

MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

CRUISE EX-12-01 Ship Shakedown and Patch Test Canyons and Continental Margin Exploration (Mapping)

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March 28, 2019

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1. Introduction

The NOAA Office of Ocean Exploration and Research 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.



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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-12-01, and to present a summary of the overall mapping results and mapping related cruise activities.

3. Cruise Objectives

EX-12-01 primarily focused on conducting a shakedown of the mapping systems onboard NOAA Ship *Okeanos Explorer*. The ship transited from Davisville, Rhode Island to Charleston, South Carolina. Multibeam and split-beam mapping operations were conducted 24 hours a day. The purpose of the EX-12-01 shakedown was to ensure that all vessel systems and mission equipment are fully operational and prepared for the 2012 field season. As part of the shakedown, a patch test for the EM 302 was conducted in the vicinity of Veatch Canyon. The sub-bottom profiler and EK 60 were also tested and found to be in satisfactory operating condition.

In addition to testing the mapping systems, focused mapping operations were also conducted over Toms, Berkley, and Hendrickson Canyons to supplement existing mapping coverage.

The objectives for this cruise are further detailed in the EX-12-01 Project Instructions, which are archived in the NOAA Central Library.



4. Summary of Mapping Results

Cruise Overview Map



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EX-12-01 Ship Shakedown / Patch Test Canyons and Continental Margin Exploration (Mapping) Cruise Summary Map

