Standard Operating Procedures Manual for Sidescan Sonar

Massachusetts Division of Marine Fisheries

July 2018

3rd Edition

FOREWORD

The purpose of this Standard Operating Procedures (SOP) document is to provide DMF employees with consolidated and standardized guidelines and requirements for conducting, processing, and generating sidescan sonar surveys for various purposes including habitat mapping and target identification. This manual summarizes current best practices and utilizes information from other similar guidance documents including the NOAA Field Procedures Manual for hydrographic surveys (April 2010), the Recommended Operating Guidelines (ROG) for Side-scan Sonar by Mapping European Seabed Habitats (August 2005), and procedures described in the manufacturers guidelines for the equipment referenced.

CHANGE HISTORY

This document will require periodic updating. Recommended changes and other comments regarding the manual should be forwarded via email to steve.voss@state.ma.us.

1. Description of Systems

The systems utilized for sidescan survey work include the sidescan transducers and topside processing units, the GPS signal systems, and the vessels and mounting systems used on each vessel. These are described below.

1.1. Sidescan Systems

1.1.1. Klein 3000

The Klein 3000 sidescan sonar (Figures 1 and 2) is a dual frequency single beam sonar that can simultaneously collect at 132 kHz and 445 kHz frequencies (this is commonly called a 100/500 kHz system) on both sides (two transducers). The horizontal width of the beam is 0.7° at 132 kHz and 0.21° at 445 kHz. The Klein 3000 sidescan system is owned by MIT Seagrant and is on loan to DMF. Our key points of contact at MIT Seagrant are Michael Sacarny and Chryssostomos Chryssostomidis (the Director). There is no MOU or other formal representation of our sharing relationship. The system is primarily compromised of the towfish, two tow cables (one for hand deployment, the other a winch), and the topside processing unit. The same laptop is typically used for deployments of the Klein 3000, but that laptop is also used for other activities. The winch cable is a 300m double armored steel cable (Diameter (OD): 10.2 mm/0.40 in) on a Hannay Reels Winch. The hand-reeled cable is a 75m lightweight cable (Diameter (OD): 10.3 mm/0.405 in) was used on the site selection and pilot survey. The winch cable does not require depressor weights for deeper deployments.

Figure 1. Klein 3000 towfish and hand-held cable.

Figure 2. Klein 3000 laptop and topside processing unit.

LOCATION OF ITEMS **Building B** - (Duchaine Blvd., New Bedford, MA)	QTY	DESCRIPTION	MODEL #
Loose Items	1	Klein 3000 Towfish (1,000m depth limit)	Model 3210
	1	Hannay Reels Winch (w/ slip ring)	EPC 22-30-31-20-RT
	1	& 3,000m Cable	
	1	Hannay Motor (DC)2-3 hp/12V/75amp	P56- SX043
	1	Wooden Pallet (for winch)	
DMF Purchase	1	75m Tow Cable	S11-0345/STD
In Processing Box- (wooden box)	1	Processing Unit	3110
	1	Ethernet Hub	
	1	Manual	
	1	Sonar Pro Operation Manual- Chap. 3	
	1	Copy of Sonar Operation Manual- Chap. 4	
	1	Null Modem Cable	
	3	Cat-V Cables	
	1	3COM Power Adaptor US, 120V/60Hz/21watts	
	1	3COM Power Adaptor UK, 230V/50Hz/.1amp	
	5	2 AMP/ 250V Slo-Blow Fuses	BAG # 13000045
	5	630 Ma/ 250V Slo-Blow Fuses	BAG # 13000043
In ASSY, ACCESS KIT (rubber bin)	2	O-Rings, 2.984ID X 3.262OD BUNA N	BAG # 15900006
	1	Silicone Grease, DC-4	BAG # 12700418
	5	Screws, PH MS M3X5MM SS	BAG # 12500695
	2	Screws, SHCS, M8X12MM, 316	BAG # 12500876
	2	Screws, FHMS, M6X12MM, PHLPS, 316	BAG # 12500823
	1	Hex Key, "L", 2.5mm Key	BAG # 13400063
	1	Hex Key, "L", 6mm Key	BAG # 13400064
	1	Connector, Shunt .100 Gold Plated	BAG # 12900252
	10	Cable Ties, 7.5X .185 In Black	BAG # 12700510
	1	Hazard Material Literature, DC- 4 Silicone	BAG # 17500003
	1	Tow Pin, Towfish	BAG # 16200013
	1	8-Pin Dummy Plug Connector	BAG # 12900687
	2	Tail Fins	BAG # 14202028
	1	Driver, Hex 8mm	loose
	2	Pins	loose
	1	Locking Sleeve	loose
	1	8-Pin Male Cable End	loose
	2	Thin Aircraft Cables w/ Loops	loose
	1	Shackle, 5/16 in.	loose

1.1.2. Humminbird 698

The Humminbird 698CI HD SI Combo sidescan sonar (Figure 3) has two 455-kHz, 86° transducers and an 83/200 kHz (60°/20°) dual beam downward-looking bathymetric sonar. It was purchased in spring 2015.

Figure 3. Humminbird 698CI HD SI Combo.

1.1.3. Humminbird 999

The Humminbird 999CI HD SI Combo sidescan sonar has two 455-kHz, 86° transducers and two 800-kHz, 55° transducers and an 83/200 kHz (60°/20°) dual beam downward-looking bathymetric sonar. The user must select between low (455-kHz) and high (800-kHz) resolution. It was purchased in late summer 2015.

Building B - (Duchaine Blvd., New Bedford, MA)	QTY	DESCRIPTION	MODEL #
Humminbird Sidescan	1	Full Kit	999CI HD SI
Ser.#: 14050203-0018	1	Control Head w/ cover	
	1	Head Mounting Rack	
	1	Transducer with cable	
	1	Battery cable	
	1	Mounting kit, bolts, screws	
	1	Manual	
DMF acquired seperately	1	Trolling Motor Mount	
	8	SD cards	
	1	PVC extention rod	
	1	PVC mounting piece	
	1	Mounting table	
	4	Fuses	
	1	Fuse Holder	

1.2. GPS Systems

1.2.1. Trimble GPS

Trimble ProXT with Tempest Antenna

1.2.2. Garmin GPS

Garmin GPSmap 76 handheld with Garmin antenna

1.3. Vessels & vessel mounts

Several different vessels are used to deploy the sidescan systems, including the Mya, skiffs from 14-25 feet in length, and jet skis.

1.3.1. Mya

The Mya is a 37 foot Eastern lobster vessel. It has a draft of 2 feet and is designed for work in larger harbors, bays, and sounds. It has a pothauler and a boom which can be deployed off of either gunnel and straight astern. The Klein 3000 is optimally towed by orienting the boom straight astern, hanging the towing sheave from the boom, and securing the handheld cable with a separate line secured to the cable with a whipping knot (see Figure 4) then tied to a cleat on the mast the holds the boom. This arrangement is captured in Figure 4.

