MAC Assessment Tools Workshop

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Vicki Ferrini
Giuseppe Masetti

MAC supported under NSF grant 1933720

https://mac.unols.org

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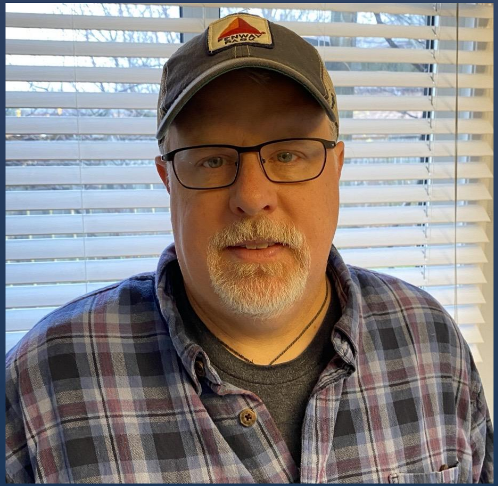

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Data Manager (UNH)

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Vicki Ferrini

Sr. Research Sci. and Assoc. Dir. DEI (LDEO) / Affiliate Assoc. Prof. (UNH)

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Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

Ocean Mapping Community Wiki

github.com/oceanmapping/community/wiki

omcadmin@ccom.unh.edu or mac-help@unols.org

Assessment Tools

kjerram edited this page on Apr 6 · 40 revisions

Overview

Multibeam assessment tools described here include:

1. Swath Coverage Plotter v0.2.3
2. Swath Accuracy Plotter v0.1.0
3. BIST Plotter v0.2.2
4. File Trimmer v0.1.5
5. ECDIS Converter v0.0.3

Distribution

The standalone Python apps are available through several avenues for different users:

1. **Typical users**: each app is packaged with all libraries and zipped for easy download on Google Drive (with version notes).
   i. Just download, unzip, and run the .exe (similar to Sound Speed Manager).
   ii. The zipped packages are not available through GitHub due to file size limits.
2. **GitHub users**: apps and libraries are packaged in the multibeam_tools_distribution repository.
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3. **Python folks**: source code is available in the multibeam_tools repository.

Using the tools

These tools are intended to give users the same plotting and reporting functions used by the MAC for routine performance testing (e.g., sea acceptance trials and quality assurance testing). Currently, only Kongsberg data formats are supported.

Hint: Most of the app features include tooltips; just hover over a button, list, or checkbox to get more information!

Instructions for data acquisition and processing are presented in the following sections. Suggestions are welcome for improving the workflow in each application.

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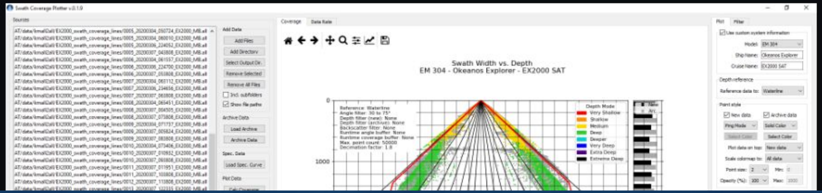


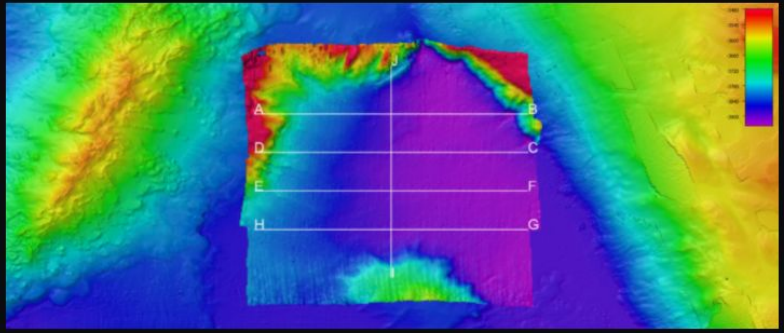
Reference survey acquisition

The reference survey should be planned over relatively flat, benign, homogenous seafloor with slopes no greater than a few degrees. Because the selected depths will likely be used for testing several different modes, the area may also be suitable for backscatter normalization across those modes [wiki development: add link to BS normalization section when complete].

The reference survey lines are planned with a few key considerations:

1. Orientation orthogonal to the crossline (or as a 'grid' if time allows)
   i. This reduces alignment of any swath biases in the reference grid with the crosslines
2. Narrow spacing (e.g., 1 WD) to achieve very high sounding density
3. Length sufficient to cover the full crossline swath width (e.g., 6-8 WD, with buffer for ship handling)
4. Number of reference lines to accommodate desired crossline length
   i. Typically 6-10 reference lines at 1 WD spacing, depending on depth, to yield several hundred crossline pings

Small regions of steeper slopes may be filtered during processing, if present (e.g., the 3900 m reference site off San Diego, below). Likewise, the number of lines may be adjusted to fit the terrain and the schedule.

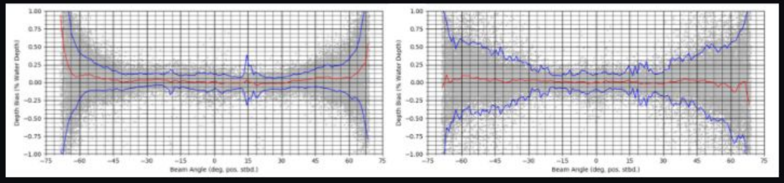


Crossline data acquisition

The primary crossline setting of interest should be the same used for the reference survey; ideally, this is a setting that would be selected automatically by the multibeam system for this depth. This provides a consistent comparison between the 'trusted' bathymetry created from a dense survey and the single-pass crossline(s) for the mode that is intended for this terrain.

As discussed in the planning constraints, there may be several modes of interest that have been grouped for this reference surface depth. Additional crosslines are added as needed and allowed by the ship schedule.

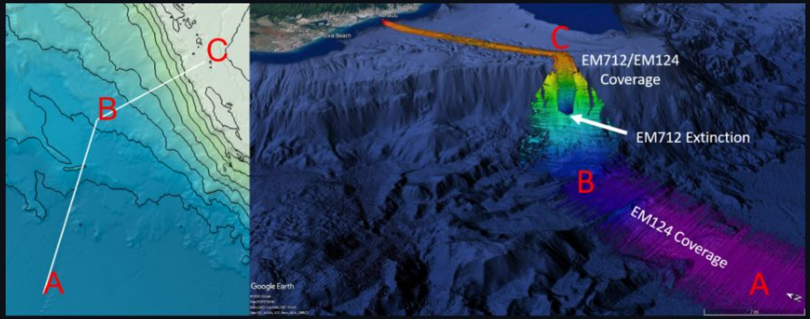
Crosslines are typically run in 'pairs' on opposite headings for each mode to assess any heading-dependent impacts, such as sea state (example below shows accuracy heading with seas and into seas shown on top and bottom, respectively). When seas are calm, this approach also supports deep roll verification using pairs of lines with the same mode and settings on opposite headings over the flat terrain.



Data collection

Ideally, swath coverage test data is collected under vessel operating parameters (e.g., speed, engine lineup, active sensors) that reflects 'typical' mapping configurations. For example, transit data collected at 12 kts with additional engines or generators online may not reflect the flow and machinery noise environment present at a typical mapping speed of 8 kts. Additional acoustic sensors (e.g., a bridge Doppler speed log) may cause interference and outliers in the coverage data that do not represent the standard mapping configuration with those sensors secured. Likewise, highly elevated sea state may not represent suitable mapping conditions.

The MAC recommends acquiring coverage test data at typical mapping speeds (e.g., 8-10 kts) and crossing contours at perpendicular angles wherever possible. Maintaining the ship heading directly up and down the slope is important for reducing coverage biases on either side of the swath that may result from the slope facing toward or away from the system. A coverage test line off HI for the R/V *Roger Revelle* EM124 / EM712 SAT is shown as an example of transiting 'up' and 'down' the major seafloor slopes in order to reduce port / starboard coverage biases across a wide depth range (~100-4000 m). In this example, the transit from waypoint A toward port was routed through waypoints B and C to cross contours more perpendicularly; this small amount of additional transit time produced much more useful data for coverage assessment.



Runtime parameters

The purpose of testing is to let the multibeam system achieve its maximum coverage under the mode it selects automatically for the given depth.

The following settings are generally recommended for Kongsberg EM systems to best illustrate 'automatic' system performance. Vessels that use different parameters during routine mapping should apply those settings where appropriate, aside from the maximum angle, coverage, and depth gates that may inadvertently limit the coverage test data.

Parameter	Recommended	Notes
Depth mode	Automatic	
Dual swath	Dynamic	
FM Transmission	Enabled	Read checkbox carefully [1]
Max angles	75°/75°	70°/70° for some systems
Max coverage	Maximum	Varies by model
Depth limits	As needed	Adjust as needed[2]
TX power	Maximum	0 dB

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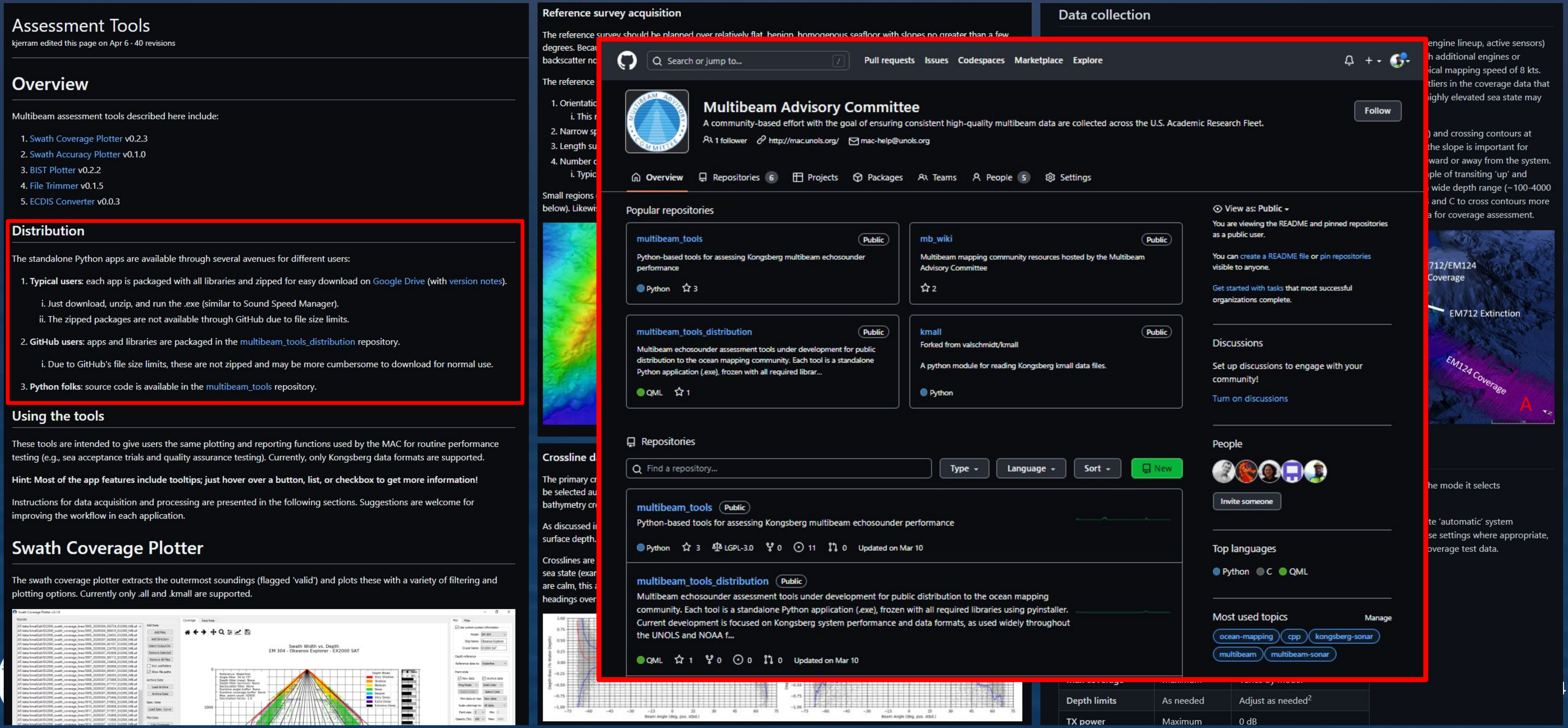

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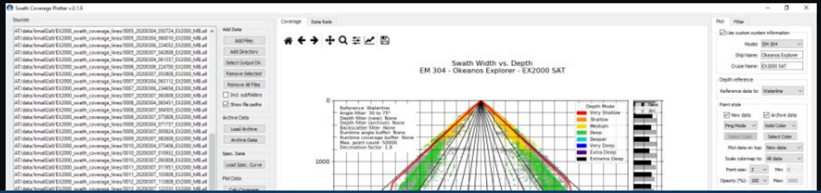

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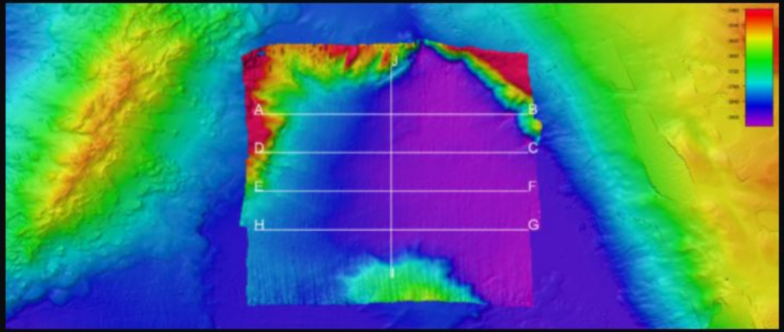

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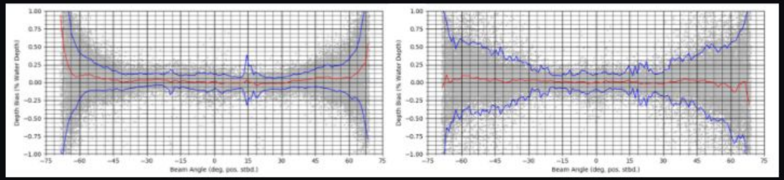

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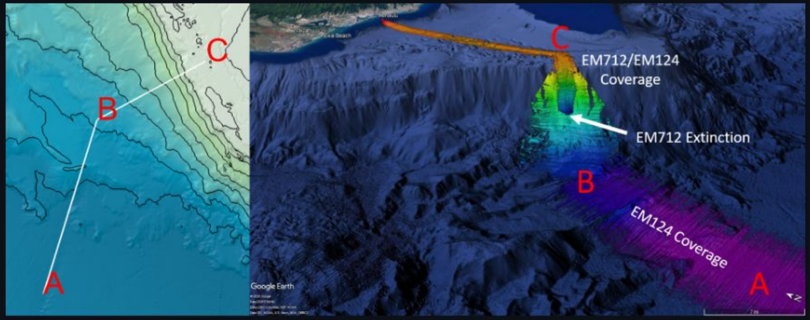

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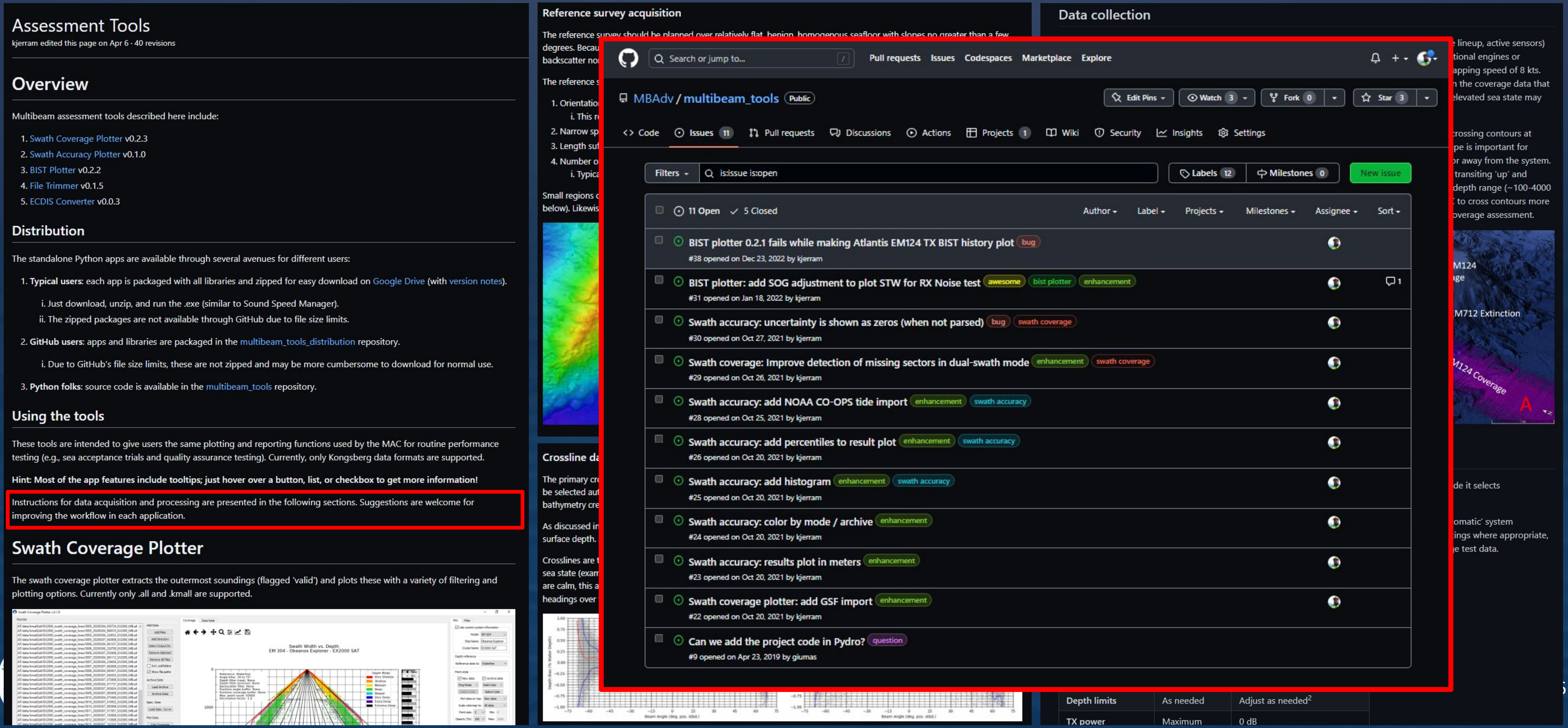

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MBAdv / multibeam_tools Public

Code · Issues 11 · Pull requests · Discussions · Actions · Projects 1 · Wiki · Security · Insights · Settings

Filters · is:issue is:open · Labels 12 · Milestones 0 · New issue

11 Open ✓ 5 Closed

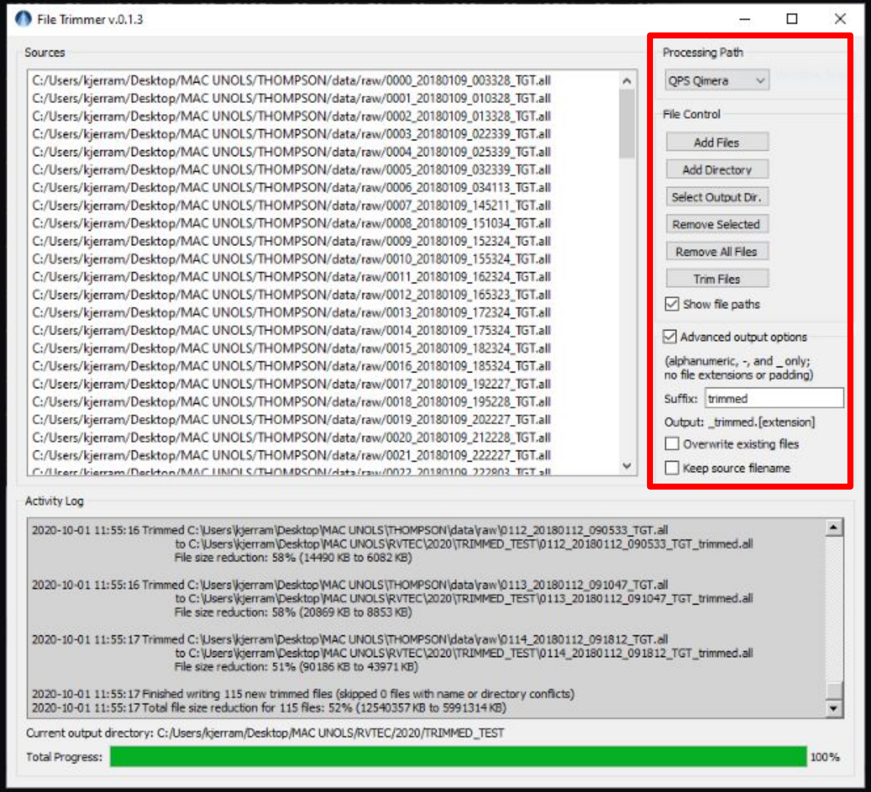
- BIST plotter 0.2.1 fails while making Atlantis EM124 TX BIST history plot `bug` — #38 opened on Dec 23, 2022 by kjerram
- BIST plotter: add SOG adjustment to plot STW for RX Noise test `awesome` `bist plotter` `enhancement` — #31 opened on Jan 18, 2022 by kjerram
- Swath accuracy: uncertainty is shown as zeros (when not parsed) `bug` `swath coverage` — #30 opened on Oct 27, 2021 by kjerram
- Swath coverage: Improve detection of missing sectors in dual-swath mode `enhancement` `swath coverage` — #29 opened on Oct 26, 2021 by kjerram
- Swath accuracy: add NOAA CO-OPS tide import `enhancement` `swath accuracy` — #28 opened on Oct 25, 2021 by kjerram
- Swath accuracy: add percentiles to result plot `enhancement` `swath accuracy` — #26 opened on Oct 20, 2021 by kjerram
- Swath accuracy: add histogram `enhancement` `swath accuracy` — #25 opened on Oct 20, 2021 by kjerram
- Swath accuracy: color by mode / archive `enhancement` — #24 opened on Oct 20, 2021 by kjerram
- Swath accuracy: results plot in meters `enhancement` — #23 opened on Oct 20, 2021 by kjerram
- Swath coverage plotter: add GSF import `enhancement` — #22 opened on Oct 20, 2021 by kjerram
- Can we add the project code in Pydro? `question` — #9 opened on Apr 23, 2019 by giumas

File Trimmer

File Trimmer

github.com/oceanmapping/community/wiki/Assessment-Tools

File Trimmer



Purpose

Reducing file sizes and increasing data transfer speeds can be critical for effective remote support and shoreside processing. The File Trimmer identifies datagram types that are unnecessary for a chosen processing path (limited to Qimera or Caris at present) and writes a new file excluding these datagrams.

Depending on ping rate and datagram types being logged, users operating in deep water (several thousand m) have achieved nearly 90% reductions in file sizes by trimming and zipping files for transfer.

Warnings

The File Trimmer has several precautions built in to prevent accidentally writing over the original raw data.

These precautions include:

1. Requiring a different output directory
   i. Preventing output to the 'source' location
   ii. Skipping any 'source' files found with the same name in the output location
2. Requiring the user to explicitly allow overwriting existing files with the same name,
3. Warning the user when the original file name must be maintained (but not allowing the overwrite option)

Despite these barriers, there are always creative ways to overwrite the original raw data.

It is ultimately up to the user to select output file naming schemes and locations that protect the original raw data.

Keeping source file names

The user must anticipate whether the remote processing project on shore will ultimately reference the raw data after download from the ship in port. If so, the project's source file names (typically) must match exactly, as only the file location and not the file name can be updated (e.g., 'Find New File Location' in Qimera).

The File Trimmer can preserve the original file names in order to support this approach, with certain other precautions in place, and assuming the user is protecting the raw data. See the pop-up windows that appear when the 'Keep source filename' option is checked.

.KMALL conversion

The File Trimmer currently supports .all (SIS 4) file format only.

SIS 5 users can convert .kmall files to .all with the conversion app provided by Kongsberg, and then run the converted .all files through the File Trimmer for a significant reduction.

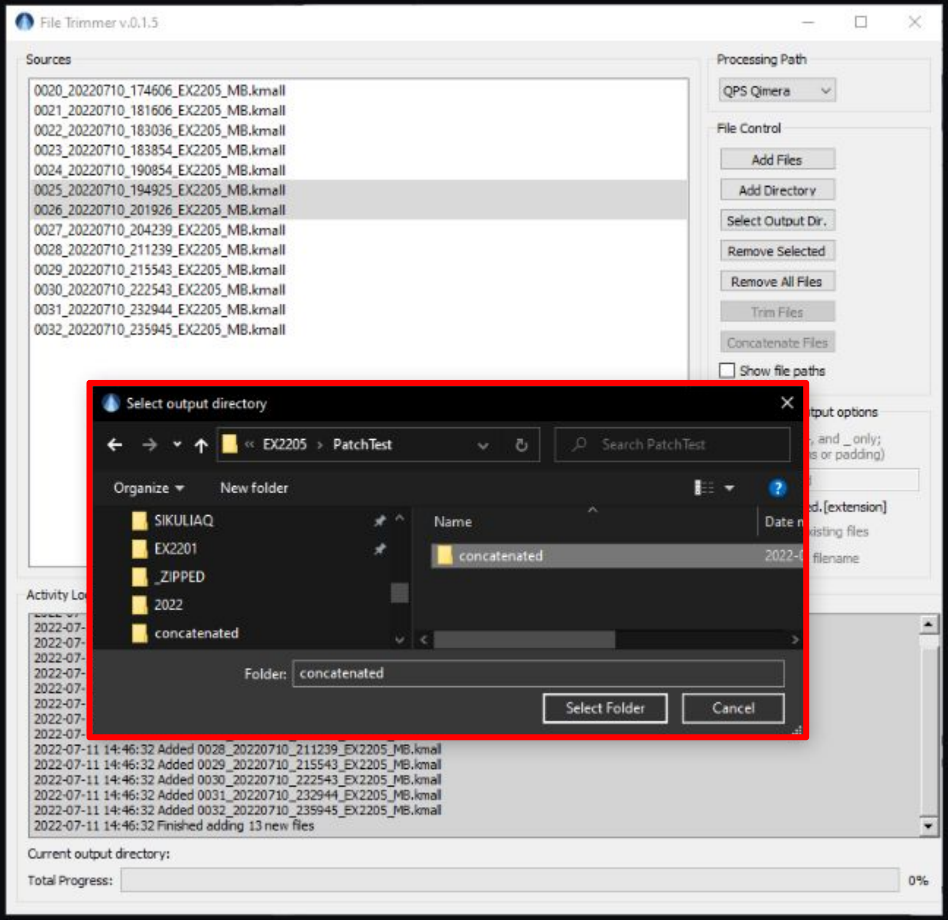
Note that, at present, a processing project developed on shore with converted and trimmed *.all* files **cannot** be re-pointed toward the original *.kmall* files.

File Trimmer

github.com/oceanmapping/community/wiki/Assessment-Tools

Output Directory

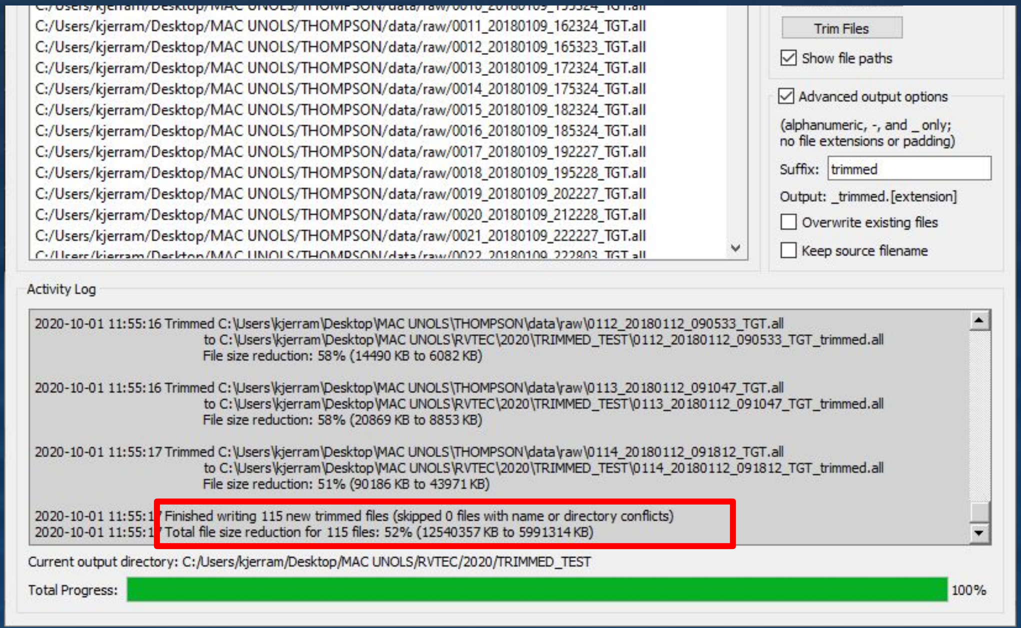
To avoid writing over the input files, the user must select an output directory that is different from the source directory. The Trim Files and Concatenate Files buttons will be disabled until an output directory is specified.



Trimming files

To trim .all files:

1. Add files or a source directory
2. Select the output directory
3. Select and advanced options, if desired
   i. The pop-up windows will describe the tradeoffs of each option
4. Select Trim Files; all loaded files will be processed
5. Review the trimmed files in your selected output folder



Lamont-Doherty Earth Observatory
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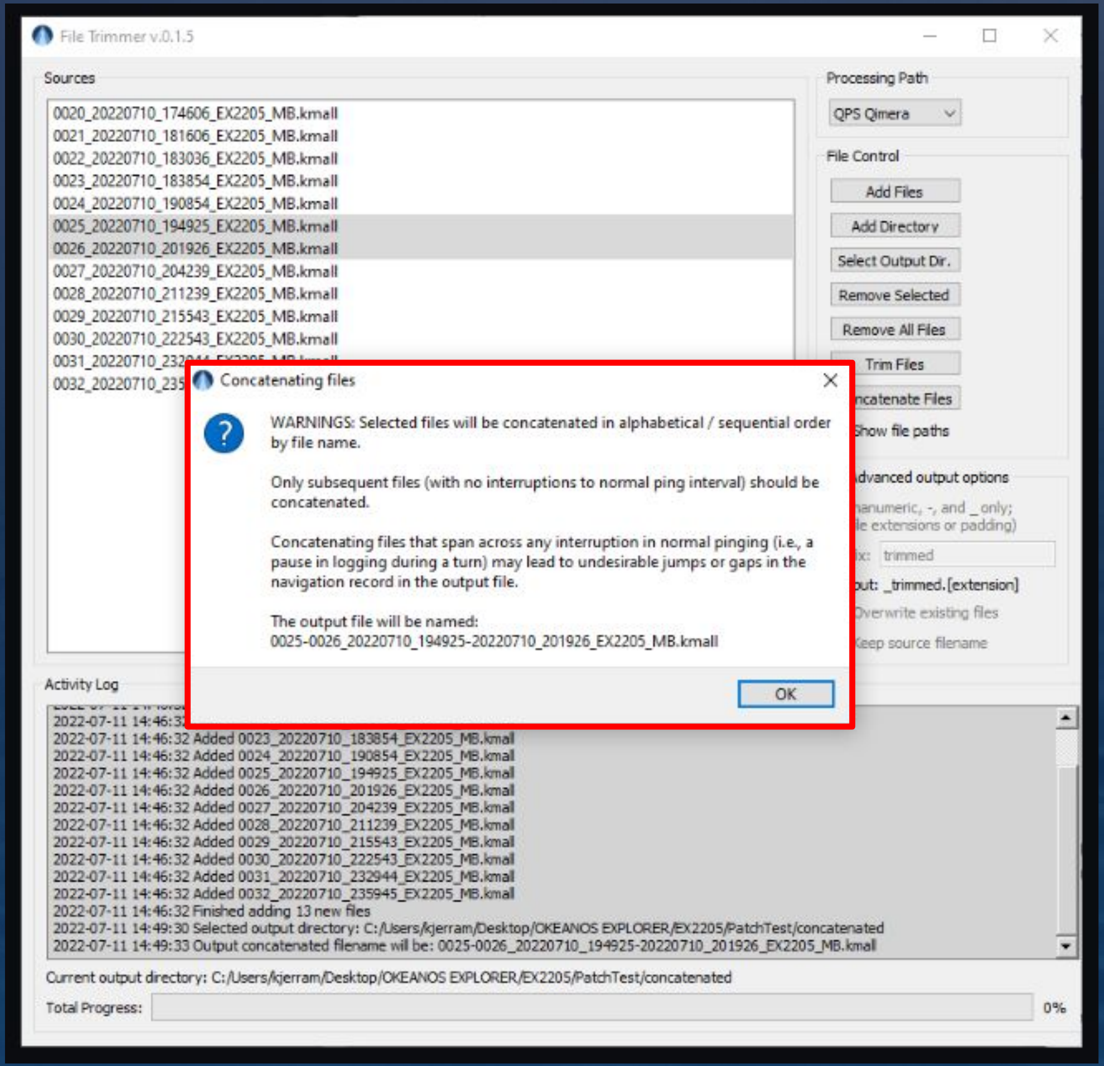
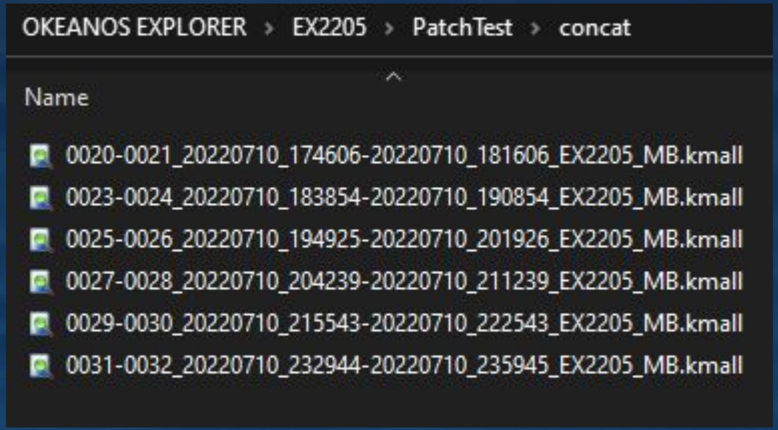


Concatenating files

The File Trimmer includes an option to Concatenate Files (.all and .kmall). This is especially helpful when files have been incremented or split at an inconvenient time during acquisition, such as in the middle of a calibration file (e.g., processing calibration data may be easier with a single file for each pass).

To concatenate .all or .kmall files:

1. Add files or a source directory
2. Select the output directory
3. Select the files to be concatenated
   i. Note: files must be highlighted to be concatenated
   ii. Files should be sequential, incremented in SIS during acquisition with no time gaps
   iii. Files with time gaps between them should not be concatenated!
4. The pop-up window will indicate the new unique file name for output, including file numbers and date / time range.
   i. It is assumed that files are sequential, and will be ordered by file name (e.g., default file numbering scheme by SIS: NNNN_YYYYMMDD_hhmmss_...)




BIST Plotter

Built-In Self-Test Plotter

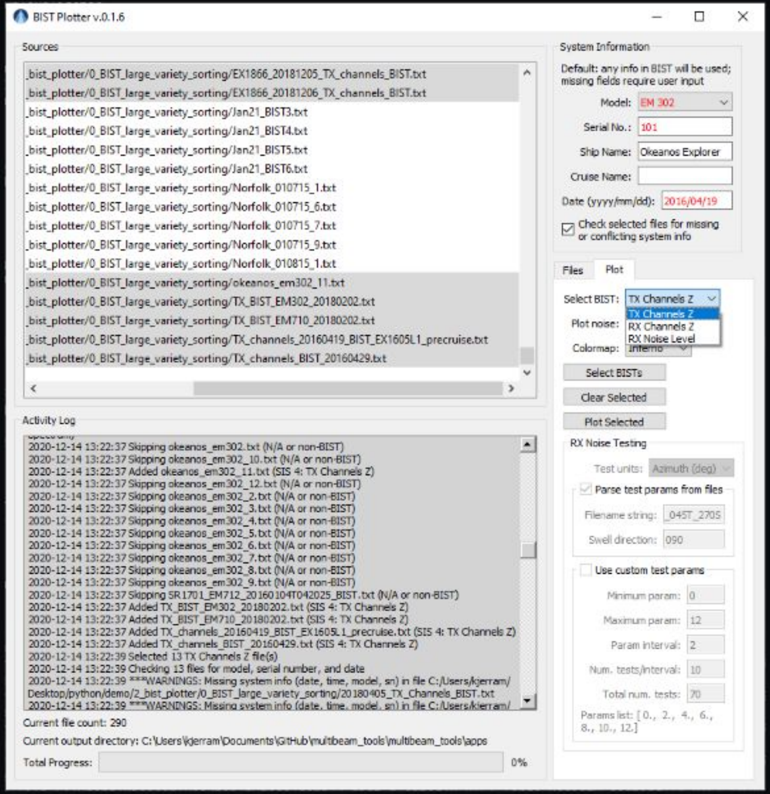
BIST Plotter

The Built-In Self-Test (BIST) plotter currently supports three types of testing:

1. TX Channels
2. RX Channels
3. RX Noise Level

Collecting BISTs describes BIST logging in general, whereas specific acquisition steps for each test type are detailed in their respective sections.

