E/V Nautilus

Kongsberg EM302 Multibeam Echosounder Quality Assessment

Cruise: NA105

Engineering Shakedown
April 29 – May 5, 2019

Report prepared by:
Paul Johnson
Lindsay Gee

Photo Credit: ocean exploration trust
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<th>Role</th>
<th>Affiliation</th>
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<tr>
<td>Nicole Raineault</td>
<td>Expedition Leader</td>
<td>OET</td>
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<td>Paul Johnson</td>
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<td>Lindsay Gee</td>
<td>Mapping Coordinator</td>
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<td>Renato Kane</td>
<td>Navigation &amp; Mapping</td>
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<td>Miles Saunders</td>
<td>Navigation &amp; Mapping</td>
<td>OET</td>
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<tr>
<td>Neah Baechler</td>
<td>Navigation &amp; Mapping</td>
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<td>Jamie Wagner</td>
<td>Science Management</td>
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<td>Justin Lowe</td>
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<td>Tim Burbank</td>
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<td>Ben Craik</td>
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<tr>
<td>Josh Chernov</td>
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<td>Ocean Dynamics, Inc</td>
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<td>Jon Zand</td>
<td>ROV engineer</td>
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<td>Bob Waters</td>
<td>ROV engineer</td>
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<td>ROV engineer</td>
<td>Ocean Dynamics, Inc</td>
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<tr>
<td>Scott Hansen</td>
<td>ROV engineer</td>
<td>OET</td>
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<tr>
<td>Mark Deroche</td>
<td>Deck Chief</td>
<td>OET</td>
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<tr>
<td>Ed McNichol</td>
<td>Video engineer</td>
<td>OET</td>
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<tr>
<td>Wayne Bornio</td>
<td>Video engineer</td>
<td>OET</td>
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<tr>
<td>Jeff Dennerline</td>
<td>Video Engineer</td>
<td>OET</td>
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<tr>
<td>Scott Stamps</td>
<td>Satellite Engineer</td>
<td>OET</td>
</tr>
<tr>
<td>Samantha Wishnak</td>
<td>Communications</td>
<td>OET</td>
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<tr>
<td>Peggy Knoebel</td>
<td>Guest</td>
<td>OET</td>
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NA105 Executive Summary

• Heading into the 2019 operating season, the EM302 and associated sensors aboard the E/V Nautilus are working very well compared to the 2018 NA093 Quality Assurance Test (QAT) and earlier shipboard assessments.

• The EM302 was calibrated for residual angular offsets using the Seapath 330-5+ as the primary positioning/attitude system. The NA105 patch test revealed only very slight pitch and roll adjustments were required. These biases were entered into the SIS installation parameters for Attitude 1, COM2/UPD5, and should not be changed unless modifications are made to the system or there is evidence that another ‘patch test’ is necessary. If any changes are made please notify Johnson for amendment of this report.

• Swath accuracy assessments were conducted over existing shallow and deep reference surfaces that had been collected during the 2017 NA079 QAT. Eight different operational settings were run (5 on the deep surface and 3 on the shallow) and analyzed. Results indicate expected and acceptable performance when comparing the data to previously collected accuracy assessments and to other system which have been evaluated. There were some issues with proper sound speed correction for the reference surfaces, which did bias the results for the outer portions of the swath. This issue was further exacerbated by the lack of a functioning surface sound speed sensor.

• NA105 was able to collect deep data down to 3750 meters water depth for swath performance analysis (extinction) as had NA093. The NA105 swath performance was as good or better than the NA093 performance over this depth range.

• Due to a small sample size of NA105 extinction data for depths deeper than ~2500 meters and the soft sediment bottom type for that range of depths it is somewhat difficult to assess if there has been a decrease in swath width at those depths as compared to historic data. If more data is collected during the 2019 field season, please transfer the data to Johnson for analysis.
NA105 Executive Summary

• Initial noise testing in the Catalina Basin area using the Built-In Self Test in SIS initially seemed to reveal a higher than expected noise floor. However, after conducting another set of noise testing offshore at the deep water ROV dive site it was shown that the E/V Nautilus’s noise floor (40-44 dB) were much lower than what had been observed during 2018 (50-54 dB) over the same speed range. The 2019 levels were similar to those observed during the initial shipboard acceptance testing done in 2013 (~40 dB).

• A noise test was conducted to look at the noise while underway with the jet pump (~38 dB) into and with the seas at 3 knots VS no propulsion (~37 dB). This indicates that the jet pump is producing little to no acoustic noise at the frequencies detected by the EM302.

• The heading/sea state related noise testing showed that there was significant difference in the ship’s self noise between heading going into the seas and headings with the seas. When the heading was directly into the seas or with seas on the port bow, the self-noise of the ship was ~47-~51 dB. When travelling with the seas (waves on stern) or waves on the starboard stern, the ships self-noise was ~50-~57 dB.

• From a strictly qualitative assessment, the bathymetric data appeared very clean with few flyers and excellent bottom tracking. This was especially apparent at the patch test site where the pitch and yaw lines on the slopes were much easier to work with than the data collected on the same lines in 2017 and 2018. This was remarked on by both Johnson and Gee while undertaking the patch test.

• Using a known seep, detected during previous E/V Nautilus mapping, a series of lines were setup to pass directly over the seep, and then be offset from the seep by 450 meters, 900 meters, and 1350 meters ranges. The seep was easily detected in the water column data on both the port and starboard side at all ranges.
NA105 Executive Summary

- Qimera was used during the seep detection evaluation. It provided ray traced positions with fairly low uncertainty in position to the seep during each of the offset lines (0, 450 meters, 900, and 1350 meters).

- A backscatter equalization assessment was done looking at inter-sector and inter-mode (medium to deep transitions) over a relatively benign area of seafloor. Historic data (2017) had indicated that FMGT was not correctly handling the balancing between modes at this site. Test data collected during NA105 showed the same imbalances in both the waterfall (raw) data and in the mosaics generated from the test data. This issue would be well worth spending some more time looking at during the next QAT.

- The Sound Speed Manager software (https://www.hydrooffice.org/soundspeed/main) was updated to the latest version and was used during NA105. The new version of the software was successfully tested for importing sound speed profiles from a Hercules ROV dive.

- The Underway CTD (UCTD) had been sent out to recalibrated during the off season and had not been returned in time to be used for NA105. A loaner unit provided by Teledyne Ocean Science, but this unit was non-functional due to battery issues. The recalibrated UCTD was returned to the ship post-NA105.

- The AML Surface Sound Speed Sensor was not working for the QAT. A replacement unit was delivered to the ship immediately following the end of NA105.

- There were some issues with SIS stability. This was likely due to heat related issues (the cooling system was disabled at one point) and issues with card connectivity. Temperature in the sonar room should be carefully monitored.
NA105 Executive Summary

• It would be well worth clearing out the SIS list of prior surveys before continuing too long with the 2019 field season (this was an unchecked action item from NA105).

• Please contact Paul Johnson, pjohnson@ccom.unh.edu, if there are any questions on any of these matters or any other future questions.
Introduction

The E/V Nautilus undertook a multibeam echosounder quality assurance test from April 29 to May 5, 2019 during an engineering shakedown leg (NA105) in order to perform an assessment of the vessel’s Kongsberg EM302 multibeam echosounder.

Data were collected near the Southern Channel Islands (figure to right), offshore from San Pedro, California. Paul Johnson (UNH/CCOM-JHC) and Lindsay Gee (OET) provided logistical and technical support for mission planning, data collection, and analysis.