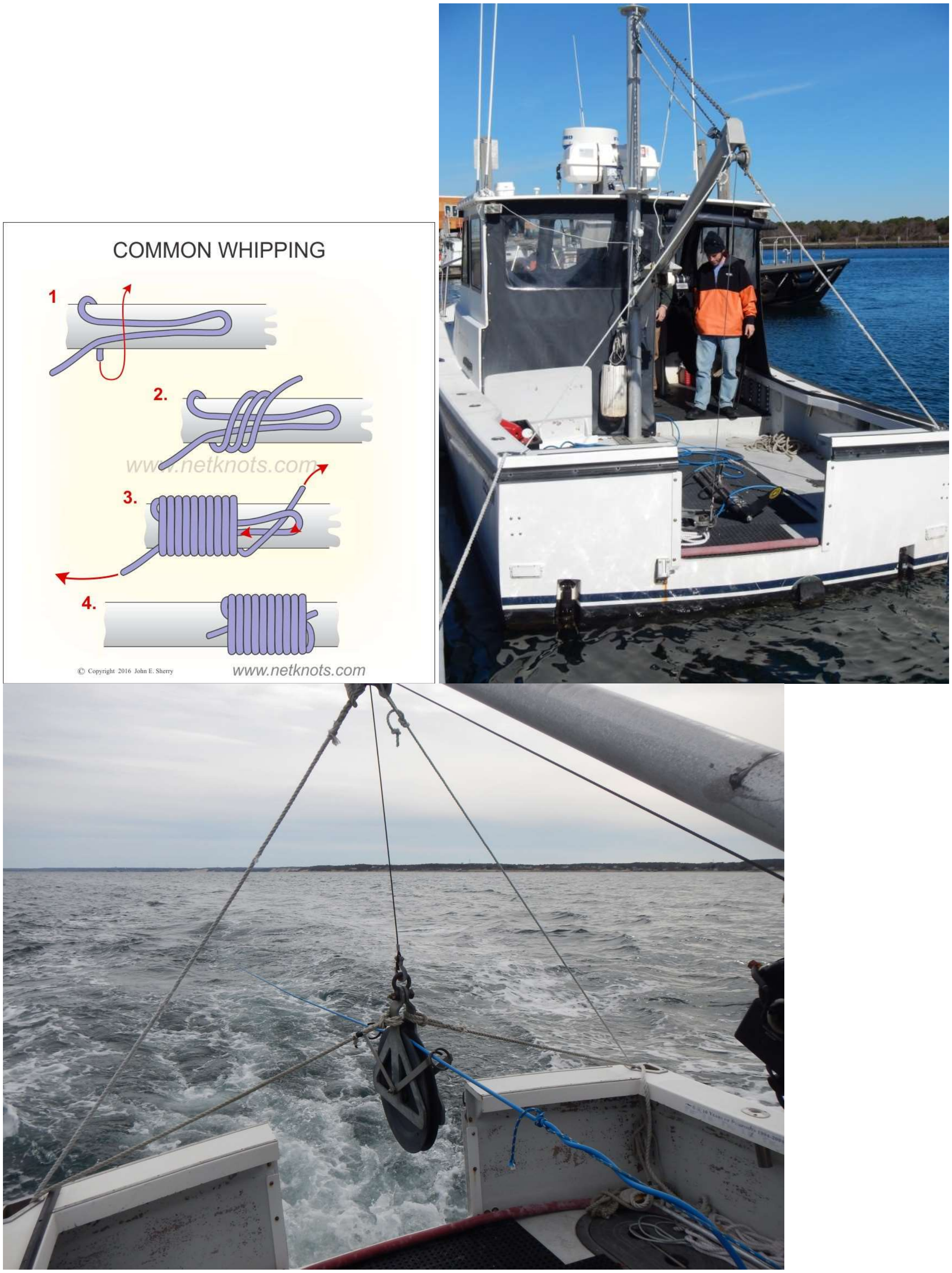


Figure 4. Deployment arrangements for a towfish on the Mya research vessel.

1.3.2. *Flatfish*

The Flatfish is a 15 foot bass boat. It is designed for shallow, calm waters. The Humminbird units can be deployed off of this boat with a trolling motor mount. They can be powered by hooking up to the boat battery but a fuse must be in line.

1.3.3. *Jetski*

Jetskis are designed for shallow, calm waters. The Humminbird units can be deployed off of this type of boat with a trolling motor mount (Figure 5). They can be powered by hooking up to the boat battery but a fuse must be in line. We found jetskis to be uncomfortable for more than a couple of hours of surveying but their rapid deployment and capability in very shallow waters can be advantageous.

Figure 5. Jet ski and trolling motor mount of a Humminbird transducer.

1.3.4. Maritime skiffs, privateers

DMF skiffs tend to be roughly 17’ long center consoles with engines in the 200 hp range. They typically have a draft on the order of 1.5 feet and are designed for work in small and large harbors as well as bays and sounds in calmer weather conditions. The Klein 3000 can be towed by securing the handheld cable with a separate line secured to the cable with a whipping knot (Figure 4) then tied to a cleat on the gunwale. The Humminbirds can be pole mounted using a variety of gunwale mounts (Figure 6). A generator is required to power the Klein 3000 and a large battery or hooking up to the vessel battery is required for the Humminbirds.

Figure 6. Gunwale mounts available for transducers and GPS antennas.

1.3.5. Other vessels

When a vessel is chartered for sidescan sonar surveying, the key vessel components to ensure adequate operating conditions include:

Cover. Adequate protection from the elements. The Klein requires a computer and the processing unit is not weather tight. The Humminbirds are more forgiving and can be exposed even to light rain.

GPS. A place to connect the GPS antenna and route it to the Klein processing unit. The Humminbirds will need signal access since the GPS antenna is built into the processing (head) unit.

Power. The Humminbirds can be powered off of a battery. The Klein requires 120v AC on the vessel or a generator.

Towing/mounting. How the towfish (Klein) or transducer head (Humminbird) will be towed or mounted is a critical consideration. We have built tow bars for the Klein and used a variety of gunnel mounts for the pole-mounted Humminbird transducers (Figure 7).

Speed. We commonly survey at 2-4 knots.

Navigation. How the vessel will navigate survey lines and have access to the sidescan view or not should be considered.

Figure 7A. Aluminum L-bracket bar across stern of an offshore lobster vessel. Sheave is hanging from the middle of the bar. It did begin to sag, so a pipe or U or square pipe bar might have been a better choice for longer-term work.

Figure 7B. Support bracket for bar mounted to gunnel.

Figure 7C. Whipping knot securing blue tow cable to exhaust post on the centerline of the offshore lobster vessel.

2. Preparation & Maintenance

2.1. Calibration Requirements and Methods

2.1.1. Sidescan Sonar Systems

Sidescan sonar object detection and classification performance is largely a function of the original system specifications. The towfish pressure sensor in the Klein 3000 will be serviced and calibrated by the manufacturer whenever the horizontal positioning accuracy of side scan targets is in doubt.

The table below identifies dates of service.

Date	Description of service

2.1.1.1. Sidescan Sonar Calibration

A calibration test should be conducted at least every five years to demonstrate the system's ability to detect and accurately position seafloor targets across the system's range on both sonar channels. Test information is recorded in a Sidescan Calibration Table which is stored in the cruise report logbook. The Sidescan Calibration Test consists of a minimum of 10 sidescan passes on a target approximately 1 m x 1 m x 1 m. The target is imaged from a variety of ranges and directions, with survey speed, water depth, and weather representative of typical survey conditions. A dedicated test target lobster pot with a taught buoy line can be used for this check or a site such as the Sculpin Ledge artificial reef. The absolute position of the target should be established prior to sampling by getting a GPS fix on the buoy. Targets of opportunity, such as buoy blocks, lobster pots, and appropriately sized rocks, may be sufficient as long as a high accuracy absolute position of the target can be established for comparison with sidescan detected positions. The recommended line plan for conducting a Sidescan Calibration Test is in Figure 8.

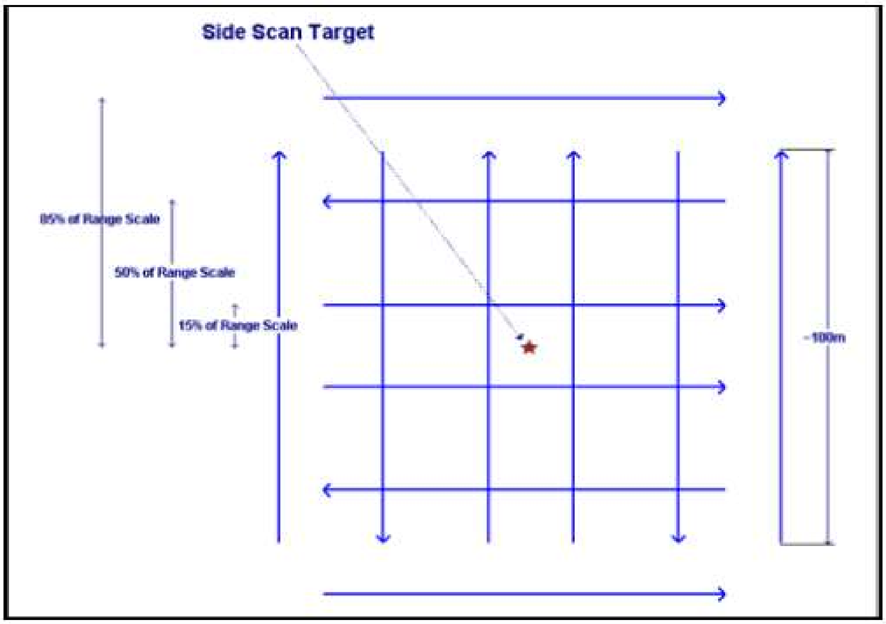


Figure 8. Recommended line plan for the Sidescan Calibration Test.

Test data is processed in CARIS or SonarTRX and evaluated to identify any systematic problems with the sonar or vessel offsets. If the contact is not detected in at least nine of the 10 passes, the system should be re-tested. If detection remains problematic, the system should be returned to the original equipment manufacturer for assessment.

Successful object detections will be used to compare the mean detected position with the absolute target position and to compute the approximate 95% Confidence Radius for the system. This radius should not exceed 5 meters for hull-mounted systems and 10 meters for towed systems. Several methods can be used to estimate the 95% Confidence Radius. 1) Plot the detected target positions in ArcGIS, and use the "Compute Statistics" function to compute the sample standard deviation of the x and y components of the detection positions (computing statistics of the Eastings and Northings yields values in meters). 2) Enter the x and y coordinates in two columns in Excel. Calculate the standard deviation(σ) of each. Use the following formula to calculate the 95% Confidence Radius: 95% confidence radius ≈ $\sqrt{(\sigma_x^2 + \sigma_y^2)}$

Assuming a normal distribution, 95% of the samples will fall within 1.96 standard deviations of the mean. If the distribution of detections is similar in x and y, the 95% Confidence Radius is roughly 1.96 times the square root of the sum of the squares of the standard deviation of detected positions in x and y. If the distributions in x and y are not similar, it is likely that a systematic bias exists that was not canceled by ensonifying the target from multiple ranges and directions. 3) Measuring the error for each detection (the distance from the absolute target position to the detected position) and compute the sample mean and standard deviation of the errors. The approximate 95% Confidence Radius is then the sample mean plus 1.96 times the standard deviation.

