Overview of MAC Resources & Update on Sea Acceptance Tests of Multibeam Systems on New Vessels

Vicki Ferrini (LDEO)
Paul Johnson (UNH/CCOM-JHC)
Kevin Jerram (UNH/CCOM-JHC)

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What is the MAC?

- Multibeam Advisory Committee
- A community-based effort with the goal of ensuring that high-quality multibeam data are consistently collected across the U.S. Academic Research Fleet
- Motivated by 2010 workshop at NSF focused on issues with MB performance
- Funded in 2011; Renewed in 2015

CCOM JHC

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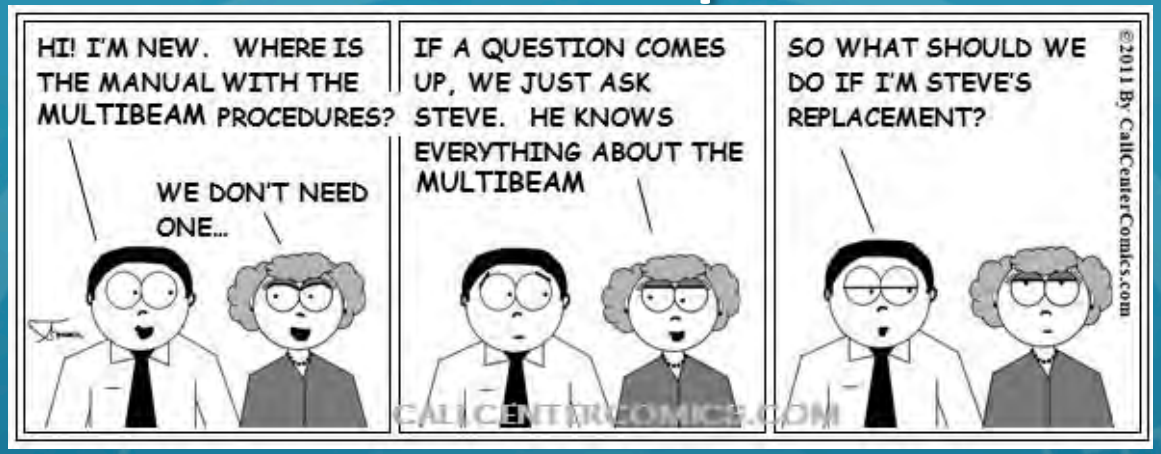
NSF

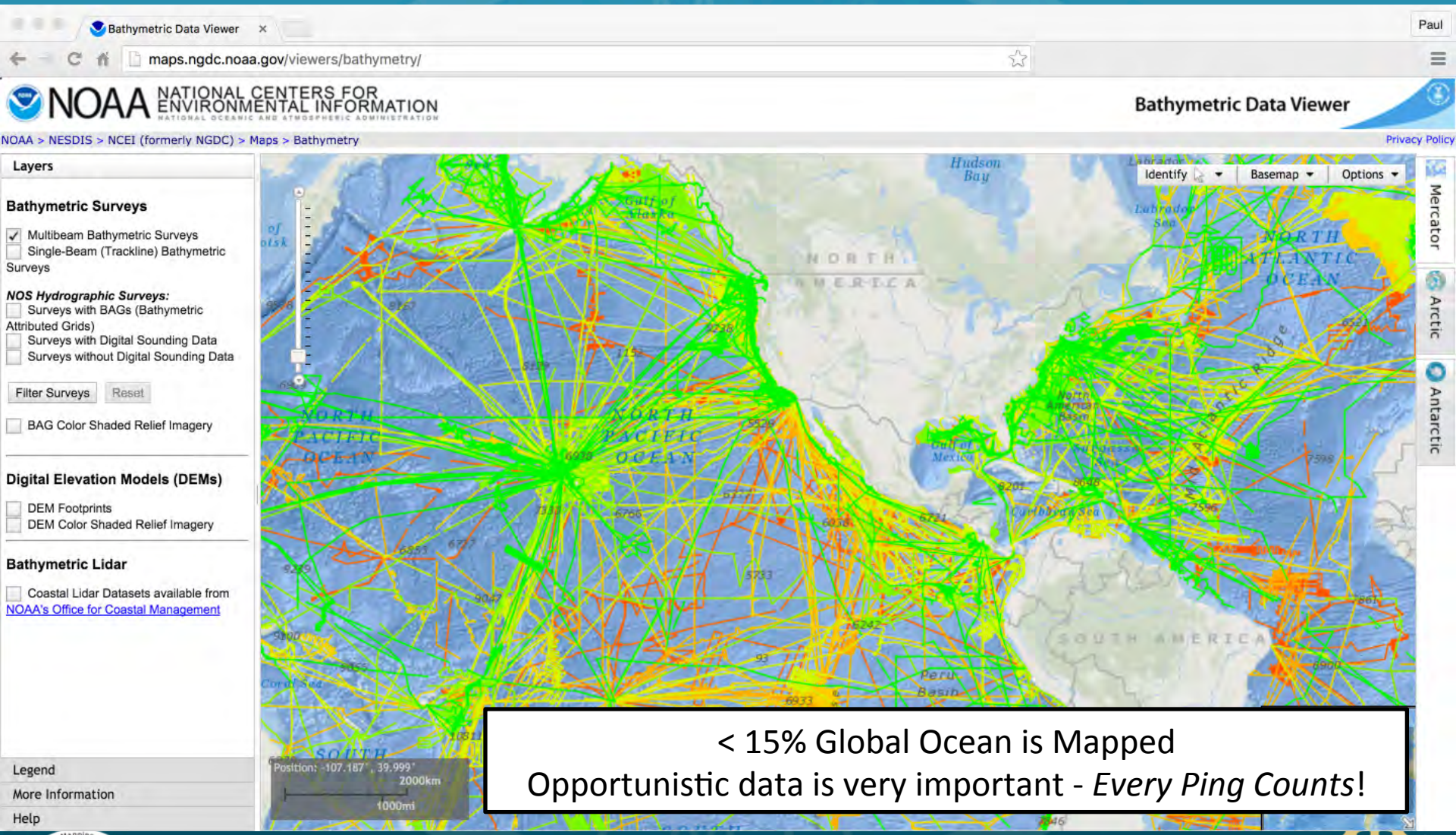
What was the problem ?



Modified From: http://evillusionist.files.wordpress.com/2012/05/call-center-cartoon-149.jpg

- Research vessels are used for many different types of oceanographic work
- Multibeam systems are just one of many complex sensors on each ship
- "Tribal Knowledge" does not scale
- Efficiencies gained through coordination

Why Is It Important ?



< 15% Global Ocean is Mapped

Opportunistic data is very important - *Every Ping Counts*!

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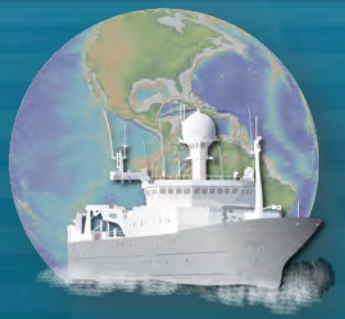
Complementary Fleet-Wide Multibeam Efforts

Data Acquisition

Data Documentation & Preservation

Data Reduction & Synthesis



MAC
2011

R2R
2009

GMRT
1992

***GOAL**: Well-documented high-quality publicly available data*

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Multibeam Advisory Committee (MAC)

SAT - Ensure all hull-mounted multibeam systems are installed, calibrated, and configured properly and consistently (Johnson, Jerram)

ANT - Perform acoustic noise tests to assess and potentially improve sensor efficiency (coverage) and data quality (Gates)

QAT - Ensure multibeam sonar systems are operated in a consistent manner that maximizes data accuracy, precision, and scientific utility (Ferrini, Jerram, & Johnson)

MAC Goals

- Engage Community of Stakeholders
  - Operating Institutions, Technicians, Scientists, Funding Agencies
  - Industry – hardware/software
  - Specialists
- Share information within and beyond UNOLS (e.g. NOAA, OET, SOI, etc)
- Facilitate communication
- Develop consistent protocols & best practices
- Complement other fleet-wide efforts
- Educate the next generation

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MBES Across the Fleet

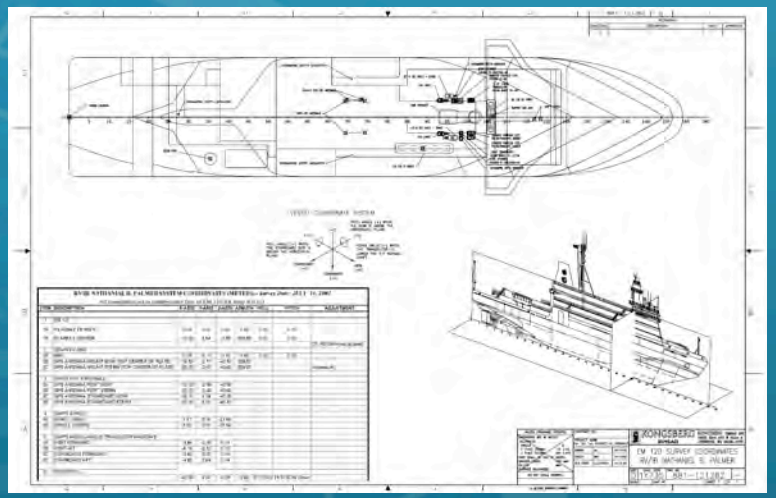
	Kongsberg EM122	Kongsberg EM302	Kongsberg EM710/EM712	Reson 7125
Atlantis	X			
Healy	X			
Kilo Moana	X		X	
Langseth	X			
Melville	X			
Armstrong	X		X	
Palmer	X			
Revelle	X			
Ride	X		X	
Sikuliaq		X	X	
Thompson		X		
Sharp				X

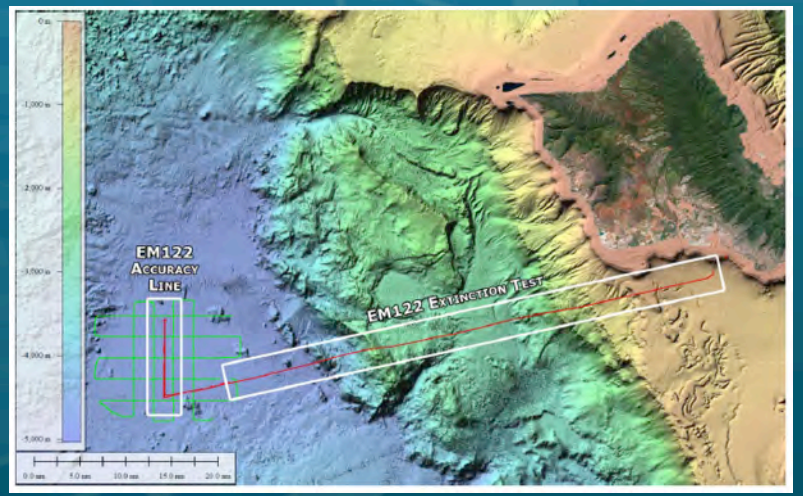
MAC Ship Visits

- At the request of Operators
- Most useful interaction – "boots on the deck"
- Different team(s) deployed, depending upon needs of ship
  - SAT/QAT/ANT share common tools and techniques
- Standard protocols for assessing systems across fleet
- Report generated for each visit
  - Initially only for the operator
  - After review, publicly available on MAC website

Ship Visits – SAT/QAT

- System Review
  - Sensor locations/offsets
- Patch Test
- Accuracy Assessment
- Swath Performance Test
- Noise Testing
- Water Column & Backscatter
- MAC activities complement manufacturer testing & assessment
- SAT = baseline; QAT = check-up





System Review

- Review & Document Sensor Offsets
  – MBES TX/RX, GPS, MRU
- Review Reference Frames