This report presents:

• an overview of the data collected and the processing methods applied to it
• a history of all changes made to the system configuration, starting from the initial install and up through the most recent path test calibration
• an accuracy assessments at two depth ranges and swath coverage analysis across all depths surveyed
• amplitudes of vessel self-noise measured by the multibeam receiver at various speeds and headings relative to a prevailing swell
• EM302 impedance data to document receiver and transducer health
• a seep detection assessment trial
• a backscatter equalization assessment
<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
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</thead>
</table>
| **2019-04-28** (Sunday) | Board R/V *Nautilus* at AltaSea, San Pedro, CA  
Safety Briefing  
Introduction and Cruise Discussion  
Install Updated Sound Speed Manager |
| **2019-04-29** (Monday) | Validate updated Seapath Configuration  
Depart Alta Sea for Engineering Shakdown  
RXnoise Speed Testing – Catalina Basin |
| **2019-04-30** (Tuesday) | Extinction Testing  
RXnoise Azimuth Testing - Offshore  
RXnoise Speed Testing – Offshore  
Argo & Traction Winch Testing |

* Activities in **BOLD** are Quality Assessment tasks.
# Onboard Activities

<table>
<thead>
<tr>
<th>Date</th>
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<tbody>
<tr>
<td>2019-04-30 (Tuesday)</td>
<td>ARGO sidescan Testing</td>
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<tr>
<td>2019-05-01 (Wednesday)</td>
<td>Extinction Testing</td>
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<tr>
<td></td>
<td>Patch Test</td>
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<tr>
<td></td>
<td>Deep Water Reference Test</td>
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<td></td>
<td>Mooring Deployment</td>
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<tr>
<td></td>
<td>Argus Sidescan Testing</td>
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<td></td>
<td>USBL Calibration</td>
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<tr>
<td>2019-05-02 (Thursday)</td>
<td>Seep Detection Testing</td>
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<tr>
<td></td>
<td>Shallow Water Reference Test</td>
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<tr>
<td></td>
<td>Deep Water Reference Test</td>
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<tr>
<td></td>
<td>Deep Water Reference Test</td>
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<tr>
<td></td>
<td>Little Hercules Dive</td>
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* Activities in **BOLD** are Quality Assessment tasks.
## Onboard Activities

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
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<tbody>
<tr>
<td>2019-05-02 (Thursday)</td>
<td>USBL Verification</td>
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<tr>
<td>2019-05-03 (Friday)</td>
<td>Hercules Dive Preparation</td>
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<td>Underway CTD Testing</td>
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<td></td>
<td>USBL Mooring Recovery</td>
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<td></td>
<td>Satellite and Video Tests</td>
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<td></td>
<td>Sub-bottom Profiler and Multibeam Acquisition Testing</td>
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<td></td>
<td><strong>Backscatter Assessment</strong></td>
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<tr>
<td>2019-05-04 (Saturday)</td>
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<td></td>
<td><strong>Backscatter Assessment</strong></td>
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<tr>
<td></td>
<td><strong>Shallow Water Reference</strong></td>
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<tr>
<td>2019-05-05 (Sunday)</td>
<td>Hercules Dive</td>
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<tr>
<td></td>
<td><strong>XBT &amp; CTD Sound Speed Profile Assessment</strong></td>
</tr>
<tr>
<td></td>
<td>Return to AltaSea, San Pablo</td>
</tr>
</tbody>
</table>

* Activities in **BOLD** are Quality Assessment tasks.
The mapping system consists of the following primary components:

1. Kongsberg Maritime EM302 multibeam echosounder (30 kHz), v1.3.1, s/n 110
2. Kongsberg Maritime Seafloor Information System (SIS), v4.3.2
3. Kongsberg Seatex Seapath 330-5+ vessel navigation system
   I. Seapath 330+ GNSS antennae
   II. MRU 5+, s/n C126NS2018
4. AML Oceanographic Micro-X surface sound speed sensor *
5. Sippican MK21 expendable bathythermograph (XBT) profiling system
6. Teledyne Oceanscience UnderwayCTD with Seabird Electronics CTD Profiler **

* Sound speed sensor had been sent for repairs and replacement unit was not able to be properly configured. Issue was resolved with a new unit post-NA105.

** Underway CTD had been sent for calibration and loaner unit supplied was non-functional. Issue was resolved post-NA105.
System Geometry Review

The term ‘system geometry’ means the linear and angular offsets of the primary components of the multibeam mapping system, including the transmit array (TX), receive array (RX), and ship navigation sensor (MRU).

<table>
<thead>
<tr>
<th>Date</th>
<th>Cruise ID</th>
<th>Location</th>
<th>Event</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013 March</td>
<td></td>
<td>Istanbul, Turkey</td>
<td>Install EM302 MBES, Seatex Seapath 330+ MRU, AML Oceanographic surface sound speed sensor, Sippican XBT profile; establish vessel reference frame and survey sensor offsets</td>
<td>Kongsberg Maritime (KM) Harbor Acceptance Test (HAT) report, Parker Maritime survey report</td>
</tr>
<tr>
<td>2013 April</td>
<td>NA025</td>
<td>Toulon, France</td>
<td>EM302 sea acceptance trials; MRU angular offsets determined by patch test and applied in SIS</td>
<td>UNH/IFREMER Sea Acceptance Trials (SAT) report, Gates Acoustic Services report</td>
</tr>
<tr>
<td>2013 June</td>
<td>NA030</td>
<td>Gulf of Mexico</td>
<td>Original MRU 5+ unit replaced with spare by KM engineer at start of NA030</td>
<td>2014 EM302 Multibeam Echosounder System Review</td>
</tr>
<tr>
<td>2014 May</td>
<td>NA040</td>
<td>Gulf of Mexico</td>
<td>Original MRU 5+ unit reinstalled by KM engineer at start of NA040; EM302 system performance review; residual angular offsets determined by patch test and applied in SIS</td>
<td>2014 EM302 Multibeam Echosounder System Review</td>
</tr>
<tr>
<td>2015 April</td>
<td>NA055</td>
<td>Gulf of Mexico</td>
<td>EM302 system performance review; residual angular offsets determined by patch test and applied in SIS</td>
<td>2015 EM302 Multibeam Echosounder System Review</td>
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<tr>
<td>2016 April</td>
<td>NA070</td>
<td>Victoria, British Columbia</td>
<td>EM302 system performance review; residual angular offsets determined by patch test and applied in SIS</td>
<td>2016 EM302 Multibeam Echosounder System Review</td>
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<tr>
<td>2017 May</td>
<td>NA079</td>
<td>San Pedro, California</td>
<td>MRU 5+ reinstalled after factory service; EM302 system performance review; residual angular offsets determined by patch test and applied in SIS</td>
<td>2017 EM302 Multibeam Echosounder System Review</td>
</tr>
<tr>
<td>2018 June</td>
<td>NA093</td>
<td>San Pedro, California</td>
<td>EM302 system performance review; residual angular offsets determined by patch test and applied in SIS</td>
<td>2018 EM302 Multibeam Echosounder System Review</td>
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<tr>
<td>2019 May</td>
<td>NA105</td>
<td>San Pedro, California</td>
<td>System installation review for the Seapath 330-5+ following a firmware update to the topside unit. EM302 system performance review; residual angular offsets determined by patch test and applied in SIS</td>
<td>2019 EM302 Multibeam Echosounder System Review</td>
</tr>
</tbody>
</table>
Vessel Survey

- Vessel survey conducted by Parker Maritime AS in Istanbul, Turkey from March 16-20, 2013
- Survey reviewed by UNH/IFREMER team during Sea Acceptance Trials, April 2013, in Toulon France.
- **Origin** of survey reference (the Coordinate Reference Point, CRP) is at x=0 at centerline, y=0 at AP/frame 0.
- **Linear offsets** reported in meters
  - +X starboard (does not agree with KM/Seapath convention)
  - +Y forward (does not agree with KM/Seapath convention)
  - +Z up (does not agree with KM/Seapath convention)
- **Angular offsets** reported in decimal degrees
  - +Roll with starboard side down (agrees with KM/Seapath convention)
  - +Pitch with bow down (agrees with KM/Seapath convention)
  - +Heading with bow rotation to stbd and port (does not agree with KM/Seapath convention)
System Geometry Review

