

SonarPoint™

Manual
Version 1.11
Desert Star Systems LLC

Prepared by Jacob Wolf, Nov 10th, 2017



Disclaimer : This manual is intended to serve as a quick-start guide for the end user. For further documentation on technical specifications, mission-based questions, analysis questions and more please contact Desert Star Systems at customerservice@desertstar.com

Please carefully read and follow the instructions in this manual, failure to do so may result in product/data loss and failure.



Table of Contents

Background.....	2
Advantages.....	2
Cost.....	2
Modular Design.....	2
Battery Design & Depth Rating.....	3
Non-corrosive.....	3
Localization & Automatic Time Synchronization.....	3
Pre-deployment.....	4
Inspection.....	5
Configuration.....	10
LED Blink Patterns.....	14
Deployment.....	15
Buoy Configuration.....	15
Short-term.....	15
Long-term.....	15
Thoughts on Deploying Buoy Systems.....	15
Submerged Configuration.....	17
Retrieval.....	19
Physical Retrieval.....	19
Data Retrieval.....	19
Data Localization.....	19
Ishmael.....	20
Audacity.....	23
Further reading.....	26

Background

The SonarPoint system is the third generation of Desert Stars passive underwater acoustics monitoring toolkits. Derived from the MicroMARS, the SonarPoint is a modular recorder with localization capabilities, flexible storage capacities, long run-time, and easy to service components at an affordable price. As a continuation and improvement on MicroMars, SonarPoint incorporates field tested technology with highly precise localization capabilities. A modular design also means the mission flexibility and portability of SonarPoint is adequate for most any mission and deployment medium.

The following section discusses some of the various advantages and limitations SonarPoint has to offer.

Advantages

Cost

Perhaps the most important aspect of any equipment is the cost. SonarPoint was developed specifically to serve as a low cost underwater acoustics monitoring system without sacrificing recording function, serviceability or lifetime. At a base price of \$3,500 US, SonarPoint is a low cost solution for an adaptable recorder with localization capabilities. Additionally, runtime, and maintenance for SonarPoint can be done from any boat due to its small size and easily serviceable modular design.

Modular Design

The low cost of the SonarPoint is due in part to its modular design. Encased in Delrin pipe, an electronic stack resides within the main housing of the SonarPoint. Sd card as well as the lithium ion battery can be easily replaced and serviced without the need for advance knowledge. The hydrophone endcap can also be replaced or tuned to specific recording frequencies. Infact, SonarPoint toolkits are easily serviceable from any deployment medium from large research vessels to zodiacs and everything in between. The modular design also means retrieval of data is easy. The 300 meter depth single battery model holds four sd card compartments each with two slots (4x2=8 Sd Cards). At the time of this writing, the highest

capacity sd card in standard production is limited to 512GB, which would yield a total capacity of just over 4 tb or 8 tb for the extended four battery model. However, depending on mission purpose, configuration options and run-time, sd storage capacity can easily be configured at low cost to each specific project/mission. The onboard lithium ion battery is housed directly under the electronic stack making replacement a simple and quick process.

Additionally, your SonarPoint(s) hydrophone end cape is customizable and easily replaceable. You may consider choosing a low gain end-cap for strong signals and a high gain end-cap for weak signals. Hydrophones with a sloped frequency response are also possible where strong low frequency sounds may be monitored while monitoring for faint high frequency vocalizations.

Battery Lifetime & Depth Rating

Your SonarPoint has varying lifetimes based on chosen sampling rate and purchased model. Table 1.0 below illustrates the approximate battery lifetimes based on sampling rates. Black indicates a single battery model (SP300-1) and red indicates a four battery model (SP300-8, or SP1000-8)

Table 1.0

Model	Battery Quantity	Depth Rating(meters)	Storage Capacity(TB)
SP300-2	1	300	1
SP300-8	4	300	4
SP1000-8	4	1000	4

Table 1.1

Sample Rate(khz)	Endurance(days)	Memory(GB)	Sd Cards(GB)
25	27 / 115	108 / 463	64 *2 / 64 * 8
100	22 / 96	359 / 1540	256 * 2 / 256 * 8
250	17 / 71	670 / 2876	512 * 2 / 512 * 8
416	13 / 56	871 / 3738	512 * 2 / 512 * 8

Note: SonarPoint ONLY supports Sandisk Extreme Pro Sd Cards. Use of other brands may result in complete data loss.

Non-corrosive

SonarPoints external housing and parts are non-corrosive. The plastic is made out of bio-fouling resistant Delrin. All exposed screws are also titanium, a non-corrosive metal, while the optional buoy power/data port is also made from non-corrosive metals and comes with a protective cap if not used. Therefore, the SonarPoint's lifetime limit is more so dictated by recovery since the external materials have such long life times.

Localization & Automatic Time Synchronization

Beyond standalone recording your SonarPoint has localization capabilities. If configured in a multi-recorder array, the SonarPoint is capable of localizing various marine mammal vocalizations to within a 1-3m accuracy (see "Localization" section). SonarPoint's localization method relies on a differential time of arrival of each vocalization between the deployed recorders. Using this method, vocalizations may be plotted on a hyperbola relative to the recorder positions and DTOA.

In submerged arrays, time drift between recorders can influence the precision of localization. Therefore, SonarPoint has several mechanisms to reduce time drift, as well as account for said time drift in the post-retrieval phase. Upon powering on your SonarPoint device, an integrated GPS module will match the on board clock to within a microsecond of accuracy with true GPS time. On board clock drift while deployed is then minimized via a TCXO (temperature compensated crystal oscillator). For longer-term deployments, a pinger may also be used, which emits a signal every thirty seconds into each new recording segment. This ping is then measured between recorders, the difference in time received can be used to further minimize clock drift when the data is retrieved. In buoy systems, clock drift is not an issue as a GPS module in the buoy may receive true GPS time consistently and transmit that time via a tether to your SonarPoint.

In the next section you will learn about inspecting the unit, and configuring for mission readiness through the included software.

Pre-deployment

In this section you will visually inspect the SonarPoint system.

First, you should inventory the provided parts. The following inventory includes all materials provided in your starter kit(s).

Table 1.2

Item	Quantity	Inventory
Pelican 1170 for mm kits	1.000	
USB A Male to USB B Mini 3'	1.000	

H53		
32 GB SanDisk Extreme Pro Sd Card Note : Seperate Sd Cards may be purchased from third parties, Sandisk Extreme Pro ONLY	All slots equipped	
Lithium ion battery	1.000-4.000 depending on model (see table 1.0)	
SD to USB stick H50	1.000	
O-Ring 2-130 E515 Q9	4.000	
Silicone Grease 1/4 oz H51	1.000	
Sea & Sea O-Ring Removal Tool H37	1.000	
TOOL-3/32" Allen Wrench (ARC-1) H14	2.000	
Windows PC with supporting software	1.000	

