Ocean Exploration
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MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

CRUISE EX-17-06: Laulima O Ka Moana

Exploring Deep Monument Waters Around Johnston Atoll (ROV/Mapping)

July 7 to August 02, 2017

Honolulu, HI – Honolulu, HI

Cruise in support of Campaign to Address Pacific monument Science, Technology, and Ocean NEeds (CAPSTONE)

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1. Introduction

NOAA's Office of Ocean Exploration and Research (OER) is the only federal organization dedicated to exploring our unknown ocean. OER works with partners to identify priority areas for exploration; support innovations in exploration tools and capabilities; and encourages the next generation of ocean explorers, scientists, and engineers. The publicly available data and information gained from our expeditions and the research we fund gives resource managers, the academic community, and the private sector the information they need to identify, understand, and manage ocean resources for this and future generations of Americans.

NOAA Ship Okeanos Explorer is the only federal vessel dedicated to exploring our largely unknown ocean for the purpose of discovery and the advancement of knowledge about the deep ocean. America's future depends on understanding the ocean. We explore the ocean to make valuable scientific, economic, and cultural discoveries, and we explore because ocean health and resilience are vital to our economy and to our lives. Exploration supports NOAA mission priorities and national objectives by providing high-quality scientific information about the deep ocean to anyone who needs it.

In close collaboration with government agencies, academic institutions, and other partners, OER conducts deep-ocean exploration expeditions using advanced technologies on the Okeanos Explorer. From mapping and characterizing previously unseen seafloor to collecting and disseminating information about ocean depths, this work helps to establish a foundation of information and fill data gaps. Data collected on the ship follow federal open-access data standards and are publicly available shortly after an expedition ends. This ensures the delivery of reliable scientific data needed to identify, understand, and manage key elements of the ocean environment.

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2. Report Purpose

The purpose of this report is to briefly describe the mapping data collection and processing methods, and to report the results of the mapping portion of the cruise. For a detailed description of *Okeanos Explorer* mapping capabilities, see the section 'Kongsberg EM 302 Multibeam Sonar Description and Operational Specifications' and the ship's readiness report, which can be obtained by contacting the *Okeanos Explorer* Mapping Tea (oar.oer.exmappingteam@noaa.gov).

This report focuses on the mapping exploration of EX1706. The cruise was a combined ROV exploration and mapping of the area in vicinity of Johnston Atoll. The first few days of the expedition were focused on shaking down the ship and mission equipment after an extended repair period and dry dock just before this expedition. Though the ship carried out telepresence enabled ROV dives during the expedition with participation from scientists onshore, this report only provides details of mapping related activities during the expedition. The ROV mapping report corresponding to EX1706 can be found in the NOAA Library archives.

3. Cruise Objectives

The cruise objectives were identified in EX1706 Project Instructions (found at the NOAA Library archives). EX1706 operations included collecting baseline-characterization data of poorly known areas over a wide area of the US EEZ within Johnston Atoll Marine National Monument (MNM). All objectives were successfully met during this expedition. The mapping specific objectives included the following:

1. Objectives in support of the EX1706 shake down:

    a. Conduct GAMS calibration;
    b. Conduct multibeam patch test;
    c. Conduct 38 kHz and 300 kHz ADCP calibration during transit out of harbor;
    d. Conduct calibration of 38 kHz ADCP in deep water;
    e. Assess Reson SVP probe following cable repairs; if possible, compare the SVP probe with the shipboard CTD cast;
    f. Assess XBT hand launcher and confirm cabling not impacted by dry dock activities; and
    g. Test new, secondary sound velocity profiling computer (pending installation status).

2. EX1706 Expedition objectives related to the Johnston Atoll mapping included:

    a. Collect high resolution mapping data from all sonars in priority areas as dictated by operational needs as well as science and management community needs;
    b. Support planning of ROV operations with mapping products and visualization;
    c. Conduct mapping operations during transit(s), with possible further development of exploration targets;

d. Collect XBT casts as data quality requires during mapping operations;
e. Create daily standard mapping products;
f. Collect sun photometer measurements as part of an ongoing Exploration Project of Opportunity (EPO) with NASA;
g. Continue to test the integration of the new EK60 frequencies and the ADCPs;
h. Continue to train new Survey Technician on mapping operations and Standard Operating Procedures;
i. Continue to integrate Qimera into standard multibeam bathymetric data processing routines;
j. As necessary, conduct contingency mapping on days where ROVs dives are not possible due to weather or other delays.

During EX1706, ROV operations were conducted during the day light hours. Mapping operations were conducted at night, anytime ROV operations were suspended and while transiting between ROV dive locations. The dive target sites were primarily over previously mapped seafloor carried out during *Okeanos Explorer* cruises EX1504 and *Falkor* 2016 cruises. Transit mapping between dive sites focused on filling in any holidays in the existing datasets and edge matching to the existing coverage. Multibeam, single beam, and sub-bottom profile data were generally collected for 12 hours during overnight transits between dive target sites. Expendable bathythermograph (XBT) casts were conducted at an interval defined by prevailing oceanographic conditions, generally every four to six hours. All multibeam sonar bathymetric data were fully processed according to established onboard procedures using QPS Qimera (Ver 1.5.X). Multibeam sonar seafloor backscatter and water column backscatter, Knudsen sub-bottom profiler and EK 60 data were sporadically processed to support ROV operations but no systematic effort was made to process all the seafloor and water column backscatter due to lack of mapping staff during this cruise (Table 1). All multibeam data along with ancillary sonar datasets will be archived at National Centers for Environmental Information (NCEI) formerly known as National Oceanographic Data Center or the National Geophysical Data Center.

Table 1. Following personnel participated in the cruise in support of mapping operations.

NAME	ROLE	AFFILIATION
CDR Eric Johnson	Commanding Officer	NOAA Corps
LT Aaron Colohon	Field Operations Officer	NOAA Corps
Kelley Elliott	Expedition Coordinator	NOAA OER
Dr. Chris Kelley	Science Team Lead	University of Hawaii
Mashkoor Malik	Mapping Team Lead	NOAA OER
Charles Wilkins	Senior Survey Technician	NOAA
Kevin Jerram	Watch Lead	UCAR
Neah Beachler	Watch Lead	UCAR
Nikola Rodriguez	Explorer in Training	NOAA (Education Partnership Program)

4. Summary of Mapping Results

In this section various mapping results related to the shake down portion of the cruise as well as mapping operations conducted in Johnston Atoll area are highlighted.

GAMS Calibration

The first at-sea shakedown activity of EX1706 was a POS MV GAMS calibration conducted between 0611-0819 on 08 July 2017 (UTC). This calibration followed the GAMS SOP, except only two iterations were performed (instead of the recommended three) due to the duration of each iteration and need to commence multibeam calibration. The second GAMS result was applied in the POS MV configuration before the start of data collection for multibeam calibration.

Figure 1 shows the pre- and post-calibration GAMS solutions. Differences between the pre- and post-calibration GAMS solutions correspond to a horizontal rotation of the GNSS antenna lever arm (from the primary antenna to the secondary antenna) of approximately 0.25° [i.e., arctan(dX/dY)] in the clockwise direction looking down (positive compass convention). The X component shows the largest change in this lever arm, according to the GAMS result. It is not clear whether this 10 mm alongtrack difference resulted from slight physical alteration of the antenna location or other causes rooted in the uncertainty / repeatability of the GAMS. At the very least, it confirms that no major modification was made unintentionally to the antenna position during dry dock. Because the POS MV utilizes antenna phase measurements to augment the motion sensor heading data, this GAMS result may be partially reflected in the multibeam heading calibration result of 0.1°.

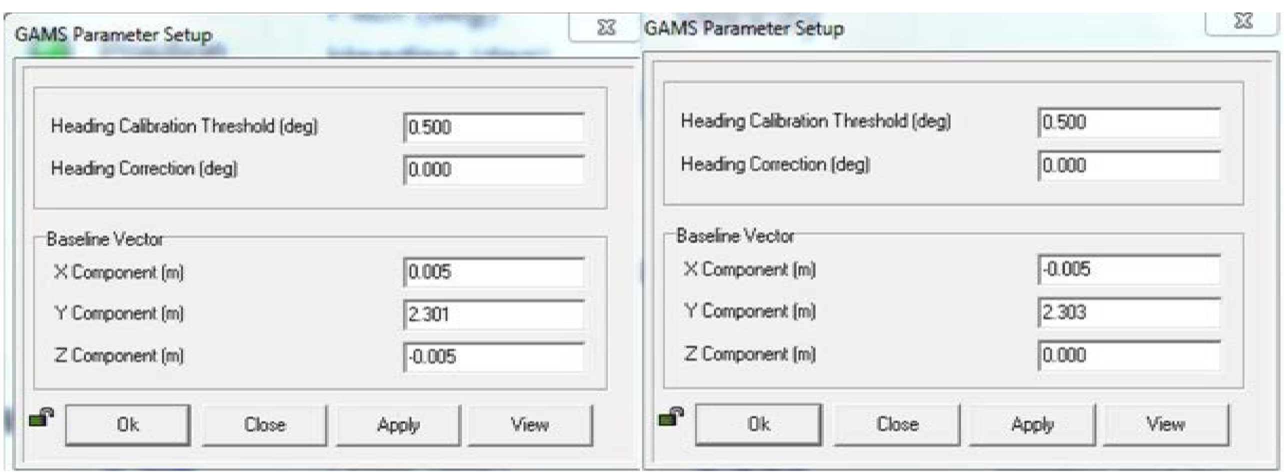
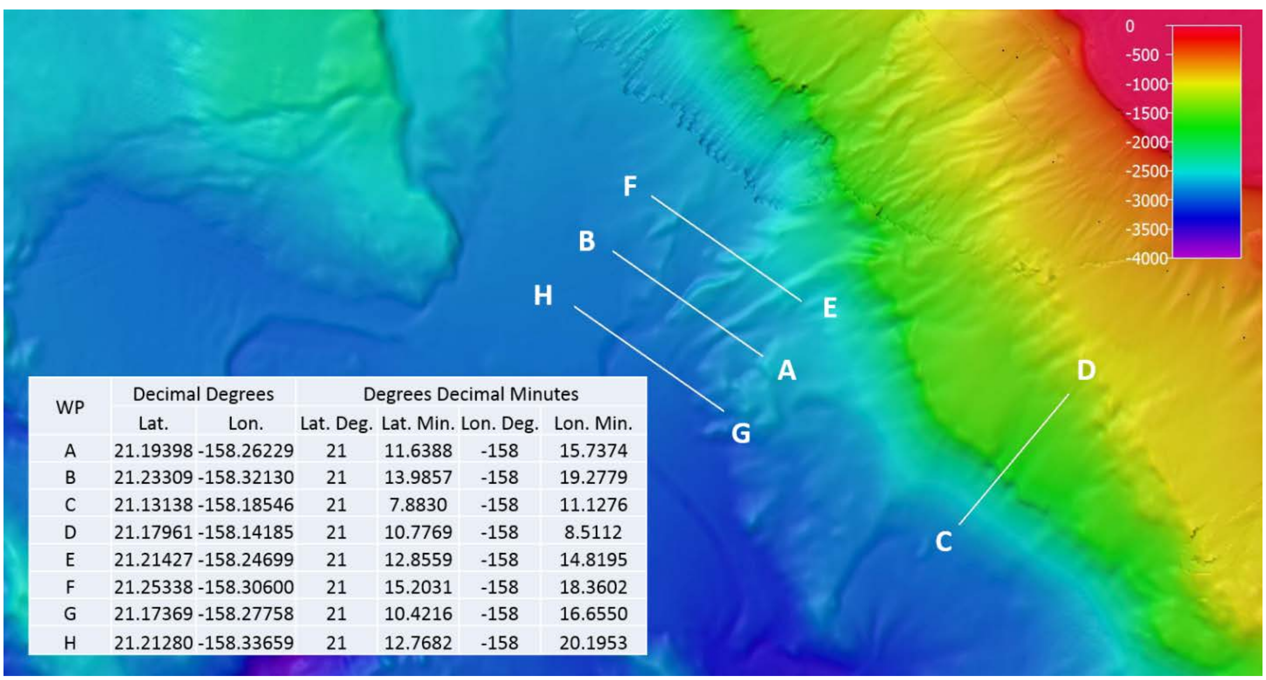


Figure 1. Pre-calibration (05 July 2017, left) and post-calibration (08 July 2017, right) GAMS parameters. The GAMS solution calculated at the start of EX1706 was applied immediately before data collection for multibeam calibration.

Multibeam sonar (EM 302) Patch Test

After the GAMS calibration, a geometric calibration ("patch test") of the multibeam system was conducted between 0906-1444 on 08 July 2017 (UTC) in the vicinity of seafloor features used for previous calibrations (Figure 2). Patch tests reveal biases in the bathymetry data resulting from small residual misalignments among the arrays and motion sensor (assuming all linear offsets are properly surveyed and configured). The TX and RX array angles are estimated very accurately during dry dock installation, shimming, and vessel survey; furthermore, they are not separately identifiable from bathymetry data. Thus, the patch test results are attributed exclusively to the motion sensor alignment. The patch test includes several reciprocal and parallel survey lines that can be scrutinized to effectively isolate each of the three alignment biases of interest (pitch, roll, and heading), assuming they are small angles (typically less than a few tenths of a degree). Table 2 lists the EM302 calibration offsets for pitch, roll, and heading.

The planned pitch/heading lines were adjusted to run up/down slopes of 20-30°, based on multibeam compilation grids for the area (GMRT, marine-geo.org). The roll calibration line ('CD') was relocated and extended to include a wider and slightly shallower depth range to fully utilize the angular swath coverage and better exaggerate any roll bias. The alongtrack slope of the southern roll calibration area is also suitable for pitch calibration/verification.



WP	Decimal Degrees		Degrees Decimal Minutes			
	Lat.	Lon.	Lat. Deg.	Lat. Min.	Lon. Deg.	Lon. Min.
A	21.19398	-158.26229	21	11.6388	-158	15.7374
B	21.23309	-158.32130	21	13.9857	-158	19.2779
C	21.13138	-158.18546	21	7.8830	-158	11.1276
D	21.17961	-158.14185	21	10.7769	-158	8.5112
E	21.21427	-158.24699	21	12.8559	-158	14.8195
F	21.25338	-158.30600	21	15.2031	-158	18.3602
G	21.17369	-158.27758	21	10.4216	-158	16.6550
H	21.21280	-158.33659	21	12.7682	-158	20.1953

Figure 2. Overview map of calibration lines southwest of O'ahu. Map created in ArgGIS.

Table 2. EM302 calibration time estimates and runtime parameters (credit to Paul Johnson, UNH CCOM / Multibeam Advisory Committee, for creation of the original table that is modified here).