**Parker Convention**
Source: Parker Report (Document 1306029-13000225)

X, Y, Z, and heading convention are different

**Kongsberg Convention**
Source: Kongsberg EM302 Installation Manual

**Seapath Convention**
Source: Applanix POS MV Installation Manual

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**Coordinate Systems**

4.3.1 Vessel reference system

The following has to be surveyed:
- All vessels have a defined Cartesian coordinate system that all sensors can be referenced to. In this right hand system, the X-axis is positive forwards, which is parallel to the centre line of the vessel, the Y-axis positive towards starboard, and the Z-axis, which is positive downward.
- The origin in the vessel reference system is typically frame 0 at keel level or the surveyed origin in a survey report, i.e., where X, Y and Z are all 0.
- The coordinate reference point (CRP) is defined to be in the intersection between stem, keel line parallel to the keel. In case the keel is not parallel with the base line, the reference for CRP is where the keel crosses the vertical section amidships. The location of CRP vs the origin is configurable, and is typically set based on the survey report.
- The reference plane in this system must be well defined and described. This can be a Best Fit Plane on main deck, or a Best Fit Plane through the draught marks on the hull. This is particularly important on a floating vessel, as it is not possible to project the horizontal plane from land.
- The chosen convention must be made clear to all parties involved, both survey personnel performing the survey and the users of the survey results. Any deviation from the defined coordinate system, shown in the figure Definition of Origin on vessel and positive X, Y and Z axes directions on page 54, should be well described in both text and drawings to avoid common misunderstandings.

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**Figure 36 Reference points**

Reference points must be established on the vessel at selected positions. These are needed during measurements of the sensor positions. Visual markings at these positions should be prepared and noted on the vessel drawings with XYZ coordinates in the vessel coordinate system.

**Figure 10 Definition of Origin on vessel and positive X, Y and Z axes directions**

The heading of the transducers is measured as the average heading of the two fore-and-aft oriented sides of each transducer array. Thus, the heading of the transducer is the heading along the keel while the heading of the receiver array is the heading across the keel. For the receive transducer it may be better to measure the heading along the keel, and then subtract 90° to achieve the correct value. The measurement accuracy is required to be within one-fifth of the beamwidth of the transducer received.

Note however that the measurement accuracy of the relative heading between the transmit and receive transducers must be better than 0.1°.

**Transducer heading**

The heading of the transducers is measured as the average heading of the two fore-and-aft oriented sides of each transducer array. Thus, the heading of the transducer is the heading along the keel while the heading of the receiver array is the heading across the keel. For the receive transducer it may be better to measure the heading along the keel, and then subtract 90° to achieve the correct value. The measurement accuracy is required to be within one-fifth of the beamwidth of the transducer received.

Note however that the measurement accuracy of the relative heading between the transmit and receive transducers must be better than 0.1°.

**Transducer roll and pitch**

Roll and pitch measurements are made according to standard conventions with positive pitch angle if the transmitter array's forward end is above the aft end (tilts up), and positive roll if the starboard side of the receiver array is lower than the port side.

Note that the roll and pitch angles to be measured are relative to the horizontal plane as defined by the vessel's coordinate system, i.e., for roll the angle that the transducer's y-axis have with respect to the horizontal and for pitch the angle that the transducers x-axis have with respect to the horizontal plane. The multibeam echo sounder converts the measured angles as entered into the installation menu to rotation angles before use i.e. do not do such a conversion before entering them into the system.
Seapath antennas are installed on an antenna beam on top of the control van.

Antenna locations as entered into the Seapath 330+ control software are referenced to an origin at the centerline of the ship (Y=0) at frame 0 at the aft end of the ship.

- **Antenna 1 (aft)**
  - X = 18.317 meters
  - Y = -0.200 meters
  - Z = -16.053 meters

- **Antenna 2 (fwd)**
  - X = 20.818 meters (20.815 in Parker)
  - Y = -0.175 meters (same as Parker)
  - Z = -15.986 meters (-15.994 in Parker)

Note: Antenna 1 lever arms exactly match the Parker survey values. Antenna 2 locations have small differences from the values recorded in the Parker report. This is from having run the Calibration wizard, which will adjust the 2nd antenna location as needed.
System Geometry Review

Seapath IMU Lever Arms

- Parker surveyed the center of top plate for the IMU
- Parker result were used for the lever arm distances from the origin to the IMU in Seapath configuration (‘MRU Geometry’)

Primary IMU Position Distance From Origin:

- X: 33.657 meters
- Y: -0.067 meters
- Z: -2.628 meters

- The IMU is the reference point in the Kongsberg coordinate system.

Primary IMU Position Kongsberg Reference Frame:

- X: 0.000 m
- Y: 0.000 m
- Z: 0.000 m
Parker surveyed the center of top plate for the IMU

Angular offsets from the Parker report were transformed into the Kongsberg convention.

**Primary IMU Angles:**
- Roll: 179.400 degrees
- Pitch: 1.760 degrees
- Yaw: -0.510 degrees
System Geometry Review

TX & RX Linear Offsets

- Linear offsets from Parker report were transformed into the Kongsberg convention
  - Origin at MRU center of top plate
  - All units in meters
  - +X forward
  - +Y starboard
  - +Z down

- Values entered into the SIS installation parameters Locations panel were verified to match those determined during the system geometry review.

- **EM302 TX Transducer**
  - X: 3.496 m
  - Y: -0.137 m
  - Z: 2.731 m

- **EM302 RX Transducer**
  - X: 1.516 m
  - Y: 0.033 m
  - Z: 2.732 m
System Geometry Review

TX & RX Angular Offsets

• Angular offsets from Parker report were transformed into the Kongsberg convention
  • All units in degrees
  • +Roll starboard side down
  • +Pitch bow up
  • +Heading bow to starboard (compass convention)

• Values entered into the SIS installation parameters Angular Offsets panel were verified to match those determined during the system geometry review.

• EM302 TX Transducer
  Roll: 0.61 degrees
  Pitch: 0.01 degrees
  Heading: 0.22 degrees

• EM302 RX Transducer
  Roll: 0.72 degrees
  Pitch: 0.32 degrees
  Heading: 0.08 degrees
The waterline value entered in the Installation Parameters/Locations tab was derived during the 2013 shipboard acceptance test.

By evaluating the 2013 pre-departure draft marks at the front of the vessel (figure 1) and rear (figure 2) it was determined that the ship rests slightly bow up by about ~0.8 meters.

Using this information, a waterline adjustment of 0.6 meters was calculated in the ship’s reference plan at the TX array face. This adjustment changed the water line z from -2.372 to -1.77.

Calculated NA105 2019 Water Levels (as reported by the bridge). These values were not used during NA105.

- Forward: 4.2 meters
- Stern: 4.85 meters
- The ship rests slightly bow up, by ~0.65 m
- The length at the waterline is approximately 58 m
- Ship has a static positive trim of \( \tan(0.65/58) = 0.7 \) deg
- The center of the TX array is approximately 40 m from the stern
- The draft at the sonar head is \( 4.85(m) - 40(m) \times \tan(0.7 \text{ deg}) = 4.35 \) m
- Draft at the sonar head: \( 4.85(m) - 40(m) \times \tan(0.7 \text{ deg}) = 4.35 \) m
- \( \text{WLZ} = -2.372 + 0.55 = -1.82 \) m
1. The calibration site used for NA105 had been successfully during the QATs in 2017 (NA079) and 2018 (NA093) This area was selected because of the availability of seafloor features with optimal slopes, bathymetric relief, and proximity to the operations area.

