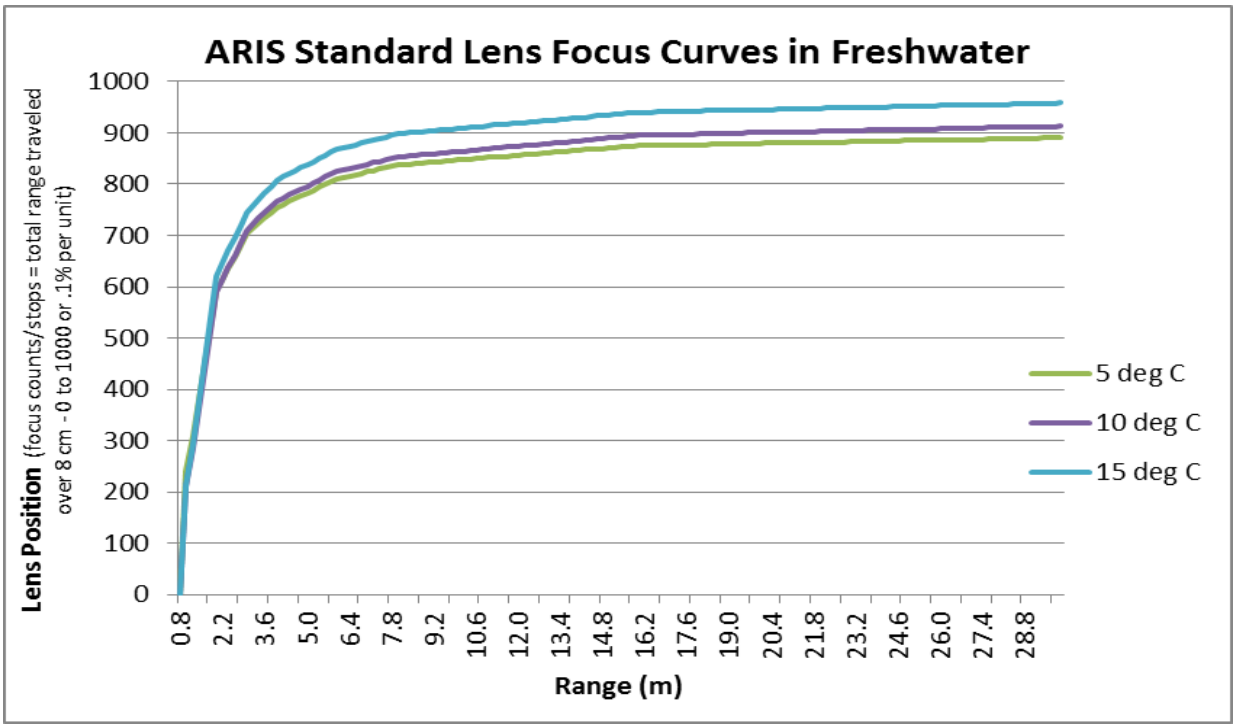
Both Modes
Max Frame Rate (range dependent) 2–21 frames/s
Field-of-view 29°
Remote Focus 1 m to infinity
Control & Data Interface UDP Ethernet
Aux Display NTSC Video
Max cable length (100/10BaseT) 61 m/152 m (200 ft/500 ft)
Max cable length (twisted pair, Patton Extender) 1220 m (4000 ft)
Max cable length (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

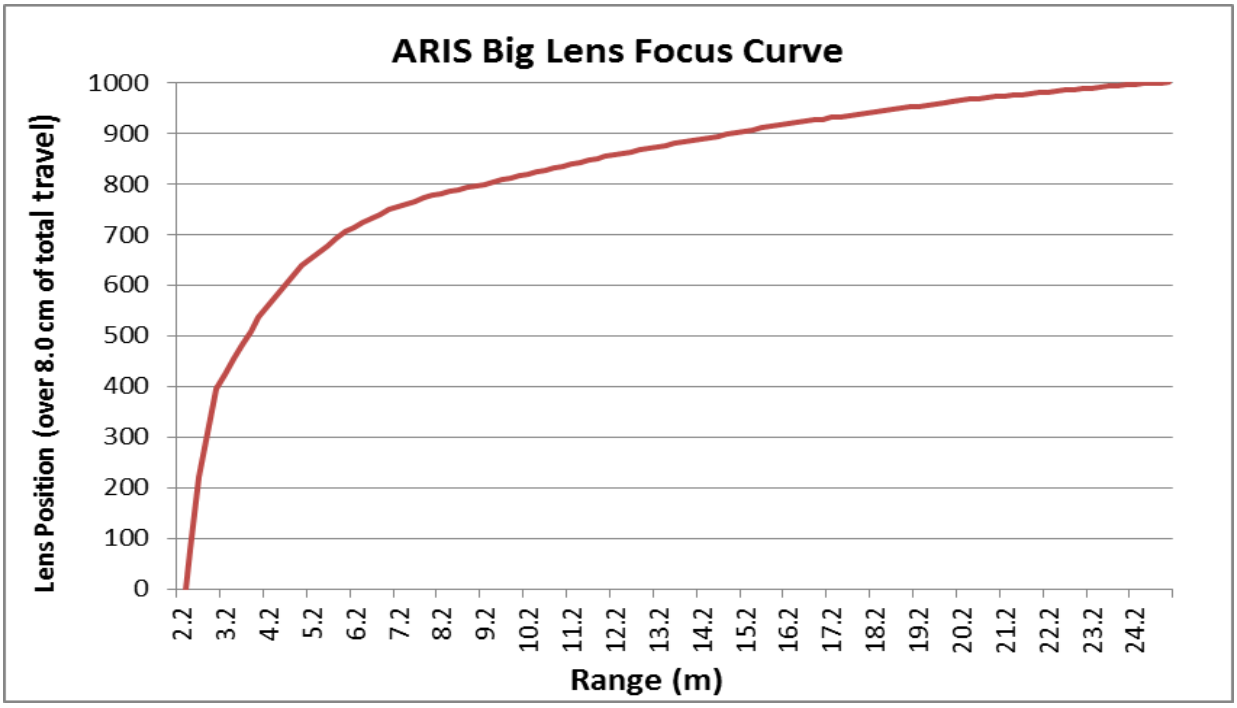


Appendix B3.–Diagram showing the horizontal plane of a DIDSON-LR or ARIS 1200 with a high-resolution lens.

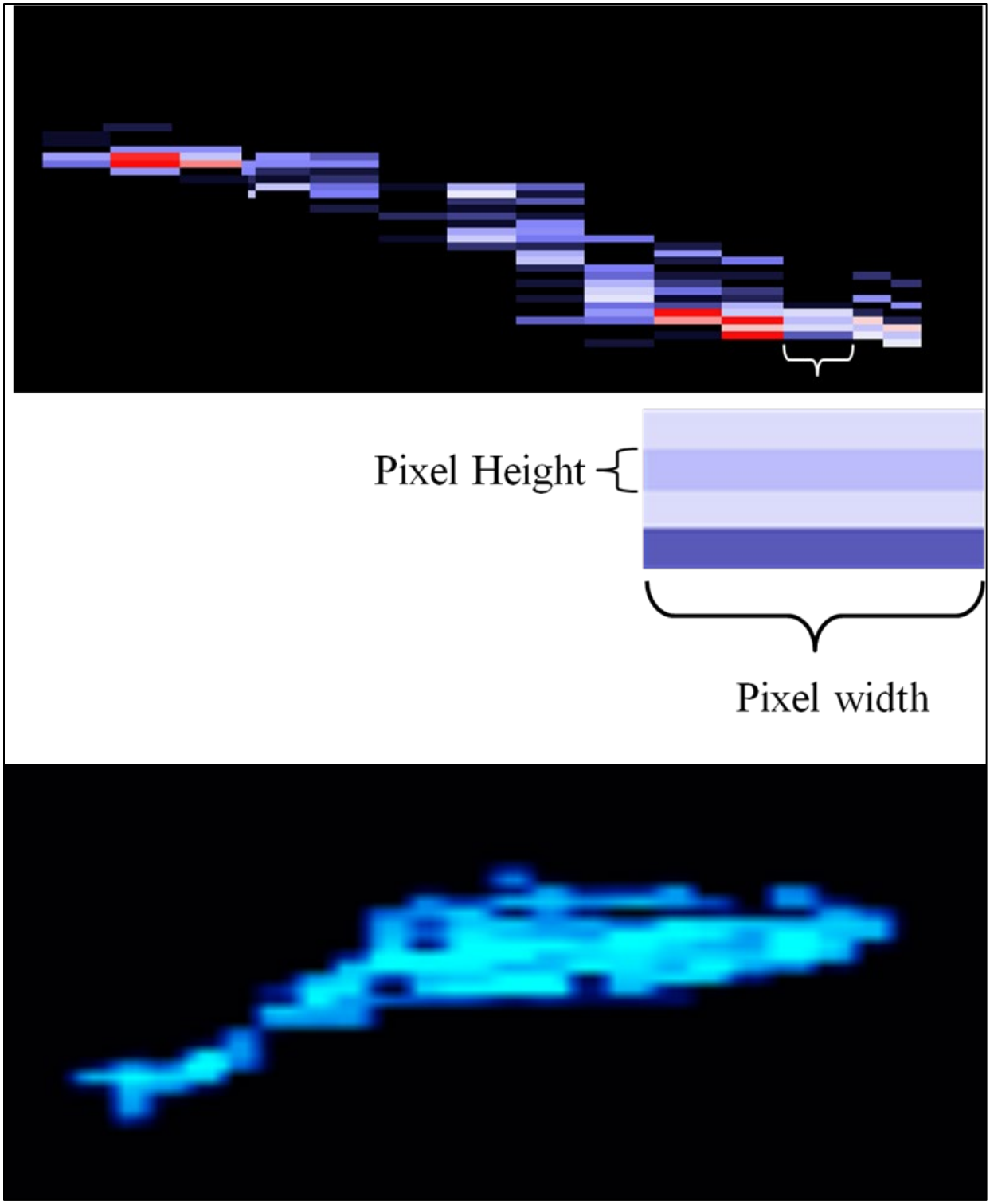
Source: Burwen et al. 2007.

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

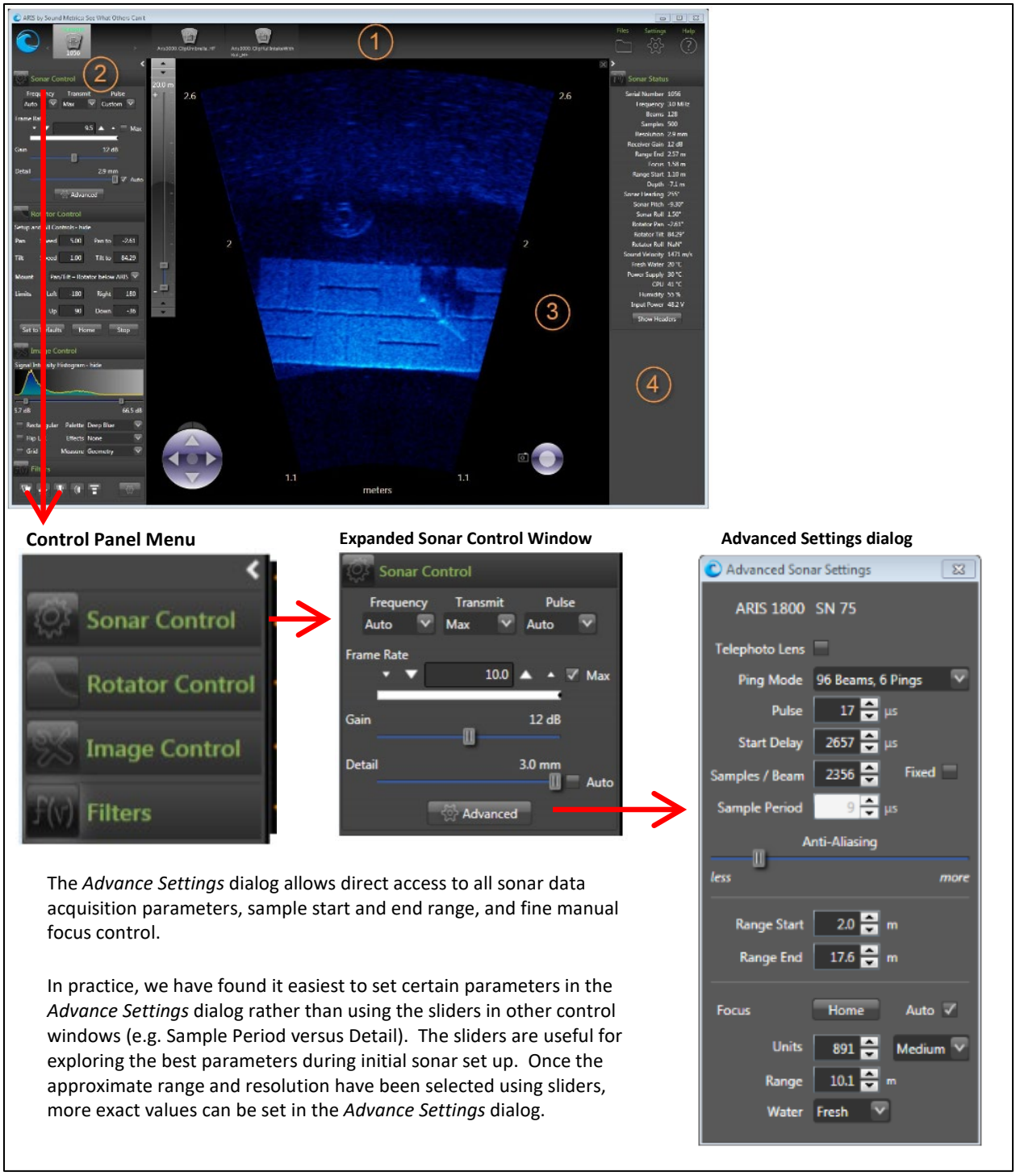




Appendix B4.–Relationships between focal length and lens position for ARIS.