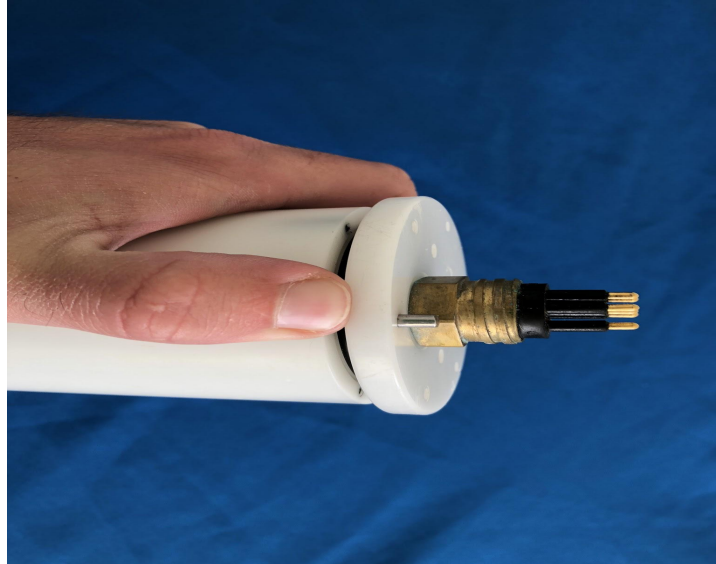
Inspection

Now you will visually inspect your SonarPoint(s). Look for any signs of cracks within the outside casing. Make sure to inspect all surfaces of the casing including exposed screw caps

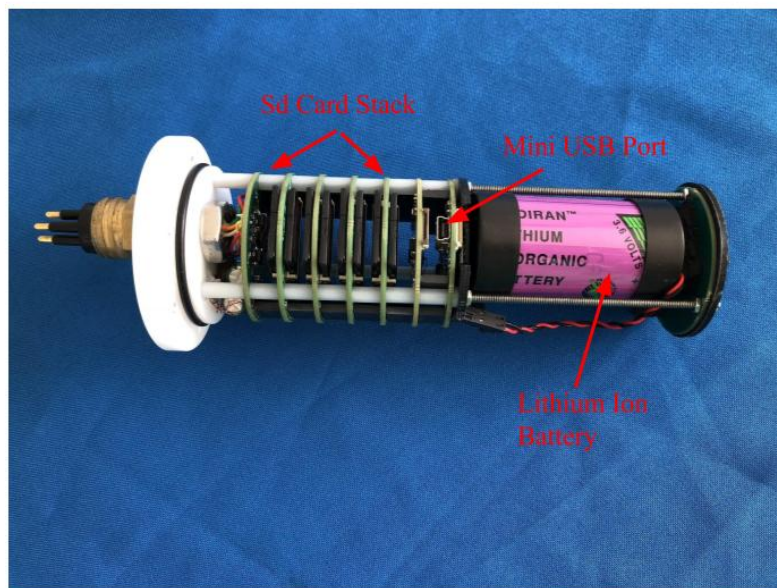


Remove the dummy cap on the top of the Sonar Point device.

- Gently twist the black cylindrical cap counterclockwise in order to loosen the cap.
- When the cylindrical clasp no longer grips the divets, gently pull upwards on the base of the cap.
- Underneath the cap you will see six pins which are used for physical power connections to buoy systems (more about this use in the Deployment section).
- Inspect the six pin connectors, ensure these pins are not bent or missing.
- Next remove the screws on the top of the Sonar Point System.
- Find the $\frac{3}{32}$ " Allen Wrench included in your starter kit and loosen the top screws by turning the allen wrench counterclockwise.
- Place both of your thumbs under the lip of the top lid. Gently push up with both thumbs will firmly grasping the outside casing. Push until the top lid becomes loose.



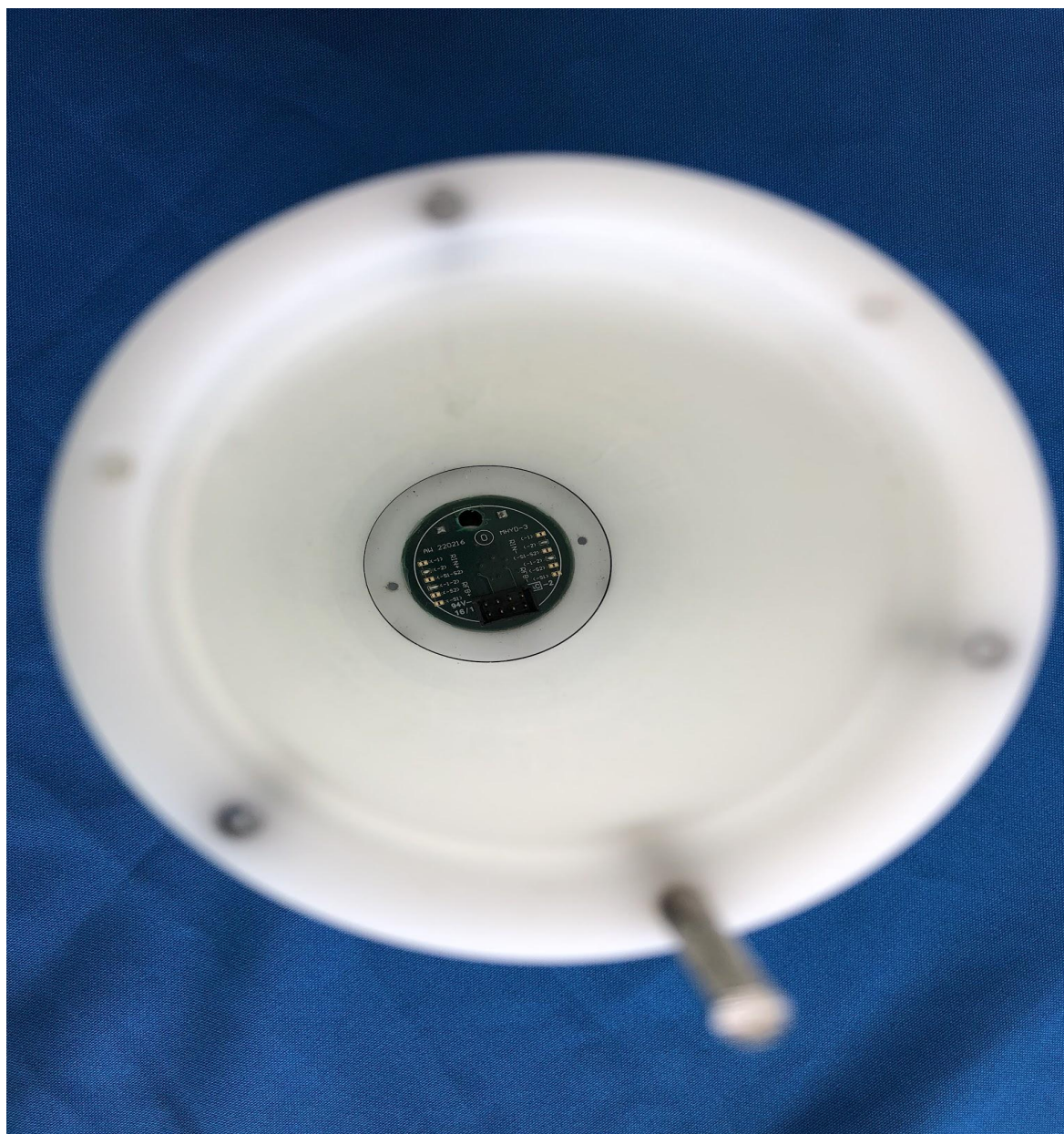
- Gently grab the top lid and pull upwards to remove the electronic stack.
- Visually inspect the electronic stack to ensure internal components are structurally intact.