2. Lines were run at 12 kts, instead of the usual 6kts due to engine constraint issues, in the order of pitch, roll, and then heading.

3. XBTs were collected as needed throughout the calibration process.

4. It should be noted that the EM302 tracked the slopes of the pitch and heading lines very well, with a minimal amount of noise, this was in contrast to NA079 and to some extent NA093 where the slopes had not been tracked as well.
EM302 Calibration

Pre-Calibration Configuration

1. All *Attitude 1, COM2/UDP5* angular offsets were left with the offsets determined during the 2018 NA093 QAT in the *SIS Installation Parameters / Angular offsets* panel (see figure to left).

2. Calibration data were examined by Johnson and Gee using patch test tools in both SIS and Qimera; results were agreed upon both Johnson and Gee.

3. The biases determined during each test were updated in the *SIS Installation Parameters* for *Attitude 1, COM2/UDP5* prior to starting the next test, in order to reduce the effects of coupling.

4. As the offsets were very small, there was no need to run verification lines to test the results.

5. No latency test was conducted as previous testing of the system had not revealed any latency and no latency-related artifacts have been observed. It is also not clear that if a minute amount of latency did exist within the system that it would be detectable during a deep-water patch test of an EM302 system.
EM302 Calibration

Results: Roll

- Roll verification lines shown at left in the Qimera Patch Test Tool

1. Pre-NA105 roll offset value: +0.14°
2. NA105 calculated bias: -0.03°
3. Final roll offset: +0.17° entered into the SIS Installation Parameters/Angular Offsets panel.
EM302 Calibration

Results: Pitch

- Pitch verification lines shown at left in the Qimera Patch Test Tool

1. Pre-NA105 pitch offset value: -0.13°
2. NA105 calculated bias: -0.03°
3. Final pitch offset: -0.16° entered into the SIS Installation Parameters/Angular Offsets panel.
EM302 Calibration

Results: Heading

• Heading verification lines shown at left in the Qimera Patch Test Tool

1. Pre-NA105 pitch offset value: +0.01°
2. NA105 calculated bias: 0.0°
3. Final heading offset: +0.01° entered into the SIS Installation Parameters/Angular Offsets panel.
Post-Calibration Configuration

1. The small offsets applied to the pitch and roll in the *Attitude 1* angular offsets reflect a very stable system with no significant changes in either the system geometry or integration.

2. The *Installation Parameters: Angular Offsets*, shown at left, should not be changed, unless a new patch test is undertaken.

3. If new values are determined during the 2019 field season, please let Johnson know so that this report can be updated to reflect the current values.
1. Accuracy of a multibeam echosounder under ‘normal’ survey conditions can be assessed by examining soundings collected during a single-pass survey lines over a trusted bathymetric surface (a reference surface).

2. Reference surfaces typically cover flat or gently sloping terrain that have been carefully and densely surveyed, providing a large sample count and high degree of confidence in the depth of each grid cell.

3. Accuracy assessments during quality assessment testing provides a baseline to judge system performance against previous years results. This testing can help reveal both potential changes to the system itself, as well as changes to the operation environment.

4. With rigorous testing protocols and consistent analysis methods, accuracy performance data can provides a critical window into performance over the system’s service life and may help to identify early signs of component failure.
5. For a complete evaluation, accuracy data should be collected in all operational modes over reference surfaces in depths appropriate for those modes.

6. ‘Deep’ and ‘Shallow’ operational modes for the EM302 were tested during NA105 cruises using two reference surfaces collected during NA079 QAT in 2017.

7. The two surfaces cover significantly different depth ranges and therefore test different modes of the sonar.

8. By using the NA079 reference surfaces, a significant amount of time was saved by not needing to survey the whole of the surface.
1. Swath accuracy over ‘deep’ terrain (relative for the 30-kHz EM302) was assessed by running a series of crosslines over a ‘deep’ reference surface in 1250-1350 m depths which had been collected during the 2017 NA079 QAT. Figure to the left shows the reference lines run in thick blue trending WNW/ESE.

2. Crosslines (shown in red in the figure to the left) were oriented to maximize coverage across reference surface and were orthogonal to the lines used to collect the data contributing to the surface, in order to reduce any potential coupling of EM302 biases across the swath.

3. Deep accuracy crosslines were run in five settings, starting with the most conventional configuration for the environment (changes from previous settings are shown in red in the table on the next page).

4. An XBT profile was collected prior to crosslines

5. All lines were run at 12 knots, note that this is faster than the 8 knots at which the lines were run at in 2017 (NA079) and in 2018 (NA093).
EM302 Accuracy Testing

Deep Accuracy: Data Collection

* With FM enabled, in this depth range, the EM302 used a ‘MIX’ transmission with CW inner sectors and FM outer sectors. With FM disabled, only CW pulse forms were used for all sectors (e.g., Setting 2 and Setting 4).

** RMH = Relative Mean Heading

<table>
<thead>
<tr>
<th>Crossline Setting</th>
<th>Ping Mode</th>
<th>Swath Mode</th>
<th>Pulse Form</th>
<th>Yaw Stabilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting 1</td>
<td>Deep</td>
<td>Dual Swath (Dynamic)</td>
<td>FM Enabled*</td>
<td>RMH**</td>
</tr>
<tr>
<td>Setting 2</td>
<td>Deep</td>
<td>Dual Swath (Dynamic)</td>
<td>CW</td>
<td>RMH**</td>
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<td>Setting 3</td>
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<td>Single Swath</td>
<td>FM Enabled*</td>
<td>RMH**</td>
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<tr>
<td>Setting 4</td>
<td>Deep</td>
<td>Single Swath</td>
<td>CW</td>
<td>RMH**</td>
</tr>
<tr>
<td>Setting 5</td>
<td>Deep</td>
<td>Dual Swath (Dynamic)</td>
<td>FM Enabled*</td>
<td>Off</td>
</tr>
</tbody>
</table>
EM302 Accuracy Testing

Deep Accuracy: Analysis Procedure

1. The bathymetric data were corrected for tide using the Oregon State Tidal model.
2. The reference surface was gridded at 40 m (Fig 1).
3. Grid cells with <10 soundings in a node were removed from the reference surface (Fig 2).
4. Grid cells with slopes >5° were removed from the reference surface (Fig 3).
5. The remaining grid cells with ≥10 soundings and slopes ≤5° were used for analysis of the NA105 deep accuracy crossline data (Fig 4).
6. Crosslines were very lightly processed to remove extreme outliers, “flyers”, from being included in the analysis.
7. The mean depth bias and depth bias standard deviations as a percentage of water depth were then computed in 1° angular bins across the swath for each configuration.
EM302 Accuracy Testing

Deep Accuracy: Results

- The EM302 provides fairly unbiased soundings over the majority of the swath in all of the different modes tested over the deep reference surface.
- A noticeable non-linear refraction bias (frown) is present in the outer portions of the swath for each mode tested. An XBT was taken prior to the start of the collection of the crossline data, but no surface sound speed was available to monitor for changes during testing, and to determine takeoff angle.
- The observed trends in standard deviations (right-top plots of the crossline results) are still within the expected performance tolerances of the system and are very similar to those observed during previous QATs.
- The standard deviations about the mean bias are typically within +/-0.15% to +/-0.25% water depth (1-σ) across the majority of the swath with higher uncertainties at the limits of the swath, as expected and typical for these systems.
- At TX sector boundaries (approx. ±32-35°) with FM enabled, the mean depth bias tends to jump by ~0.05% WD and the depth standard deviation tends to jump by ~0.025% WD.
- The 2019 accuracy assessment shows depth standard deviation trends across the swath that are as good as previous evaluations.

Example of swath accuracy as a percentage of water depth (left) and depth (right) with NOAA thresholds

Results for each setting are presented in the following slides
EM302 Accuracy Testing

Deep Setting 2 - DUAL/DEEP/CW/RMH

Red: Mean Depth Bias   Blue: Depth Std. Dev.