Line Acquistion Information

Test	XBT	Pitch Pass 1	Turn B to B	Pitch Pass 2	Transit A to C	XBT	Roll Pass 1	Turn D to D	Roll Pass 1	Transit C to E	XBT	Heading Line 1	Turn F to B	Transit B to A for LATENCY CHECK*	Turn E to A	Heading Line 2
XBT Prior to Line		Yes		No			Yes		If necessary			Yes				If necessary
SIS Line Name																
Start Point (see figure)		A		B			C		D			E				G
End Point (see figure)		B		A			D		C			F				H
Speed (kts)		8	8	8	10		8	8	8	10		8	8	4	8	8
Distance (nm)		4.0		4.0	5.5		3.8		3.8	6.0		4.0		4.0		4.0
Course Over Ground		305		125			40		220			305				305
Time (est. minutes)	15	30	15	30	33	15	29	15	29	36	15	30	15	60	15	30

Sonar Runtime Parameters

Sector Coverage		Pitch Pass 1	Turn	Pitch Pass 2	Transit		Roll Pass 1	Turn	Roll Pass 1	Transit		Heading Line 1	Turn	Transit	Turn	Heading Line 2
Max angle (port)		30		30			70		70			60				10
Max angle (sbtd)		30		30			70		70			10				60
Max Coverage (port)		5000		5000			5000		5000			5000				5000
Max Coverage (stbd)		5000		5000			5000		5000			5000				5000
Angular Coverage Mode		AUTO		AUTO			AUTO		AUTO			AUTO				AUTO
Beam Spacing		HD EQDST		HD EQDST			HD EQDST		HD EQDST			HD EQDST				HD EQDST

Depth Settings		Pitch Pass 1	Turn	Pitch Pass 2	Transit		Roll Pass 1	Turn	Roll Pass 1	Transit		Heading Line 1	Turn	Transit	Turn	Heading Line 2
Force Depth		n/a		n/a			n/a		n/a			n/a				n/a
Min depth (m)																
Max depth (m)																
Dual swath mode		DYNAMIC		DYNAMIC			DYNAMIC		DYNAMIC			DYNAMIC				DYNAMIC
Ping mode		AUTO		AUTO			AUTO		AUTO			AUTO				AUTO
FM disable		Unchecked		Unchecked			Unchecked		Unchecked			Unchecked				Unchecked

Transmit Control		Pitch Pass 1	Turn	Pitch Pass 2	Transit		Roll Pass 1	Turn	Roll Pass 1	Transit		Heading Line 1	Turn	Transit	Turn	Heading Line 2
Pitch stabilization		ENABLED		ENABLED			ENABLED		ENABLED			ENABLED				ENABLED
Along direction		0		0			0		0			0				0
Auto Tilt		OFF		OFF			OFF		OFF			OFF				OFF
Yaw stab. Mode		REL. MEAN HDG***		REL. MEAN HDG***			REL. MEAN HDG***		REL. MEAN HDG***			REL. MEAN HDG***				REL. MEAN HDG***
***NOTE: TURN OFF YAW STABILIZATION DURING TURNS, THEN TURN BACK ON TO REL. MEAN HDG. AFTER THE SHIP IS LINED UP FOR EACH SURVEY PASS.																
heading		n/a		n/a			n/a		n/a			n/a				n/a
heading filter		MEDIUM		MEDIUM			MEDIUM		MEDIUM			MEDIUM				MEDIUM
Min Swath Dist		0		0			0		0			0				0
Enable Scanning		Off		Off			Off		Off			Off				Off

Sound Speed		Pitch Pass 1	Turn	Pitch Pass 2	Transit		Roll Pass 1	Turn	Roll Pass 1	Transit		Heading Line 1	Turn	Transit	Turn	Heading Line 2
Source		SENSOR		SENSOR			SENSOR		SENSOR			SENSOR				SENSOR

Filters and Gains		Pitch Pass 1	Turn	Pitch Pass 2	Transit		Roll Pass 1	Turn	Roll Pass 1	Transit		Heading Line 1	Turn	Transit	Turn	Heading Line 2
Spike Filter Strength		MEDIUM		MEDIUM			MEDIUM		MEDIUM			MEDIUM				MEDIUM
Range Gate		NORMAL		NORMAL			NORMAL		NORMAL			NORMAL				NORMAL
Phase Ramp		NORMAL		NORMAL			NORMAL		NORMAL			NORMAL				NORMAL
Penetration Filter Strenths		WEAK		WEAK			WEAK		WEAK			WEAK				WEAK
Slope		Checked		Checked			Checked		Checked			Checked				Checked
Aeration		Unchecked		Unchecked			Unchecked		Unchecked			Unchecked				Unchecked
Sector Tracking		Unchecked		Unchecked			Unchecked		Unchecked			Unchecked				Unchecked
Intereference		Unchecked		Unchecked			Unchecked		Unchecked			Unchecked				Unchecked
Normal incidence corr. (deg)		6		6			6		6			6				6
Use Lambert's Law		Unchecked		Unchecked			Unchecked		Unchecked			Unchecked				Unchecked
Absorption Coefficent Source		CTD Profile		CTD Profile			CTD Profile		CTD Profile			CTD Profile				CTD Profile
Salinty (parts per thousand)		35		35			35		35			35				35
TX power level (dB)		Max		Max			Max		Max			Max				Max
Soft startup ramp time		0		0			0		0			0				0
Water Column log R		30		30			30		30			30				30
dB Offset		20		20			30		30			30				30
Special Mode Sonar		Unchecked		Unchecked			Unchecked		Unchecked			Unchecked				Unchecked

To reduce transit time, the traditional order of pitch-roll-heading was modified to pitch-heading-roll; this did not practically impact the data collection because the calibration results were not determined or applied between tests. All data were collected with the existing (post-EX1705, pre-EX1706) SIS configuration and the EX1706 GAMS solution.

XBT profiles were collected, processed, and applied in SIS at the start of the pitch / heading lines and after the roll lines (an XBT could not be collected before the start of the roll line because of limited watchstander availability on deck at night). The sound speed environment appears to have remained quite stable during the tests and refraction artifacts do not appear to complicate the data analysis. The calibration data were analyzed in SIS and Qimera with excellent agreement; screenshots of the Qimera analysis are shown here, with a table summarizing the Installation Parameter changes made as a result of this calibration.

SIS Installation Parameters were left unchanged during the first survey off O'ahu and transit to the first ROV dive site. The calibration results were applied in SIS at ~17:50 on 13 July 2017 (UTC) while the multibeam was secured at the first ROV dive site (after line 0142). This change in SIS also corresponded with a transition from the original Qimera data processing project in UTM zone 4N to a new project in zone 2N (starting with line 0143). Plots of calibration lines are seen in Figures 3 – 10; applied offsets are listed in Table 3.

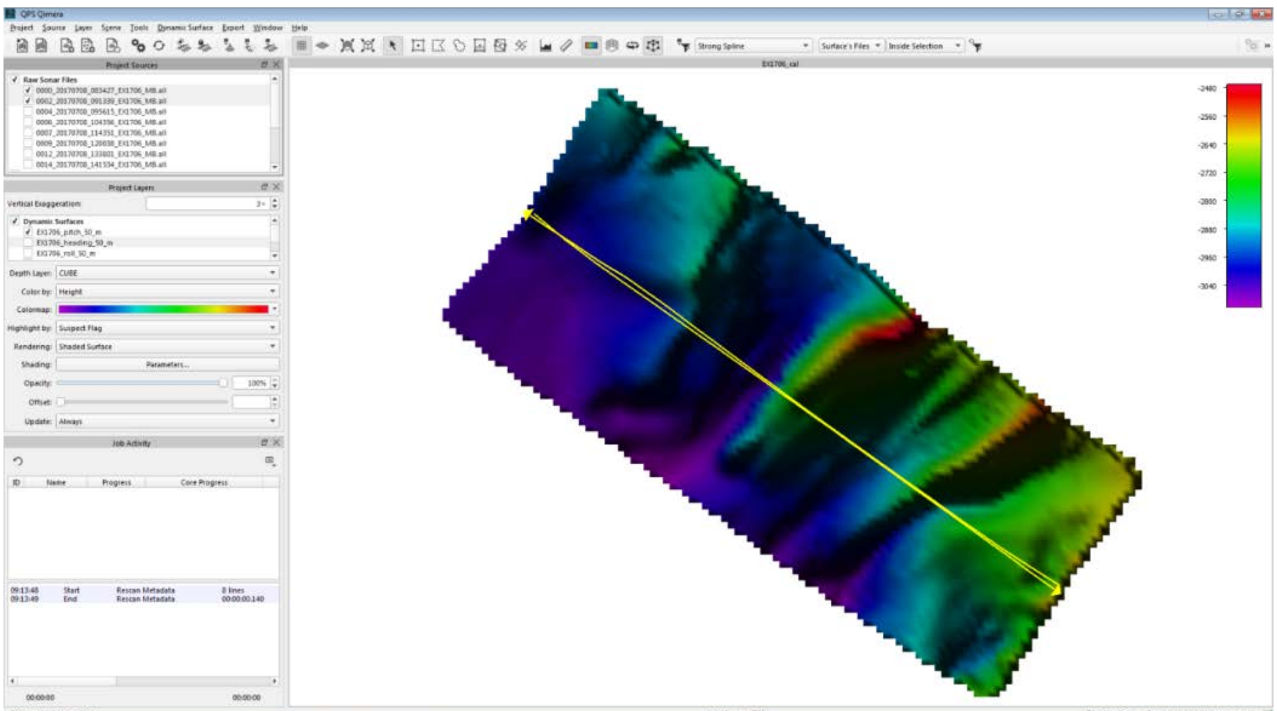


Figure 3. Plot of pitch calibration lines (files 0000 and 0002) gridded at 50 m in Qimera.

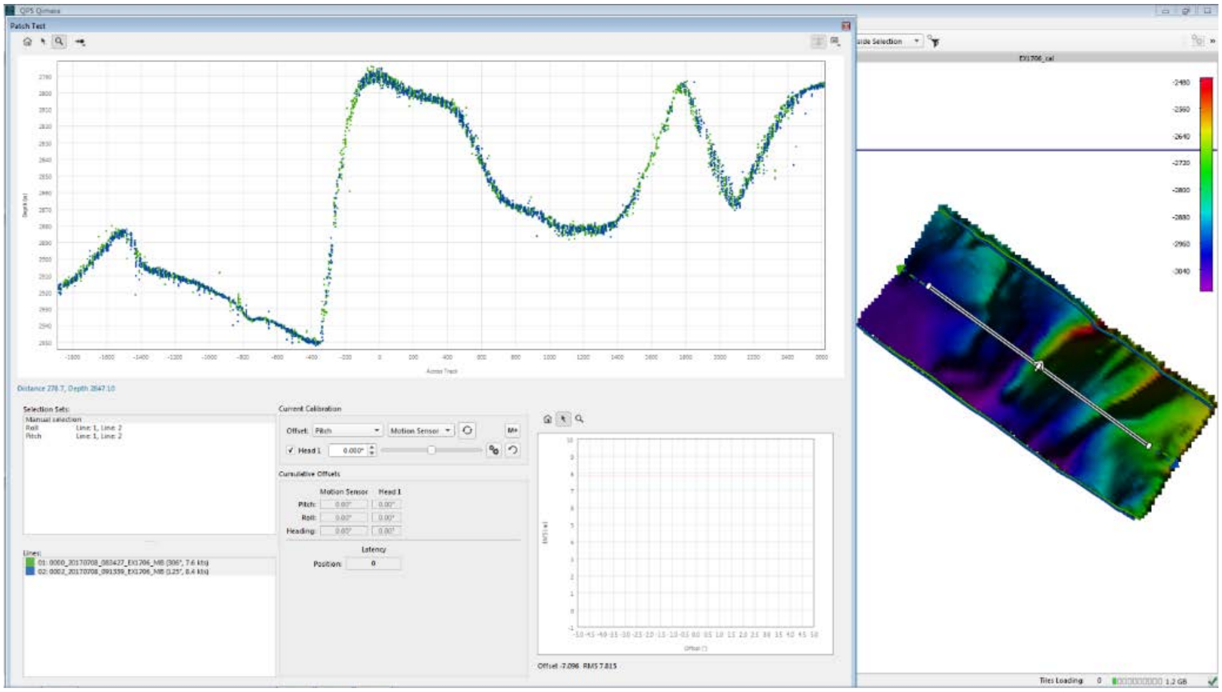


Figure 4. Plot of pitch calibration results in Qimera, showing zero residual bias.

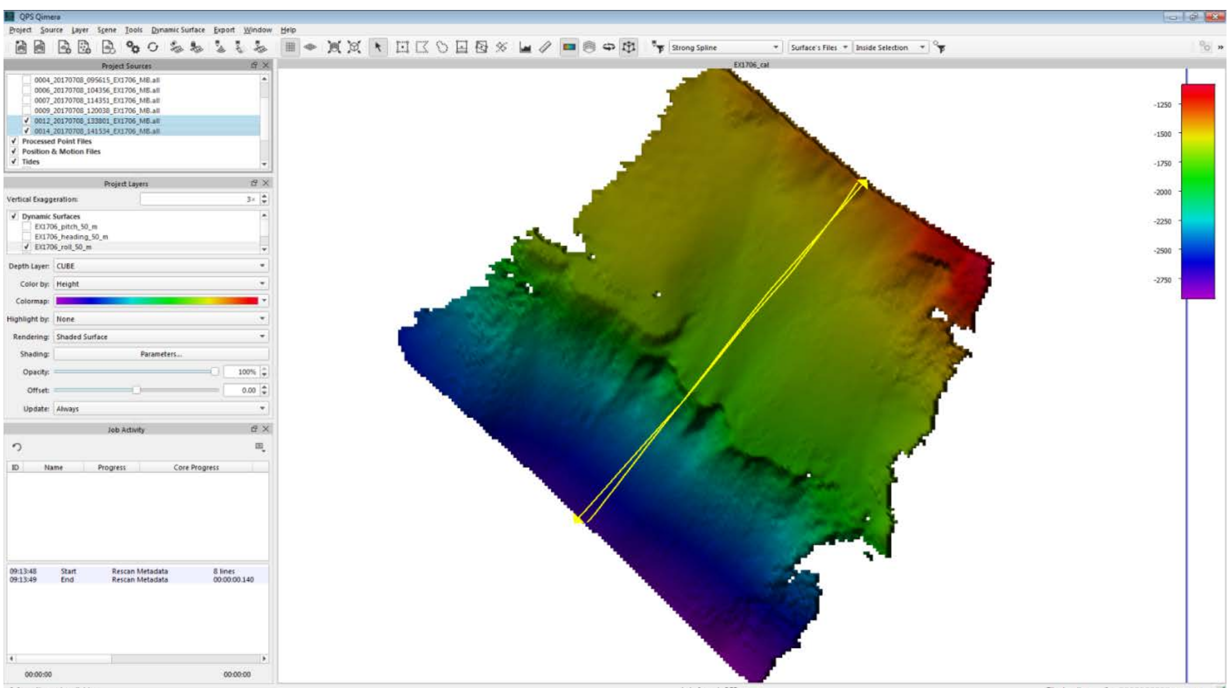


Figure 5. Plot of roll calibration lines (files 0012 and 0014) gridded at 50 m in Qimera.