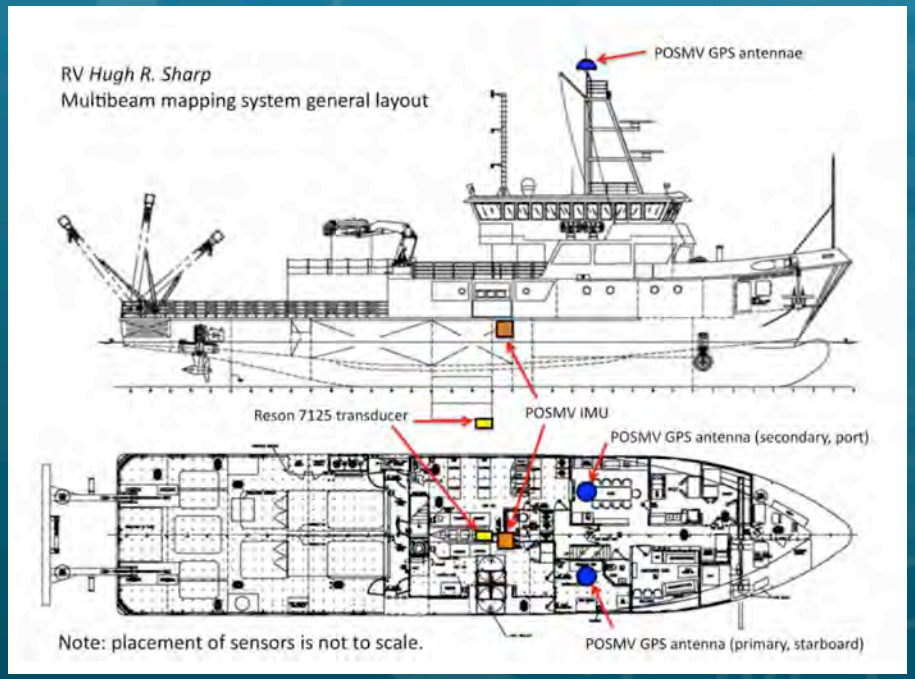


Table 2. Sensor offsets after system geometry review and calibration during HRS1602; only the 7125 angular offsets were modified, with all other linear offsets maintained from the 2013 updated configuration provided by the MAC. Note that the values in this table represent the documented physical layout of sensors using a vessel reference frame centered at the IMU and a given sign convention. The spacing between acoustic centers of the TX and RX arrays at each frequency is given by the Reson schematic copied in Figure 2, showing that the RX array acoustic center is forward of the TX array acoustic center by 0.20 m at 200 kHz and 0.18 m at 400 kHz. At both frequencies, the RX array acoustic center is 0.024 m below the TX array acoustic center. These values are included here for complete description of the physical sensor layout. The sensor and data collection software configurations tend to require only the sonar reference point (TX acoustic center) and use reference frames and/or sign conventions different from those in this table. Table 3 provides the Hypack configuration, and screenshots of all configurations are available in the Appendix.

Drop Keel	Sensors in VESSEL frame Origin at IMU	Alongship BOW +	Athwartship STBD +	Vertical UP +	Pitch BOW UP +	Roll PORT UP +	Yaw COMPASS +
-1' Recessed inside hull	7125 TX	-1.767	-0.125	-3.289	0.60	1.04	1.00
	7125 RX (200 kHz)	-1.567	-0.125	-3.313			
	7125 RX (400 kHz)	-1.587	-0.125	-3.313			
0' Flush with hull	7125 TX	-1.767	-0.125	-3.594	0.60	1.04	1.00
	7125 RX (200 kHz)	-1.567	-0.125	-3.618			
	7125 RX (400 kHz)	-1.587	-0.125	-3.618			
3' Extended below hull	7125 TX	-1.767	-0.125	-4.508	0.60	1.04	1.00
	7125 RX (200 kHz)	-1.567	-0.125	-4.532			
	7125 RX (400 kHz)	-1.587	-0.125	-4.532			
6' Extended below hull	7125 TX	-1.767	-0.125	-5.423	0.60	1.04	1.00
	7125 RX (200 kHz)	-1.567	-0.125	-5.447			
	7125 RX (400 kHz)	-1.587	-0.125	-5.447			
POS-MV IMU		0.00	0.00	0.00	0.00	0.00	0.00
POS-MV GPS Antenna – Primary – STBD		4.947	1.940	15.792	-	-	-
POS-MV GPS Antenna – Secondary - PORT		4.980	-1.804	15.795	-	-	-
Waterline		-	-	-0.48	-	-	-

Table 3. Hypack configuration of sensor offsets after system geometry review and calibration during HRS1602. These values reflect the offsets in Table 2 translated into the Hypack reference frame, which takes its vertical reference from waterline and treats downward as positive. Because no new waterline measurement was made during HRS1602, the previous waterline value of 0.48 m below the IMU was maintained. New waterline measurements should be made to update the waterline value in Table 2 and the Hypack vertical reference. For example, if a new waterline measurement of 0.50 m is recorded (e.g., using clear plastic tubing from a through-hull valve near the IMU, as documented in 2012), the difference of 0.02 m (0.50 m new height of IMU above waterline minus the 0.48 m original measurement) should be subtracted from the existing vertical measurements in Hypack. Thus, the IMU height in Hypack would become -0.048 m – 0.02 m = -0.50 m for all drop keel positions. In this hypothetical example, the 7125 vertical offsets for the 3' drop keel positions would become 4.028 m – 0.02 m = 4.008 m, and so on for the other drop keel positions. This table should be updated whenever new waterline measurements are available. Under the existing data collection setup, the angular offsets should be entered for the Reson transducer in the Hypack configuration prior to data acquisition. Alternatively, data recorded using the Reson software directly (without Hypack) can be adjusted using these angular offsets in post-processing. It was observed that Hypack HSX files correctly preserved the angular offset configuration for post-processing, whereas HSX.s7k files logged in Hypack and native s7k files logged in the Reson software did not.

Drop Keel	Sensors in HYPACK frame Origin at IMU	Alongship BOW +	Athwartship STBD +	Vertical DOWN +	Pitch BOW UP +	Roll PORT UP +	Yaw COMPASS +
-1' Recessed inside hull	7125 Reference Point	-1.767	-0.125	2.809	0.60	1.04	1.00
	IMU	0.00	0.00	-0.48	0.00	0.00	0.00
0' Flush with hull	7125 Reference Point	-1.767	-0.125	3.114	0.60	1.04	1.00
	IMU	0.00	0.00	-0.48	0.00	0.00	0.00
3' Extended below hull	7125 Reference Point	-1.767	-0.125	4.028	0.60	1.04	1.00
	IMU	0.00	0.00	-0.48	0.00	0.00	0.00
6' Extended below hull	7125 Reference Point	-1.767	-0.125	4.943	0.60	1.04	1.00
	IMU	0.00	0.00	-0.48	0.00	0.00	0.00

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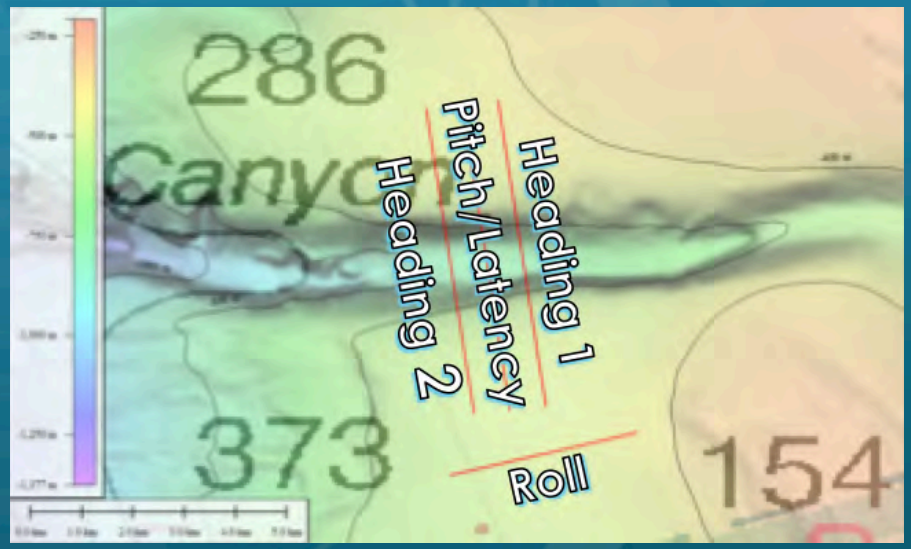
Patch Test

- Residual angular offsets between motion sensor and sonar arrays (pitch, heading, and roll)
- Timing issues (latency)
- Recommended when:
  - system is new
  - ancillary systems are moved (e.g. MRU, GPS)
  - multibeam data is a primary cruise objective
- Can be conducted remotely



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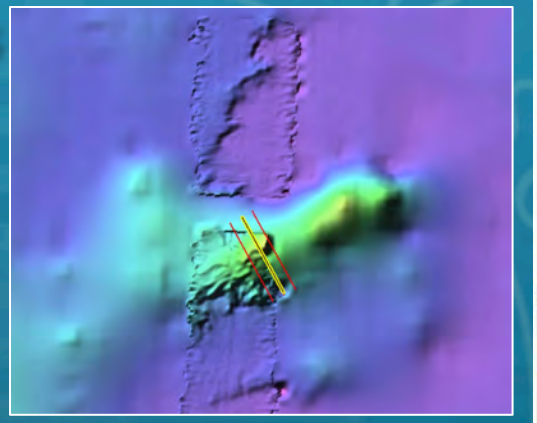
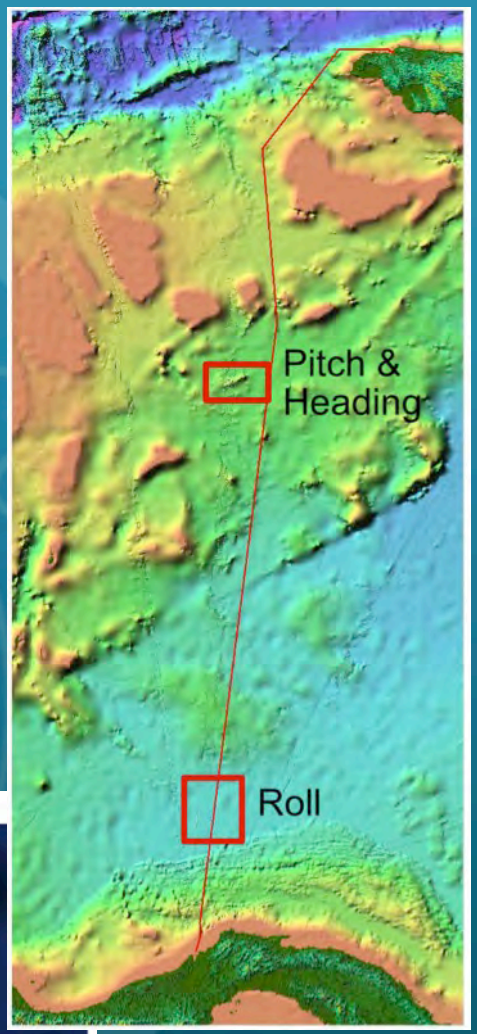
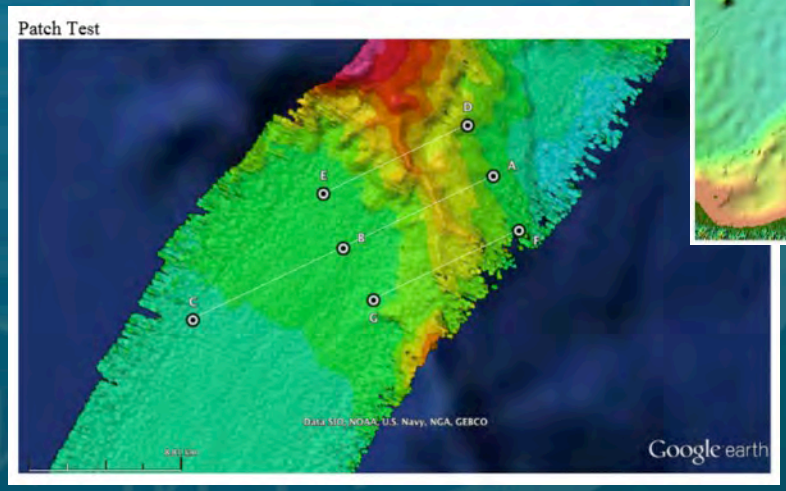
Remote Patch Test