Red: Mean Depth Bias   Blue: Depth Std. Dev. (top: 2\sigma ~ 95% CI)

Order 2
Order 1
Special Order

Order 2
Order 1
Special Order
EM302 Accuracy Testing

Deep Setting 3 - SINGLE/DEEP/MIX/RMH

E/V Nautilus - EM302 - Xline 3 - Deep/Single/FM

- Red: Mean Depth Bias
- Blue: Depth Std. Dev.

- Order 2
- Order 1
- Special Order

Red: Mean Depth Bias    Blue: Depth Std. Dev. (top: $2\sigma \sim 95\%$ CI)
EM302 Accuracy Testing

Deep Setting 4 - SINGLE/DEEP/CW/RMH

Red: Mean Depth Bias   Blue: Depth Std. Dev. (top: 2σ ~ 95% CI)
EM302 Accuracy Testing

Deep Setting 5 - DUAL/DEEP/MIX/NO YAW

E/V Nautilus - EM302 - Xline 5 - Deep/Dynamic/FM/NoYaw

Red: Mean Depth Bias  Blue: Depth Std. Dev.

Red: Mean Depth Bias  Blue: Depth Std. Dev. (top: $2\sigma \sim 95\%$ CI)
EM302 Accuracy Testing

Shallow Accuracy: Testing Procedure

1. Swath accuracy over ‘shallow’ terrain (relative for the 30-kHz EM302) was assessed by running a series of crosslines over a ‘shallow’ reference surface in 100-150 m depths collected during the 2017 NA079 QAT (thick blue lines trending NW/SE).

2. Crosslines (thick red line trending WSW/ENE) were oriented to maximize coverage across reference surface and were orthogonal to the lines used to collect the data contributing to the surface in order to reduce any potential coupling of EM302 biases across the swath.

3. Shallow accuracy crosslines were run in three settings, starting with the most conventional configuration for the environment (changes from previous settings are red in the table below).

4. An XBT profile was collected prior to crosslines

5. All lines were run at 12 knots

<table>
<thead>
<tr>
<th>Crossline Setting</th>
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<th>Swath Mode</th>
<th>Pulse Form</th>
<th>Yaw Stabilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting 1</td>
<td>Shallow</td>
<td>Dual Swath (Dynamic)</td>
<td>CW</td>
<td>RMH*</td>
</tr>
<tr>
<td>Setting 2</td>
<td>Shallow</td>
<td>Single Swath</td>
<td>CW</td>
<td>RMH*</td>
</tr>
<tr>
<td>Setting 3</td>
<td>Shallow</td>
<td>Dual Swath (Dynamic)</td>
<td>CW</td>
<td>Off</td>
</tr>
</tbody>
</table>

* RMH = Relative Mean Heading
1. Bathymetric data were corrected for tide using the Oregon State Tidal model.

2. The reference surface was gridded at 5 m (figure 1).

3. Grid cells with <10 soundings in a node were removed from the reference surface (figure 2).

4. Grid cells with slopes >5° were removed from the reference surface (figure 3).

5. The remaining grid cells with ≥10 soundings and slopes ≤5° were used for analysis of the NA105 deep accuracy crossline data (figure 4).

6. Crosslines were very lightly processed to remove extreme outliers, “flyers”, from being included in the analysis.

7. The mean depth bias and depth bias standard deviations as a percentage of water depth were then computed in 1° angular bins across the swath for each configuration.
EM302 Accuracy Testing

Shallow Accuracy: Results

- The EM302 provides fairly unbiased soundings over the majority of the swath in all of the different modes tested over the shallow reference surface.
- A noticeable non-linear refraction bias (smile) is present in the outer portions of the swath for each mode tested.
- Within +/−10° the data shows ‘Erik’s Horns’, a nadir-ring bottom tracking artifact. Which has been seen before when mapping in shallow water.
- The observed trends in standard deviations (right-top plots of the crossline results) are still within the expected performance tolerances of the system in this water depth, and are almost identical to that observed during previous QATs.
- The standard deviations about the mean bias are typically within +/−0.2% to +/−0.3% water depth (1−σ) across the majority of the swath with higher uncertainties at the limits of the swath, as expected and typical for these systems.
- As has been noted before, running the system with dual swath off yields data with higher accuracy when compared to the two passes with dual swath enabled.
- The 2018 accuracy assessment shows depth standard deviation trends across the swath in shallow depths that are as good as previous evaluations.

Example of swath accuracy as a percentage of water depth (left) and depth (right) with NOAA thresholds

Results for each setting are presented in the following slides
EM302 Accuracy Testing

Shallow Setting 2 - SINGLE/SHALLOW/CW/RMH

Red: Mean Depth Bias   Blue: Depth Std. Dev.

Order 2
Order 1
Special Order
EM302 Accuracy Testing

Shallow Setting 3 - DUAL/SHALLOW/CW/NO YAW

Red: Mean Depth Bias   Blue: Depth Std. Dev.
Overview

- During all NA105 transits the EM302 was left run in automatic ping mode with swath angle limits set to ±75°. This allows the EM302 to automatically select its preferred depth mode and attempt to maximize swath coverage.

- Distance from nadir was then calculated for the outermost port and starboard soundings for each ping and then plotted against depth to evaluate trends in the achieved swath width versus depth.

- Soundings that appeared to be outliers, relative to the surrounding bathymetry, were removed from analysis; likewise, soundings that had abnormally high or low backscatter strengths (characteristic of slopes facing toward or away from the EM302) were also ignored during analysis.

- The results provide a baseline swath coverage curve in depths of approximately 80-3750 m; this curve is useful for survey planning and comparison to future swath coverage data.

* NOTE: The lines used to calculate swath coverage were run at 12 kts, rather than the speed of 6-8 kts, used during most QATs. The lines were not always run orthogonal to seafloor structure as normally preferred.
EM302 Swath Coverage

Results

• The plot to the left shows the swath coverage (extinction) in rainbow colors for the EM302 over the range of 80m to 3750 meters water depth.

• The underlying grey points document the historic swath performance of the system from data collected during the 2013 SAT, data from the 2014, 2015, 2016, and 2018 QATs, as well as data from collected during leg NA099.

• While the system is performing better than 2017 QAT, it does not appear to be doing quite as well as it had been historically (grey dots in figure), especially when comparing it to the NA089 transit, which was collected following the cleaning of the array face.

• However, this might be due to the lack of data in the deeper ranges of the plot and from surveying over different bottom types. If any further data is which is suitable for extinction analysis, please submit it to Paul Johnson for further analysis.
EM302 Swath Coverage

Full depth range (0-3750 meters) swath coverage plot for NA105

Results

Shallow depth range (0-500 meters) swath coverage plot for NA105.
The above two plots document the swath width over the same depth range. The plot on the left shows the 2019 data collected during NA105 and the plot on the right shows the NA093 data collected in 2018. 2017 QAT testing had revealed a decrease in swath width due to marine growth. The 2018 testing showed that with proper cleaning of the hull, the swath width as a function of depth had nearly rebounded to historically measured levels. Data from 2019 shows the system doing as well or better than 2018. It should be noted that there is a decrease in swath width at depths around 1500 meters, but at depths deeper than that and down to ~2500 meters the system is doing as well as it has since 2013. The sample size at depths greater than ~2500 meters is small and was collected over a soft sediment bottom.
The NA105 trials area did not include depths beyond ~3750 meters and for the most part was in depths shallower ~2000 meters. Because of this the QAT was not able to provide a full extinction plot for the EM302. With the help of Gee, a number of historic cruises were evaluated as a potential source for more fully defining the performance of the system. The plot to the left and on the next two slides are from the NA099 cruise which covered depths between 100 meters and almost 6000 meters.
EM302 Swath Coverage

Swath Width vs Depth – Water Depth

Swath Width vs Depth - Angles

Historic Coverages – NA099
Overview

• A full Built-In Self-Test (BIST) diagnostic routine was run prior to departure as well as a few times while underway to test the system in different operational environments.

