

# **MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT**

## **CRUISE EX-14-01 Mission Systems Shakedown and Patch Test**

**Meme Lobecker<sup>1</sup>, Derek Sowers<sup>1</sup>**

March 28, 2019

<sup>1</sup>Cherokee Nation Strategic Programs, at NOAA Ocean Exploration and Research

## 1. Introduction

The NOAA Office of Ocean Exploration and Research (OER) is the only federal program dedicated to exploring our deep ocean, closing the prominent gap in our basic understanding of U.S. deep waters and seafloor and delivering the ocean information needed to strengthen the economy, health, and security of our nation.

Using the latest tools and technology, OER **explores** previously unknown areas of our deep ocean, making discoveries of scientific, economic, and cultural value. Through live video streams, online coverage, training opportunities, and real-time events, OER allows scientists, resource managers, students, members of the general public, and others to actively **experience** ocean exploration, expanding available expertise, cultivating the next generation of ocean explorers, and engaging the public in exploration activities. From this exploration, OER makes the collected data needed to **understand** our ocean publicly available, so we can maintain the health of our ocean, sustainably manage our marine resources, accelerate our national economy, and build a better appreciation of the value and importance of the ocean in our everyday lives.



# Contents

CRUISE EX-14-01 Mission Systems Shakedown and Patch Test .....	1
1. Introduction .....	2
2. Report Purpose .....	4
3. Cruise Objectives.....	4
4. Summary of Mapping Results .....	5
5. Mapping Statistics.....	8
6. Mapping Sonar Setup.....	9
7. Data Acquisition Summary.....	9
8. Multibeam Sonar Data Quality Assessment and Data Processing.....	10
9. Data Archival Procedures.....	12
10. Cruise Calendar .....	13
11. Daily Cruise Log Entries.....	14
12. References .....	16



## 2. Report Purpose

The purpose of this report is to briefly describe the acoustic seafloor and water column mapping data collection and processing methods used during exploration expedition EX-14-01, and to present a summary of the overall mapping results and mapping related cruise activities. A detailed description of the *Okeanos Explorer's* mapping capabilities is available in the 2014 NOAA Ship *Okeanos Explorer* Survey Readiness Report, available in the NOAA Central Library.

## 3. Cruise Objectives

The objectives for this cruise are fully detailed in the EX-14-01 Project Instructions, which are archived in the NOAA Central Library.

EX-14-01 was primarily focused on the annual ship and system shakedown and multibeam patch test operations, acoustic analysis of the multibeam transducers and ship noise profile by technicians from Gates Acoustics, and telepresence system shakedown items.