- Protocol
  - MAC selects site & develops survey plan
  - Ship runs survey plan
  - Python script minimizes data file size
  - Data transmitted to shore
  - MAC evaluates & advises
- 2014
  - *Marcus G. Langseth*
- 2016
  - *Marcus G. Langseth*
  - *Atlantis*







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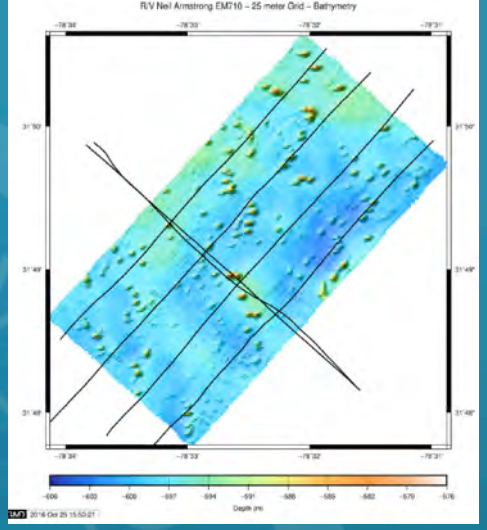
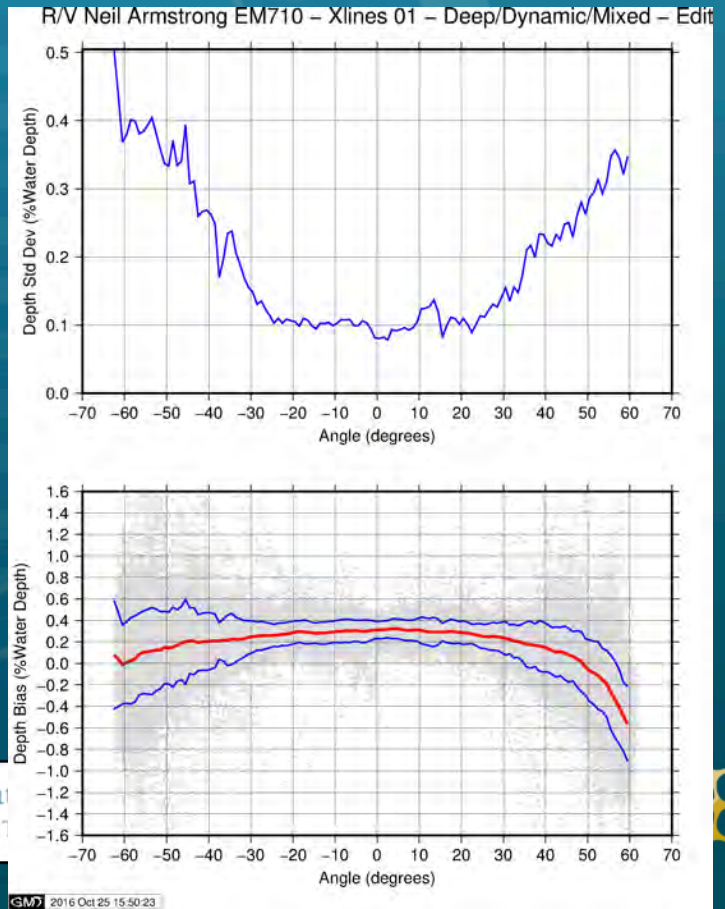
Accuracy Assessment

- After system assessment
- Small survey with cross-line
- Analysis
  - Exclude grid nodes with:
    - Few pings
    - Slopes > 5°
  - Compute depth bias
  - Compute depth standard deviation
- Reference Surface grids are publicly available





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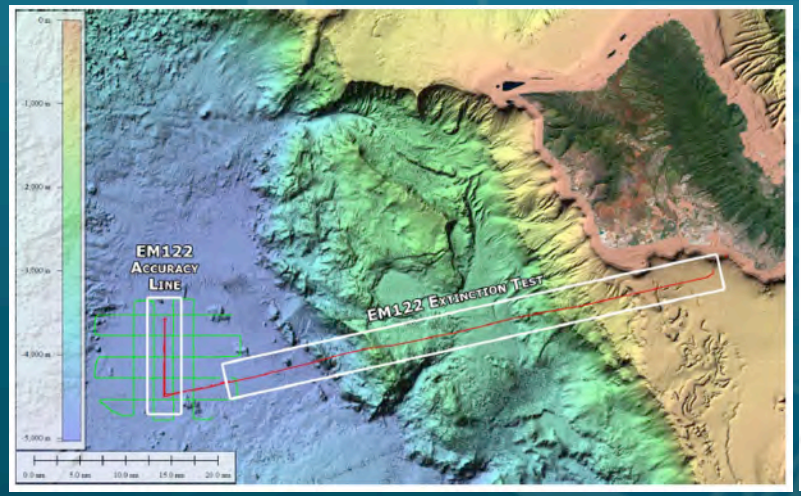
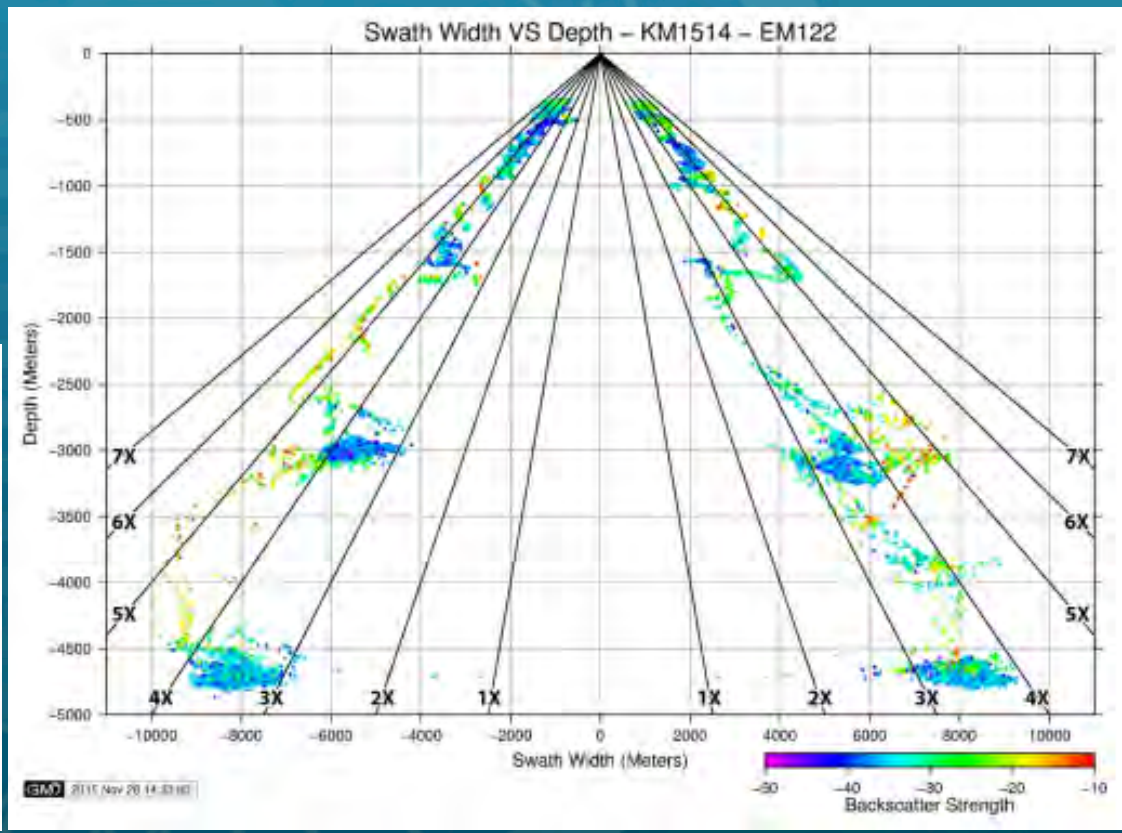
Swath Performance Test

- Quantify swath width at a range of depths
- System health
- Important for survey planning





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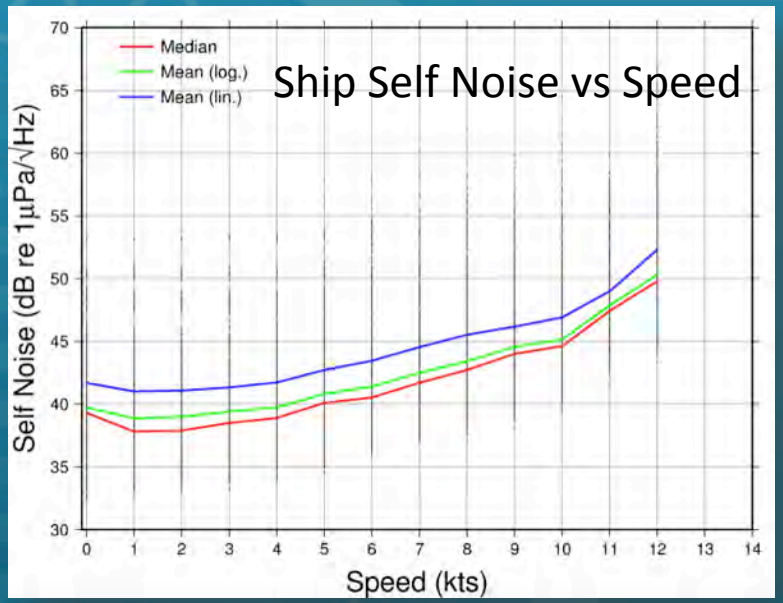
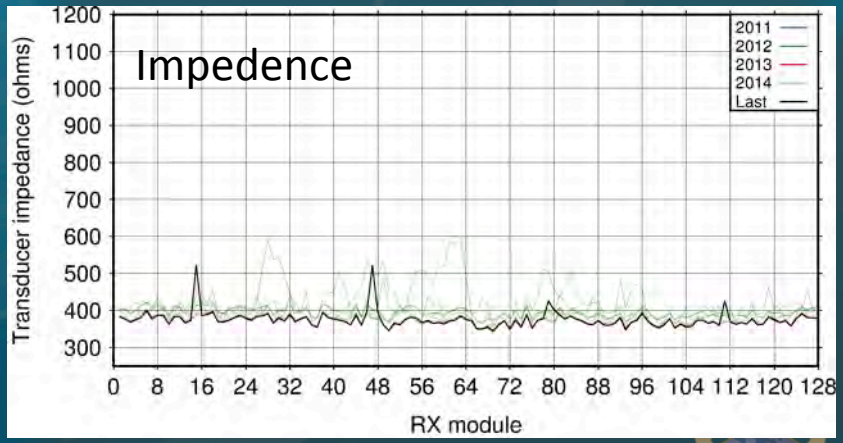
Basic Noise Testing

- Built-In Self Test (BIST)
- Platform noise environment
  - Active and passive RX noise measurements
  - Variety of speeds
  - Variety of headings relative to the prevailing swell
- Impedance measurements
  - Baseline & monitoring early warning signs for transducer degradation
- Routine BISTs encouraged





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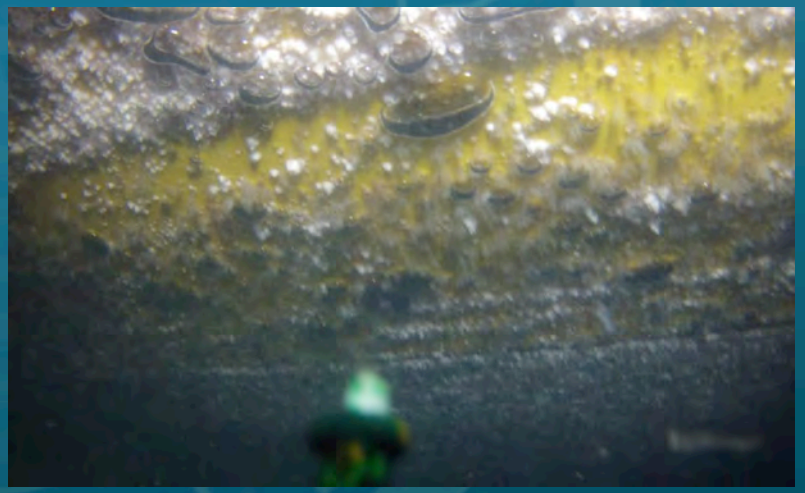
Acoustic Noise Team (ANT)