2.1.1.2. Periodic Quality Assurance

Before surveying with the Klein 3000 system, a "rub test" should be performed to confirm that the whole system (towfish and topside unit) is operational prior to deployment. For the rub test the operator or an assistant physically rubs one transducer on the towfish and then the other while the system is pinging. A return on the corresponding channel of the imagery should be visible. A rub test failure can indicate system errors such as incorrect gain or power settings, a faulty cable, or damaged transducers. This test should be conducted while the towfish is out of the water and dry, to avoid the possibility of electric shock. This check should be annotated on the field set-up sheet.

The rub test is not required prior to surveying with the Humminbird transducers since they are simple to remove from the water and assess if there is no signal once surveying has begun.

Caution: Do not leave the Klein 3000 towfish turned on or the Humminbird transducers pinging for more than 3 minutes while out of the water. These systems are cooled by being in the water and can be damaged by excessive heat buildup if left on when not deployed.

2.1.1.3. Offset Measurement

The purpose of our sidescan surveys is habitat mapping and target identification (as opposed to bathymetric surveys) therefore, vessels are not surveyed for parameters such as instrument positions, waterline, or dynamic draft. Depending upon survey goals and whether the sonar configuration is pole-mounted or towed, the need for offset measurements will vary. Whether or not an offset is necessary for a particular survey will be identified by the survey lead and indicated on the field set-up sheet. Offset requirements for each type of configuration are described below.

2.1.1.3.1. Pole-mounted configuration

The transducer is affixed to a pole which is secured to the gunnel of the vessel. The depth of the transducer below waterline will be measured with a measuring tape with the vessel not moving and the vessel as balanced as possible. In some circumstances, the GPS antenna can be placed directly above the transducer on the top of the pole and no additional measurements are needed. If the GPS antenna is offset from the pole, the X and Y offset will be measured with a measuring tape and recorded on the field sheet. All measurements shall be recorded on the field set-up sheet.

2.1.1.3.2. Towed configuration

The actual towfish position is typically calculated using the tow point, the towfish depth, and the cable out measurements. Towfish depth may be determined by a depth sensor installed in the towfish or calculated by subtracting the towfish height (determined by a separate echosounder installed in the towfish or the first return of each sonar ping) from the depth of water (determined from a vessel echosounder). Cable out can be estimated visually from calibrated markings on the cable or measured with an electronic cable counter. Cable out should be recorded in feet. All measurements shall be recorded on the field set-up sheet.

1.3.2. GPS Systems

1.3.2.1. Trimble GPS

No calibration done.

1.3.2.2. Garmin GPS

No calibration done.

2.2. Annual Maintenance

Sidescan sonar systems should undergo an annual assessment of condition, thorough cleaning, and parts inventory. This activity will typically occur in the winter. Further detail is provided in each section below.

2.2.1. Sidescan Systems

2.2.1.1. Klein 3000

Rinse instrument and cable. Check all connections, clean and apply grease as needed. Inventory parts. Reorder missing parts. Verify that all survey data is removed from hard drive. Update computer hardware and software.

2.2.1.2. Humminbird 698

Rinse instrument and cable. Check all connections, clean and apply grease as needed. Inventory parts. Reorder missing parts. Remove SD cards.

2.2.1.3. Humminbird 999

Rinse instrument and cable. Check all connections, clean and apply grease as needed. Inventory parts. Reorder missing parts. Remove SD cards.

2.2.2. GPS Systems

2.2.2.1. Trimble GPS

Rinse antenna and cable. Check all connections, clean and apply grease as needed. Inventory parts. Reorder missing parts.

2.2.2.2. Garmin GPS

Use damp cloth to wipe down instrument. Dry. Rinse antenna and antenna cable with damp cloth. Dry. Neatly coil in storage box. Check all connections, clean and apply grease as needed. Remove extra waypoints.

2.2.3. Vessels

Several different vessels are used to deploy the sidescan systems, including the Mya, skiffs from 14-25 feet in length, and jet skis. All of these vessels have routine maintenance conducted as needed.

2.3. Storage

All instrumentation is rinsed and then allowed to air dry. It is then stored in original packaging or in plastic boxes, adequately padded to protect from damage.

2.4. Software Systems

The software utilized for field collection is SonarPro for the Klein 3000 and the Humminbird proprietary software built into the Humminbird display unit. The software utilized for data viewing/replay is SonarPro for XTF and SDF files and HumViewer for DAT and XTF files. The software utilized for data processing is CARIS HIPS/SIPS and SonarTRX. The following computer and software maintenance should be conducted annually, usually in the wintertime: 1) All survey data files are backed up to storage devices in at least two locations (for example, the V drive and an external hard drive); 2) Delete all survey data files from the field/data collection system; 3) Complete any software and computer hardware upgrades.

3. Pre-Survey Planning

3.1. Crew & Vessel Safety

The number one priority the safety of the crew and vessel. Safety shall be the foremost consideration in all aspects of sidescan sonar surveys. It is the responsibility of the field leader, as well as vessel crew, to be aware of safety hazards and take steps necessary to ensure undue risks are avoided, even if it means ceasing operations. Good planning and information can minimize risks.

Recommended practices to increase safety include, but are not limited to the following:

- Use historical weather information to prepare for seasonal patterns.
- Review the survey region for exposed areas, constricted areas, shallow areas, surf, etc.
- Plan on surveying challenging areas when weather, tides, and currents are optimal.
- Review prior survey field sheets. Often, the field sheets will describe deficiencies, hazards, and challenges from prior surveys and field experience.
- Discuss survey area with other DMF personnel familiar with the site.
- Work progressively from safe water towards unknown, shallow, or potentially hazardous areas.
- Use daily survey information progressively in the field to minimize hazards. Communicate survey and safety information to all personnel involved in operations.

3.2. Survey Planning

3.2.1. Survey Scope

Survey limits will be defined prior to conducting field work for the purpose of the field work.

3.2.2. Survey Line Planning

Survey lines will be established based on the desired amount of overlap of the sidescan data acquisition and the expected range. Typically 150% is the goal. This overlap should be achieved by running each successive line at a distance of ¾ swath width. The swath width will be determined by the range scale (swath width is 2x the range scale). The sidescan range scale is dependent on the frequency used (the resolution required) and the depth of the sonar unit. The sonar should be maintained at an altitude of 8-20% of the range scale during acquisition. If possible, sidescan data should be acquired by running lines generally parallel to depth contours to avoid imagery distortion caused by slopes in the athwartships direction. Line plans should be created in SonarPro or on the Humminbird chartplotters. On vessels where the vessel chartplotter is being used for navigation, the line plan can be generated on the vessel chartplotter. Lines plans should account for changeable field conditions; several line plans with varying direction should be developed prior to the start of data acquisition. It is typically preferable to head into and with the wind rather than have effects from cross-winds. If time allows, this can be done once on site when field conditions can be fully assessed. When the survey area is particularly small, running lines by site using the onboard chartplotter is acceptable.

The length of the lines will be calculated and used, along with the estimated survey speed (usually 4 knots), to estimate the number of field days needed to cover the survey scope. Estimations should include buffer to allow for transit to and from the site and turns.

Flowchart for determining survey length:

1. Draw the survey box and measure the length and width
2. Determine frequency that will be used
3. Estimate the range, this is typically about 10x the water depth for a moderate frequency (300-400 kHz instrument). The higher the frequency, the less the range. For example, we'll do a survey with a 400 kHz instrument in 10 feet of water. We'll assume a range of 100 feet on each side.
4. Multiply range * 2 to get the swath width. For our example, 100 feet*2=200 feet.
5. Determine the line spacing by multiplying the swath width by 0.75. For our example, 200 ft * 0.75 = 75 feet (or 0.0143 miles).
6. Establish the line length and time to run the line. We typically do a survey at 4 knots. For example, our survey box is 0.5 miles long. 0.5 miles * 4 mph = 0.125 hr (or 7.5 min).
7. Establish the number of lines you need to run by taking the survey box width and multiplying it by the spacing calculated in step 5. In our example, the box width is 0.5 miles wide. 0.5 miles * 0.0143 miles = 35 lines
8. Total time is the number of lines * the time it takes to run one line + 10% contingency. In our example: 35 lines * 7.5 min = 227 min (3.8 hours) + 10% contingency of 23 minutes = 250 min (4.17 hours).

3.2.3. Preparing the Survey Crew

At least two survey crew should conduct data acquisition. Survey crew should be identified and given a pre-cruise briefing that covers the following topics:

- Meeting location and time
- Vessel logistics (which vessel, who is driving)
- Survey location
- Expected length of the survey day
- Need for special equipment and food
- Basic overview of the plan for the day (meeting, loading, transiting and trailering boat to the field location, preparing boat and equipment, transit to survey location, survey logistics/expectations, type of data being collected, etc)
- Contact information in the event survey is cancelled due to weather

3.2.4. Preparing equipment

It is good practice to ensure all equipment is working a day or two ahead of the survey date. If equipment hasn't been used for an entire season, more time ahead of the survey should be planned to test equipment and ensure that everything is operable. Once tested, all gear should be packed carefully to ensure safety during transit to the field site. Being prepared in the field is crucial to ensure maximum efficiency. A standard gear checklist for sidescan surveys is shown in Figure X. Additional equipment or redundancy may be necessary to accommodate unusual conditions or multiple day surveys. The necessary storage media should be identified and packed. The file location on disk shall be identified on the field log sheet. A basic toolbox should be assembled and packed.