## 4. Summary of Mapping Results

### Cruise Overview Map



**Ocean Exploration  
and Research**

**EX-14-01  
Mission System Shakedown and Patch Test  
Cruise Summary Map**

February 6 - 9, 2014

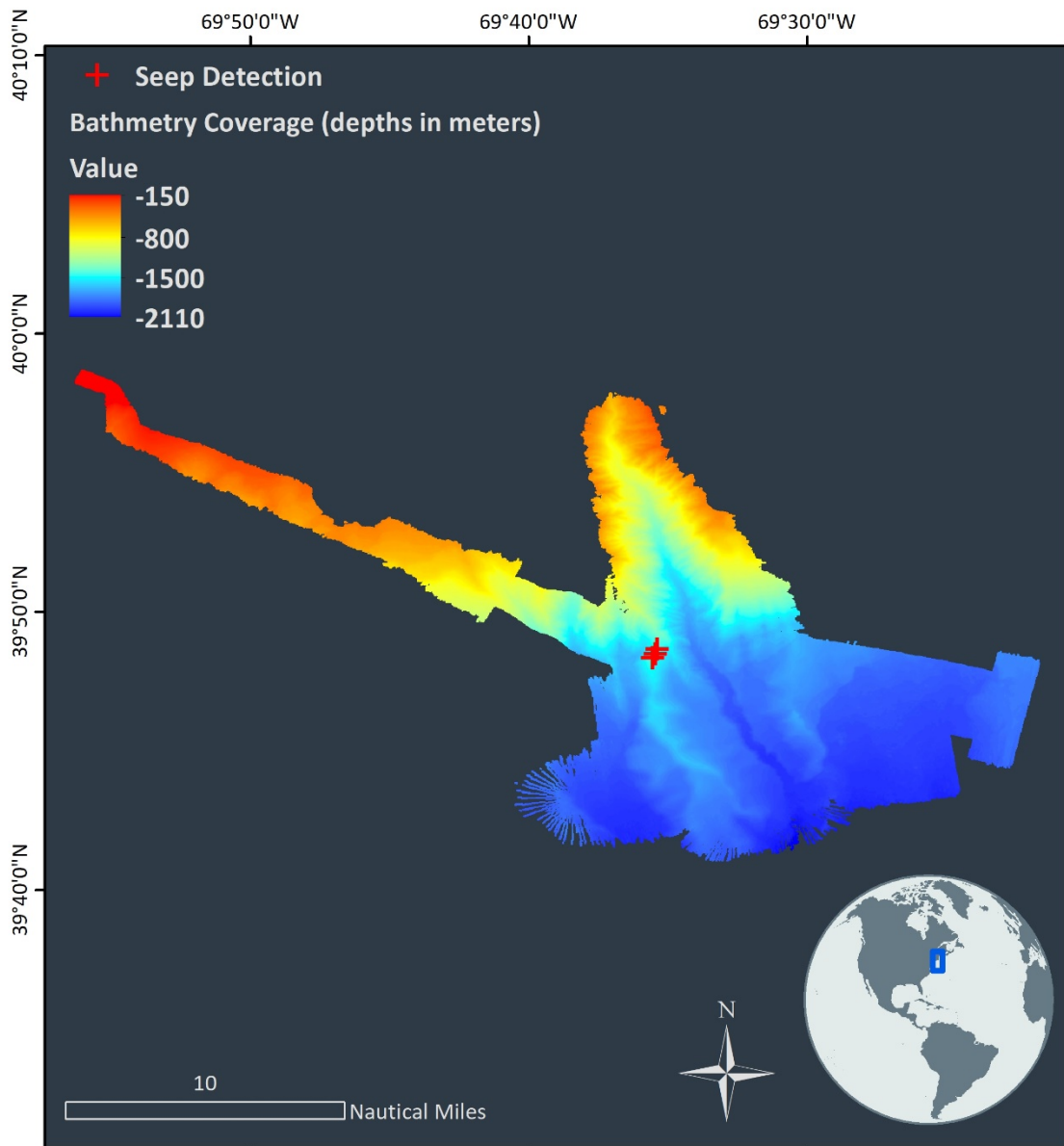


Figure 1. Cruise map showing overall EX-14-01 bathymetry coverage and Veatch Canyon seep locations. Bathymetry resolution 30 meters. Generated in ArcMap.



**Ocean Exploration  
and Research**

### *Veatch Canyon Seeps*

A group of seeps previously discovered by OER at Veatch Canyon were observed with several passes of EM 302 water column data.