- Next, looking at the bottom of the internal primary housing, ensure the bottom connection to the hydrophone is not damaged.



Ensure the six pin connector is not damaged.



Once you have confirmed your SonarPoint is not damaged, and all materials have been received you are ready to configure your SonarPoint(s).

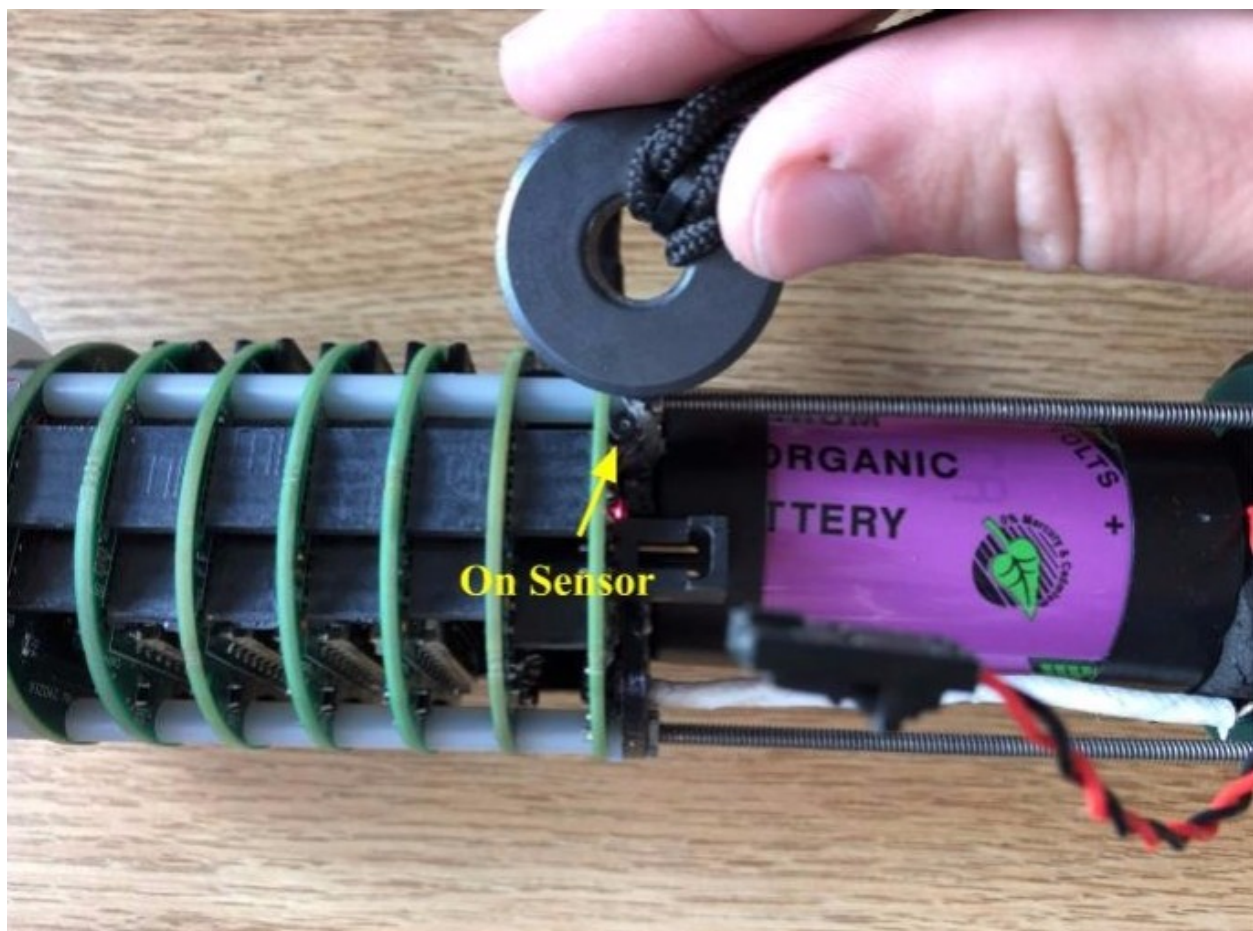
Configuration

Next you will connect the Sonar Point System to your computer, all supporting software for configuring your SonarPoint(s) comes preloaded on the included laptop.

Begin by disconnecting the battery from your SonarPoint.

Plug in the mini usb cable to your SonarPoint and included laptop.

Using the included magnet, power on the SonarPoint. Upon entering the bootloader, your SonarPoint will blink red and green in rapid succession, allow 16-20 seconds for the SonarPoint to boot.



When the SonarPoint is ready to be connected the LED will become a solid amber color.

Launch the program named “MicroMARS Dock”. This will be the interface in which recording and localization features may be configured.

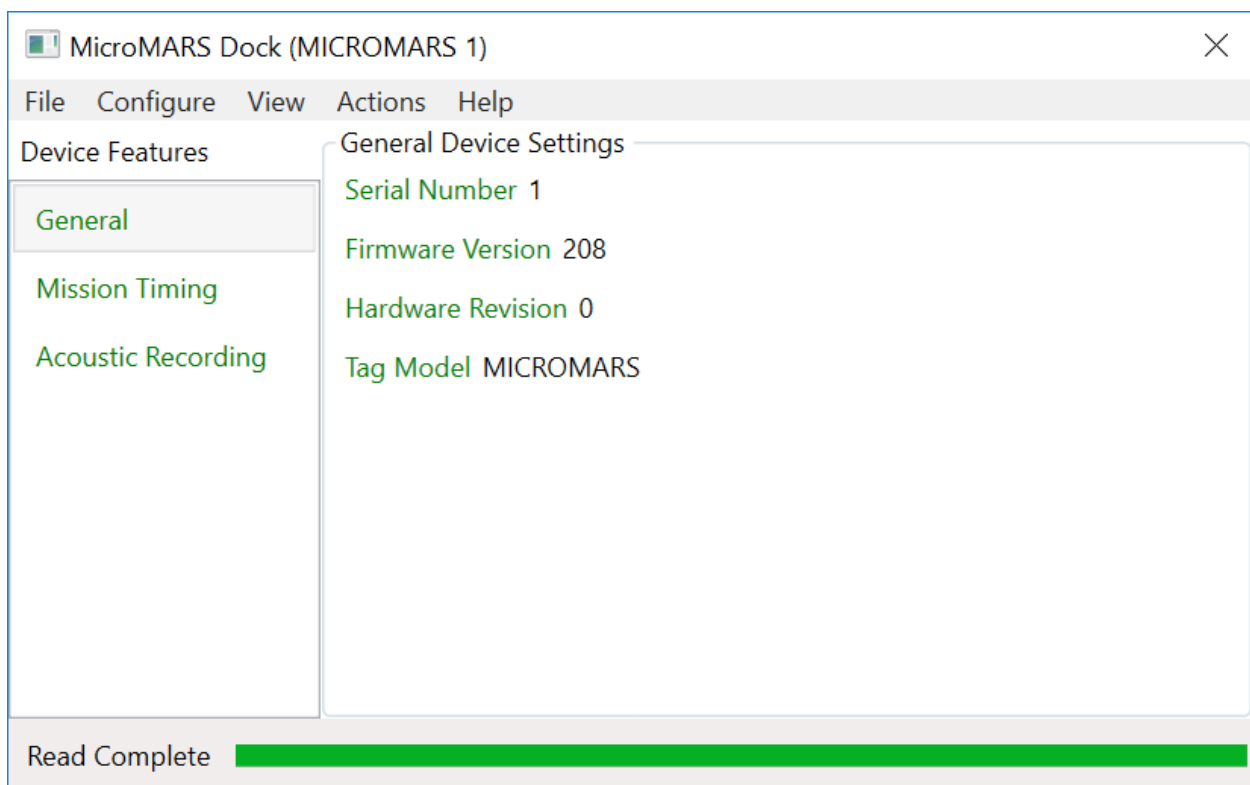
Connect the SonarPoint by selecting Configure>Communication Settings>USB Serial Port

The COM # will indicate which usb port the software is trying to connect through. Do not change the USB serial port #, this should remain 9600.