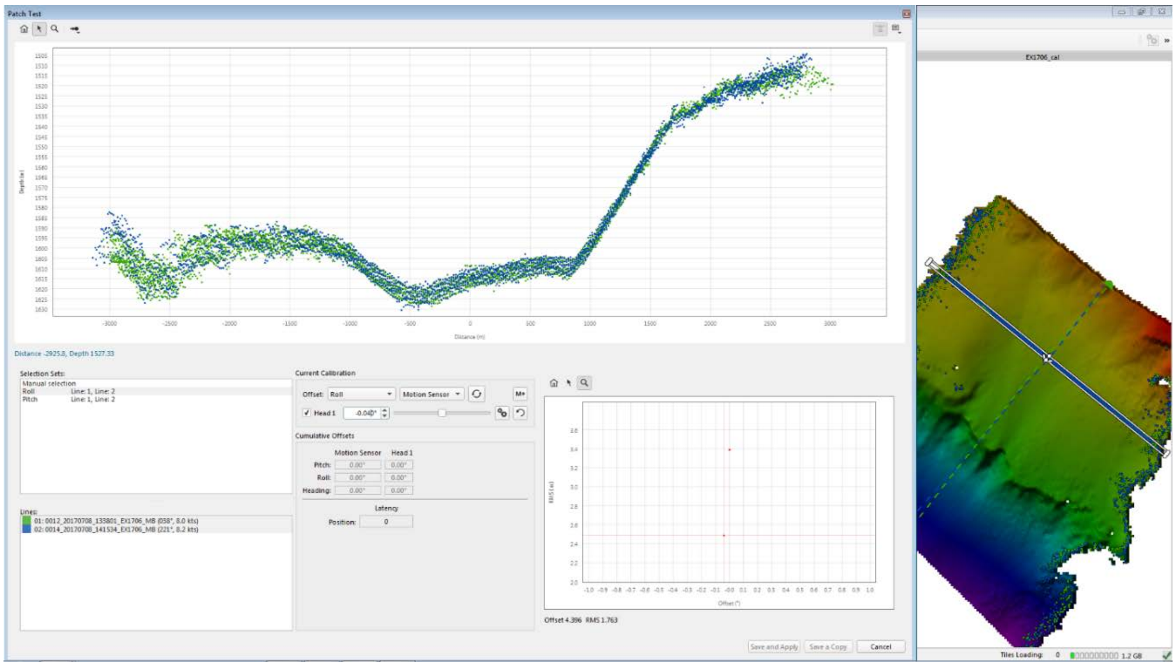


Figure 6. Plot of roll calibration results suggesting an adjustment of -0.04°.

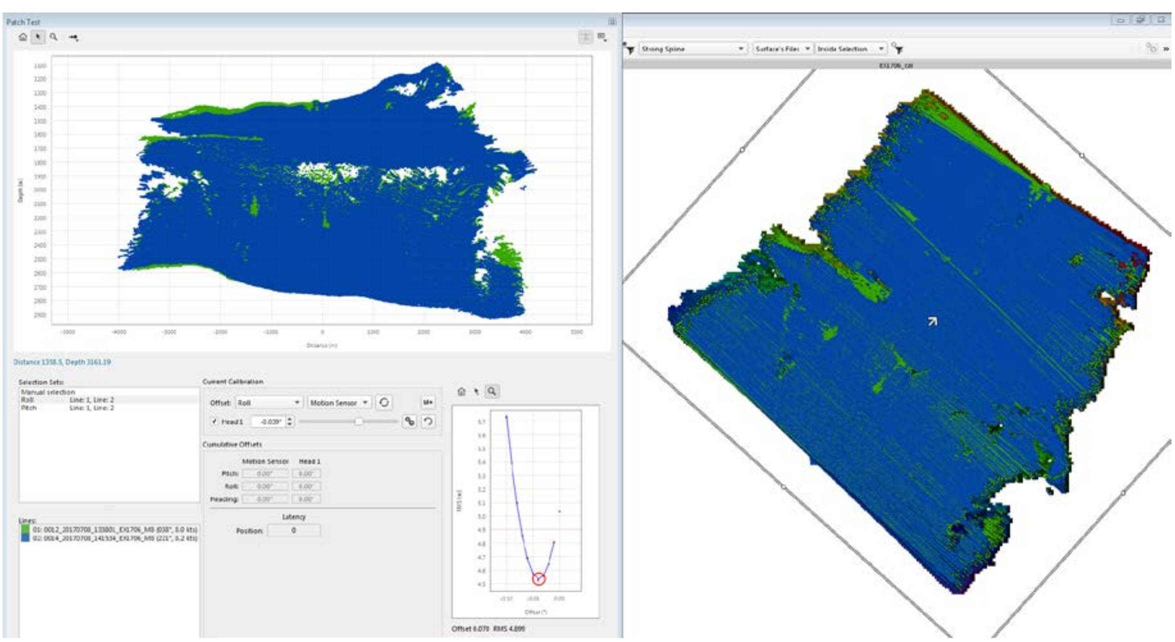


Figure 7. Testing the calibration 'Autosolver' in Qimera using all soundings in the cleaned roll calibration lines. This feature calculates the RMS error between two calibration lines over a customizable range of calibration values and reports the angular offset that is expected to produce the minimum error (naturally, this method is most reliable with large sample counts of high-quality soundings with few outliers). The 'Autosolver' result of -0.039° confirmed the visual estimate of -0.04°.

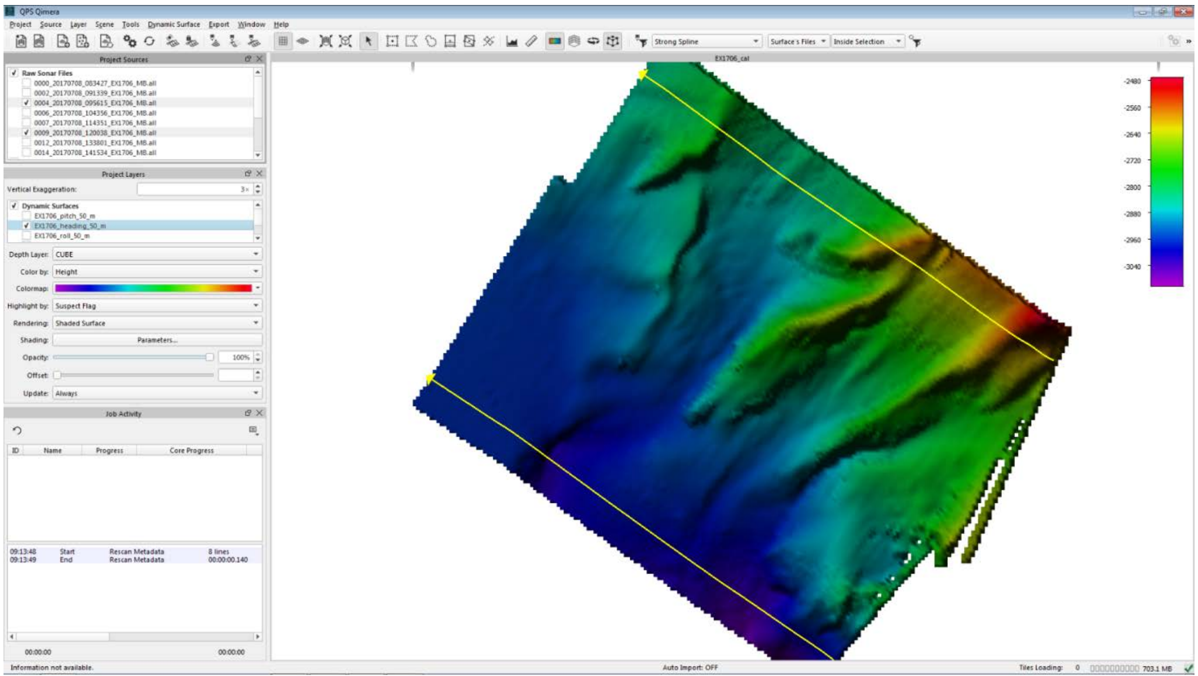


Figure 8. Plot of heading calibration lines (files 0004 and 0009) gridded at 50 m in Qimera.

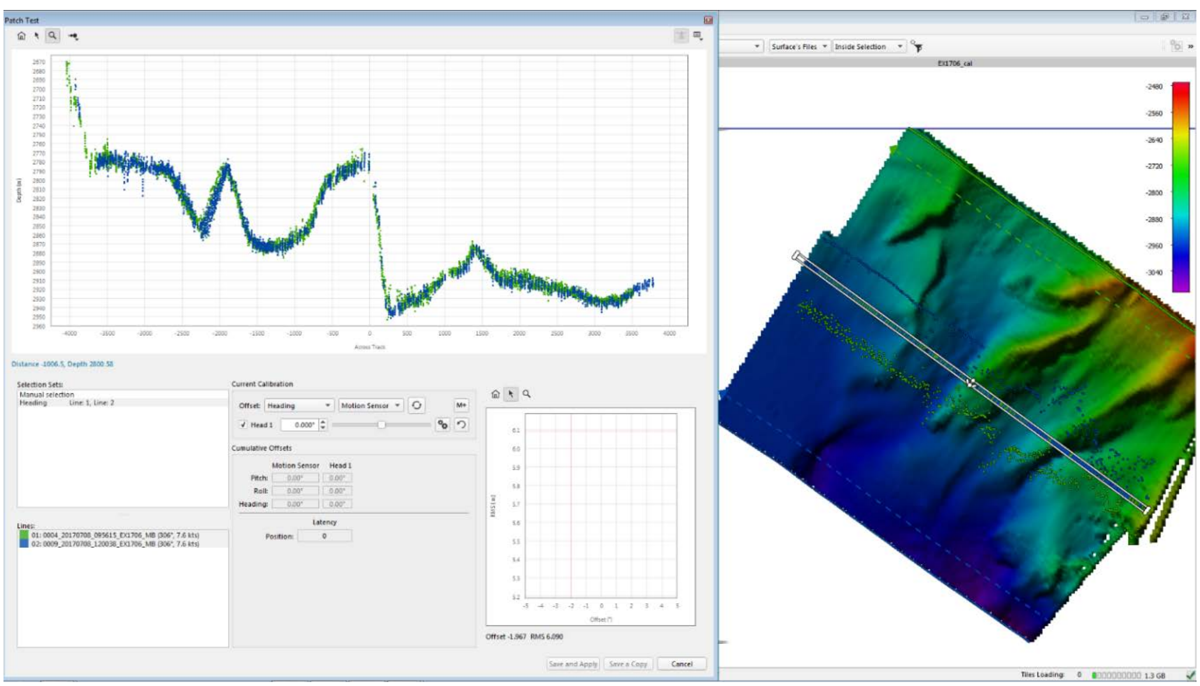


Figure 9. Plot of heading calibration in Qimera after application of the roll calibration result (-0.04°) to the motion sensor installation angle in the vessel configuration (heading analysis is extremely sensitive to pitch and roll installation angles). This is typically the most ambiguous result among these tests, and visual scrutiny of the data collected here suggest a heading adjustment of 0.00-0.10°.

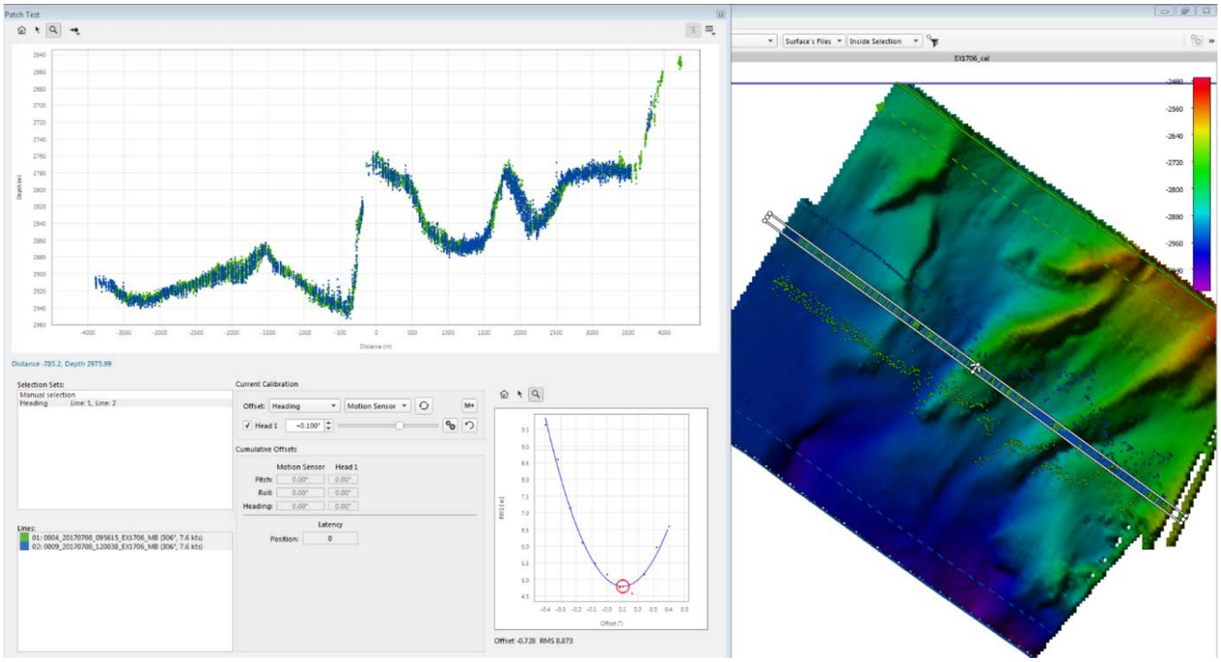


Figure 10. Plot of heading calibration analysis using the 'Autosolver' on a large subset of cleaned soundings (after application of the -0.04 ° roll calibration result in vessel configuration; no pitch change was made) suggested an adjustment of +0.10°, confirming the upper limit of the manual estimate.

Table 3. EM302 Installation Parameters after system geometry review and calibration during EX1706. Pre-modification values (where applicable) are shown in parentheses. The calibration values were applied in SIS on 13 July 2017 after line 0142 (arrival at dive site), taking effect in line 0143.