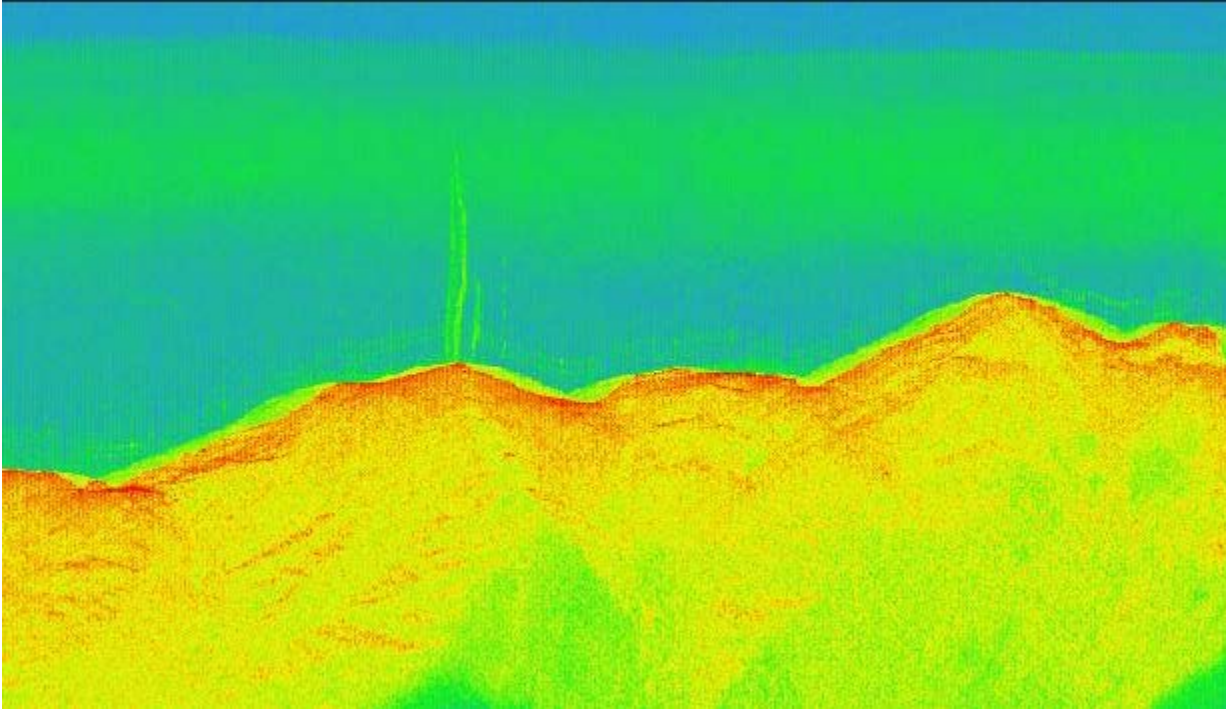


Figure 2. Screenshot showing Veatch Canyon seep group in raw EM 302 multibeam water column data in stack view of Fledermaus MidWater software.

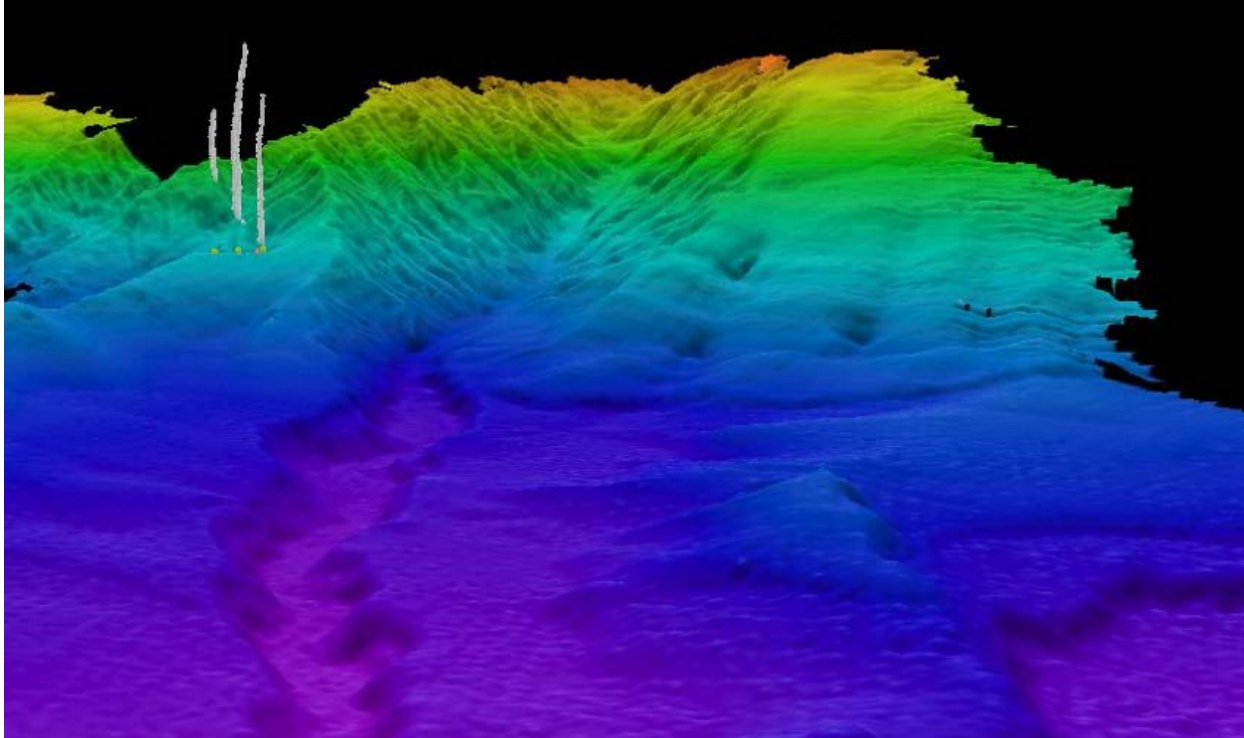


Figure 3. Screenshot showing perspective view of Veatch Canyon seep group in processed EM 302 water column data, overlain over bathymetry data, in QPS Fledermaus exploration view. Vertical exaggeration 3. Bathymetry resolution 30 meters.