February 14 - 23, 2012

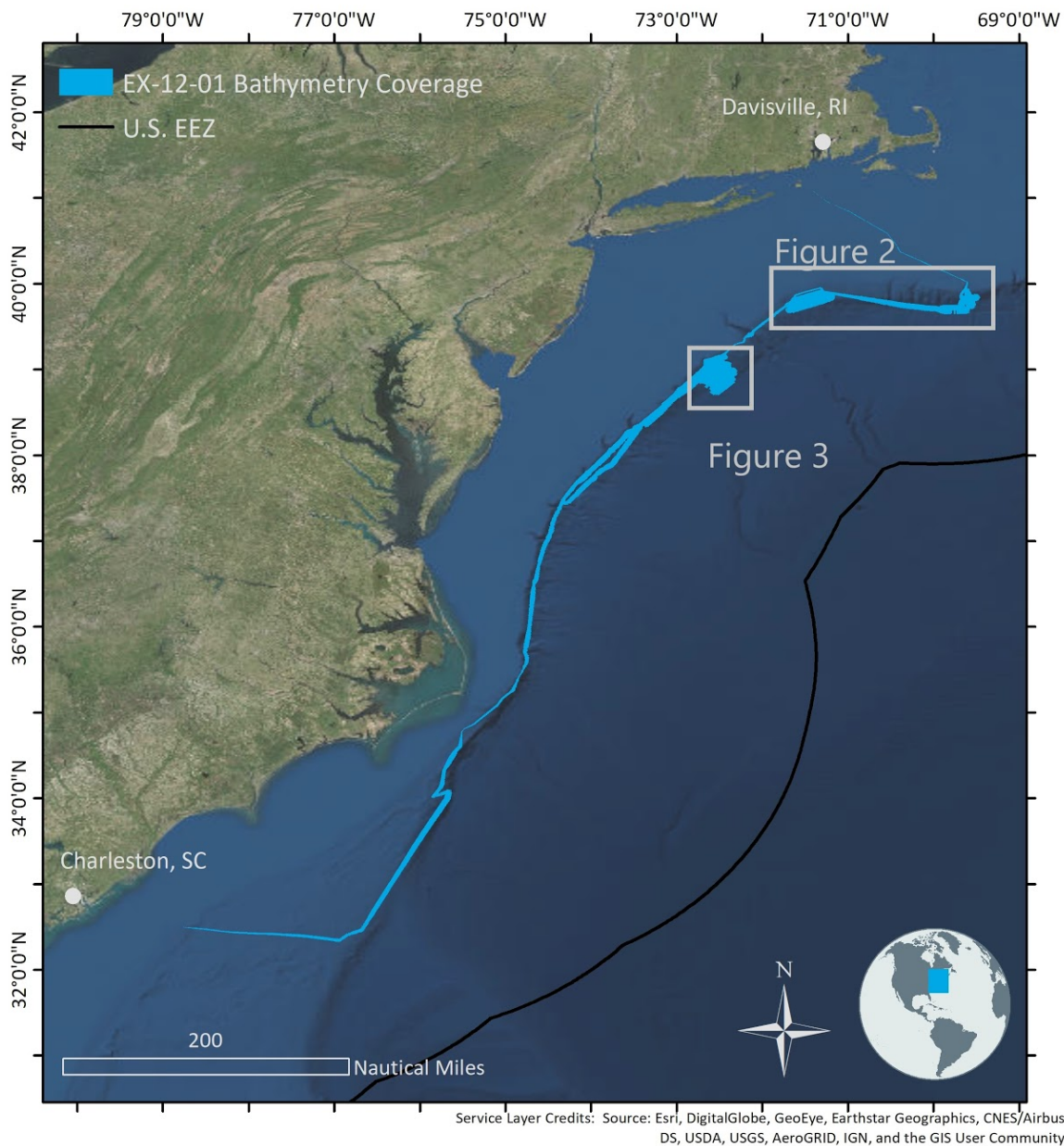


Figure 1. Cruise map showing overall EX-12-01 bathymetry coverage. Generated in ArcMap.



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The results of surveys over Veatch, McMaster and Ryan canyons are shown in Figure 2. The focused surveys over Toms, Berkley, and Hendrickson Canyons are displayed in Figure 3. These focused mapping efforts covered areas identified as habitat mapping priorities by NOAA Northeast Fisheries Science Center (NEFSC). These data will provide base layer habitat information (bathymetry, bottom backscatter, water-column backscatter) to support management efforts.

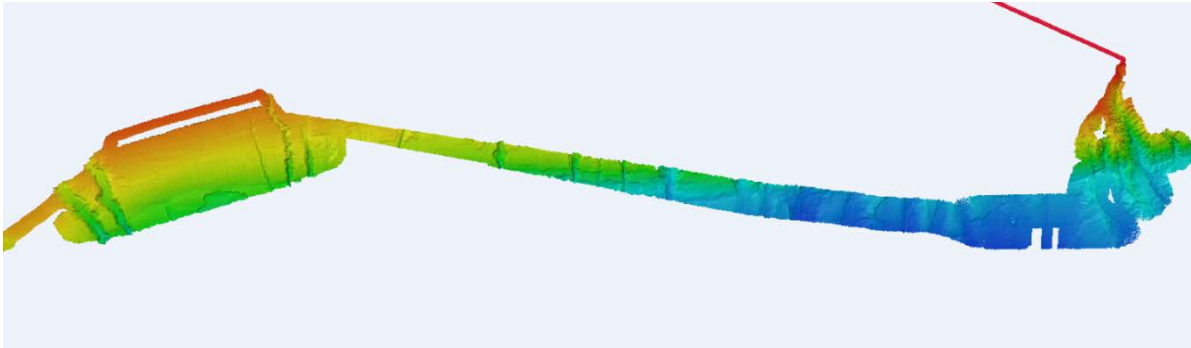


Figure 2. Map of bathymetry data collected at Veatch, McMaster, and Ryan submarine canyons.