Likewise, Plotting BISTs provides an overview of plotting steps; the individual test sections include more details.



Collecting BISTs

The BIST menu is accessed through the Installation Parameters.

SIS 4	SIS 5
	

Be aware of certain features / limitations for SIS 4 and SIS 5 and consult each test section below for recommendations on acquisition.

1. When collecting BISTs for plotting, make sure to **Clear** all previous BISTs with the **Clear BIST** button.
2. BISTs can be run individually or with the **Run All BISTs** option.
   i. For instance, it is good practice to **Run All BISTs** after system startup and prior to survey
3. **Save** the results to text files with a logical naming scheme, such as *YYYYMMDD_hhmm_BIST_Vessel_EM999_TestType.txt*.
   i. Tests are usually saved by default in sisdata\common\bist
      a. There may be multiple *sisdata* directories, each with different purposes!

SIS 4

SIS 4 supports one test at a time, which is sufficient for TX and RX Channels.

For RX Noise testing, it is often desirable to have multiple BISTs for each speed or vessel parameter. This requires clicking the test button for each run, after which all tests may be saved to a single text file. Make sure to clear all BISTs in the SIS menu after saving the text file to avoid appending multiple test series to each successive text output.

[For collecting repeat series of 10-20 RX Noise and RX Spectrum BISTs in SIS 4, please contact the MAC for an AutoBIST script.]

Warnings

SIS 4 does not log TX Channels in the BIST text output. SIS 4 will run the TX Channels test, but the results are not logged. SIS 4 TX Channels collection describes how to log SIS 4 TX Channel data to a text file for plotting.

SIS 5

SIS 5 provides a "continuous tests" option (toggle button) that is particularly useful for RX Noise testing.

This option is not typically used for TX or RX Channels.

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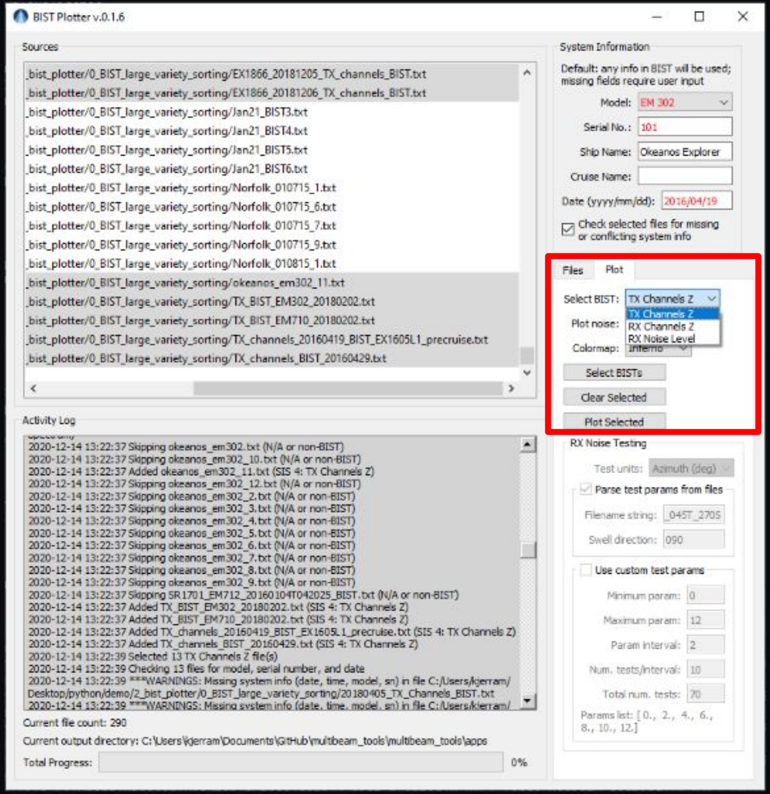

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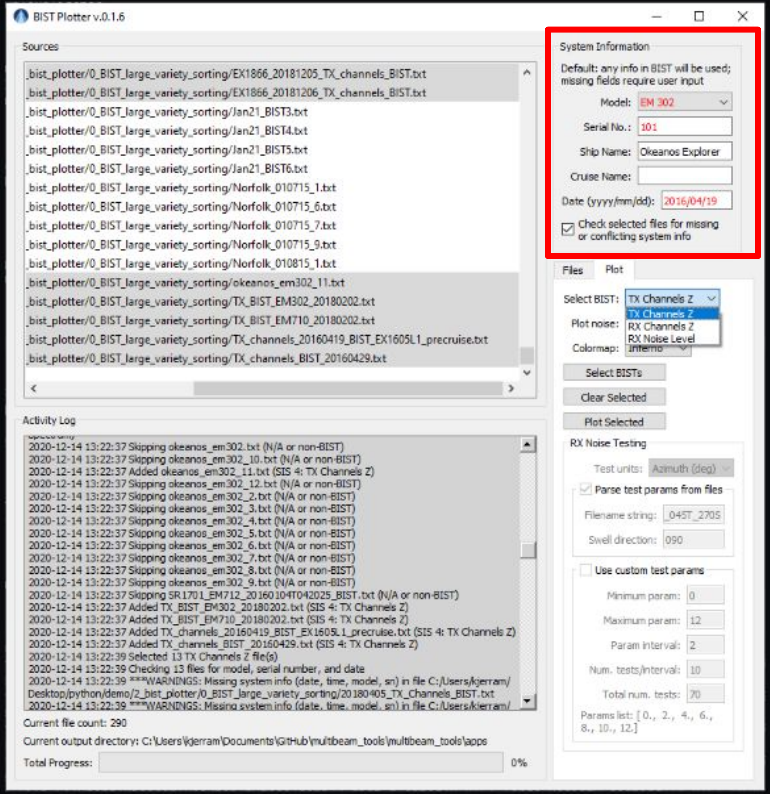
BIST Plotter

The Built-In Self-Test (BIST) plotter currently supports three types of testing:

1. TX Channels
2. RX Channels
3. RX Noise Level

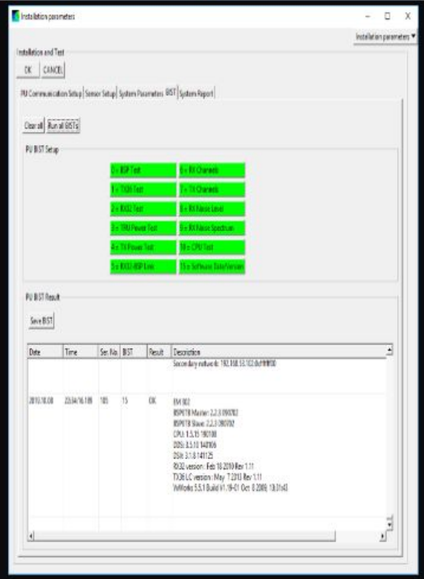
Collecting BISTs describes BIST logging in general, whereas specific acquisition steps for each test type are detailed in their respective sections.

Likewise, Plotting BISTs provides an overview of plotting steps; the individual test sections include more details.



Collecting BISTs

The BIST menu is accessed through the Installation Parameters.

SIS 4	SIS 5
	

Be aware of certain features / limitations for SIS 4 and SIS 5 and consult each test section below for recommendations on acquisition.

1. When collecting BISTs for plotting, make sure to **Clear** all previous BISTs with the **Clear BIST** button.
2. BISTs can be run individually or with the **Run All BISTs** option.
   i. For instance, it is good practice to **Run All BISTs** after system startup and prior to survey
3. **Save** the results to text files with a logical naming scheme, such as *YYYYMMDD_hhmm_BIST_Vessel_EM999_TestType.txt*.
   i. Tests are usually saved by default in sisdata\common\bist
      a. There may be multiple *sisdata* directories, each with different purposes!

SIS 4

SIS 4 supports one test at a time, which is sufficient for TX and RX Channels.

For RX Noise testing, it is often desirable to have multiple BISTs for each speed or vessel parameter. This requires clicking the test button for each run, after which all tests may be saved to a single text file. Make sure to clear all BISTs in the SIS menu after saving the text file to avoid appending multiple test series to each successive text output.

[For collecting repeat series of 10-20 RX Noise and RX Spectrum BISTs in SIS 4, please contact the MAC for an AutoBIST script.]

Warnings

SIS 4 does not log TX Channels in the BIST text output. SIS 4 will run the TX Channels test, but the results are not logged. SIS 4 TX Channels collection describes how to log SIS 4 TX Channel data to a text file for plotting.

SIS 5

SIS 5 provides a "continuous tests" option (toggle button) that is particularly useful for RX Noise testing.

This option is not typically used for TX or RX Channels.

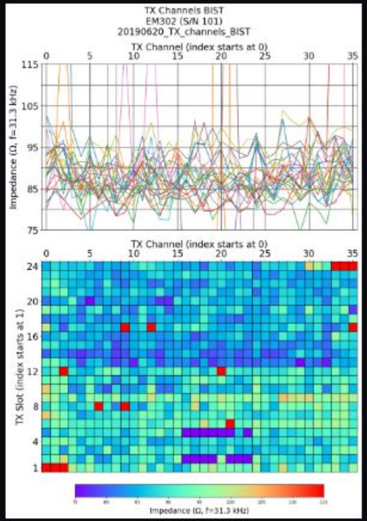
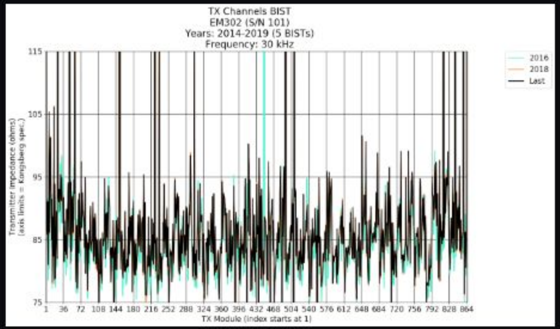
BIST Plotter: **TX and RX Channels**

TX and RX Channels

TX Channels and RX Channels data can be used as **proxies** for hardware health, such as identifying and tracking channels with abnormally high impedance (open circuit) or low impedance (short circuit). These BISTs are NOT a substitute for direct impedance analyses of transducer elements, which may reveal other modes of degradation outside the scope of TX and RX Channels BISTs.

These tests can be particularly helpful in troubleshooting the source of impedance anomalies (e.g., high or low values moving with a card that is relocated in the TRU or remaining associated with a particular module / cable).

Example TX Channels plots for a single test and history of tests (2014-19) for one system are shown below. These plots illustrate increasing numbers of element failures over time, despite consistent average impedance trends for the 'good' elements. (This TX array was replaced after 11 years in service.)

TX Channels BIST	TX Channels history
	

Note that TX Channels tests have been observed to fail in 'shallow' water (e.g., in port). In this case, the test should be repeated in 'deep' water (e.g., >500 m).

SIS 4 TX Channels Logging

TX Channels tests can be run from the SIS BIST menu, but results are not logged to the text output. Experienced users can follow the SIS 4 TX Channels Logging instructions to record these tests from a telnet session.

SIS 5 TX Channels Logging

TX Channels tests can be run and logged from the SIS 5 BIST menu.

Instructions for Kongsberg EM Multibeam Echosounder

TX Channels Testing (SIS 4)

Multibeam Advisory Committee

2021 Jan 28

Warning

This procedure involves a tel
environment, should be perfo
below includes exporting the

Purpose

Poor transmitter performance
limits swath width, and can s
performance may not be rea
slow pace of degradation, bu

The general health of a Kong
measure proxies for impedan
array. When monitored routi
owners/operators of degradi

Multibeam performance asse
time, are available at http://m
data from the UNOLS fleet a
testing aboard other vessels

Note that the TX Channels B
this is useful for tracking gen
measure element impedance

Collect TX Channels

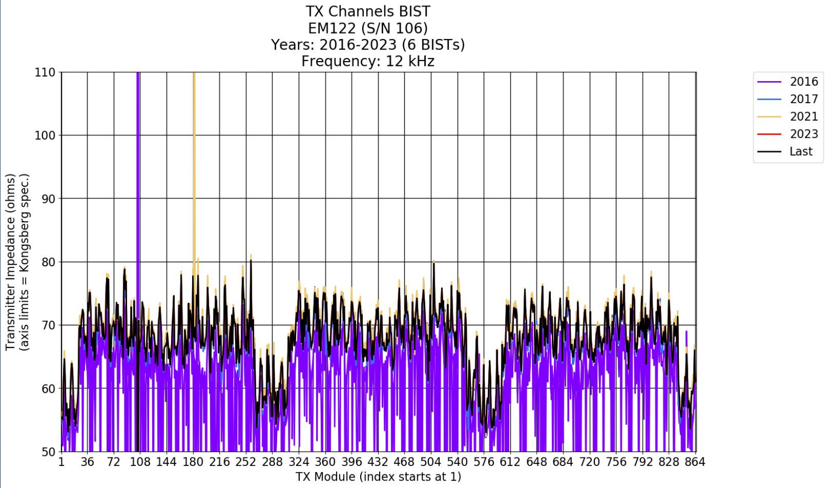
The routine suite of BISTs ru
does not record the results i
record the results to a text fil
voltage is an indicator of ele
which may result from cycling

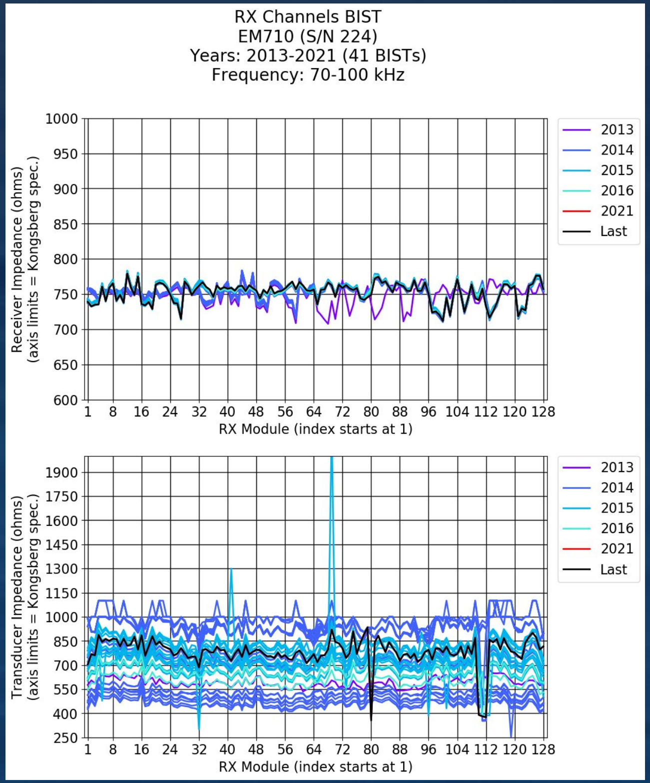
1. **Ensure TRU is ON**
2. **Open SIS, scan for echosounders, and load the appropriate echosounder**
3. **Ensure pinging is stopped**
4. **Export PU Parameters file**
   a. File Export PU Parameters Save to ...\sisdata\common\pu_param
   b. Use a consistent file naming strategy including the date or cruise name
5. **Open the command prompt**
   a. Start type 'cmd' and hit ENTER
6. **Type 'telnet –f TX_channels_BIST_[date in YYYYMMDD].txt [TRU IP address]' and hit ENTER**
   a. **Typical TRU IP addresses:**
      i. **EM122 and EM302: 157.237.14.60**
      ii. **EM710: 157.237.2.71**
7. **Type 'bist' and hit ENTER**
   a. Note: disregard any interruptions of 'P40 – update parameter' and keep typing
   b. Next: keep track of which test has been requested/completed
8. **Type '30' (i.e., for TX channels slot 1-5) and hit ENTER**
   a. Do not touch any other keys
   b. Wait for the BIST to finish
   c. Continue only after the BIST menu pops up
   d. **Repeat a. through c. during each of the remaining tests**
   e. **The number of TX Channels tests available in the BIST menu will depend on the number of TX modules; ensure that all tests are run in order**
9. **Type '31' and hit ENTER (i.e., slot 6-10)**
10. **Type '32' and hit ENTER (i.e., slot 11-15)**
11. **Type '33' and hit ENTER (i.e., slot 16-20)**
12. **Type '34' and hit ENTER (i.e., slot 21-24)**
13. **If the BIST menu includes additional TX Channels tests (beyond test number '34' or slot 24), then complete those tests in order, as above, before continuing**
14. **Type '-1' and hit ENTER to quit**
15. **Close the command prompt or type 'exit' and hit ENTER**
16. **Move the output text file from C: to a suitable BIST directory (e.g., ...*\sisdata\common\bist)***

BIST Plotter: **TX and RX Channels**

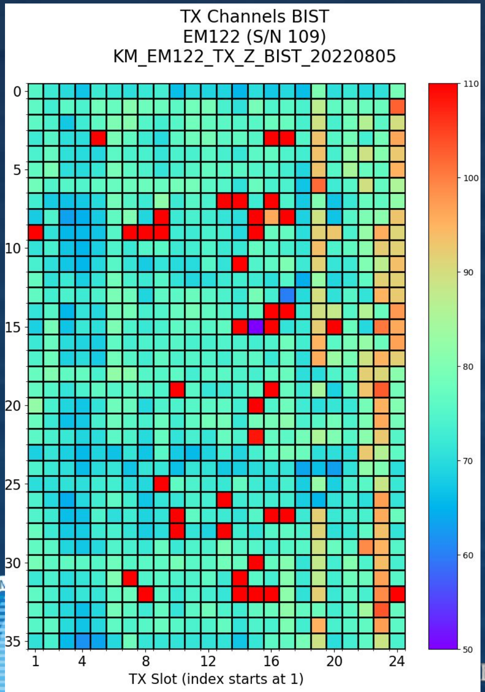
1. Verify all channels pass during SAT
2. Track failures of individual channels
3. Monitor general trends across the arrays
4. Plan direct impedance measurements

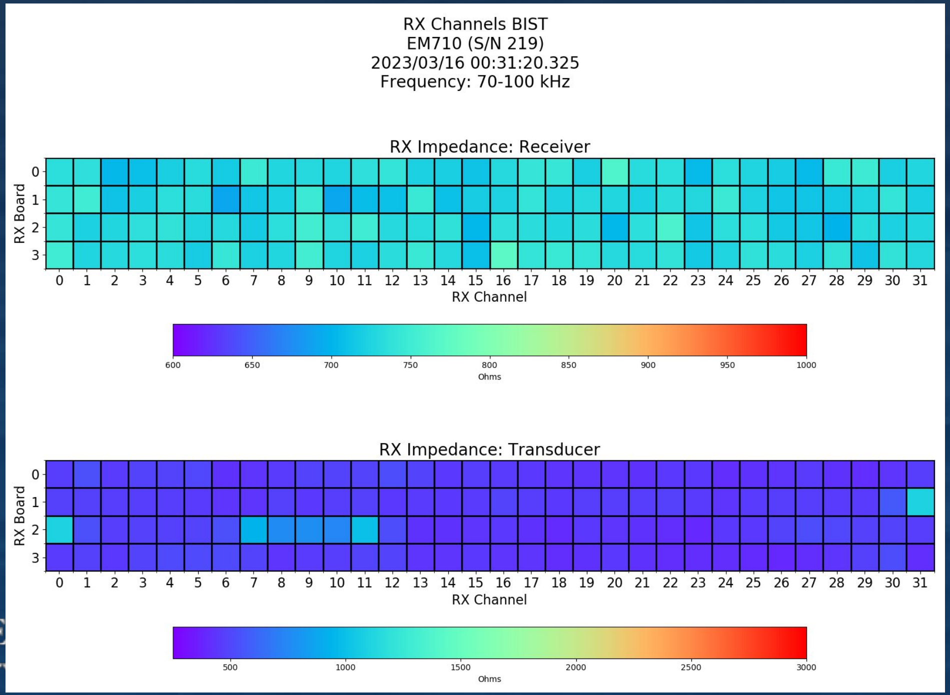
TX and RX Channels history





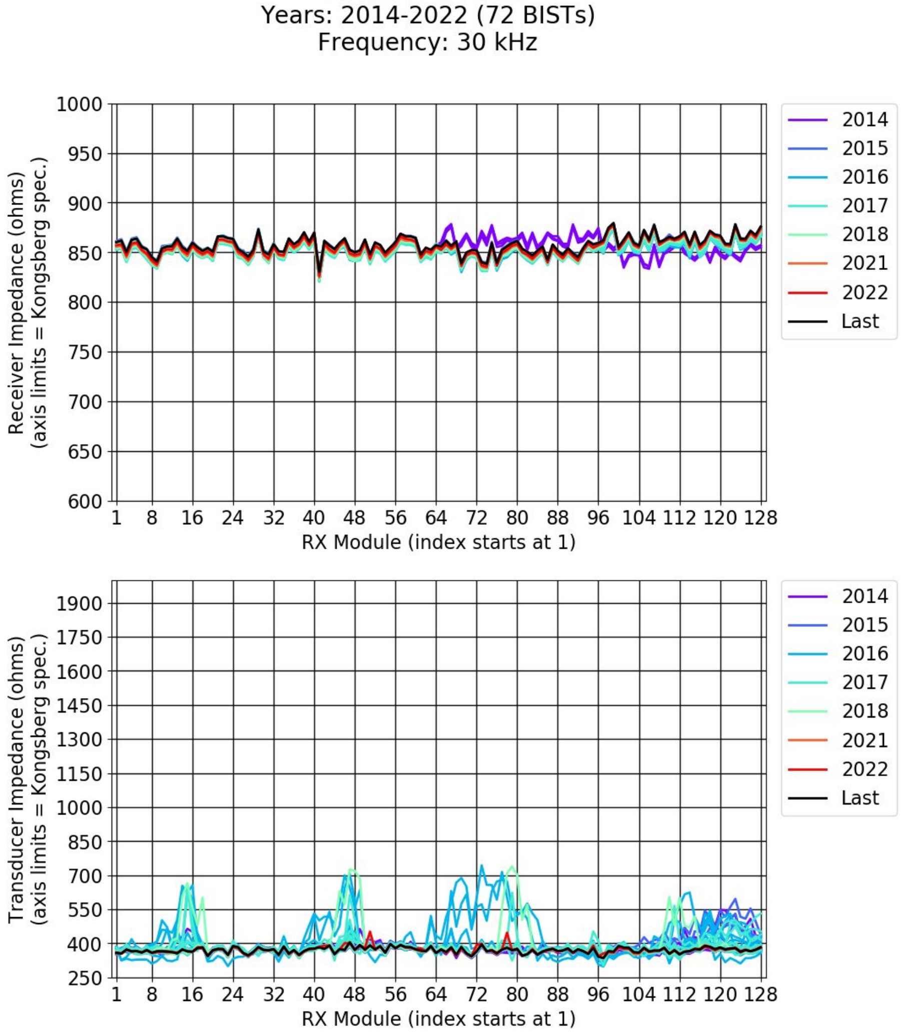
Single TX and RX Channels BISTs

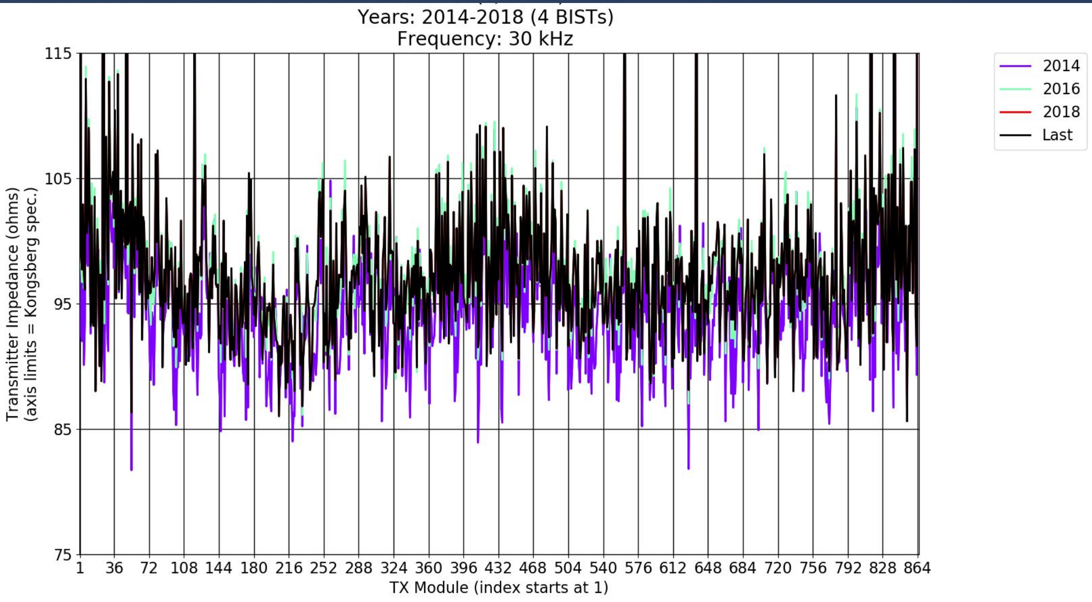


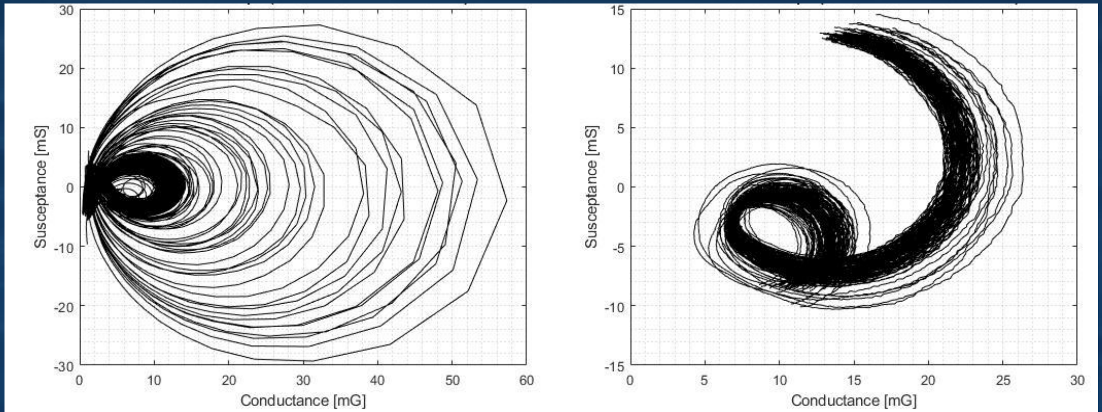


Example from the Field: **Hardware Health**

- Routine BIST monitoring is extremely useful for tracking **general system health**
- **Direct impedance analysis** is critical; some element-level trends not reflected in BISTs

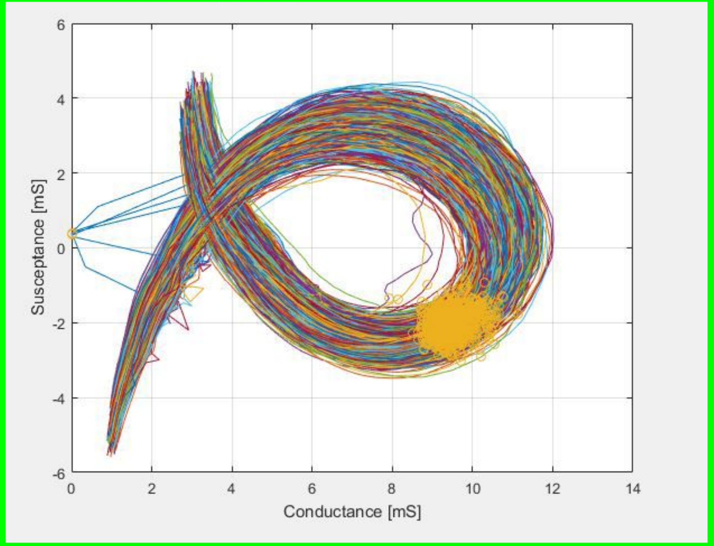




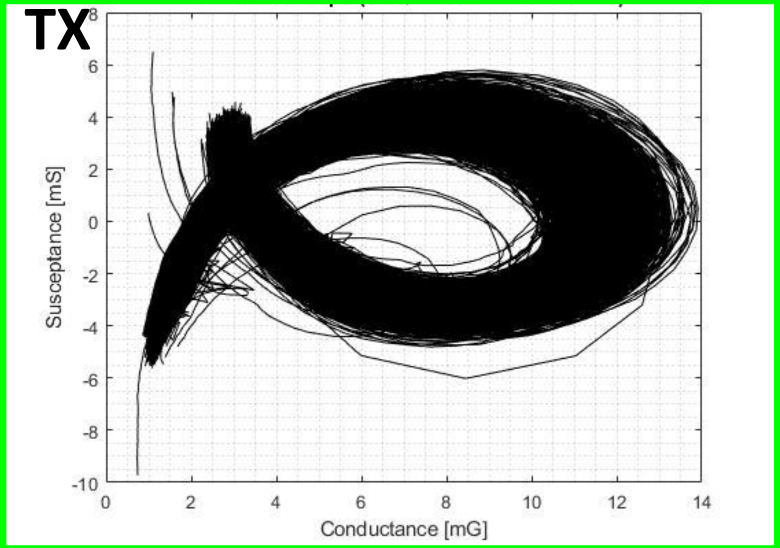


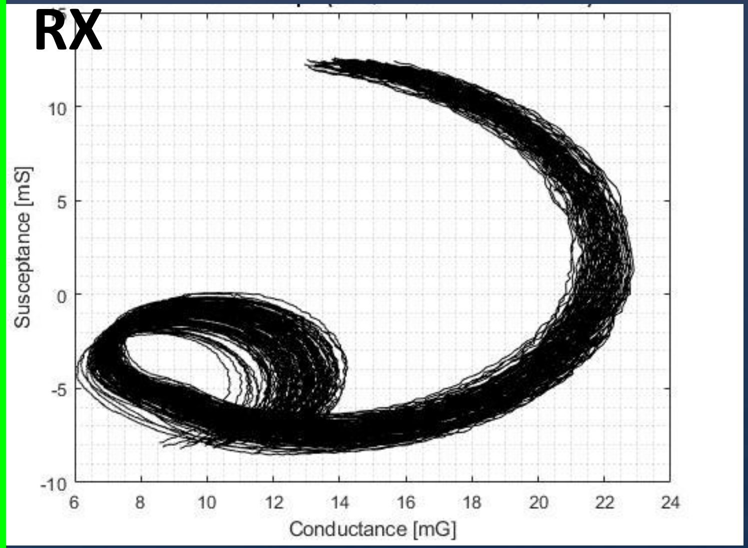
Example from the Field: **Hardware Health**

‘Healthy’ EM302 TX (**Kongsberg**)

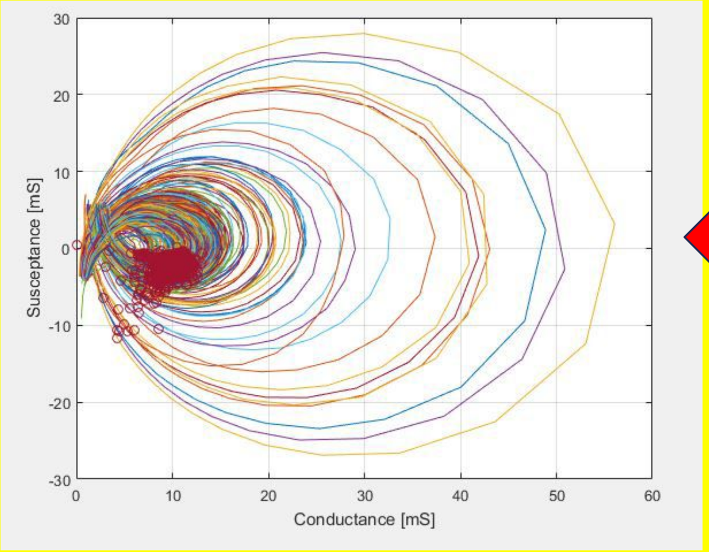


UNOLS EM302 (2020, 6 yrs)

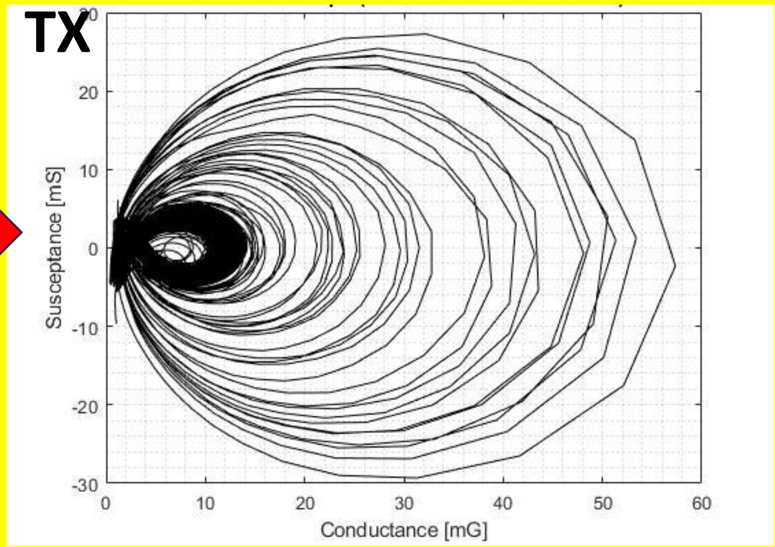


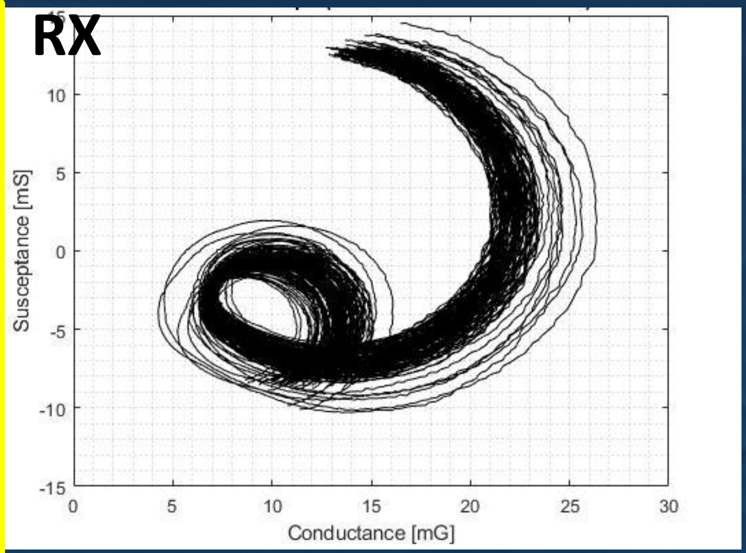


‘Failing’ EM302 TX (**NOAA**, 12 yrs)



UNOLS EM302 (2022, 8 yrs)





BIST Plotter: **RX Noise Levels**

1. Evaluate noise trends vs. speed and sea state
2. Pre- and post-shipyard noise check

RX Noise vs. other parameters

RX Noise data can be collected to assess other parameters, and the BIST Plotter provides some support for standard test parameters that can be appended to the file names (see parameter drop-down menu in the BIST Plotter for examples and tool tips).

Test parameters not directly supported by the BIST Plotter (i.e., listed in the drop-down menu) may still be examined by logging individual BIST files for each parameter of interest. These files may include multiple BISTs, but each file should represent a unique parameter or configuration and the user will need to ensure good note-taking for each BIST file.

If the BIST plotter does not support a particular test parameter, the BIST files may still be plotted individually for comparison (e.g., with custom system information or plot titles). Please reach out to the MAC with requests (and examples) for other test parameters.

SIS 4 RX Noise Logging

RX Noise logging in SIS 4 can be done through manual logging or with an AutoBIST script.