Once the port has been selected, exit out of the Dock Configuration window, the settings will be saved.

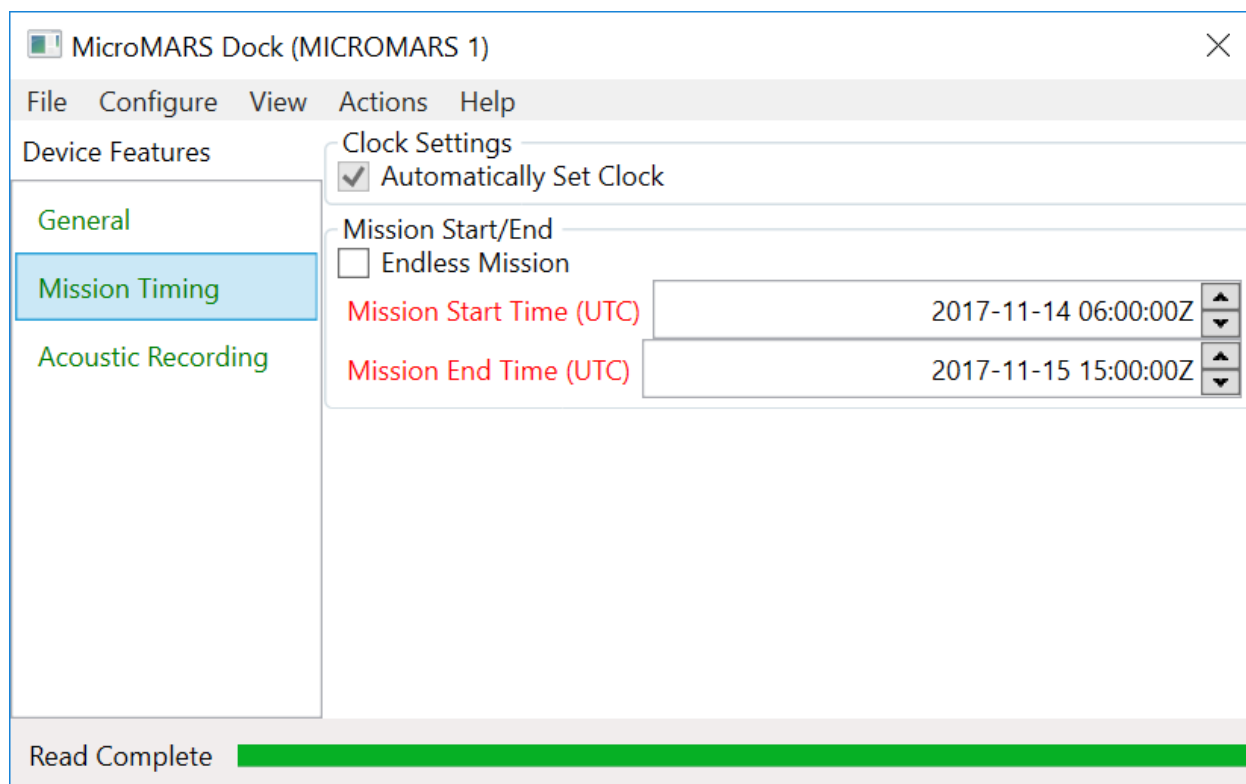
Next, select Actions>Connect Device

When connected, MicroMARS Dock will indicate ‘read complete’. Now you are ready to configure your SonarPoint.



The general tab displays basic information about the connected SonarPoint.

Now select the ‘Mission Timing’ tab.



Automatically set clock will synchronize the recorder with GPS time via a 1PPS signal before submersion, it is recommended you leave the option checked.

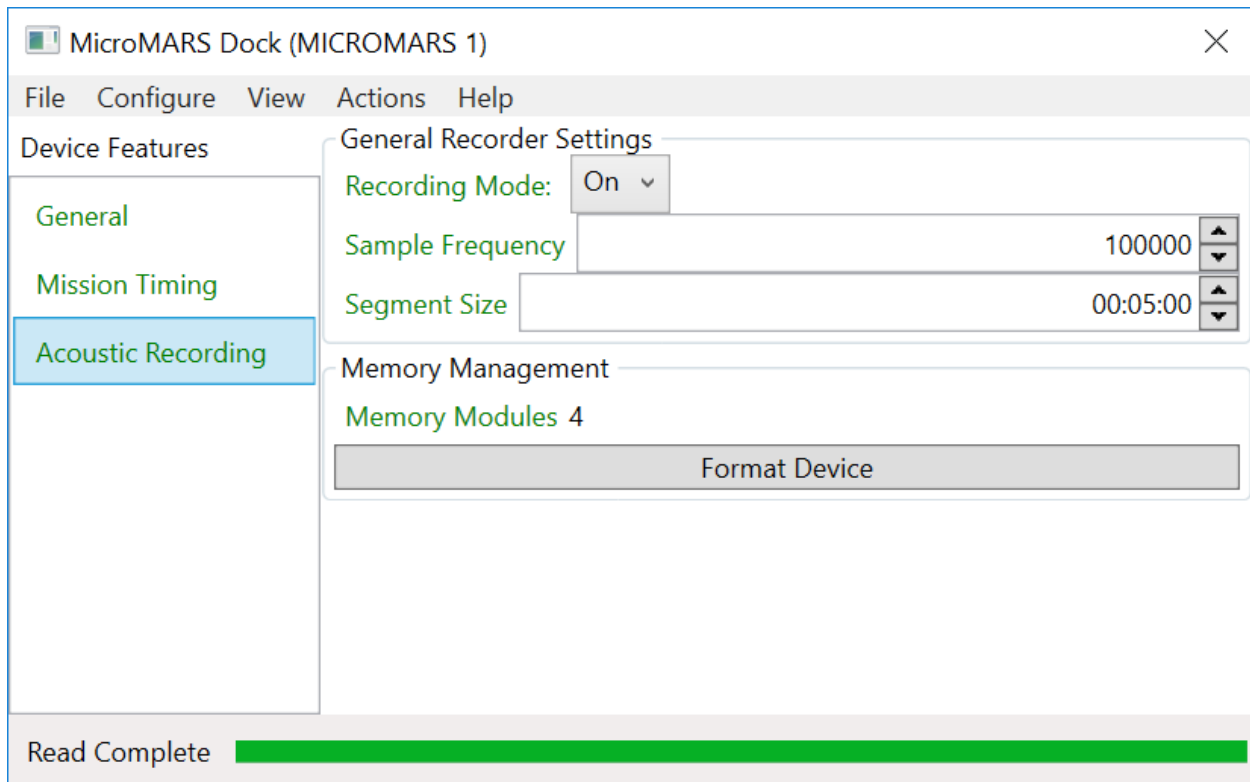
The endless mission setting will set immediate continuous recording until the onboard battery is depleted or storage is filled.