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).



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.

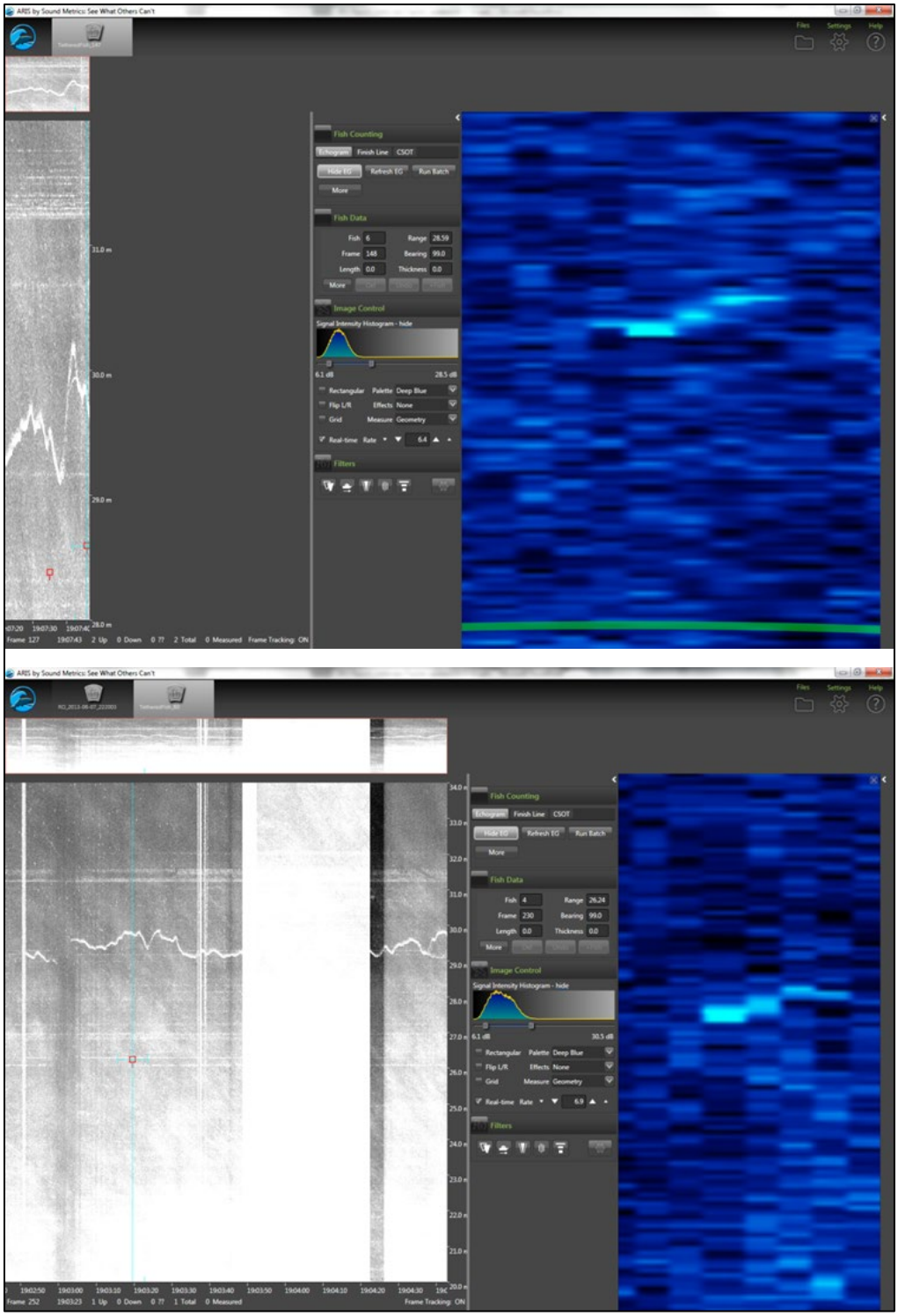
Appendix B7.–Summary of ARISCope data acquisition parameters that affect downrange resolution.

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. Consequently, 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).

-continued-

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).

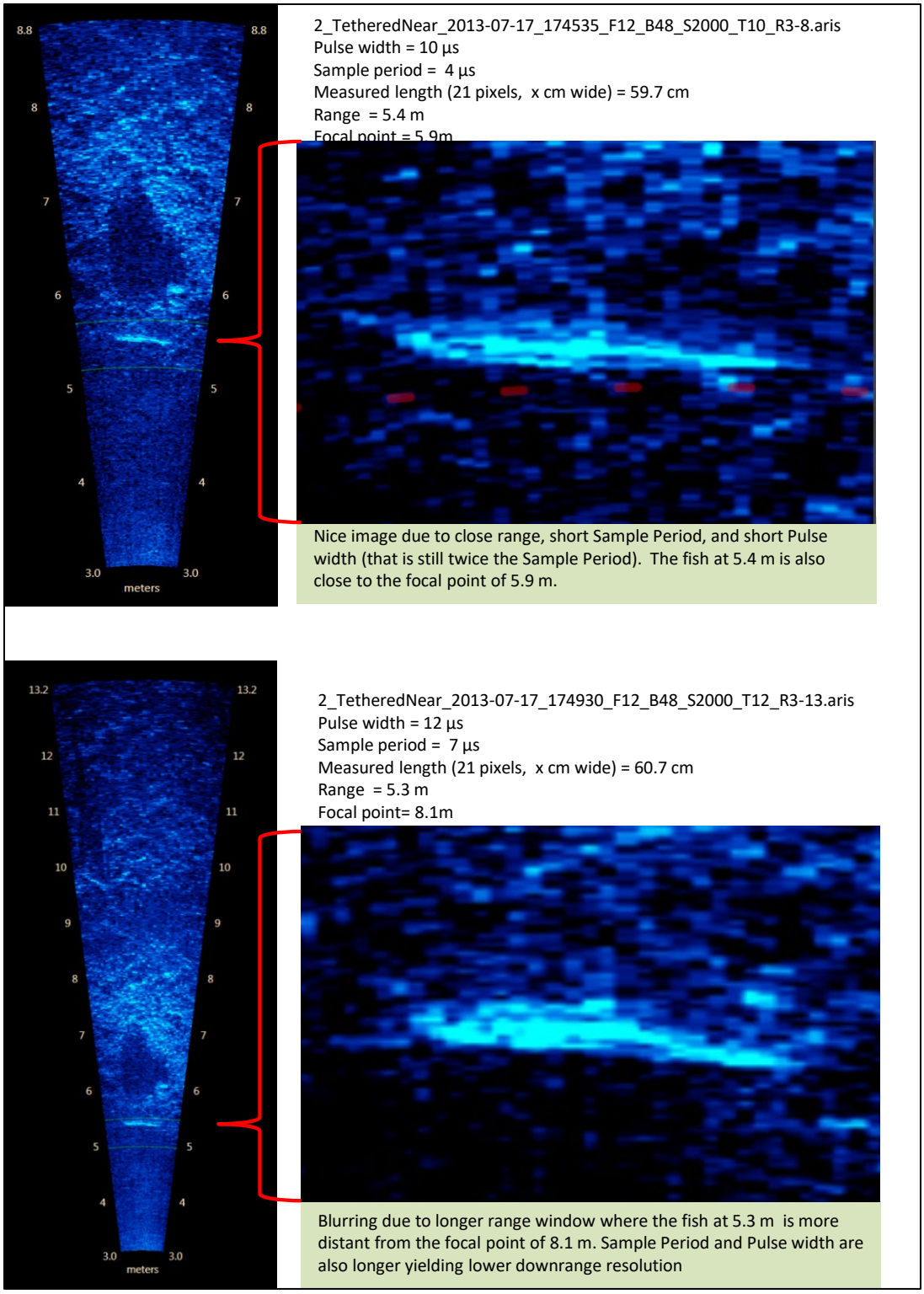
Source: files 2014-07-21_190721_F12_B48_S1378_T29_R27-31 (top) and 2014-07-21_190245_F12_B48_S1931_T33_R19-34_HF (bottom).

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

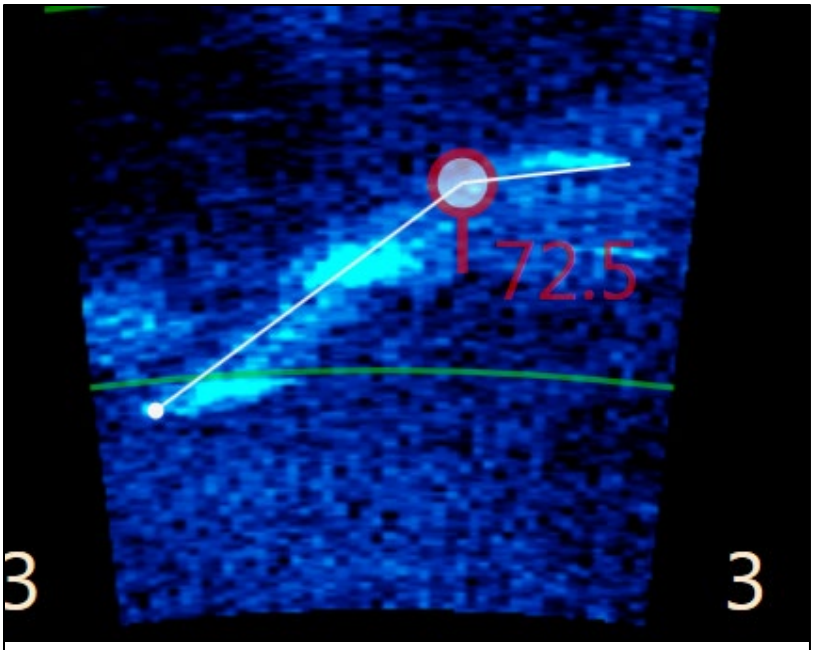
[a] Bill Hanot recommends a fixed **Sample Period** (i.e., constant downrange resolution) using a longer pulse length

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.

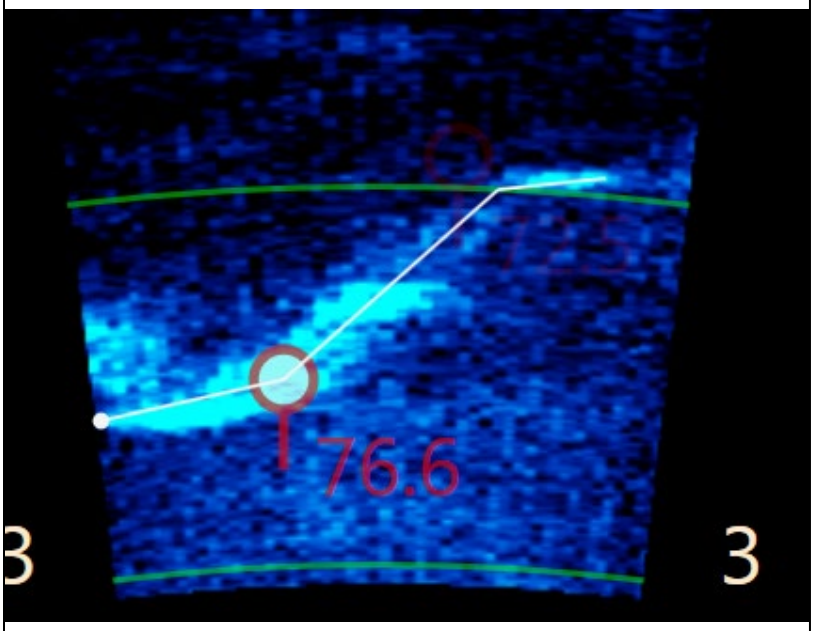


Appendix B10.–Images from a close-range tethered fish at 2 different range windows demonstrate the advantage of a shorter range window and higher sample period for close range sampling.

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.