EM302	X	Y	Z	Pitch	Roll	Yaw
Origin at IMU	BOW +	STBD +	DOWN +	BOW UP +	PORT UP +	COMPASS +
EM302 TX	6.147	1.822	6.796	0.00	0.00	359.98
EM302 RX	2.497	2.481	6.790	0.00	0.00	0.03
Pos, COM1 (POS MV)	0.000	0.000	0.000	-	-	-
Attitude 1, COM2/UDP5 (POS MV)	0.000	0.000	0.000	-0.725	-0.04 (0.00)	0.17 (0.07)
Waterline	-	-	4.42	-	-	-

EX1705 and EX1706 EM302 RX Noise and Spectrum Testing

A series of RX Noise Level and RX Noise Spectrum Built-In Self-Tests (BISTs) were collected at speeds of 0-9.5 kts during EX1705 to characterize the EM302 RX array noise environment prior to the dry dock maintenance period. These tests were run again during EX1706 at speeds of 4-10 kts to examine any changes in the RX noise levels perceived at these common survey speeds.

All speeds are approximate speeds through the water, after taking into account the bridge officer's estimate of the magnitude and direction of current relative to the course over ground during each data collection period. The full speed range of the ship was limited slightly in both cases by different wind, sea state, and machinery conditions; however, the range of roughly 4-10 kts covered during both expeditions is of primary importance for mapping operations.

Conditions were favorable for speed-noise testing during both data collection periods (e.g., swell of 1-2 ft; no breaking seas or apparent bubble sweep along the hull; light to moderate winds; open ocean conditions in water depths > 3000 m; no known marine traffic or other acoustic sources in the vicinity). Ten BISTs were collected at each speed and concatenated into one text file (see Table 4) using an 'autobist' script written by Ashton Flinders and Paul Johnson (UNH CCOM). Paul Johnson provided processing support from shore to analyze the BIST data with scripts written for the NSF-funded Multibeam Advisory Committee (MAC) to illustrate the noise levels and spectra across the receiver hardware (Figures 11-13).

Table 4. EM302 RX Noise Level and RX Noise Spectrum BIST files collected during EX1705 (pre-shipyard) and EX1706 (post-shipyard). Each file contains ten BISTs for statistical significance.

EX1705	
RX NOISE files (UTC date, UTC time, speed in kts)	**RX SPECTRUM files (UTC date, UTC time, speed in kts)**
EM302_RXnoise_5192017_061728_9p5_kts.txt	EM302_RXspectrum_5192017_062043_9p5_kts.txt
EM302_RXnoise_5192017_062727_8_kts.txt	EM302_RXspectrum_5192017_063049_8_kts.txt
EM302_RXnoise_5192017_065029_6_kts.txt	EM302_RXspectrum_5192017_065427_6_kts.txt
EM302_RXnoise_5192017_070404_4_kts.txt	EM302_RXspectrum_5192017_070753_4_kts.txt
EM302_RXnoise_5192017_071841_2_kts.txt	EM302_RXspectrum_5192017_072151_2_kts.txt
EM302_RXnoise_5192017_072954_0_kts.txt	EM302_RXspectrum_5192017_073256_0_kts.txt
EM302_RXnoise_5192017_074307_1_kts.txt	EM302_RXspectrum_5192017_074626_1_kts.txt
EM302_RXnoise_5192017_075950_3_kts.txt	EM302_RXspectrum_5192017_080306_3_kts.txt
EM302_RXnoise_5192017_081422_5_kts.txt	EM302_RXspectrum_5192017_081813_5_kts.txt
EM302_RXnoise_5192017_082934_7_kts.txt	EM302_RXspectrum_5192017_083242_7_kts.txt
EM302_RXnoise_5192017_084131_9_kts.txt	EM302_RXspectrum_5192017_084441_9_kts.txt
EX1706	
RX NOISE files (UTC date, UTC time, speed in kts)	**RX SPECTRUM files (UTC date, UTC time, speed in kts)**
EM302_RXnoise_7252017_125054_10_kts	EM302_RXspectrum_7252017_125345_10_kts
EM302_RXnoise_7252017_125953_8_kts	EM302_RXspectrum_7252017_130321_8_kts
EM302_RXnoise_7252017_131051_6_kts	EM302_RXspectrum_7252017_131400_6_kts
EM302_RXnoise_7252017_132051_4_kts.txt	EM302_RXspectrum_7252017_132340_4_kts

Taken together, the plots in Figures 11, 12, and 13, show a significant improvement in the noise environment perceived by the RX array across the range of speeds (4-10 kts). The trend of increasing noise levels with increasing speed observed during EX1705 (pre-shipyard) is not readily apparent in the EX1706 (post-shipyard) data, suggesting a significant reduction in flow noise along the array faces and/or vessel noise. Because no major machinery or electrical changes are known to have occurred during the shipyard period, this improvement in noise levels can likely be attributed to removal of biofouling from the array faces and hull, as well as the repair of fairing compound/epoxy on the array edges.

These RX noise level and spectrum results clearly demonstrate that the EM302 benefited from this attention and confirm that no major vessel platform noise (electrical or machinery interference) was introduced by other maintenance done during the shipyard period. Qualitatively, these results concur with the observed high quality of EM302 data in its intended/ideal operational depth ranges during EX1706.

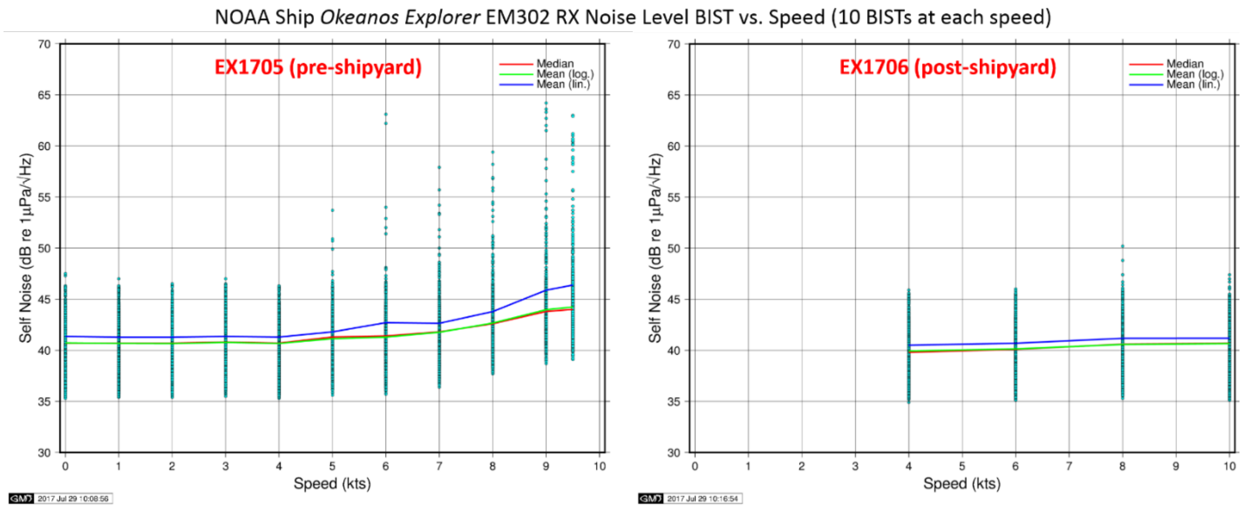


Figure 11. Plots of EM302 RX Noise Level BIST results during EX1705 (left) and EX1706 (right). Speeds greater than 4 kts during EX1705 (pre-shipyard) showed increasing noise levels, which are not observed at higher speeds in the EX1706 (post-shipyard) data. These results suggest a significant reduction in flow noise associated with removal of biofouling and repair of fairing compound along the array edges. The EX1706 noise levels at 4-10 kts are in a similar range as those observed on other vessels (e.g., UNOLS ships) considered to be relatively quiet platforms.

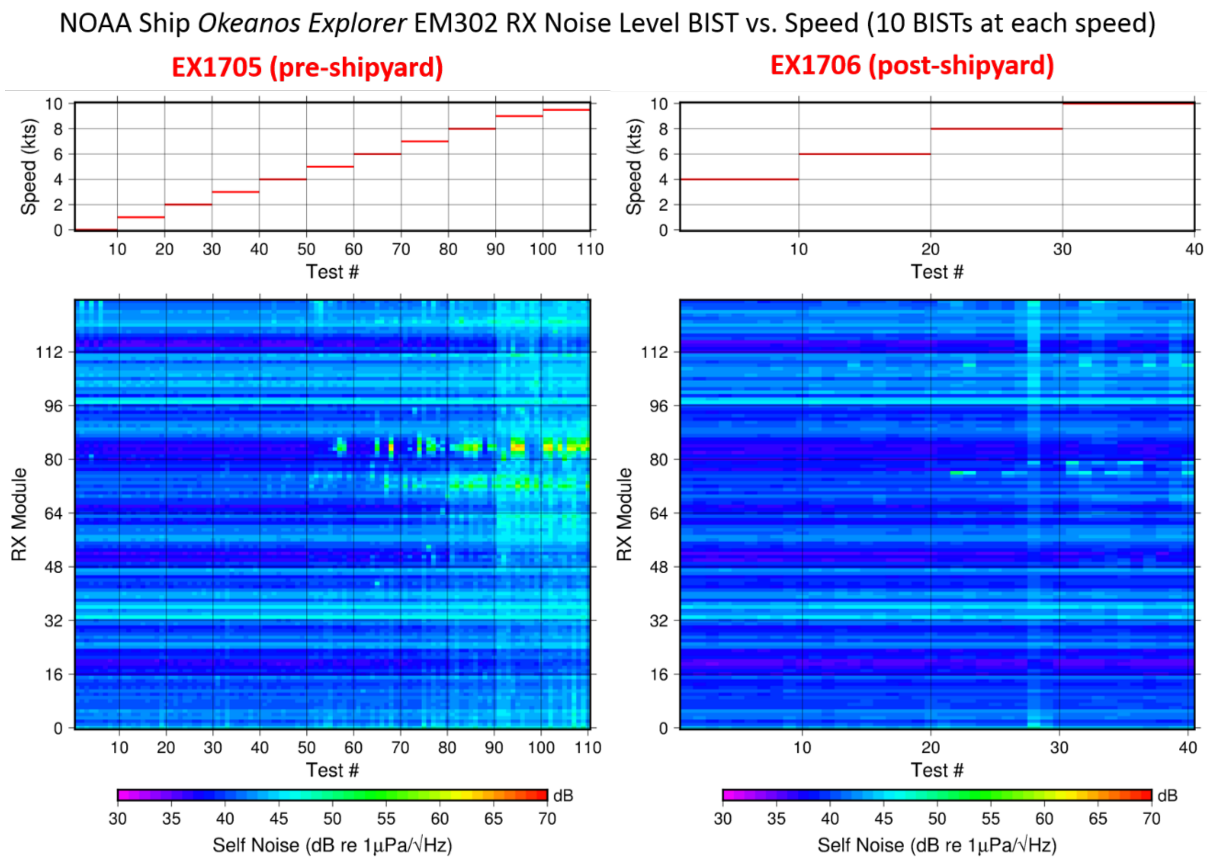


Figure 12. Plots of EM302 RX Noise Level BIST results plotted for each RX module across all tests. This format clearly shows that some modules exhibit consistently higher or lower noise levels across both datasets (horizontal stripes). The direct relationship between speed and flow noise is clear in the shift from dark blue to light blue in the EX1705 panel (left). No significant increase in flow noise is observed in the EX1706 panel (right); note that test 28 resulted in higher noise levels across all modules, likely due to swell impact on the hull or transient machinery noise.

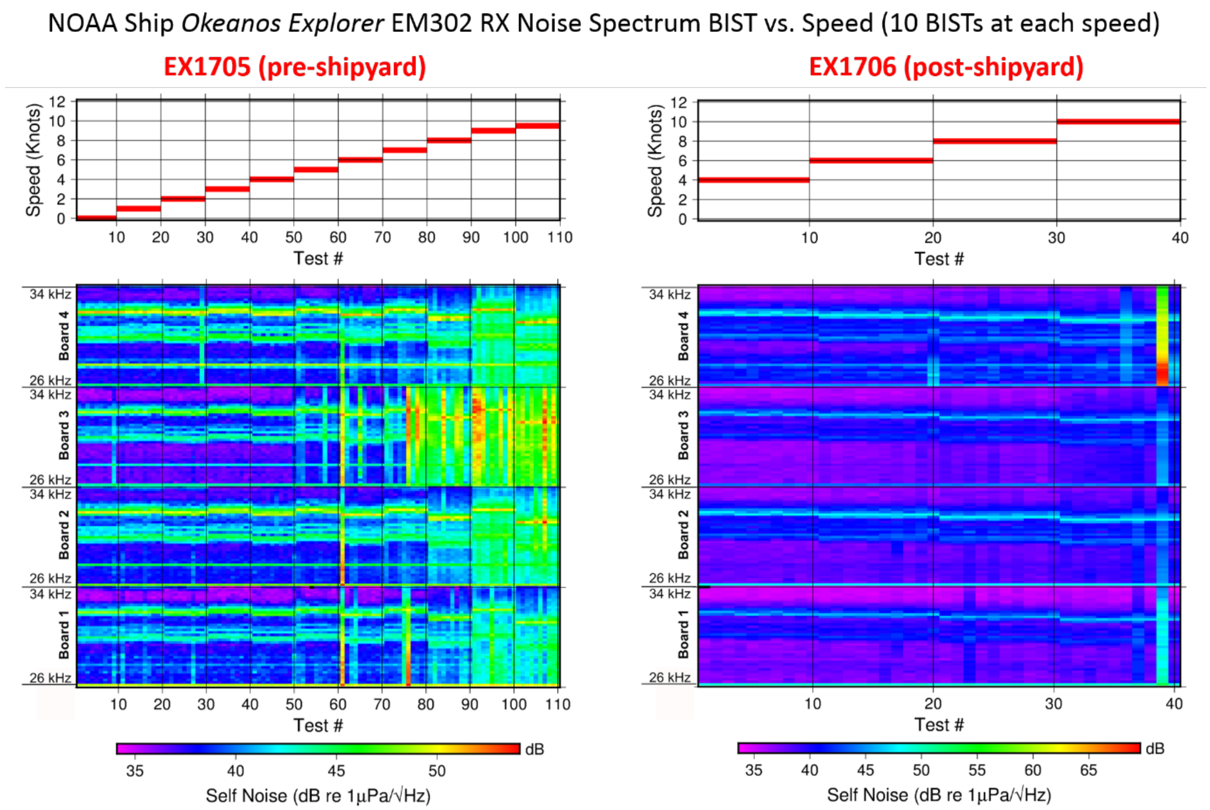


Figure 13. Plots of EM302 RX Noise Spectrum BIST results for EX1705 and EX1706. These plots indicate the noise levels at frequencies of interest (26-34 kHz) measured on each RX board. A clear improvement is made from EX1705 to EX1706, even at low speed and low flow conditions (i.e., at 4 kts, before the start of the strong direct relationship between speed and noise develops in the noise level plots above). The cause of the high value in EX1706 test 39 (especially on Board 4) is not clear, but this appears to be an isolated event in that dataset.