Mission start time indicates the date and time at which the recorder should begin a new mission.

End mission time indicates when the recorder should stop the mission. All time is in UTC.

Within mission start and end times, you may also indicate the type of recording the SoarPoint will do.

Under the Acoustic Recording Tab, you may configure your SonarPoint's localization and recording segment options.



There are three localization modes

- Standalone - Recording ONLY, no localization
- Submerged Array - Underwater array (3 or more recorders)
- Buoy Array - Surface buoy array (3 or more buoy's)

After selecting your localization preference, select the desired recording mode.

- DutyCycle indicates fragmented time recording and time off. For example, you could set your SonarPoint to record ten minutes of every hour, this will preserve battery life.
- On will set recording to continuous until one of three conditions are met, either depleted battery, full storage, or mission end time is reached.
- AcousticEvent mode will prompt the recorder to record only when a defined frequency audio event is detected. (This is only recommended once you have already defined your targets typical vocal frequency).

Sample frequency sets the threshold, while segment size defines the time to record after an acoustic event has been detected.

Once you have determined your recording parameters you are ready to write the settings to your SonarPoint.

Select Action>Write Settings. You will be prompted with a format warning, if all data has been backed up or no data was present then select 'Yes'.

Note : Before removing the usb cable reattach the battery otherwise the on-board clock will reset.

Reassemble the SonarPoint(s).

LED Blink Patterns

Table 1.3

Red LED Blink Pattern (Recording)	
Sample Frequency	Red Blink Rate
(1 blink every) samples 500k/sec	Once every 1 sec
250k samples/sec	2 sec
100k samples/sec	5 sec
50k samples/sec	10 sec

Table 1.4

Green LED (Standby)	
State	Sample Size
Standby Recording begins on acoustic detection or next duty cycle ON phase.	(1 blink every) 16 seconds
Ready-to-go Recording begins on mission start time.	32 seconds
Done with recording	64 seconds

Orange (Dock Mode)

Your SonarPoint will continuously light orange while a connection to MicroMARS Dock software is detected. Make sure to wait until your SonarPoint is orange before connecting the device in MicroMARS Dock.

Deployment

Before deploying your SonarPoint(s) it is critical to consider the purpose of your deployment and which configuration may be the most beneficial to your cause. SonarPoint is deployable as buoy or submerged configurations and may be deployed in singles or arrays.

Buoy Configuration

This type of deployment is useful for both short-term and long-term recording sessions. However, since this configuration has a surface buoy, drift (current speed) should be accounted for. Especially in shallow waters where bottom anchors may become entrenched and subsequently pulled under the surface. In the case of shallow water you have several approaches to prevent buoy submersion. Lighter anchors, shorter line, or deploying and retrieving during slack tides. Otherwise, shorter-term deployments are not as prone (see below).

Short-term

One drifter configuration is deploying buoys when the targeted animal has been spotted in some known location. Once spotted, deployment of the buoy system is rapid, retrieval and repositioning in a relatively short time span is also possible. Therefore short-term use of buoy's yields quick deployment in conjunction with known animal movement. However, this configuration requires a high degree of maintenance and must be attended to for the duration of the deployment. You must also ensure contact with animals while retrieving or moving the SonarPoint is done so responsibly and legally. As a real world reference, deployment, six repositions and retrieval of a four buoy array was accomplished within a four hour time span on an 18' RIB boat. The portability of multi-array systems is therefore highly flexible and easy.

Long-term

Other than short-term deployments, buoy drifters can also be used for larger scale migratory pattern tracking. Buoy systems allow for significantly long operating time due to solar power arrays on top of the buoy. Additionally, time drift (applies to short deployments as well) is not a significant factor as a GPS module in the buoy can remain time synchronized through a '1PPS' signal. You should also consider time of deployment and projected tidal drift in order to retrieve the array; distance between SonarPoint's in an array may also vary due to anchor used and tidal currents.

Thoughts on deploying buoy systems

Buoy configurations are provided by Desert Star for both short and long-term deployments (daily deployments to week long ocean drifter projects). In this configuration, a SonarPoint device is tethered to the buoy surface station via a kevlar cable with a maximum

communication length of 1200 meters. For GPS time synchronization and location data, the buoy has a RPT-1 repeater which also reports recorder status. Use with ARGOS is also possible through compatibility with Desert Stars SATX-1 satellite transmitter.

In order to power the SPT-1 surface buoy, two solar panels (rated at 2W) are installed at the base of the antenna and top of the buoy. In this configuration, the SPT-1 as well as the tethered SonarPoint are powered by both solar panels. If battery power in the SonarPoint reaches a critically low state, the SPT-1 power logic will switch the SonarPoint to OFF and the SPT-1 itself to standby mode. Both devices will remain in such state until the recorder's battery is again sufficiently charged. In such case, the recorder will switch to ON mode and continue the previously defined mission settings. RPT-1 location, time and RF reports will also again be activated.



When deploying a buoy system you should consider how the local tides, boat activity and more will impact your SonarPoint.

- Check local current and tidal information. Be aware of how they change throughout the day.
- Do not deploy where buoys may drift into shallow water. If a buoy becomes submerged, boat to the last known location just before slack tide. The buoy should resurface.
- Deploy arrays in areas with consistent currents, typically away from shoreline so the entire array will drift as one.
- Keep all buoys in short-term deployments in visible range. Typically a visual and radio observer will suffice. High visible materials on the buoy also help.

- Real Time monitoring of buoy position may be done with ‘Mysticetus’

Four buoy array near deployment on a RIB boat.



Submerged Configuration

Submerged array configurations offer more static long-term deployments, at the cost of recording productivity. When deploying your SonarPoint array, one primary factor will be actual animal location. When deploying buoy systems, visual confirmation of animal position is used, however submerged arrays should be placed where animal movement is predicted, however not certain. Submerged units may also be consistently retrieved from the use of Acoustic Releases, which according to a timed response, will bring buoy payloads to the surface, consequently bringing the recorder with it. The benefit to such retrieval is consistency, and avoidance of theft since no surface buoys are present until retrieval. Other anchoring systems and methods of keeping a fixed position are not discussed here.

While buoy systems also remain time synced via cheap but effective GPS modules, submerged arrays are more prone to time drift. Besides the synchronization before deployment, pinger devices may also be used to account for the time difference recieved between recorders. This difference may then be used to account for any additional time drift when analyzing data.

Submerged array setup with acoustic releases (ARC-1's)



Submerged system with ARC-1, and a deck box for signal release.

Retrieval

In this section, you will learn methods to retrieve your SonarPoint(s) and how to retrieve data from your SonarPoint(s) as well as the basics of localizing data through either Ishmael or Audacity.

Physical Retrieval

Depending on which configuration you've chosen (buoy vs. submerged) there are several options for retrieval.