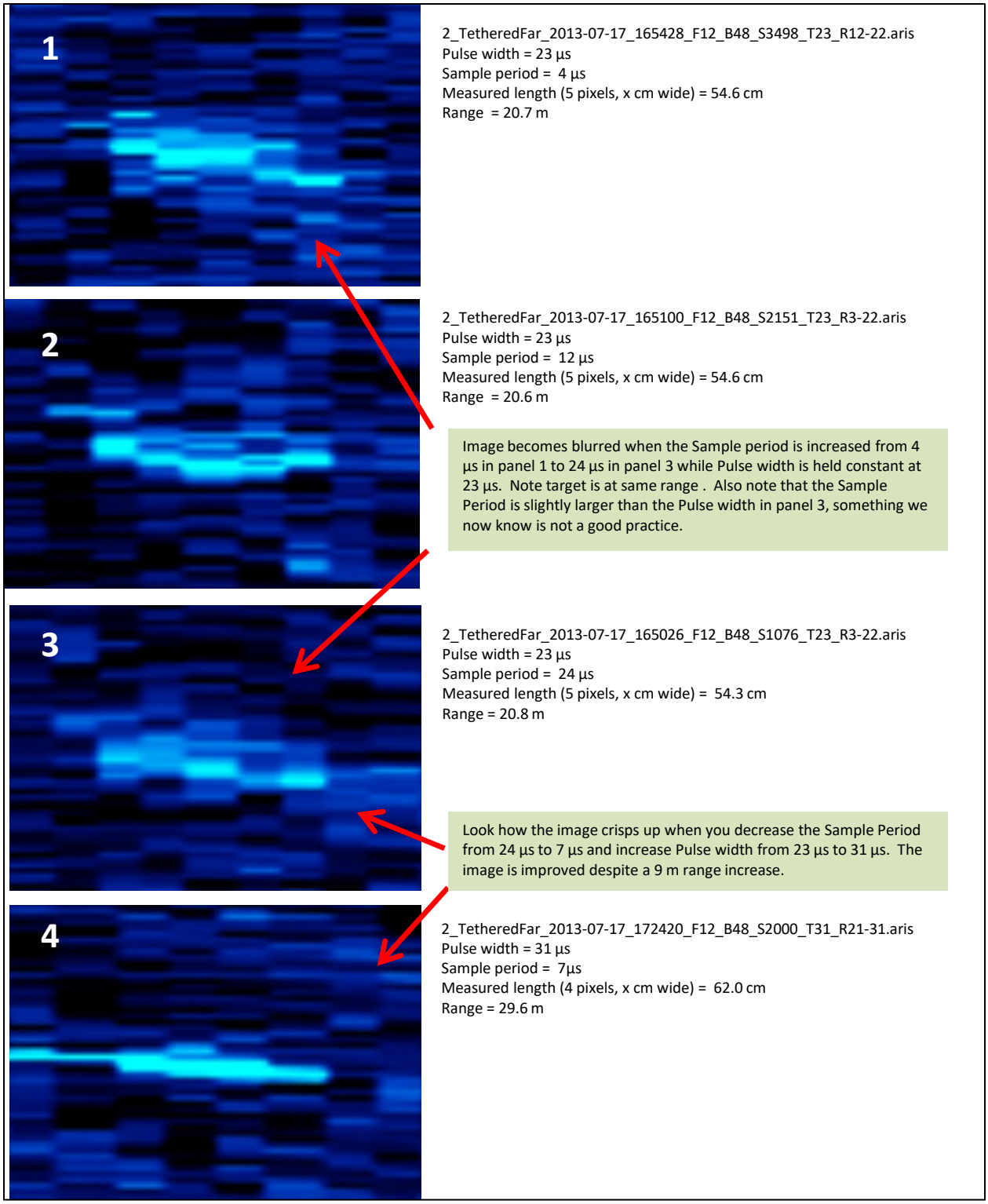


3_TetheredNear_2013-07-17_182746_F12_B48_S1724_T08_R3-8.aris
Fish Range: 3.35 m
Frame 2498
Fish size 72.5 cm

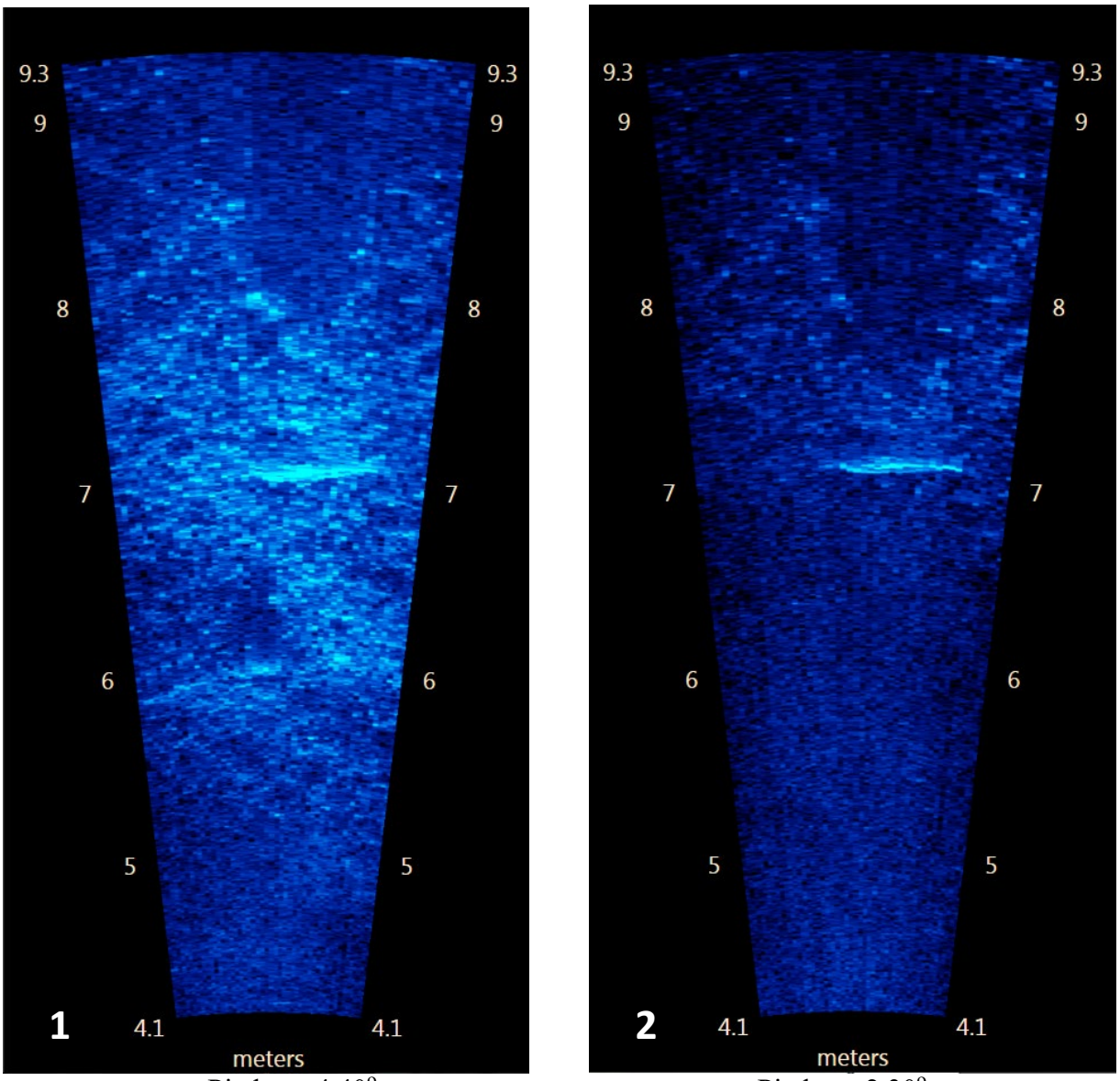


3_TetheredNear_2013-07-17_182746_F12_B48_S1724_T08_R3-8.aris
Fish Range: 3.17 m
Frame 1896
Fish size 76.6 cm

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.



Appendix B12.–Data collected from tethered fish (in this case, a 60 cm sockeye salmon) provided the opportunity to compare the effects and interrelationship between 2 parameters affecting image resolution, transmitted pulse length, and sample period.



Pitch = −4.40° Pitch = −2.30°

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]
Username: admin

Default IP Address: NONE
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: [for Didson network. Aris sonar uses 169.254.xxx.xxx network.]

Right_Bank (tent side of the river)
SSID: RightBank
IP Address:
Subnet Mask: 255.255.255.0
Gateway: None
Wired MAC Address: 50-3D-E5-D9-6B-7A
Radio MAC Address: 00-3A-99-D0-97-C0