• BISTs provide the ability to perform impedance measurements of the transmitter and receiver arrays and receiver.

• These types of test results may be used as proxies for the health of array transducer elements and receivers.

• Routine RX and TX Channel BISTs may aid early detection of element degradation. This is an important condition to monitor, as these arrays have been known to degrade with time.

• It is important to note that the BIST impedance measurements do not provide a full characterization of transducer properties as a function of frequency.
EM302 Transducer Health

Impedance – Receiver

- EM302 receiver impedance levels collected by BIST tests from 2013 to 2019.
- This plot includes all BISTs which have been collected and stored on the EM302 acquisition machine, regardless of the reason they were collected.
- Most recent test, conducted on 2019-05-03, is shown as a thick black line.
- Y-Range for impedance is based on the acceptable range defined to pass a BIST test as defined by Kongsberg.
- Current receiver impedance values show relatively uniform levels across all channels and confirm no open or short-circuit conditions at the start of the system’s service life.
- There has been very little change in amplitude or variation in pattern over the 6 year testing period.
EM302 Transducer Health

Impedance – Receiver Transducer

- EM302 receiver transducer impedance levels collected by BIST tests from 2013 to 2019.
- This plot includes all BISTs which have been collected and stored on the EM302 acquisition machine, regardless of the reason they were collected.
- Most recent test, conducted on 2019-05-03, is shown as a thick black line.
- Y-Range for impedance is based on the acceptable range defined to pass a BIST test as defined by Kongsberg.
- Current receiver transducer impedance values show relatively uniform levels across all channels and confirm no open or short-circuit conditions at the start of the system’s service life.
- There has been very little change in amplitude or variation in pattern over the 6 year testing period.
EM302 Transducer Health

Impedance - TX Channels

- 2019 TX impedance (figure to left) looks remarkably like that observed during 2018 (see figure below).
- All but one transmitter array element impedance value fell within the expected normal ranges.
- Channel 15 in TX slot 12 still reports a high impedance value. However, this single element was noted starting in 2014 as exceeding the expected range, and no change has been observed since.
Overview

- A potentially major limitation of multibeam performance can stem from elevated noise levels due to hull design, engine and other machinery, sea state, biofouling, electrical interference, etc.

- The NA105 QAT included a series of tests to identify contributions to the noise environment perceived by the EM302 receiver array due to vessel speed, and vessel heading relative to the prevailing swell.

- These tests were run using a script which imitated and recorded 10 individual RXnoise Built-In Self-Tests (BIST) under different speeds and different headings relative to the swell direction in order to characterize the vessel’s platform noise.

- Initial RX noise speed testing was conducted in the Catalina Basin, but the noise floor observed were higher than expected.

- A second round of noise testing was conducted at an offshore site, close to where a deep ROV dive, where results were much better.
Environmental Conditions

- **Catalina Basin**
  - Wind Speed: 15 kts
  - Wind Direction (from): 15 degrees
  - Swell Height: 0.5 – 1 meter
  - Swell Direction (from): 315 degrees

- **Off Shore Test Site**
  - Wind Speed: 12 kts
  - Wind Direction (from): 270 degrees
  - Swell Height: 1 meter
  - Swell Direction (from): 315 degrees

- **Off Shore Test Site – Jet Puump**
  - Wind speed: 9kts
  - Wind Direction (from): 283 degrees
  - Swell Height: 2 meters
  - Swell Direction: 325 degrees
EM302 Noise Level Assessment

E/V Nautilus EM302 Self Noise vs Speed - IS

Main Engine Speed Tests – Into Seas
EM302 Noise Level Assessment

Main Engine Speed Tests – With Seas
EM302 Noise Level Assessment

Jet Pump 3 kts – Into Seas
EM302 Noise Level Assessment

No Propulsion
EM302 Noise Level Assessment  

Speed Tests - Results

- RXnoise level assessment using the main engine were only conducted at 8, 10, and 12 knots to reduce stress on the ship’s engine. However, the 10 – 12 knots is the typical survey speed for the E/V Nautilus while underway.

- 2018 noise level testing had shown significant noise level improvements as measured through the RXnoise Built-In Selft Test (~48 dB) from the elevated noise levels (~50-54 dB) observed during the 2017 quality assurance testing. This was revealed to have been from bio-fouled array faces.

- 2019 noise levels (~40 dB - ~44 db) are very close to those during the 2013 SAT (~40 dB) shown in the figure to the bottom right.
EM302 Noise Level Assessment

E/V Nautilus EM302 Self Noise vs Azimuth - Octagon

Self Noise (dB re 1μPa/√Hz)

Test #

RX Module

Azimuth (deg)

Test #
• Environmental Conditions:
  • Swell: 1 meters
  • Winds: 12 kts
  • Wind Direction: 270 degrees
  • Ship Speed: 12 knots

• Heading has been adjusted so that 0 degrees is into seas.

• The plot to the left shows that travel with the seas (waves on the stern) and waves impacting on the port stern quarter caused the greatest increase in noise (~57 db). Seas on the stern and port quarter are significantly quieter (~48 dB = ~50 dB).

• This is result is the inverse of that observed during the previous year. However, this test was run at a significantly faster speed (12 kts vs 8 kts), and also in a different sea state (1 meter vs 2 meter).
• As in prior years, a goal of the QAT was to assess the quality of the sound velocity profiles derived from:
  - Sippican MK21 XBT
  - Seabird SBE49 FastCAT CTD mounted on ROV Hercules – calibrated over offseason

• Normally we would have also included the Teledyne Oceanscience Underway CTD in this comparison. However, this year the unit was sent in for calibration of 2019 and was not finished and returned by the date of departure, April 29, for the QAT.

• This year we were able to take the XBT spatially close to the location of the ROV dive, and within a half an hour of completion of the dive, unlike the longer delay we experienced in 2018

• The figure to the left shows the results of the profile from Hercules and the XBT data.

• The profiles derived from the XBT and Hercules CTD data are consistent in shape but divert some in the mid-range. This is likely be from uncertainty in the drop rate of the XBT which is used to calculate the depth.

• We will look at completing the full comparison between the XBT and Underway CTD during the NA107 California mapping (please submit data to Johnson when a full comparison dataset has been collected).
Like 2017 and 2018 QATs, during NA105 we once again tested the seep detection capabilities of the E/V Nautilus’ EM 302 on a known seep in Santa Monica basin.

The test was conducted where the local seafloor depth of the seep was ~900m deep (see contours on plot to left). Over the seep, a series passes were run South to North and then North to South; initially directly over the seep, and then followed by lines 450 meters out, 900 meters out, and then 1350 meters out (see line layout in the figure to the left).

A line was also run East to West over the seep.

The EM302 was restricted to +/- 70 deg. swath width and all the lines were run in the Deep mode. The seep was detected on each pass and there did not appear to be any detection differences on the either the starboard or port sides of the swath. Figures on the next two pages show the water column data for the seep detection as well as the range from the seep.
Water Column

Directly Across Seep

Seep Detection Assessment

Line Offset By 450 meters
• Nautilus uses FM Midwater for routine processing and locating seeps. However, the geo-picked location of the seeps using that software are not correctly ray traced, and Qimera is used for ROV dive planning to provide a ray traced position with reduced uncertainty.

• The seep position is geo-picked in the Qimera water column display where it is estimated the seep is exiting the seafloor, and varies depending on the angle and distance of the seep for the ship.

• The location of the seep was geo-picked from every line and the result shown in the figure to the left. The distance from the ship is shown by the size of the bubble and labeled.