During deployment make sure to note the GPS coordinates of each buoy, as well as anticipate potential drift. When retrieving buoy systems, programs like Mysticetus offer real time tracking of equipment.

With submerged systems, retrieval is more cumbersome, but can be reliably done with the use of an acoustic release. Desert Stars' ARC-1 offers this functionality for retrieval of submerged arrays, further information about Acoustic Releases is available on Desert Star's website : <http://www.desertstar.com/page/arc-1xd> .

Data retrieval

Extract the sd card from your SonarPoint(s). Insert the sd card into your sd card reader then connect to your computer.

Windows will ask what action to take, open the file and copy the contents of the sd card to a backup location.

You are now ready to analyze the recorded data.

Data Localization

When localizing your collected data, several programs may be used, however for this manual, only Ishmael and Audacity will be used as examples. Both programs are free, however Ishmael offers automated localization capabilities at a cost of accuracy. Ishmael uses a signal cross correlation in which signal peaks are correlated as vocalizations. While automated, Ishmael is not capable of well-defined pattern recognition to the degree beyond a 10 meter accuracy (generally speaking). Whereas using Audacity requires manual pattern recognition (takes much longer), but is generally more accurate.

Table 1.5

Program	Price	Automated?	Accuracy (meters)
Ishmael	Free	Yes	± 10
Audacity	Free	No	$\pm 1-3$

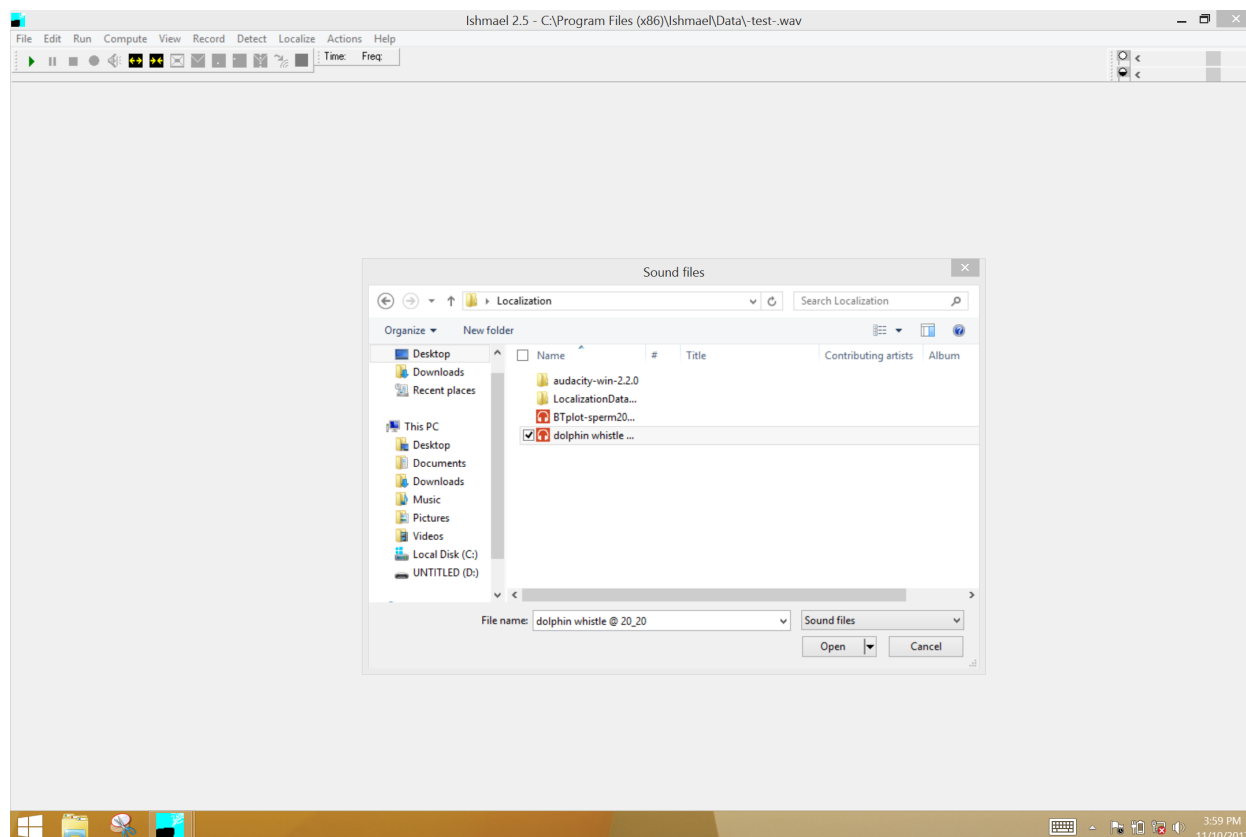
Ishmael

Developed by Oregon State University, Ishmael is an open-access underwater acoustics analysis program. While Ishmael can do more than just localize, this manual will only cover Hyperbolic X-Y Calculation. This method, while most simple is not the only localization method Ishmael offers.

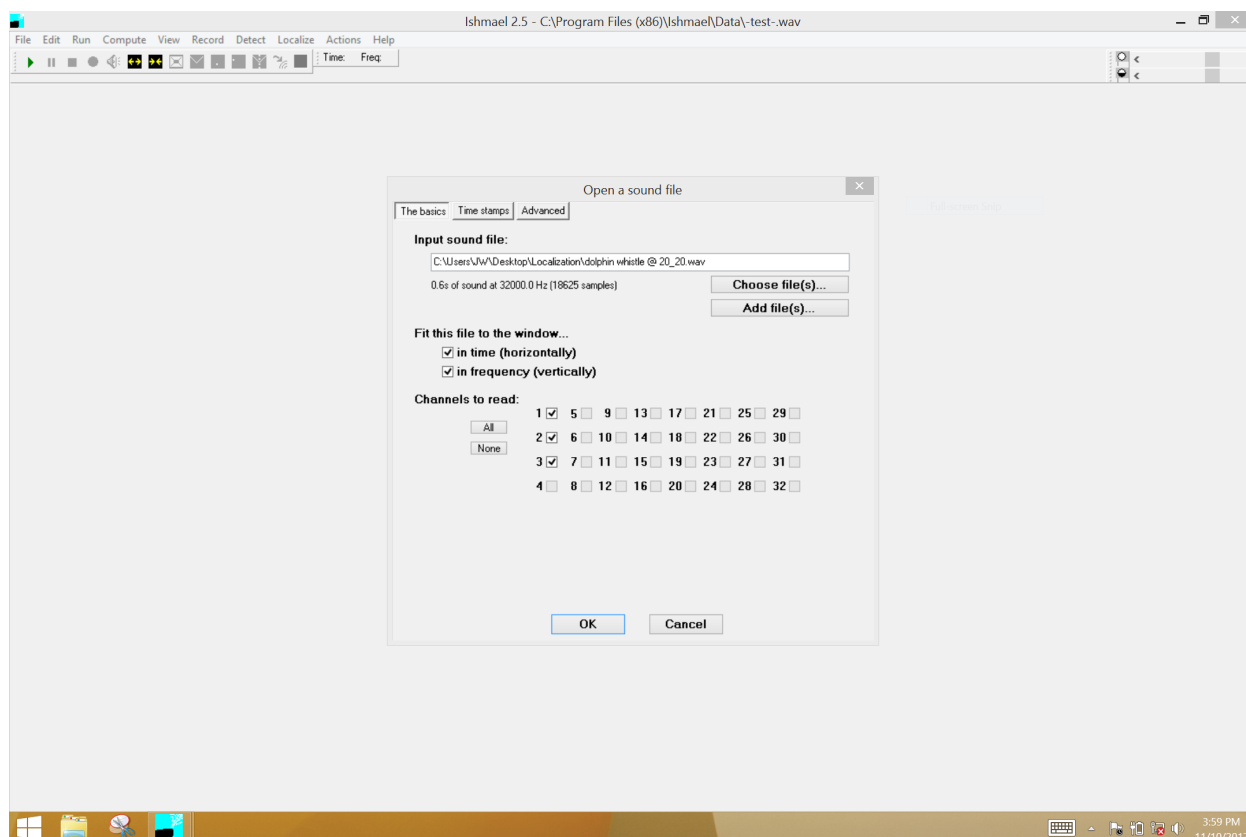
Information and tutorials on localization begin on Appendix 3 (Page 67) of the Ishmael automatic detection workshop manual. For further documentation please see the Ishmael website : <http://bioacoustics.us/ishmael.html>