Left_Bank (bluff)
SSID: LeftBank
IP Address:
Subnet Mask: 255.255.255.0
Gateway: None
Unit MAC Address: 00-07-7D-4D-18-16
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-

```
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:**

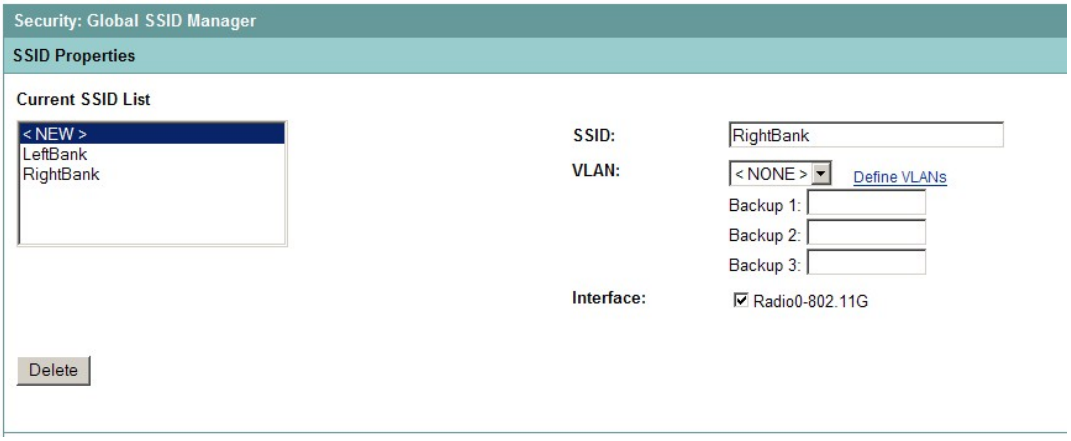
	IP:	**Subnet mask:**	
`ip address`		`255.255.255.0`	[Didson Camp Bridge]
`ip address`		`255.255.255.0`	[Didson remote Bridge]
`ip address`		`255.255.0.0`	[Aris Camp Bridge]
`ip address`		`255.255.0.0`	[Aris remote Bridge]

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

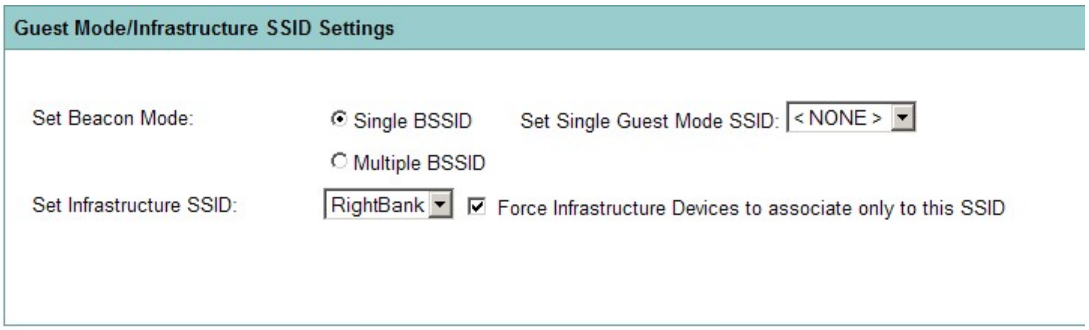
-continued-

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:)

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:

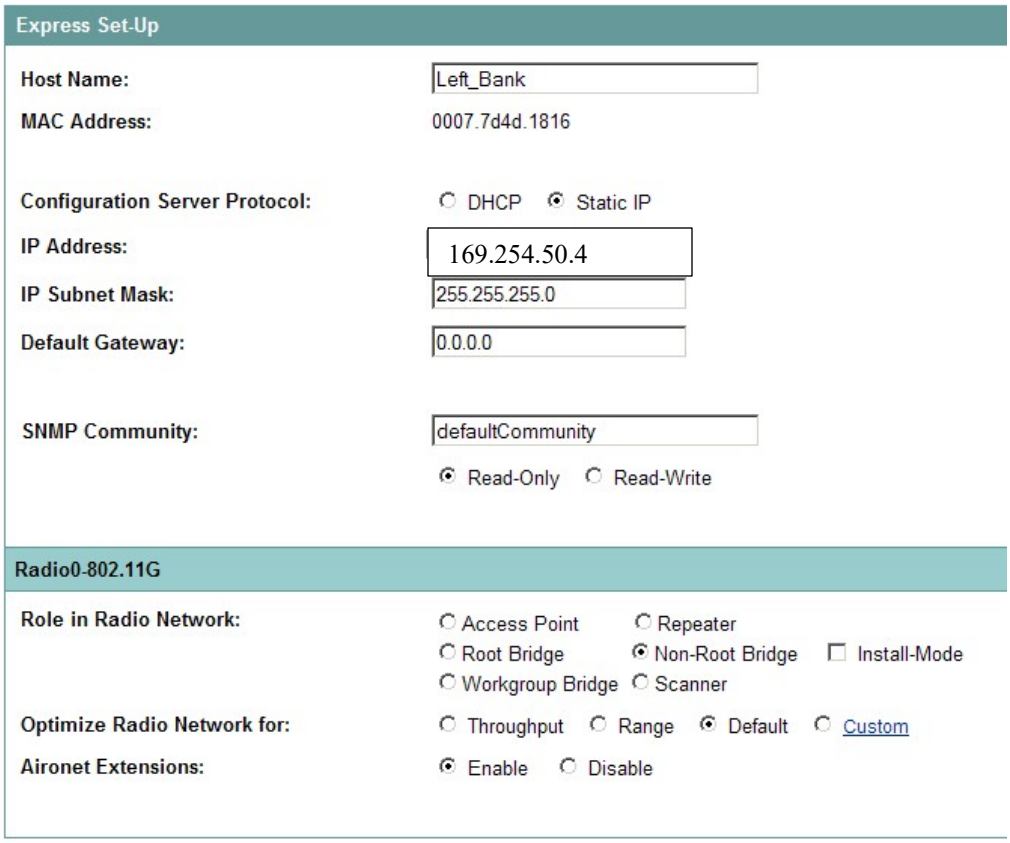
Host Name is Right_Bank or Left_Bank
Configuration Server Protocol is Static IP
Role in Radio Network for Right Bank is Root Bridge and Left Bank is Non-Root Bridge.
Leave everything else default.
Click Apply

-continued-

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.



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.

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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.

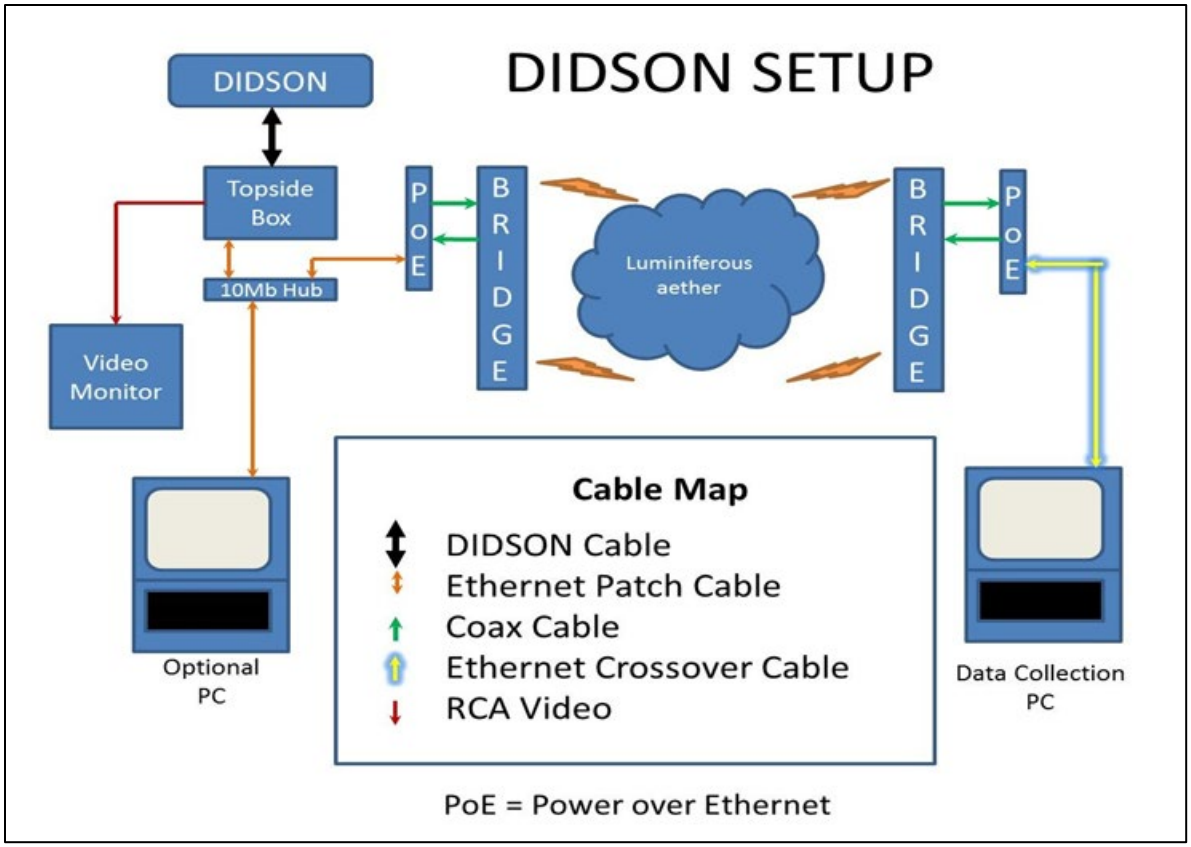
CISCO AERONET WIRELESS SYSTEM TO DIDSON

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)
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)
Ping left bank bridge (ping) – 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.)



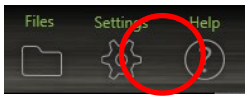
Appendix C2.–Wireless bridge diagram.

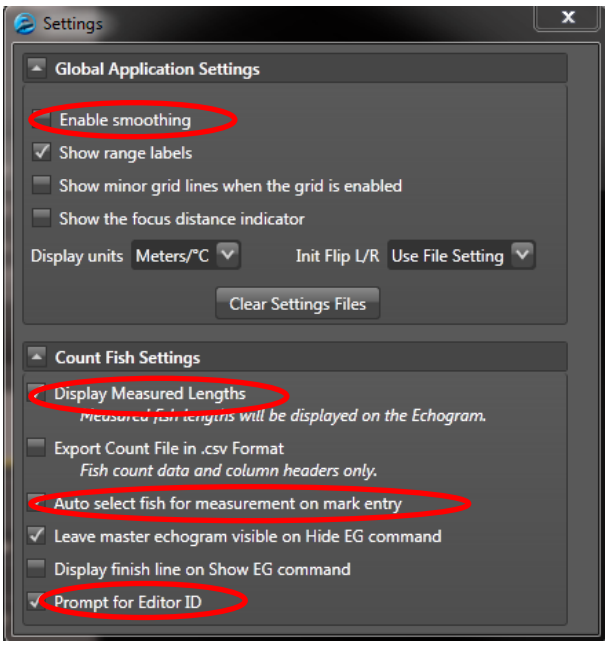
APPENDIX D: INSTRUCTIONS AND SETTINGS USED FOR MANUAL FISH LENGTH MEASUREMENTS FROM ARIS IMAGES USING ARISFISH SOFTWARE VERSION 2.3

Appendix D1.–Instructions and settings for manual length measurements from ARIS images 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:

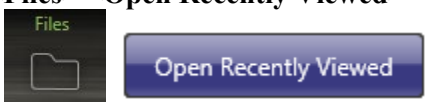




b) Enable smoothing is ***off***.
c) Display Measured Lengths is ***on***.
d) Auto select fish for measurement on mark entry is ***on***.
e) Prompt for Editor ID is ***on***.

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)

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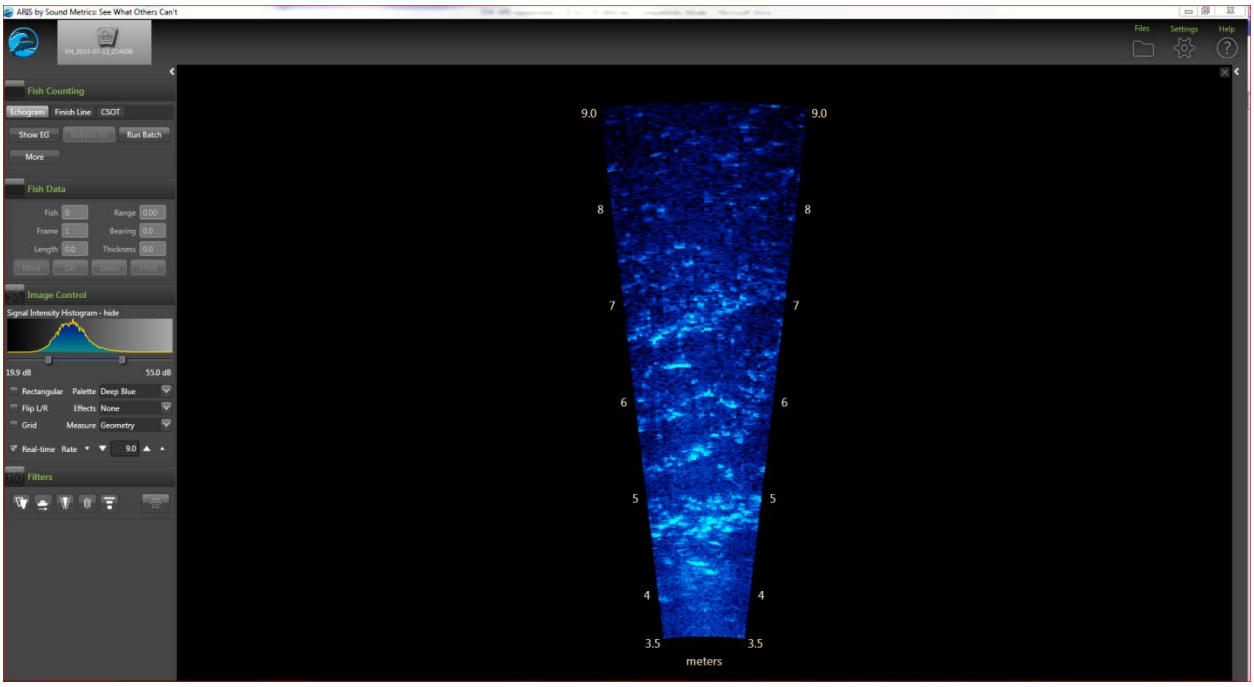
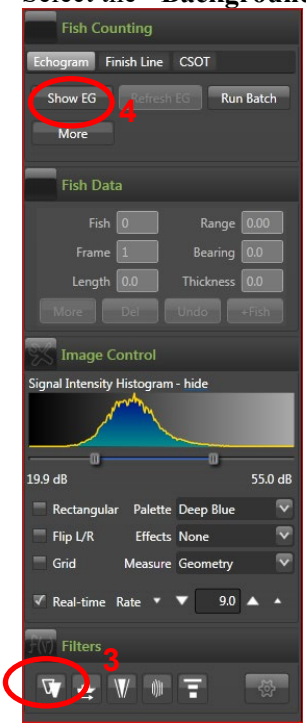
At this point, the ARISFish display should look similar to the image below:



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.

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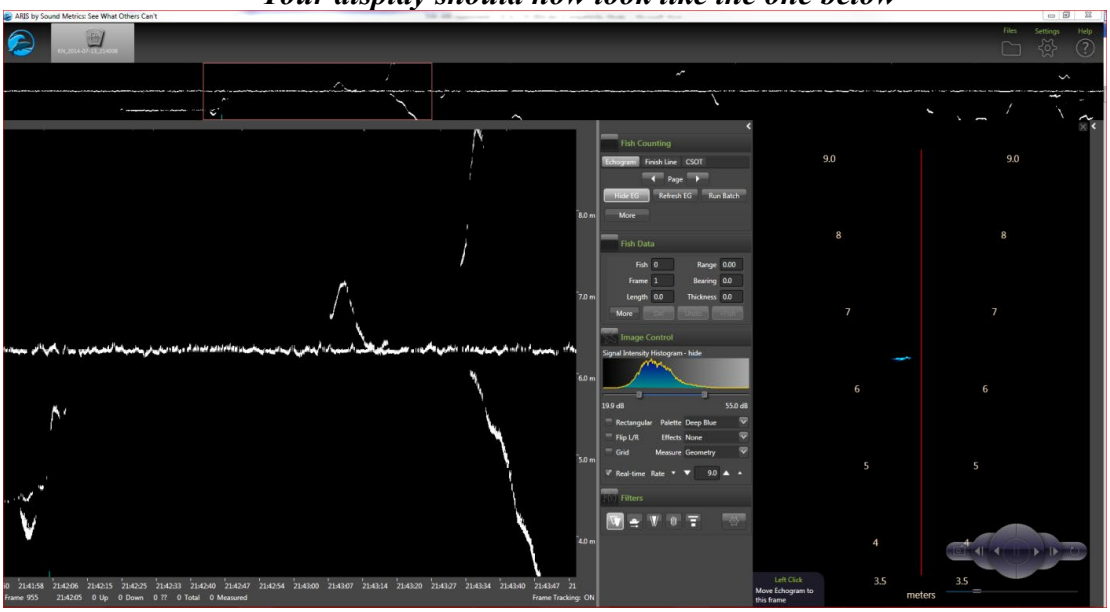
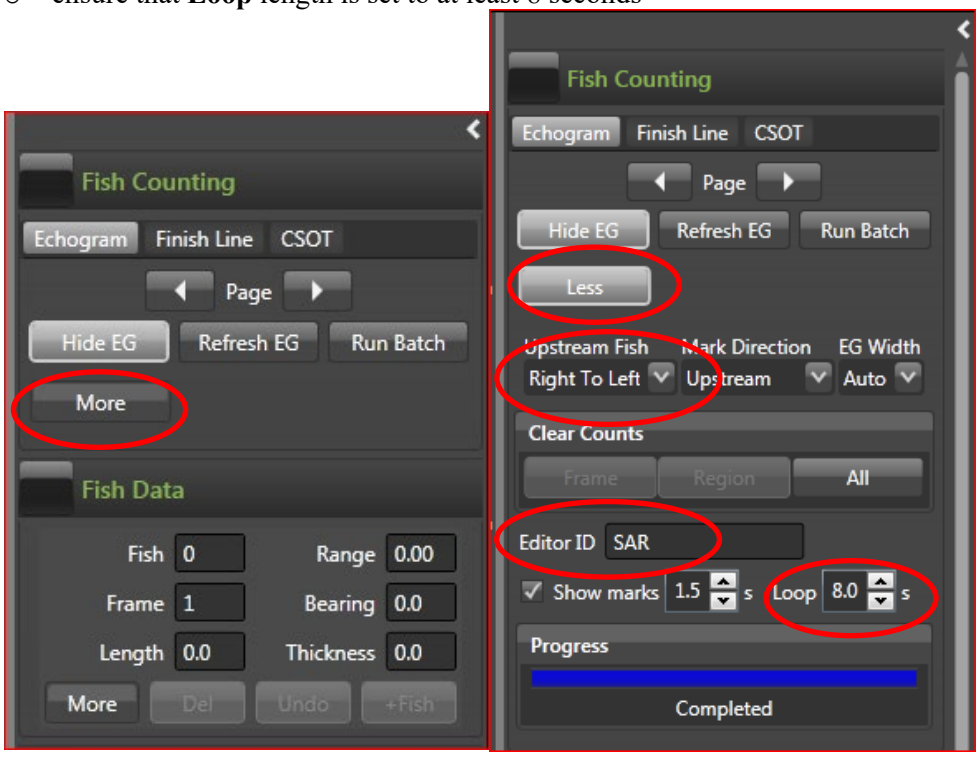
Your display should now look like the one below



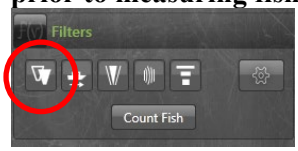
c) Select **<More>** from the Fish Counting window to get the extended window where you can
   - enter your **Editor ID** initials
   - set the **Upstream Fish** direction
   - ensure that **Loop** length is set to at least 8 seconds



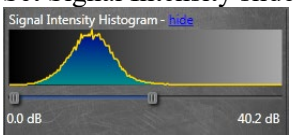
   - then select **Less** to unexpand Fish Counting window (you'll be able to access other controls like BS easier if you do this)

-continued-

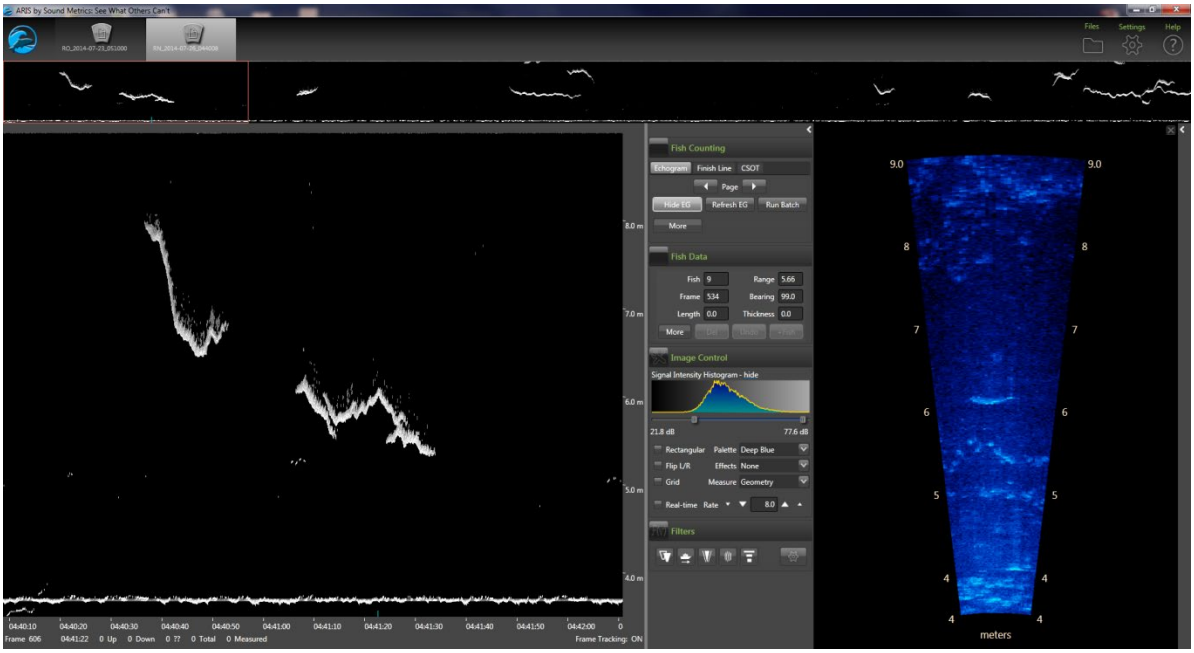
a) Select **<Background Subtraction>** icon on Filters Menu (Toggle)—this will now turn background subtraction off on the video image. **Failing to turn background subtraction off prior to measuring fish image length may result in an underestimate of actual fish length**[9]**.**



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.

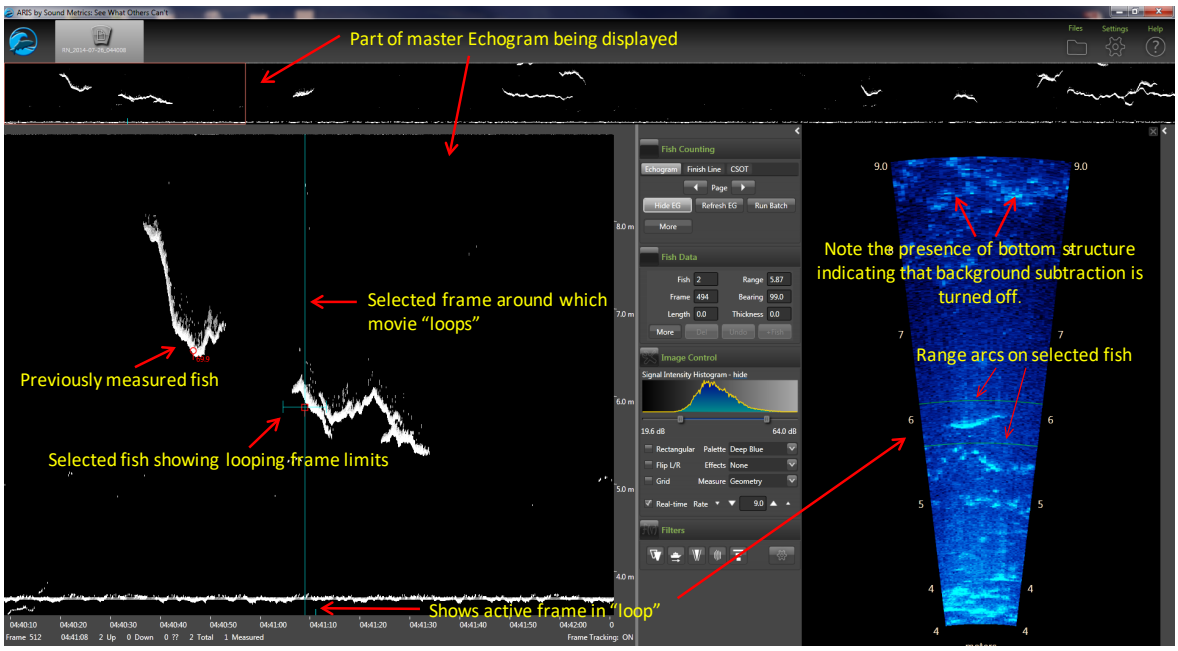
-continued-

[9] 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.



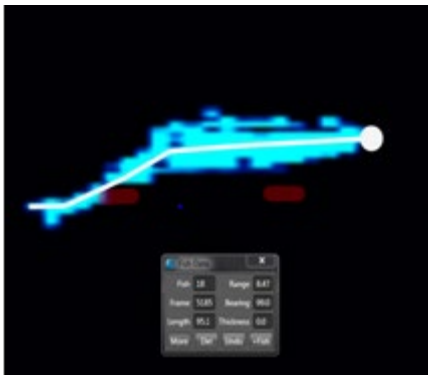
- Press **<space bar>** to start or stop the video playback.

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.
- Measurements should be taken from frames where contrast between the fish image and background are high and where the fish displays its full length.
- 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.
- 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.

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

Use of a programmable mouse is recommended to increase efficiency

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.
   - If a fish enters or exits the beam on the near- or far-range boundary (beginning or end range), the snout of the fish must cross the centerline before it can be considered a valid fish to measure.
   - If the snout of the fish enters the near- or far-range boundary right on the centerline, the fish should be considered valid for measurement.

b) Exclude fish that hold throughout the length of the sample.

c) Exclude fish that are holding at either the beginning or the end of the sample.