• This is a subjective assessment but shows less uncertainty in the distance away from the ship, smaller easting range, compared to the northing range that depends on the bearing of the seep.

• Nautilus will continue to geolocate seeps and water column targets for ROV dives using the Qimera processing path.
In 2013 during the Nautilus’s EM302 shipboard acceptance tests (SAT) a significant amount of time was spent collecting and analyzing data to generate a *bscorr* file that would correctly balance inter-sector backscatter differences, as well as inter-mode imbalances.

Following the 2018 NA093 QAT there was discussion on conducting an assessment during the 2019 QAT.

A qualitative look (visual examination) of historic data collected by the EM302 in 2017 showed that QPS’s FMGT was not fully able to correct for transitions from backscatter data collected in the medium mode to the deep mode (or vice versa). This can be seen in the imagery shown in the red boxes in the figure to the left.
A series of lines were run (close to the seep detection site) which transited through the medium to deep conversion point.

Seafloor in the area was benign with low slopes and very few features.

Inter-mode (medium to deep) imbalances in the backscatter were detected in both the waterfall (right figure) and in the final mosaic (left figure).

Detectable inter-sector imbalances were also seen in the waterfall data and in the mosaic at different times.

The water mass used for the 2019 assessment was very different than the Mediterranean Sea used in 2013.

It would well worth the time to monitor if array response changes as all during future QATs.
Appendix 1 – Speed Noise Tests - Offshore
Appendix 1 – Speed Noise Tests

Into Seas – Offshore
Appendix 1 – Speed Noise Tests

Into Seas – Offshore
Appendix 1 – Speed Noise Tests

Into Seas – Offshore
Appendix 1 – Speed Noise Tests

With Seas – Offshore
Appendix 1 – Speed Noise Tests

With Seas – Offshore
Appendix 1 – Speed Noise Tests

With Seas – Offshore
Appendix 1 – Speed Noise Tests

Into Seas – Catalina Basin
Appendix 1 – Speed Noise Tests

Into Seas – Catalina Basin
Appendix 1 – Speed Noise Tests

Into Seas – Catalina Basin
Appendix 1 – Speed Noise Tests

With Seas – Catalina Basin
Appendix 1 – Speed Noise Tests

With Seas – Catalina Basin
Appendix 3: SIS Configuration
Appendix 3: SIS Configuration

Installation Parameters
Appendix 3: SIS Configuration

Installation Parameters
Appendix 3: SIS Configuration

Installation Parameters
Appendix 3: SIS Configuration

Installation Parameters
Appendix 3: SIS Configuration

Installation Parameters
Appendix 3: SIS Configuration

Installation Parameters

- PU Communication Setup
- Sensor Setup
- System Parameters
- EIST
- System Report

Installation Parameters window with various setting options and test results.
Appendix 3: SIS Configuration

Installation Parameters
Appendix 3: SIS Configuration

Runtime Parameters
Appendix 3: SIS Configuration

Runtime Parameters

NA105 was run using Profile as the Surface Sound Speed Sensor was non-functional.

Sensor is the normal setting.
Appendix 3: SIS Configuration

Runtime Parameters

- Filtering:
  - Spike Filter Strength: MEDIUM
  - Range Gate: NORMAL
  - Phase ramp: NORMAL
  - Penetration Filter Strength: OFF

- Absorption Coefficient:
  - Source: CTD profile
  - Salinity (parts per thousand): 35

- Water Column:
  - 30 kg R
  - 30 dB Offset

- Mammal protection:
  - TX power level (dB): Max.
  - Soft startup ramp time (min.): 30

- Real Time Data Cleaning:
  - None
  - High
  - Rule set: AUTOMATIC

- Backscatter Adjustment:
  - Normal incidence cor. (deg.):
  - Beam Intensity:
    - Use Lambert's law
Appendix 3: SIS Configuration

External Sensors
Appendix 3: SIS Configuration

PU Sensor Status
Appendix 3: SIS Configuration

Parameters
Appendix 3: SIS Configuration

Parameters
Appendix 3: SIS Configuration

Parameters
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Parameters

Setup for start of echo sounders and SIS

Projections
Appendix 4: Seapath Configuration
Appendix 4: Seapath Configuration
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### Interface Configuration Details

<table>
<thead>
<tr>
<th>Interface</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TelgearsOut1</td>
<td>Ethernet</td>
<td>Binary Data 23 Ref. MPT to ROV/Nay.</td>
</tr>
<tr>
<td>TelgearsOut15</td>
<td>Ethernet</td>
<td>Binary Data 23 Ref. MPT to ROV/Nay.</td>
</tr>
</tbody>
</table>

### I/O Properties

- **Random I/O**
  - Broadcast
  - Unicast
  - Multicast

### Telegram Out Properties

- **Format**
  - Telgears binary 23
- **Destination**
  - W0884
- **Monitoring Point**
  - MPT

### Telegram Timing

- **Interval (s)**: 0.200
- **Event Driven**
- **Timer Driven**
Appendix 4: Seapath Configuration
Appendix 4: Seapath Configuration
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### Interface Settings

<table>
<thead>
<tr>
<th>Interface</th>
<th>IP address</th>
<th>Subnet mask</th>
<th>Default gateway</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.1.10</td>
<td>192.168.2.10</td>
<td>255.255.255.0</td>
<td>0.0.0.0</td>
</tr>
</tbody>
</table>

### Additional Configuration Options

- **Server Configuration**
- **Network Setup**
- **Communication Interface**
- **Input/Output**
- **Telemetric Information**
- **Data Pool**
- **Network**
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![Operator software configuration interface]

**Motion Data**

- Compass
- Sky View

**Appearance**
- Display correction satellites
- Signal strength
- Shadow sectors
- Image mask
- Display elevation mask value

**Shadow Sectors**
- Azimuth:
- Elevation:

Right-click in the Sky View to add/remove sectors.
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Overview
In 2018 we had weird usbl cal results, and then dug in and found some reference frame discrepancies.

The seapath is sending motion data to the tracklink that is based off MP1. MP1 is 5 meters forward of the usbl transceiver - at the subbottom transducer. We suggested changing this by creating an MP2 that is based at the transceiver and sending motion data from that point to the tracklink. Further, we suggest sending data from the Nav Reference Point (NRP) [the location of the MRU] out as our canonical ship position. In 2018 ship position was recorded from the subbottom transducer (MP1).

The following is a testing/implementation plan that lays out all steps and when they are or are not appropriate to undertake. It had breakpoints for actions that should be done in port etc.

Testing/Implementation Path

1. Change Seapath LAN 4 to 10.1.70.100
   a) Restart required. Do this later, further down in this doc.

2. Wire spare cat6 cable (labeled: Sonar Room A) in sonar room to back of seapath (LAN 4) in some way that won’t get ripped out. Connect Sonar Room A port in Rack Room patch panel to cross racks patch panel, port 13. Connect port 13 to instrument switch.

3. Create LAN 4 Seapath Binary data format #23 output of MP1, broadcasting (for now, just to test) to instrument network on port 14110 from Telegram 13 (Settings: Broadcast LAN 4, Seapath Binary #23, 0.200 second timer driven interval)

4. Create test iteration of capSeapath yaml config file with new port number (but same data from MP1)

5. Test that capSeapath is not doing anything funny and works with new source of data.
   a) Compared output of current (serial line spsol) data to new (lan4 broadcast) data, very slight time differences led to very small position differences (e.g. 0.1319 second difference means 0.0000016 degree latitude difference, which is equal to ~0.018 meter difference)

6. Create new moxa port (#7) that will receive MRU data from seapath (moxa config same as existing MRU (TSS) moxa port #2 configuration).