Begin by opening Ishmael

To open a sound file (.wav format) press 'ctrl+O'. A pop-up window will open, select the .wav file you wish to analyze.



After choosing your file select 'all' for channels to be read. You may also wish to select 'in time' and 'in frequency' for better visual analysis.



Next, select run to process the .wav file. Reference the Ishmael sound workshop manual for further display options.

Now, select localize>loc options>basic info. Select the corresponding .arr (phone array) file. The .arr file contains information on the location of each recorder relative to some origin.

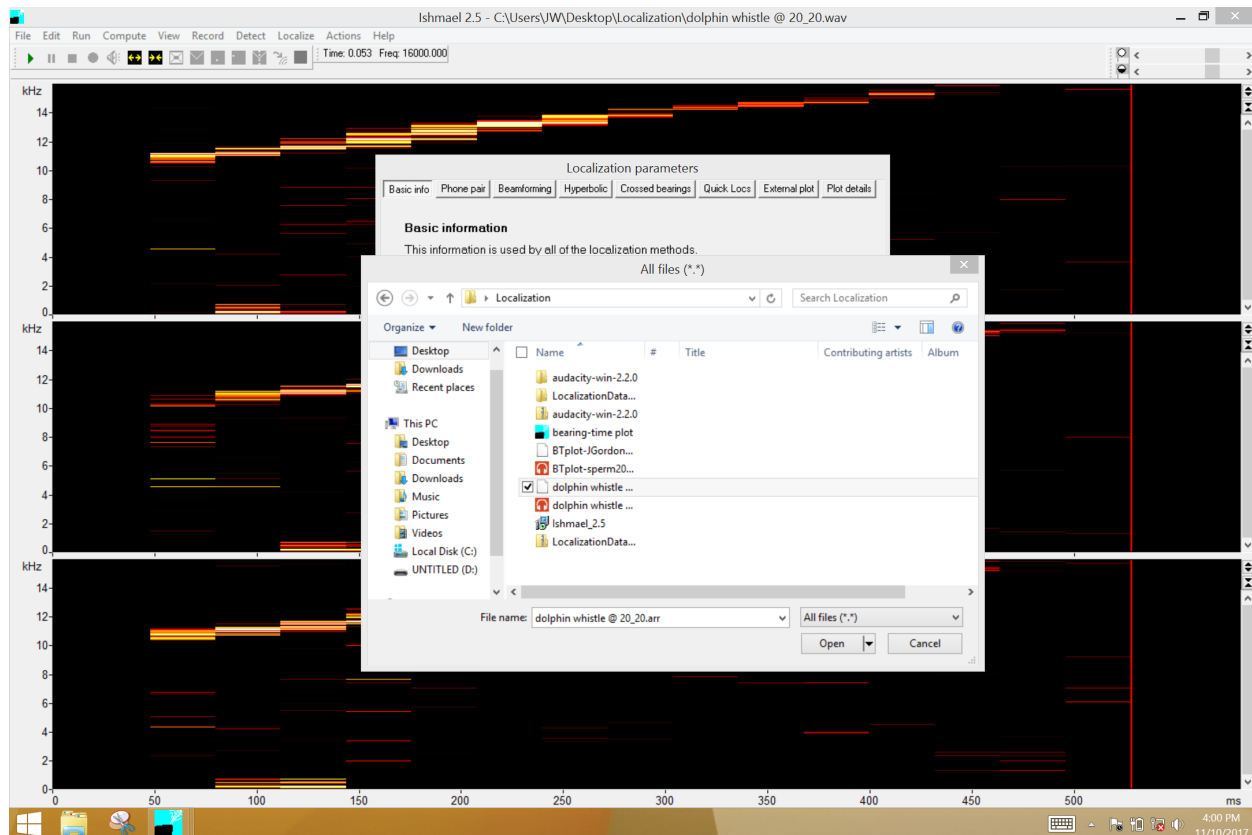
For example, you could designate GPS coordinates in the center of your array as the origin. Then each line should contain X-Y location in meters relative to the origin. Therefore recorder one would be 20 meters to the west and 150 meters north of the GPS origin point.

Ex.