   - Fish that are actively migrating (not holding) as the sample begins or ends should be considered valid targets for measurement as long as they cross the centerline.

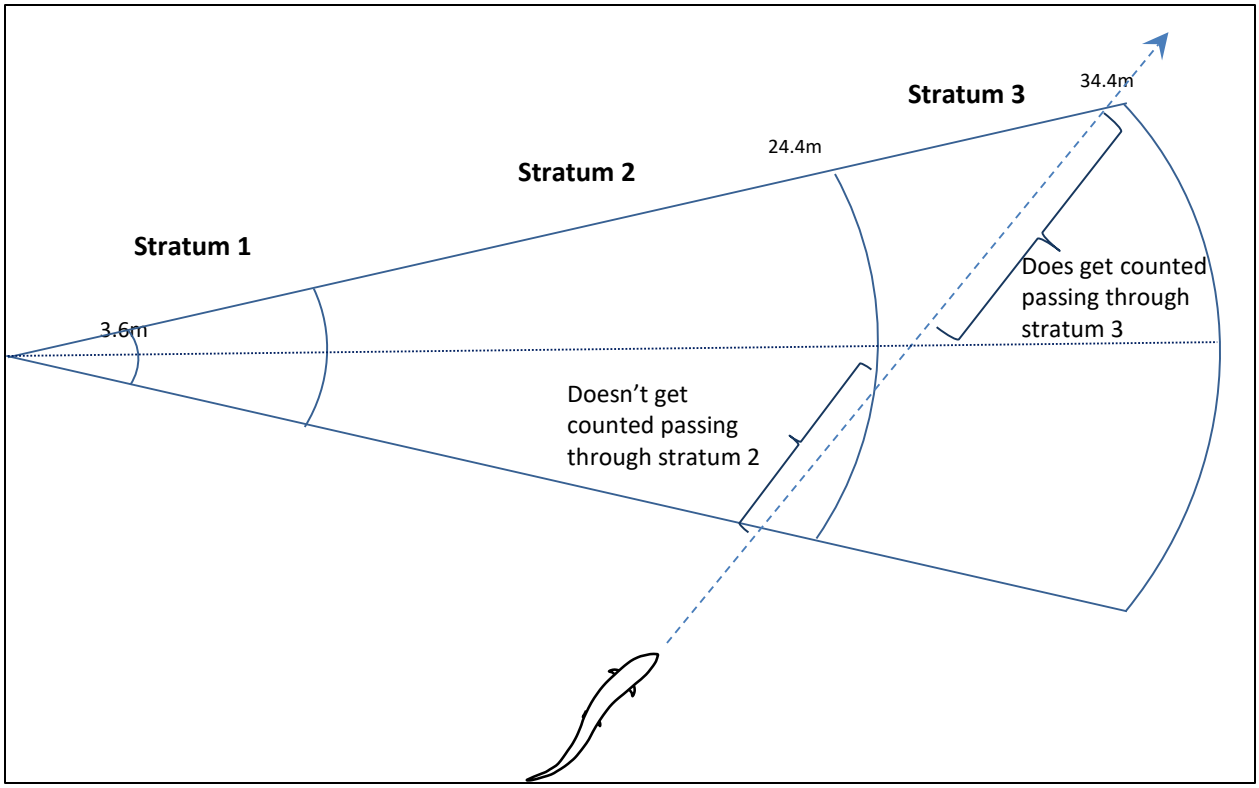
d) Exclude fish that enter the beam from upstream, then exit the beam upstream (do not measure even if they cross the centerline).

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

f) Exclude fish that enter the beam from either upstream or downstream and then disappear from the image (unless there is evidence to suggest direction of travel).

g) Use the video image to identify actively migrating fish when several holding fish are present. If you have several fish holding throughout the sample, use the video mode or run your cursor across the echogram while watching the ARIS image to observe fish that are actively transiting the image. Measure fish that are actively transiting the image and that meet all criteria listed above.

Consult with others if you come across a questionable trace (fish) or are unclear of the rules listed above.

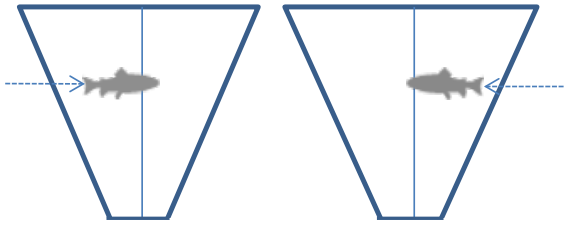


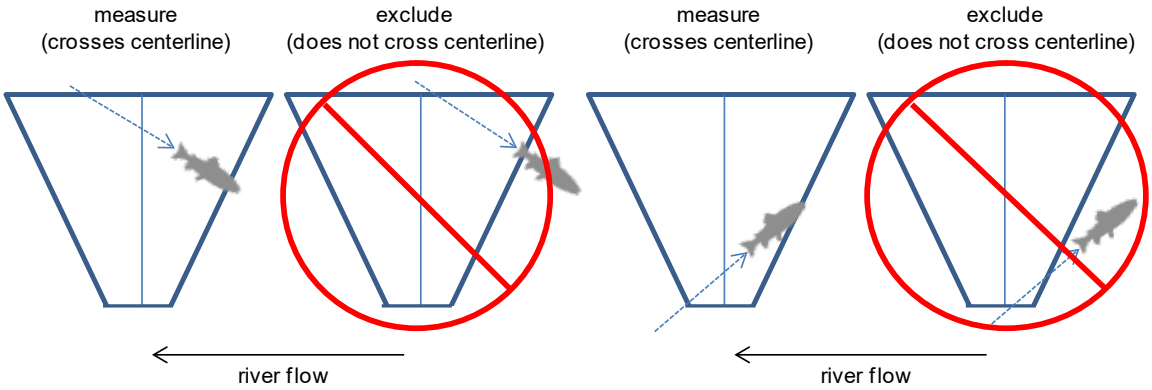
Appendix D2.–Illustration of the problem of double-counting.

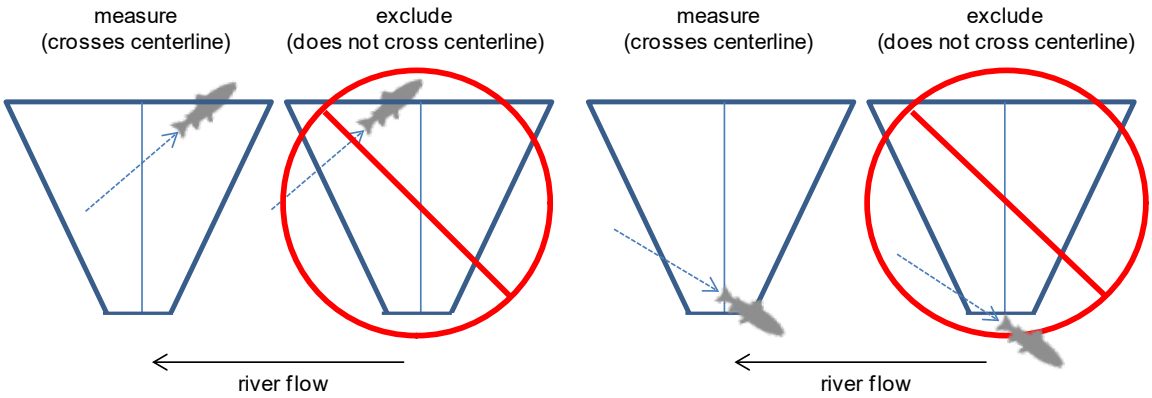
Note: To avoid counting this fish in both stratum 2 and stratum 3, the fish will only be counted in stratum 3 where it crosses the centerline of the beam.

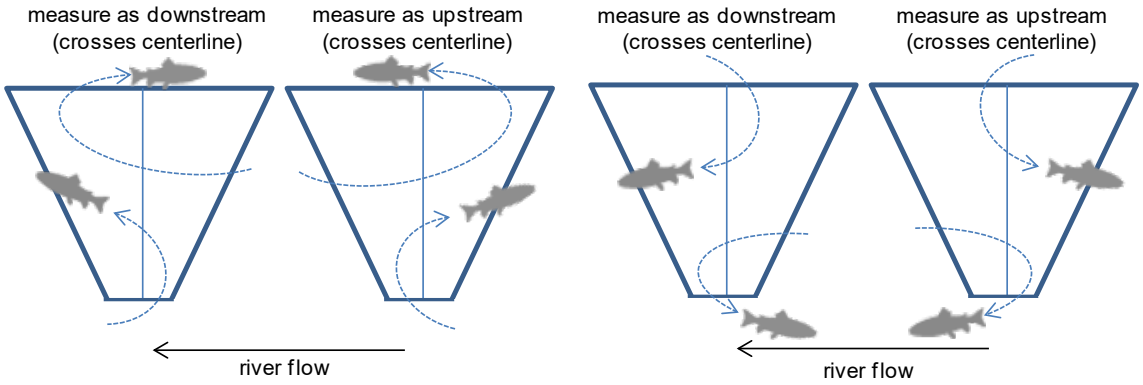
Appendix D3.–Specific examples for applying the "Centerline Rule" when selecting fish for counting and measurements.

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



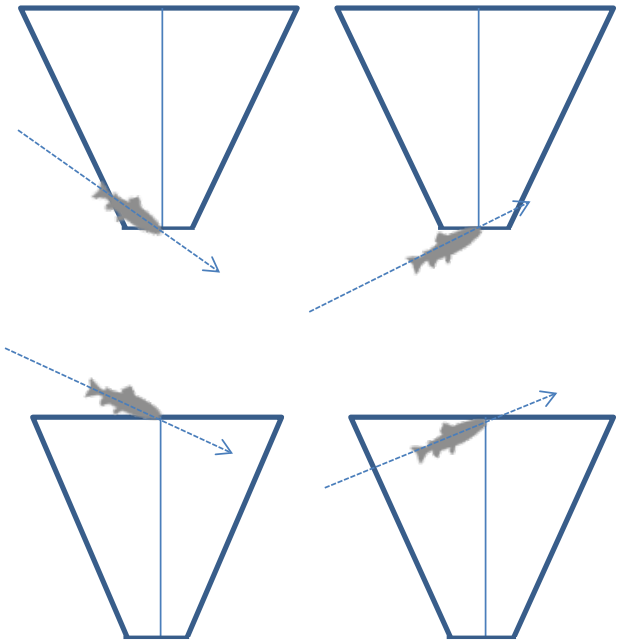




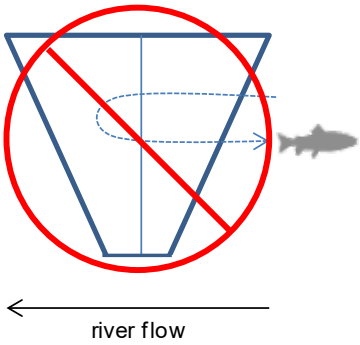


-continued-

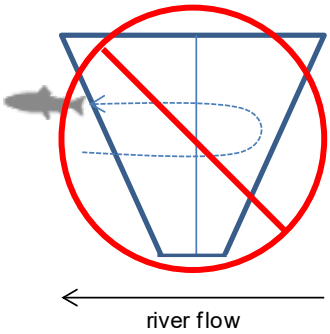
If the snout of the fish enters the near- or far-range boundary right on the centerline, the fish should be considered valid for measurement.



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

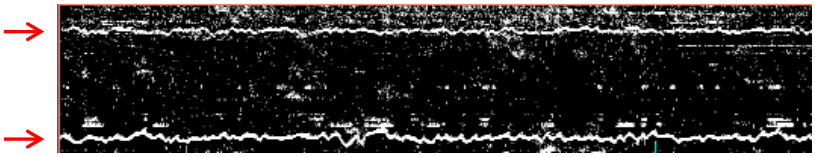


Exclude fish that enter the beam from downstream, then exit the beam downstream (do not measure even if they cross the centerline).



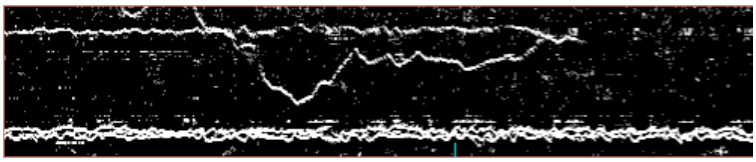
-continued-

Exclude fish that hold throughout the length of the sample.

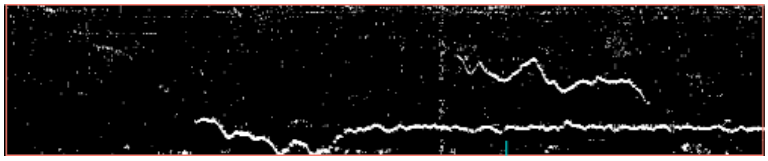


Two fish hold throughout the entire file.
Exclude both fish.

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



Fish holding as sample begins, then exits the beam about 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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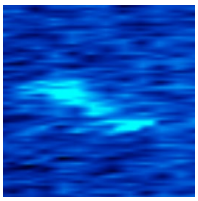
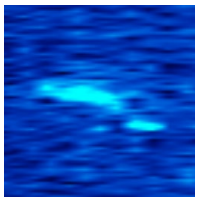
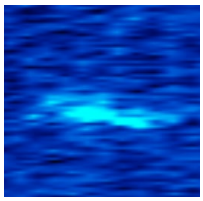
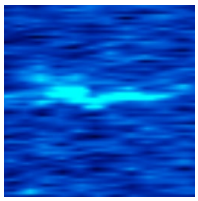
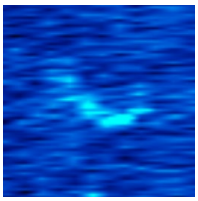
A fish passing through the beam that turns perpendicular to the axis and disappears should be excluded unless there is other evidence to indicate direction of travel.

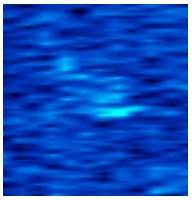

Frame #2353

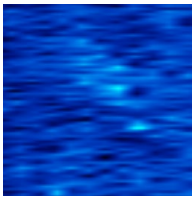

Frame #2354

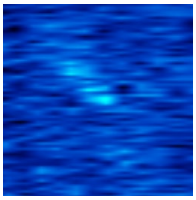

Frame #2355

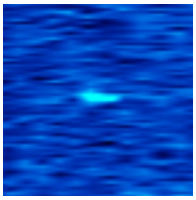

Frame #2356

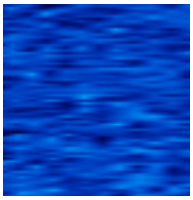

Frame #2357


Frame #2358


Frame #2359


Frame #2360


Frame #2361


Frame #2362

APPENDIX E: PROCEDURES FOR DAILY ARIS PROCESSING

Appendix E1.–Steps for processing RM 13.7 daily ARIS data using batch files for Kenai River Chinook salmon sonar.

The following was last updated April 2020 by Brandon Key.

Note that dates using 20XX in filenames, directory structures, and batch files correspond to each individual field season and will be updated annually.

Raw Data Transfer and Storage

Field data hard drives are brought into the office daily around 8:00 AM. These drives have data from the previous day from approximately 0800 to 2359 hours and from the current day from 0000 to 0759. Each hard drive requires 2 separate uploads when done manually (1 for each day).

1) Make sure that backup drive **X:** is present and has enough room to back up data (about 150 GB). Note: The batch file has the option to upload the next morning's data as well. Make sure there is enough space for the whole day on the backup.
2) Plug in the first field hard drives and allow each one to connect using the USB3 hub. Note the DRIVE LETTER should not matter as the batch file detects sonar files and uses the appropriate drives accordingly.
3) RUN the *UploadMenu* batch file and follow prompts to select correct **Date.** The batch file will cycle through the drives and upload all data into the appropriately dated folder on the network. After the previous day's data are complete, the current day's partial data will be uploaded if the option was selected.