### *Ship Acoustic Profile Testing*

The team from Gates Acoustics was onboard to analyze the acoustic operating profile of the multibeam sonar and ship. Hydrophones were lowered below the hull to record noise levels while the ship maneuvered at various speeds. Testing included cyclical securing of major systems including selected engines, A/C, all mission equipment, the mission UPS, sewage pumps, air compressors, fans, galley equipment, lighting, and the VSAT. Two acoustic anomalies were found, one at 33 kHz and one at 40 kHz. The 33 kHz anomaly was found to be the Doppler speed log. The source of the 40 kHz anomaly is unknown but out of the impact frequency range for the multibeam. The important results of the test are summarized below. The full report can be obtained by contacting the OER mapping team at [oar.oer.exmappingteam@noaa.gov](mailto:oar.oer.exmappingteam@noaa.gov).

- Propeller cavitation was determined to incept between 130 and 140 RPM (approximately 8-9 knots) but did not impact sonar acoustic levels
- Baseline EM 302 sonar levels were determined to be in the low 40 dB range
- Doppler speed log operation created a sonar degradation that will impact sonar performance
- Appendage cavitation was not detected at any time during the acoustic test.

- Initial acoustic results indicate the ship has an excellent sonar mount with very little bubble sweep down as compared to the other T-AGOS ships that Gates Acoustics has previously analyzed.
- During speed / noise tests conducted by mapping personnel last year, transients were observed to be concentrated at 7 and 8 knots. During the Gates team’s test, transients were observed throughout all speeds.

Following were the major recommendations from noise test:

- Turn off Doppler speed log during multibeam sonar operations
- Replace Doppler speed log during future availability with a higher frequency, quiet design model
- Continue to explore the source of 40 kHz band of energy detected in reference hydrophone data
- Acquire and install electronic equipment to provide the capability to listen to and process on board reference hydrophone data

The mapping team would like to express sincere kudos and thanks to the Chief Marine Engineer and the two Electronics Technicians onboard for providing great support during the acoustic testing.

## 5. Mapping Statistics

<b>Dates of cruise</b>	<b>February 6 – 9, 2014</b>
<b>Ship’s draft</b> <b>Start of cruise</b> <b>End of cruise</b>	<b>Fore: 15' 8", Aft: 14' 8"</b> <b>Fore: 14' 8"; Aft: 14' 6.5"</b>
<b>Linear kilometers of survey with EM 302</b>	<b>279</b>
<b>Square kilometers mapped with EM 302</b>	<b>445</b>
<b>Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)</b>	<b>35 files/ 1.8 GB</b>
<b>Number / Data Volume of EM 302 water column multibeam files</b>	<b>35 files / 6.7 GB</b>
<b>Number / Data Volume of EK 60 water column split beam files (.raw)</b>	<b>0 / 0GB</b>
<b>Number / Data Volume of sub-bottom sonar files (.segy, .kea, .keb)</b>	<b>0 / 0 GB</b>





<b>Number of XBT casts</b>	<b>5</b>
<b>Number of CTD casts (including test casts)</b>	<b>1</b>

## 6. Mapping Sonar Setup

### *Kongsberg EM 302 Multibeam Sonar*

The NOAA Ship *Okeanos Explorer* is equipped with a 30 kHz Kongsberg EM 302 multibeam sonar capable of detecting the seafloor in up to 8,000 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 a target, such as the seafloor or bubbles in the water column.

### *Kongsberg EK 60 Split-Beam Sonar*

The ship is also equipped with one Kongsberg EK 60 split-beam fisheries sonar. The 18 kHz transducer and transmits a 7° beam fan. This sonar is a quantitative scientific echosounder 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 sub-bottom 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 sub-seafloor stratigraphy and features while the bottom bathymetry is simultaneously being mapped by the multibeam sonar. The data generated by this sonar is fundamental to helping geologists interpret the shallow geology of the seafloor.