Manual logging

Any number of BISTs can be run and logged sequ
test and wait for it to complete before starting th

AutoBIST

The MAC can provide an 'autoBIST' Windows scrip
RX Spectrum tests and log the results to a BIST te
Plotter app. Please contact the MAC for these scri

There is one .wsf file for RX Noise and one .wsf fil
TRU, request the appropriate BISTS, and log the r

It is imperative that no other keys or buttons are
interruption will interfere with the telnet session a
closed only after 'Connection to host is lost' is dis

Before running the autoBIST scripts, first open ea
correct IP address for the Kongsberg TRU in line
autoBIST_RXspectrum.wsf for each Kongsberg EM
running SIS to reduce opportunity for confusion b

After the scripts are updated/confirmed with the

Logging procedure

The SIS 4 logging procedure is similar for testing

Note the magnitude and direction of currents, as
speed through water (STW). For instance, a test se
filename] + 1 kt [entered in plotter] = [STW on pl

1. Clear all BISTs
2. Secure transmission for all acoustic systems (
3. Bring the vessel up to steady-state operation
lineup)
4. Wait for confirmation from the bridge that th
5. If manually logging:
   i. Click the BIST button of interest
   ii. Wait for the BIST to complete
   iii. Repeat for desired number of BISTs for t
   iv. SAVE the BIST text file
6. If running AutoBIST:
   i. Run the autoBIST_EMXXX_RXnoise.wsf fi
   ii. DO NOT CLICK/PRESS ANY OTHER KEYS
   iii. The autoBIST script will conduct 10-20 B
   iv. Close the command window only after '
   v. Repeat with the autoBIST_EMXXX_RXspe
   interference
7. Append the test parameter to the file name,
   i. **Speed test:** add speed to end of filenam
   ii. **Azimuth test:** add ship heading as "_045

SIS 5 RX Noise Logging

SIS 5 supports continuous logging of BISTs, which allows a somewhat simpler approach to assessing noise levels across a wide range of parameters.

The RX Noise Level test is sufficient for general characterization of the noise trends, and RX Noise Spectrum can be added for testing specific sources of interference if any are identified. RX Noise Level and RX Noise Spectrum can be run continuously and simultaneously, at the expense of lower repetition rates for each test and fewer tests of each type in the BIST text file.

Logging procedure

The SIS 5 logging procedure is similar for testing against speed, azimuth, or any other parameter.

Note the magnitude and direction of currents, as these can be applied in the BIST Plotter to adjust speed over ground (SOG) to speed through water (STW). For instance, a test series *into a 1-kt current* can be plotted as [SOG parsed from the SIS 5 BIST file] + 1 kt [entered in plotter] = [STW on plot axis].

1. Clear all BISTs
2. Secure transmission for all acoustic systems (EM, EK, SBP, ADCP, USBL, DVL, bridge sounder, etc.)
3. Clear all / stop logging all BISTs

For RX noise vs. SPEED

1. Slow the ship to the lowest speed allowable under the sea state (drifting if possible)
2. Start continuous logging for the RX Noise Level BIST
   i. Add RX Noise Spectrum only if necessary for troubleshooting a particular source of interference
   ii. Results will be logged (with speed in SIS 5 for non-EM2040 models) to a new BIST text file
3. **Very slowly** bring the ship up to the maximum speed allowable
   i. Ensure at least 10 tests within each one-knot speed interval (e.g., a test over 0-12 kts should include *at least* 120 BISTs)
   ii. Note any changes in propulsion modes (times, speeds, engine lineups, pitch, etc., as necessary to characterize changes in the noise results)
4. The gentle acceleration process may take 5-10 minutes, depending on how quickly the BISTs are completed
   i. The more gradual the acceleration, the more closely each test resembles a 'steady state' speed test
5. Stop logging (toggle 'continuous tests' off) and SAVE
6. Ensure the speed series file name has a suitably descriptive file name, e.g., "_2-10kts_into_1m_seas.txt" or "_0-14kts_calm.txt"
7. Clear old BISTs after verifying BIST file contents in a text editor

If time allows, after the gently accelerating RX Noise vs. speed test:

1. Clear all BISTs
2. Start continuous logging while the vessel very slowly decelerates back to drifting
3. Stop logging and save the second batch of continuous BISTs

For RX noise vs. AZIMUTH

1. Bring the vessel to the azimuth of interest
   i. This is usually pointing 'into the seas' (azimuth = 0)
2. Wait for confirmation from the bridge that the vessel is steady
3. Start continuous logging for the RX Noise Level BIST
4. Log for at least 5 minutes, keeping speed and azimuth constant
5. Stop logging (toggle 'continuous tests' off) and SAVE
6. Add ship heading as "_045.txt" or "_045T.txt"
   i. Identify the test heading into the seas, e.g., "045_into_seas.txt"
7. Clear old BISTs after verifying BIST file contents in a text editor
8. Repeat for all azimuths in 45-degree increments (or desired step size) until the vessel is pointing back into the seas

Transient vs. steady state

Some vessels exhibit **significantly higher** noise levels under even the slightest acceleration (e.g., +1 kt/minute) compared to the 'steady state' speed-noise trends that are of interest for selecting a survey speed.

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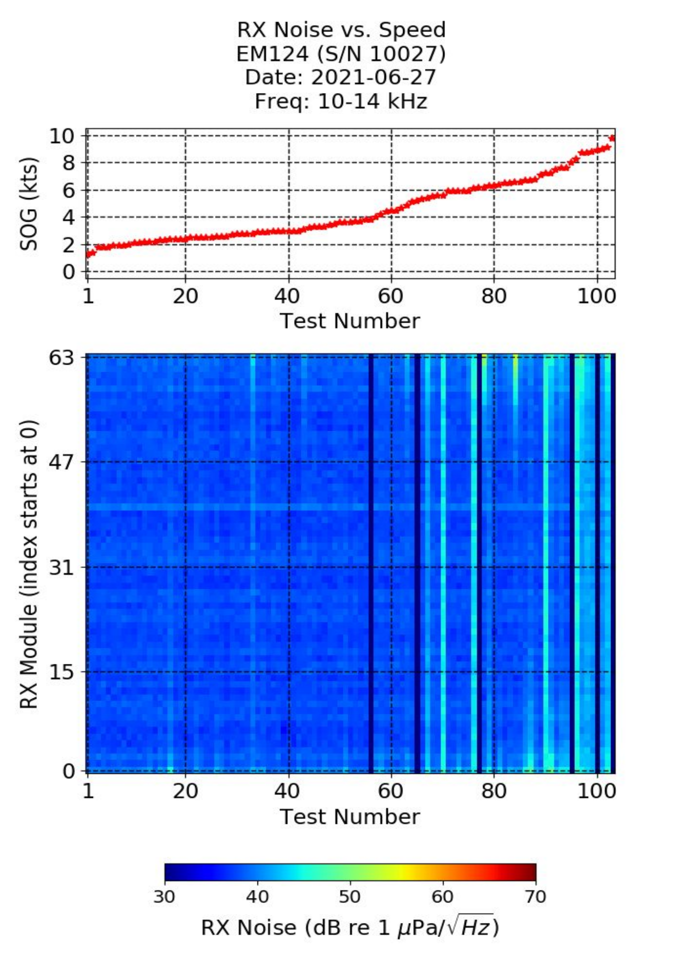
BIST Plotter: **RX Noise vs. Speed**

1. Evaluate noise trends in **calm seas**
2. Plot noise levels versus:
    a. Speed over ground
    b. Speed through water
    c. Engine or shaft speed
    d. Propeller pitch
    e. Thrust load (% of max)
    f. Engine / generator / machinery

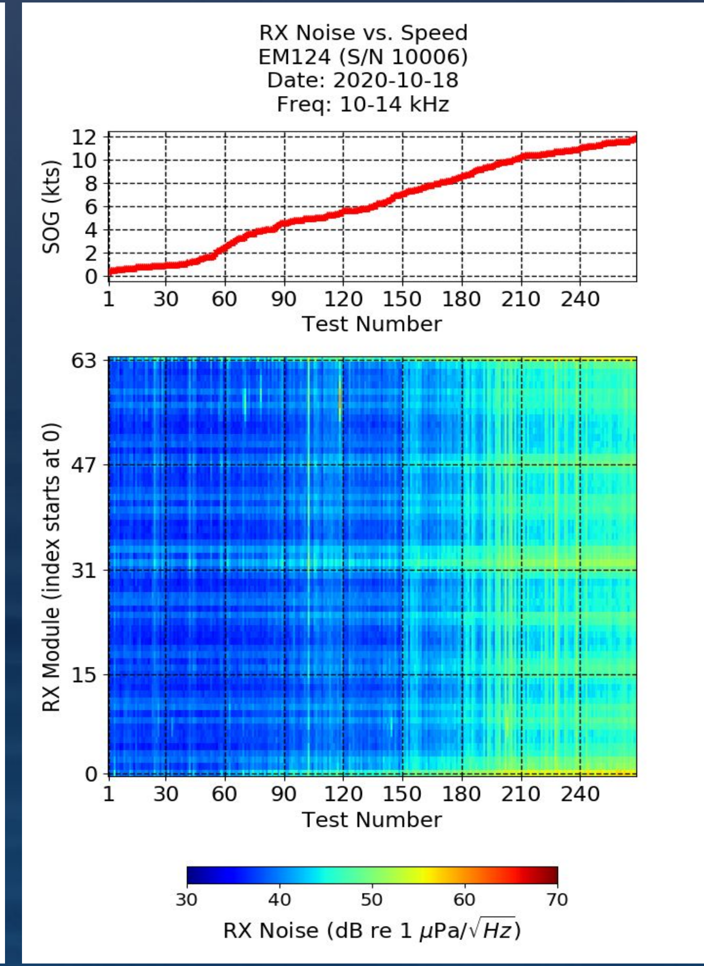
Vertical stripe = swell impact (all channels)

Horizontal stripe = noisy channel (all tests)

Vessel 1



Vessel 2



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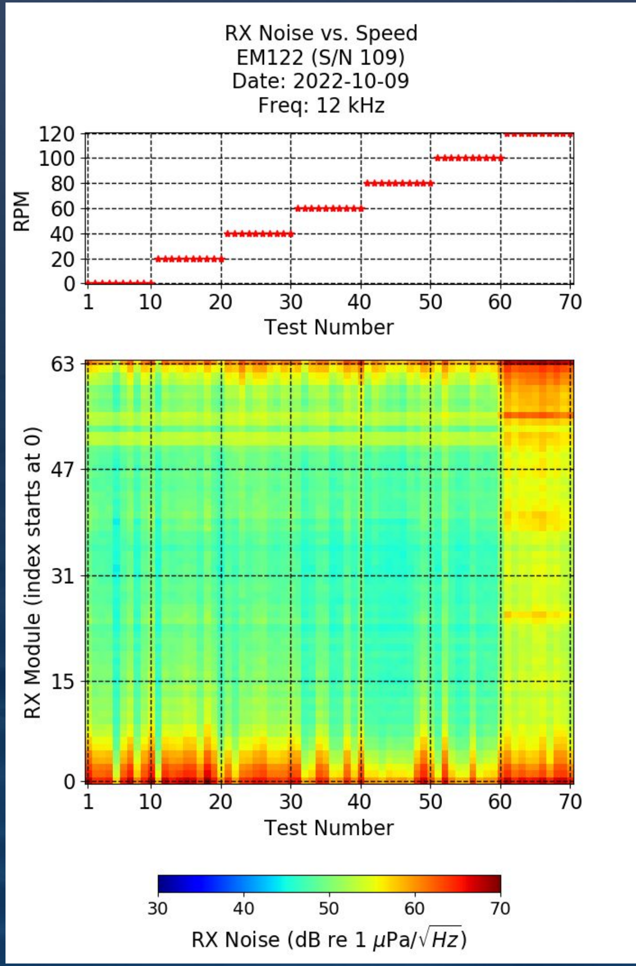
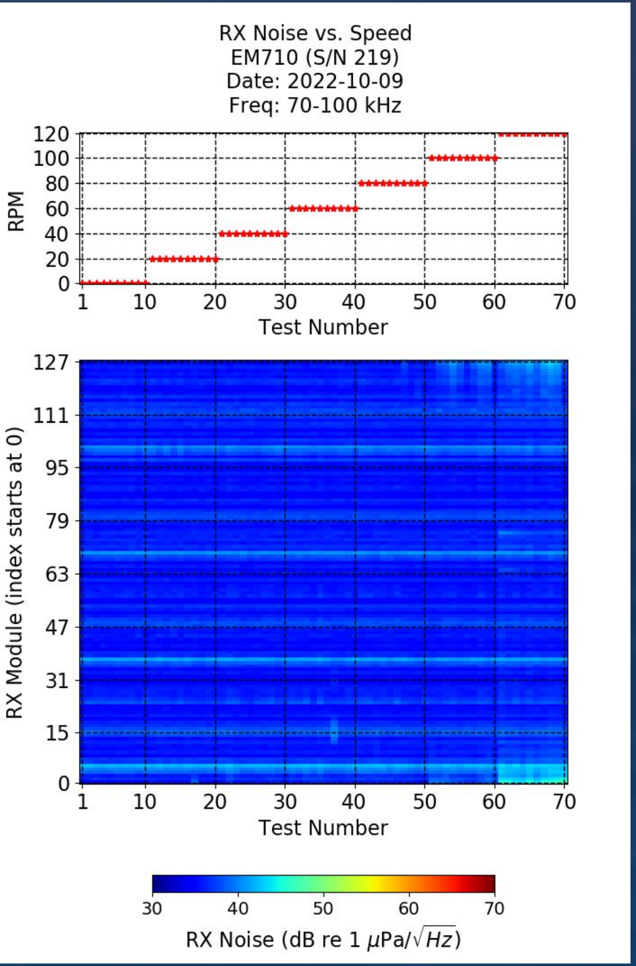
BIST Plotter: **RX Noise vs. Speed**

1. **Frequency-dependent** noise trends
2. Same test, same ship, different systems
3. Detect interference from other sonars

12 kHz



70-100 kHz



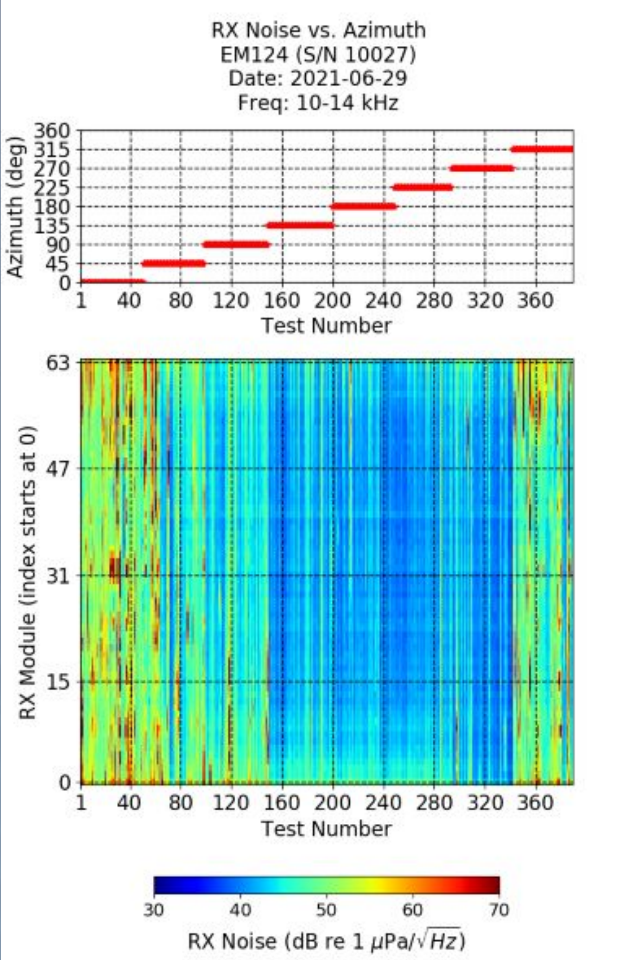
Vertical stripe = swell impact (all channels)

Horizontal stripe = noisy channel (all tests)

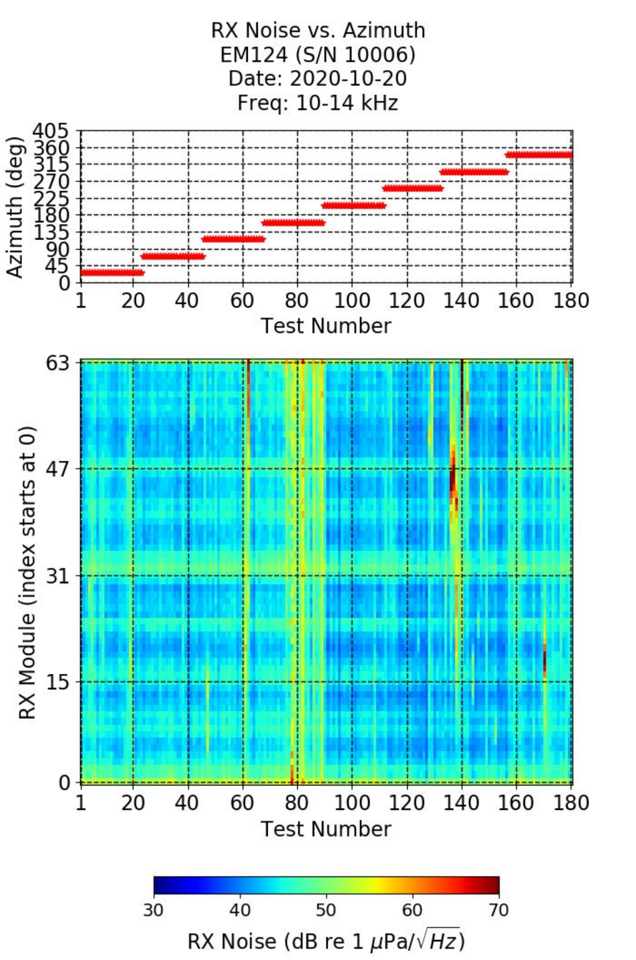
BIST Plotter: **RX Noise vs. Swell Direction**

1. Evaluate noise trends in **elevated seas**
2. Identify quietest survey orientations
3. Assess bubble sweep, gondola, etc.
4. Highly vessel-dependent

Vessel 1



Vessel 2



Azimuth 0° = heading into swell

Vertical stripe = swell impact (all channels)

Horizontal stripe = noisy channel (all tests)

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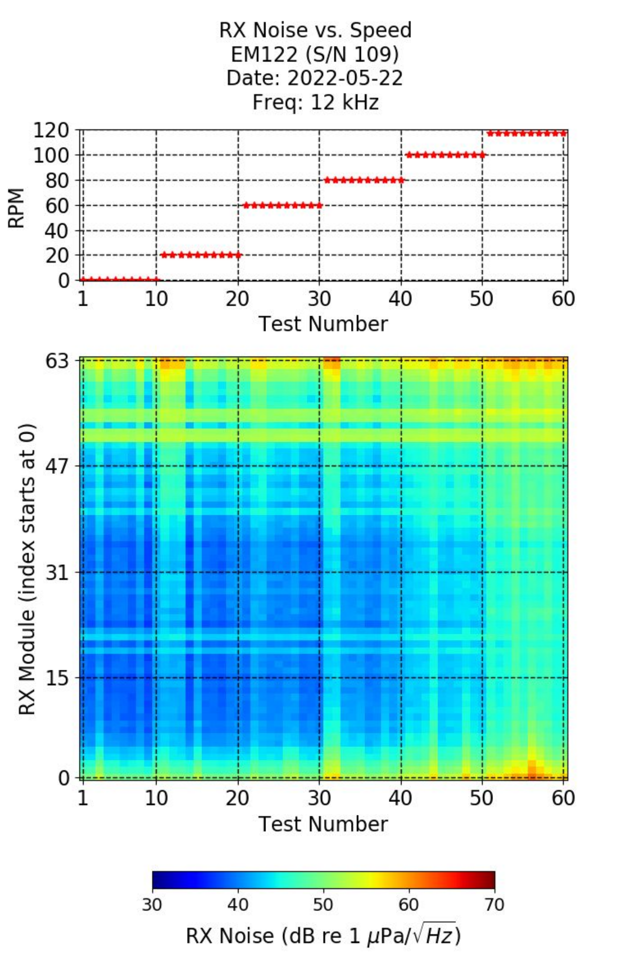
Example from the Field: **RX Noise Tracking**

May 2022

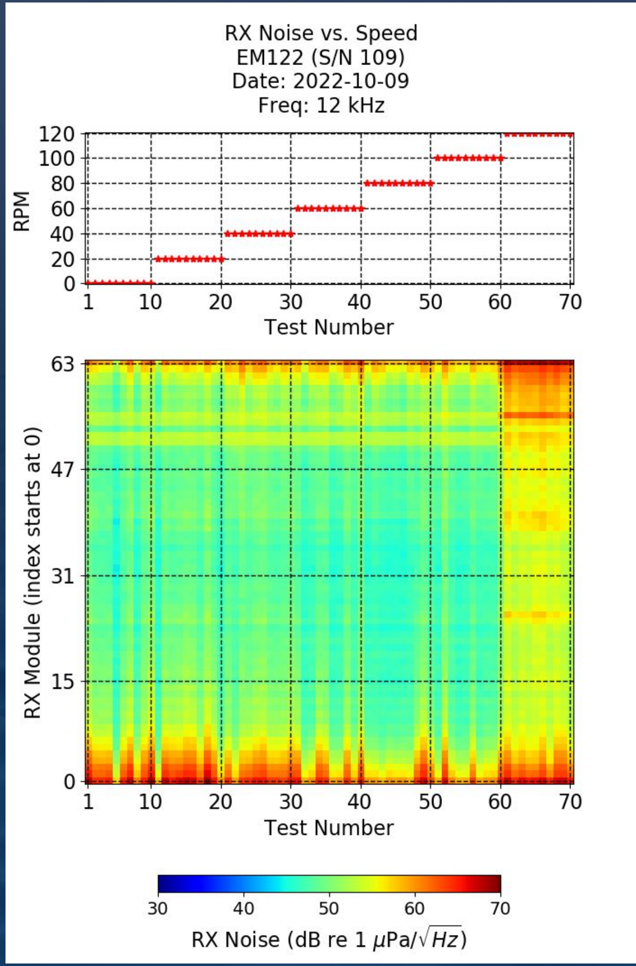


Same vessel…
What changed?

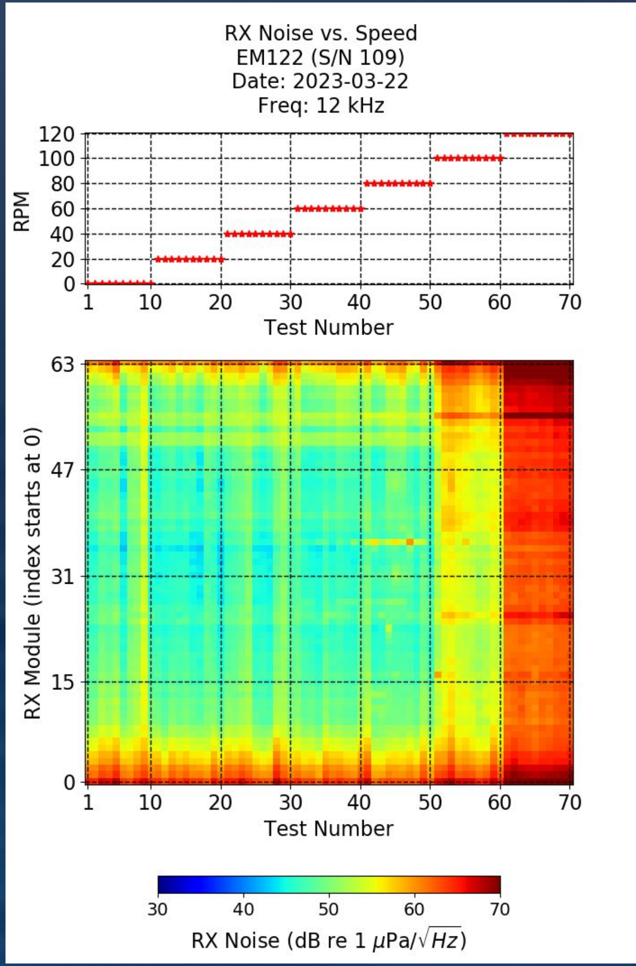
Noise levels increased across all speeds…
Machinery?
Recent work?

Noise levels increased at 100-120 RPM…
Fouling? Cavitation?

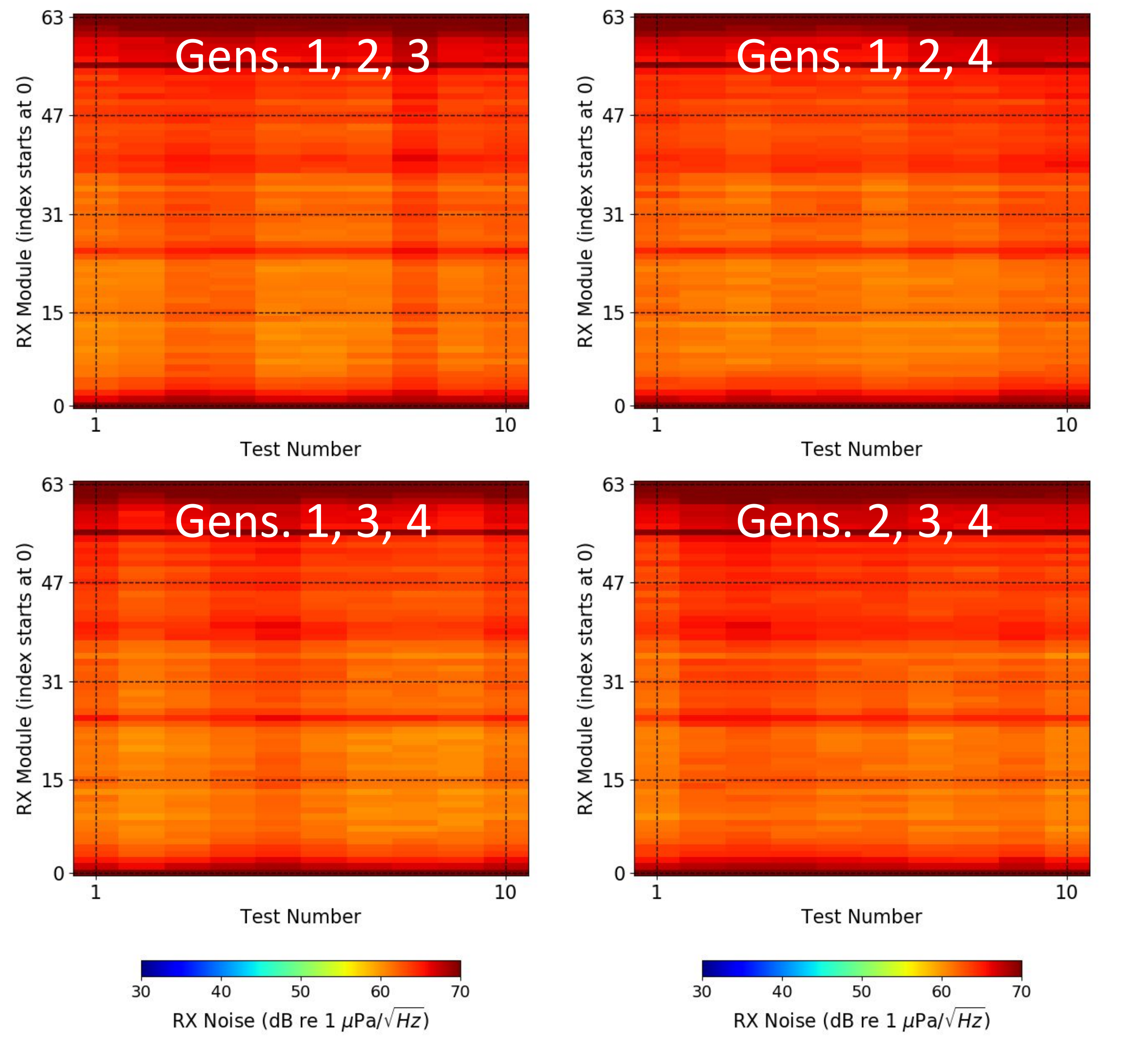
October 2022



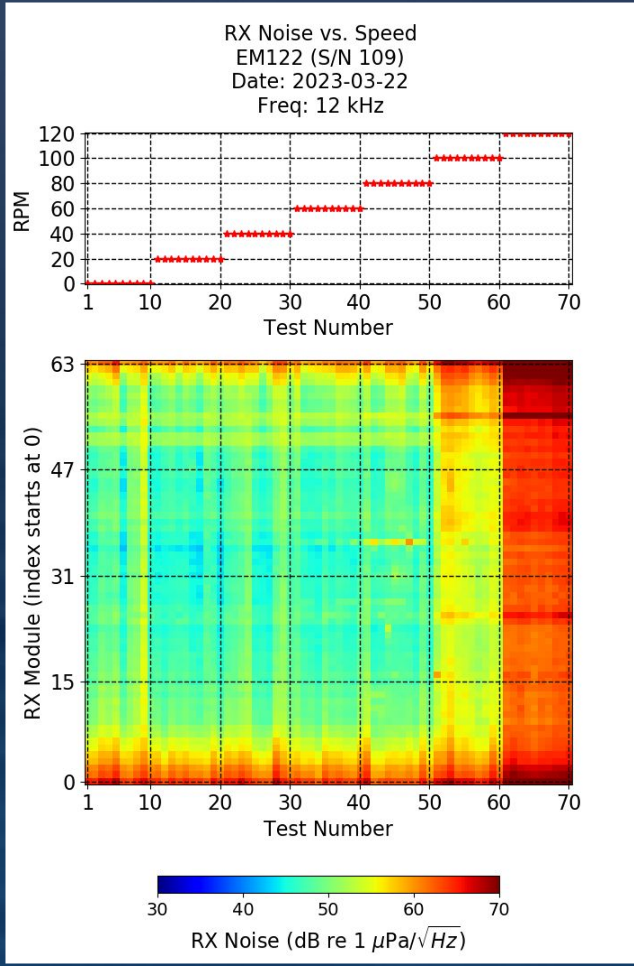
March 2023



Example from the Field: **RX Noise Tracking**

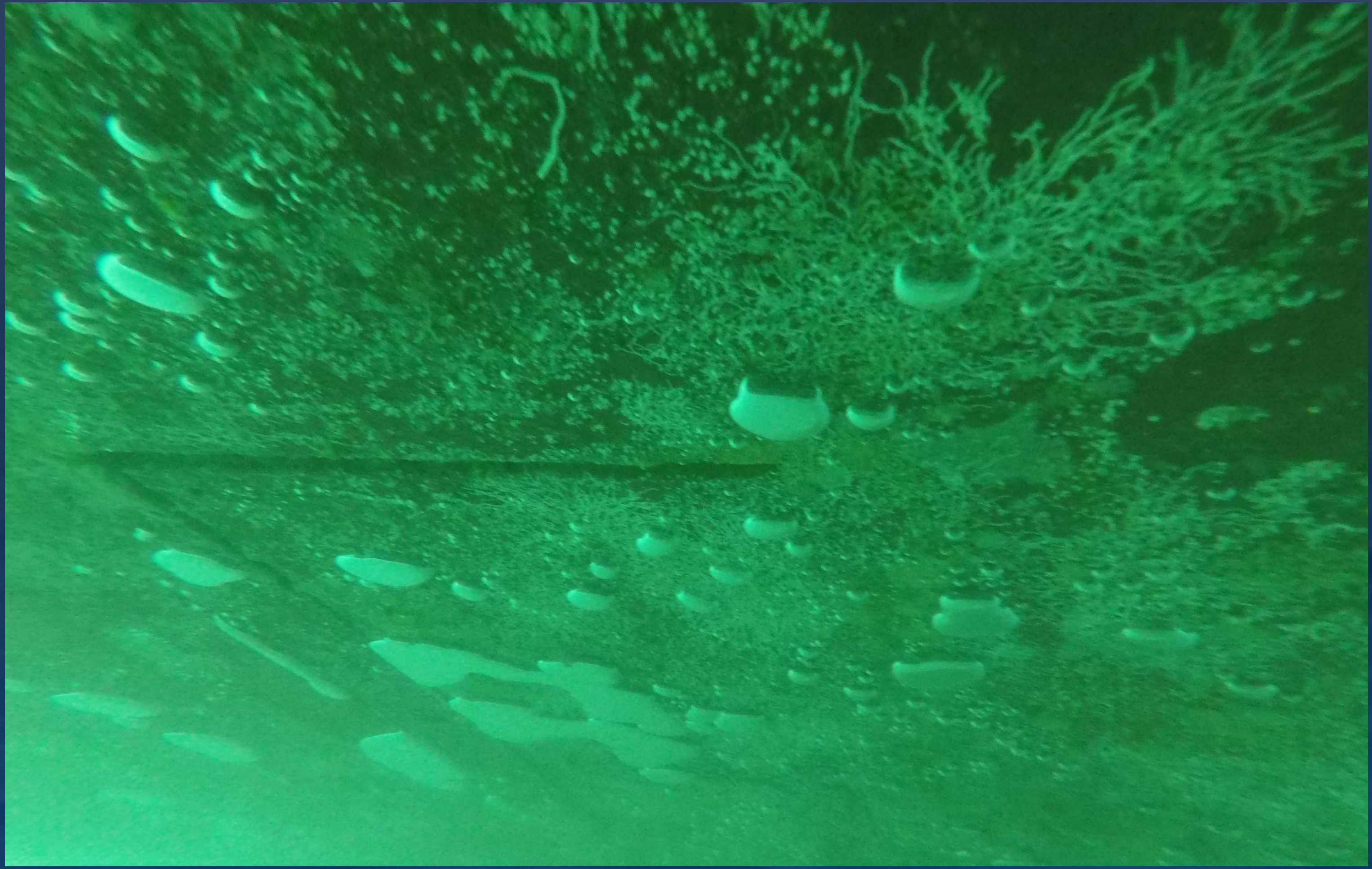


March 2023

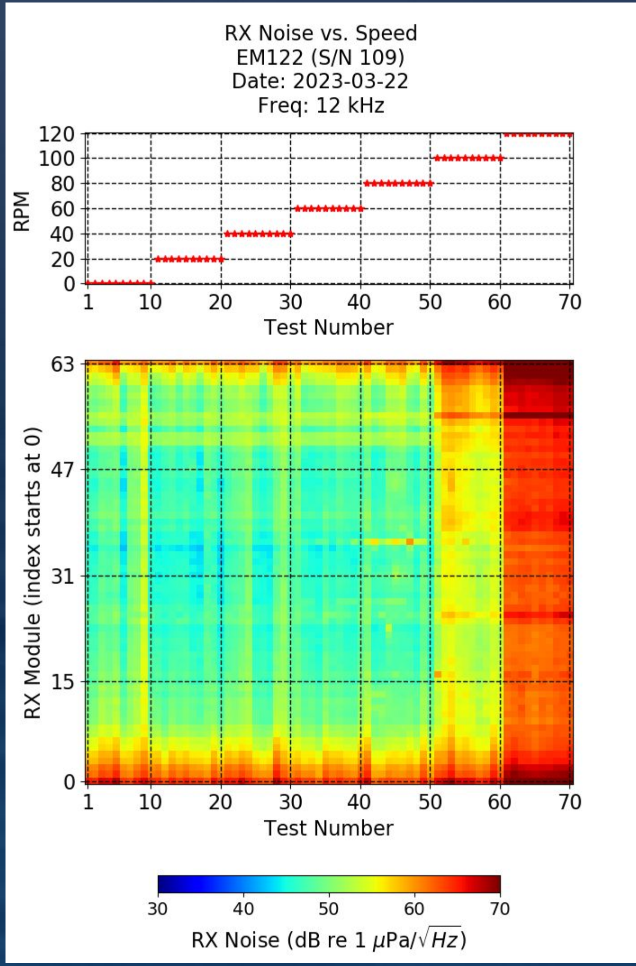


Example from the Field: **RX Noise Tracking**

Diver inspection showing biofouling on/near arrays (April 2023)