4) Verify file and folder prompts.
5) The batch process should upload to the backup drive **X:** and Net App **U:** (with optional tones indicating progression)
6) Eject the DRIVEs when done.

The day's data for the 5 ARIS sonars are now backed up to X: and ready for processing (on *U:\Data20XX*).

Manual Target Measurement

1) Use the ***ARISFish*** application to process all Set1 (or Set2) **.aris* files of an individual sonar for manual measurement of targets (see Appendix D).
2) process each *.aris* file, select parameters, create echogram, and measure fish according to specified protocols: i.e., Standard(ST), Fast Track(FT), Large Fish only(LFO).
3) If Set1 data are missing or corrupt, use corresponding Set2 data if available.

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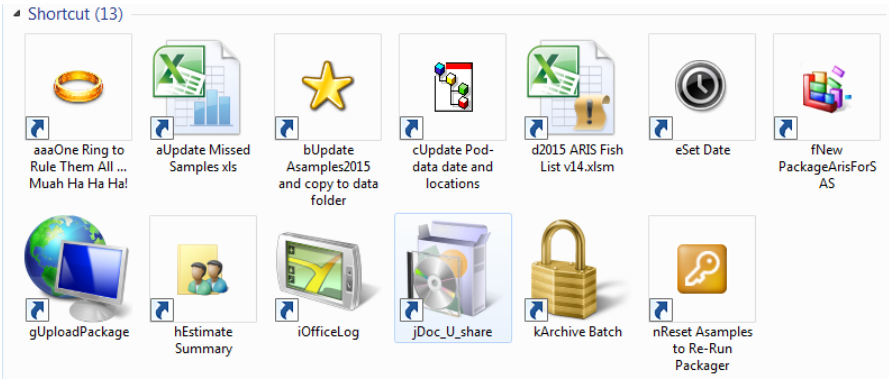
<u>Processing Data</u> (To be done from the data processing computer only)

1) **Open the desktop folder "NewProcess Data20XX."**

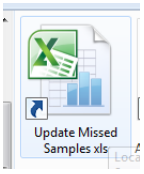


This opens the process folder with icons listed in proper sequence for processing data

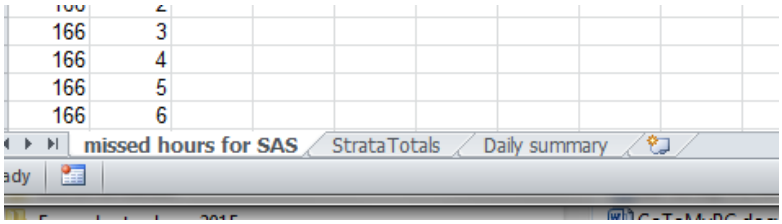
2) **Double-click the "One Ring to Rule Them All…" icon.** This starts the master batch file that opens batch or other files in the proper sequence for processing. Using the "One Ring…" helps to reduce human error in repetitive-sequential processing. Alternatively, the technician can process the data in sequence using the remaining icons, as long as the "Set Date" batch file is run before any subsequent batch file in the sequence. 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</u> at the end). 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 "*<u>20XX Aris daily summary of data quality</u>*" Excel workbook, located in *U:\Spreadsheets*
   b. Click on "missed hours for SAS" tab at the bottom of the sheet.



   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.

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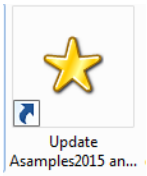
d. Enter zeros for missing data: “1” for measured data and “x” for nonexistent strata.

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 Asamples20XX” icon**

a. This opens “*Asamples20XX.txt*” file, located in *U:\DataProc16\SAS\SASinput*

b. Copy current day’s data (all 24 hours) from the “*20XX 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 “*Asamples20XX.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.”

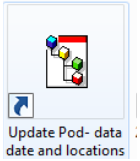
e. *[Skip e. if you are using the “One Ring…” batch. It does this for you.]* On the menu bar at the top, click on “File” then “Save as.” Save in the following directory: *U:\Data20XX\[current JD folder]*.

f. Close “*Asamples20XX.txt.*”

g. Close “*20XX ARIS daily summary of data quality.xls.*”

-continued-

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

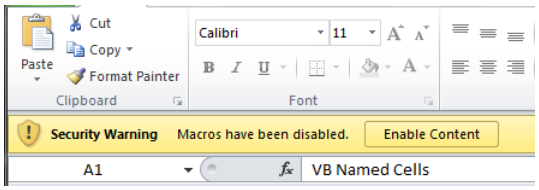


a. This opens "*ADaily20XX.*tx"t file, located in *U:\DataProc16\SAS\SASinput*.
b. Copy previous day's row down, then update columns as necessary (**be sure to update dates**). Only the dates will typically change, unless a pod was reset. If a pod was reset, the new pod location is always a distance from the OHW on left bank.

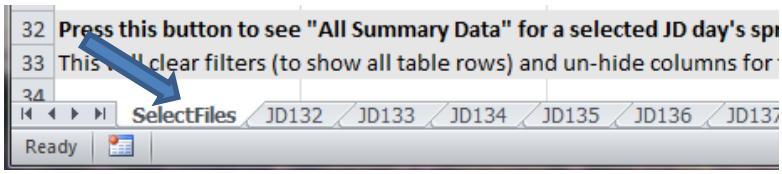
JD	MON	DAY	LN	LF	RF	RN	CH	MAXLN	MAXRN	OLAP	ENDLO	ENDRO
136	5	16	5.0	11.3	78.3	87.5	94.0	3.4	8.7	0.0	33.5	33.5
137	5	17	5.0	11.3	78.3	87.5	94.0	3.4	8.7	0.0	33.5	33.5
138	5	18	5.0	11.3	78.3	87.5	94.0	3.4	8.7	0.0	33.5	33.5
139	5	19	5.0	11.3	78.3	87.5	94.0	3.4	8.7	0.0	33.5	33.5
140	5	20	5.0	11.3	78.3	87.5	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 "*ADaily20XX.txt.*"

6) **Double-click the "20XX ARISfish list" icon**
a. This opens "*20XX ARIS Fish List v17.xls*," located in *U:\Spreadsheets*
b. Click on Enable Content tab at top in yellow bar, if it appears.

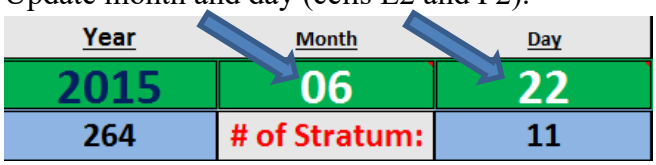


c. Click "*SelectFiles*" tab , located in the bottom left hand corner.

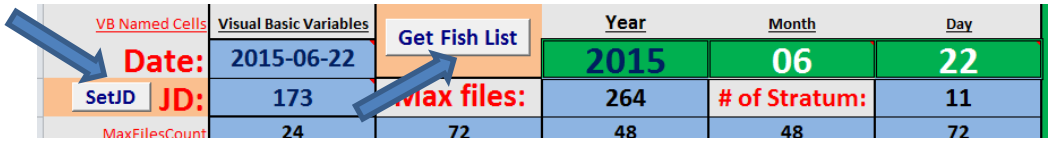


-continued-

d. Update month and day (cells E2 and F2).

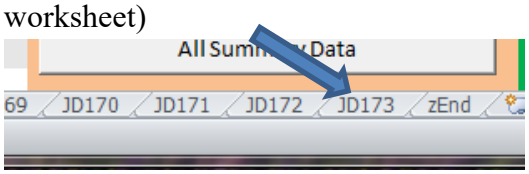


e. (Optional: Click on "***SetJD***" button (cell A3). "***Get Fish List***" does this for you.) (updates Julian Date).



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)

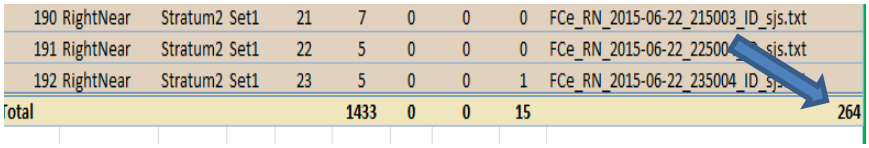


i. Scan the "*Aris File Summary*" data table (on this *JDxxx* sheet) for any yellow cells.

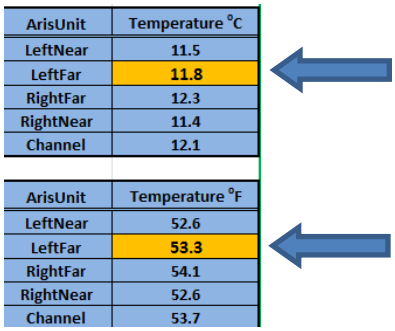
ii. If yellow cells are found, make corrections to corresponding text files if necessary (text files found in *U:\Data20XX\[current JD folder]*.

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

iv. Verify total file count at bottom of the table.