## 7. Data Acquisition Summary

EX-14-01 operations included EM 302 multibeam data collection and acoustic testing. A multibeam patch test was conducted at Veatch Canyon. Expendable bathythermographs were collected every two to four 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 a thermosalinograph. Data from these two systems was monitored for consistency throughout the cruise.

Tables listing all sonar files collected, products created, and ancillary support files created during the cruise are provided with the archived sonar datasets.

Neither the EK 60 split beam sonar nor the Knudsen 3260 sub-bottom profiler were operated for data collection during the cruise.

## 8. Multibeam Sonar Data Quality Assessment and Data Processing

Raw multibeam bathymetry data files were acquired by SIS, then imported into Caris HIPS and SIPS for processing. In Caris, attitude and navigation data stored in each file were checked, and erroneous soundings were flagged off. Gridded digital terrain models were created and posted to the ship's file transfer protocol (FTP) site for daily transfer to shore. Final bathymetry QC was completed post-cruise onshore at the Center for Coastal and Ocean Mapping at the University of New Hampshire. With the vast majority of surveying completed in deep water, depth measurements were not adjusted for tides, as they are an essentially insignificant percent of the overall water depth.

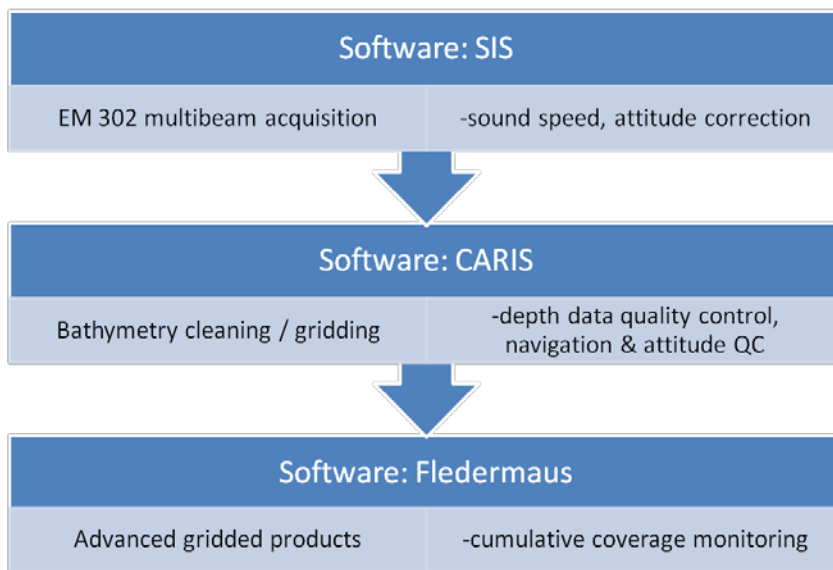


Figure 16. Shipboard multibeam data flow.

*Okeanos Explorer's* annual multibeam patch test was conducted at Veatch Canyon and the results are discussed below. This is the third annual patch test conducted by *Okeanos Explorer* at Veatch Canyon, providing a long term data set of this feature and the gaseous seeps present there.

A patch test was run on February 7<sup>th</sup> and 8<sup>th</sup> over Veatch Canyon. The previous year's angular offsets were applied and confirmed during the patch test. Pitch and roll stabilization were both enabled during the patch test. The results were analyzed by three experienced mapping scientists using the CARIS 7 Calibration Tool and the results are tabulated below.

Offset Test	Line Name	Speed (knots)	Heading	Offset
Timing	0006_20140207_214807_EX1401_MB.all	4.8	167	0
	0011_20140208_042113_EX1401_MB.all	8.6	167	
Pitch	0008_20140208_024149_EX1401_MB.all	8.6	347	-0.725
	0011_20140208_042113_EX1401_MB.all	8.6	167	
Heading	0014_20140208_061203_EX1401_MB.all	8.5	347	0
	0015_20140208_071202_EX1401_MB.all	8.4	347	
	0021_20140208_081024_EX1401_MB.all	9	167	
Roll	0030_20140208_203811_EX1401_MB.all	8.3	261	0
	0031_20140208_211216_EX1401_MB.all	8.4	082	

**Table 1. EM 302 transducer angular offset values determined during EX-14-01.**

*EM 302 Built In System Tests (BISTs)*

As part of the acoustic testing objectives of the cruise, fifty-five BISTs were run and are archived with the multibeam dataset.