- Detailed assessment of ship acoustic characteristics
- Identify sources of noise
  - Ship noise
  - Cavitation
  - Bubble sweep-down
  - Machinery
  - Acoustic interference
- Recommend strategies to minimize noise



Images from Tim Gates

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MAC SAT Visits

- R/V *Hugh Sharp* – Reson 7125 [2012]
- R/V *Kilo Moana* – EM122 & EM710 [2012, 2015]
- *RVIB Nathaniel B. Palmer* – EM122 [2014, 2015]
- R/V *Sikuliaq* – EM302 & EM710 [2014]
- *R/V Neil Armstrong* - EM122 & EM710 [2016]
- *R/V Sally Ride* - EM122 & EM712 [2016]

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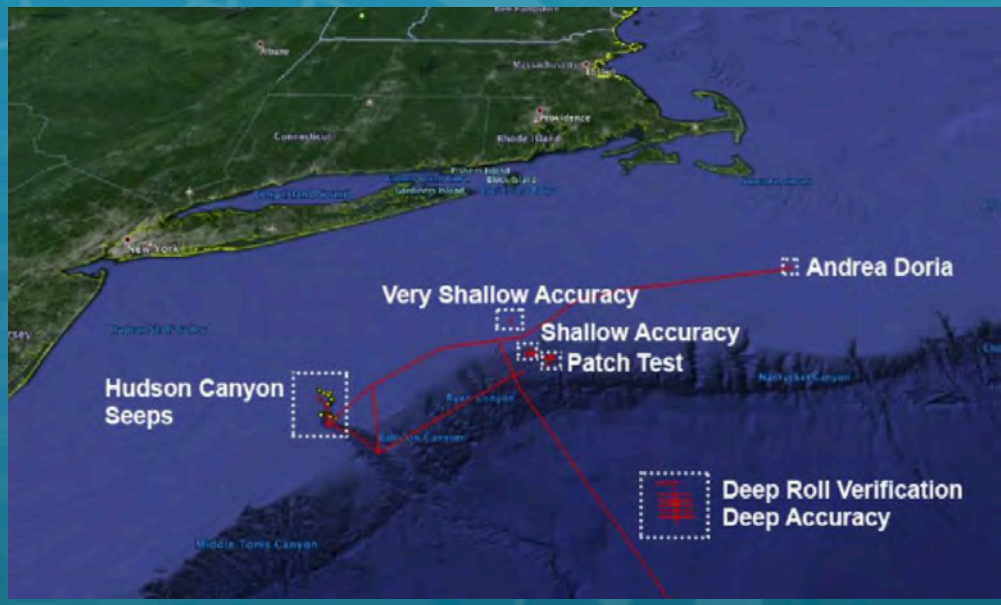
R/V Sikuliaq

- August 2014
- Plan:
  - EM302 & EM710 SAT
    - System Review
    - Patch Test
    - Accuracy Assessment
    - Swath Performance Test
    - Preliminary Noise
    - Backscatter & Water Column Review
- Reality:
  - Challenging sea state and ocean conditions at times
  - Successful calibration and testing



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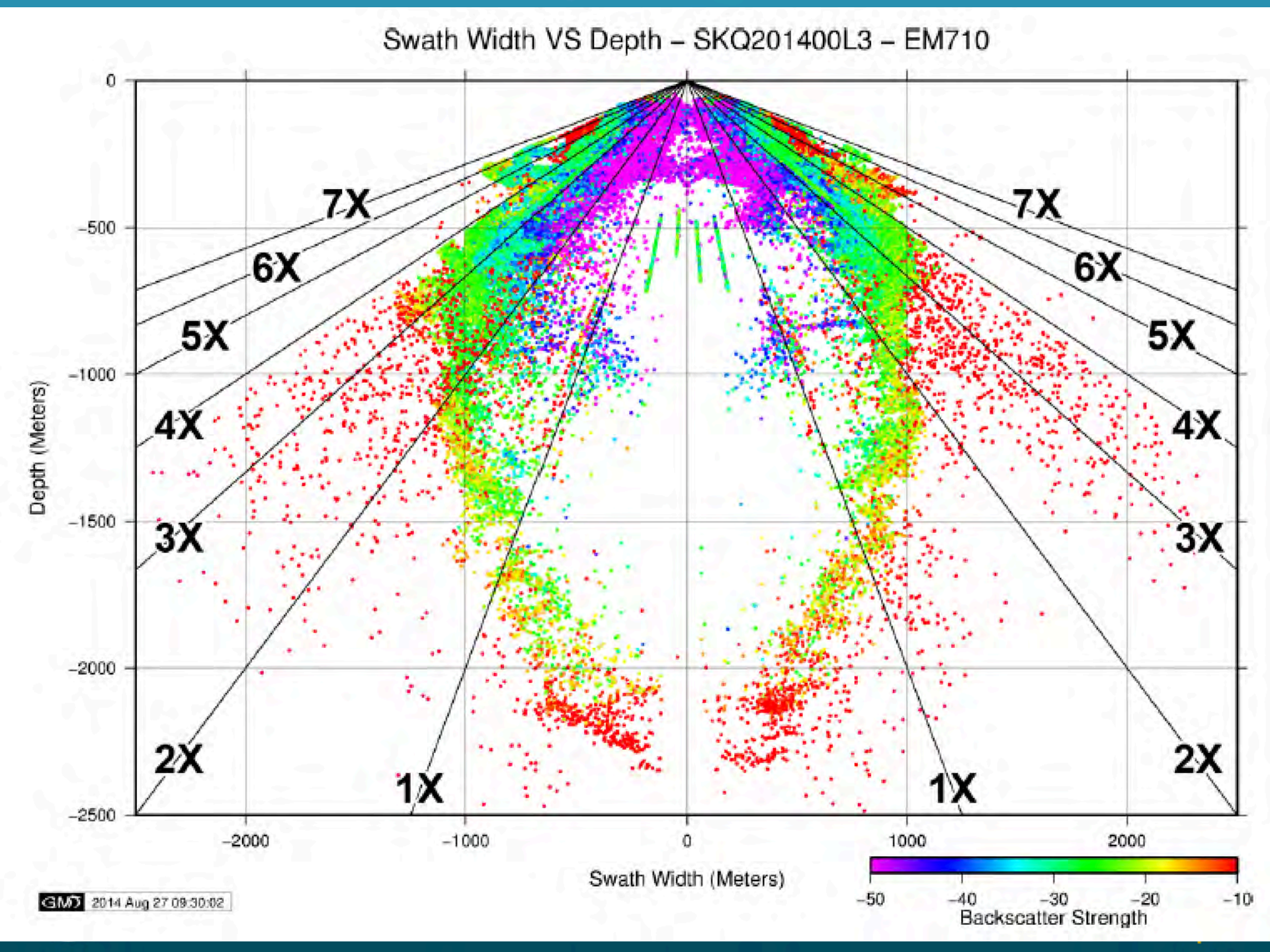
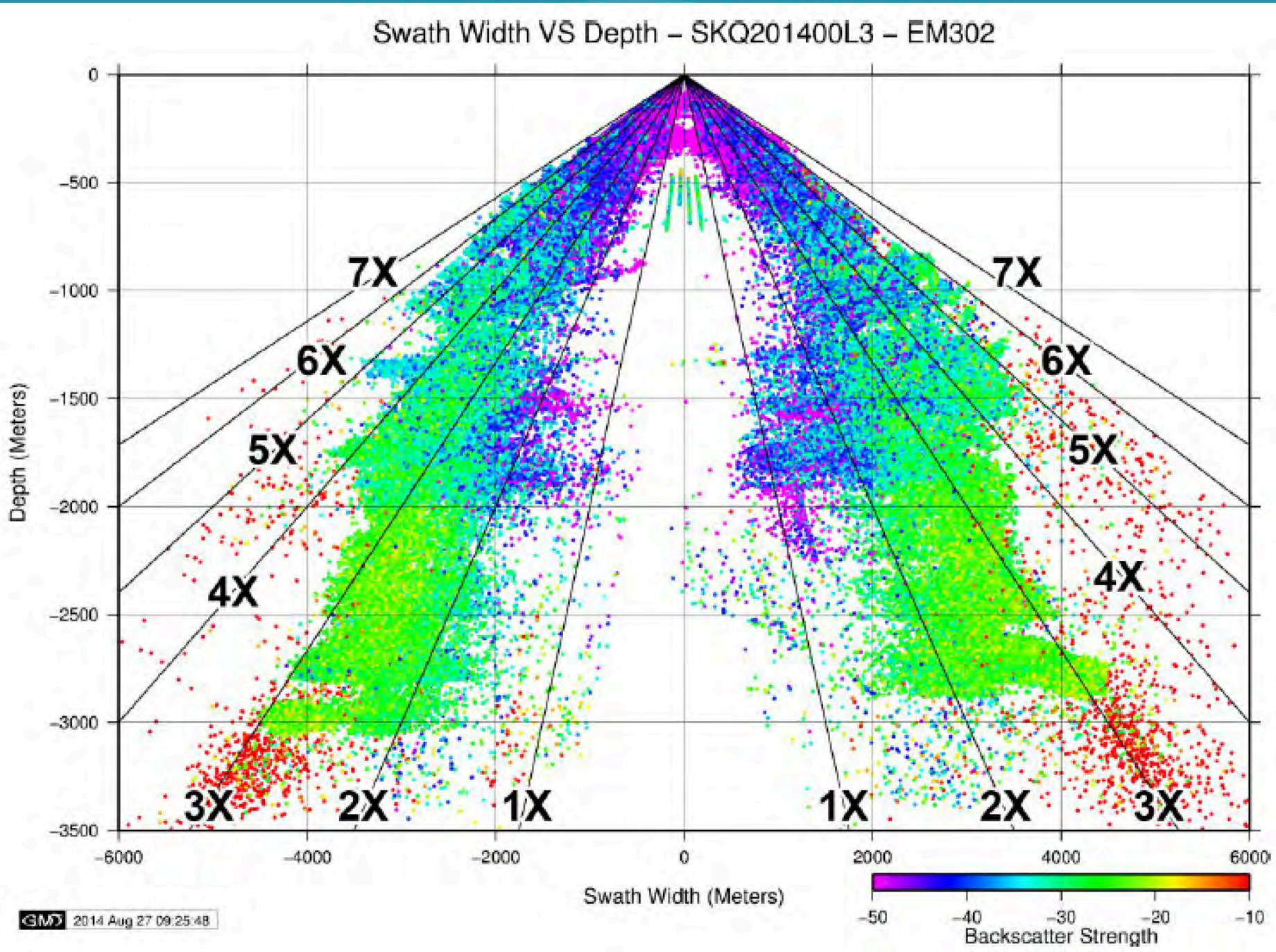
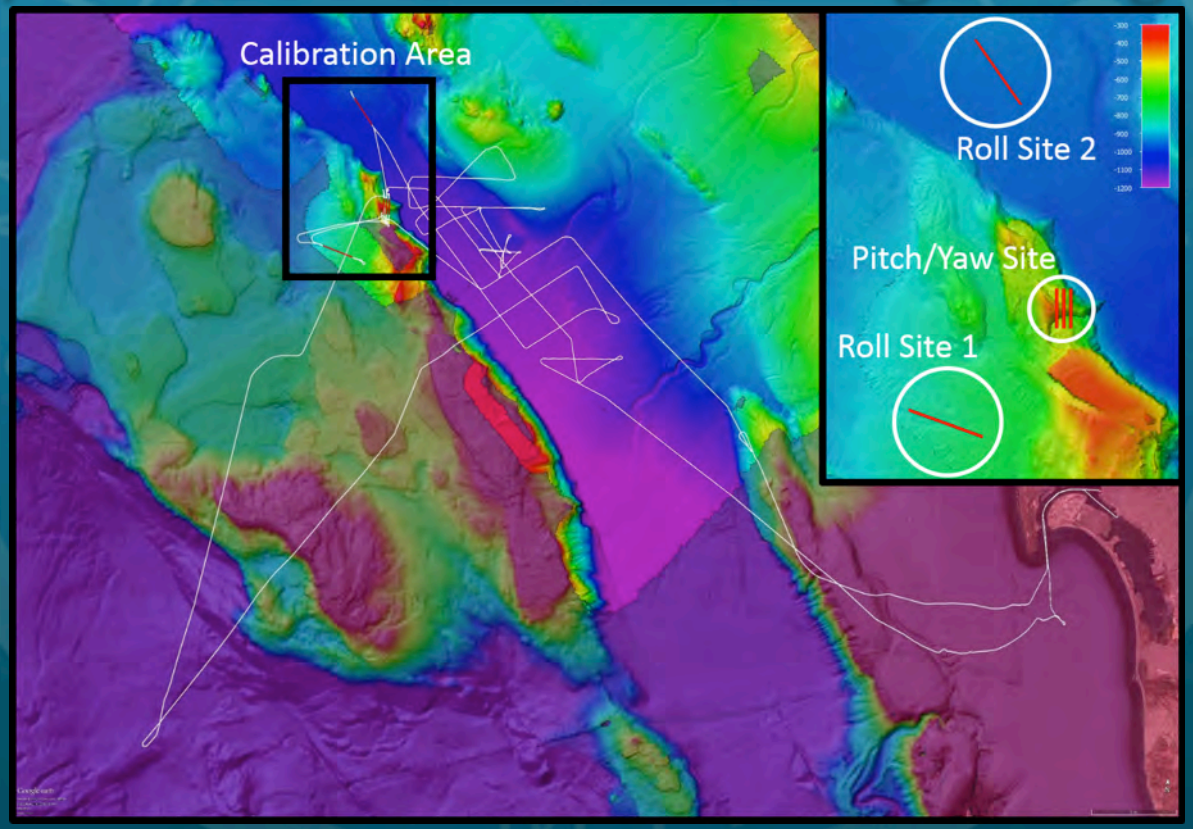