EM302 Swath Coverage / Extinction

In tandem with the RX Noise Level and Noise Spectrum BIST testing, a series of survey lines were run up and down the seabed slope offshore Oahu at the end of both EX1705 and EX1706 to examine the swath coverage over a wide range of depths (roughly 500-4500 m). The data were collected on headings as near to perpendicular to the slope as possible, within the constraints of local marine traffic and vessel crabbing due to currents.

QPS Qimera provides a Coverage Extinction Plot utility to quickly visualize the outermost soundings plotted based on depth and acrosstrack range in a selection of files. The figure below includes soundings from EX1705 (pre-shipyard, gray) and EX1706 (post-shipyard, colored by depth) to illustrate any changes in achieved swath width over this test area. Note that these results are based on only the region surveyed off Oahu in order to minimize the inclusion of soundings from seafloor surfaces facing toward or away from the EM302 (e.g., the faces of seamounts). Surfaces facing toward or away from the multibeam will artificially increase or decrease the expected swath coverage performance, respectively, over flat seafloor at a given depth.

The swath coverage results presented below in Figure 14, suggests slight improvements in swath coverage after the shipyard period, primarily between 2000-3000 m. This is a depth range where the EM302 should maintain Deep mode down to ~3300 m under typical survey conditions, according to the manufacturer specification. It was noticed during both EX1705 and EX1706 that the EM302 frequently required a ping mode change from Deep to Very Deep to maximize swath coverage and improve sounding quality in depths approaching 3000 m. The swath extinction results indicate a slightly improved ability to 'delay' this shift to deeper water (evident by a hard limit at 52° per side, or ~2.4 times water depth total coverage in Very Deep). Reduced coverage seen in the EX1706 data between depths of 600-1600 m (most notably on the port side), is likely a consequence of the vessel heading relative to the slope.

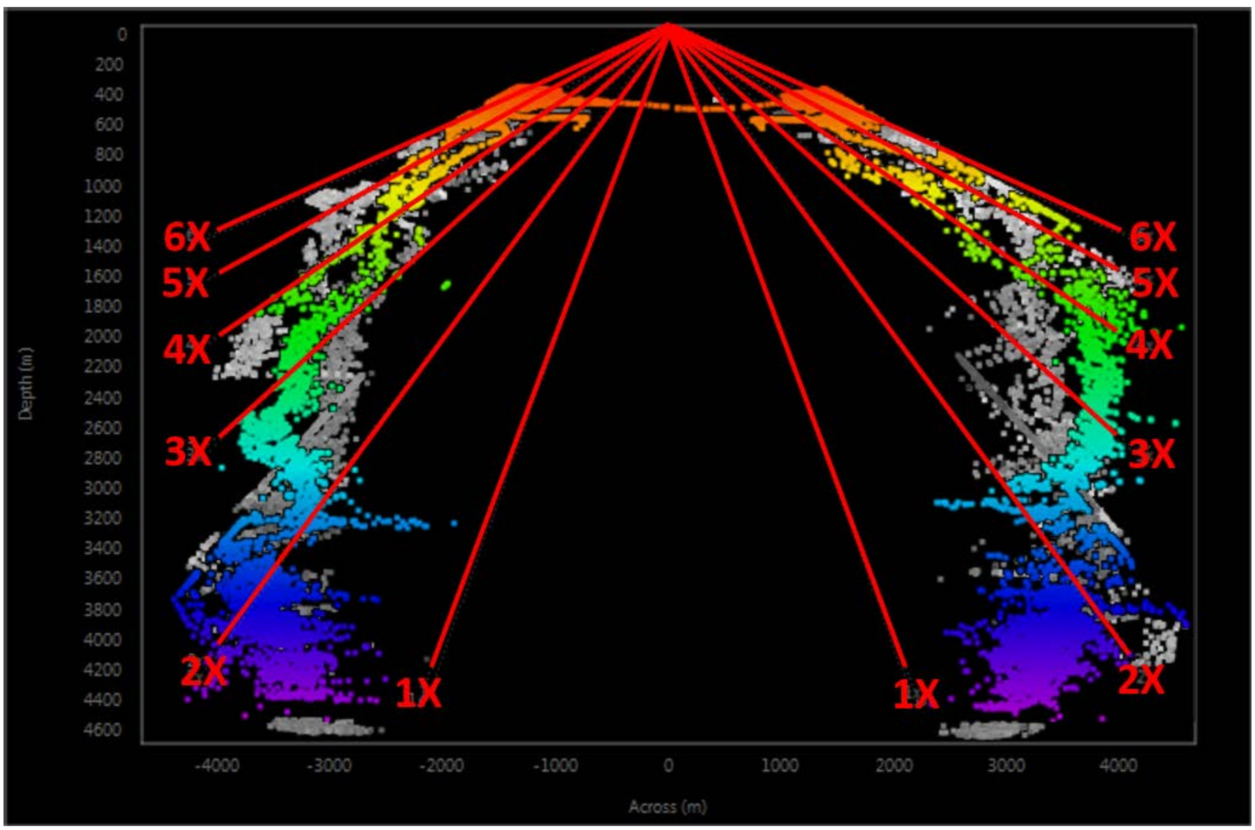


Figure 14. Chart of swath coverage versus depth for data collected offshore Oahu at the conclusion of EX1705 (pre-shipyard, gray) and EX1706 (post-shipyard, colored by depth). The outermost port and starboard soundings are plotted for each ping to visualize the maximum swath coverage achieved. The red lines indicate the total swath coverage as multiples of water depth. In general, these results indicate a general improvement in coverage in the range of 2000-3000 m.

Comparison of Reson SVP probe with ship CTD

Following replacement of Reson SVP cables during the dry dock prior to EX1706, a test CTD cast was conducted to compare the Reson SVP and XBT data against CTD. At the time of CTD cast, the CTD lost connection while ascending to surface (7/9/17 12:23 local time). The data from Reson SV probe and TSG were read manually and are presented in Table 5. Surface TSG and SBE 9 showed the sound speed to be with in 0.1 m/s while the Reson SV probe sound speed differed from CTD (SBE9) by 0.78 m/s.

Table 5. Comparison of temperature, salinity and conductivity data from surface TSG and SBE 9. Comparison of sound speed from Reson SV probe and CTD data.

	Temp	Salinity	Conductivity	Sound speed (m/s)
TSG	27.2379 C	34.5723	5.48185	1538.457
Reson SV Probe	-	-	-	1539.3
SBE 9	26.9319	34.527	5.443799	1538.52

The temperature different of ~ 0.3 °C between SBE19 and TSG is expected as the temperature sensor of TSG is not located at the input but the sampled water has to travel across the ship length to get to the temperature sensors located in dry lab. Comparison of SBE19, Reson SVP and TSG showed (Figure 15) that Reson SVP is reading sound speed 1 m/s lower than TSG and SBE 19. Comparison plots between TSG and Reson SVP over longer period of times (24 hours) showed that the sound speed difference (~ 1 m/s) was consistently observed between TSG and Reson SVP. It is recommended that Reson SVP should be monitored for its variations and manufacturer be consulted for the update on calibration of the probe.

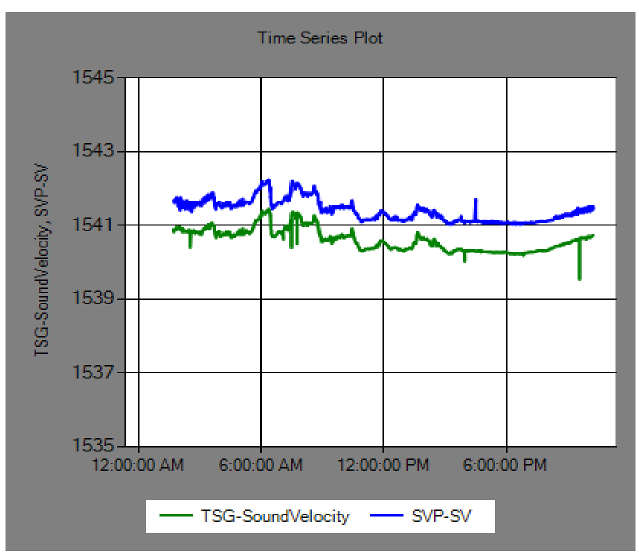


Figure 15. Plot of sound speed estimated from TSG and Reson SVP probe collected for 24 hours.

Tests of newly implemented functionalities in EM 302 / SIS

Two of the newly acquired functionalities in EM 302 / SIS allows for steering the EM 302 electronically in fore-aft direction at a given interval (minimum interval 0.1°) in +-10° angular coverage. The hope was to test this functionality to determine if increased resolution can be obtained while trying to image a target. The test was conducted over a distinct target (approximate dimensions: 5 m high from seafloor, 60 m long) that was detected in seafloor backscatter while surveying at regular speed of 8 kts (Figure 16, line #30). The combined mosaic after including the scanning data (line#21) did not provide improved results (Figure 17). A better control over heading is required to ensure that same seafloor is ensonified while scanning. The bathymetric results (Figures 18 -20) indicated that the feature was detected both in regular survey line (line#30) as well in 3D scanning data (line#21), however only few pings overlapped the location of feature in scanning mode. Sparse soundings over the target in scanning mode did not resolve the shape of the feature accurately. In scanning mode the detected feature showed a height of ~ 2 m from the seafloor with a length of ~ 50m (compare to the size of 5 m height and 60 m length obtained from regular survey line). Further tests, with a better control over heading are required to further evaluate the utility of 3D scanning functionality.

Figure 16. Seafloor backscatter mosaic (obtained from Line # 30) showing a distinct target (highlighted in red circle).

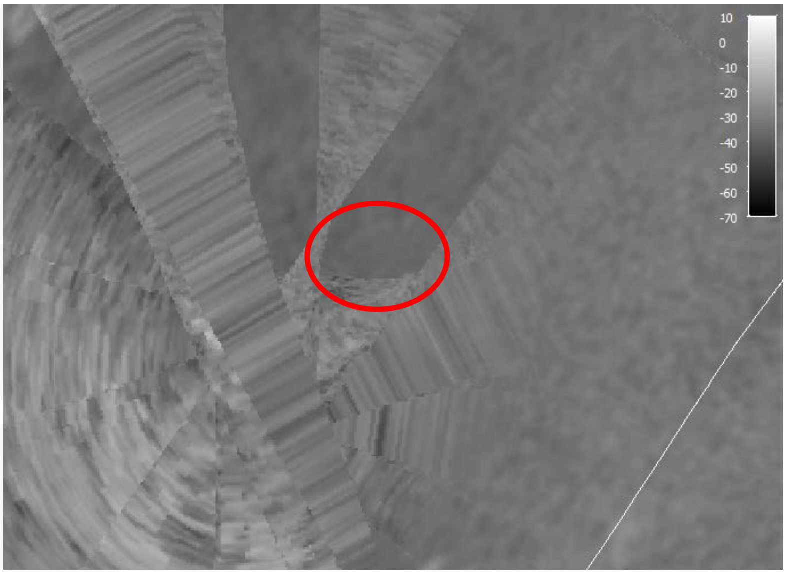


Figure 17. Seafloor backscatter mosaic after combining the data obtained with EM 302 run in 3D scanning mode (Line # 21)

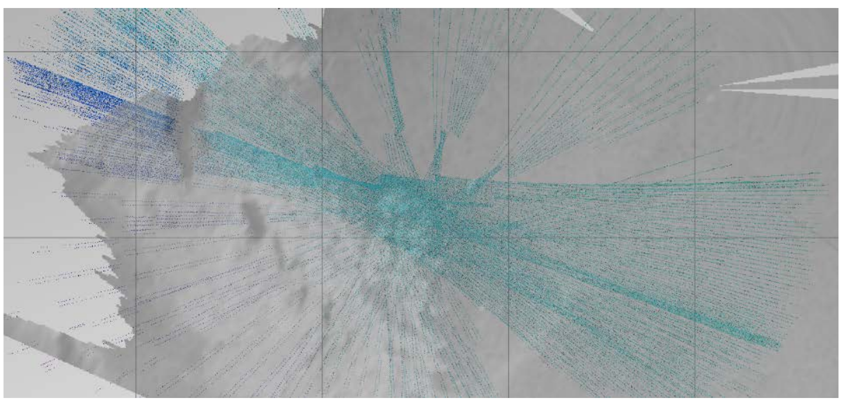


Figure 18. Plot of soundings (in color) obtained in 3D scanning mode overlaid on the DTM. The vessel heading changed considerably during the test.

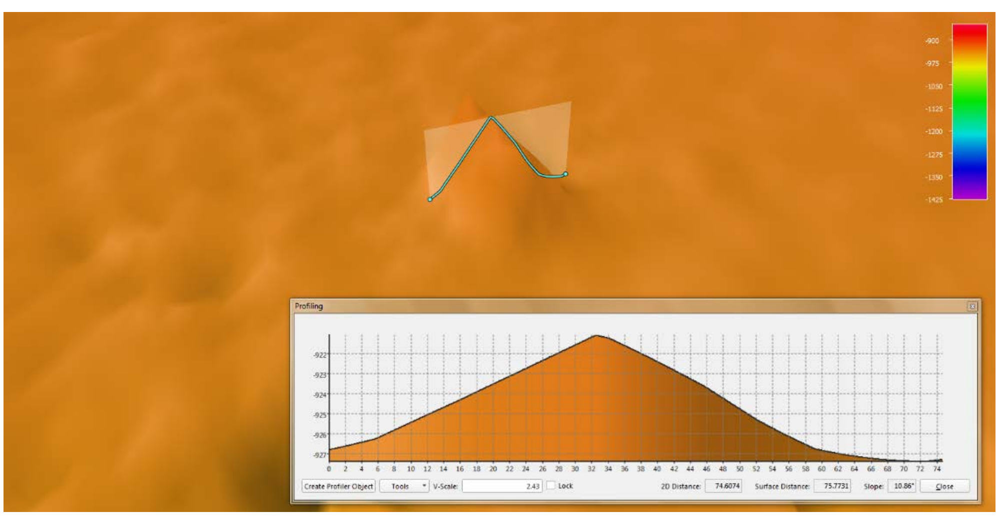


Figure 19. Profile of Line 31 bathymetry over the distinct target obtained with survey line 30.