*Crossline Analysis*

The Qimera Crosscheck analysis routine was utilized to compare gridded mainscheme data to raw crossline files.

The main scheme lines were:

- 0025\_20140208\_104816\_EX1401\_MB.all
- 0027\_20140208\_115037\_EX1401\_MB.all
- 0029\_20140208\_125547\_EX1401\_MB.all

The crossline file was:

0007\_20140207\_224806\_EX1401\_MB.all

The results showed data quality sufficient for International Hydrographic Organization Order 1 survey. Depths listed (“Z”) are in meters.

Number of Points of Comparison 299895

Data Mean -1804.194112

Reference Mean -1809.810009

Mean 5.615897

Median -23.731627

Standard Deviation 7.632425

Data Z – Range -2250.26 -1501.15

Ref. Z – Range -2030.15 -1532.89

Diff Z – Range -327.61 228.05

Mean + 2\*stddev 20.880746

Median + 2\*stddev 38.996476

Ord 1 Error Limit 23.532843

Ord 1 P-Statistic 0.002428

Ord 1 - # Rejected 728

**Order 1 Survey ACCEPTED**

## 9. Data Archival Procedures

All mapping data collected by the NOAA Ship *Okeanos Explorer* are archived and publically 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 the raw and processed data formats produced for this cruise) is available as an appendix in the EX-14-01 project instructions which is available in the NOAA Central Library.

Ancillary and supporting files are archived with the sonar datasets. These include:

*EM 302 Multibeam bathymetry and bottom backscatter dataset:*

- Mapping watch stander log
- Weather log
- Sound velocity profile log
- Multibeam acquisition and processing log
- Built-In-System-Tests (BISTs)



- Processor Unit Parameters
- Text files of telnet sessions on the EM 302 transceiver unit

*EM 302 Multibeam water column dataset:*

- Mapping watch stander log
- Weather log
- Sound velocity profile log
- Multibeam acquisition and processing log
- Built-In-System-Tests (BISTs)
- Processor Unit Parameters
- Text files of telnet sessions on the EM 302 transceiver unit
- MB WCD review log if data were reviewed for presence of seeps in Fledermaus MidWater

At the time of writing this report, the following DOIs were available as permanent links to sonar datasets:

EM 302 water column data <http://doi.org/10.7289/V54747VC>

EM 302 bathymetry data, supporting informational logs, and ancillary files are available in the NCEI Data Archives accessible at <https://www.ngdc.noaa.gov/> (last accessed 3/21/2019).

## 10. Cruise Calendar

*Generated from the daily expedition situation reports. All times listed are in local ship time which was Eastern Standard Time (EST) (-5 hours from Coordinated Universal Time (UTC)).*

February 2014						
Sun	Mon	Tues	Wed	Thur	Fri	Sat
		4 Gates Acoustics engineers began work onboard.	5 Mission personnel boarded the ship.	6 Departed for working grounds at Veatch Canyon.	7 Arrive Veatch Canyon. Commence acoustic testing. Commence multibeam patch test.	8 Acoustic testing and multibeam patch test completed. Commenced transit to port

					CTD conducted.	in the late evening.
9	Ship was alongside in RI by 1130. Final acoustic tests performed at dock. A cruise wrap up meeting was held. Mission personnel depart the ship.					

## 11. Daily Cruise Log Entries

Generated from the daily expedition situation reports. All times listed are in local ship time which was Eastern Standard Time (EST) (-5 hours from Coordinated Universal Time (UTC)).

All times listed are local ship time, which was -5 hours from UTC.

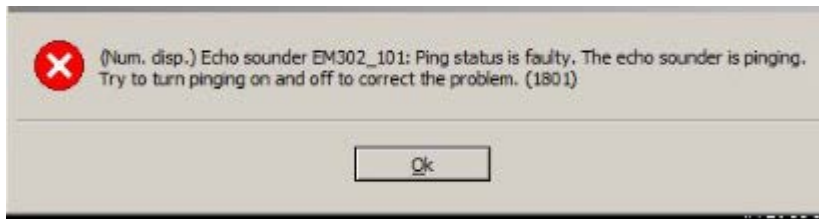
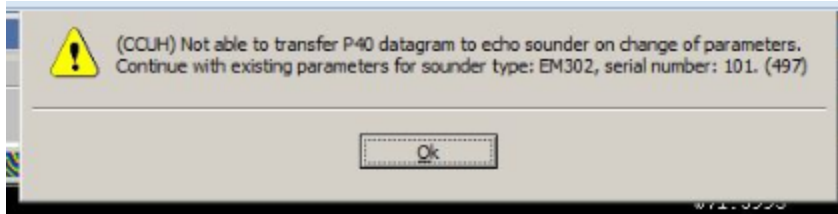
*February 5, 2014*