March 2023



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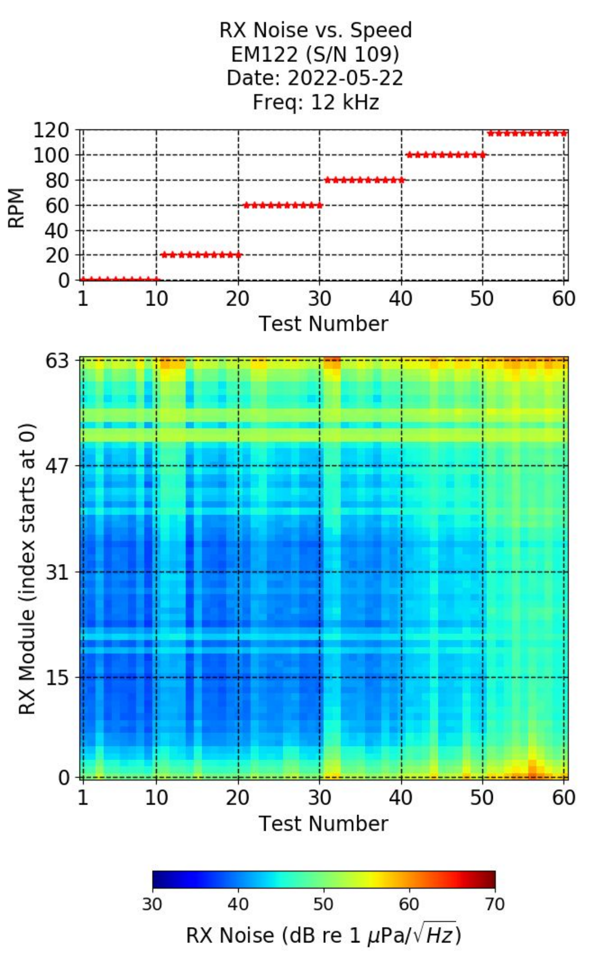
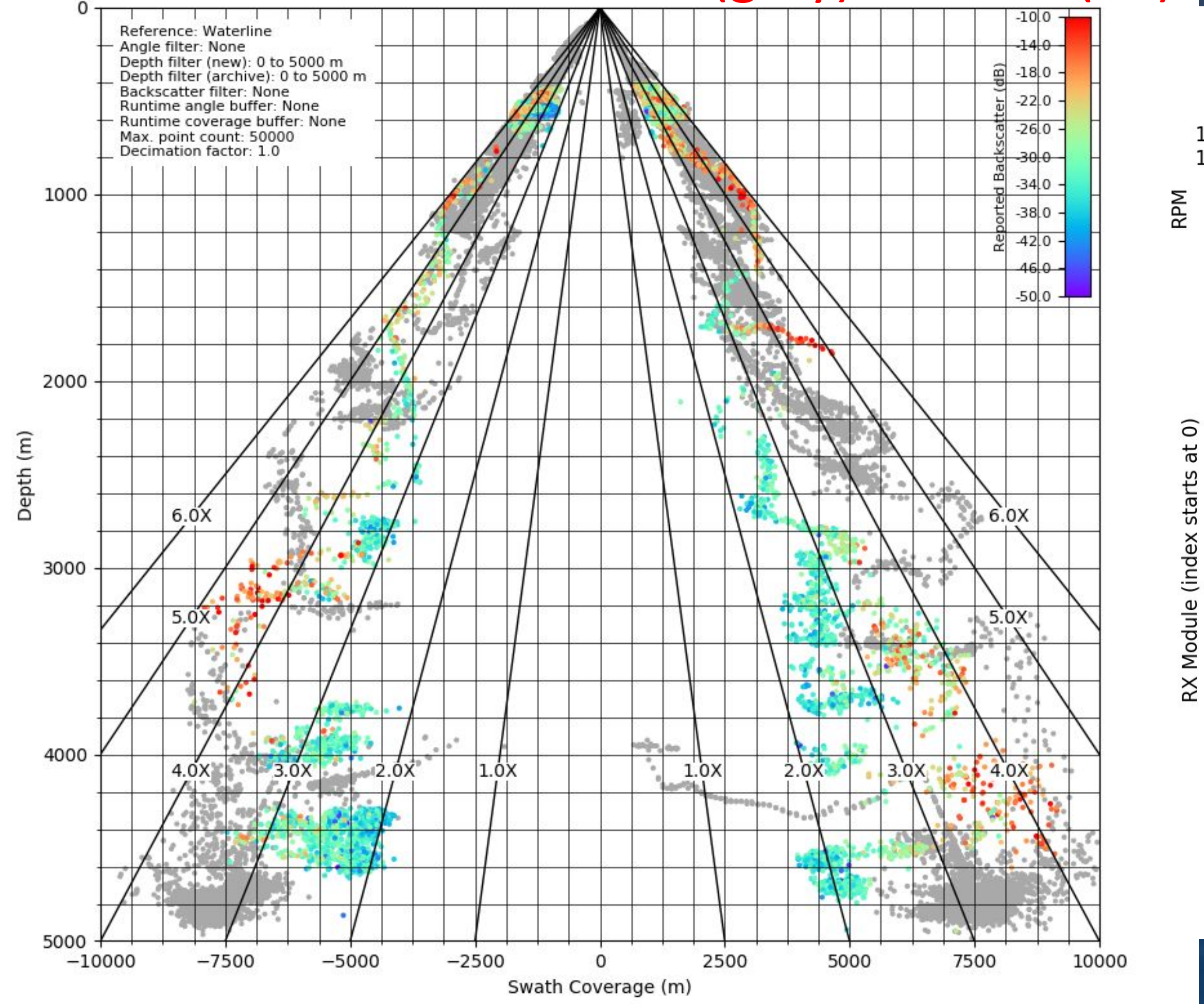
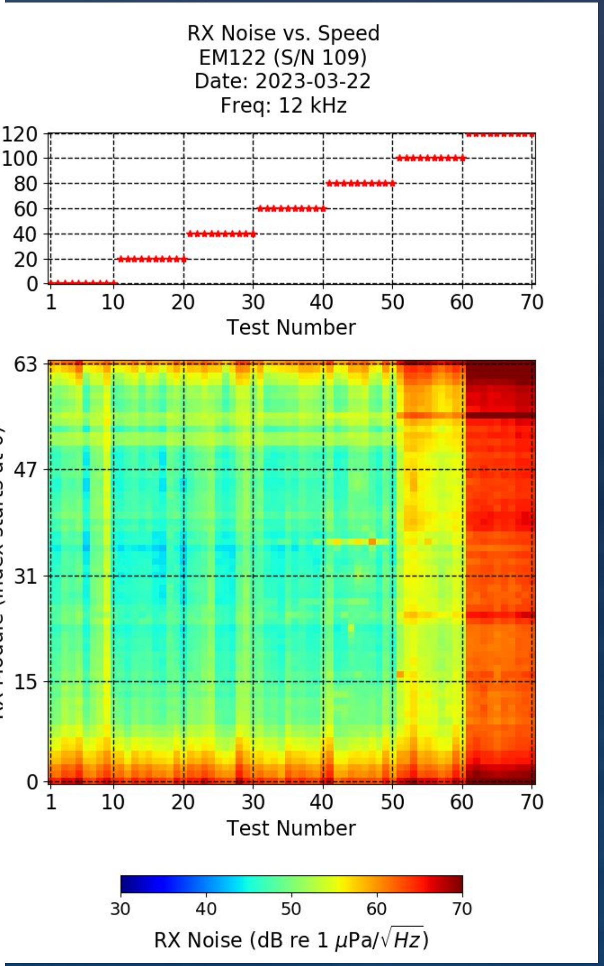
Example from the Field: **RX Noise and Swath Coverage**



1X WD reduction from 2022 (gray) to 2023 (BS)

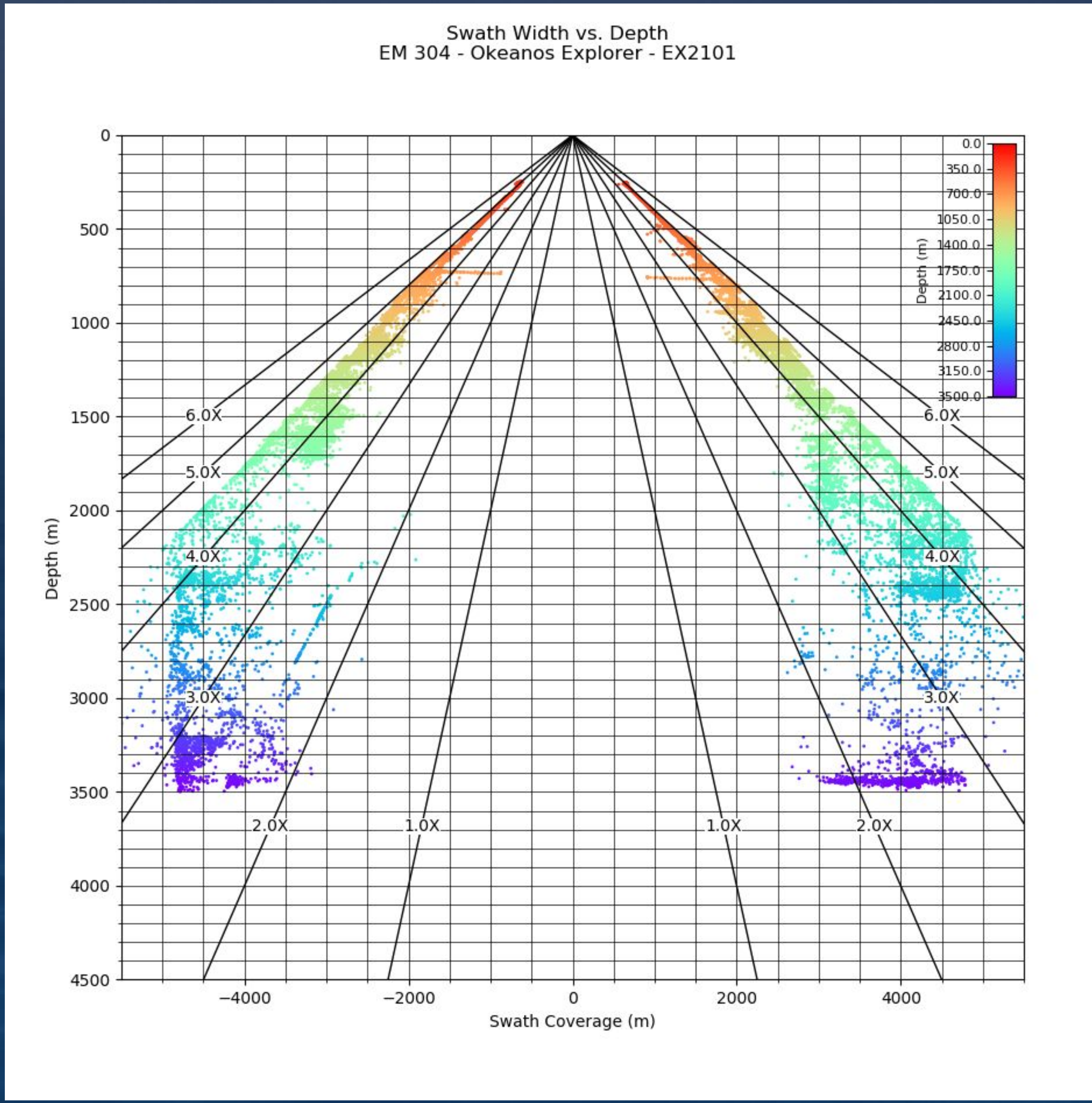





Coverage Plotter

Swath Coverage Plotter: **Coverage vs. Depth**

1. Swath coverage can be limited by many factors
2. Establish baseline coverage trends during SAT
3. Track coverage trends during routine QATs
4. Opportunistic data collection on transits
5. Verify expected performance:
   a. Coverage achieved vs. factory spec
   b. Depth mode switching behavior
   c. Effects of TX pulse forms
   d. Single- and dual-swath modes
6. Early detection of limiting factors
7. 'Real world' survey planning



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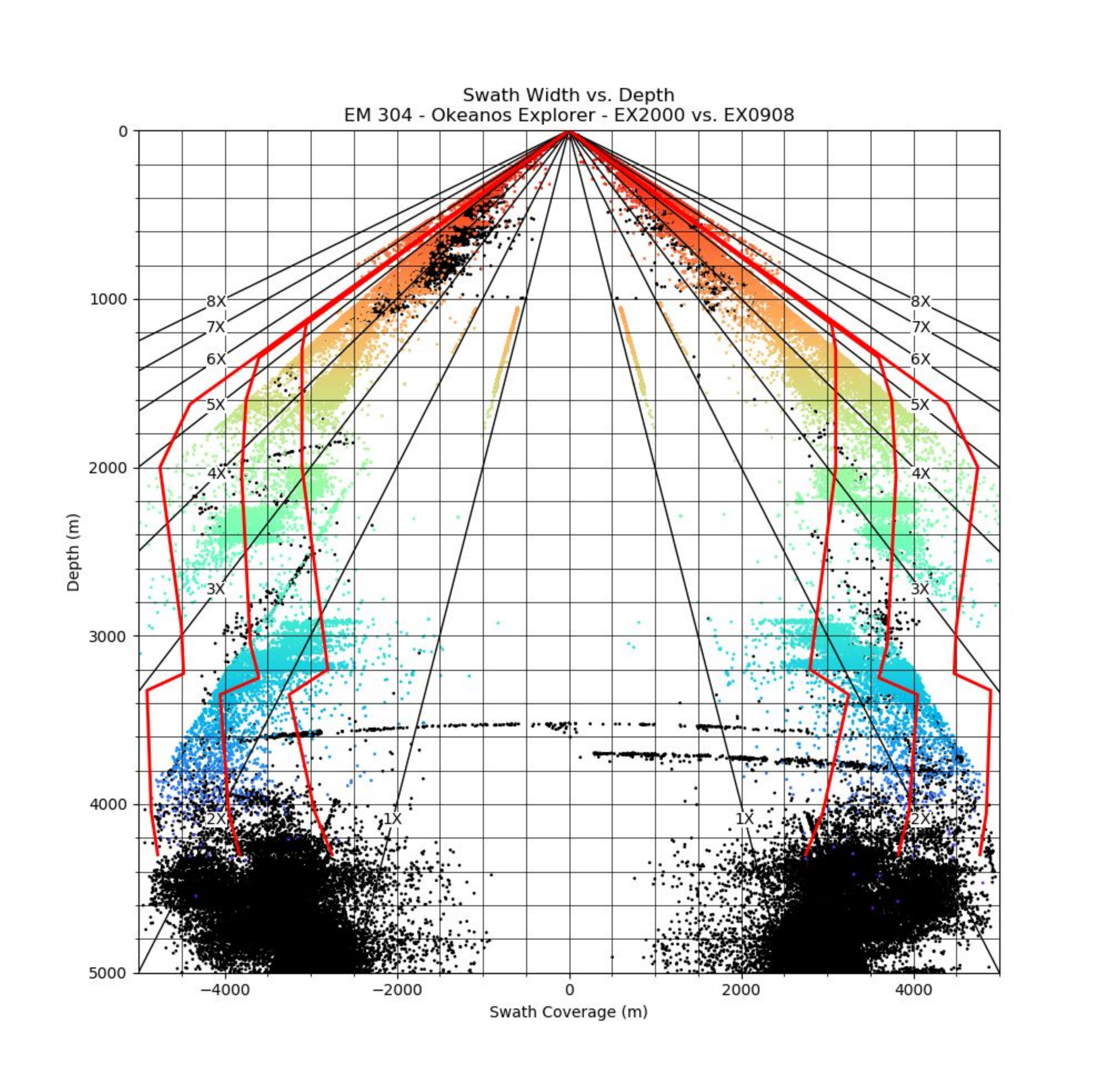
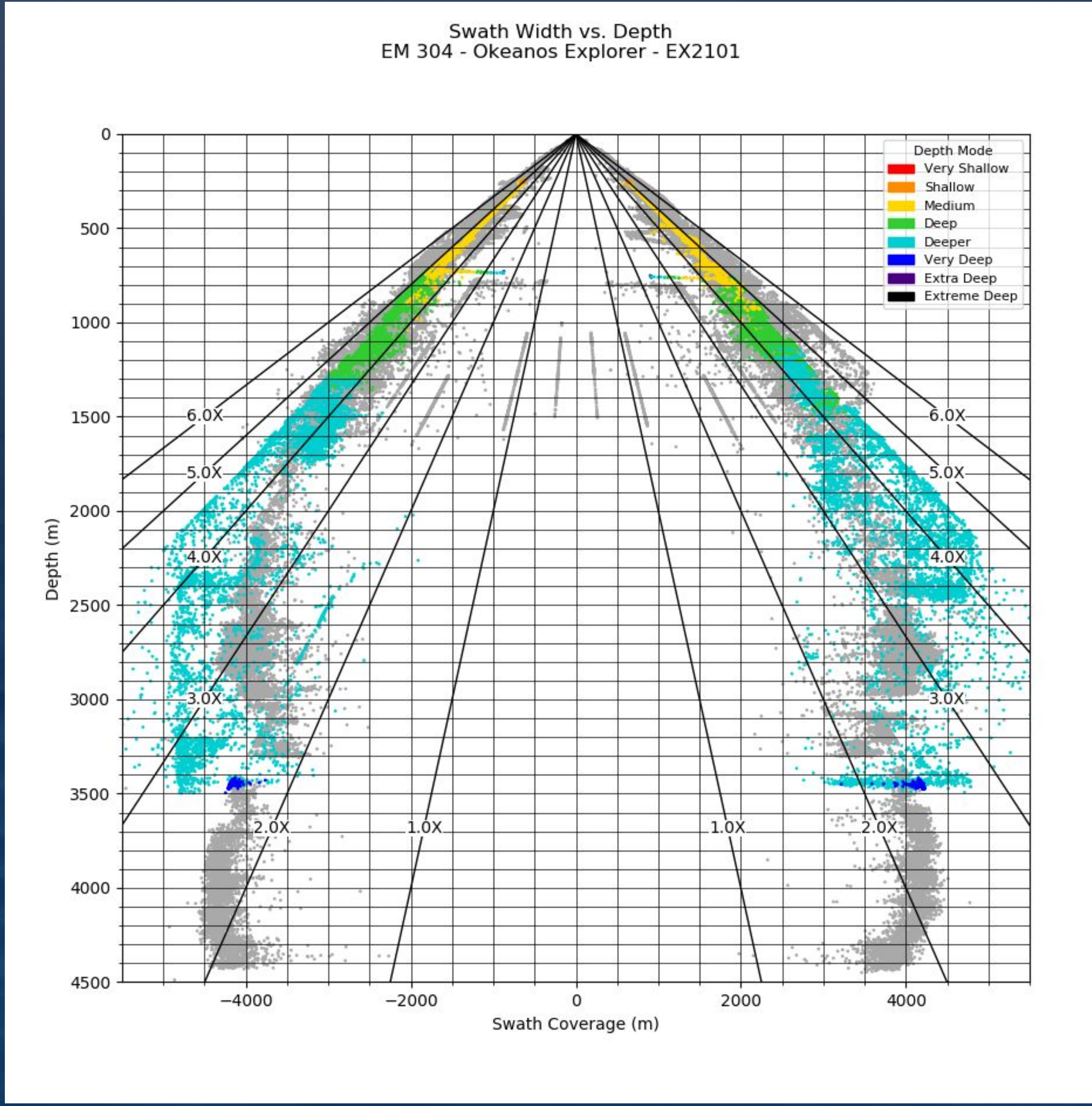
Swath Coverage Plotter: **System Comparison**

1. *Okeanos Explorer* EM302 (0.5° x 1.0°) upgraded to EM304 (topside) in 2020
2. EM304 (colored by depth) shown with historic EM302 (black) coverage data
3. Red lines are predicted coverage vs. seafloor backscatter strength (-20, -30, -40 dB)



Swath Coverage Plotter: **System Comparison**

1. *Okeanos Explorer* EM304 (0.5° x 1.0°) upgraded to EM304 MKII (TX array) in 2021
2. EM304 MKII (colored by mode) is shown over historic EM302 (gray) coverage data
3. Swath angle limiting in depths <1500 m
   a. 70° vs. 75° during SAT
4. Software limiting coverage to 5000 m / side
5. Improved coverage in target depth range



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Swath Coverage Plotter: **System Comparison**

Transit testing across Puerto Rico Trench (2022)

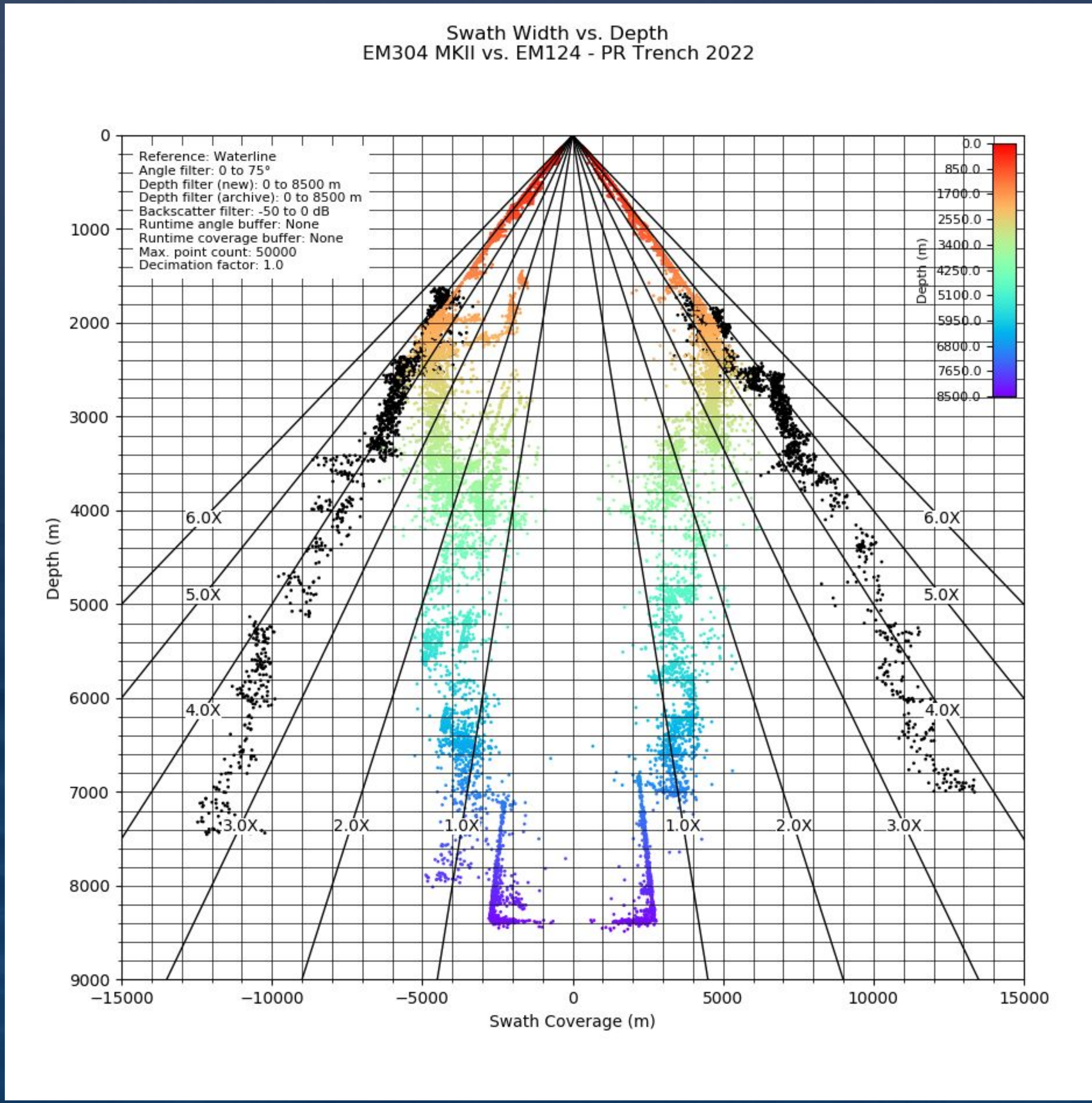
1. EM304 MKII (0.5° x 1.0°) colored by depth
2. EM124 (1.0° x 1.0°) in black

EM304 MKII supersedes EM304

1. Broader bandwidth and higher power
2. Capable of reaching full ocean depth

EM124 remains vital for deepwater work

1. Greater efficiency at depths >3000 m



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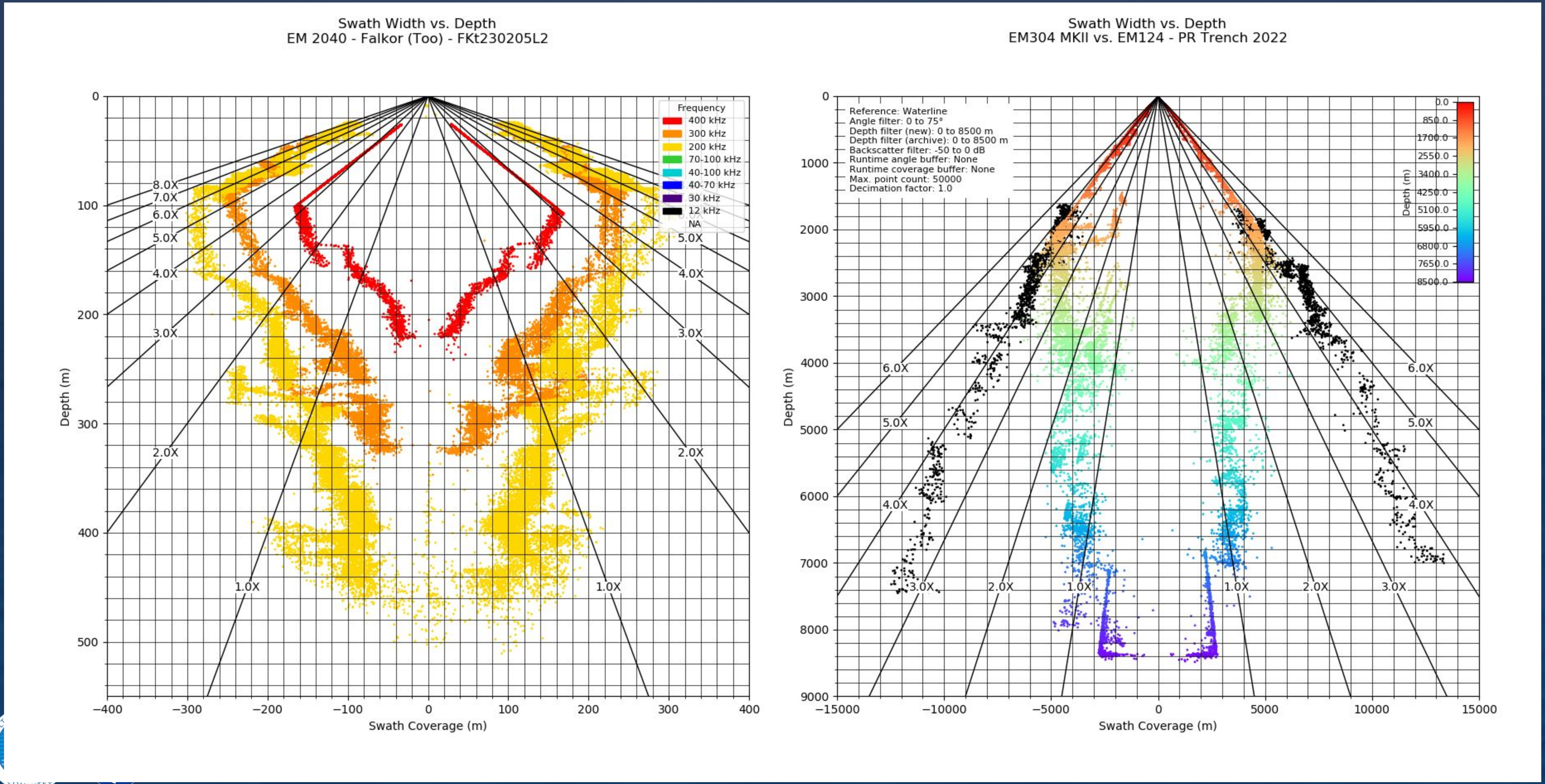
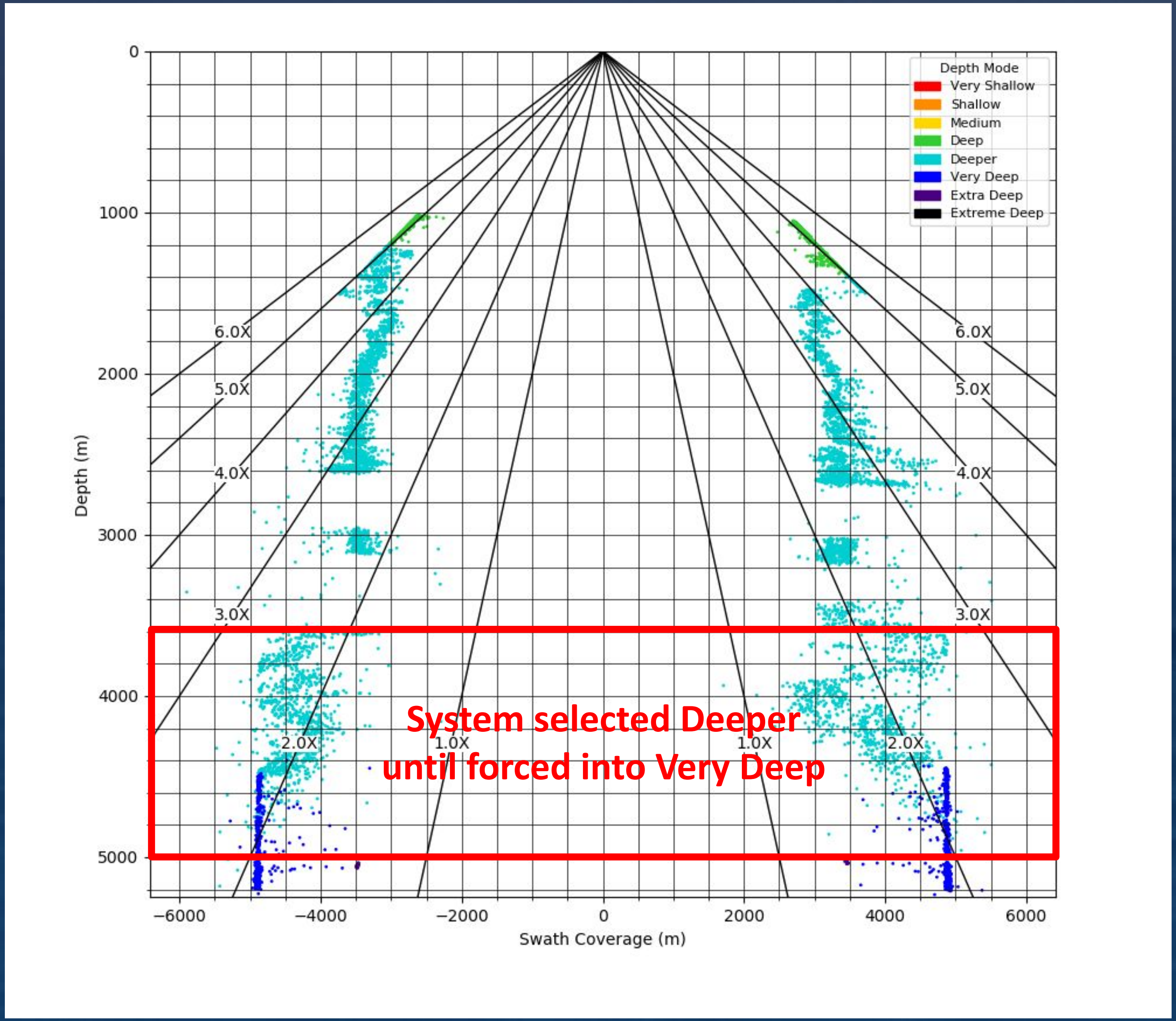
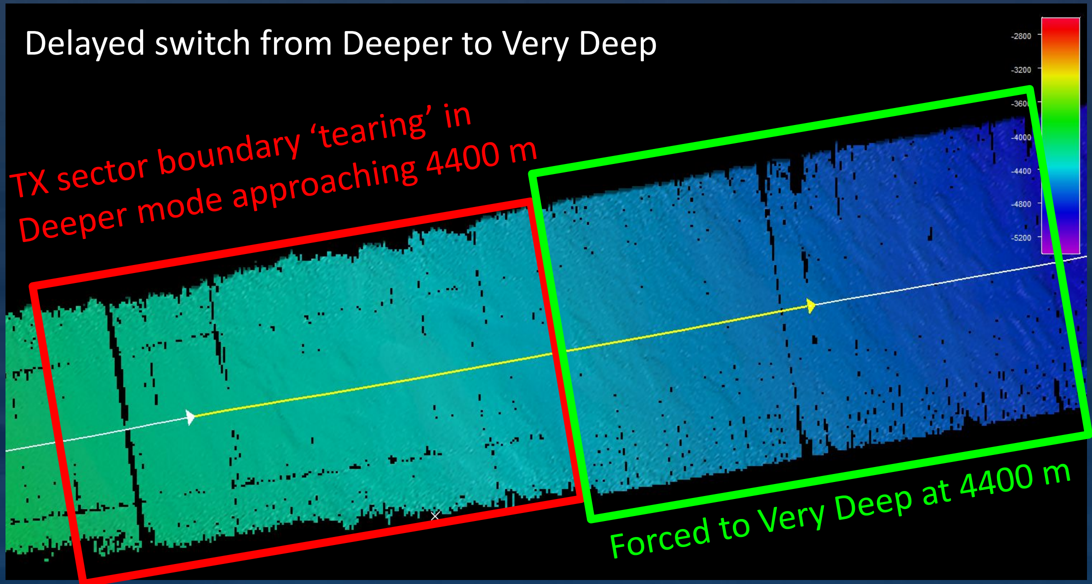
Swath Coverage Plotter: **System Comparison**



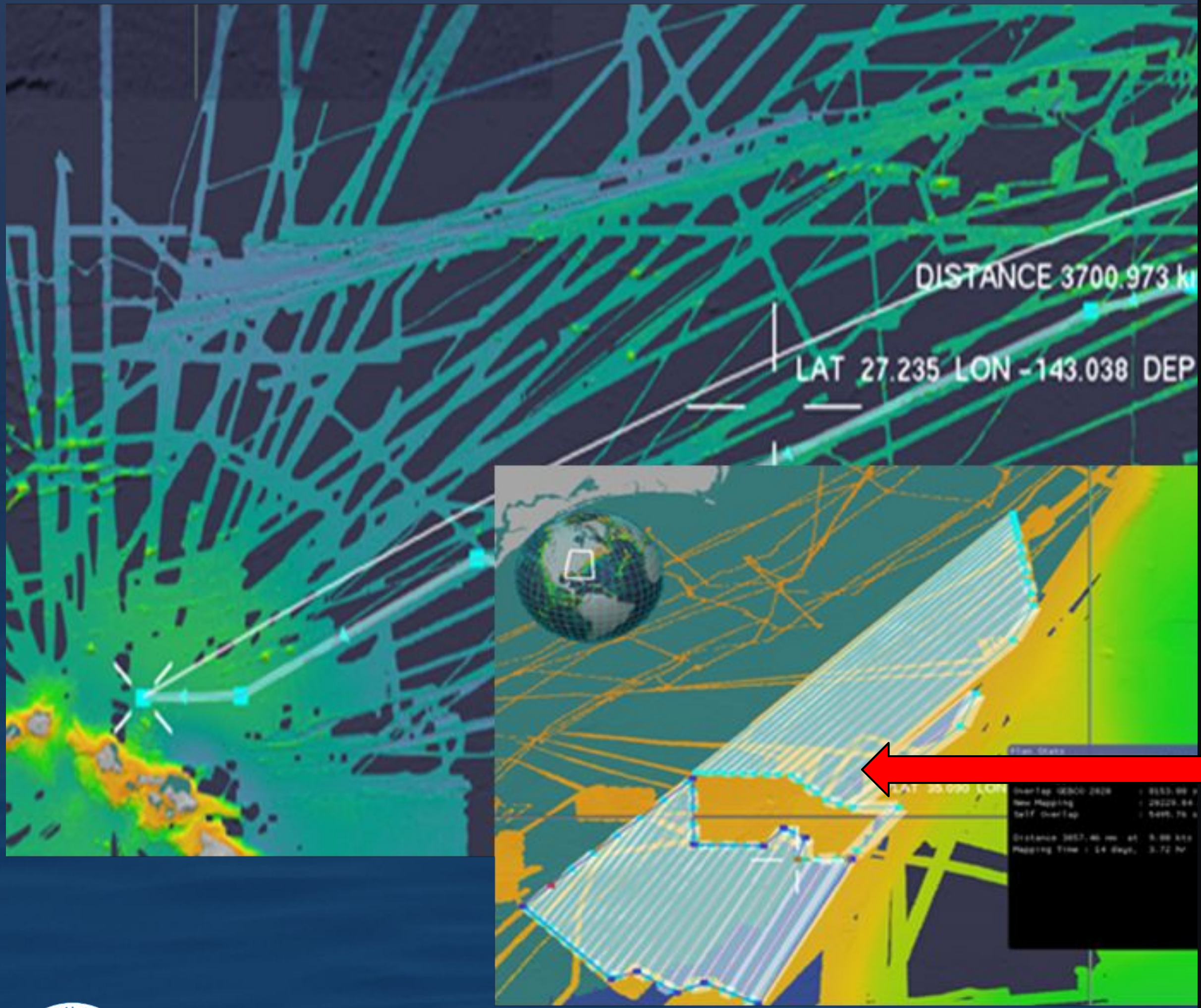
Swath Coverage Plotter: **Checking Automatic Modes**





Swath Coverage Plotter: **GapFiller**

ccom.unh.edu/vislab/tools/gapfiller

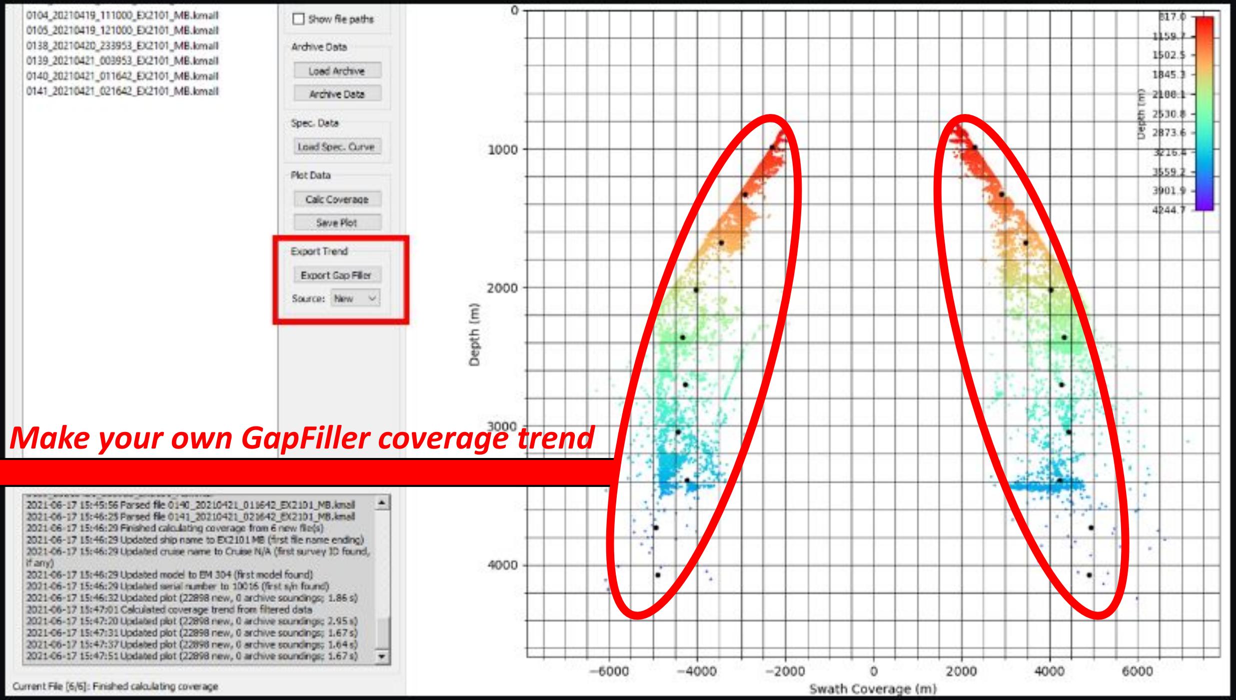


GapFiller

Coverage trends observed during this assessment can be exported for use in the BathyGlobe GapFiller developed by Colin Ware at the CCOM VisLab.