4. Data Acquisition

4.1. Sonar Imagery Acquisition

4.1.1. Klein 3000, Sonar Pro

4.1.1.1. System Setup

Follow manufacturers' instructions.

4.1.1.2. Recording Data

Follow manufacturers' instructions.

4.1.2. Humminbird

4.1.2.1. System Setup

Follow manufacturers' instructions.

4.1.2.2. Recording Data

Follow manufacturers' instructions.

4.2. Groundtruthing

Ideally all sidescan sonar surveys are followed by underwater camera surveys to verify the presence and interpretation of the patterns recorded in the acoustic imagery. The underwater camera surveys should occur as soon as possible after the sidescan sonar surveys. If done on the same day, a grid pattern of stations is recommended to record seafloor imagery. An alternative method is to process the sidescan imagery into a mosaic, identify the boundaries of various seafloor hardness/roughness patterns, and then plan video stations representative of each pattern type. Towed video can be used to help confirm the location of boundaries identified in the sidescan sonar imagery.

Video methods should follow protocols in the Standard Operating Procedures Manual for Underwater Video for the Massachusetts Division of Marine Fisheries.

4.3.Sensor Risk Management

4.3.1. Best practices for preventing loss of equipment

A fail safe line shall be attached to the gunwale mount or the tow cable.

4.3.2. Best practices for recovery of lost equipment

If the sonar transducer is lost, the Man Overboard button on the vessel-mounted GPS system should be activated. This will place a waypoint on the GPS screen which can be used to set up a search and rescue pattern. The onboard depth/fish finder should be used to scan the area in a pattern near the area of loss. If a target is identified, it should be marked as a waypoint on the GPS unit. Since our surveys typically occur in water shallower than 100 feet, recovery can be achieved by any safe method to do so (e.g.

snorkeling or scuba diving). If this is insufficient or impractical, grappling with a grappling hook is recommended.

5. Data Processing and Analysis

5.1. Data Processing Workflow

5.1.1. CARIS

5.1.1.1. Creating HIPS Vessel Files

Follows manufacturers' instructions.

5.1.1.2. Creating CARIS Projects

Follows manufacturers' instructions.

5.1.2. SonarTRX Pro

SonarTRX Pro has relatively sophisticated capabilities in an inexpensive and easy to learn software package. The main limitations of this program are that it can only process one line at a time, it cannot mosaic multiple lines together, and the correction algorithms can only assume a flat seafloor. Although this is somewhat inefficient, the program produces high quality results with minimal user input making it simple to use. It can also produce X, Y, Z data, but we do not typically use it for that so those instructions are not provided. For further help and questions, SonarTRX hosts a yahoo user group and more information can be found at http://www.sonartrx.com/web/Home/Support. There are also online video tutorials at http://www.sonartrx.com/web/Home/Tutorials. The Customer Service email is support@SonarTRX.com and the Customer Service phone number is 808-383-3007. The User Manual is on the office server at \Habitat Project\Habitat Research\EQUIPMENT\SonarTRX.

- Open SonarTRX Pro
- On the Main Menu, click on Import

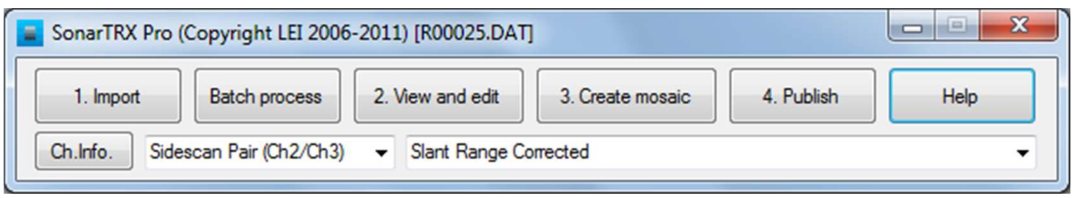


Figure 4-1. SonarTRX Pro Main Menu

- Select input file
- Select General Options as identified in Figure 4-2.

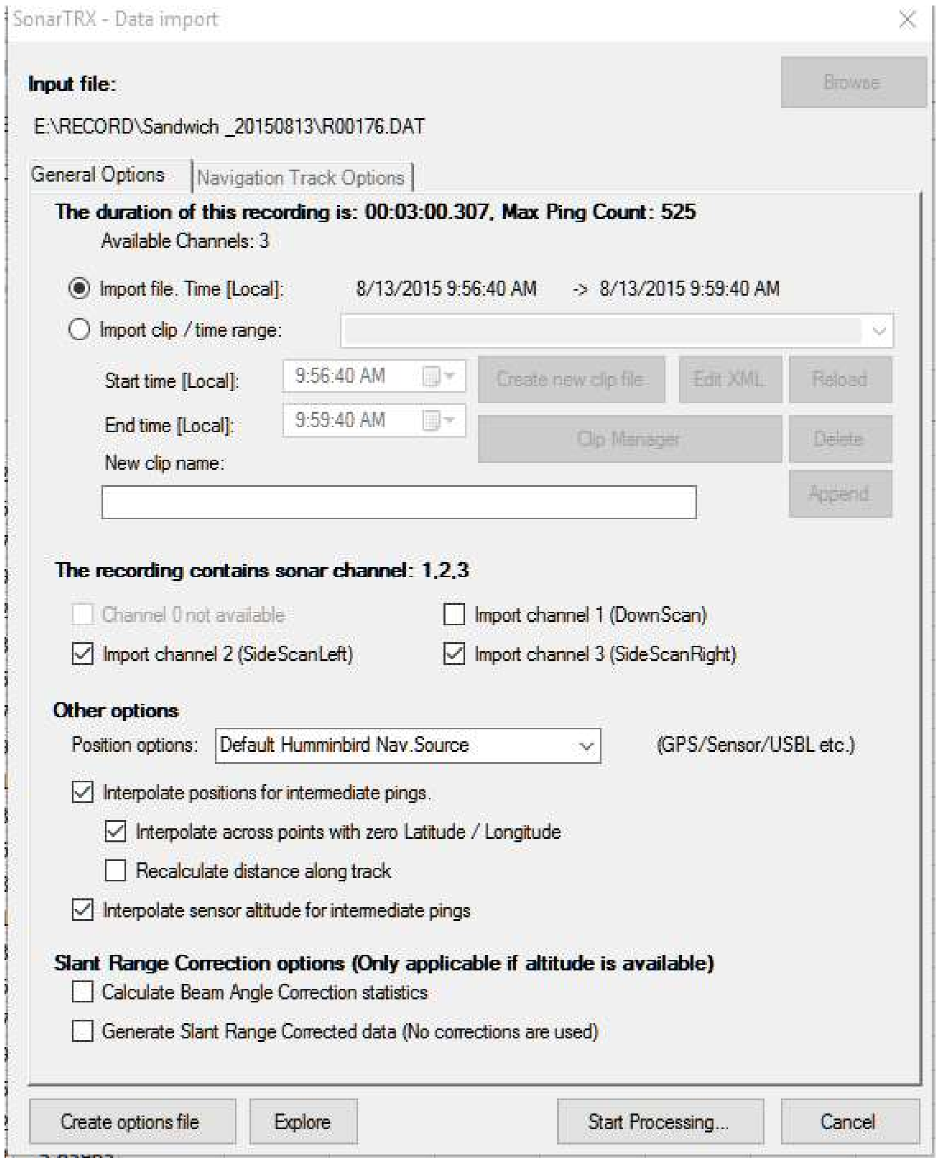


Figure 4-2. Data import selection for SonarTRX.

- Click on Start Processing then Close
- On the Main Menu, select View and Edit
- Look at navigation tab (the first tab to open) to verify line looks correct
- Select SRC/TVG tab.
- Click Calculate Histogram button.
- Conduct SRC/TVG correction.

SRC stands for Slant Range Correction and TVG stands for Time Varying Gain. A slant range distortion is an across-track distortion caused by the sidescan angle; near-range areas are more compressed in space than far-range areas. Slant range correction is a geometric correction which remaps the pixels from their apparent position to the true one, and is computed from the elapsed receiving time and the sonar platform's height (from page 65 of The Handbook of Sidescan Sonar by Philippe Blondel, Springer, 2009). Slant range correction is dependent on the altitude, so water column removal is typically done at the same time as SRC. The water column as automatically identified by SonarTRX is typically used, but if it is poorly recognized by the automatic algorithm, or if there is a data or visual quality need, the water column can be re-delineated by the sonar analyst.

Time-varying gain refers to the backscatter decreasing with increasing range; the same object at a further range from the sonar will have less backscatter than the same object closer to the sonar (from page 64 of The Handbook of Sidescan Sonar by Philippe Blondel, Springer, 2009). Most sonars have TVG amplifiers in the towfish that correct for this error. In post processing, additional gain corrections can be made to minimize gain changes that went uncorrected in data collection or still remain.