The ship was alongside in North Kingstown, Rhode Island, preparing for departure. Mission personnel boarded the ship. Acoustics engineers continued setting up equipment throughout mission and engineering spaces. Mapping computers, front and back row workstations, and network storage were woken up after being alongside for several months. A meeting was held with mission and ship personnel to review acoustic testing and multibeam patch testing plans.

*February 6, 2014*

The ship departed the dock at 0940. The compass was swung and the compass technician was transferred to shore via small boat transfer (EX1). Multibeam acoustic testing commenced in Narragansett Bay at 1410. The ship exited the Bay at 1729 and steamed towards Veatch Canyon.

Multibeam BISTs were run during compass swinging and passed after several instances of the following errors, which were also seen last year when Kongsberg tech was onboard during EX1302. These errors are observed every time SIS and the EM 302 TRU are restarted.



The first acoustic test cycle was conducted in calm water inside the bay and the results are under analysis. At 1729 the ship transited out of Narragansett Bay towards Veatch Canyon for deep water acoustic testing and the multibeam patch test.

Onboard NOAA Atlantic Hydrographic Branch visiting scientists are helping to update SOPs and working on workflow to streamline acceptance of EX data for charting as part of IOCM goals.

*February 7, 2014*

The ship arrived in the vicinity of Veatch Canyon at 0630 and deep water multibeam acoustic testing commenced. In the afternoon, the multibeam patch test commenced. In the evening a CTD was conducted.

The seas have been better than forecasted and test conditions have been favorable.

Drills were conducted including fire and abandon ship.

Upon reaching Veatch Canyon, deep water underway baseline acoustic testing was conducted. In the late morning, sea-state vs. heading testing (octagon) testing was conducted.

The multibeam patch test was completed with XBT sound speed profile. The CTD was not ready to be used prior to commencing the MB patch test.

A CTD was conducted in the evening using the seabird 911. Ancillary rosette sensors, for example the light scattering sensor, were not tested. An XBT was conducted for comparison.

The SCS software update was not completed before departure therefore SCS is not in use and the standard SCS dataset will not be available. TSG values for XBTs are read using HyperTerminal through SCS Server A.

*February 8, 2014*

The multibeam patch test at Veatch Canyon continued until breakfast. Gaseous seeps originally detected in 2012 and 2013 were observed again in the same vicinity during the patch test.

Acoustic noise testing commenced after breakfast and continued throughout the day. Final acoustic testing will be performed alongside on Sunday.

The multibeam patch test was completed in the evening and the ship began steaming to port. The patch test results confirmed the vessel offsets have not changed.

The seas have in general been better than forecast and test conditions have been favorable for all test types. Weather deteriorated slightly compared to yesterday.

*February 9, 2014*

The ship was alongside the pier in Quonset by 1130. Acoustic testing was conducted while the ship transitioned from ship to shore power and brought systems online. Mission spaces were cleaned and mapping data was finalized. Mission personnel departed the ship. An end of cruise meeting was held with all department heads to review completion of objectives outlined in the project instructions.

SCS software has been updated but is not running / has not been tested yet.

## **12. References**

The 2014 NOAA Ship *Okeanos Explorer* Survey Readiness Report can be obtained in the NOAA Central Library or by contacting the NOAA OER mapping team at [oar.oer.exmappingteam@noaa.gov](mailto:oar.oer.exmappingteam@noaa.gov).

The EX-14-01 Project Instructions can be obtained from the NOAA Central Library. The EX-14-01 Data Management Plan is an appendix of the project instructions.

EM 302 water column data <http://doi.org/10.7289/V54747VC>



EM 302 bathymetry data, supporting informational logs, and ancillary files are available in the NCEI Data Archives accessible at <https://www.ngdc.noaa.gov/> (last accessed 3/21/2019).

The following was used for reference throughout the cruise:

[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.](#)

NOAA Nautical Charts