Select **Export Gap Filler** button with the desired data source ('new' or 'archive') to calculate the median coverage across a number of depth bins. This trend (in multiples of water depth) is exported to a format describing the achieved coverage for line planning with that particular vessel or multibeam system using the GapFiller app.

In the example below, the coverage trend for GapFiller is shown as black dots. This particular dataset (collected during sea acceptance trials) revealed coverage trends that would exceed hard-coded limits (5000 m) in the acquisition software; these limits were updated by the manufacturer to support the wider achievable coverage.



Make your own GapFiller coverage trend

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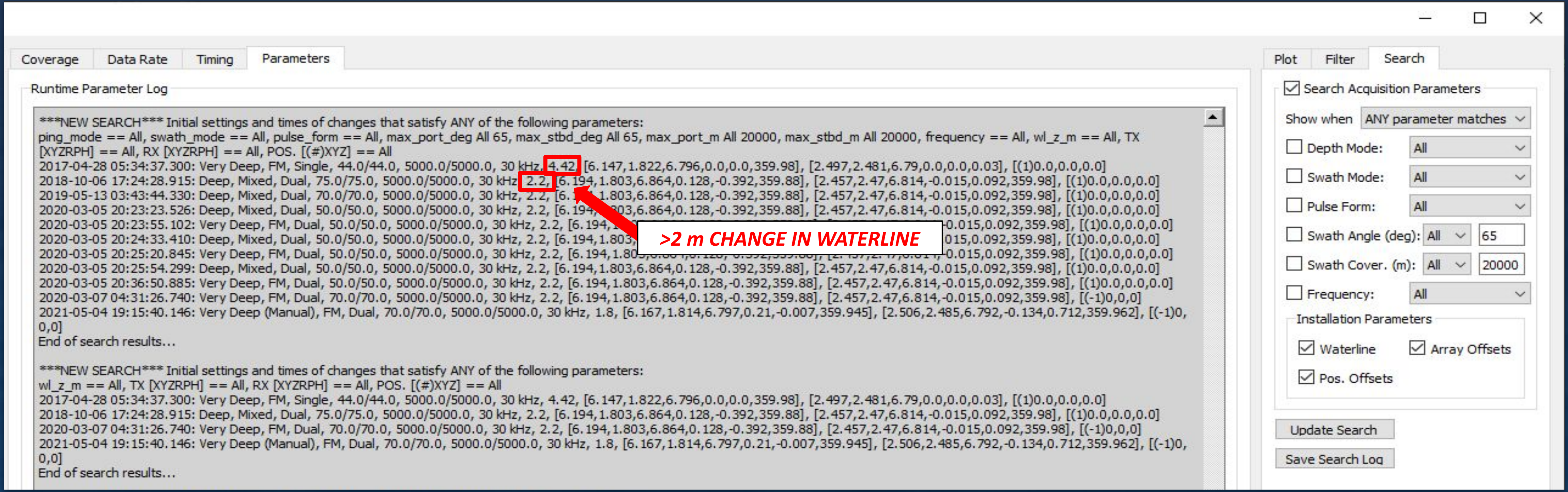
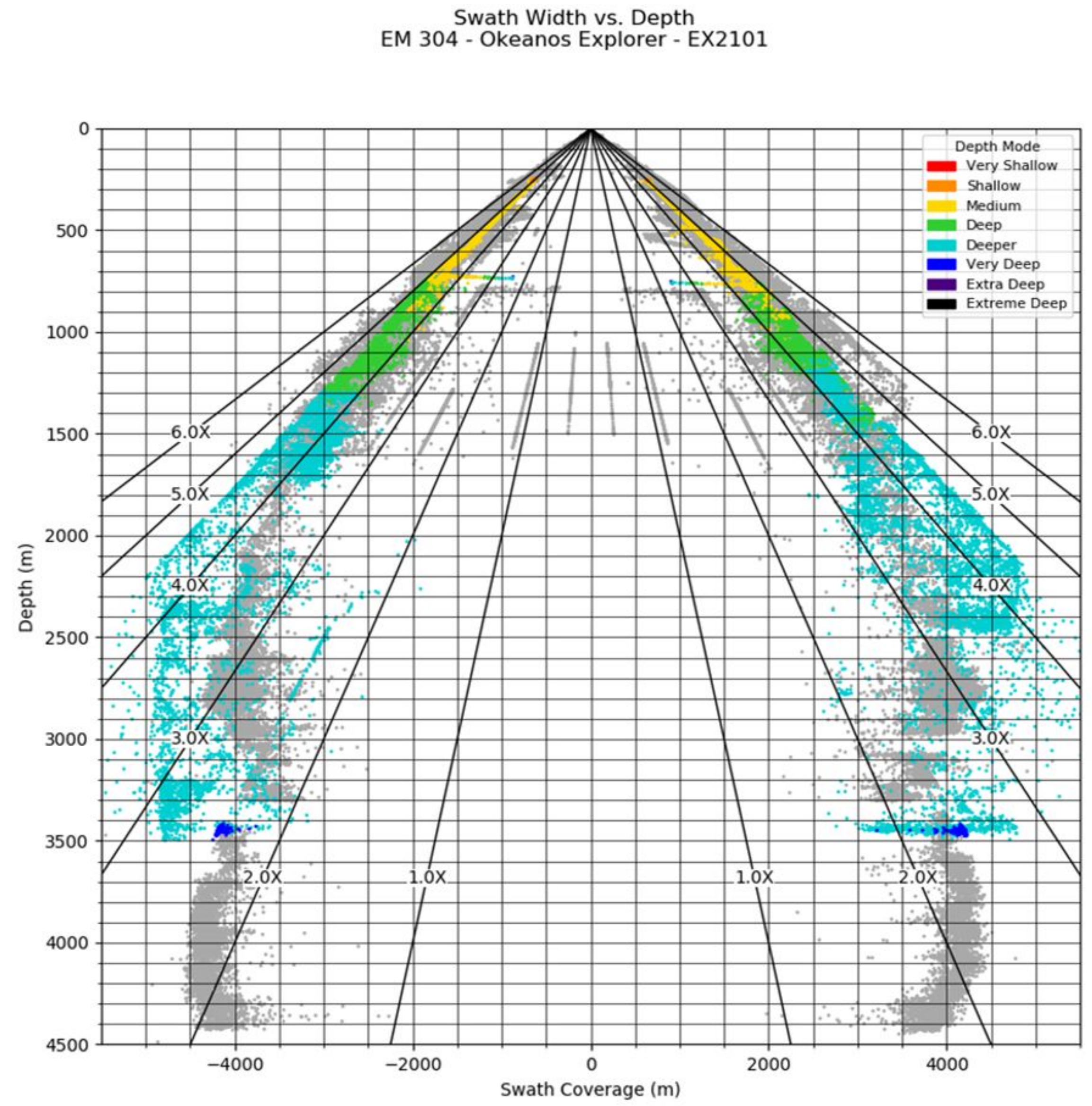
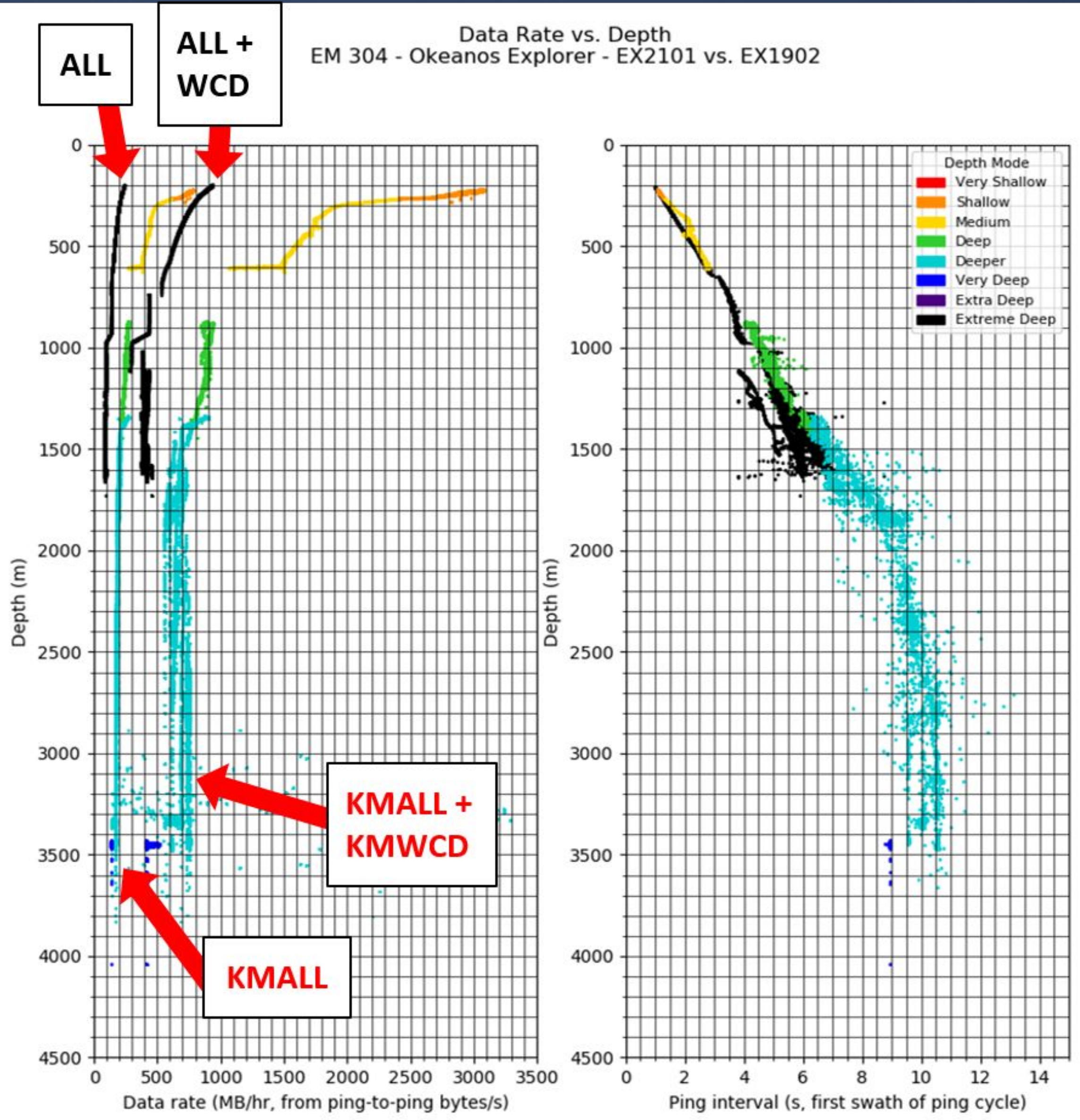
Swath Coverage Plotter: **Parameter Tracking / Search**

1. Scan large batches of files for changes to acquisition parameters:
   a. **Installation Parameters (IP)** → system geometry based on SAT/QAT
   b. **Runtime Parameters (RTP)** → sonar modes/filters selected by user
2. Query settings by thresholds (> < =) and ANY or ALL combination



Swath Coverage Plotter: **Data Rates**



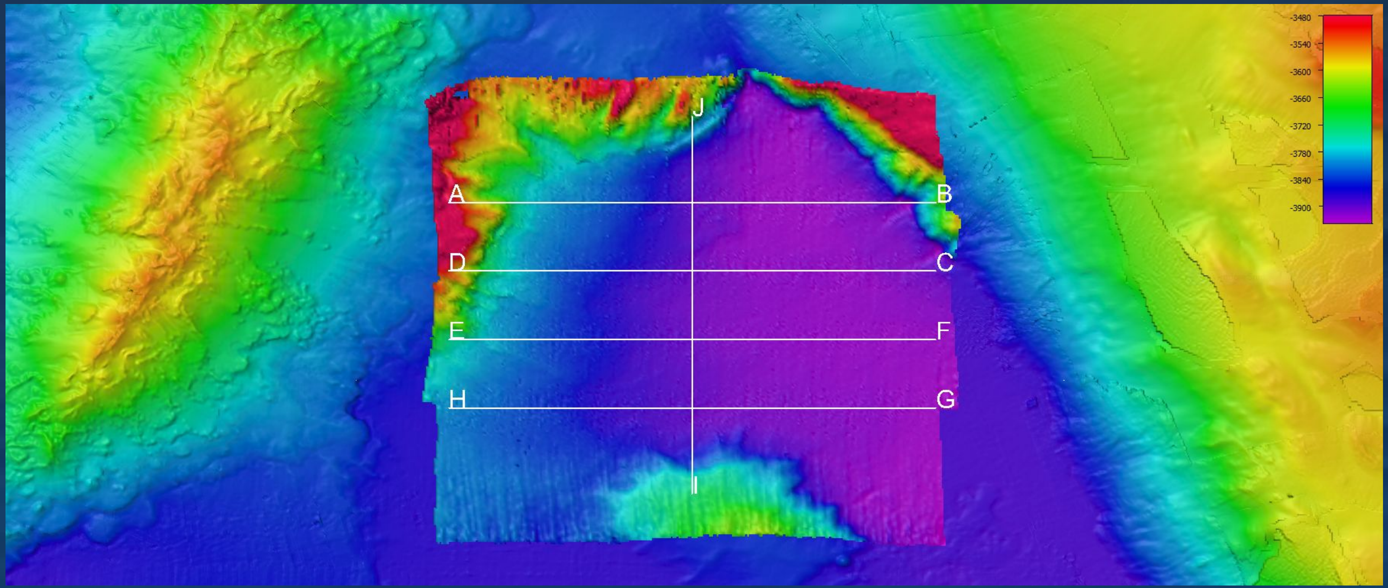


Anomalous EM304 data rates between 600-850 m have been omitted

Accuracy Plotter

Swath Accuracy Plotter

1. Swath accuracy is impacted by many factors
    a. Configuration, calibration, user settings
    b. Noise, sea state, other systems
    c. Sound speed, tide/height ref. info



Data collection

Swath accuracy test data collection is typically broken into two parts:

1. Reference surface survey
2. Accuracy crosslines

The reference surface is typically surveyed in its entirety before accuracy crosslines are run across it. However, the reverse order may be useful when there is uncertainty about approaching weather or the ship's departure time from a working area; this reverse order ensures crosslines are collected first before running as many reference survey lines as possible under the circumstances.

Scope of data collection

The scope of data collection depends on the modes of interest and their intended depth ranges.

For example, a new Kongsberg system might be tested across all depth modes (nominally, Very Shallow or Shallow through Extra Deep or Extreme Deep, depending on system) using 'typical' runtime parameters (e.g., dual-swath and FM enabled). This set of modes is typically sufficient to characterize baseline performance under the most commonly applicable settings, and might be repeated for quality assurance testing throughout the system's service life. Other testing might focus on a select few modes to investigate data artifacts in particular conditions or depth ranges.

More comprehensive testing or troubleshooting might include variations on runtime parameters or vessel operations within each depth mode to highlight the impacts of each decision, such as:

1. single- and dual-swath;
2. FM enabled and disabled;
3. yaw stabilization enabled and disabled;
4. different survey speeds; and/or
5. other acoustic systems transmitting.

The 'depth modes' for some systems are more commonly described by the frequency range and pulse length (e.g., EM2040 operating at 300 kHz with short CW pulse) rather than 'Shallow' or 'Medium' modes. Refer to the manufacturer specifications for available modes and review the typical survey runtime parameters to identify the modes of interest for a particular system.

Planning constraints

For systems with discrete depth modes, it would be ideal to conduct an entirely new reference survey and set of crosslines within the intended depth range for every mode. However, this is usually impractical (or impossible, given the available terrain) and some scheduling and planning compromises must be made.

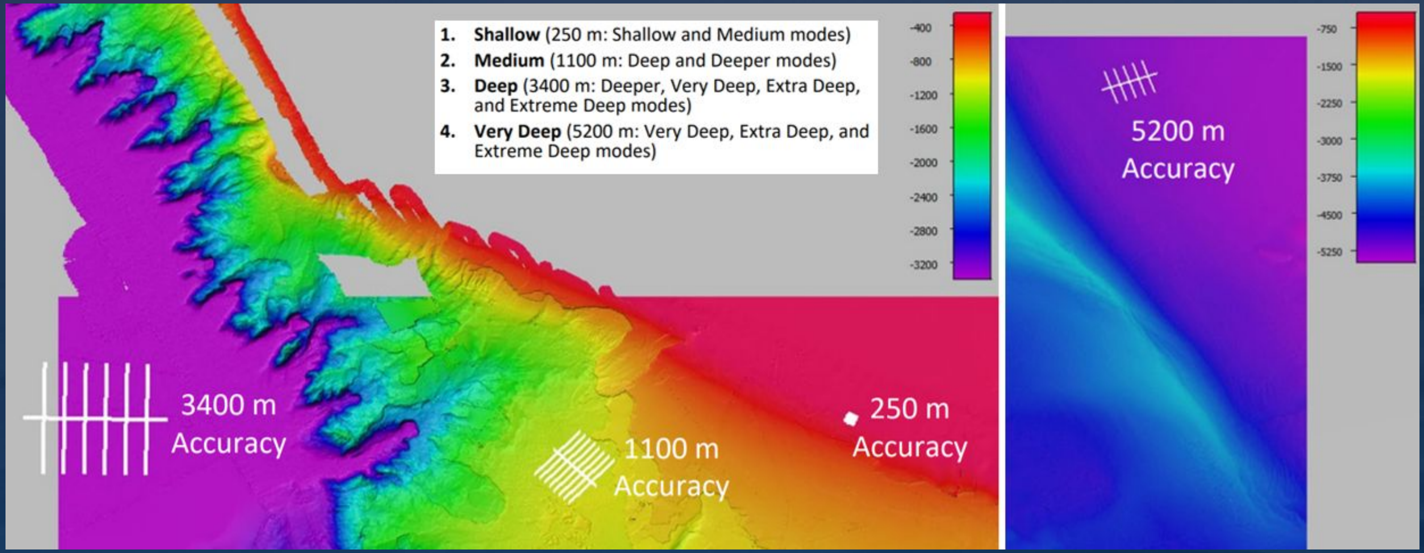
Reference depths

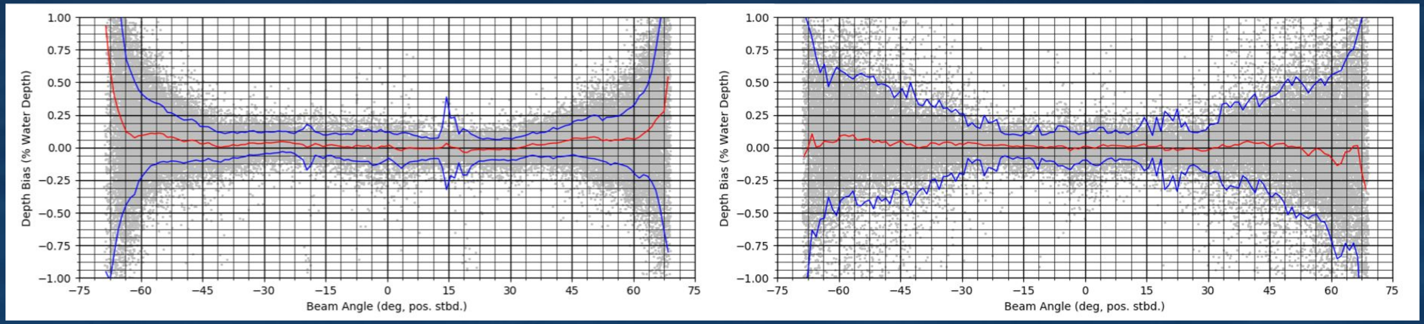
The reference survey is typically the largest time commitment for each test, so reducing the number of surveys required can yield real savings. This can be done by grouping the crossline modes of interest into depth ranges that are acceptable (if not ideal) and identifying a smaller number of reference depths that will accommodate these modes. The depth ranges required for testing, and availability of suitable seafloor, will determine the locations of the reference surfaces.

Each working area may be a compromise, selecting from the available seafloor regions in order to assess a greater number of crossline modes within the constraints of scheduling and sea state. The image below provides a planning overview of reference sites selected during EM304 MKII sea trials aboard the *Okeanos Explorer* (EX2101); four depth areas were selected for testing seven modes, building into the cruise plan across two distinct working areas in the Gulf of Mexico and off Blake Ridge. (The transits across these depth ranges were used for swath coverage testing.)

Swath Accuracy Plotter

1. Establish baseline trends (SAT, all modes)
2. Track behavior over time (QATs, opportunistic)





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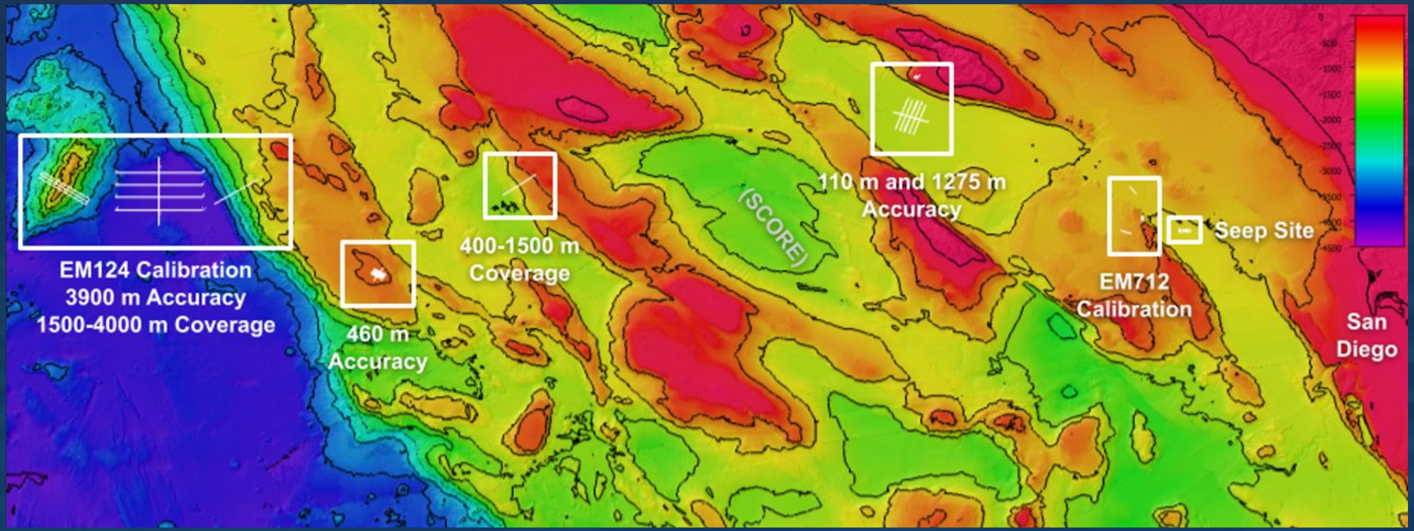
Swath Accuracy Plotter

1. Examine impacts of user settings
2. Assess interference from other sonars

Crossline Setting	Depth Mode	SBP29 Mode[3]	Swath Mode[1]	Pulse Form	Yaw Stabilization[2]	Swell Direction
1	Deeper	Off	Dual	Mixed	RMH	Into seas
2	Deep	Off	Dual	CW	RMH	With seas
3	Very Deep	Off	Single	FM	RMH	Into seas
4a	Deeper	Synced	Dual	Mixed	RMH	With seas
4b	Deeper	Burst	Dual	Mixed	RMH	With seas



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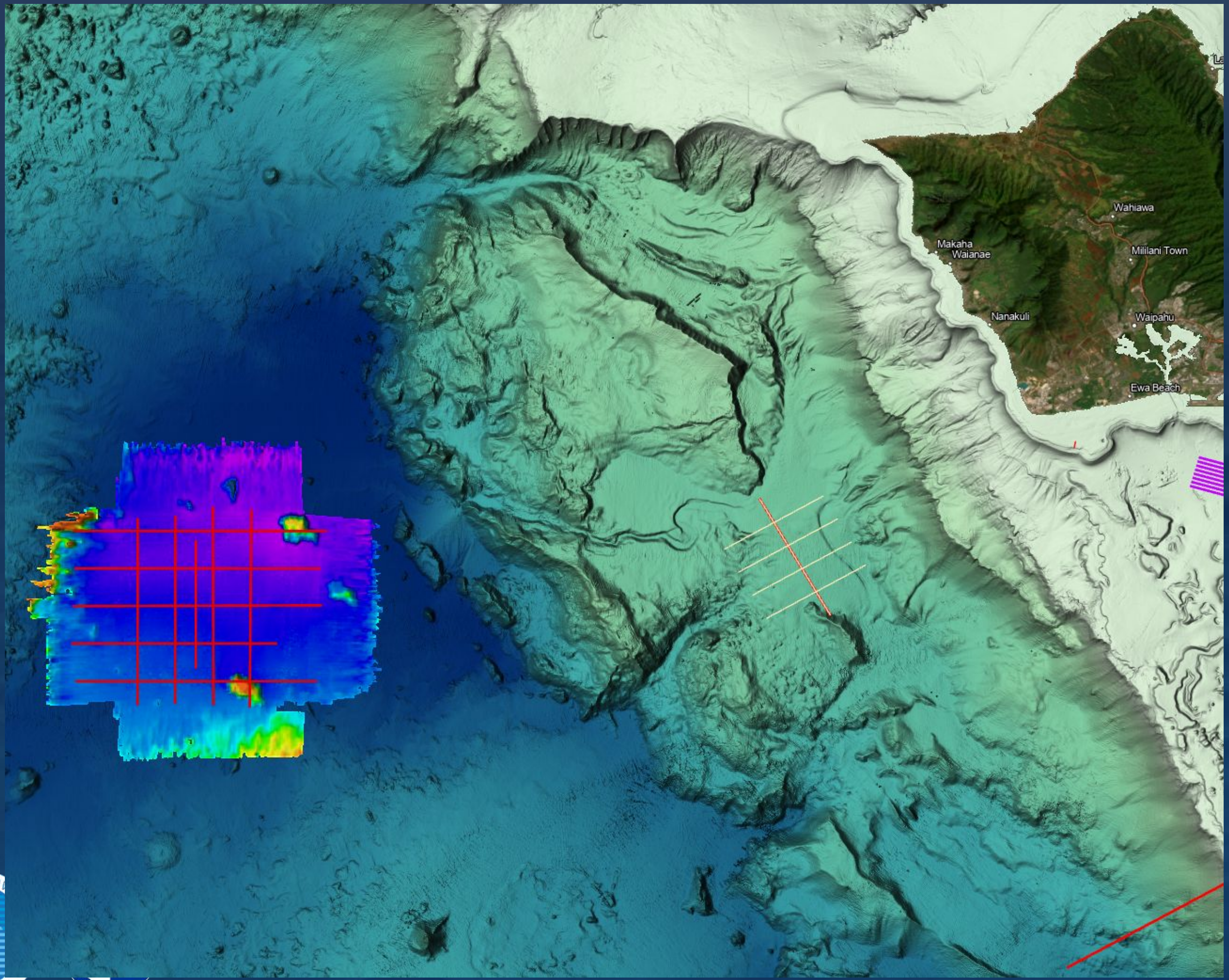
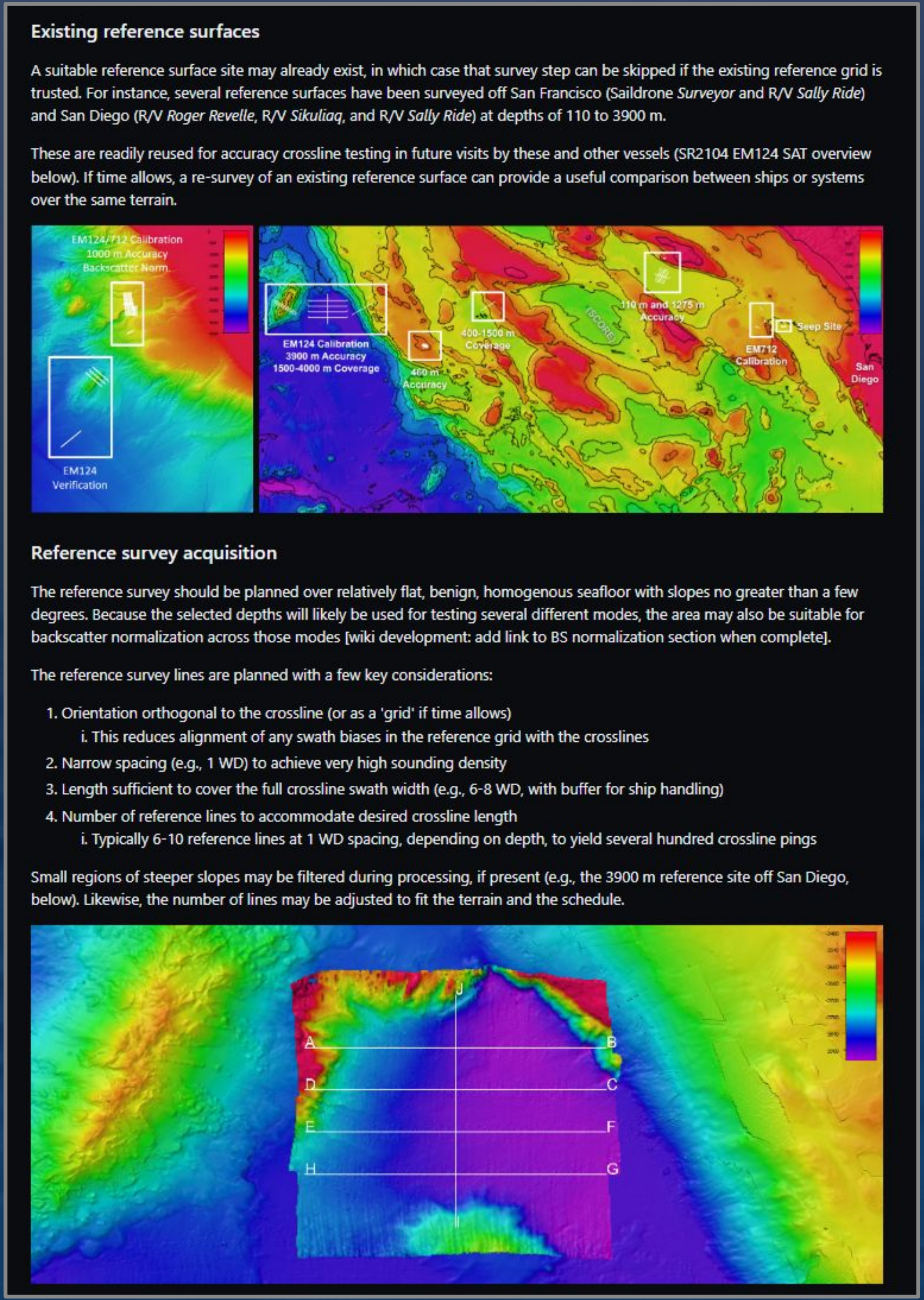
Swath Accuracy Plotter

1. Reference surfaces = largest time constraints
2. MBES Test Site Database: https://gis.ccom.unh.edu





Existing reference surfaces

A suitable reference surface site may already exist, in which case that survey step can be skipped if the existing reference grid is trusted. For instance, several reference surfaces have been surveyed off San Francisco (Saildrone *Surveyor* and R/V *Sally Ride*) and San Diego (R/V *Roger Revelle*, R/V *Sikuliaq*, and R/V *Sally Ride*) at depths of 110 to 3900 m.

These are readily reused for accuracy crossline testing in future visits by these and other vessels (SR2104 EM124 SAT overview below). If time allows, a re-survey of an existing reference surface can provide a useful comparison between ships or systems over the same terrain.

Reference survey acquisition

The reference survey should be planned over relatively flat, benign, homogenous seafloor with slopes no greater than a few degrees. Because the selected depths will likely be used for testing several different modes, the area may also be suitable for backscatter normalization across those modes [wiki development: add link to BS normalization section when complete].