v. Write down "LeftFar" temperature (both °C and °F; see 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

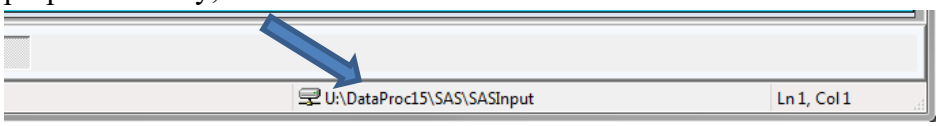
h. Click File on menu bar, then Save.

i. Close "*20XX ARIS Fish List v17.xls*."

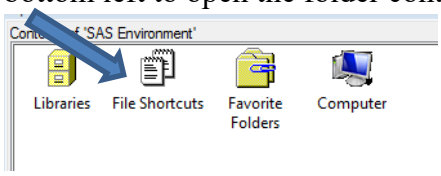
-continued-

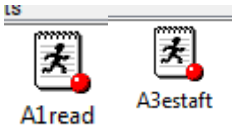
7) **Double-click the "Set Date" icon** (This is already done in Step 2 if using "***One Ring…***").
   a. This opens "*MonthDayMenu.bat*" file, located in "*U:\Batch\AutoDated*."
   b. Follow instructions to set the 2-digit month and 2-digit date. This is used in all subsequent batch files.
   c. Change 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.
      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.





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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 (st) or fast track (ft) 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 "<u>All Upstream Salmon Shaped Fish >=40</u>" table write down the number of fish >= 40 cm for the current day (found in the "dayPassage1" column).
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)

-continued-

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_Summary20XX.xls workbook (located in *U:\DataProcXX\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.
   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 20XX 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**).

-continued-

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.

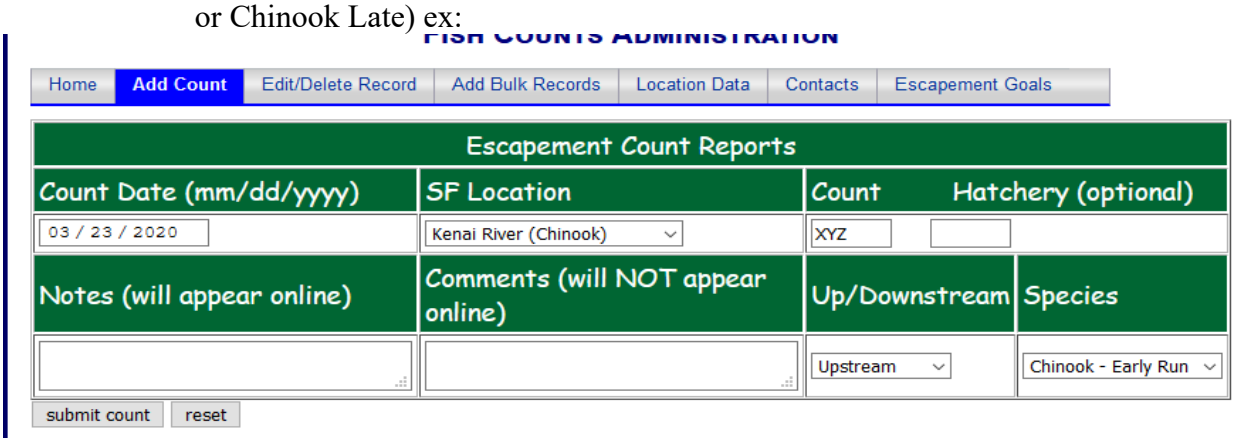
11) **Double-click the "Office Log" icon**
   a. Opens "*OfficeLog.bat*", located in "*U:\Batch\AutoDated*."
   b. Follow instructions.
   c. Automatically opens OFFICE_LOG.dotx template (located in *U:\DataProcXX\OfficeLog*).
   d. Fill in the log.
   e. Click "File" on the toolbar and then "Save As."
   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.

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.

-continued-

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 and change JD.
    g. Upload Range/Time Graph (*JDXXX.png*) from desktop; copy previous day's title first and change JD.
    h. Minimize Docushare.
    i. Continue with batch file; follow instruction.
    j. The batch file will close automatically.

14) Upload daily estimates to the "Fish Count" website
    a. https://intra.sf.adfg.state.ak.us/FishCounts/index.cfm?FA=main.home
    b. Click "Add Count" tab
    c. Make sure the "Count Date" is correct
    d. Enter: Location (Kenai), Count, Notes (rarely applicable), Species (Chinook-early or Chinook Late) ex:



    Click submit count.

15) **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.

16) **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.

17) **Put printouts of the *Office Log* and the *Daily Estimates* in the 3-ring binders.**

The following was 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 Appendix E3. Batch files, executables, and text files are given in Appendix E4.

Appendix E3.–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 NET APP SERVER	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).
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 20XXv1.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).

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Appendix E3.–Page 2 of 2.

Location	Function	Dependencies
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	Used to offload backup data	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*.

Appendix E4.– 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 NET APP SERVER 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 NET APP SERVER and to the backup portable "My Passport" hard drive. It creates several subfolders on the NET APP SERVER, 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 NET APP SERVER. 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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Appendix E4.–Page 2 of 5.

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.

-continued-

Appendix E4.–Page 3 of 5.

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 *20XX ARIS daily summary of data quality.xlsx*, OPENS *Asamples20XX.txt*, OPENS *Adaily20XX.txt*, OPENS *20XX 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 20XXv1.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_20XX-mm-dd_TxtData.Zip* from the *U:\Data20XX\RM13-Packaged* folder to the Anchorage *J:\KNCHISNR\Soldotna\ARIS* folder. It uses extensive error-checking throughout and it logs its progress.

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File Name [a]	Location [b]	Type and function