Swath Width VS Depth – SKQ201400L3 – EM710
0
-500
-1000
-1500
-2000
-2500
Depth (Meters)
7X
6X
5X
4X
3X
2X
1X
7X
6X
5X
4X
3X
2X
1X
-2000
-1000
0
1000
2000
Swath Width (Meters)
-50
-40
-30
-20
-10
Backscatter Strength
GMT 2014 Aug 27 09:30:02


Swath Width VS Depth – SKQ201400L3 – EM302
Depth (Meters)
0
-500
-1000
-1500
-2000
-2500
-3000
-3500
7X
6X
5X
4X
3X
2X
1X
1X
2X
3X
4X
5X
6X
7X
-6000
-4000
-2000
0
2000
4000
6000
Swath Width (Meters)
2014 Aug 27 09:25:48
-50
-40
-30
-20
-10
Backscatter Strength

R/V Sikuliaq - 2016

- Antenna relocation and resurvey in San Diego
- EM710 / EM302 calibration during coring trials



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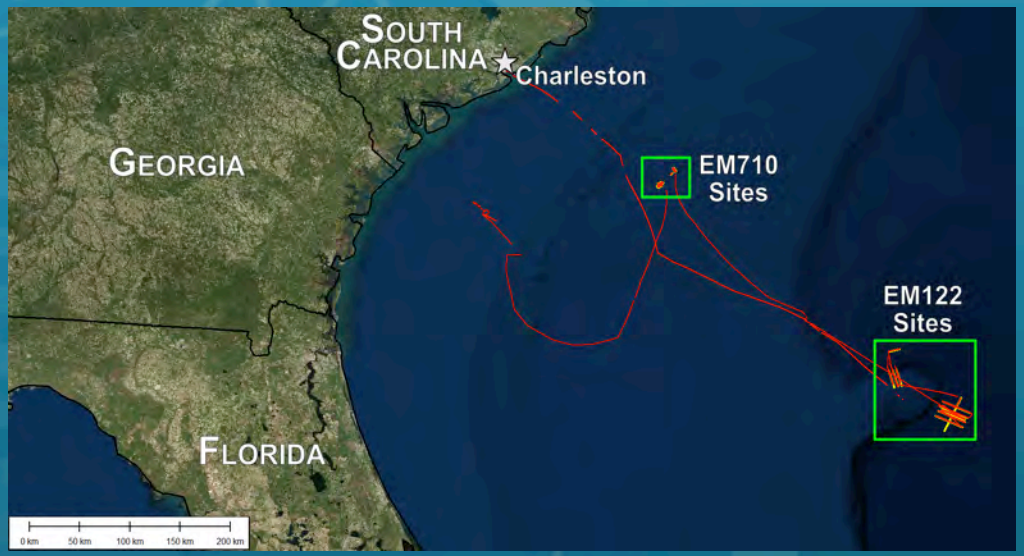
R/V Neil Armstrong

- February 2016
- Plan:
  - EM122 & EM710 SAT
    - System Review
    - Patch Test
    - Accuracy Assessment
    - Swath Performance Test
    - Preliminary Noise
- Reality:
  - Challenging sea state and ocean conditions
  - Successful calibration and testing