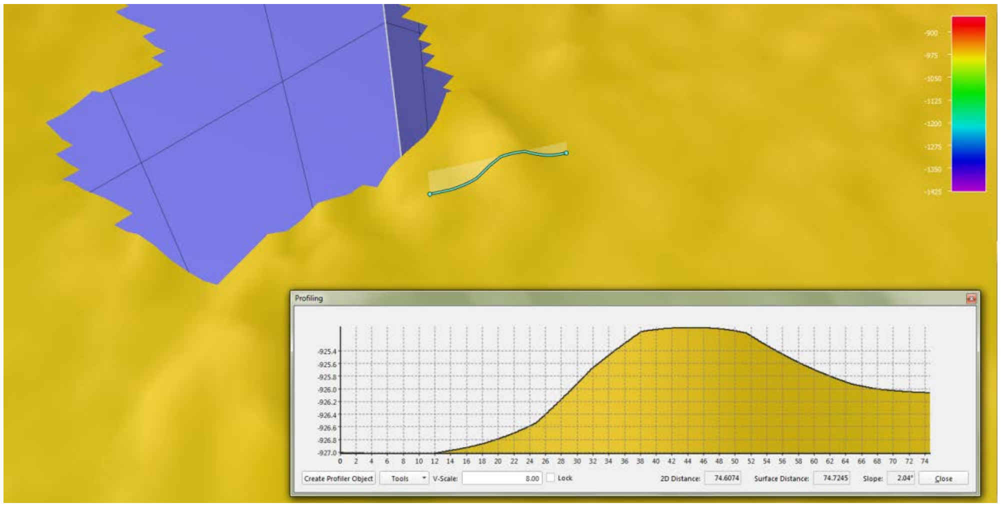


Figure 20. Profile of bathymetry over the distinct target obtained with 3D scanning mode (line#21).

Backscatter Correction File (BSCorr.txt)

The other functionality that was tested during this cruise was access to BSCorr from within SIS environment. These corrections are important for removing the differences in backscatter obtained in different operational modes of EM 302. Previously, access to BSCorr was available only through setting up a telnet session with TRU. In new version of SIS (ver. 4.3.2) BSCorr file can be edited within SIS environment (SIS screen menu > Tools > Custom > BSCorr for EM XXX). However while trying this utility, an error was received indicating no BSCorr file exists on the TRU. In consultation with Kongsberg, it was determined that file containing the backscatter correction needs to be named as BSCorr.txt on the TRU. An existing file named 'bscorr_302_transducer.txt' was found on the TRU. This file was then renamed to bscorr.txt and put back to the TRU. After the files was renamed the SIS unity started working as expected.

BSCorr.txt enables editing of three parameters for each sector: 'Source level', 'Lobe Width' and 'Lobe Angle'. Lobe width and lobe angle refer to the angular width and center angle of sector respectively. These corrections are only applied to the seabed image data and do not have an effect on the bathymetry data or the actual sector angles.

To estimate the corrections for each different depth mode, same seafloor has to be surveyed in different modes. During this cruise, the ship was stationed over a guyot (Figure 21) in dynamic position (DP) mode where the ship held position while EM302 data were collected in different modes (Table 6). Differences in backscatter in different modes were apparent (Figure 21). Further processing of these lines is in progress to estimate the corrections to BSCorr.txt.

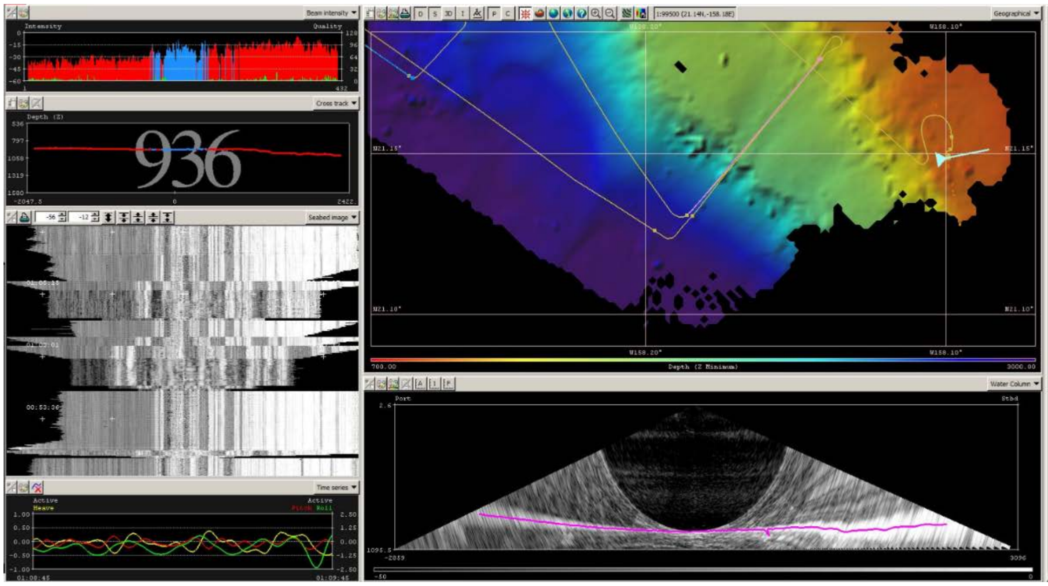


Figure 21. Plot of sound speed estimated from TSG and Reson SVP probe collected for 24 hours.

Table 6. Following lines were collected over a guyot in DP mode.

Depth Mode	EM 302 data file
MEDIUM_DUALSWATHDYNAMIC_CW***	0265_20170719_220020_EX1706_MB***
DEEP_SINGLESWATH_MIXED	0264_20170719_213314_EX1706_MB
DEEP_DUALSWATHDYNAMIC_MIXED	0263_20170719_210802_EX1706_MB
VERYDEEP_SINGLESWATH_FM	0262_20170719_204647_EX1706_MB
EXTRADEEP_SINGLESWATH_FM	0261_20170719_202845_EX1706_MB

*** File 0265 has mode changes from dual swath to single swath, according to runtime parameters and ping times

ADCP calibration and trouble shooting

On July 10 while in transit to Johnston Atoll, the ADCPs were run with bottom tracking on. These test were run to calibrate ADCP heading. These data were submitted to University of Hawaii (jules.hummon@noaa.gov) for further processing. The calibration results indicated that both systems were adjusted by ~ 1 degree (WH300: -1 deg, OS38: -1.3 deg).

During the ADCP operations, a high temperature warning was noted on OS38 system. After monitoring the temperature for few days, it was determined that the temperature sensor is in-operational as it stayed at constant ~ 92 C. In consultation with manufacturer (Teledyne, Inc.) and ROV engineering team (Dave Wright), resistance of the thermistor was tested that indicated water intrusion in transducer that may have shorted the temperature sensor. As a result, the 38 kHz system was secured till a repair plan for OS38 can be developed.

Johnston Atoll results

The mapping focused around the monument is shown in the over overall map (Figure 22). The background shows the satellite derived bathymetry. The location of ROV dives conducted from NOAA Ship *Okeanos Explorer* during the current cruise are also shown.

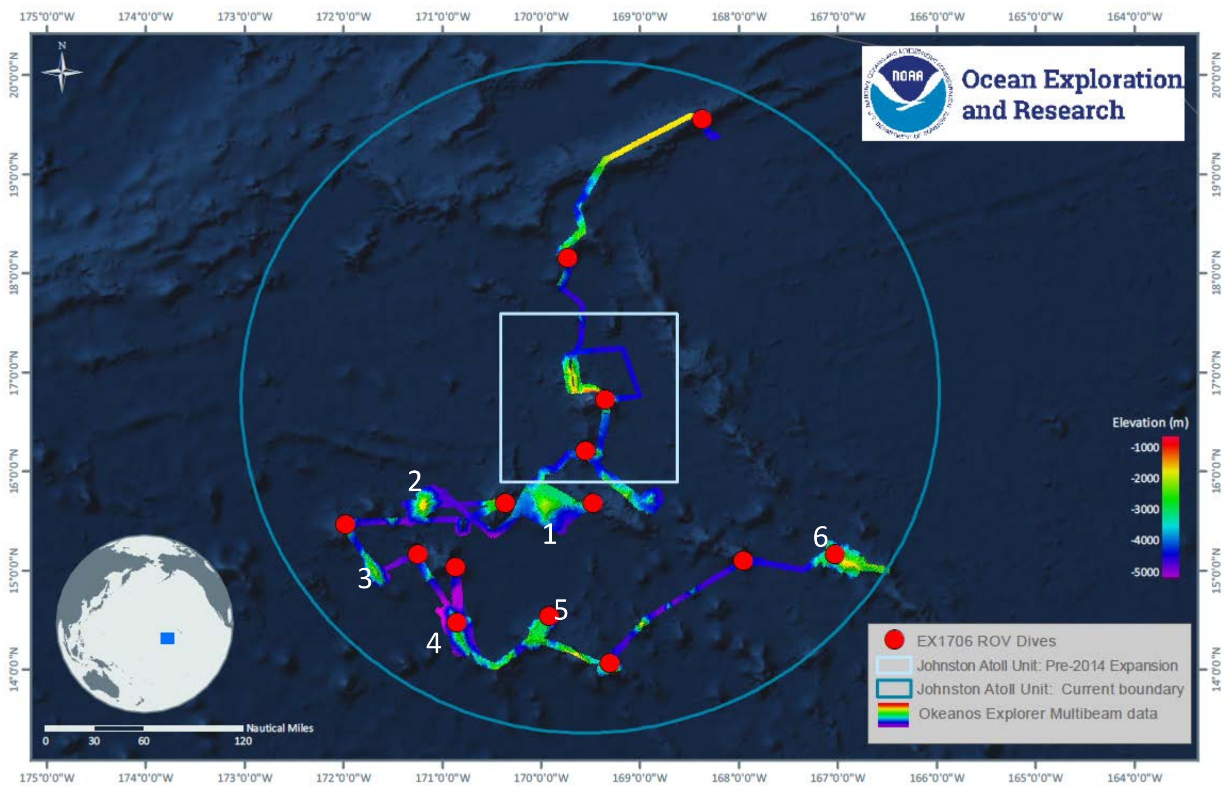


Figure 22. Cruise overview map of multibeam sonar data collected during EX1706 in Johnston Atoll unit of Pacific Remote Islands Marine National Monument. The numbers refer to the seamounts shown in Figure 23. Created in ArgGIS.

Several seamounts were mapped in detail for the first time during this expedition. These included adding coverage over a seamount adjacent to Hutchinson seamount, and several unnamed seamounts (Figure 23, for locations of these seamounts see Figure 22).

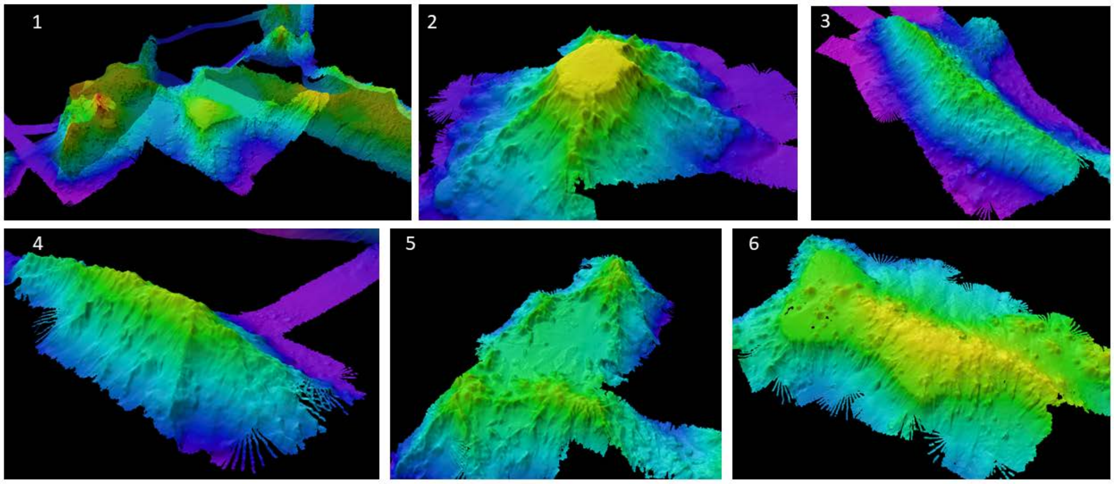


Figure 23. 3D maps of various seamounts mapped during the expedition. For locations refer to Figure 22.

This expedition built on existing multibeam coverage in the Johnston Atoll collected *by Okeanos Explorer* and R/V *Falkor* during previous years. A combined bathymetric map showing data from this current expedition with existing bathymetry is presented in Figure 23.

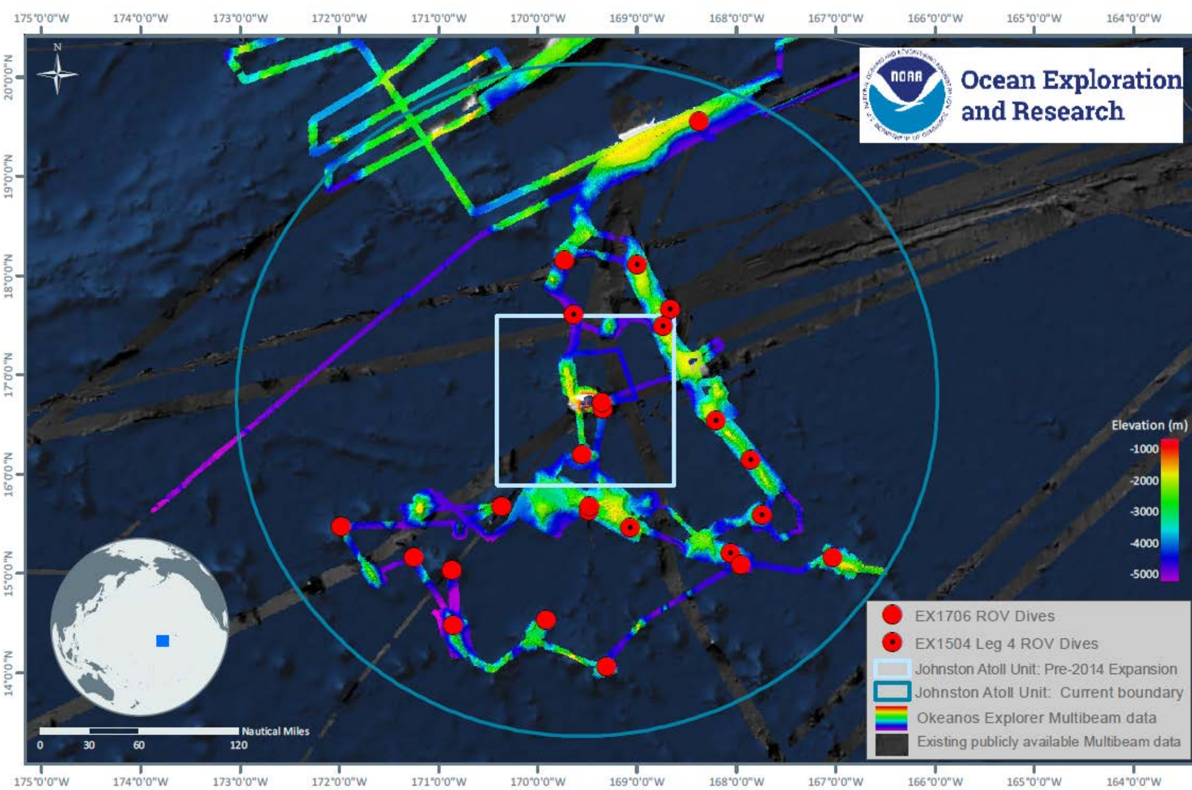


Figure 24. A bathymetric map showing the existing data acquired by *Okeanos Explorer* and R/V *Falkor* combined with the bathymetric data collected during current expedition in Johnston Atoll unit of Pacific Remote Islands Marine National Monument. Publicly available datasets are also shown in greyscale. Created in ArcGIS.