The Beam Angle Correction tool is a radiometric correction tool that accounts for the loss of resolution due to the increased beam footprint at further ranges. For our purposes, we use the automatic Beam Angle Correction (BAC). Our experience has shown that using default altitude and BAC corrections have been sufficient for our needs. However, specific projects may require manually defined altitudes or more sophisticated BAC. For those needs, refer to the SonarTRX user manual. For standard surveys, use settings indicated in Figure 4-3.

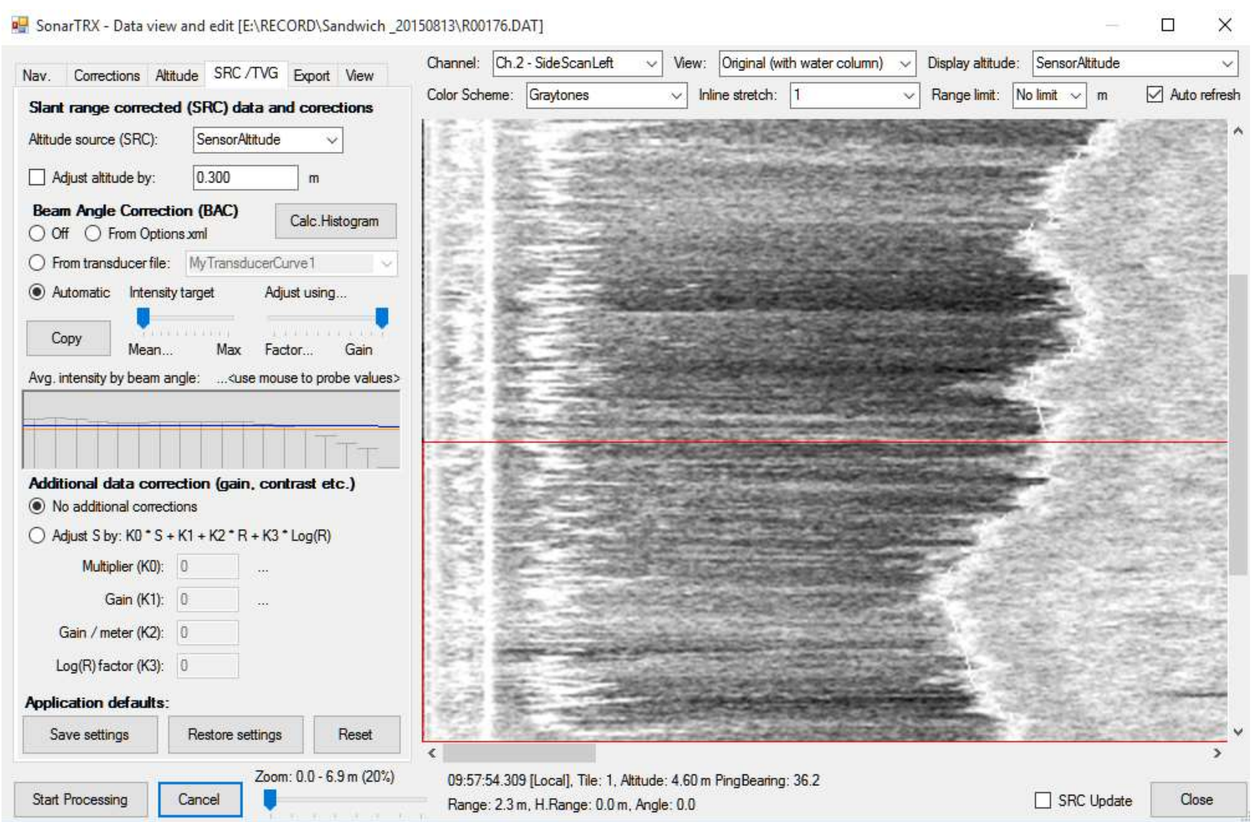


Figure 4-3. Slant range and beam angle correction window.

- Click on Start Processing.
- Click on Close.
- On the Main Menu, select Create Mosaic.
- Select the Parent Folder for Mosaics.
- Use the Default Mosaic Name.
- Click on the Sonar Mosaic Settings tab. Use the settings in Figure 4-4.
    - Image resolution may need to be adjusted for very large files.

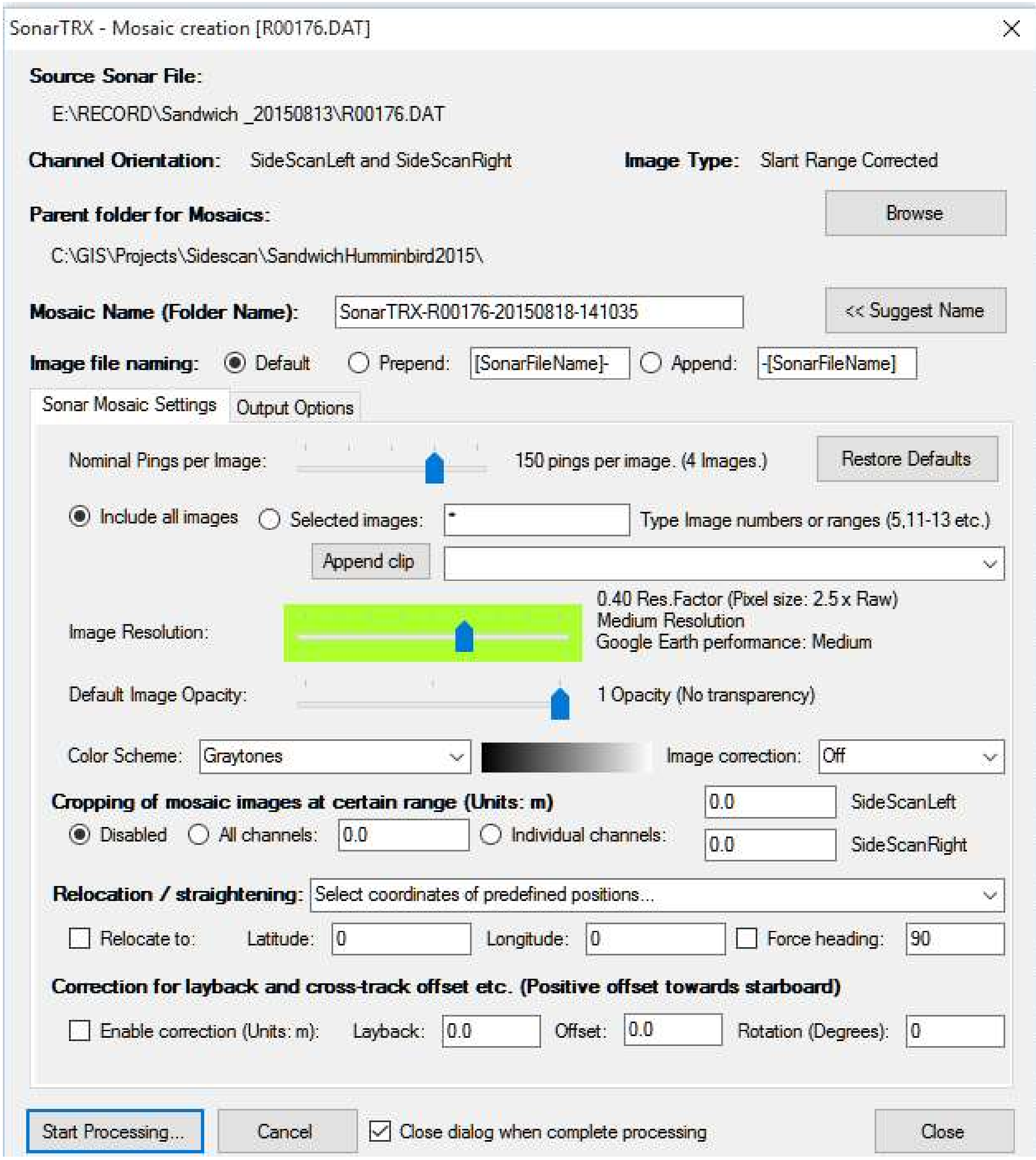


Figure 4-4. Create Mosaic, Sonar Mosaic Settings tab.

- Click on the Output Options tab. Use the settings in Figure 4-5.