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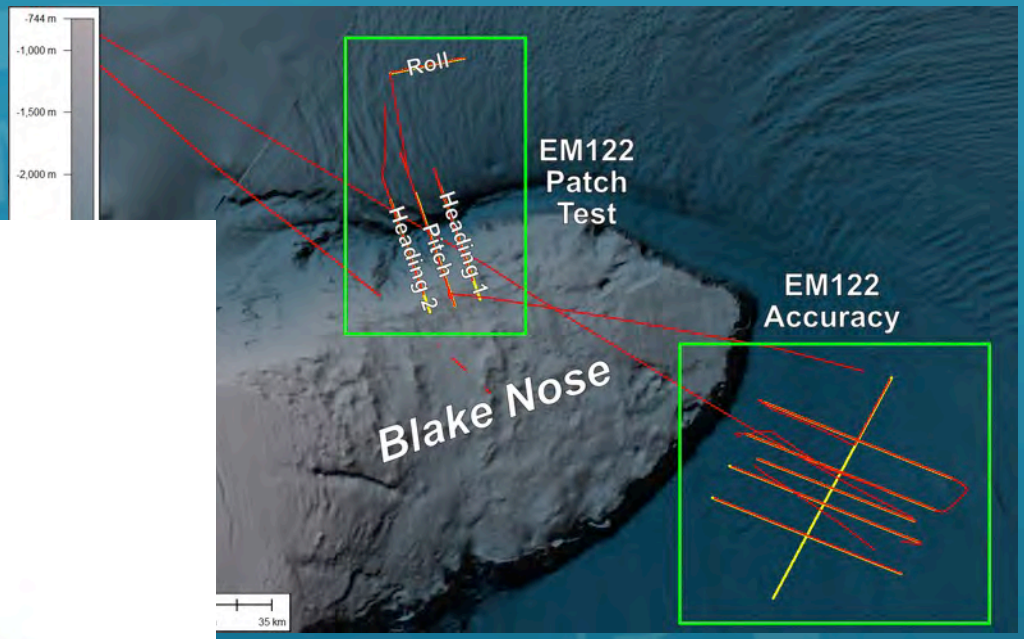
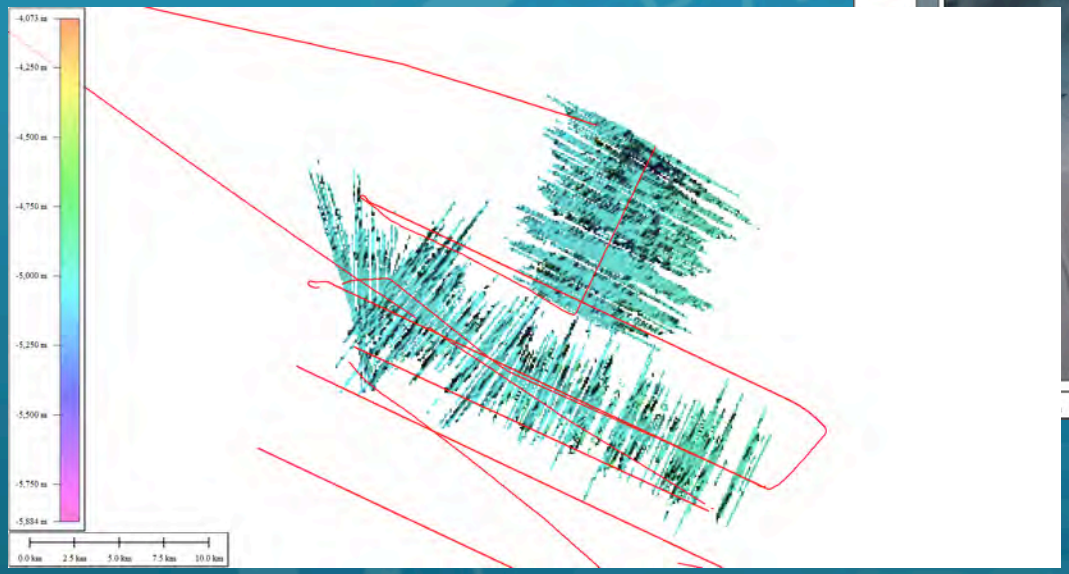
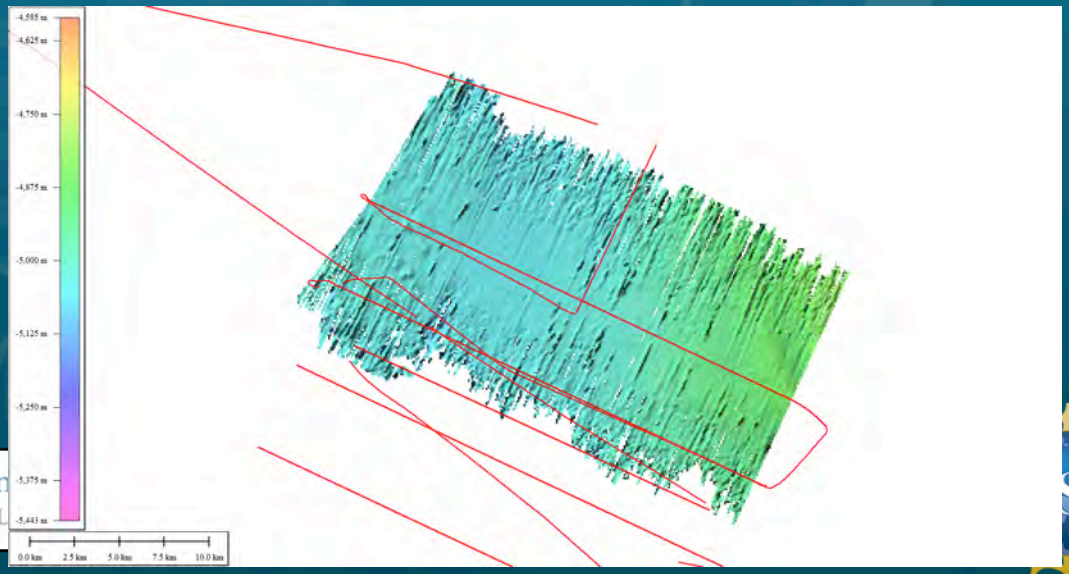
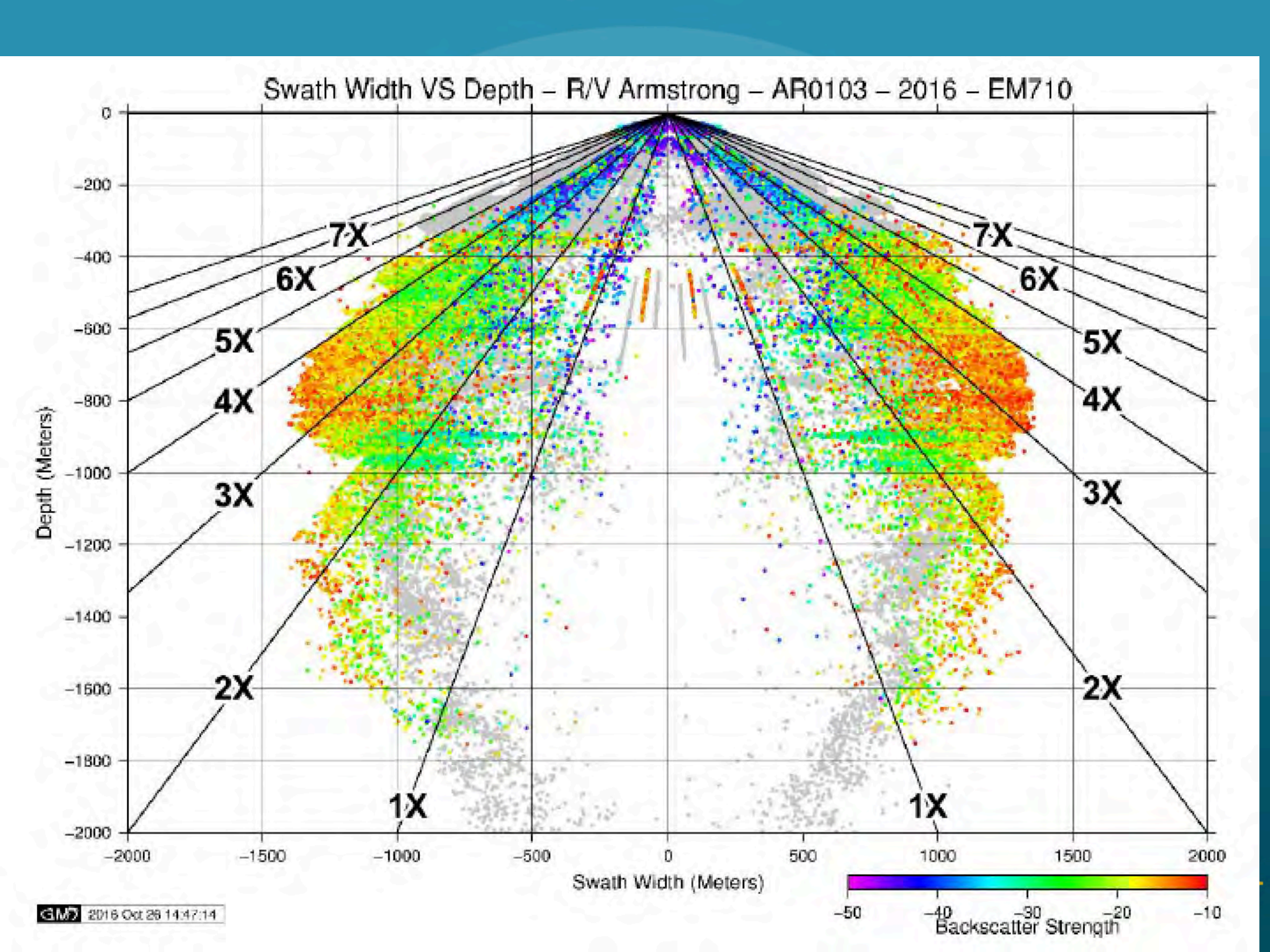
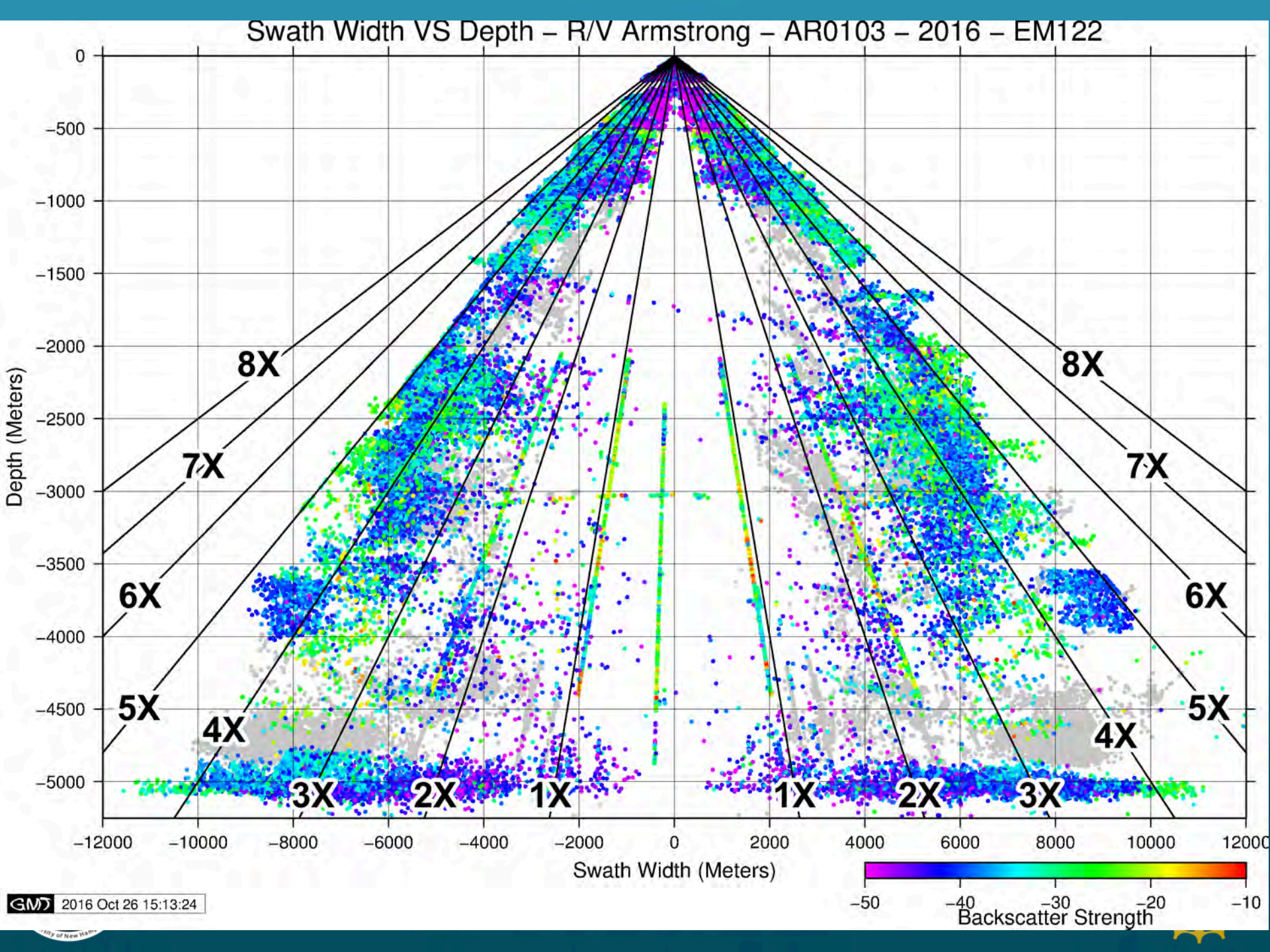

-744 m
-1,000 m
-1,500 m
-2,000 m
Roll
Heading 1
Pitch
Heading 2
EM122
Patch
Test
EM122
Accuracy
Blake Nose
35 km

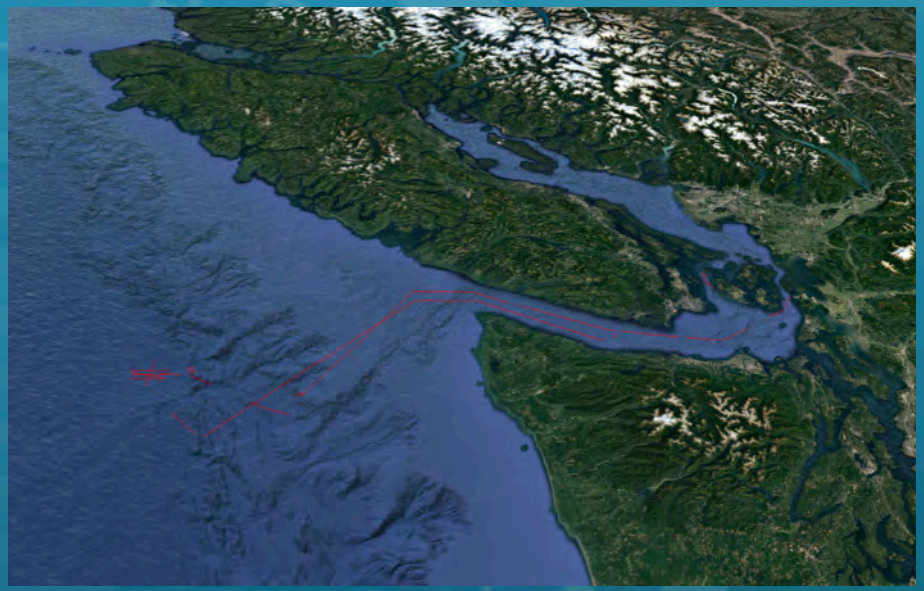

-4,073 m
-4,250 m
-4,500 m
-4,750 m
-5,000 m
-5,250 m
-5,500 m
-5,750 m
-5,884 m
0.0 km
2.5 km
5.0 km
7.5 km
10.0 km


-4,585 m
-4,625 m
-4,750 m
-4,875 m
-5,000 m
-5,125 m
-5,250 m
-5,375 m
-5,443 m
0.0 km
2.5 km
5.0 km
7.5 km
10.0 km


Swath Width VS Depth – R/V Armstrong – AR0103 – 2016 – EM710
Depth (Meters)
0
-200
-400
-600
-800
-1000
-1200
-1400
-1600
-1800
-2000
7X
6X
5X
4X
3X
2X
1X
-2000
-1500
-1000
-500
0
500
1000
1500
2000
Swath Width (Meters)
GMT 2016 Oct 28 14:47:14
-50
-40
-30
-20
-10
Backscatter Strength


Swath Width VS Depth – R/V Armstrong – AR0103 – 2016 – EM122
Depth (Meters)
0
−500
−1000
−1500
−2000
−2500
−3000
−3500
−4000
−4500
−5000
8X
7X
6X
5X
4X
3X
2X
1X
1X
2X
3X
4X
5X
6X
7X
8X
−12000
−10000
−8000
−6000
−4000
−2000
0
2000
4000
6000
8000
10000
12000
Swath Width (Meters)
2016 Oct 26 15:13:24
−50
−40
−30
−20
−10
Backscatter Strength

R/V Sally Ride - SAT



- July 2016
- Plan:
  - EM122 & EM712 SAT
    - System Review
    - Patch Test
    - Accuracy Assessment
    - Swath Performance Test
    - Preliminary Noise
- Reality:
  - Challenging sea state at times
  - Successful calibration and testing