Estimates.bat	*Batch*	Batch file used to open *Estimate_Summary20XX.xls* (located in *U:\DataProc20XX\ 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:\DataProc20XX\ OfficeLog*). Then it copies *JDxxx.docx* and *JDxxx.pdf* from the local *MYDOCS* folder to the *ProcLogFolder* (*U:\DataProc20XX\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-Asamples20XX.txt* back to *Asamples20XX.txt*, located in the dated *U:\Data20XX\20XX-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 *Asamples20XX.txt* and then renames it *JDxxx-Asamples20XX.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 20XXv1	*SASPrograms*	Configures SAS environment (paths, dates, etc…) for current SAS program
A1_ReadData_20XXv1	*SASPrograms*	Reads ARIS fish measurement data and data-recording time-stamps into SAS tables
A3_Estimate- Passage_20XXv1	*SASPrograms*	Estimates passage of fish of different lengths (>= 40, 75, 90)
A4_RangeTime 20XXv1dt	*SASPrograms*	Produces range-time graphs
A5_FreqDistnNetAL 20XXBHK	*SASPrograms*	Produces frequency-distribution graphs
EasyA4_RangeTime 20XXv1	*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 Appendix E3.

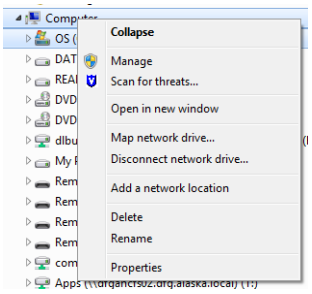
APPENDIX F: KENAI RIVER CHINOOK SALMON SONAR NETWORK CONFIGURATIONS

Appendix F1.–Soldotna sonar office computers.

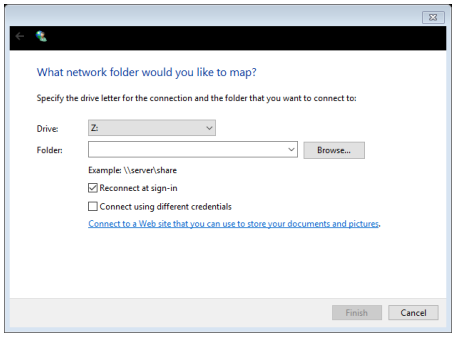
SONAR Office	IP address or network	Location	Serial no.	Username	Device name or purpose
Network Attached Storage	10.15.161.18	Soldotna		none	NetApp Server for Storage
Computers					
Dell Optiplex 7040	DHCP	Soldotna	211CJH2	State Login	DFGSXQDSF115993(BHK) Also used for data-processing
Dell Optiplex 7060	DHCP	Soldotna	C94FDW2	State Login	DFGSXQDSF122366 Main data-processing computer and upload computer
Dell Optiplex 7060	DHCP	Soldotna	C94GDW2	State Login	DFGSXQDSF122367 (JDM)
Dell Optiplex 7050	DHCP	Soldotna	C94DDW2	State Login	DFGSXQDSF122365 FWTIII workstation
Dell Optiplex 7050	DHCP	Soldotna	H89G0Q2	State Login	DFGSXQDSF119496 FWTII workstation
Dell Optiplex 7050	DHCP	Soldotna	H89H0Q2	State Login	DFGSXQDSF119497 FWTII workstation
Dell Optiplex 7050	DHCP	Soldotna	H89J0Q2	State Login	DFGSXQDSF119498 FWTII workstation

Once added to the permissions group, each technician will manually map to the current year's folder on the NetApp sever as follows:

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



2) Select "U:" from the Drive letter dropdown menu



3) Enter "\\dfg.alaska.local\Research\Sonar\Kenai\YYYY) into the Folder prompt. Where YYYY is the current year.
4) Make sure the "Reconnect at sign-in" box is checked
5) Select "Finish" at the bottom

APPENDIX G: ARIS LENGTH MIXTURE MODEL AND ASSOCIATED WINBUGS 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, panel A. 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 (Appendix G2, panel B). 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[10]; 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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[10] 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, as are age proportions $\{\theta_{Sa}\}$ and $\{\theta_{Ca}\}$ (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[11] of tethered fish data in the mixture model (Appendix G3).

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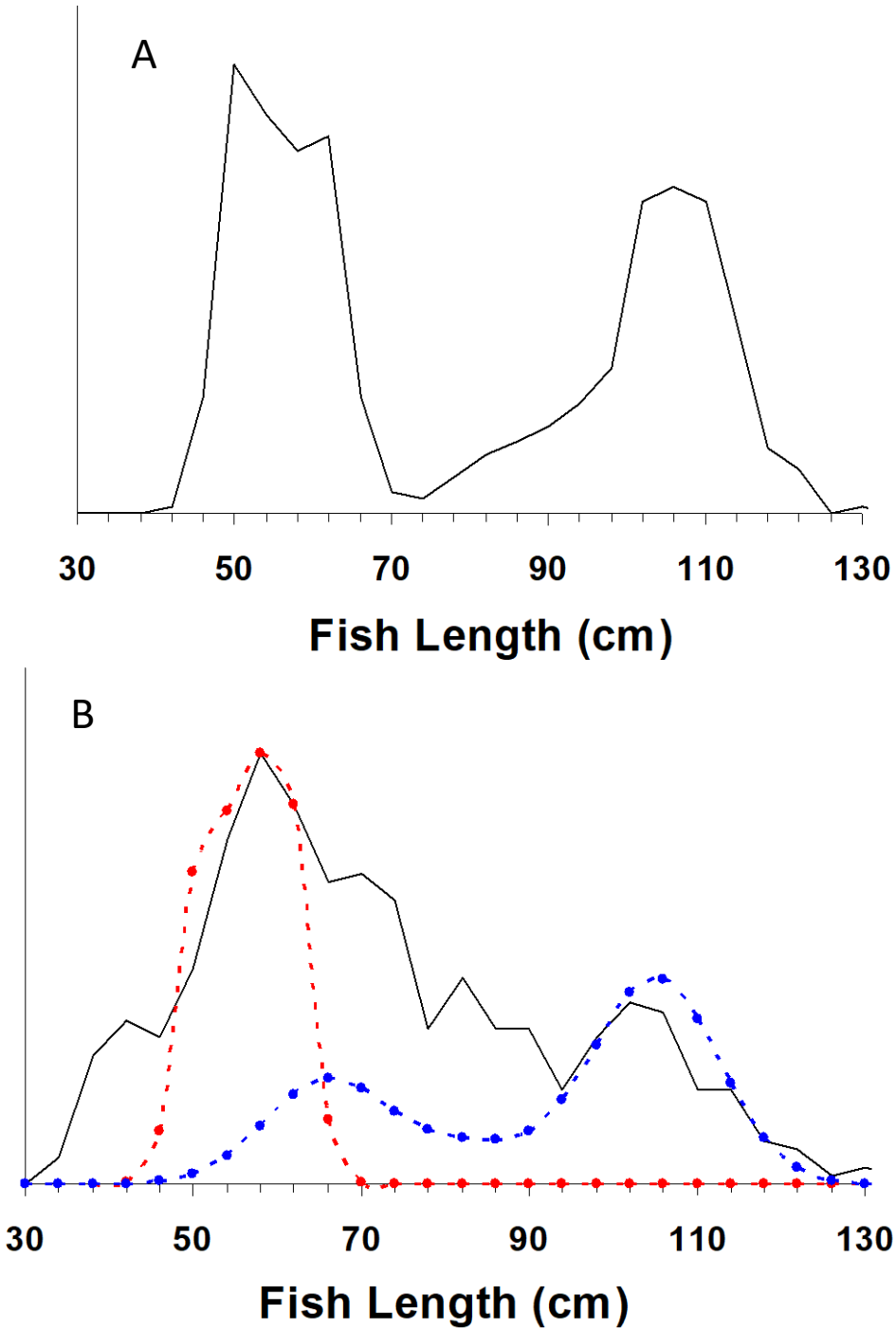
[11] ARIS length measurements of tethered fish data are not necessarily representative of measurements from free-swimming fish. Therefore, inclusion of the entire tethered fish data set can bias mixture model results. Fortunately, only weak prior information about the regression parameters is required 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.

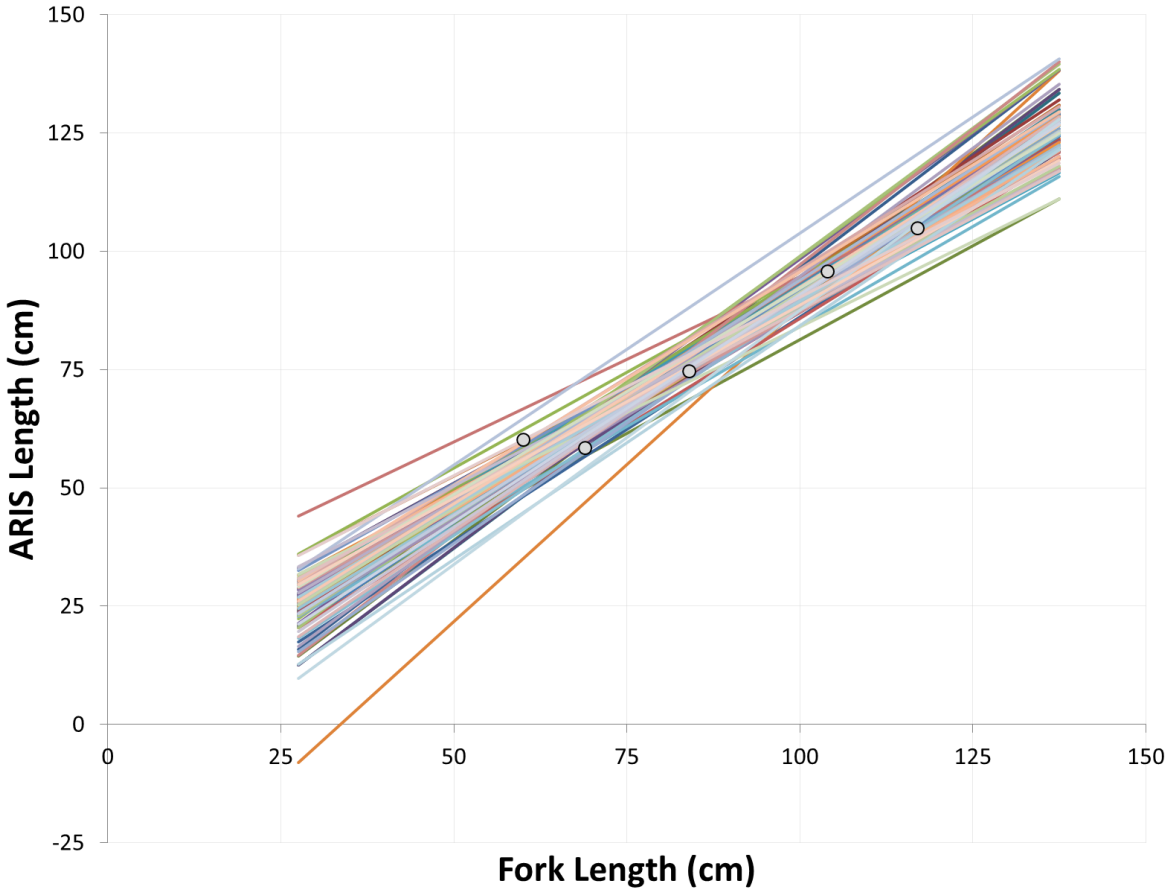
The mixture model will be fit to daily ARIS length data but will utilize 7 days of netting data ending on the date of the current ARIS lengths.

By default, data will be stratified by day; i.e., daily data from different spatial and temporal strata will be pooled and the model described above will be fit to the pooled data. Sample size limitations early in the season may necessitate pooling the data across more than 1 day.



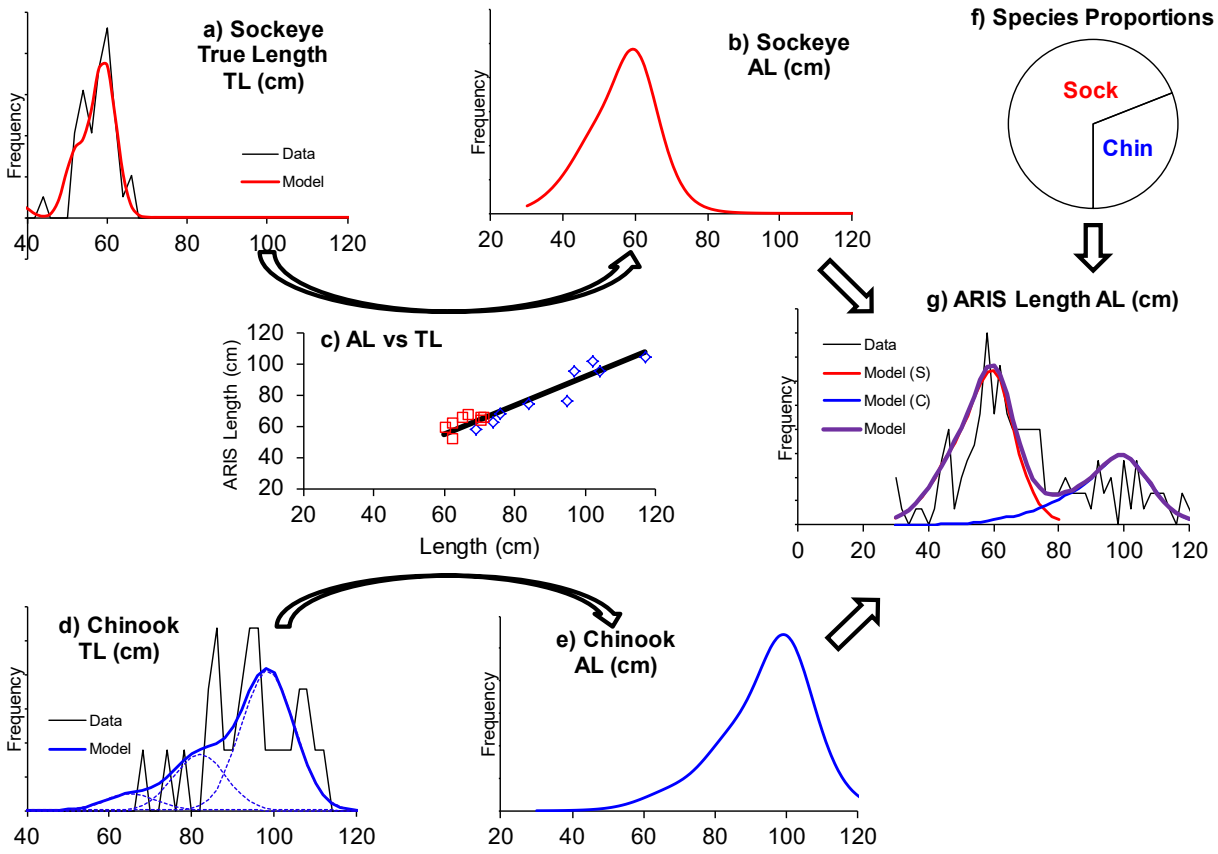
Appendix G2.–Hypothetical distributions of fish length measurements (black solid lines) from the Kenai River: (A, top) few small Chinook salmon with no measurement error and (B, bottom) 40% of Chinook salmon are small with measurement error standard deviation 10 cm.

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.

Note: Lines show a sample of 100 plausible linear relationships drawn from the resulting prior distribution.



Appendix G4.–Flow chart of the ARIS length mixture model described in the text.

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

Appendix 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.