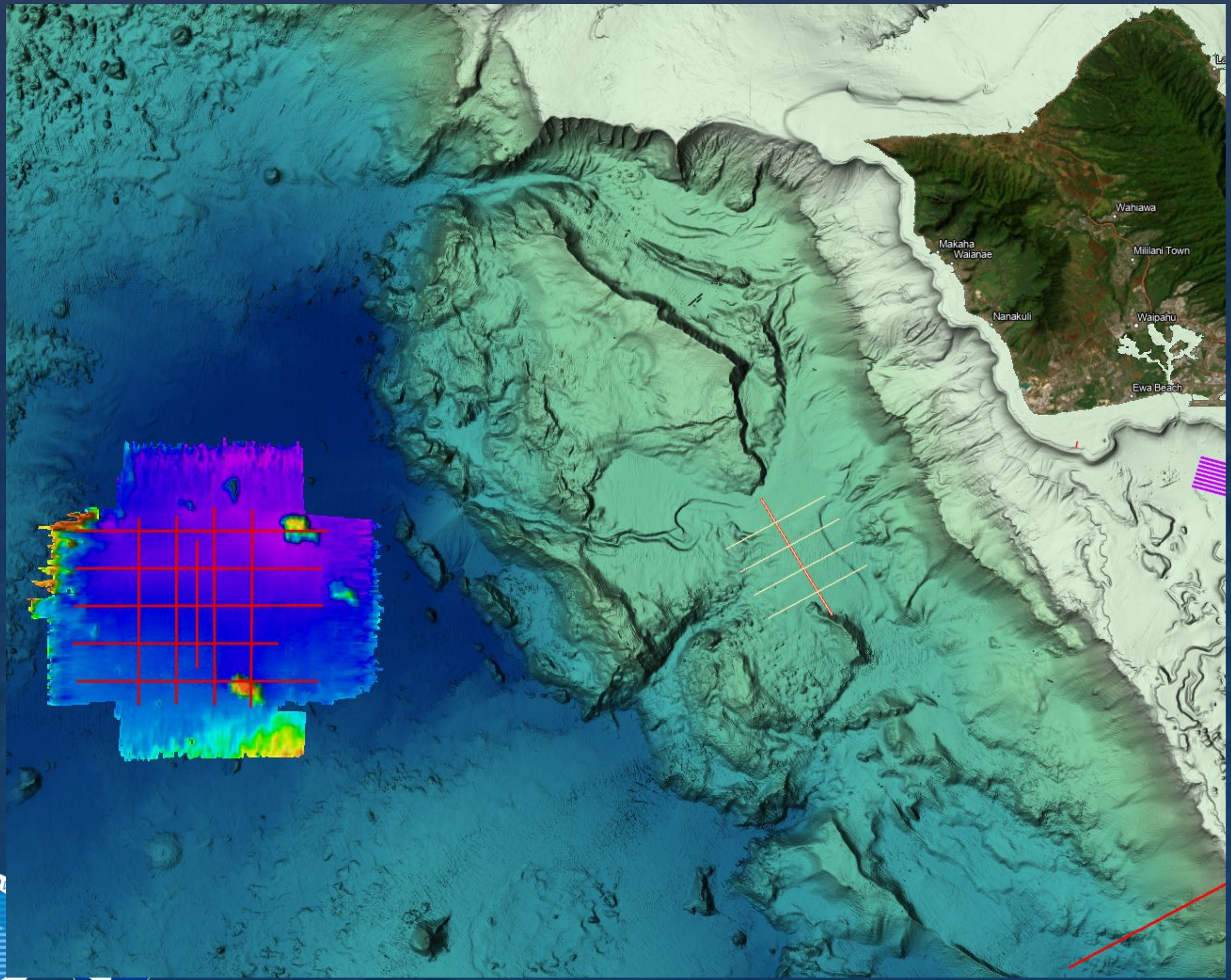
The reference survey lines are planned with a few key considerations:

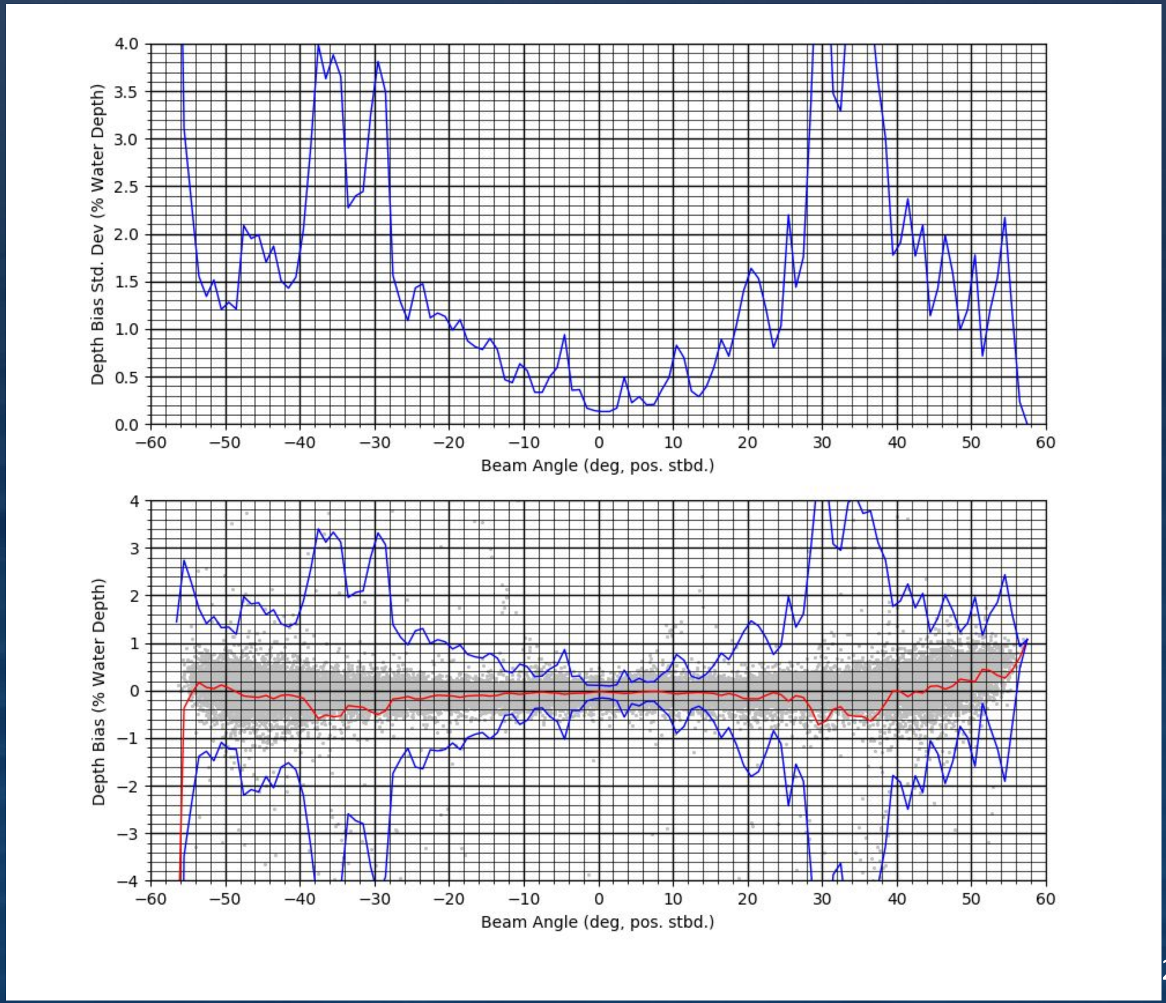
1. Orientation orthogonal to the crossline (or as a 'grid' if time allows)
   i. This reduces alignment of any swath biases in the reference grid with the crosslines
2. Narrow spacing (e.g., 1 WD) to achieve very high sounding density
3. Length sufficient to cover the full crossline swath width (e.g., 6-8 WD, with buffer for ship handling)
4. Number of reference lines to accommodate desired crossline length
   i. Typically 6-10 reference lines at 1 WD spacing, depending on depth, to yield several hundred crossline pings

Small regions of steeper slopes may be filtered during processing, if present (e.g., the 3900 m reference site off San Diego, below). Likewise, the number of lines may be adjusted to fit the terrain and the schedule.

Swath Accuracy Plotter

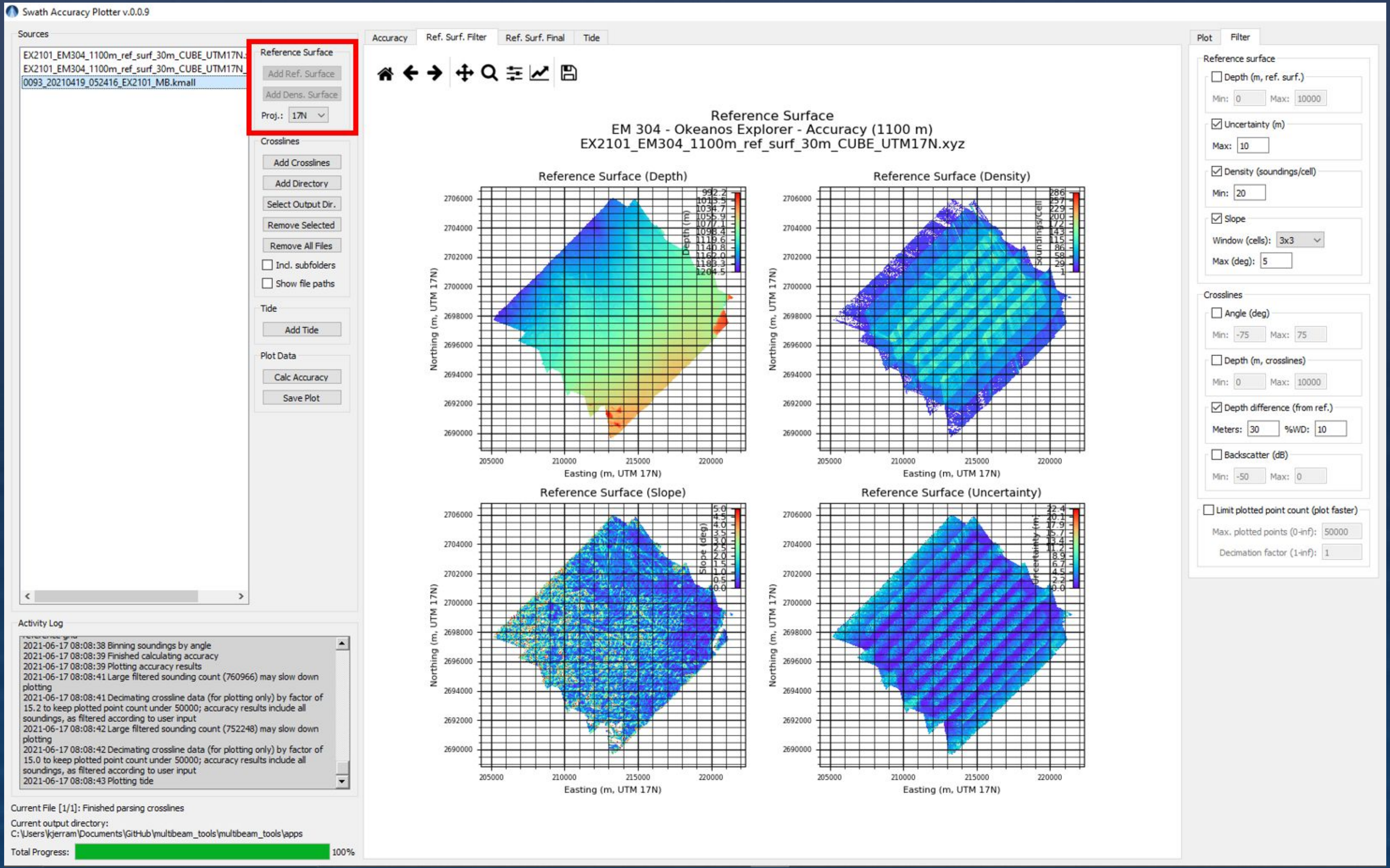
1. Opportunistic crosslines at proven reference sites
2. Catch problems before ‘normal’ survey operations





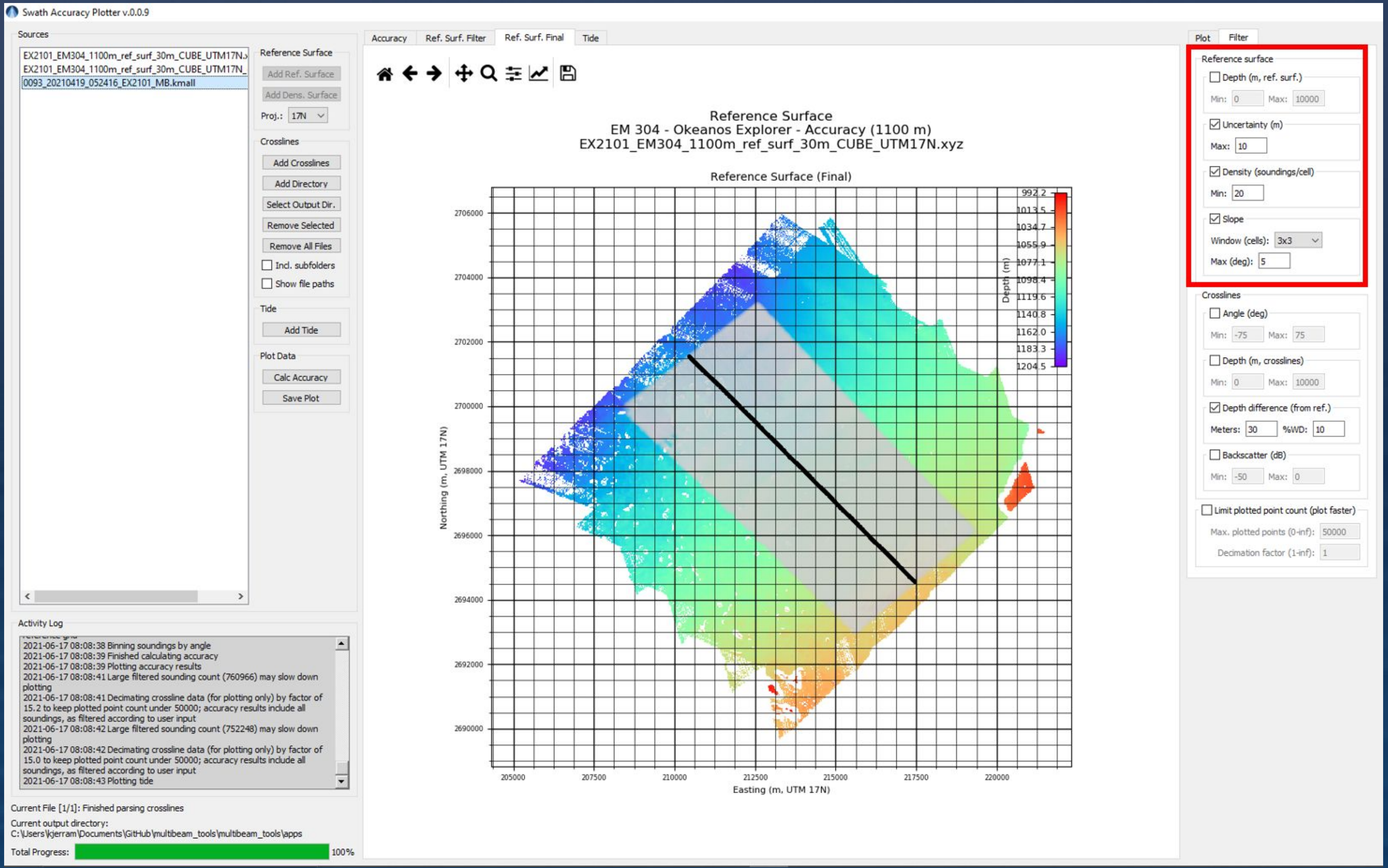
Swath Accuracy Plotter

1. Load reference surface exported in UTM from processing software



Swath Accuracy Plotter

1. Filter ref. surface by:
   a. Depth
   b. Sounding density
   c. Uncertainty (CUBE)
   d. Slope

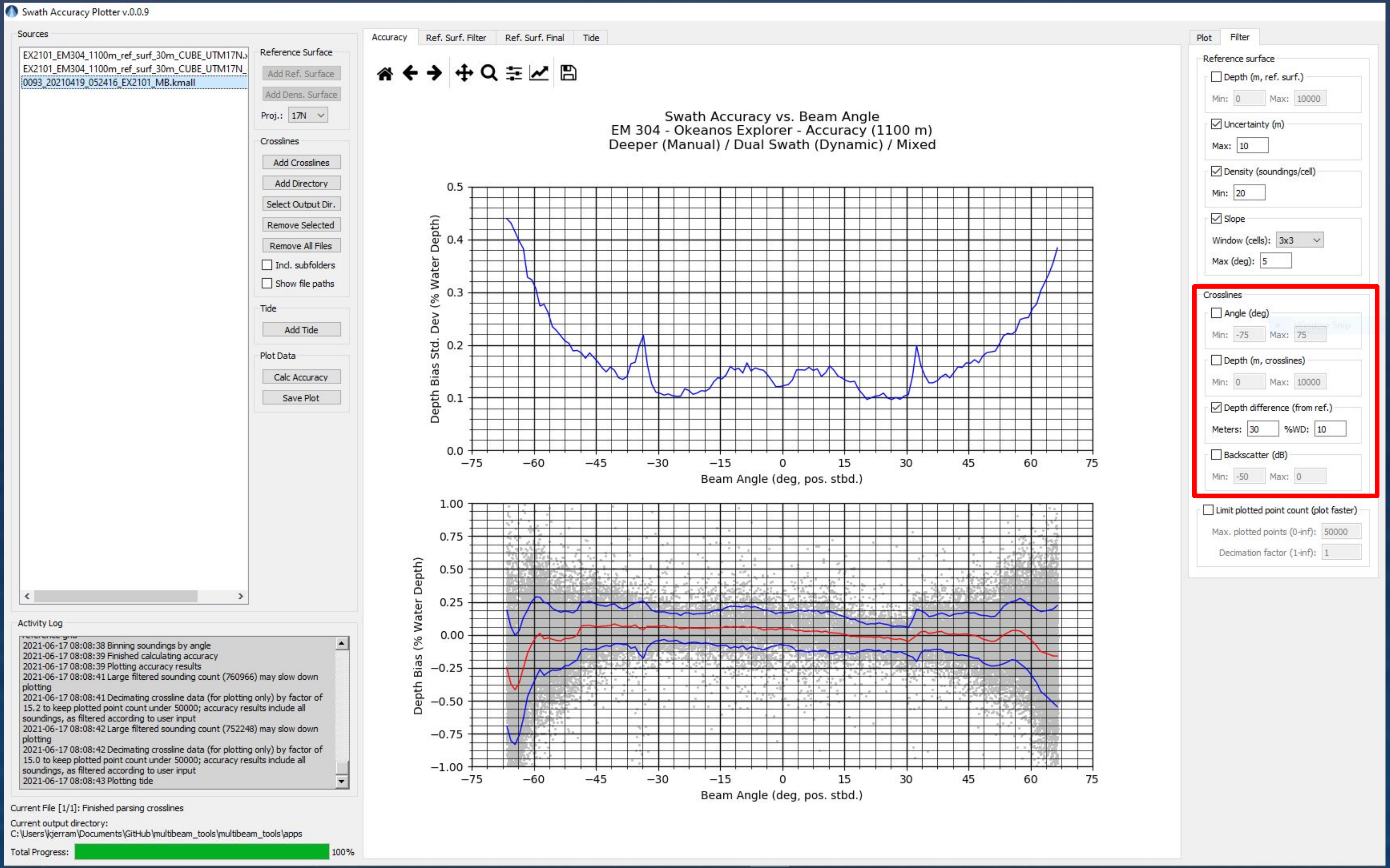


Filtered ref. surf. shown with crossline track and coverage

Swath Accuracy Plotter

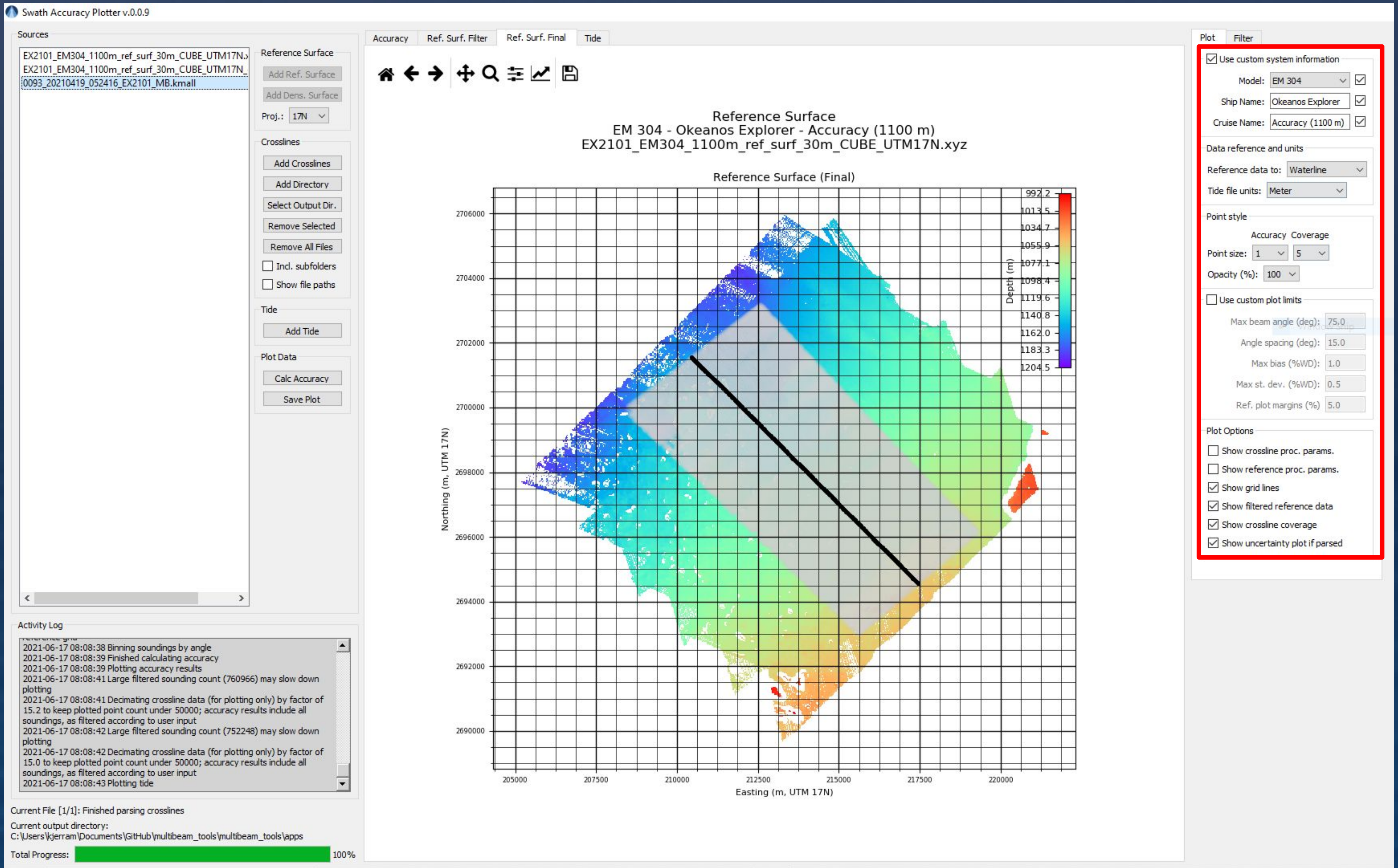
1. Load crosslines
   a. .all or .kmall only
   b. GSF some day?

2. Filter crosslines by:
   a. Angle
   b. Depth
   c. Depth difference
   d. Backscatter
   e. Depth mode



Swath Accuracy Plotter

1. Load tide
    a. TPXO (.txt)
    b. Caris (.tid)
2. Adjust waterline ref.
3. Plot with custom fields



Filtered ref. surf. shown with crossline track and coverage

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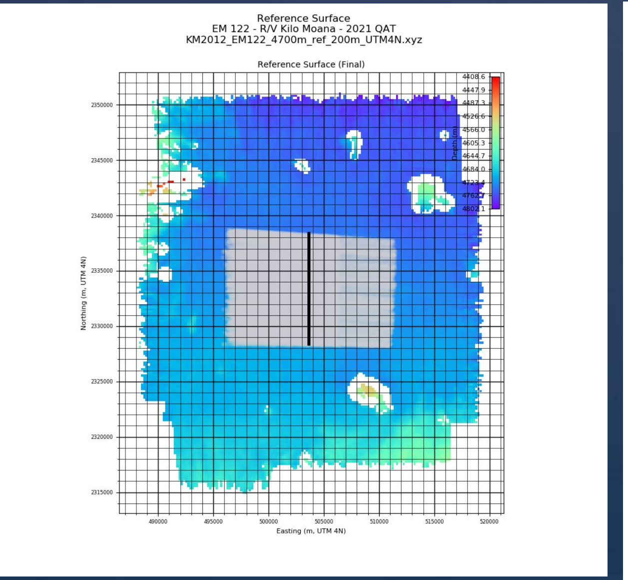
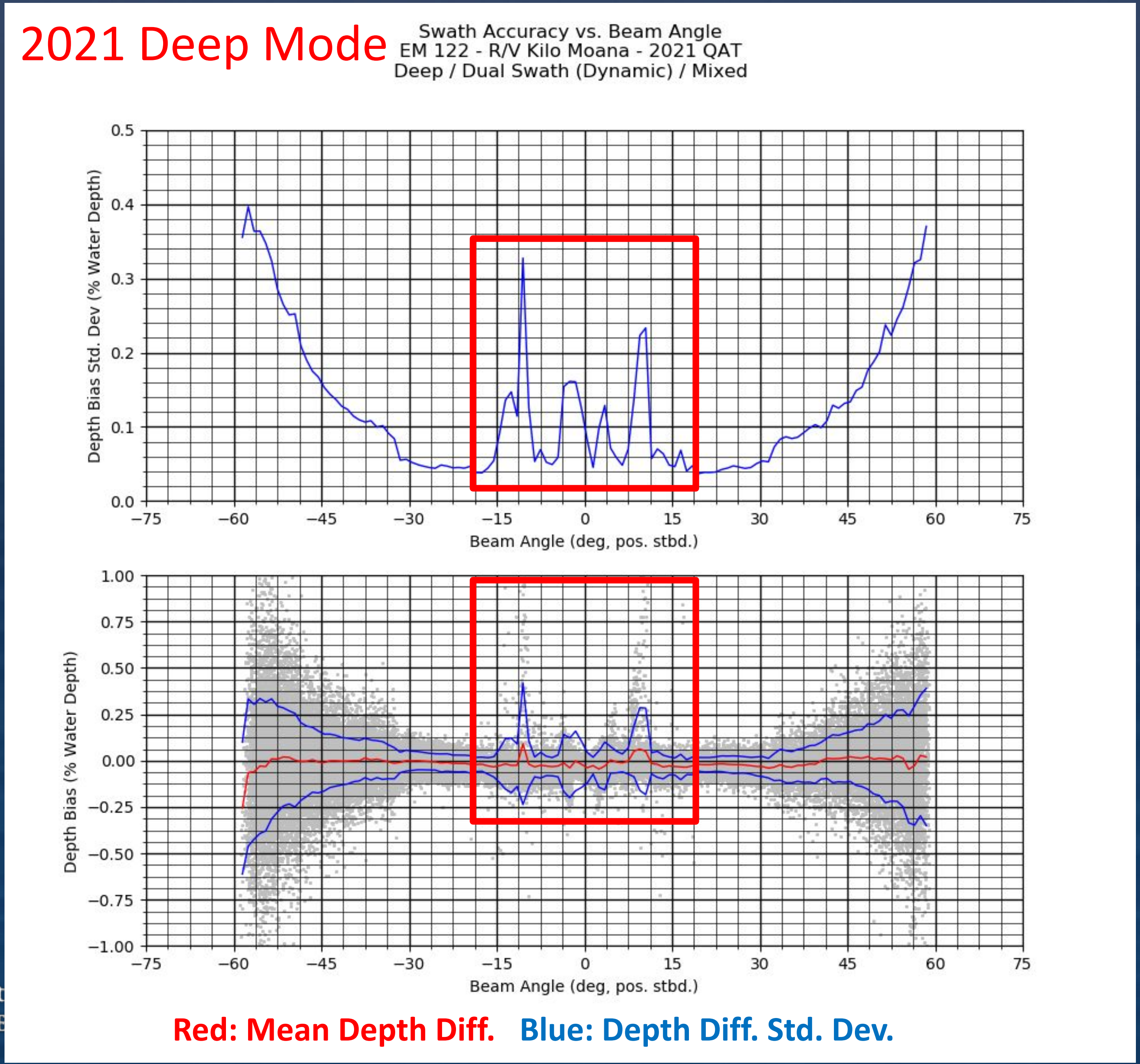
Swath Accuracy Plotter: **Tracking Performance**





Filtered to remove soundings >5% WD from ref. surface

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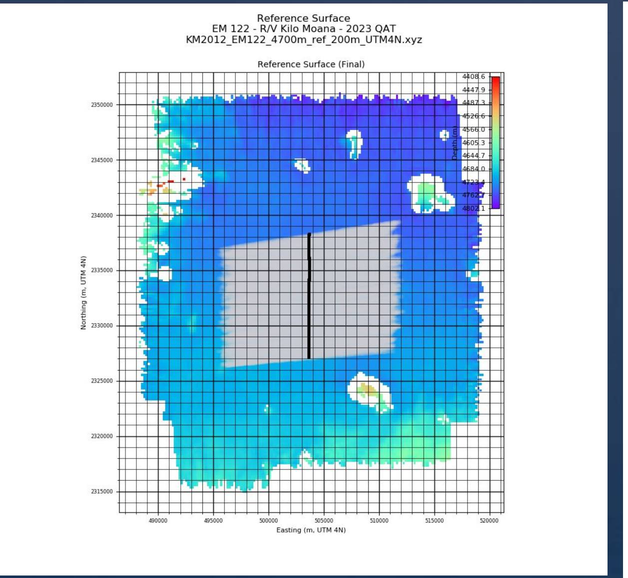
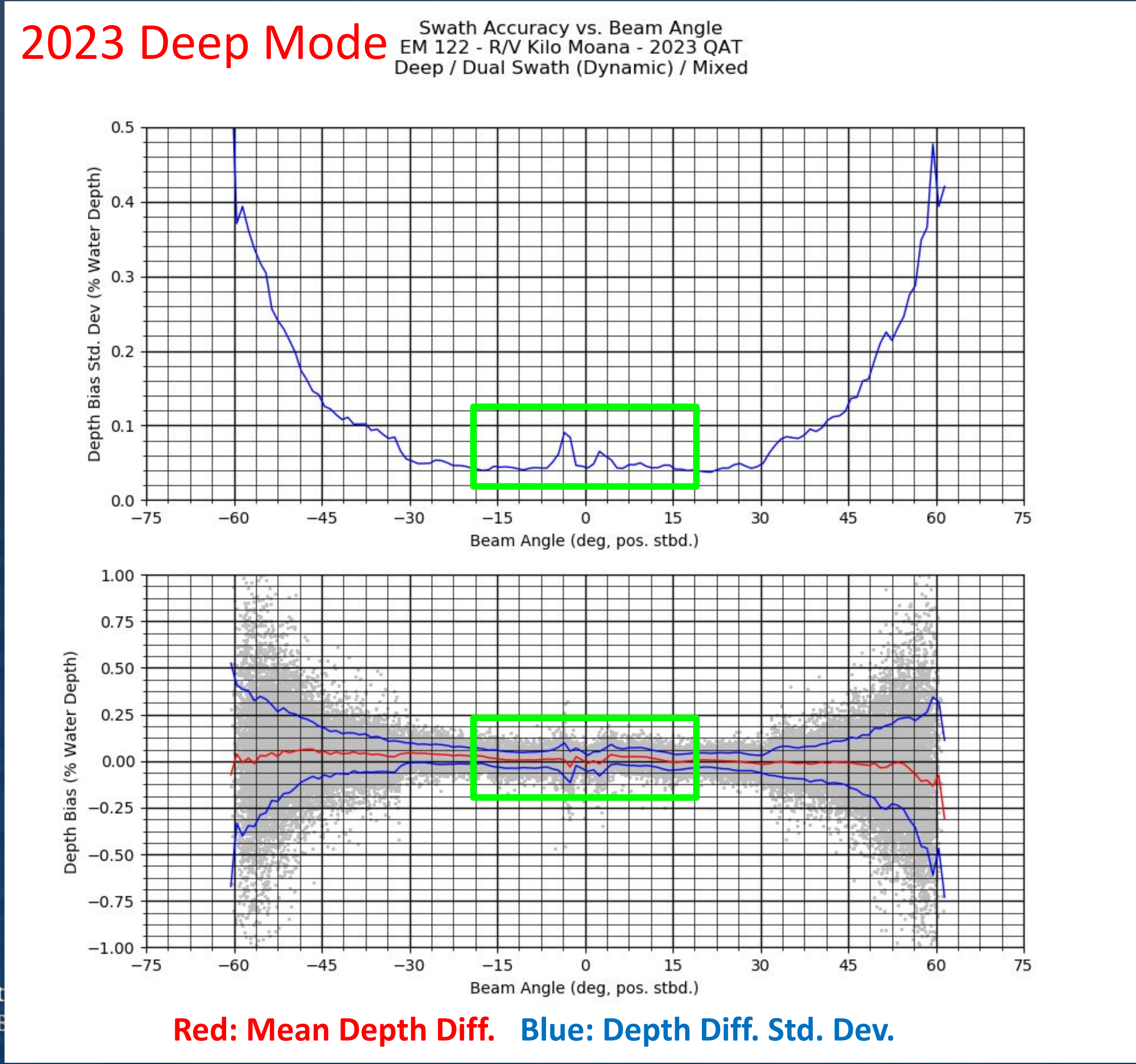
Swath Accuracy Plotter: **Tracking Performance**





Filtered to remove soundings >5% WD from ref. surface

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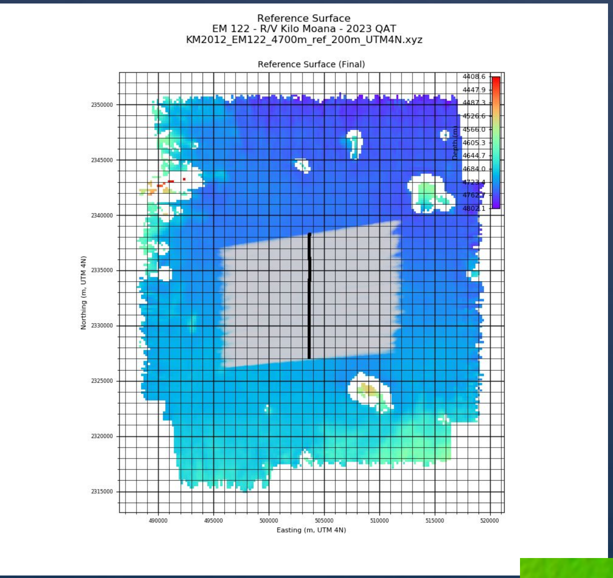
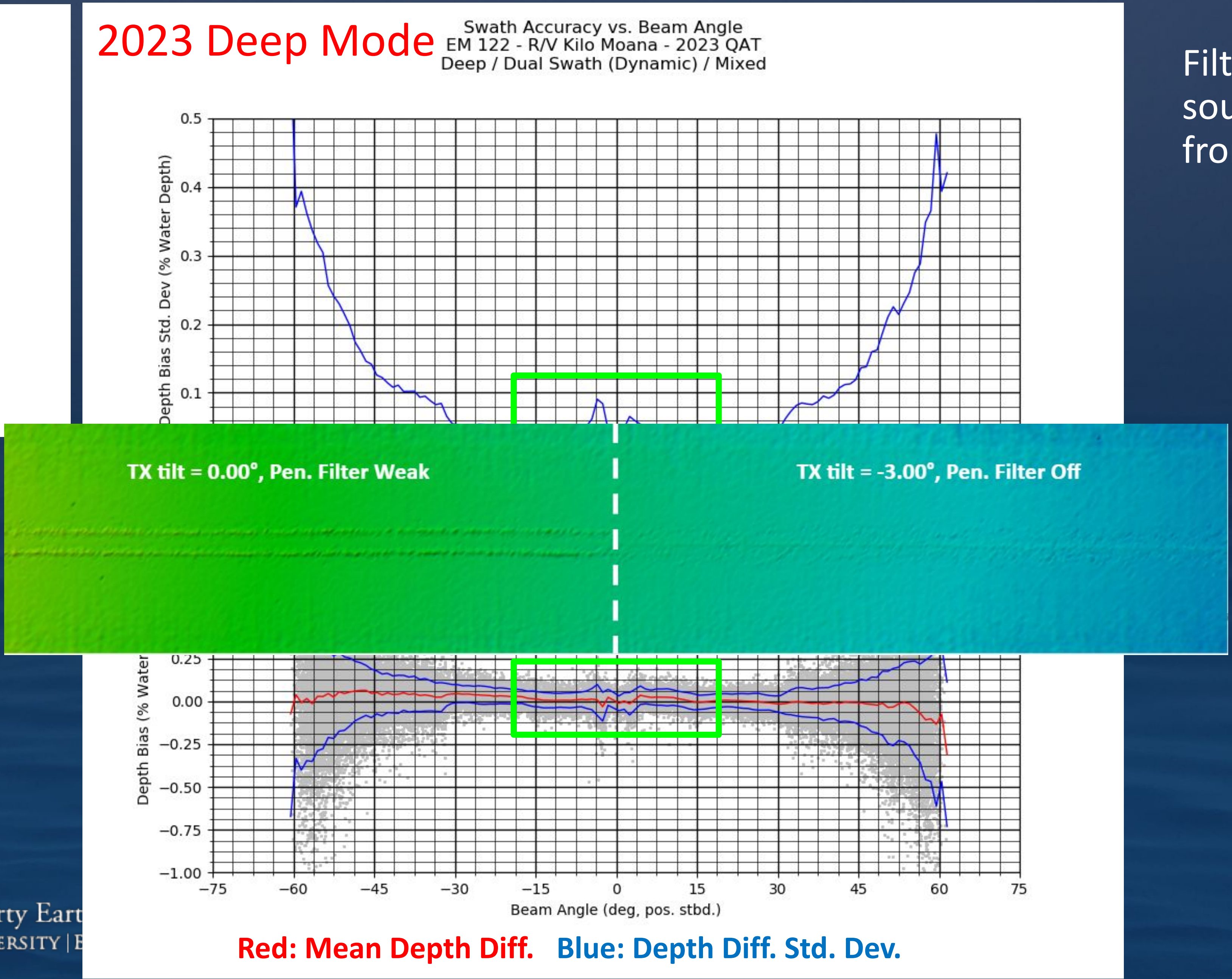
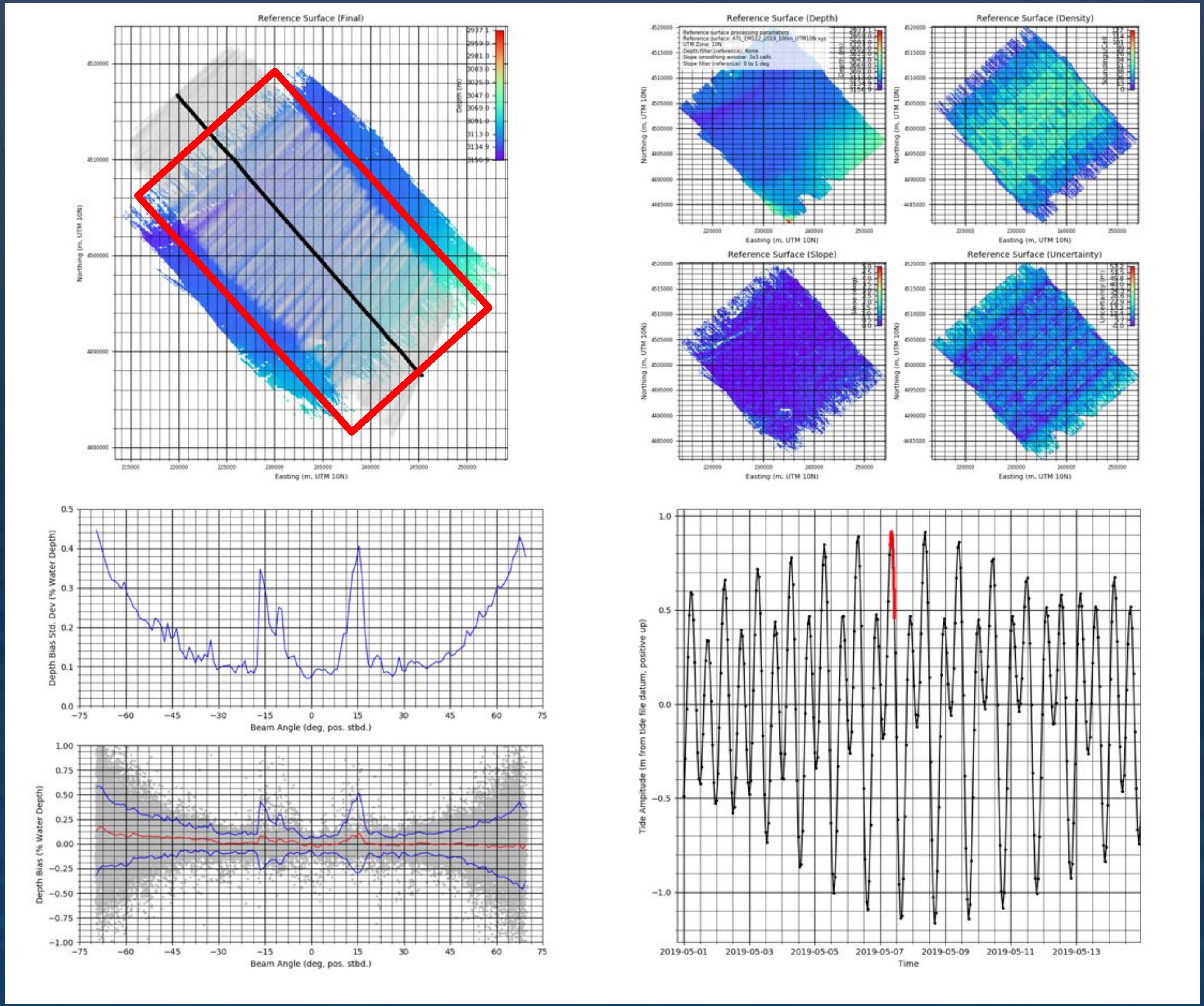