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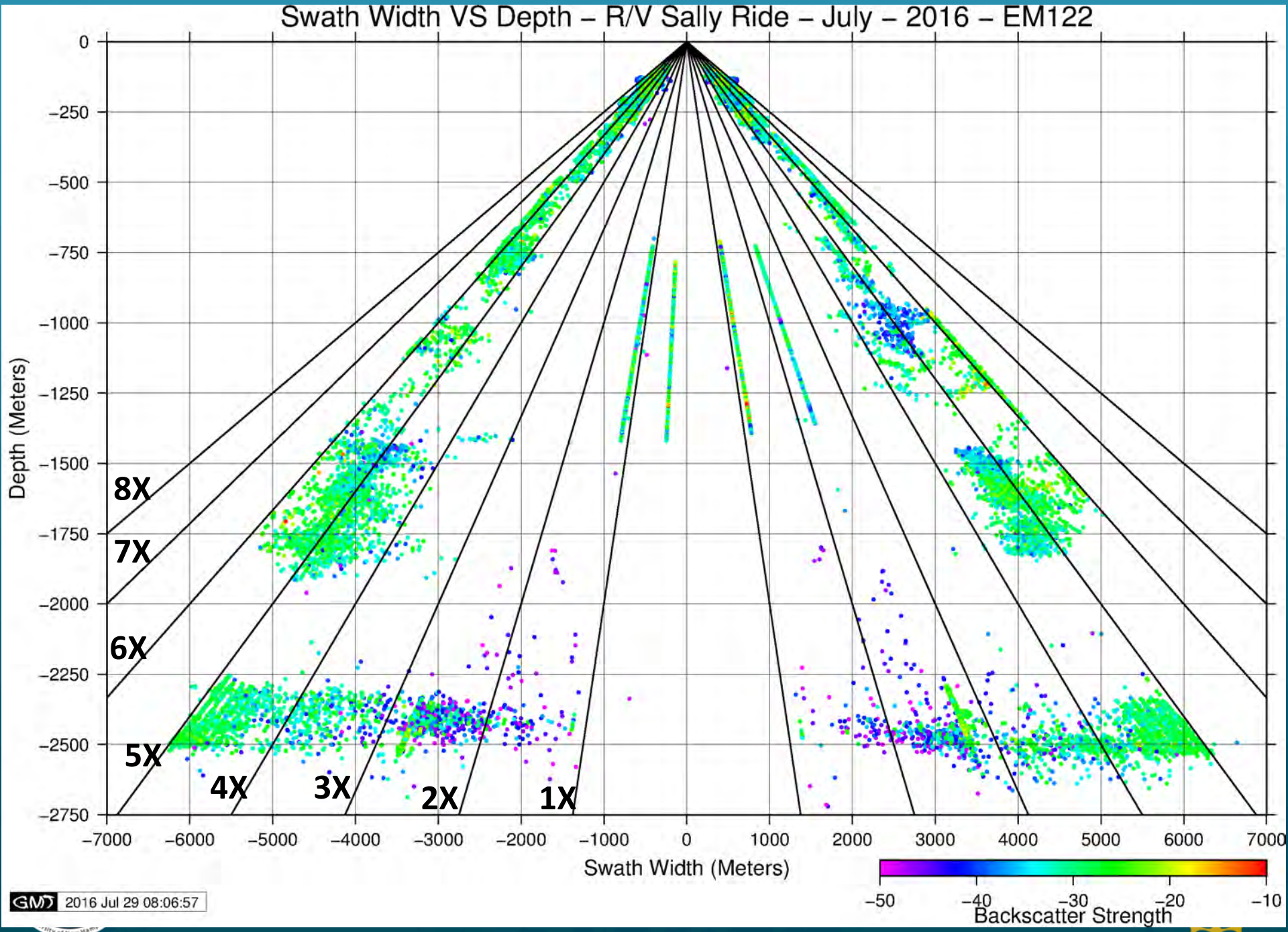
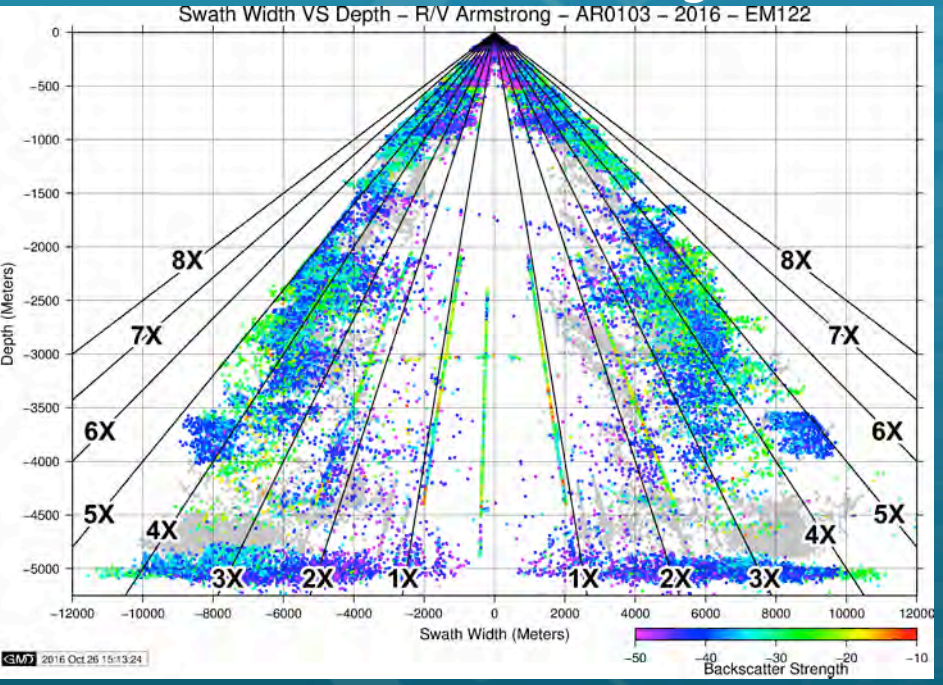

Swath Width VS Depth – R/V Sally Ride – July – 2016 – EM122
Depth (Meters)
0
−250
−500
−750
−1000
−1250
−1500
−1750
−2000
−2250
−2500
−2750
8X
7X
6X
5X
4X
3X
2X
1X
−7000
−6000
−5000
−4000
−3000
−2000
−1000
0
1000
2000
3000
4000
5000
6000
7000
Swath Width (Meters)
GMT 2016 Jul 29 08:06:57
−50
−40
−30
−20
−10
Backscatter Strength

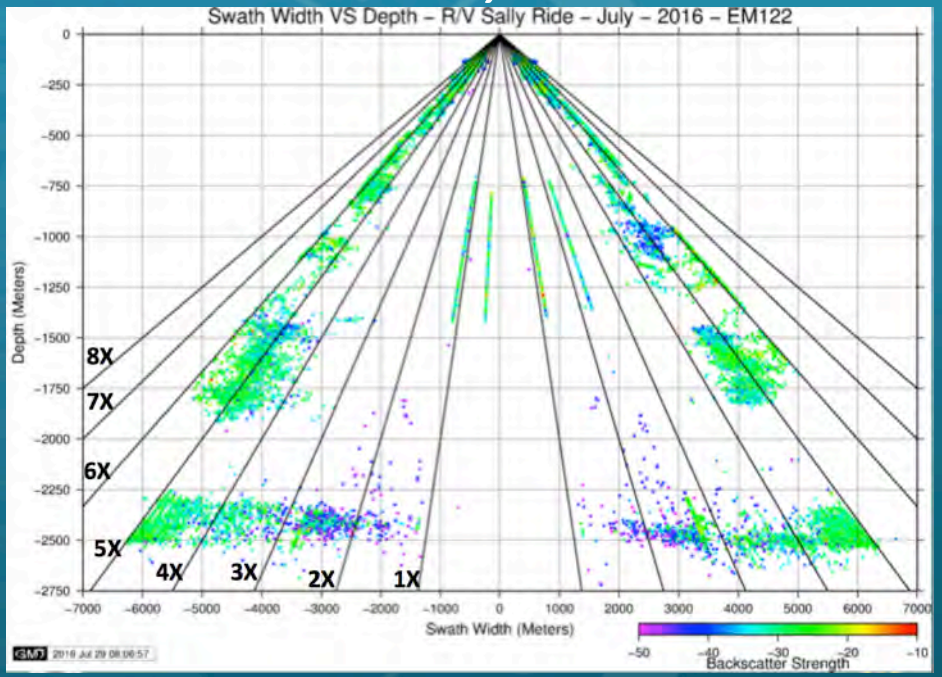
EM122 Swath Analysis Comparison

Neil Armstrong



Tested to > 5km depth

Sally Ride



Tested to < 3km depth

Both achieved > 5X water depth in water < 2 km

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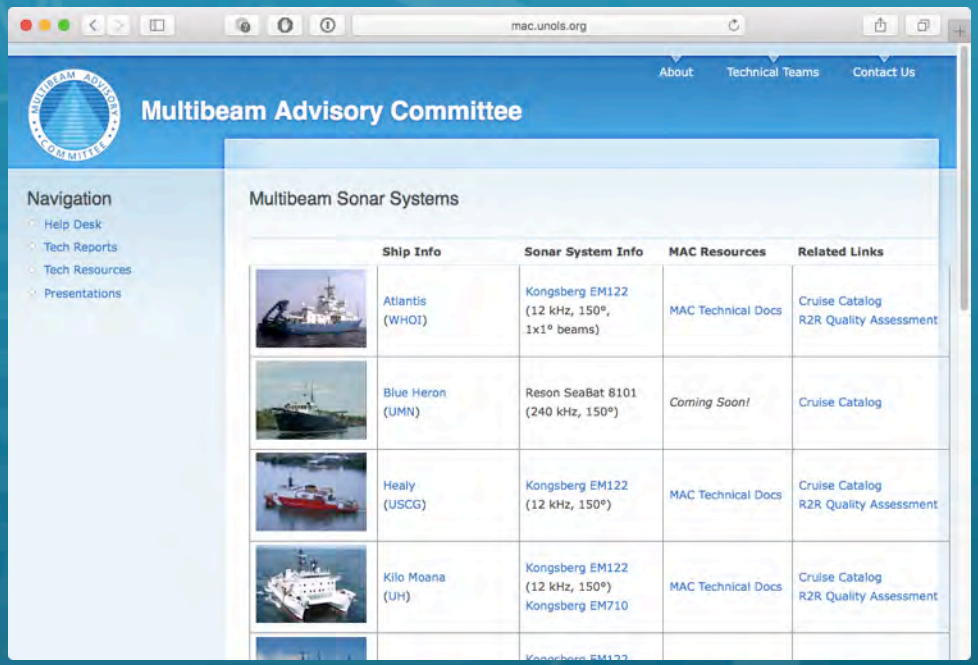
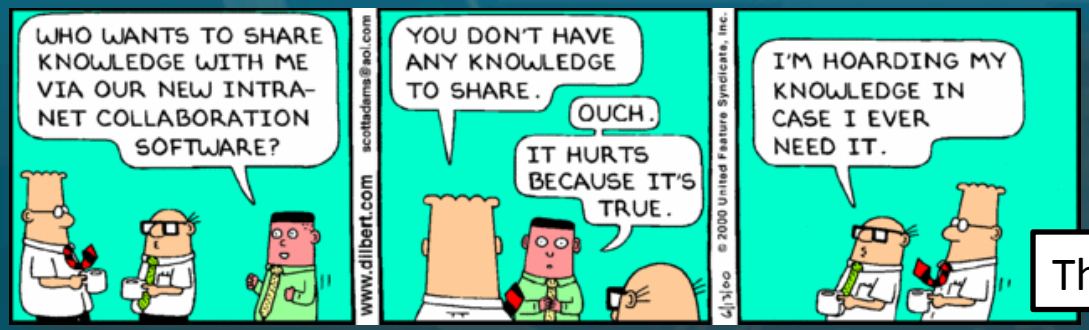
Open Access Resources & Reports