5. Mapping Statistics

Dates	July 07 – August 02, 2017
Linear kilometers of survey with EM302	6900 km
Square kilometers mapped with EM302	38,331 km2
Square kilometers mapped (with in Johnston Atoll Monument)	23,161 km2
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files	568 files/ 29 GB
Number / Data Volume of EM 302 water column multibeam files	568 files / 103 GB
Number / Data Volume of EK 60 water column singlebeam files	160 files / 18 GB
Number / Data Volume of subbottom sonar files	300 files / 7.34 GB
Number of XBT casts	57
Number of CTD casts (including test casts)	1

6. Mapping Sonar Setup

Kongsberg EM302 Multibeam Sonar

The NOAA Ship *Okeanos Explorer* is equipped with a 30 kHz Kongsberg EM 302 multibeam sonar capable of mapping the seafloor in 0 to 8000 meters of water. The system generates a 150° beam fan containing up to 432 soundings per ping in waters deeper than 3300 meters. In waters less than 3300 meters, the system is operated in multi-ping, or dual swath mode, and obtains up to 864 soundings per ping, by generating two swaths per ping cycle. The multibeam sonar is used to collect seafloor bathymetry, seafloor backscatter, and water column backscatter. Backscatter represents the strength of the acoustic signal reflected from some target, whether the seafloor or bubbles in the water column.

Kongsberg EK-60 Split-Beam Sonars

The ship is also equipped with four Kongsberg EK 60 split beam fisheries sonars, 18, 70, 120, and 200 kHz. The 18 kHz transducer and transmits a 7° beam fan. These sonars are quantitative scientific echosounders calibrated to identify the target strength of water column acoustic reflectors - typically biological scattering layers, fish, or gas bubbles – providing additional information about water column characteristics and anomalies.

Knudsen Sub-bottom Profiler

Additionally, the ship is equipped with a Knudsen 3260 subbottom profiler that produces a frequency-modulated chirp signal with a central frequency of 3.5 kHz. This sonar is used to provide echogram images of shallow geological layers underneath the seafloor to a maximum depth of about 80 meters below the seafloor. The Sub-bottom profiler is normally operated to provide information about the sedimentary features and the bottom topography that is simultaneously being mapped by the multibeam sonar. The data generated by this sonar is fundamental in helping geologists interpret the shallow geology of the seafloor.

Teledyne ADCPs

The ship utilizes a 38kHz Teledyne RDI Ocean Surveyor Acoustic Doppler Current Profiler (ADCP), with a ~1000 m range; and a 300 kHz Teledyne RDI Workhorse Mariner ADCP, with a ~70 m range. The ADCPs gather data prior to ROV deployments in order to assess currents at the dive site in support of safe operations. They are kept running throughout the ROV dives. The ADCPs are typically not run concurrently with the other sonars due to interference issues.

7. Data Acquisition Summary

Mapping operations included EM 302 multibeam, EK 60 singlebeam, Knudsen subbottom profile, and ADCP data collection. The schedule of operations included overnight transit mapping and mapping whenever the ROV was on deck. Lines were planned to maximize either edge matching of existing data or data gap filling in areas where existing bathymetry coverage existed. In regions with no existing data, exploration transit lines were planned to optimize potential discoveries. Approximately 38,331 square kilometers of seafloor were mapped during the cruise, including 23,161 square kilometers inside the Johnston Atoll Unit of the PRIMNM.

Throughout the cruise, multibeam data quality was monitored in real-time by acquisition watchstanders. Ship speed was adjusted to maintain data quality as necessary. Most of the mapping was conducted along transit lines, however in places where focused surveying was conducted, line spacing was planned to ensure at least ¼ swath width overlap between lines at all times. Cutoff angles in SIS were generally adjusted on both the port and starboard side to ensure the best data quality and coverage. Archived sonar data products are in Field Geographic WGS84 coordinates, with vertical reference in meters undefined since all of the depth measurements are relative to the water surface during the time of surveying. With the vast majority of surveying completed in very deep water, depth measurements were not adjusted for tides, as they are essentially insignificant as a percent of overall water depth.

Expendable bathythermographs were collected every four to six hours to correct multibeam data for changes in sound speed in the water column, and were applied in real time using Seafloor Information Software (SIS). Sound speed at the sonar head was determined using a Reson SVP-70 probe and the thermosalinograph (TSG). Data from these two systems was monitored for consistency throughout the cruise, and whichever was performing better was applied in realtime using SIS.

Background data used for operational planning included existing multibeam data collected by *the Okeanos Explorer* and R/V *Falkor*, and Sandwell and Smith satellite altimetry derived bathymetric data.

8. Multibeam Sonar Data Processing

Raw multibeam bathymetry data files were acquired by SIS, then imported into QPS Qimera multibeam sonar processing data (Figure 25 indicates the basic workflow process). In Qimera, attitude and navigation data stored in each file were checked, and erroneous soundings were removed using Swath Editor, Slice Editor, and 3D Editor tools. Gridded digital terrain models were created and posted to the ship's ftp site for daily transfer to shore. Bathymetric grids were used for detailed ROV dive planning and initial QC checks. Final bathymetry QC was completed post-cruise onshore at the Center for Coastal and Ocean Mapping at the University of New Hampshire.

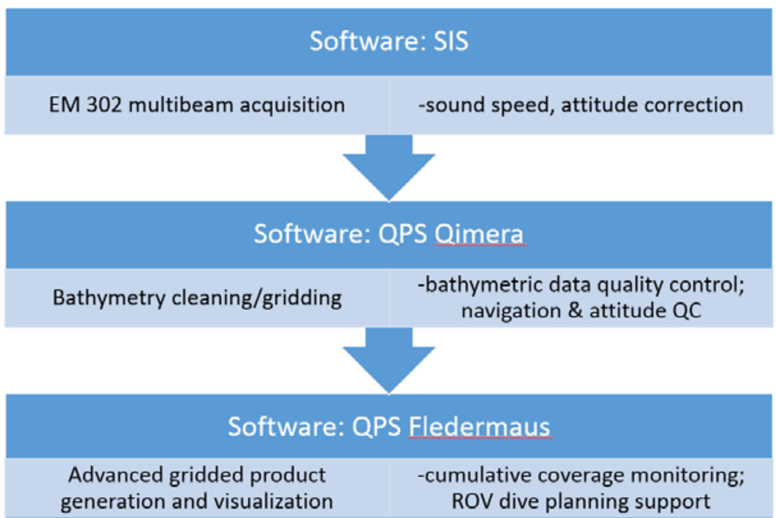


Figure 25. Shipboard multibeam data flow.

ADCP (38 kHz) was observed to cause significant interference with EM 302 resulting in bad bottom detections. ADCP (300 kHz) was also unexpectedly observed to interfere with EM 302. The interference with ADCP (300 kHz) increased noise in the STBD sector of EM 302 (Figure 26,27). It is recommended that cause of this interference be investigated further as EM 302 (30 khz) and ADCP (300 kHz) are not expected to interfere acoustically.

Figure 256. The water column display of EM 302 showing interference pattern with ADCP (both 38 kHz and 300 kHz) on.

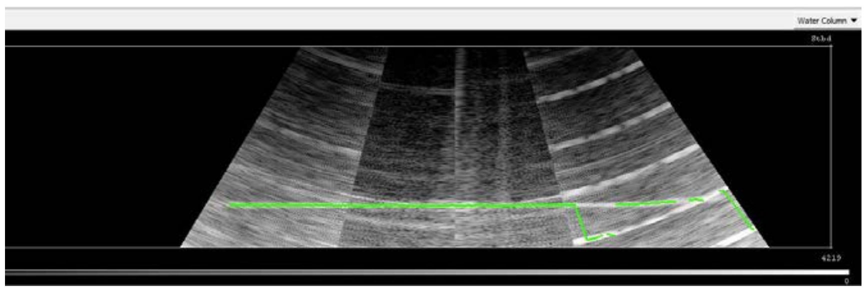


Figure 267. Water column display of EM 302 showing interference pattern with only 300 kHz ADCP.

9. Data Archival Procedures

All mapping data collected by Okeanos Explorer are archived and publicly available within 90 days of the end of each cruise via the National Centers for Environmental Information (NCEI) online archives. The complete data management plan which describes raw and processes data formats produced for this cruise is available as an appendix in the project instructions. Data can be accessed via the OER Digital Atlas:
https://www.ncddc.noaa.gov/website/google_maps/OE/mapsOE.htm
This site hosts an interactive map in which users can select/ explore any OER funded expedition and have access to all data to come from that cruise.

10. Cruise Calendar

February / March 2016						
Sun	Mon	Tues	Wed	Thur	Fri	Sat
				7/6	7/7 Fueling in morning Ship departed	7/8 GAMS Patch test Western Survey area 3D Scan (?)
7/9 Eastern Survey area CTD cast	7/10 Left Honolulu area for Johnston Atoll. Transit mapping commenced.	7/11 In transit to Johnston Atoll. Data analysis of patch test continues. In transit mapping continued.	7/12 In transit to Johnston Atoll. Data analysis of patch test survey continues.	7/13 ROV dive #2 Arrived in location of Dive 02. Mapping operations after the ROV was recovered.	7/14 ROV dive #3 Overnight mapping operations added coverage to existing data en-route to location of dive # 3.	7/15 ROV dive #4. After completion of dive # 4, mapping operations continued to add coverage to existing multibeam north of Johnston Atoll.
7/16 ROV dive #4. ROV dive cancelled. The mapping operations focused on adding coverage to existing multibeam data south of Johnston Atoll.	7/17 ROV dive #5. Overnight ship transited to location of ROV dive. Mapping operations commenced after completion of dive #5.	7/18 ROV dive #6. Overnight ship transited to location ROV dive # 6. ROV dive was aborted due to ROV power failure.	7/19 No ROV dive. Mapping operations continued over unnamed seamount. Overnight ship transited to start mapping over another seamount.	7/20 No ROV dive. Mapping operations continued over unnamed seamount. Overnight ship transited to location of ROV Dive # 7	7/21 ROV dive #7. Mapping operations enroute to dive location.	7/22 ROV dive #8. Mapping operations enroute to dive location.
7/23 ROV dive #9. Mapping operations enroute to dive location.	7/24 ROV dive #10. Mapping operations enroute to dive location.	7/25 ROV dive #11. After completion of dive, mapping operation commenced to identify a suitable target for dive #13	7/26 ROV dive #12. After completion of dive, mapping operation commenced to identify a suitable target for dive #13	7/27 ROV dive #13. Mapping operations enroute to dive location.	7/28 ROV dive #14. Mapping operations enroute to dive location.	7/29 ROV dive #15. Mapping operations enroute to dive location.
7/30 Transit to Honolulu. In transit mapping continued.	7/31 Transit to Honolulu. In transit mapping continued.	8/1 Transit to Honolulu. In transit mapping continued.	8/2 Arrive Honolulu. Secured mapping operations			

11. Daily Cruise Log Entries

Generated from the daily expedition situation reports. All times listed are in local ship time (+13 hours from UTC)

7/5/2017

All mapping personnel arrived onboard.

7/6/2017

CTD frame was brought back to the ship. It was decided to take the CTD frame with the ship for EX1706 so that SST and deck department was work on the frame to recover SBE 32 unit that needs to be sent to Seabird for repair.

All mapping computers were turned on and connectivity to the ancillary sensors tested.

7/7/2017

Mapping watches commenced. ADCPs were turned on while leaving harbor and were kept on with bottom tracking (for the purposes of calibration). The data will be examined by UH. Further tests may need to be run for ADCP. EM 302 passed all BISTs, Knudsen and EK 60s were turned on and appear to be working well.

Overnight, ship conducted GAMS (GNSS Azimuth Measurement System) calibration for the purposes of calibrating heading determined by POS MV. After GAMS calibration, the ship conducted Patch test for EM 302. Data analysis continues to determine Pitch, Roll, and heading offsets. Preliminary results indicated no changes in offsets from last patch test. GAMS calibration also did not result in any changes in the location of POS MV antennas.

The Reson SV probe (to measure sound speed at EM 302 sonar head) stopped working overnight. Currently there are no data coming out of Reson SV probe. EM 302 has been switched to use sound speed coming out of TSG sensor.

The SIS computer used to control EM 302 multibeam sonar restarted itself twice over night. The cause for the restart is still undermined. Mapping team will continue monitoring the computer.

CTD (SBE 11) was re-attached to the CTD frame in preparation for CTD casts being planned to support calibration of TSG, Reson SV probe and XBT (tentatively planned for 7/8/2017).

7/8/2017

After completion of patch test, the ship transitioned to the DP testing. The DP testing was conducted at a location of a known wreck site. The EM 302 was run during the DP tests to analyze performance of newly added functionality of 3D scanning. The data are under review to assess if this functionality can be useful in imaging potential wreck sites. The EM 302 data will be restricted until OER staff (Frank) can review the data and release it publicly.

Reson SV probe communication with EM302 was restored. Troubleshooting indicated that splitting of SV probe signal to feed both SCS and EM 302 is not possible. This might have been the result of replacing the old SV probe cable by a longer cable during dry dock. As a temporary solution, Reson input is directly being fed into EM 302 only and SCS is not receiving SV probe signal currently. ET Blessing is investigating it further.

Overnight ship will continue running an additional test survey in water depth of 900 - 3000 m. [Not sure if we should mention that this survey will be part of submarine wreck search?]

7/9/2017

Overnight ship continued test survey in water depths of 900 – 3000 m. Reson sound speed probe input issue has now been resolved and EM 302 as well as SCS are receiving Reson SV data.

A CTD cast to water depth of 760 m was conducted. A XBT cast was also conducted after recovering CTD. During the upcast, the connection to CTD failed showing the error that "It was unable to initialize the water sampler". SST Wilkins plans to work on trouble shooting the connection issue before attempting to dismantle the CTD frame.

In the evening, the multibeam SIS computer crashed. After restart it showed an error about NVIDIA display driver. ET Blessing have installed an updated driver and watch standers will continue monitoring the health of the system.

Overnight ship plans to run a test survey.

7/10/2017

Overnight the test survey continued. All sonars are performing as expected. The EM 302 computer continues to be monitored closely for any errors with video card. After the small boat pickup of personnel, the ship started her transit towards Johnston Atoll. ADCP calibration line was run till depth of 1450 m. The data are being analyzed by UH for updating ADCP calibration.

ONC primary ship server is now connected to shore and was updated. Backup server is still not responding. Awaiting confirmation from ONC that all required updates have been installed on the ship server. During the test dive, shore instance of Seascribe was used that was challenging due to frequent drop outs on internet connection.