Filtered to remove soundings >5% WD from ref. surface

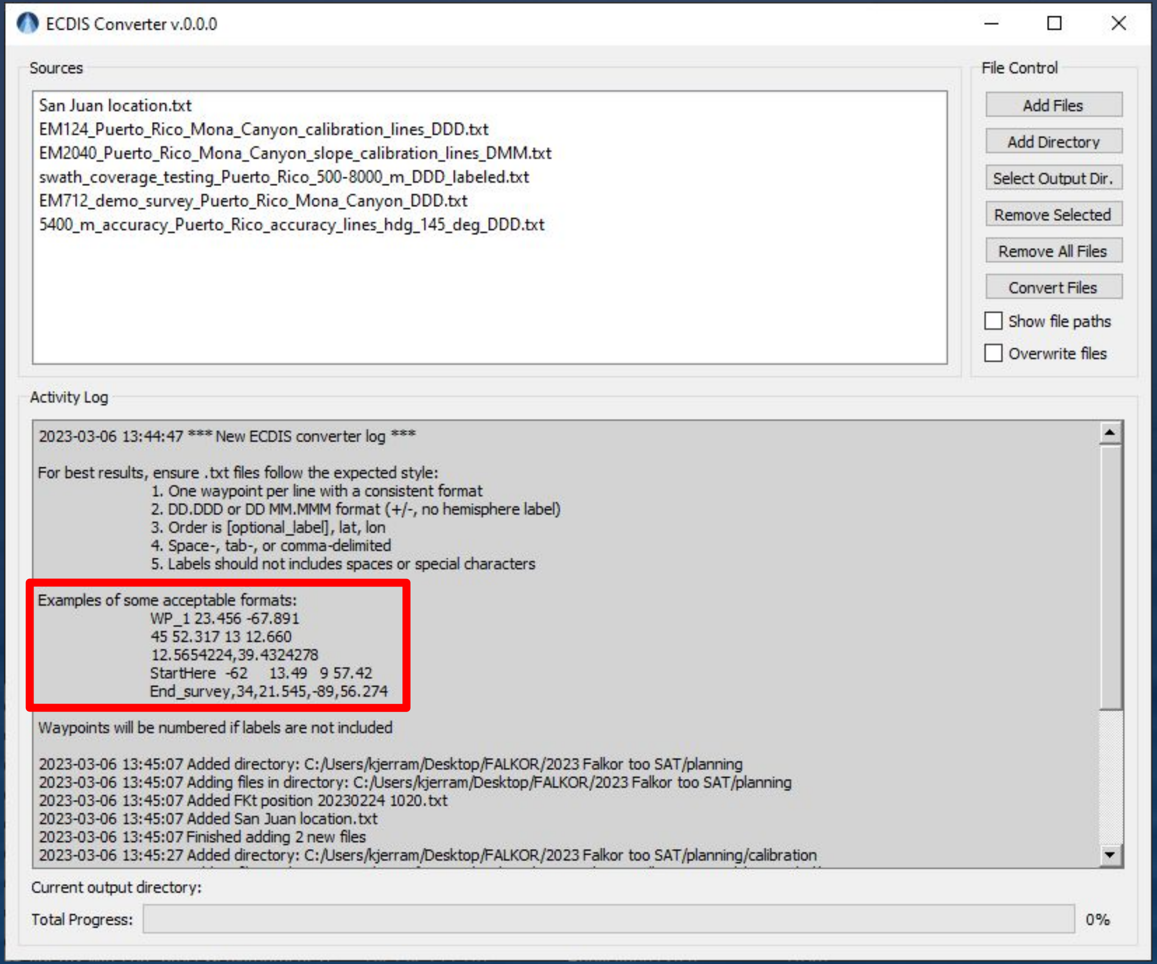
Swath Accuracy Plotter: **Detecting Other Issues**




ECDIS Converter

ECDIS Converter

github.com/oceanmapping/community/wiki



ECDIS Converter

The ECDIS Converter loads waypoint text files and exports ECDIS .lst files for easier ingestion into ships' navigation systems. This can reduce the time, effort, and opportunity for error in transcribing scientists' waypoints into the bridge officers' preferred formats.

This application is in development and does not provide any verification for correctness of the converted waypoints. Users are responsible for checking .lst output files for agreement with expectations and safety of navigation. If in doubt, convert the waypoints manually or with other software.

Waypoint text file input

The ECDIS Converter expects the following input .txt format:

1. One waypoint per line with a consistent format
2. DD.DDD or DD MM.MMM format (+/-, no hemisphere label)
3. Order is [optional_label], lat, lon
4. Space-, tab-, or comma-delimited
5. Labels should not includes spaces or special characters

Converting to ECDIS format

To export ECDIS .lst files:

1. Add waypoint text files or a source directory
2. Select the output directory, if desired
   i. If an output directory is not selected, each .lst export will be written to its corresponding input location
3. By default, any existing .lst files with the same name will be skipped to avoid overwriting
   i. Select 'Overwrite files' to overwrite existing .lst files, if desired
4. Select 'Convert Files' to convert all loaded .txt files to .lst
5. Check the activity log to review any warnings or skipped files
6. Review the waypoints in the ECDIS software to verify correct interpretation
   i. *Users are responsible for safety of navigation in all circumstances*

Feedback

Please provide feedback to mac-help@unols.org if you encounter (format-compatible) text file inputs that do not parse correctly or find .lst export files that do not load properly into a vessel's ECDIS system.

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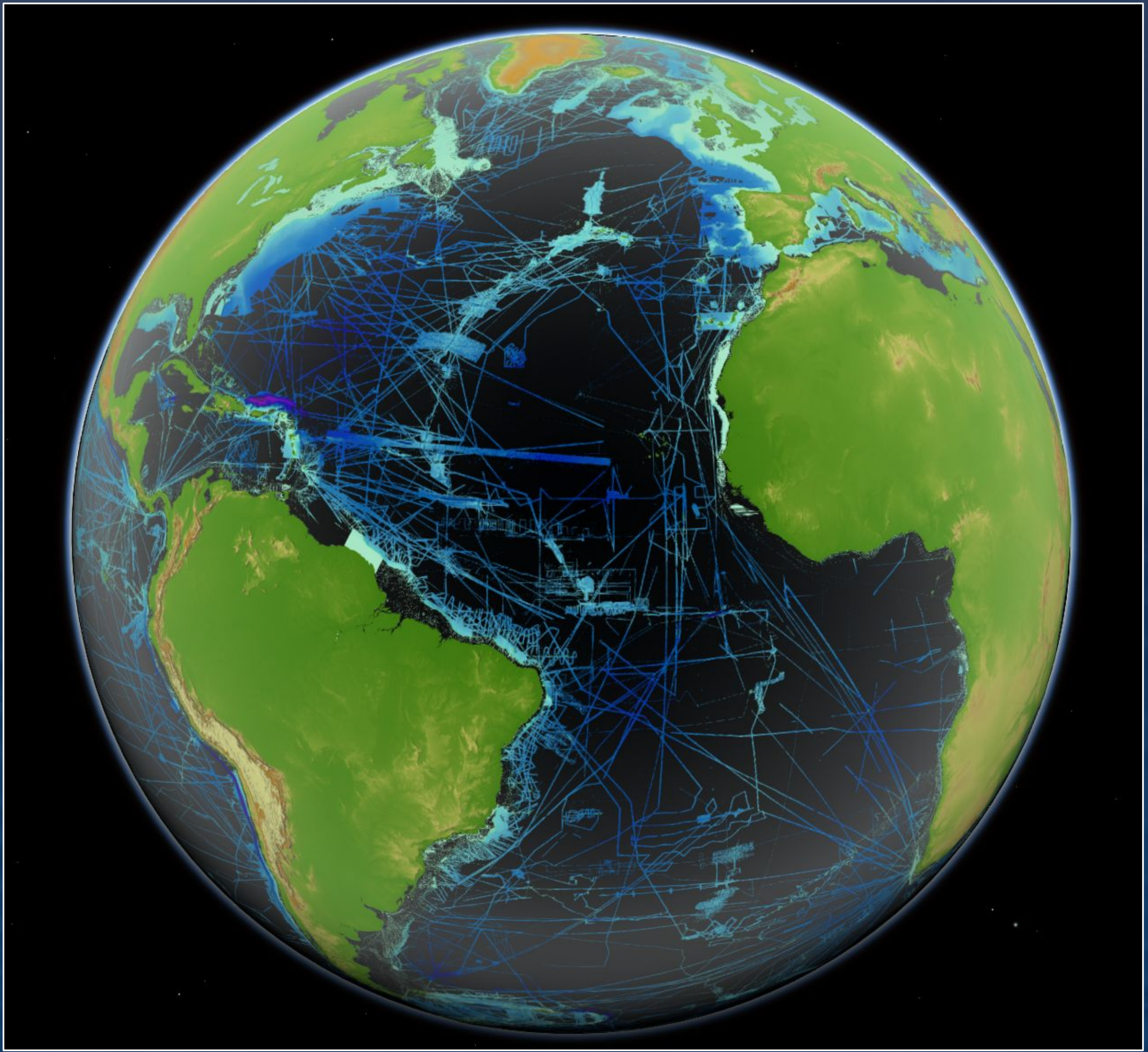
Transit Mapping

Transit Mapping: **Opportunities**

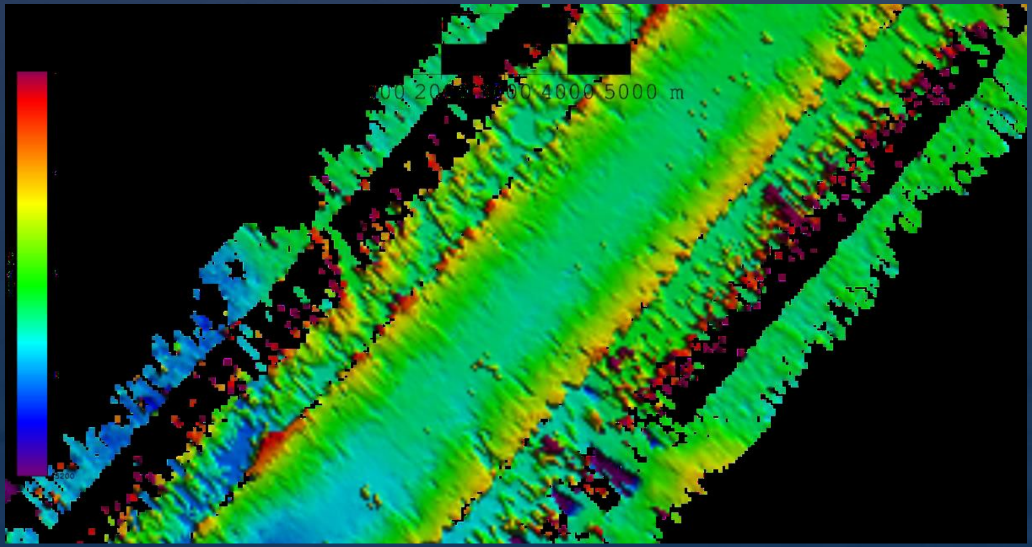
Contribute to global efforts
to ***Map The Gaps***

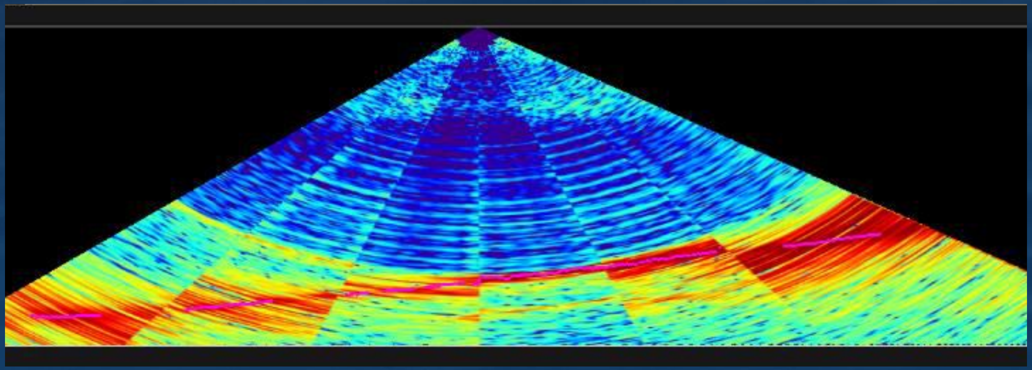
- Seabed 2030 / GEBCO
- UN Ocean Decade
- GMRT
- US EEZ / NOMEC Strategy

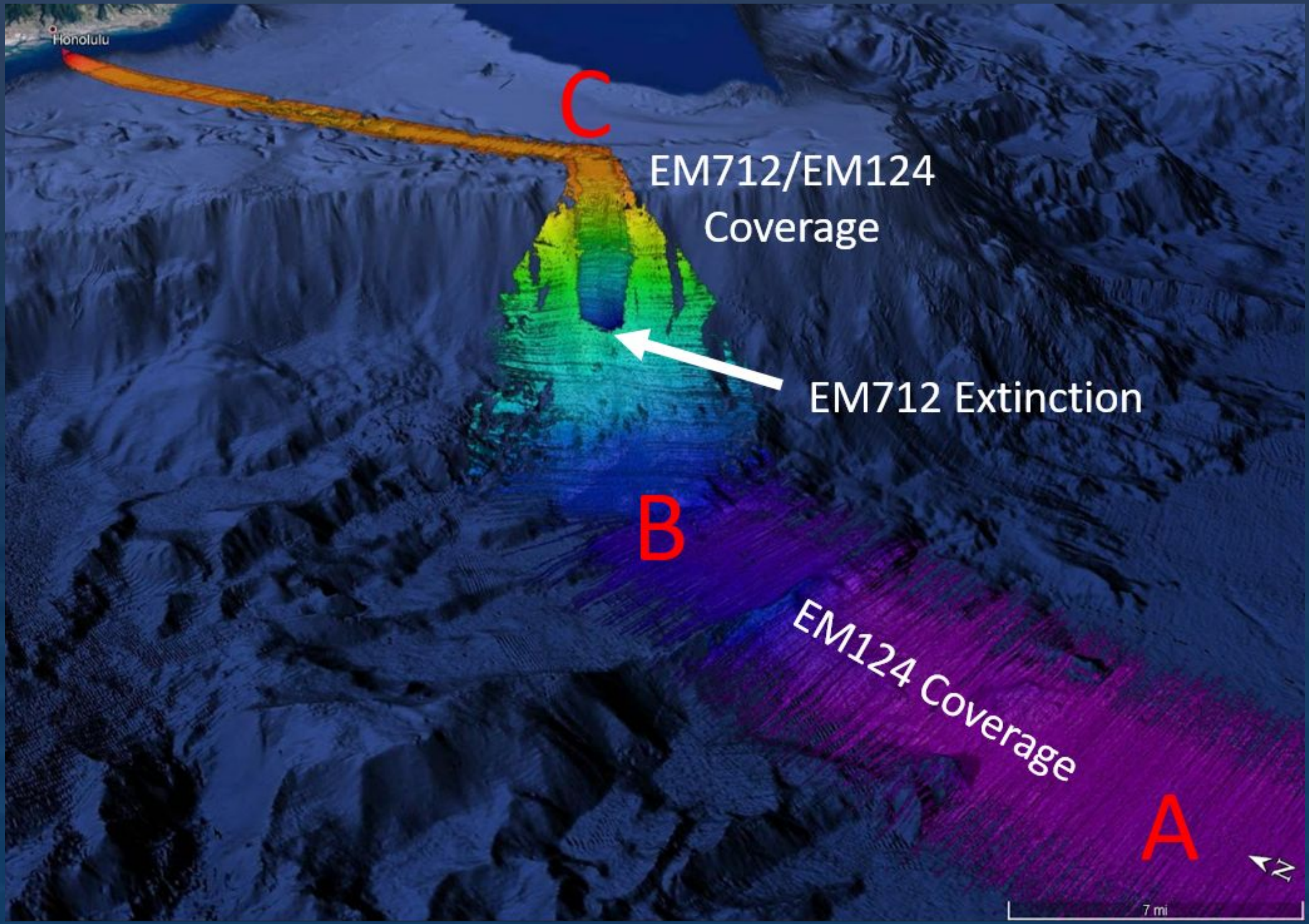


Transit Mapping: **Opportunities**

System performance testing **before** ‘real’ mapping cruises







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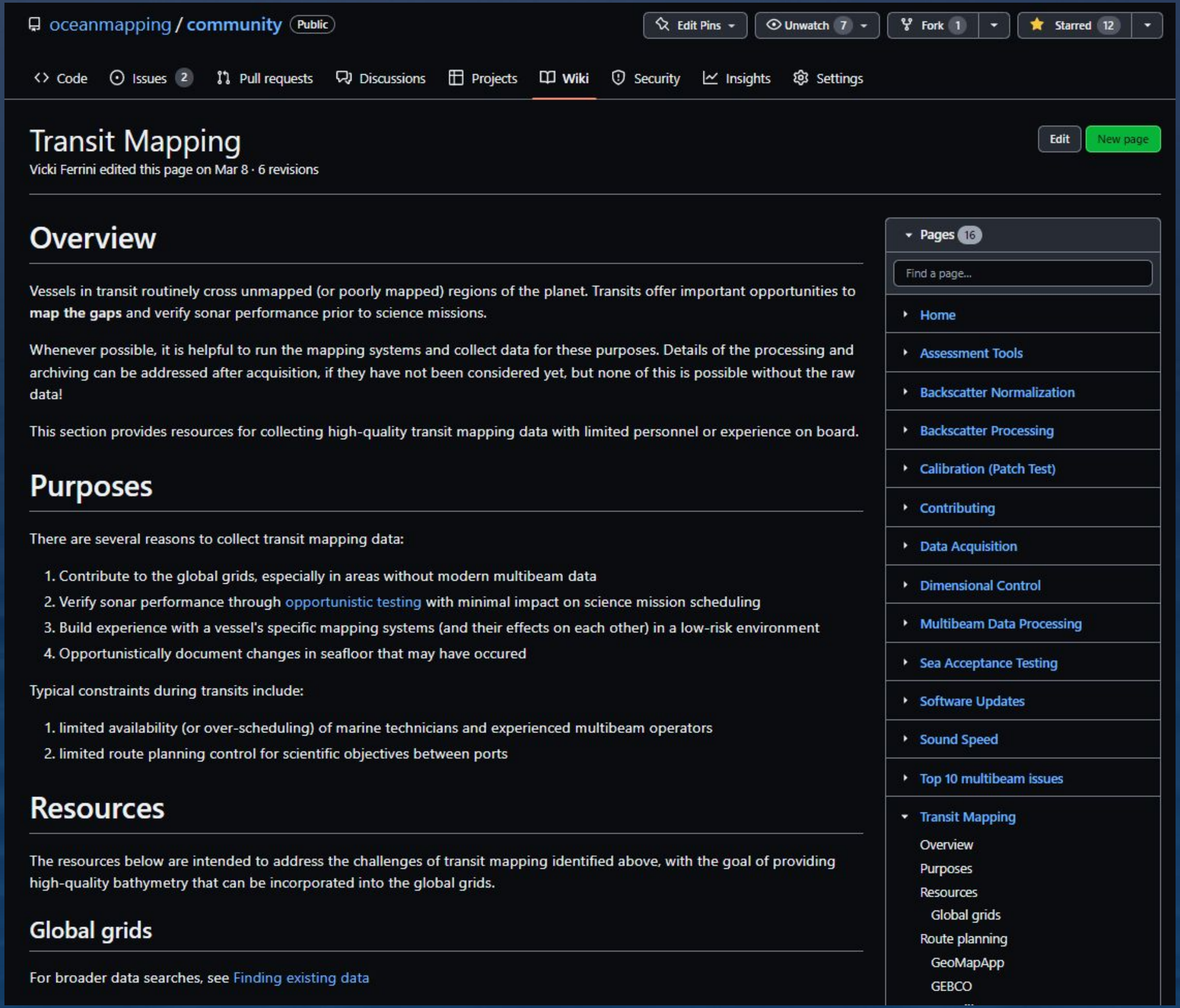
Transit Mapping: **Resources**

1. **Transit Mapping** in progress
2. Contributors welcome for this section **and many others**

omcadmin@ccom.unh.edu

mac-help@unols.org

github.com/oceanmapping/community/wiki



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Transit Mapping

Vicki Ferrini edited this page on Mar 8 · 6 revisions

Edit | New page

Overview

Vessels in transit routinely cross unmapped (or poorly mapped) regions of the planet. Transits offer important opportunities to **map the gaps** and verify sonar performance prior to science missions.

Whenever possible, it is helpful to run the mapping systems and collect data for these purposes. Details of the processing and archiving can be addressed after acquisition, if they have not been considered yet, but none of this is possible without the raw data!

This section provides resources for collecting high-quality transit mapping data with limited personnel or experience on board.

Purposes

There are several reasons to collect transit mapping data:

1. Contribute to the global grids, especially in areas without modern multibeam data
2. Verify sonar performance through opportunistic testing with minimal impact on science mission scheduling
3. Build experience with a vessel's specific mapping systems (and their effects on each other) in a low-risk environment
4. Opportunistically document changes in seafloor that may have occured

Typical constraints during transits include:

1. limited availability (or over-scheduling) of marine technicians and experienced multibeam operators
2. limited route planning control for scientific objectives between ports

Resources

The resources below are intended to address the challenges of transit mapping identified above, with the goal of providing high-quality bathymetry that can be incorporated into the global grids.

Global grids

For broader data searches, see Finding existing data

Pages 16

Find a page...

- Home
- Assessment Tools
- Backscatter Normalization
- Backscatter Processing
- Calibration (Patch Test)
- Contributing
- Data Acquisition
- Dimensional Control
- Multibeam Data Processing
- Sea Acceptance Testing
- Software Updates
- Sound Speed
- Top 10 multibeam issues
- Transit Mapping
  - Overview
  - Purposes
  - Resources
    - Global grids
  - Route planning
    - GeoMapApp
    - GEBCO

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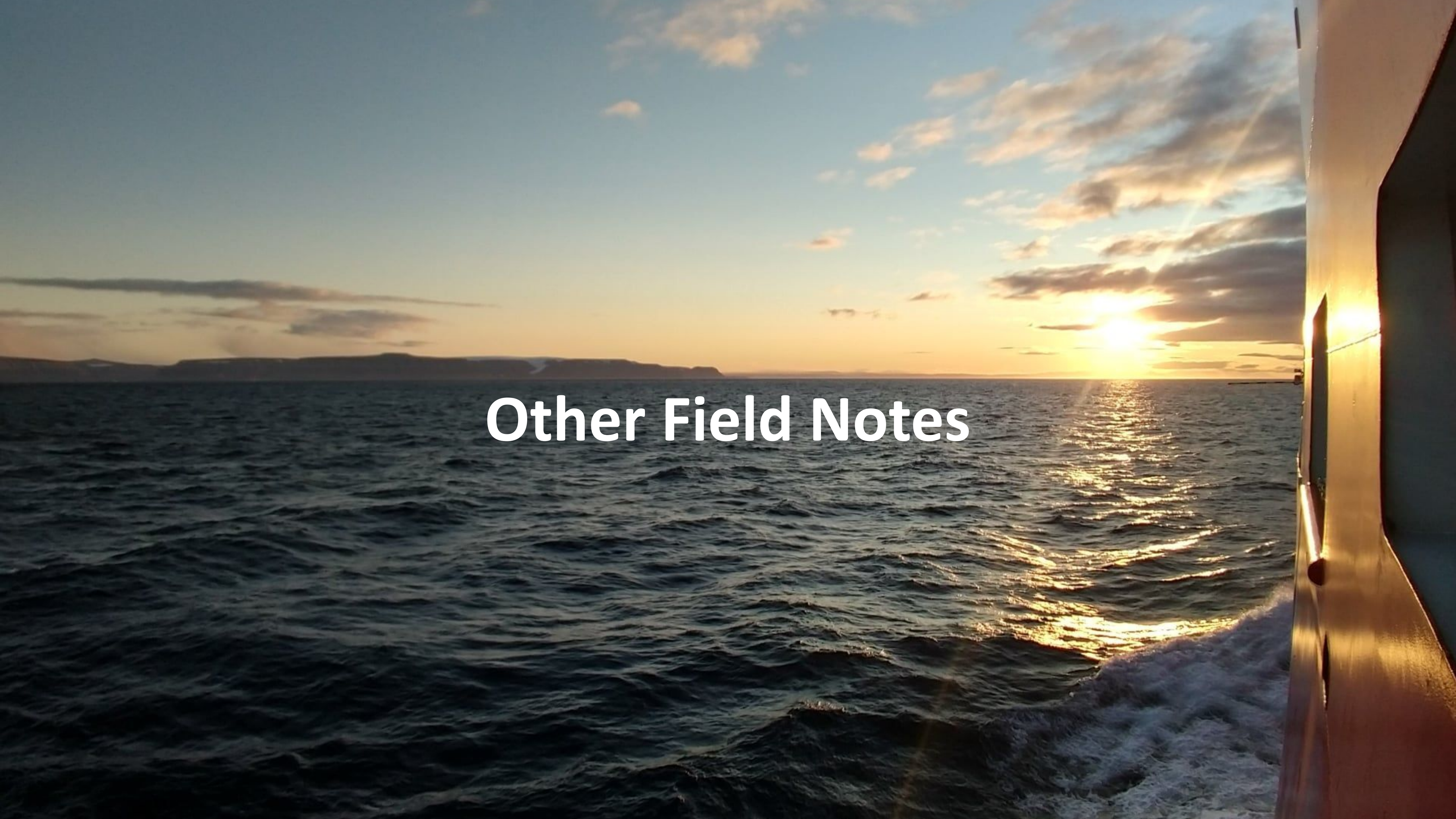
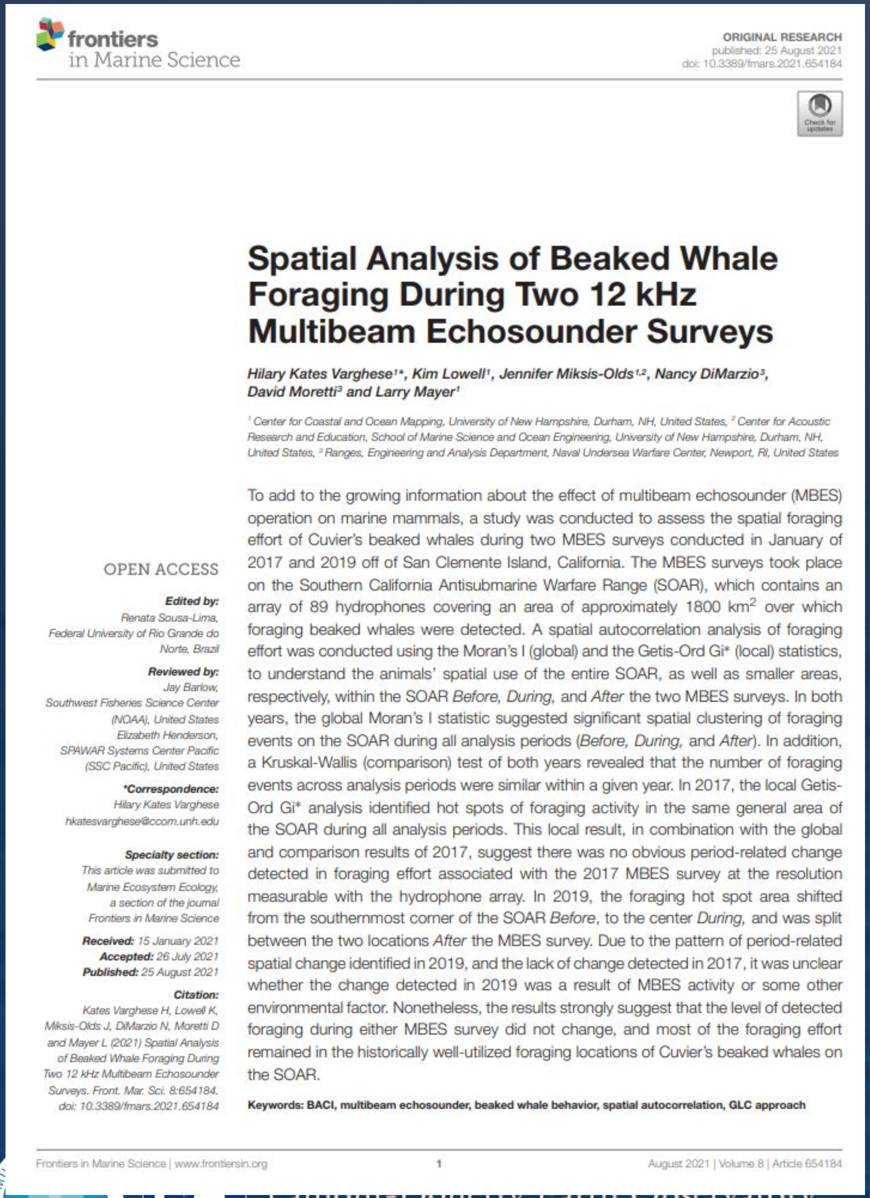

Other Field Notes

EM122 TX Characterization (2017-19)



frontiers in Marine Science

ORIGINAL RESEARCH
published: 25 August 2021
doi: 10.3389/fmars.2021.654184

Spatial Analysis of Beaked Whale Foraging During Two 12 kHz Multibeam Echosounder Surveys

Hilary Kates Varghese[1*], Kim Lowell[1], Jennifer Miksis-Olds[1,2], Nancy DiMarzio[3], David Moretti[3] and Larry Mayer[1]

[1] Center for Coastal and Ocean Mapping, University of New Hampshire, Durham, NH, United States, [2] Center for Acoustic Research and Education, School of Marine Science and Ocean Engineering, University of New Hampshire, Durham, NH, United States, [3] Ranges, Engineering and Analysis Department, Naval Undersea Warfare Center, Newport, RI, United States

To add to the growing information about the effect of multibeam echosounder (MBES) operation on marine mammals, a study was conducted to assess the spatial foraging effort of Cuvier's beaked whales during two MBES surveys conducted in January of 2017 and 2019 off of San Clemente Island, California. The MBES surveys took place on the Southern California Antisubmarine Warfare Range (SOAR), which contains an array of 89 hydrophones covering an area of approximately 1800 km^2 over which foraging beaked whales were detected. A spatial autocorrelation analysis of foraging effort was conducted using the Moran's I (global) and the Getis-Ord Gi* (local) statistics, to understand the animals' spatial use of the entire SOAR, as well as smaller areas, respectively, within the SOAR *Before*, *During*, and *After* the two MBES surveys. In both years, the global Moran's I statistic suggested significant spatial clustering of foraging events on the SOAR during all analysis periods (*Before*, *During*, and *After*). In addition, a Kruskal-Wallis (comparison) test of both years revealed that the number of foraging events across analysis periods were similar within a given year. In 2017, the local Getis-Ord Gi* analysis identified hot spots of foraging activity in the same general area of the SOAR during all analysis periods. This local result, in combination with the global and comparison results of 2017, suggest there was no obvious period-related change detected in foraging effort associated with the 2017 MBES survey at the resolution measurable with the hydrophone array. In 2019, the foraging hot spot area shifted from the southernmost corner of the SOAR *Before*, to the center *During*, and was split between the two locations *After* the MBES survey. Due to the pattern of period-related spatial change identified in 2019, and the lack of change detected in 2017, it was unclear whether the change detected in 2019 was a result of MBES activity or some other environmental factor. Nonetheless, the results strongly suggest that the level of detected foraging during either MBES survey did not change, and most of the foraging effort remained in the historically well-utilized foraging locations of Cuvier's beaked whales on the SOAR.