- Technical Reports
- Technical Resources
- Help Desk





http://mac.unols.org

The Early Days of the MAC

CCOM JHC

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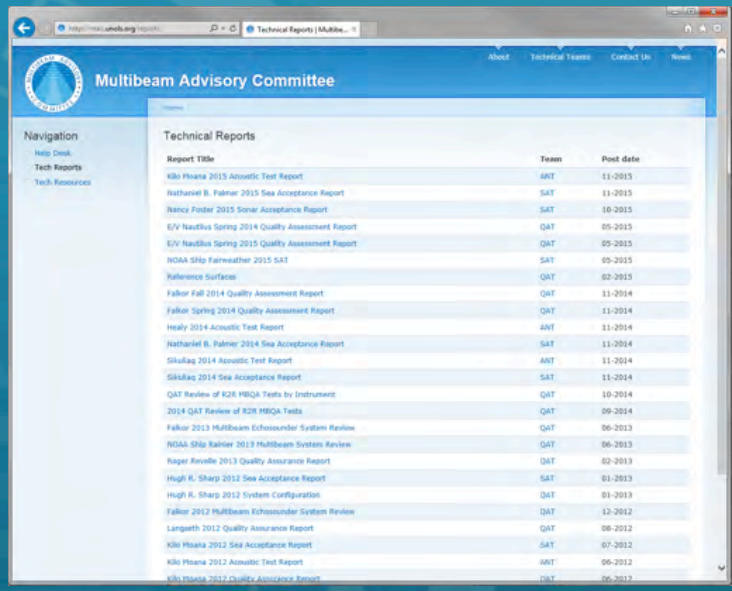
Technical Reports

- UNOLS ship visits
  - ANT, QAT, & SAT Reports
  - Reports from pre-MAC visits
- NOAA ship visits
- Other ship visits
  - R/V *Falkor* & EV *Nautilus*
  - Not supported under NSF Grant
  - Allows for development of new tools & techniques to be contributed back to MAC
  - Broadens our understanding of MBES



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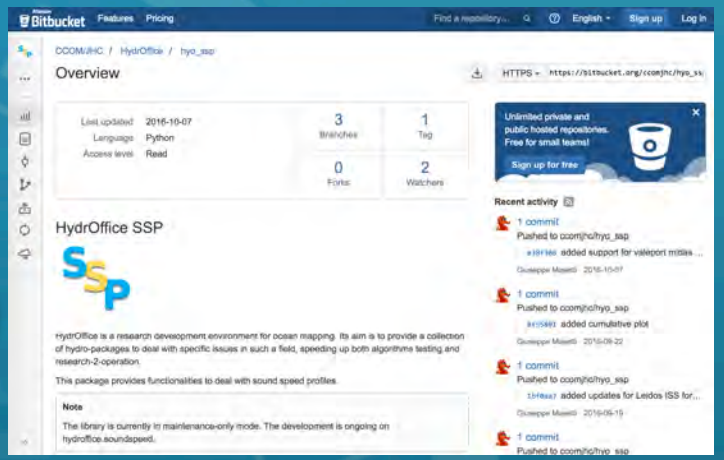
MAC Technical Resources

- Software Tools
  - SVP Editor (new version in 2016)
  - Extinction Tool (VM - 2016)
  - Accuracy Assessment (VM - 2016)
  - Mapping Tools (VM - 2016)
  - BIST Plotting (VM - 2016)
  - BIST Database (2016)
- Cookbooks
  - Using SIS, Caris, etc…
  - More Coming…
- Documentation
  - GEBCO, NOAA, etc…



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Cookbooks

Working With Caris

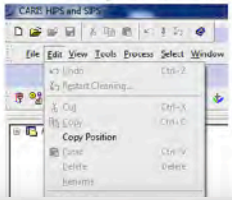
Caris Vessel Setup.pdf

Caris Vessel Creation

thin Caris HIPS and SIP, start the Vessel Editor by selecting:

Edit > Vessel Editor

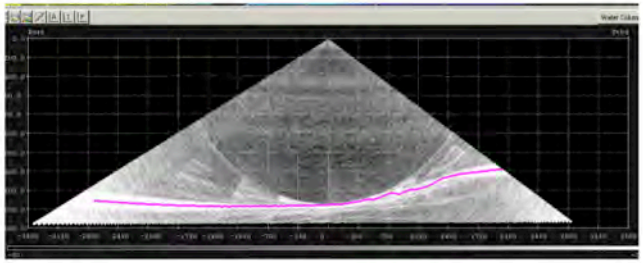
Or Edit > Vessel Configuration



Water Column Optimization

mac.unols.org/sites/mac.unols.org/files/EM302%20Water%20Column%20Settings.pdf

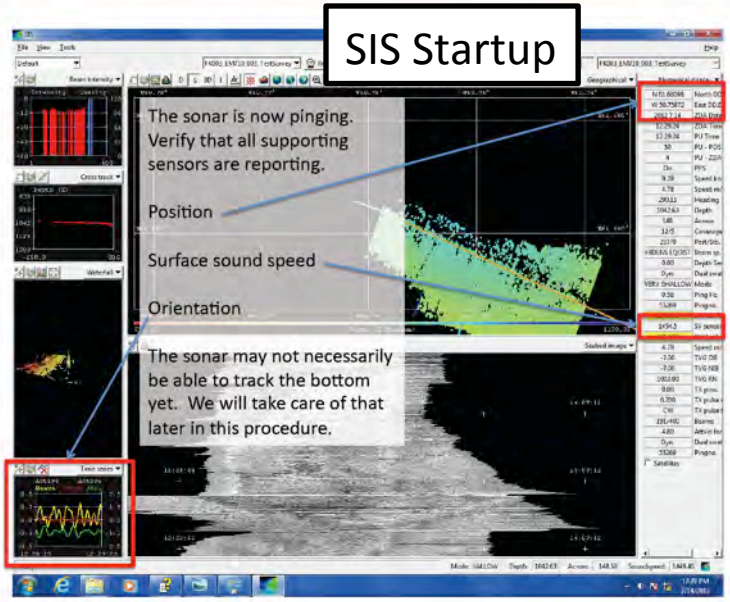
ascertain the
mpting to find
water column targets, it is inconvenient if the reference frame in the image changes from ping to ping. Fixing the image scale may be of particular importance for operations where the water column display imagery is used to help coordinate other operations such as CTD or ROV.



Fixing the image scale can be done through the "Show/Hide" interface which is accessed via the top left button in the water column imagery display. The "Depth Start Range Mode" and "Depth Stop Range Mode" should be set to fixed with reasonable scale values entered (e.g. image should stretch vertically from X meters to Y meters). The same is done for the "Across Start Range Mode" and "Across Stop Range Mode". The number of grid lines are then set for both the X and Y Axes. This particular procedure is non-intuitive and some experimentation will be required to get a particular combination of Start/Stop range and number of grid lines to give reasonable (and usable) scales on the image. A more intuitive procedure would be to set the grid interval, however, this is not currently possible in SIS.

SIS Startup_0.pdf

SIS Startup



Multibeam Advisory Committee – July 14, 2012

11

- Coming Soon…
  - Patch Test (Caris & Qimera)
  - Site Selection
  - Updated SIS

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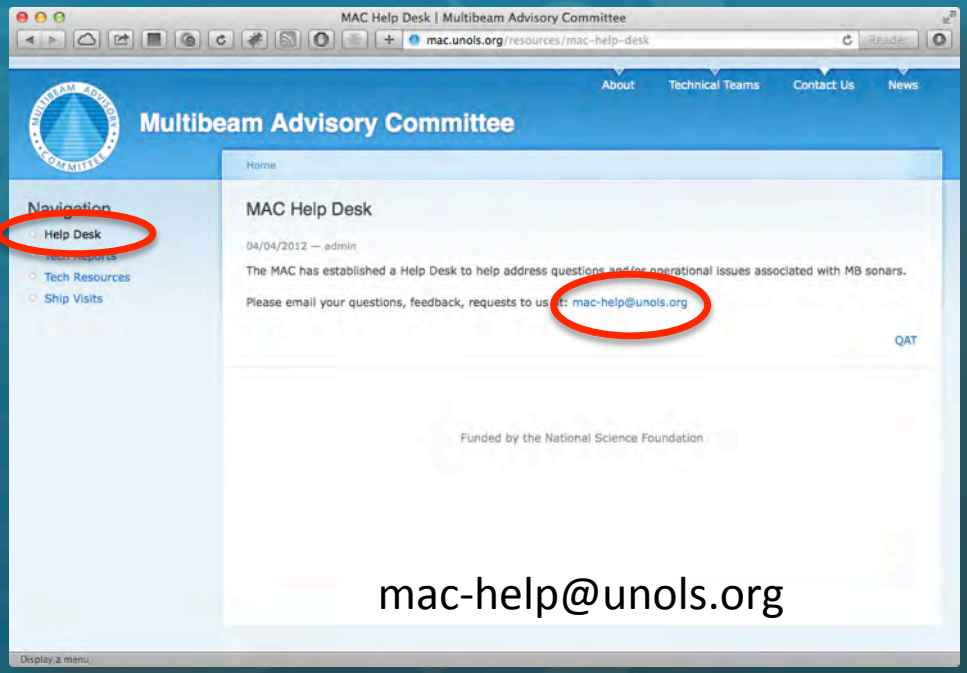
QAT – Shore-based Activities

- Develop Best Practice Documentation
- Remote Patch Tests
- Help Desk
- Troubleshooting
- Assist Scientists
  - survey planning
  - data processing



mac-help@unols.org

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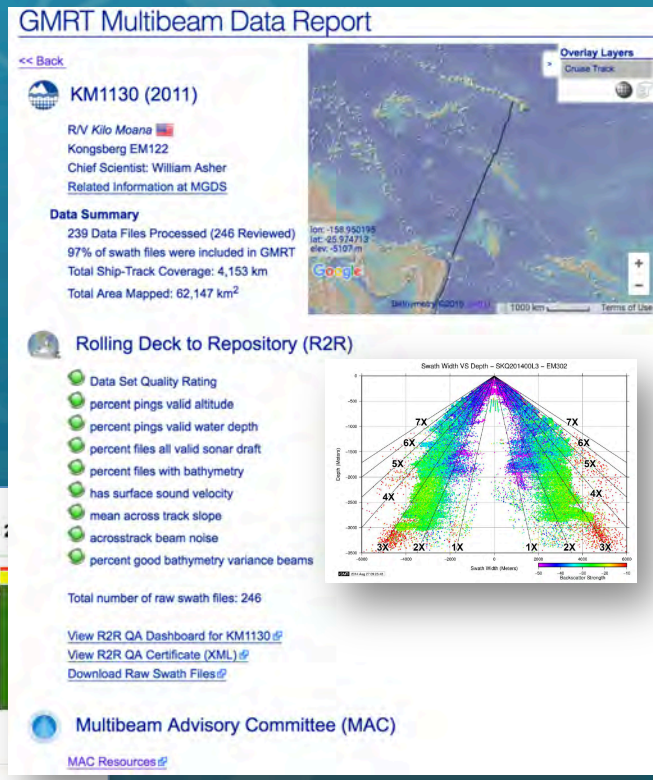
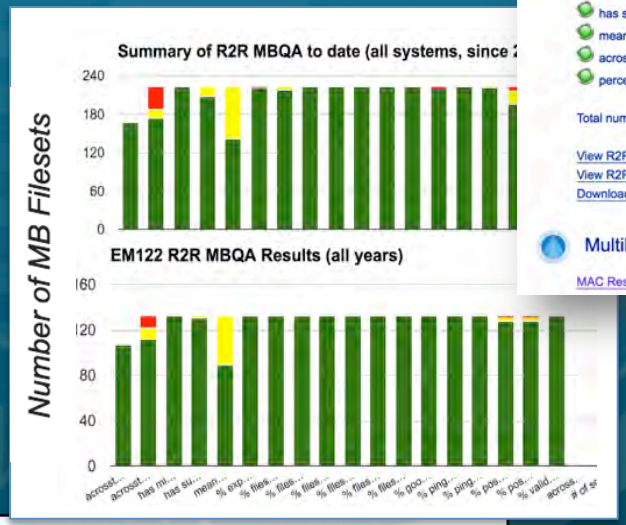
QAT – Coordinate with Fleet-wide MB Data Quality Efforts

- Code share & review
  - Extinction plots integrated into GMRT workflow & reports
- Assessment of R2R MB QA
  - Compare with GMRT reports





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Next Steps…

- Ongoing MAC Technical Team activities
- Poster at 2016 AGU
- BIST Database [under development]
- Encyclopedia of lessons learned
  - Problems
  - Diagnostics
- UNOLS-wide coordination related to potential acoustic interference

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