7. Restart Moxa for changes to take effect.

8. Close tracklink. Create new COM port on USBLNAV with NPort manager (COM 7)

9. Restart Tracklink and make sure existing COM port 3 (which gets TSS from rack room .86 moxa port #2) still works.

10. Create MP2 located at the tracklink USBL transceiver head. We won’t use the data from this for quite a few steps though.
Testing/Implementation Path Continued

11. Create LAN 4 GGA message on telegram 10 of NRP, UDP broadcast (importantly to to NavCook and dsLog) on port 14100. (Port Numbers also documented in Nautilus Network Port Assignment Procedure) Turn off for now.

12. Create LAN 4 GGA message on telegram 11 of MP1, UDP broadcast (importantly to to NavCook and dsLog) on port 14101. Turn off for now. (This is redundant to Seapath COM 13 to GGA the Moxa, but makes a more homogenous system, even if left off)

13. Create LAN 4 GGA message on telegram 12 of MP2, UDP broadcast (importantly to to NavCook and dsLog) on port 14102. Turn off for now.

14. Switch from `seapath serial->moxa->rovnav` spsol ini, to `seapath lan4-> .70 broadcast` spsol ini and restart spsol

15. Verify logging was not affected by switching to new seapath ini file. (i.e. still logging data, and data is not weird)

16. On Seapath: Stop telegram 6 output of binary seapath data on seapath COM 14. Create telegram 14 output of MRU (TSS) data from MP2 to tracklink through Seapath COM 14 (via the rack room moxa, using the same cable that previously gave binary data to now deliver a secondary TSS data fee) (mimic settings from telegram 4, which is the MP1 MRU data).

17. Reopen tracklink. Change config so VRU (MRU/TSS) data is now coming from port 7. Run Test -> VRU. (Now USBLNAV has MP1 VRU data on COM port 3, and MP2 VRU data on COM port 7)

18. Pause. Test with a dive!

19. When logging is already stopped: Restart seapath PU. Verify network change of LAN 4 took effect.
   a) Change did not take effect. Bugger.

20. Turn off telegram output 13 (Seapath binary #23 over LAN 4) & telegram output 14 (TSS from MP2 over seapath COM 14 to Rack Room Moxa port 7). Turn on telegram 6 (seapath binary #23 over seapath COM 14 to rack room Moxa port 4)

Testing/Implementation Path Continued

21. Swap cable from rack room moxa port 7 to port 4.

22. Change SPSOL config to use old port number & restart capSeapath.


24. Changed eth2 (LAN 4) to 10.1.70.100/255.255.0 using kongsberg’s instructions.

25. Rebooted Seapath PU and it came back with new/correct network address for LAN 4!

26. WAIT. DO NOT PROCEED DURING A CRUISE (Progressed up to here at end of 2018 season)

27. Create seapath outputs of the NMEA (GGA HDT ZDA VTG) strings and the SPSOL (Binary 23) data from NRP, MP1, MP2.

28. Surprise! NavCook doesn’t like the way Seapath sends LAN/UDP messages (All 4 at once in one long line, vs one NMEA string at a time via serial) So rather than edit NavCook code last minute, I created another serial line from Seapath COM1 to Moxa .86 (Rack Room) port 7 that is used for TSS MP2 data (and used the old Seapath binary com14 to now send GGA MP2 data). I used the blue wire from the bulk serial line coming from the Sonar Room to the back of Rack 3 in the rack room for TSS data.

29. Create iteration of NavCook yaml config file with new port number of NMEA/GGA MP2 data (14008), and offsets of MP2 to NRP, instead of current offsets of MP1 to tracklink transceiver head.

30. Test that NavCook is not doing anything funny and works with new source of data and the new MP2 yaml config (do not save data in real data tree, these are NRP sourced positions)
Appendix 4: Seapath Configuration

Testing/Implementation Path Continued

31. Stop capSeapath (not totally necessary as no config changes on capSeapath’s end, but data file has a clear gap in time in logging then)

32. Load capSeapath ini file that accepts data from MP2

33. Do we want to record MP2 or NRP?
34. Then deal with cascading changes below

35. Hypack drawing based off MP2 now. So make ship 5.131m longer in front and shorter in back. (MP2 is 0.087m higher than MP1 and 0.346m to port, which shouldn’t matter for drawings or measurements)

36. NavEst drawing and sensor offsets based off MP2 now as well

37. Changes to calEst?
   a) No. It just runs off point sources

38. Update offset documents (include list here of said docs)
   a) /mnt/nautilusfs/share/repos/data-docs/navOffsets-[DATE].pdf

39. Update data user guide verbiage

Current Setup
As of 2019-05-10 JKL

<table>
<thead>
<tr>
<th>Tgram</th>
<th>Output</th>
<th>Destination</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Com11 RS422</td>
<td>Moxa .86, Port 2</td>
<td>TSS of MP1 to Knudsen</td>
</tr>
<tr>
<td>5</td>
<td>Com13 RS422</td>
<td>Moxa .86, Port 1</td>
<td>GGA, HDT, ZDA, VTG of MP1 to Knudsen</td>
</tr>
<tr>
<td>6</td>
<td>Com14 RS422</td>
<td>Moxa .86, Port 8</td>
<td>GGA, HDT, ZDA, VTG of MP2 to Tracklink &amp; NavCook</td>
</tr>
<tr>
<td>13</td>
<td>Com1 RS232</td>
<td>Moxa .86, Port 7</td>
<td>TSS of MP2 to Tracklink</td>
</tr>
<tr>
<td>10</td>
<td>Lan 4 (.70)</td>
<td>Broadcast</td>
<td>GGA, HDT, ZDA, VTG of NRP to .70 network</td>
</tr>
<tr>
<td>11</td>
<td>Lan 4 (.70)</td>
<td>Broadcast</td>
<td>GGA, HDT, ZDA, VTG of MP1 to .70 network</td>
</tr>
<tr>
<td>12</td>
<td>Lan 4 (.70)</td>
<td>Broadcast</td>
<td>GGA, HDT, ZDA, VTG of MP2 to .70 network</td>
</tr>
<tr>
<td>14</td>
<td>Lan 4 (.70)</td>
<td>ROVNav</td>
<td>SPSOL (Binary 23) of NRP</td>
</tr>
<tr>
<td>15</td>
<td>Lan 4 (.70)</td>
<td>ROVNav</td>
<td>SPSOL (Binary 23) of MP1</td>
</tr>
<tr>
<td>16</td>
<td>Lan 4 (.70)</td>
<td>ROVNav</td>
<td>SPSOL (Binary 23) of MP2</td>
</tr>
</tbody>
</table>
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Transcription of 1st Round of Notes

Current
1. COM 11 RS422 -> Moxa port 18, TSS of MP1 goes to Knudsen & Tracklink
2. COM 13 RS422 -> Moxa GGA, HDT, etc of MP1 goes to Knudsen (SubBottom Computer), NavCook (ROVNav), dsLog (capture) & dsLog reflector (shiphouse)
3. COM 14 RS422 -> Moxa binary seapath data to capSeapath

Future
1. COM 11 RS422 -> Moxa port 18, TSS of MP1 goes to Knudsen
2. COM 13 RS422 -> Moxa GGA, HDT, etc of MP1 goes to Knudsen
3. COM 14 RS422 -> Moxa TSS of MP2 to Tracklink
4. Lan 4 -> Moxa Port XX1, GGA, etc of NRP to NavCook (.NAV) & dsLog (.INNAV)
5. Lan 4 -> Moxa Port XX2, binary seapath data of NRP to capSeapath (.SPSOL)

Offset Changes Required
(LAN 4 would go on 10.1.70.x network)
1. Seapath
2. NavCook
3. Calest?
4. Hypack Drawing
5. NavEst drawing and sensor offset
6. Offsets doc x2
7. Data docs text
Appendix 5 – Sound Speed Manager Configuration
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