Keywords: BACI, multibeam echosounder, beaked whale behavior, spatial autocorrelation, GLC approach

OPEN ACCESS

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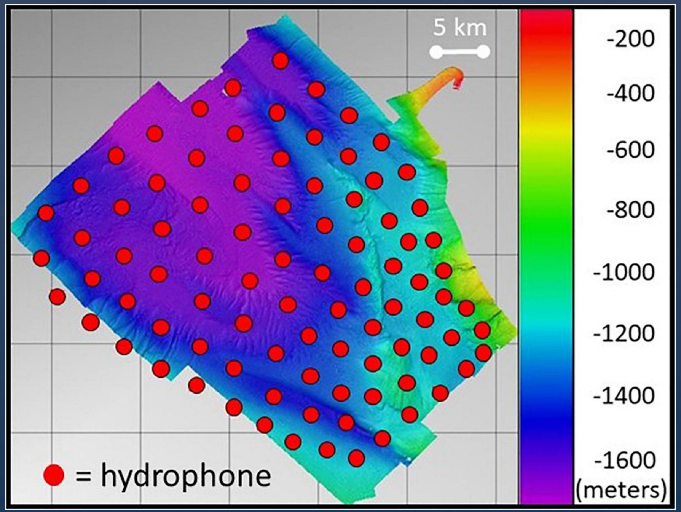

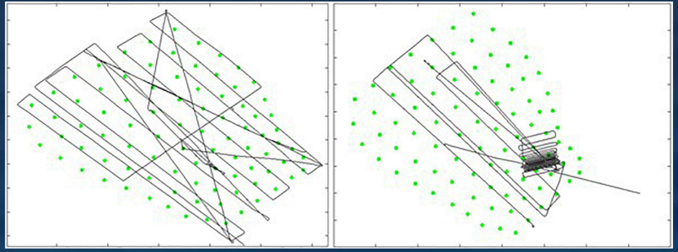

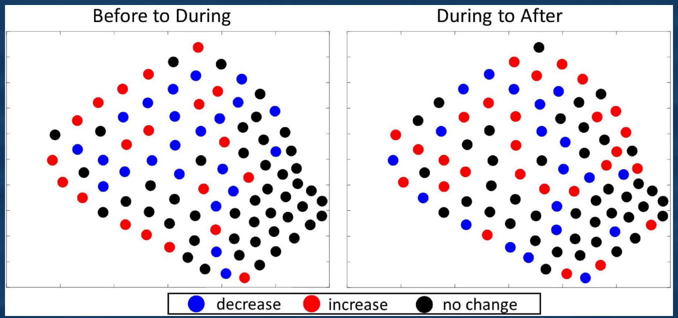

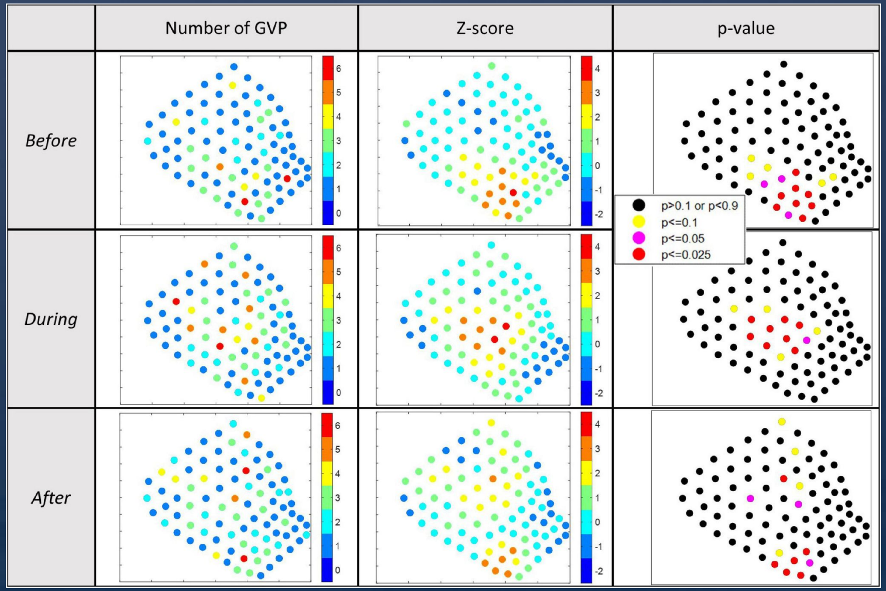

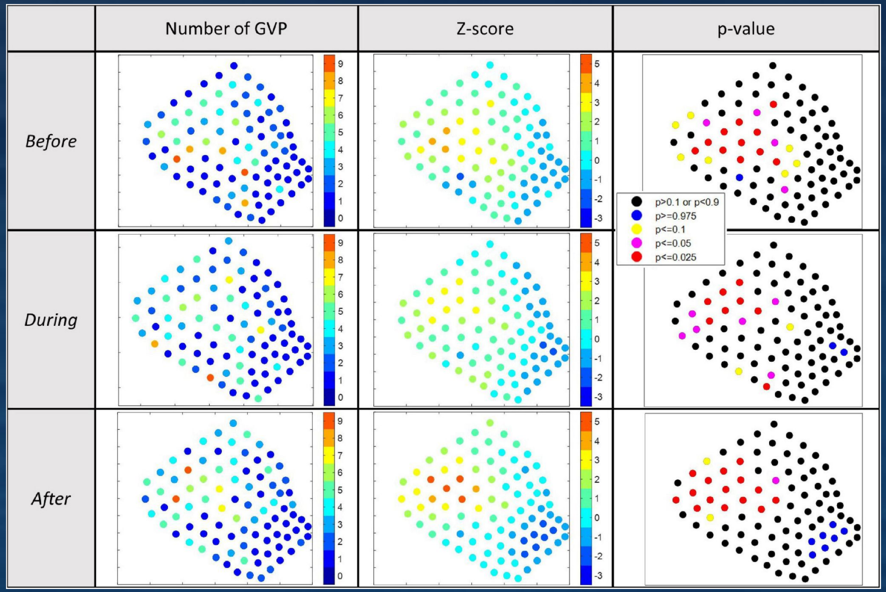

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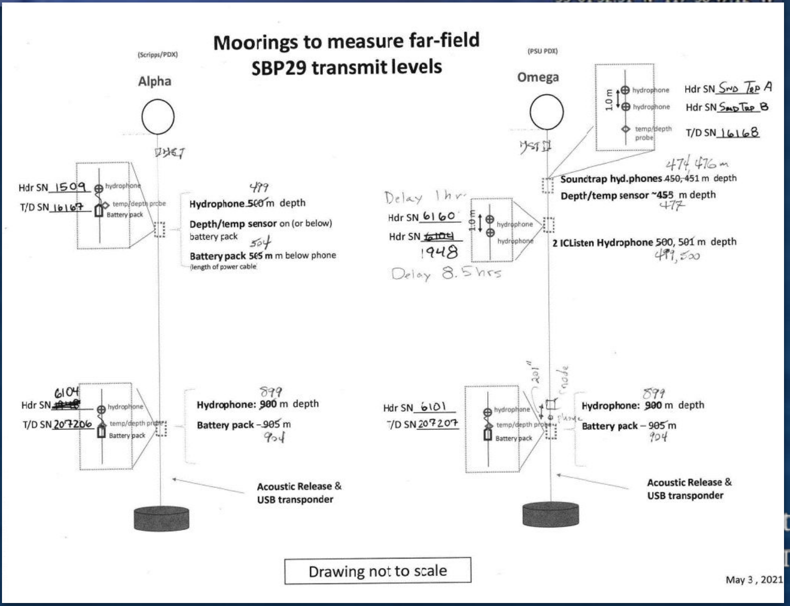
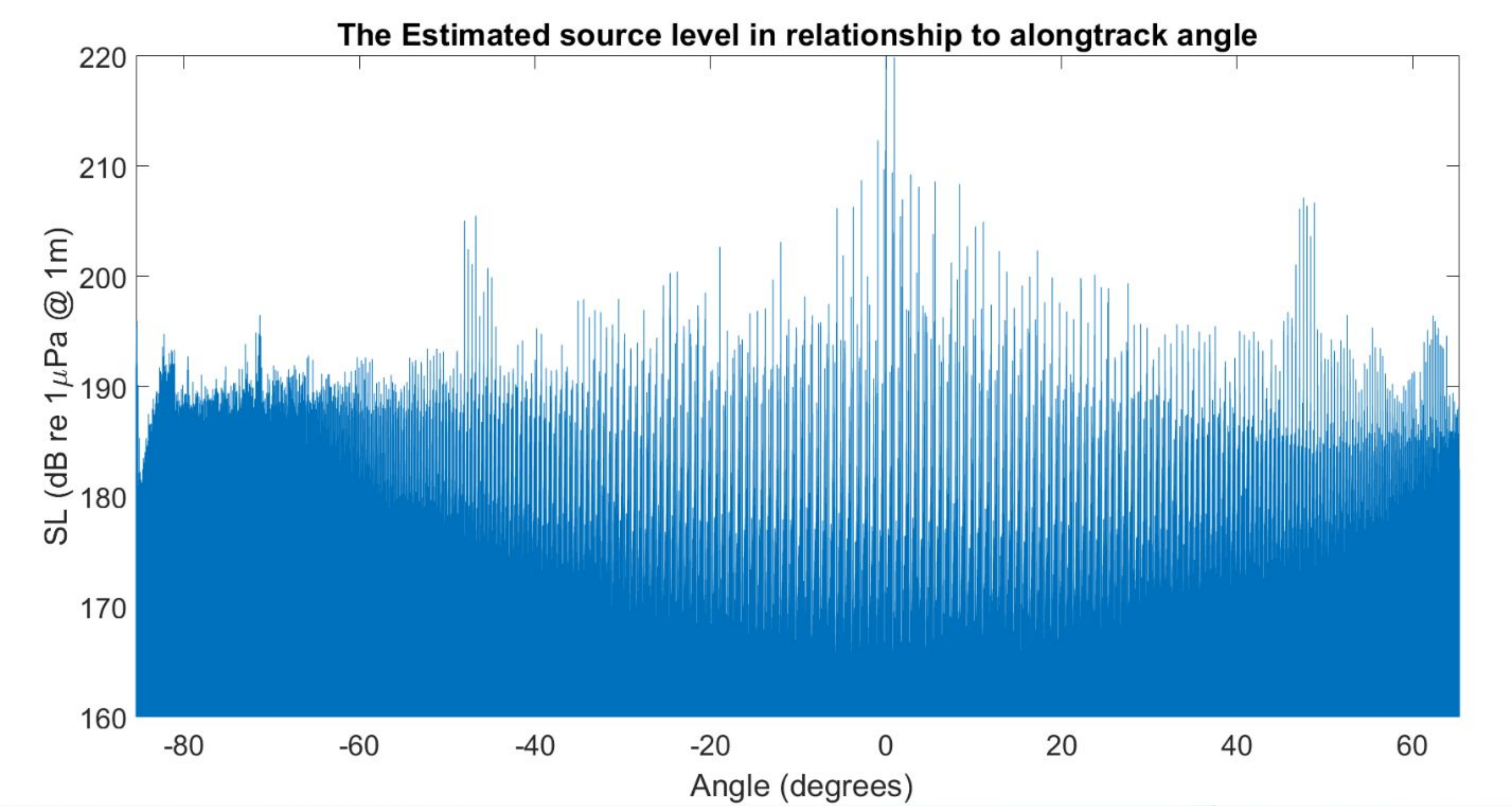
https://www.frontiersin.org/articles/10.3389/fmars.2021.654184/full

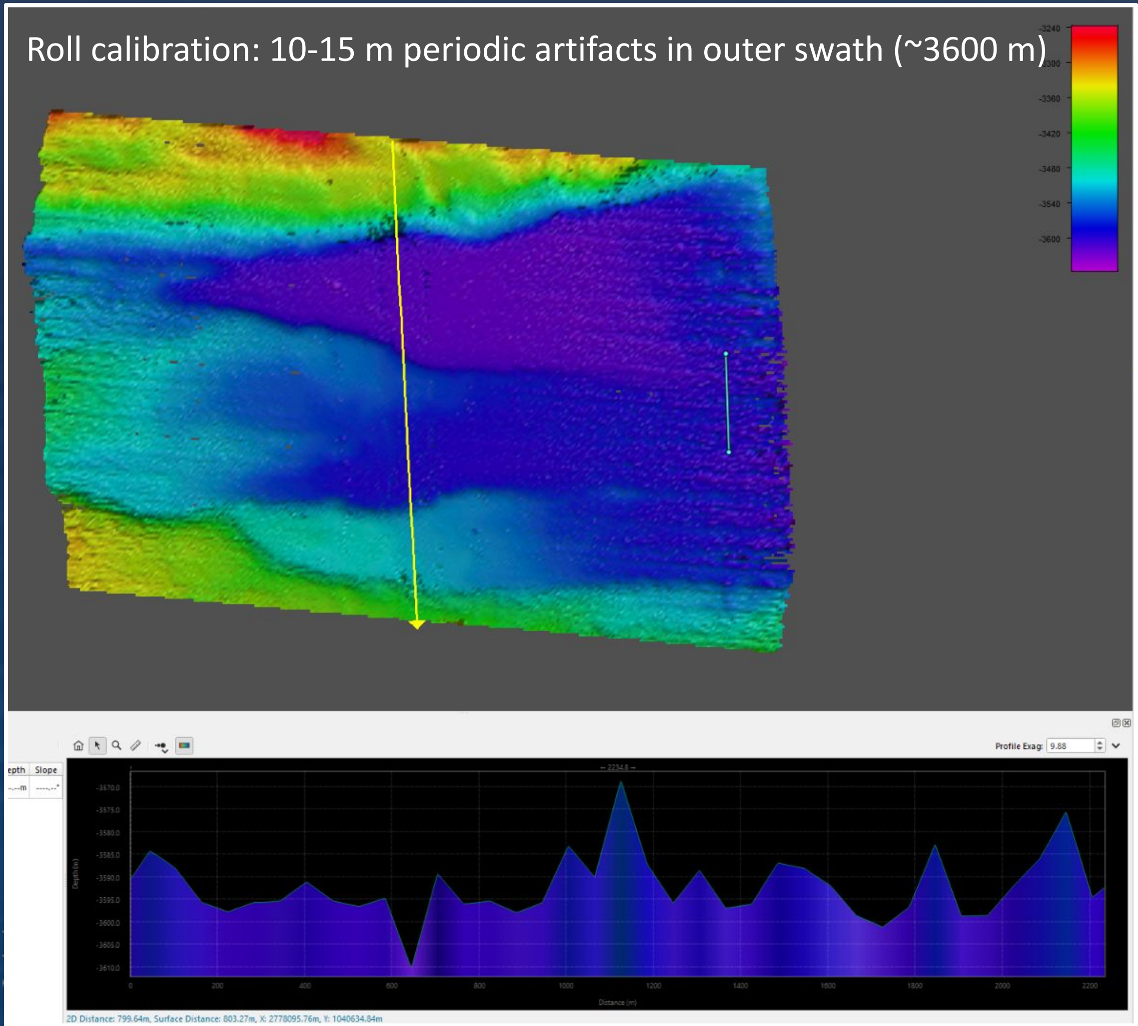
EM124 TX Characterization (2021)

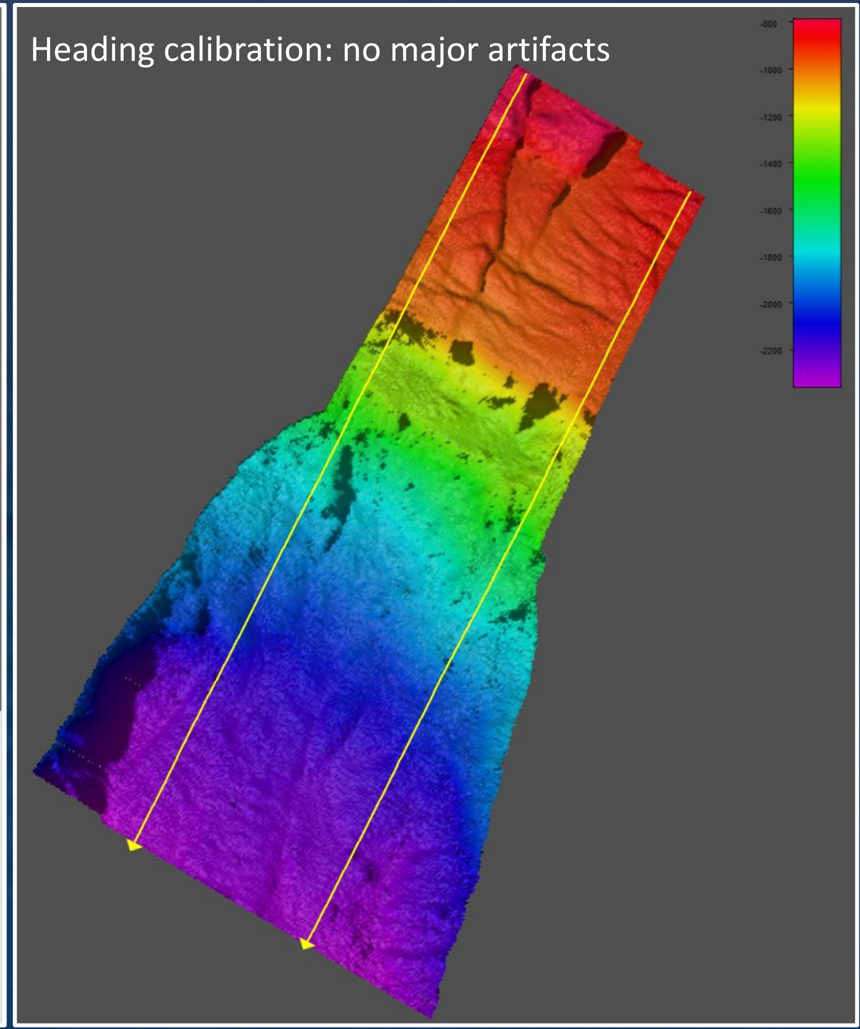




Example from the Field: Swath Wobbles

1. Multibeam systems up to date with total geometry review, calibrations, noise testing
2. ‘Wobbles’ in some data (left) but not all (right) during calibration

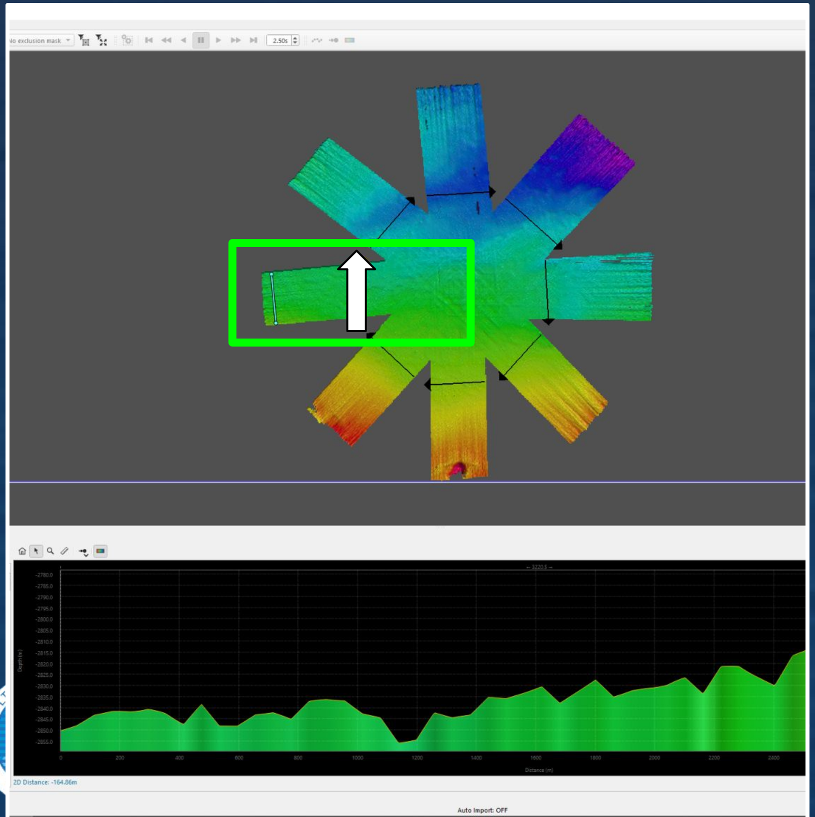




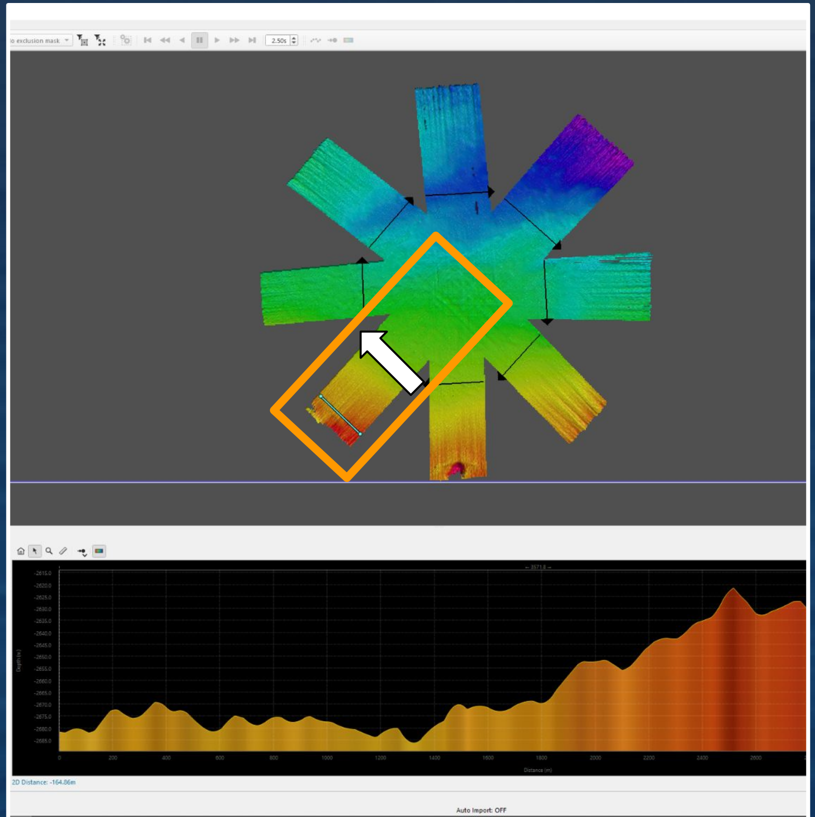
Example from the Field: Swath Wobbles

1. Asked ship to run a mapping 'octagon' with 10-15 minutes on eight headings (2650-2850 m)
2. Try to assess changes in swath behavior with orientation to potential internal wave field
3. Typical 1-3° roll and pitch with stable surface sound speed on all headings

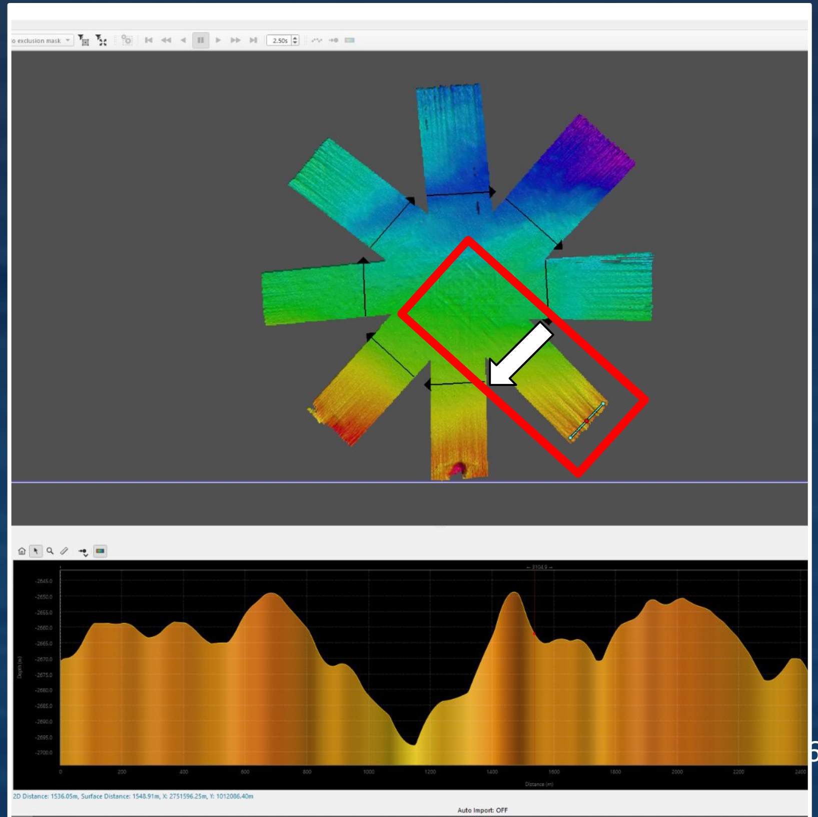
'Best' case:
~5 m ripples (N)



'Middle' case:
~20 m waves (NW)

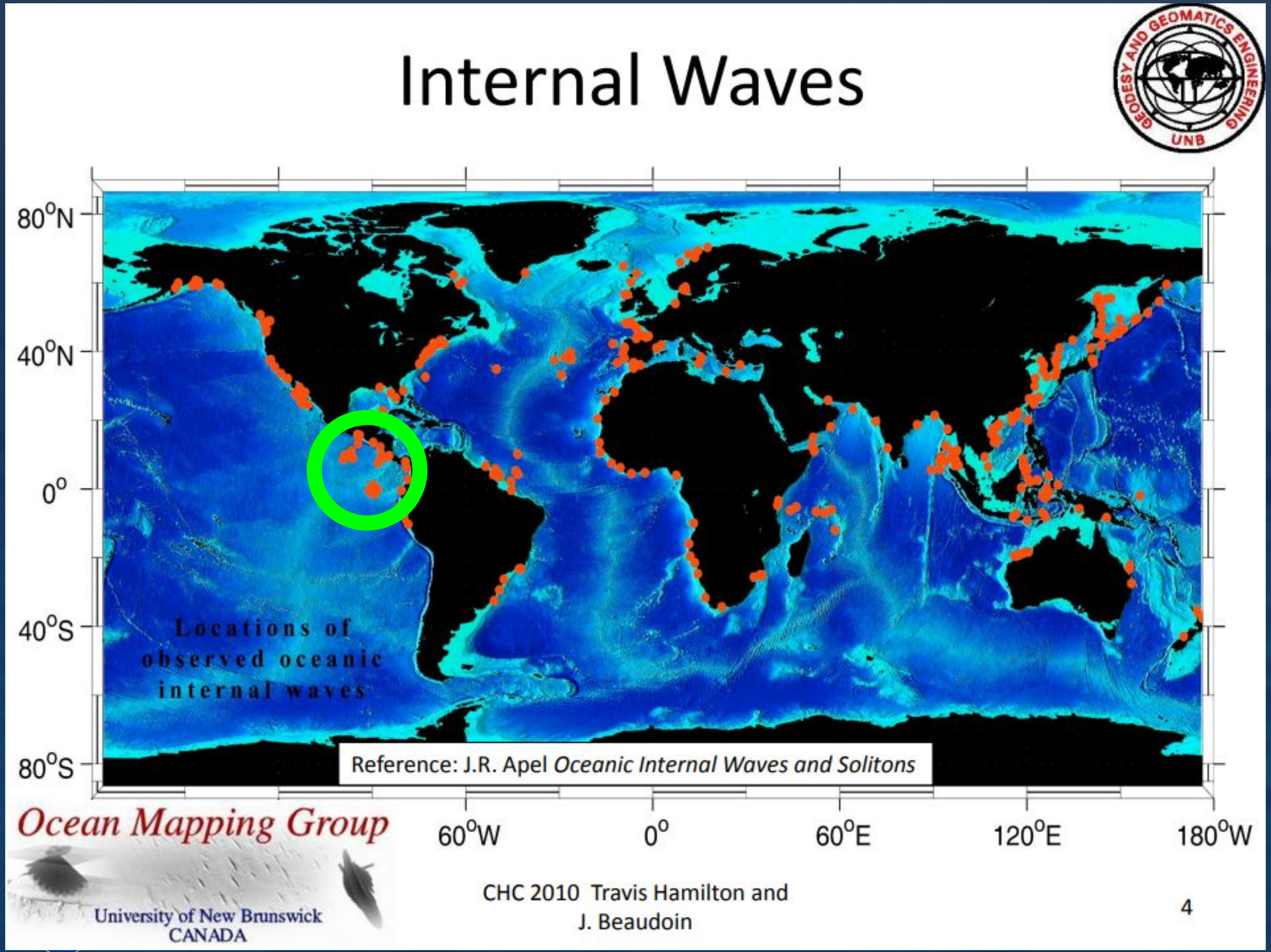


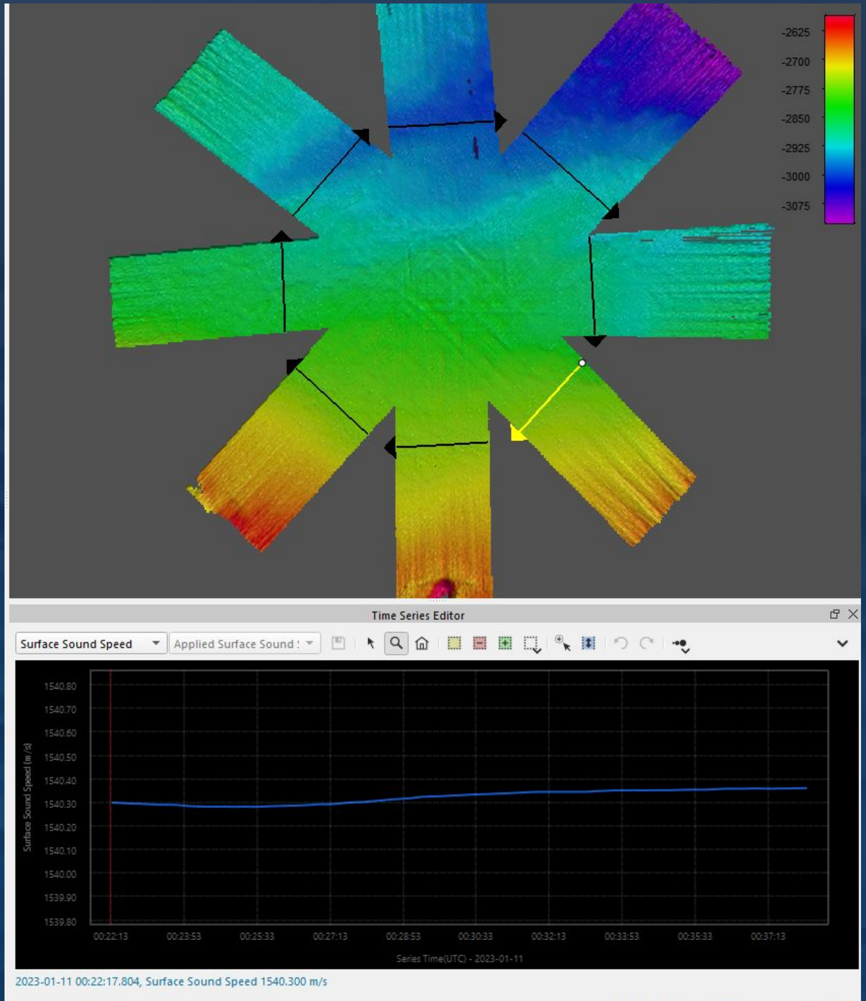
'Worst' case:
~50 m wobbles (SW)



Example from the Field: Swath Wobbles

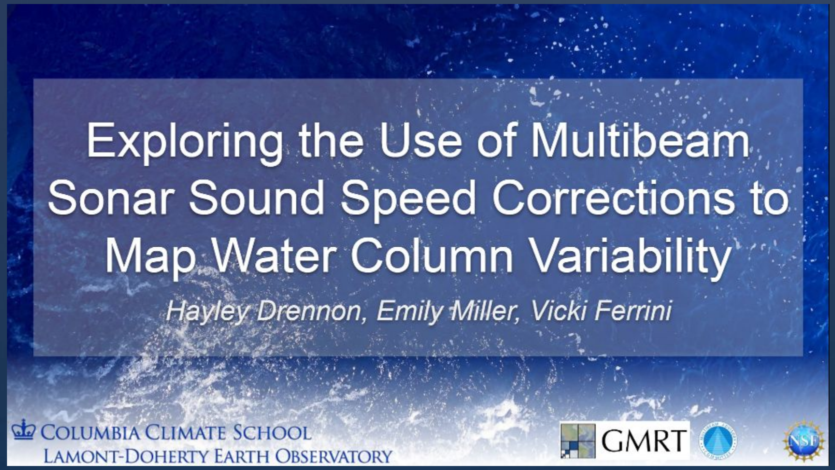
1. Oceanography: Internal waves?
2. Flow-through TSG: Intake depth? Temperature change? Lag time?

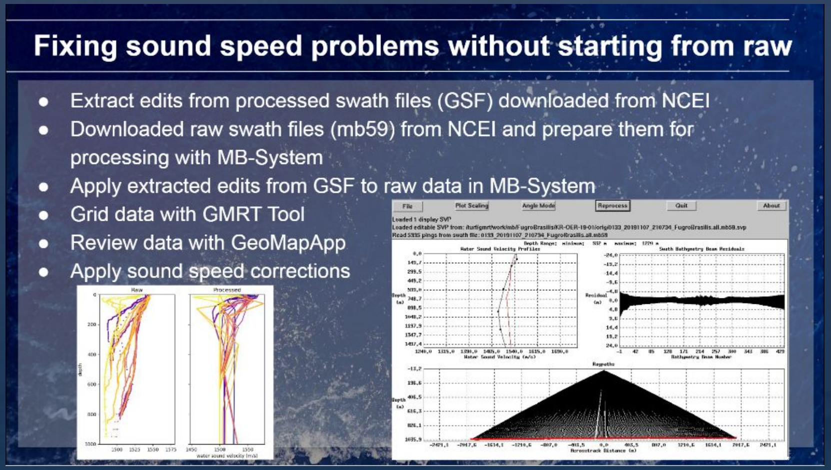


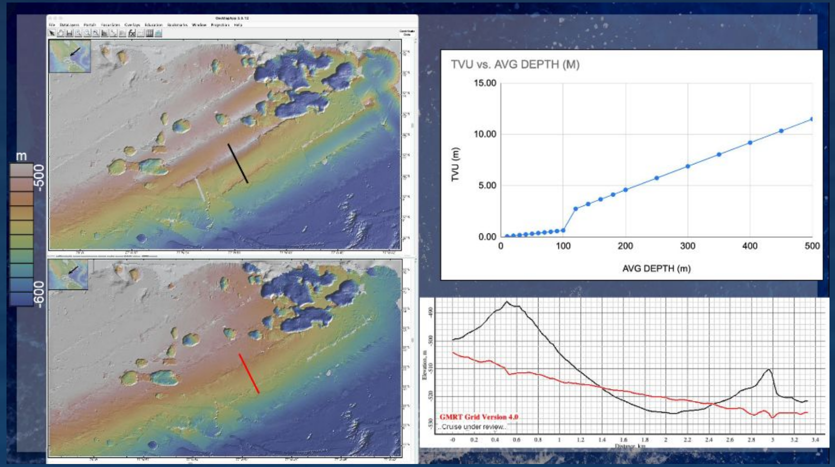


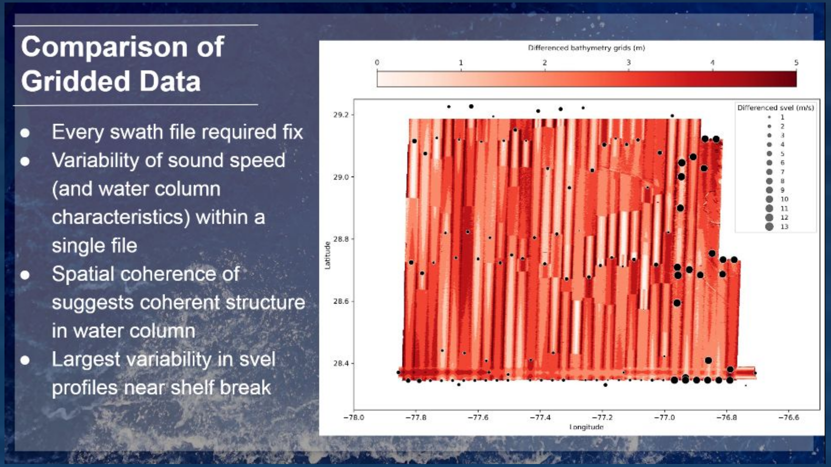
Ocean Mapping Community Wiki

github.com/oceanmapping/community/wiki









https://github.com/oceanmapping/community/blob/main/Drennon_OSM2022.pdf

Positioning

Positioning topics

Helpful links

1. GPS Visualization

Resources

Below are a few helpful resources to find, manage and evaluate ocean mapping data.

Open-source data tools

1. HydrOffice - a collaborative research-to-operations framework, including Sound Speed Manager and QC Tools
2. Ocean Data Tools - tools for data acquisition, management and event logging, including OpenRVDAS, OpenVDM and Sealog
3. GMRT Tiler - compare processed data to the GMRT grid to identify issues with sound velocity, etc., and ensure suitability for archive
4. MB-SYSTEM - open source; commonly used for automated / scripted processing of data from AUVs and other vehicles

Best practices

1. Ocean Best Practices - repository for ocean science SOPs from around the world
2. IHO-IO GEBCO Cookbook - technical reference manual focused on how to build grids
3. NOAA OER Deepwater Exploration Mapping - reference for NOAA OER mapping operations on the NOAA Ship *Okeanos Explorer*
4. Australian Multibeam Guidelines 2.0 - technical reference manual focused multibeam operations

Helpful presentations and papers

1. Sonar Synchronization and Tradeoffs
2. Rolling Deck to Repository Overview - 2020 RVTEC
3. Open Vessel Data Management - 2020 RVTEC
4. Lessons Learned from a Successful Integration of the EM 304 MKII Variant Multibeam Sonar
5. Ocean Exploration in a Data-Rich World - white paper from 2022 National Ocean Exploration Forum
6. Exploring the use of Sound Speed Profiles... - 2022 Ocean Sciences
7. Calibration of Acoustic Instruments - Summarizes fundamental sonar theory and details calibration methods.
8. Multibeam Sonar Theory of Operation - a clear overview of sonar concepts (multibeam and sidescan)

Why map the ocean?

Most of this wiki focuses on *how* to map the watery 71% of our planet. Here are a few examples of *why*.

Beyond the critical role of safety of navigation, ocean mapping is important for a wide array of reasons:

1. confirming plate tectonics and ancient oceans
2. understanding ocean circulation and climate
3. studying historic tsunamis and present risks
4. managing fisheries and food sources
5. tracking sources of greenhouse gases
6. routing global submarine cables
7. catching up to maps of our moon and Mars

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Planning for Limited Support

EM302/EM122 now in Limited Maintenance

Transducer modules can be replaced for the entirety of the product's life expectancy as these are still being produced.

The availability of transceiver unit spare parts is limited.

Transceiver Units can be repaired at factory until 1 January 2028 if the necessary spare parts are available. Contact Customer Support.

https://www.kongsberg.com/contentassets/7f008d26cb084b718a8378ff293366f4/454606ab_em302_limited_maintenance.pdf

https://www.kongsberg.com/contentassets/c83267864a104ae18476ebe642551f3e/458450ab_em122_limited_maintenance.pdf

EM710 Limited Maintenance expected soon

Questions? Answers? Reach out!

Ocean Mapping Community Wiki

github.com/oceanmapping/community

omcadmin@ccom.unh.edu

Multibeam Advisory Committee

mac.unols.org

mac-help@unols.org

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