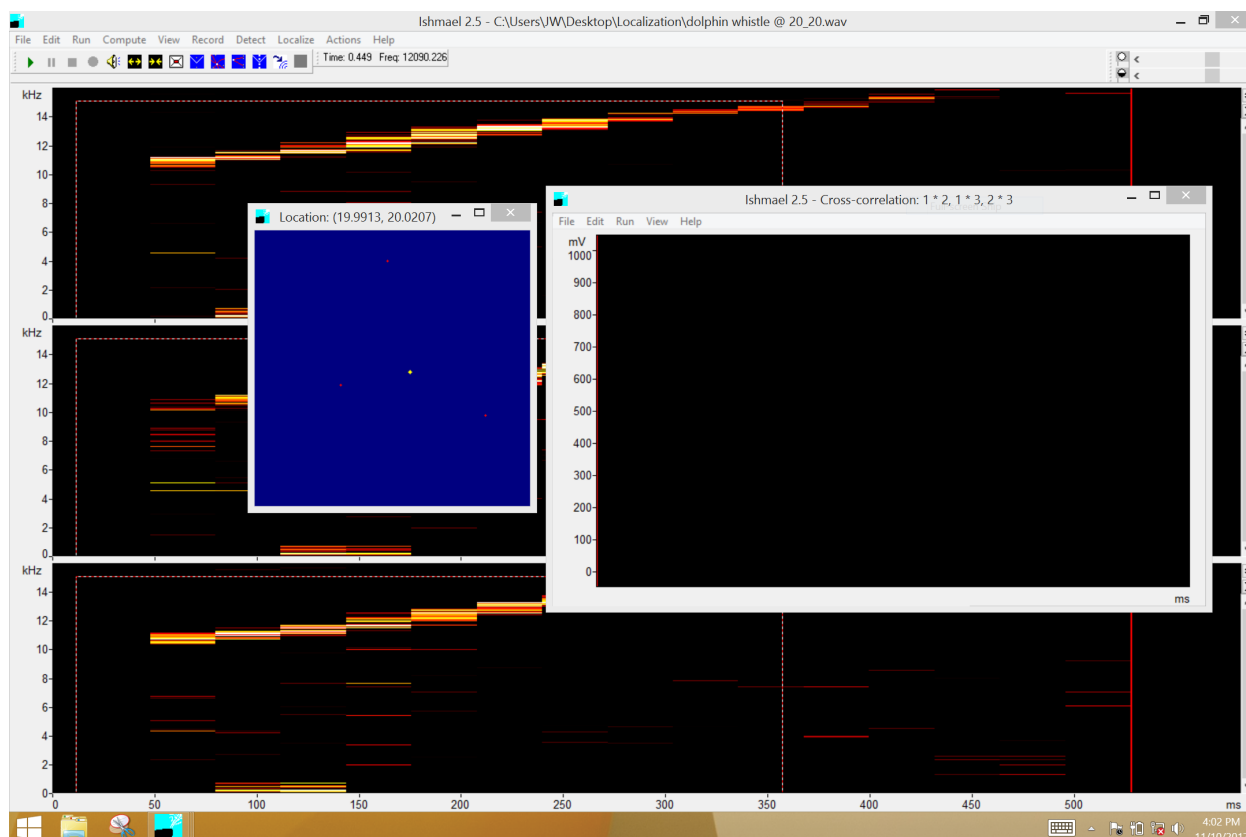
-20 150

100 30

75 -30



Select the 'Hyperbolic' tab, ensure the map area matches your array spacing. Click okay.
Find the tool bar directly under 'file'. Track right until you see the hyperbolic icon and click it.
The yellow icon is the predicted source of vocalization while the red icons represent recorders.



You have now localized a specific vocalization.

Audacity

This method and procedure were authored by Dan Schultz and Marco Flagg.

While Ishmael offers automatic detection, in some instances further accuracy may be required. In this section, you will learn about manual localization using an open-source program called Audacity. Please note, this method is done by manual pattern recognition and therefore requires a higher time investment. However, accuracy by this method is generally more precise than Ishmael.

Step #1:

- Extract the GPS log from each original SonarPoint .WAV file using the gpsvs.exe command line utility. Gpsvs will store the log in a .csv file of the same name.

Step #2:

- Combine all recordings for a given time period into a single multi-channel .WAV file. This can be done in Audacity:
 - Load all recording files into Audacity, by dragging the files into the main window.
 - Select *Edit -> Preferences... -> Import/Export -> When Exporting Tracks to an Audio File -> Use Custom Mix.*
 - Select the *Project Rate* in the lower left corner to be at least as high as the original sample rate.
 - Select File -> Export Audio.

Step #3:

- Identify vocalizations or sounds and measure DTOA in Audacity.
 - Open the localizer_template .csv in Excel or similar, and save as a new .csv with a distinct file name. CAUTION: When editing the .csv file, you must make sure that all pieces of information stay in the same row and column as in the template.
 - Enter the general information in row 7, specifically
 - **Search Boundary (m):** How far the position solution search extends beyond the maximum and minimum northing and easting of the recorder array. If the sound sources are mostly inside the array, use a few hundred meters. You can use a few km as well.
 - **Search Grid Size (m):** The intervals at which candidate positions are tested.
 - **Speed of Sound (m/s):** Specify accordingly, salinity, temperature etc... affect sound speed.
 - **UTM Zone:** All coordinates are in UTM.
 - **Max. Residual Error (m):** This number defines the size of the confidence region for the sound localizations. To obtain the 50% confidence region, specify the square root of the squares of the individual error components. The main error sources are the accuracy of the DTOA measurements, the accuracy of the recorder GPS fix, and the sound speed error as applied over the signal run distance between the sound source and a recorder. For example, assume that DTOA is measured with 1ms accuracy (~1.5m sound travel distance), the GPS fixes in the log have a HDOP (horizontal dilution of precision) of 0.6m, the sound speed error is

0.33% due to a 1 deg C temperature uncertainty, and the array is 500m x 500m translating to about 350m average sound travel distance. The average error in a position fix might thus be $\sqrt{(1.5^2 + 0.6^2 + (0.0033 * 350)^2)} = 1.98\text{m}$. If you specify a larger number, the confidence region will be larger and the probability that the position is within the region will be greater. A small specified residual error draws a tighter region, but equals less confidence that the true position is within that region.

- Enter sound localizations into the localizer spreadsheet, starting at row 9:
 - Enter the sound name in column A. This name will appear in the sound source identification and corresponding recorder positions. Enter a comment describing the sound in column B. This will appear in the pop-up bubble associated with the sound localization.
 - Enter the recorder locations (UTM Eastings and Northings in columns E through J) If a recorder isn't available, or sound not apparent, enter 666 for both Easting and Northing of that recorder. At least three recordings are needed to localize a sound source.
 - Measure DTOA and enter in columns K-P:
 - Experiment if sounds are better identified in the spectral view or the time domain view. Select by clicking on the pull-down box on the left associated with each channel.
 - Find the most distinct feature in each sound, making sure it is apparent in at least three recordings.
 - Left click on the point of the distinct feature in the reference recorder channel, and sweep to the same feature in the secondary recorder.
 - Enter the selection length (in seconds) into the corresponding column for the measured DTOA

NOTE: When using three recordings, enter only two measurements, both relative to one of the three recorders selected as the reference recorder. If using four recorders, three DTOA measurements relating three secondary recordings to a reference recording should be used. Specifying more than these two or three measurements does not provide a benefit and generally introduces an additional measurement error (jitter). Step #4:

- Solve the locations using localizers.exe. You will be prompted for the localizer spreadsheet produced in

Step #4. You then have two options per a second prompt:

- Enter Y to produce the DTOA tracks in addition to the localized sounds, associated confidence regions and associated recorder locations. The file will have the base name, plus _Track.csv
- Enter N to produce the sound localization, associated confidence regions and recorder locations only. The file will have the base name, plus _Map.csv
- The _Map.csv or _Track.csv can now be used for further analysis with any software. Alternatively, proceed to Step #5 for viewing in Google Earth.

Step #5:

- The _Map.csv or _Track.csv file is formatted for conversion to .KML using the Earthpoint on-line service available here:

<http://www.earthpoint.us/ExcelToKml.aspx>

- Note these limitations of Earthpoint:
 - Without a subscription, you will be limited to 200 entries. This is OK for plotting without the DTOA tracks, but you will need to get a subscription (\$5 per month or \$50 per year) to plot the DTOA tracks.
 - Earthpoint is limited to 35000 entries. You may hit the limit if you specified too large a boundary or too small a grid interval size.
- To convert to .KML:
 - Click the **Browse...** button and enter your _Map or _Track file as generated in step #4
 - Click **View on Google Earth**

Further Reading

For more detailed technical review please see the ONR SonarPoint Final Report. In this report, the development of underwater acoustics recorder leading to SonarPoint are discussed. Real-world applications and specific technical information is also available in this document.

For further information on the SonarPoint or other Desert Star products please visit www.DesertStar.com

	<p>desertstar.com +1(831) 384-8000 Made in Monterey Bay CA, USA</p>	<p>Bio-Waves info@bio-waves.net 760-203-2363 biowaves.net</p>
---	--	--