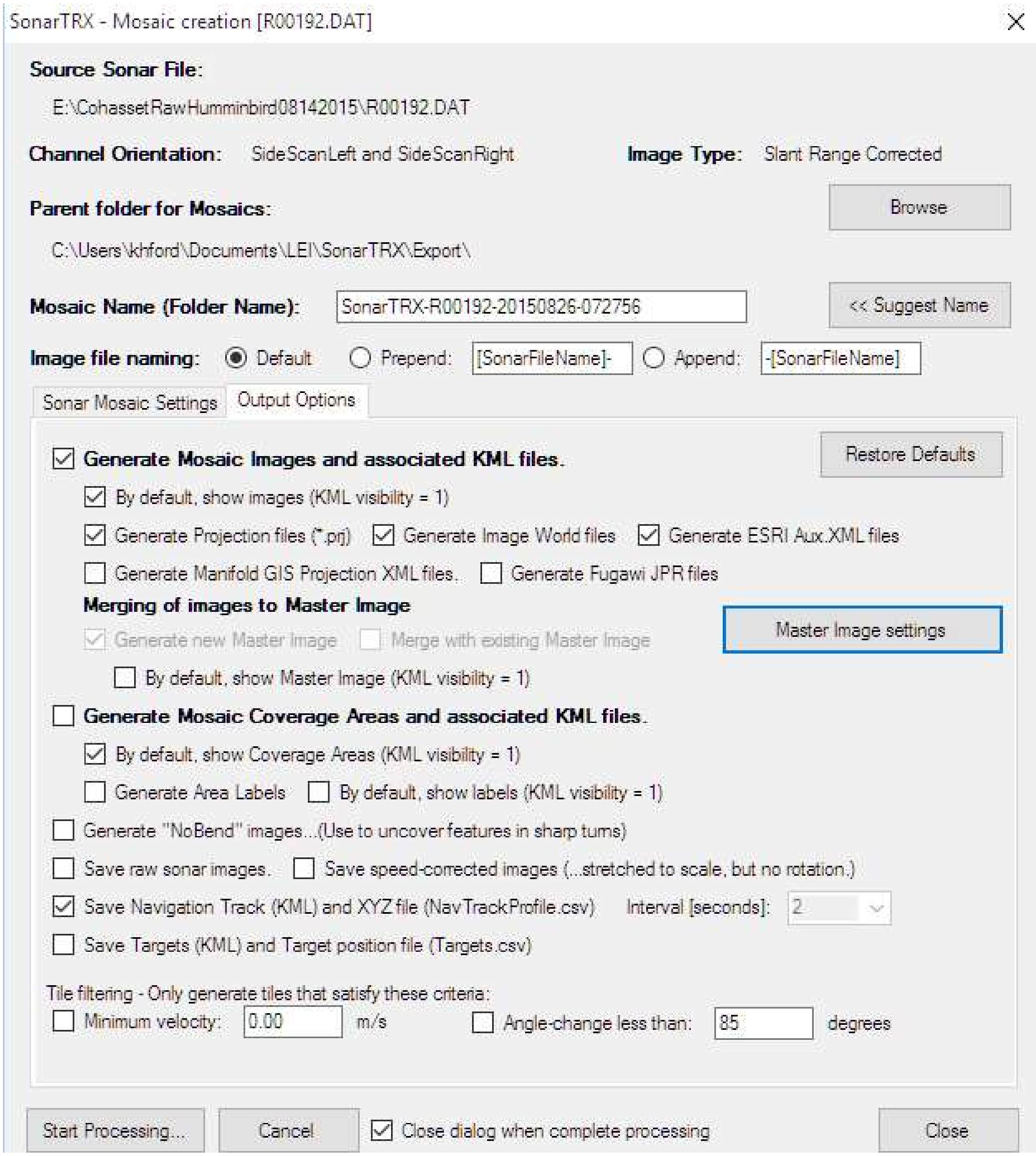


Figure 4-5. Create Mosaic, Output Options tab.

- Click on the Master Image Settings button. Use the settings in Figure 4-6.

  SonarTRX processes each line file to a set of smaller tiles. The Master Image creates a mosaic of those smaller tiles so each line file is a single GeoTIFF/shapefile for ease of use in Google Earth and ArcGIS.

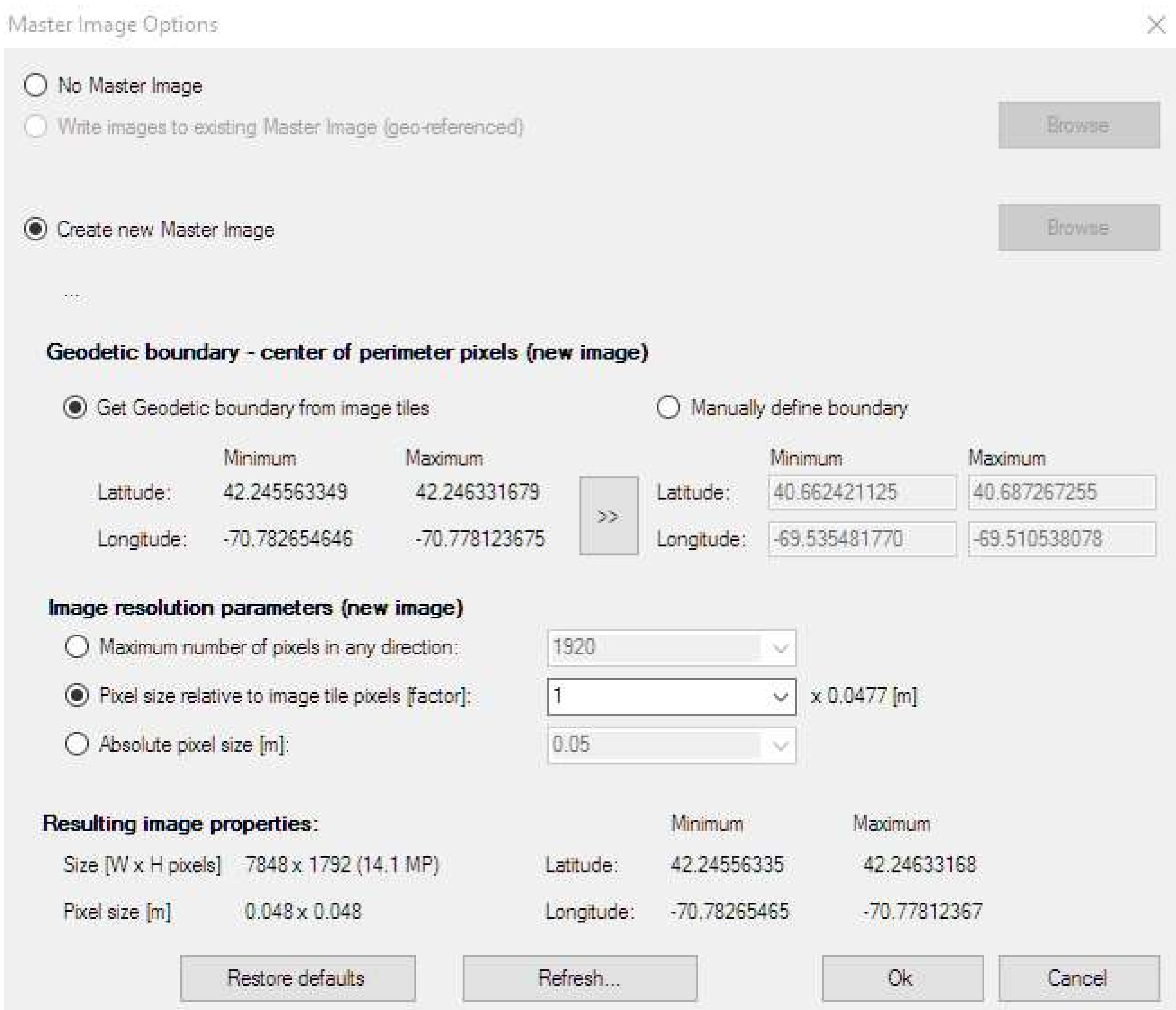


Figure 4-6. Master Image Options.

- Click OK.

5.2. Analyzing Sonar Data

5.2.1. Habitat types

The primary program used for interpreting habitat types is ArcGIS. First, sonar mosaics and groundtruthing points are imported into ArcGIS. Baseline data, in particular aerial photography and NOAA charts, are imported into the project. A new polygon file is created and turned on for editing. The interpreter uses the available information to interpret boundaries between different habitat types evident in changes the backscatter signal in the sonar mosaic. These boundaries are drawn into the new polygon file. An attribute column is created in the polygon file to identify the habitat type.

To be added: discuss boundary snapping/topology, scale, and the standard habitat types that should be used for the habitat description.

5.2.2. Target recognition

Targets are identified in raw sonar data during data acquisition or in processing in the lab. Anthropogenic targets are identified by their unique, non-natural shapes such as straight lines (often seen in fishing pots) or distinctive shapes such as shipwrecks or airplanes. Targets such as “hard bottom” or “eelgrass” are identified by the presence of characteristic patterns in the sonar data. Depending on the survey goals, target points are made and an image of the target is recorded.

5.2.3. Resolution

Information about resolution is provided from http://www.emodnet-seabedhabitats.eu/pdf/MeshA_ROG_Sidescan_Sonar_v4.0.pdf

The resolution in the along-track direction, Δ_{rx}, measures the resolution parallel to the line of travel. It will be strongly dependent on the horizontal beam width, θ_{hx}, and range, R, and can be expressed as:

$$\Delta_{rx} = \theta_{hx}.R$$

According to this expression, the along-track resolution of a sonar, working under the same operational conditions, degrades with distance to the transducer (Fig. 7). Therefore, two objects will be detected as separated entities if they are separated by a distance which is less than the spread of the sonar beam Δ_{rx}

at that range.