7/11/2017 – 7/12/2017

On the evening of 10 July, ship started her transit towards Johnston Atoll. ADCP track line was run at request of UH. All sonars are performing as expected. Due to limited time available to get to Dive 02 location, only a straight transit was planned instead of laying a track parallel to existing coverage. Mapping team also will start producing daily products effective today.

ONC has confirmed that not all the updates to onboard server have been successful. The remote connection to onboard server kept on failing. Currently not all the onboard users have access to onboard server. The use of shore server is an option but with extremely slow internet connection, it will be very difficult for ship users to annotate on shore server. Three dummy SeaScribe accounts created earlier for use as a contingency are available and will most likely be used by ship personnel during Dive 02.

7/13/2017

Overnight mapping operations continued till arriving at Dive site on morning of 13 July. No major issues were encountered. Analysis of patch test and test surveys conducted in vicinity of Oahu was completed. The patch test analysis showed a change of -0.03 degrees roll and 0.1 degree heading. The updated values have been entered into SIS. If schedule allows, mapping team will try to run few post-patch test verification survey lines. The test survey data covered suspected locations of wrecks of WWII men of war. The data were assessed by onboard science and mapping lead, and after verification with OER staff (Cantelas), it was decided not to restrict these data.

The position drop outs reported in EX1705 related to the buffer box have started to re-appear. Currently the position drop outs are not a major concern as they have been only observed once - twice a day. ET Blessing have been notified and replacement of buffer box is being planned prior to next expedition.

During dive 02, EK 60s (all frequencies) were operated at request of scientists interested in water column. 18 and 38 Khz EK 60 showed interference with ROV USBL (see Figure 28). Possible solutions to mitigate interference between USBL and EK 60 are being assessed.

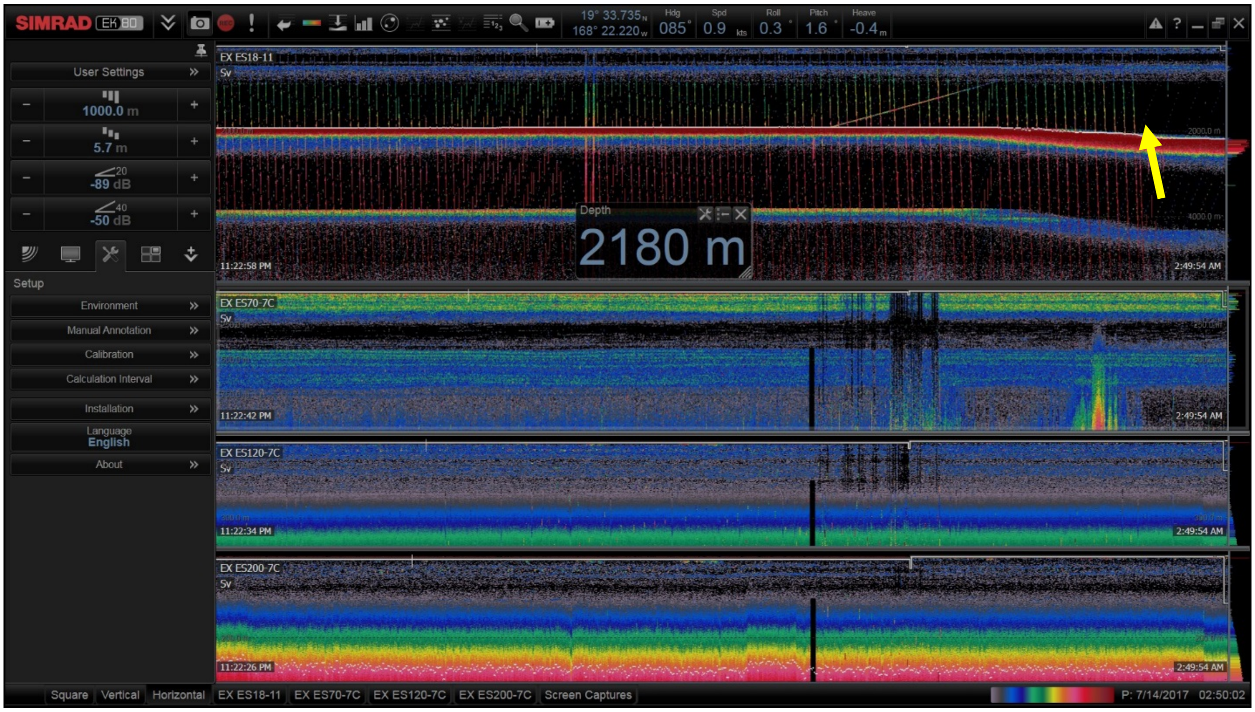


Figure 8. Plot of EK60 top panel showing 18 kHz EK 60 data. Yellow arrow shows the location of ROV recovery.

ONC: In-spite of incomplete updates to the ship server due to inconsistent internet connections, the onboard users were able to access Seascribe using onboard server and able to create annotations during dive 02. Pending resolution of internet connection, ONC is currently unable to access ship server for updates.

7/14/2017

Overnight mapping operations were successfully completed. Multibeam lines were laid out to add data to existing coverage. No additional items to report at this time.

7/15/2017

Overnight mapping operations continued to add coverage to existing multibeam data. No issues were encountered during mapping operations.

SST Wilkins started working on removing SBE32 from the frame and made good progress today in removing several stripped bolts. The top portion of the frame has now been removed.

Work on trouble shooting ADCP high temperature has been deferred till 17 July to ensure availability of ADCP data critically needed for ROV dives near Johnston Atoll.

7/16/2017

The overnight mapping lines were planned to get ship outside of 25 NM from Johnston Atoll to ensure ship's water making system can be operated. Chief Engineer recommended not to make water within 25 NM as a precaution against any contaminants in waters around Johnston Atoll. The mapping operations added coverage to existing *Okeanos* coverage from 2015. As a result of cancellation of dive 05, there were about 9 extra hours that were utilized today to add coverage to existing mapping data over a guyot and a seamount south of Johnston Atoll. Overnight the ship transited to location of "Sally Seamount" in preparation of ROV dive. Except for heading directly into seas, the data quality remained 'Fair'. Work on CTD was deferred due to inclement conditions.

7/17/2017

Overnight mapping coverage was added to the existing *Okeanos* data from 2015. During the dive operations EK 60 were operated continuously in support of water column transects. The ADCP still continues to provide high temperature. Chief ET Blessing, SST Wilkins, Malik and Wright (GFOE) worked on assessing the ADCP transducer. Several tests recommended by manufacturer were run including checking the cable for water intrusion. Initial assessment indicates that there is indeed water intrusion in the cable that is perhaps short circuiting the temperature sensor. The test data are being shared with Teledyne to get further guidance on repair. While rebooting the ADCP system, the 300 kHz system did not start. Further trouble shooting of the ADCP continues. 38 kHz is however operational.

SST Wilkins and Malik were able to disassemble the CTD frame today. SBE 32 has now been recovered from the frame and will be ready for shipment at end of current expedition to Seabird for further evaluation and repair. Several stripped screws and bolts had to be drilled out / hammered. SST Wilkins and PS Malik will continue to assess the condition of frame in order to recommend if the existing frame can be re-configured for use or acquisition of a new frame is necessary.

7/18/2017

The ship transited to Dive 06 overnight collecting mapping data over previously unmapped seamount. The work on ADCPs trouble shooting / repair continued. The problem with 300 kHz system was identified to be communication loss due to disconnected serial cable. Chief ET Blessings and Wright inspected and re-soldered pins on communication cables for both ADCPs and added cable housing (covers). The housing is needed to provide necessary strain relief and to screw the connector to the back of the deck units. Now cables for both systems are seated and screwed down. The 300 kHz system is now operational. The 38 kHz system continues to show symptoms of water intrusion on the wet side. Additional test data (resistance of dry and wet end of transducer cable) was collected and shared with Teledyne (manufacturer) for further trouble shooting. Teledyne has recommended to secure the 38 kHz system until further notice to safeguard against any further damage. After recovery of ROV mapping data acquisition continued over the unnamed seamount.

7/19/2017

Overnight mapping operations continued to add coverage to the unnamed seamount. As a result of dive cancellation today, additional time became available for conducting further mapping of the seamount and to complete tests to improve backscatter results of multibeam sonar. The tests were conducted while the ship held position in DP mode over the flat top of the seamount being mapped in water depth of ~ 2000 m. 200 pings were collected for each of the deep water depth modes (Extra deep, Very Deep, and Deep). These modes are most commonly used by EM 302 while surveying in water depths > 1500m. No further update is available about 38 kHz ADCP system. The resistance results of the cable have been shared with ADCP manufacturer and currently we are awaiting the feedback.

7/20/2017

Overnight mapping operations completed mapping over an unnamed seamount. After completion of mapping to ~ 4000 m water depth around the seamount, the ship transited west to map another unnamed seamount. ADCP manufacturer confirmed after reviewing the test results that 38 kHz has been damaged due to water intrusion and the only option to repair is to take it out of water. As a result, the 38 Khz system has been secured. For ROV deployment / recovery 300 kHz ADCP will remain available though its depth limit is ~ 150 m.

7/21/2017

Mapping operations continued overnight while in transit to location of ROV dive. After completion of ROV dive, mapping data were collected while in transit to the next day's ROV dive site.

7/22/2017

After the completion of ROV dive the mapping operations commenced. Tonight mapping operations will be focused on mapping a seamount that has been identified as a target based on satellite derived bathymetry.

7/23/2017

Overnight mapping over a seamount was completed. After completion of ROV dive, the ship transited over another seamount that has no prior mapping data.

7/24/2017

Overnight, mapping coverage was added to the seamount selected for today's dive. Mapping team has begun to synthesize the data and produce end of cruise mapping products.

7/25/2017

All mapping systems continue to operate optimally. Overnight mapping operations added further coverage to the seamount selected for Dive #11. After the completion of ROV dive, ship transited over several potential seamounts enroute to location of Dive #12.

Mapping team completed inventory of mapping computers and equipment. SST Wilkins and Malik continue to assess the condition of CTD frame.

7/26/2017

Overnight ship transited to prospective location of dive # 12. The dive location had no prior mapping data available and the location was chosen based on satellite derived bathymetry. Mapping team was able to process and build mapping products for onboard science team soon after finishing the mapping to select a dive location. After the completion of dive, ship started her transit to next dive site – another seamount inferred from satellite derived bathymetry.

7/27/2017

Overnight mapping efforts focused on developing coverage on a seamount identified through satellite derived bathymetry as prospective location for dive #13. Mapping team compiled mapping products early in morning to facilitate selection of ROV dive site. After completion of ROV dive, ship transited to location of dive #14.

Mapping team is in process of identifying end of cruise products in consultation with onboard and shore scientists. ROV CTD data from dive 1 – 12 were processed in SeaBird data processing software. One of the dives showed (Dive #7) showed erroneous data. The cause of the issue is being investigated.

New version of QPS Midwater (ver. 7.7.6) was tested to process EK 60 data collected using ER80 data acquisition software installed this year. Preliminary results indicate FMMidwater is now able to process all the different frequencies of the EK60 collected using ER80.

7/28/2017

Overnight ship transited to the location of dive #14. Due to heavy seas, only a straight line transit between dive site locations was selected to provide optimal ride conditions. Dive #14 was conducted on a feature previously mapped by *Okeanos Explorer* in 2015. After completion of ROV dive, ship started her transit to location of the dive # 15 over an unmapped seamount.

7/29/2017

Overnight ship transited to location of dive #15 to conduct pre-dive mapping. Due to time constraints, only three lines of multibeam survey were run over the seamount. Still partial mapping of the seamount enabled onboard team to select a dive site. After the completion of the ROV dive, mapping operations continued overnight on the seamount to complete the mapping over seamount before starting transit back to Honolulu.

7/30/2017 – 08/2/2017

Transited to Honolulu, HI. Mapping data were collected while in transit. Ship arrived Honolulu, HI on 8/2/2017. Mapping operations were secured.

12. References

1) The 2016 Survey Readiness Report can be obtained by contacting NOAA Ship *Okeanos Explorer* at ops.explorer@noaa.gov.

2) EX-17-06 Project Instructions can be obtained by contacting NOAA Ship *Okeanos Explorer* at ops.explorer@noaa.gov.

3) National Center for Environmental Information (NCEI) Autogrid Multibeam Bathymetry Data Web Mapping Tool. https://www.ngdc.noaa.gov/maps/autogrid/

4) Sandwell, D. T., and W. H. F. Smith, Global marine gravity from retracked Geosat and ERS-1 altimetry: Ridge Segmentation versus spreading rate, J. Geophys. Res., 114, B01411, doi:10.1029/2008JB006008, 2009.

13. Ancillary Data

Ancillary data files are archived with the sonar dataset. These include:

1. Project Instructions
2. EM 302 Processing Parameters in use during the cruise
3. EM 302 Built In System Test (BIST) Results
4. Tables of Data File Logs
5. Daily Watchstander Log
6. Weather Log

Appendix A: Acronyms

AERONET – Aerosols Robotic Network
AHB – Atlantic Hydrographic Branch
ASCII – American Standard Code for Information Interchange
AUV - autonomous underwater vehicle
BIST – built in system test
CDR – Commander
CO – Commanding Officer
CTD – conductivity, temperature, depth
dB - decibel
DNP – do not process
EEZ - Exclusive Economic Zone
ERT – Earth Resources Technology Corp.
ET – Electronics Technician
EX – NOAA Ship Okeanos Explorer
FM – frequency modulated / modulation
FTP – file transfer protocol
FV - free vehicle
GB - gigabytes(s)
KB - kilobytes(s)
kHz – kilohertz
km – kilometer
kts – knots
LT – Lieutenant
LSS - light scattering sensor
m - meters
MAN – Maritime Aerosols Network
MB – multibeam sonar
MB – megabytes(s)
ms – millisecond
NASA – National Aeronautics and Space Agency
NCDDC – National Coastal Data Development Center
NCEI - National Center for Environmental Intelligence
NCCOS - National Centers for Coastal Ocean Science
NGDC – National Geophysical Data Center
NMEA – National Marine Electronics Association
NOAA – National Oceanic and Atmospheric Administration
NODC – National Oceanographic Data Center
OER – NOAA Office of Ocean Exploration and Research
OMAO – NOAA Office of Marine and Aviation Operations
OPS – Operations Officer
PRIMNM - Pacific Remote Islands Marine National Monument

PRT - Puerto Rico Trench
ROV – remotely operated vehicle
SBP – subbottom profiler
SCS – scientific computer system
SIS – Seafloor Information System
SST - Senior Survey Technician
SVP – sound velocity profile
TRU – transceiver unit
TSG - thermosalinograph
TX – transmit
UCAR - University Corporation for Atmospheric Research
UPRM - University of Puerto Rico, Mayaguez
USGS – United States Geological Survey
W - watt
XBT – expendable bathythermograph
XO – Executive Officer