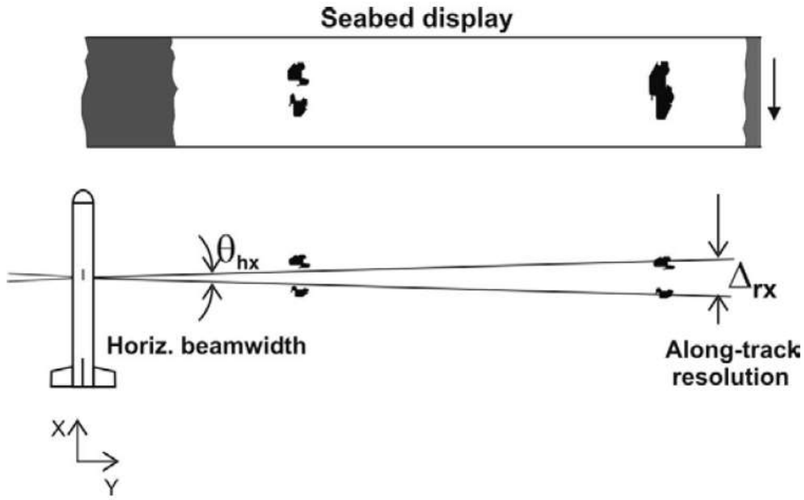


Figure 7- The along-track resolution of a sidescan sonar is dependent on the horizontal beamwidth and the slant range. The resolution improves at lower depths.

The Klein has a 0.21 degree horizontal beam width in the high res (455 kHz) channel. At 50 meter range that's 10.5 cm resolution.

At 70 meter ranges that's 14.7 cm resolution.

The across-track resolution Δ_{ry} (Fig. 8), is defined as the minimum distance between two objects perpendicular to the line of travel that can be distinguished as separated entities in the sonar image.

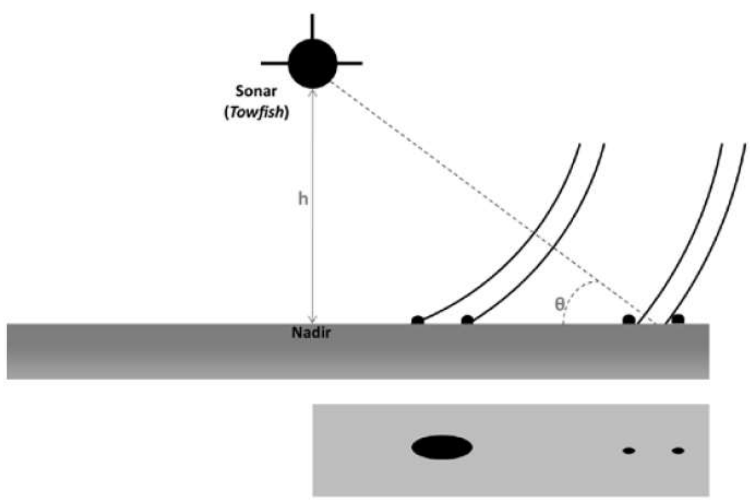


Figure 8- The across-track resolution of a sidescan sonar is dependent on the grazing angle θ and the pulse length T (after Mazel, 1985).

The pulse length, T, is the overriding operational parameter determining this resolution. As the acoustic wave direction is oblique to the seabed, this resolution can be expressed as:

$$\Delta_{ry} = \frac{T.c}{2}.\sec\theta$$

where θ is the grazing angle.
Additionally, to ensure full coverage in the swath area, no gaps between ensonified areas from two successive pings should exist (Blondel, 2009). This complete coverage condition depends on the transducer length, L, the vessel speed, v, and the ping rate, fp. The ping rate can be calculated by the sound velocity in water, c, and the selected range, R (the theoretical sonar range resolution, across-track in the case of sidescan sonar):

$$f_p = \frac{c}{2 \cdot R}$$

For a given transducer length, *L*, a working ping rate (determined by the selected range), allows a complete coverage (without gaps) when a maximum vessel speed, v_{max}, is not exceeded:

$$V_{\max} = L \cdot f_p = \frac{L \cdot c}{2 \cdot R}$$

A short pulse will produce a thinner spatial pulse length, resulting in a higher spatial resolution, whilst a longer pulse will be less sensitive to the background noise, resulting in improved range performance. As a consequence, for greater seabed depths, ping rates must decrease to cope with longer range scales R involved. In such cases, the operator can be forced to slow down the tow speed to maintain total coverage along the swath.

6. Data Management and Products

6.1. Data Filing and Organization

6.1.1. Raw and Processed Survey Data

6.1.1.1. In the Field

All raw survey data will be stored on the local computer (Klein) or SD drive (Humminbird) until the following day when the data will be copied to the V drive. For multiple day surveys, the data must be backed up nightly to an external hard drive. Once the multiple-day survey is complete, all raw data should be copied to the V drive and removed from the field computer, SD drive, and/or external drive.

6.1.1.2. In the Office

All raw survey data will be stored on the V drive under the Habitat Folder according to the following naming convention: V:\Habitat\[Project Name-YY]\[Project Name]Raw[SonarUnitName][MMDDYYYY]

Copies of the raw data can be transferred to the hard drive of the processing computer. Once processed, all processed survey data will be stored on the V drive under the Habitat Folder according to the following naming convention: V:\Habitat\[Project Name-Year]\[Project Name]Processed[SonarUnitName][MMDDYYYY]

6.1.1.3. Archives and Backups

The raw and processed data will be backed up by EEA IT according to its backup schedule for the V drive. The backup procedure is currently not published but a daily onsite backup was described by Bob Sigren, EEA IT. It will also be backed up to an external hard drive immediately after a survey is complete and after any project updates are complete . The external drive will be stored offsite (Duchaine Boulevard storage building).

6.1.2. Interpreted Data

6.1.2.1. Working Files

Copies of the raw data can be transferred to the hard drive of the processing computer. These files should be placed in a file location convenient to the person doing the processing. All working files, including Google Earth and ArcGIS files, should be placed in W:\Habitat Project\Habitat Research\[Project Name-Year]\GIS.

6.1.2.2. Long-term storage

Once a survey is completed, all interpreted survey data will be stored as a Map Package on the V drive under the Habitat Folder according to the following naming convention: V:\Habitat\[Project Name-Year]

The Map Package should be generated such that it can be sent to a potential user and opened with all interpreted files, the sonar mosaic, groundtruthing points, and relevant baseline files intact.

6.1.2.3. Archives and Backups

These data will be backed up by EEA IT according to its backup schedule for the V drive. The backup procedure is currently not published but a daily onsite backup was described by Bob Sigren, EEA IT. It will also be backed up to an external hard drive immediately after a survey is complete and after any project updates are complete . The external drive will be stored offsite (Duchaine Boulevard storage building).

6.1.3. Reports

A Cruise Report will be generated for every field day or set of field days dedicated to imaging a single survey area. The Cruise Report will be placed in W:\Habitat Project\Habitat Research according to the following naming convention: [Project Name-

Year]\CruiseReportMMDDYYY with the date referring to the date of the survey or the last date of a multiple-day survey.

Final Project Reports will be generated on a per-project basis and placed in W:\Habitat Project\Habitat Research according to the following naming convention: [Project Name-Year]\FinalReportMMDDYYY. The date refers to the date the final report was finished. Whenever possible, final reports will be submitted to the DMF Technical Report series.

7. Appendix

7.1.Klein 3000 Specifications Sheet

These images were copied from the pdf available at the Klein website:
http://www.kleinmarinesystems.com/PDF/Klein_System_3000_rev0216.pdf Accessed 11/7/2016

SYSTEM 3000 SIDE SCAN SONAR

DUAL-FREQUENCY SINGLE BEAM SONAR

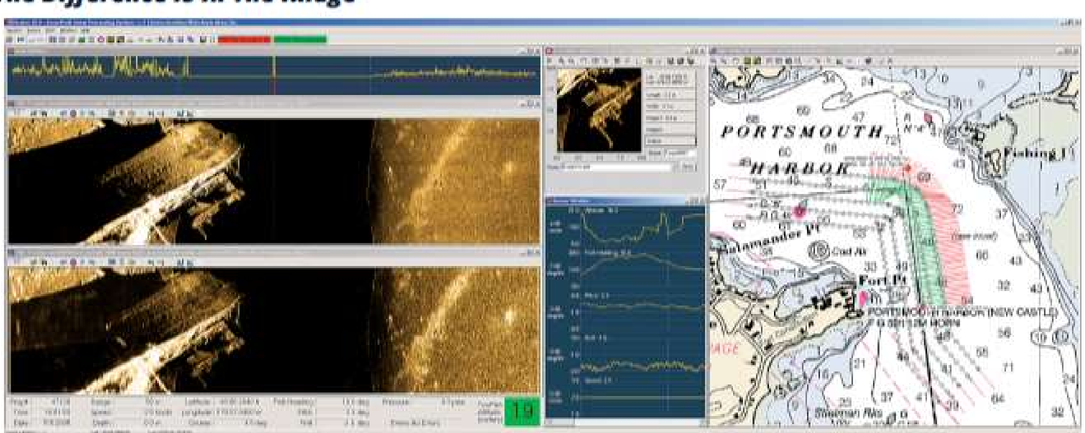
Digital Side Scan Sonar:

The Klein System 3000 presents the latest technology in digital side scan sonar imaging. The simultaneous dual-frequency operation is based on new transducer designs, as well as the high-resolution circuitry recently developed for the Klein multi-beam focused sonar. The System 3000 performance and price is directed to the commercial, institutional and governmental markets.

Key Features:

- Advanced signal processing and transducers produce superior imagery
- Cost-effective, affordable
- PC-based operation with SonarPro® software, dedicated to Klein sonars
- Small, lightweight and simple designs - easy to run and maintain
- Easily adapted to ROV's and custom towfish
- Meets IHO & NOAA Survey specifications

The Difference Is In The Image



SYSTEM 3000 SIDE SCAN SONAR

DUAL-FREQUENCY SINGLE BEAM SONAR

Specifications:

System 3000 Towfish	
Frequencies	100 kHz (132 kHz, ± 1% actual) 500 kHz (445 kHz, ± 1% actual)
Transmission Pulse	Tone burst, operator-selectable from 25 to 400 µsecs; Independent pulse controls for each frequency
Beams	Horizontal: 0.7° @ 100 kHz 0.21° @ 500 kHz Vertical: 40°
Beam Tilt	5°, 10°, 15°, 20°, 25° down, adjustable
Range Scales	15 settings - 25 to 1,000 meters
Maximum Range	600 m @ 100 kHz 150 m @ 500 kHz
Depth Rating	1,500 m standard; other options available
Construction	Stainless Steel
Body Length	122 cm (48 in)
Body Diameter	8.9 cm (3.5 in)
Weight	29 kg (63.9 lbs) in air
Standard Sensors	Roll, Pitch, Heading
Options	Magnetometer, pressure sensor, acoustic positioning, sub-bottom profiler

Transceiver Processor Unit (TPU)	
Operating System	VxWorks® with custom application
Basic Hardware	Splash-Proof 2 (SP2) TPU
Outputs	100 Base-Tx, Ethernet LAN
Navigation Input	NMEA 0183
Power	120 watts @ 120/240 VAC, 50/60 Hz (includes towfish)
Interfacing	Interfaces to all major sonar data processors
Options	19-in rack mount TPU

Tow Cable
Klein offers a selection of coaxial, Kevlar® reinforced, lightweight cables, and interfaces to fiber optic cables. All cables come fully terminated at the towfish end.

Klein Sonar Workstation	
Operating System	Windows
Sonar Software	SonarPro®
Data Format	SDF or XTF or both, selectable
Data Storage	Internal Hard Drive, CD/DVD-RW
Hardware	Industrial PC
Options	Optional Waterproof Laptops

SonarPro® Software	
Custom-developed software by users and for users of Klein Side Scan Sonar Systems operating on Windows 7. Field-proven for many years. SonarPro® is a modular package combining ease of use with advanced sonar features.	
Basic Modules	Main program, data display, information, target management, navigation, data recording & playing, and sensor display.
Multiple Display Windows	Permits multiple windows to view different features as well as targets in real-time or in playback modes. Multi-windows for sonar channels, navigation, sensors, status monitors, targets, etc.
Survey Design	Quick and easy survey set up with ability to change parameters, set tolerances, monitor actual coverage and store settings.
Target Management	Independant windows permitting mensuration, logging, comparisons, filing, classification, positioning, time & survey target layers, and feature enhancements. Locates target in navigation window.
Sensor Window	Displays all sensors in several formats (includes some alarms) and responder set up to suit many frequencies and ping rates.
Networking	Permits multiple, real time processing workstations via a LAN including "master and slave" configurations.
"Wizards"	To help operator set up various manual and default parameters.
Data Comparisons Real Time	Target and route comparisons to historical data.

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www.kleinmarinesystems.com

7.2 Humminbird 698 Specifications Sheet

Display Size - Diagonal: 5"
Display Pixel Matrix: 480H x 640V
Display Type: Color TFT
Display Colors Grayscale: 256 Colors
Sonar Standard: Side Imaging/Down Imaging/DualBeam PLUS
Standard Sonar Coverage: 20°, 60° & (2) 85° @ -10db (Total of 180°)
Standard Sonar Frequency: 200/83/455 kHz
Sonar Optional: None
Target Separation: 2.5"
Power Output RMS: 500 Watts
Power Output Peak to Peak: 4000 Watts
Depth Capability: 100 ft (SI/DI), 1500 ft
Temperature: Built In Transducer
Speed: GPS Speed Included
Backlight: LED
Unit Size - Gimbal Mount: 6.9"W x 7.5"H x 4.5"D
Mount A Type: Quick Disconnect
Unit Size - Indash Mount: 6.9"W x 5.4"H x 1.25"D
Mount B Unit Size2: Optional In-Dash
Mounting Options: Quick Disconnect or Optional In-Dash
Transducer Standard: XNT 9 SI 180 T
Transducer Mounting: Transom
HD Side Imaging Sonar Coverage: Total 180°
Power Input: 10-20 VDC
Power Draw: 615 mA
GPS Receiver: Included
GPS Tracking: Included
GPS Chartplotting: Included
Waypoints, Routes, Tracks/Points: 2,500, 45, 50/20,000
Humminbird Mapping: Optional
Navionics+: Optional
Navionics Platinum+: Not Supported
Platinum Capable: Not Supported
C-Map 4D: Not Supported
360 Imaging: Not Supported
i-Pilot Link: Not Supported
HD Radar: Not Supported
NMEA 2000: Not Supported
5 Port Expansion Module: Not Supported
WeatherSense: Not Supported
Precision GPS: Included
Heading Sensor GPS: Not Supported
PC Connect: Optional
External GPS Receiver: Not Supported
AS Interlink: Not Supported
AIS Compatability: Not Supported
SwitchFire Sonar: Included
Screen Snap Shot: Included
Sonar Recording: Included
Humminbird PC: Included
Upgradable Internal Software: Included
Split Screen Zoom: Included
Split Screen Bottom Lock: Included
3D Chart View: Included
Large Digits View: Included
Wide/Narrow Cone Split Screen: Included
Custom View Selections: Included
Custom Digital Readout: Included
View Preset Keys: Included
Temperature Graph: Not Supported
Temperature Alarm: Included
Freeze Frame: Included
Instant Image Update: Included
Mark Structure on Sonar: Included
Selective Fish ID+: Included
Real Time Sonar: Included
Triplog: Included
X-Press Menu System: Included
Card Reader Available: Yes
Card Slots: 1

7.3.Humminbird 999 Specifications Sheet

Display Size - Diagonal: 8"
Display Pixel Matrix: 800H x 480V
Display Type: Color TFT
Display Colors Grayscale: 65,000 Colors
Sonar Standard: HD Side Imaging/HD Down Imaging/DualBeam PLUS
Standard Sonar Coverage: 20°, 60°, (2) 86° & (2) 55° @ -10db (Total of 180°)
Standard Sonar Frequency: 200/83/455/800/50* kHz
Target Separation: 2.5"
Power Output RMS: 1000 Watts*
Power Output Peak to Peak: 8000 Watts*
Depth Capability: 150 ft SI/DI, 1500 ft, 3000 ft*
Temperature: Built In Transducer
Speed: GPS Speed Included
Backlight: LED
Unit Size - Gimbal Mount: 11.25"W x 6.75"H x 4.25"D
Mount A Type: Gimbal Mount
Unit Size - Indash Mount: 10.75"W x 6"H x 2.5"D
Mount B Unit Size2: Optional In-Dash
Mounting Options: Gimbal or Optional In-Dash
Transducer Standard: XHS 9 HDSI 180 T
Transducer Mounting: Transom
HD Side Imaging Sonar Coverage: Total 180°
Power Input: 10-20 VDC
Power Draw: 780 mA
GPS Receiver: Included
GPS Tracking: Included
GPS Chartplotting: Included
Waypoints, Routes, Tracks/Points: 2,750, 45, 50/20,000
Humminbird Mapping: Optional
Navionics+: Optional
Navionics Platinum+: Optional
Platinum Capable: Optional
C-Map 4D: Not Supported
360 Imaging: Optional
i-Pilot Link: Optional
HD Radar: Optional
NMEA 2000: Optional
5 Port Expansion Module: Optional
WeatherSense: Not Supported
Precision GPS: Included
Heading Sensor GPS: Optional
PC Connect: Optional
External GPS Receiver: Optional
AS Interlink: Not Supported
AIS Compatability: Optional
SwitchFire Sonar: Included
Screen Snap Shot: Included
Sonar Recording: Included
Upgradable Internal Software: Included
Split Screen Zoom: Included
Split Screen Bottom Lock: Included
3D Chart View: Included
Large Digits View: Included
Wide/Narrow Cone Split Screen: Included
Custom View Selections: Included
Custom Digital Readout: Included
View Preset Keys: Included
Temperature Graph: Included
Temperature Alarm: Included
Freeze Frame: Included
Instant Image Update: Included
Mark Structure on Sonar: Included
Selective Fish ID+: Included
Real Time Sonar: Included
Triplog: Included
X-Press Menu System: Included
Card Reader Available: Yes
Card Slots: 2

7.4 Field Data Sheet