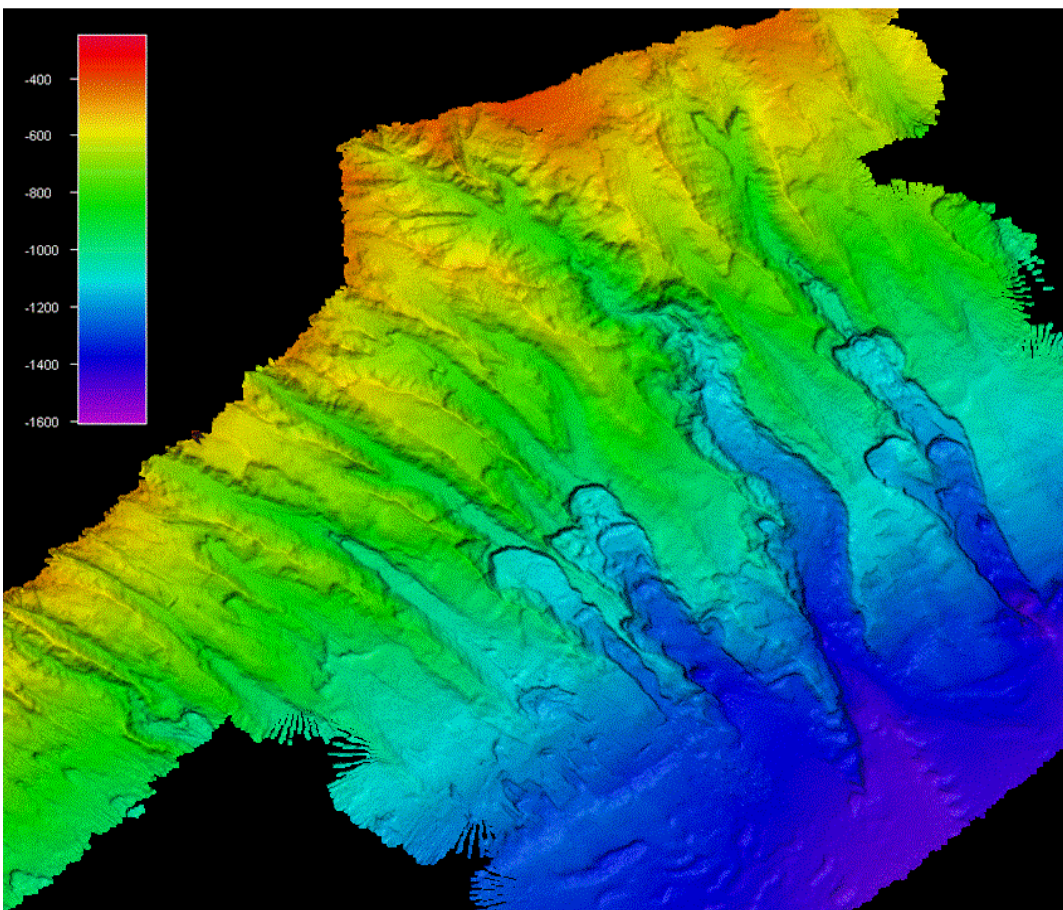


Figure 3. Bathymetry collected at Toms, Berkley, and Hendrickson submarine canyons. Depth scale in meters. Image created in QPS Fledermaus.

5. Mapping Statistics

Dates of cruise *first day of sonar data collection	Feb 14 – 23, 2012
Ship's draft Start of cruise (02/14/2012) End of cruise (02/23/2012)	Fore: 14' 5", Aft: 14' 5" Fore: 13' 9"; Aft: 15' 01"
Linear kilometers of survey with EM 302	2,902
Square kilometers mapped with EM 302	10,097
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)	105 files/ 25 GB
Number / Data Volume of EM 302 water column multibeam files	103 files / 67 GB
Number / Data Volume of EK 60 water column split beam files (.raw)	40 / 1.9 GB
Number / Data Volume of sub-bottom sonar files (.segy, .kea, .keb)	10 / 0.1 GB
Number of XBT casts	70
Number of CTD casts (including test casts)	5



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 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 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 the sedimentary features and the bottom topography that 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

Mapping operations included EM 302 multibeam, EK 60 split-beam, and Knudsen sub-bottom profile data collection.

Survey lines were planned to maximize either bathymetry edge matching of existing data or data gap filling in areas where existing bathymetry coverage existed. In regions with no existing data, lines were planned to optimize potential exploration discoveries.

Throughout the cruise, multibeam data quality was monitored in real-time by acquisition watchstanders. Ship speed was adjusted to maintain data quality as necessary and line spacing was planned to ensure at



least ¼ swath width overlap between lines. Cutoff angles in SIS were generally left wide open for maximum exploration data collection and were adjusted on both the port and starboard side to ensure the best data quality and coverage. Data were corrected for sound velocity in realtime using the Reson SVP-70 data at the sonar head, and profiles from Expendable Bathythermographs (XBTs) that were conducted at intervals no greater than 6 hours, or as dictated by local oceanographic conditions.

Simrad EK 60 18 kHz split-beam water column sonar data were collected continuously during the cruise. The screenshot below shows data holdings in www.ncei.noaa.gov (last accessed 4 April 2019).

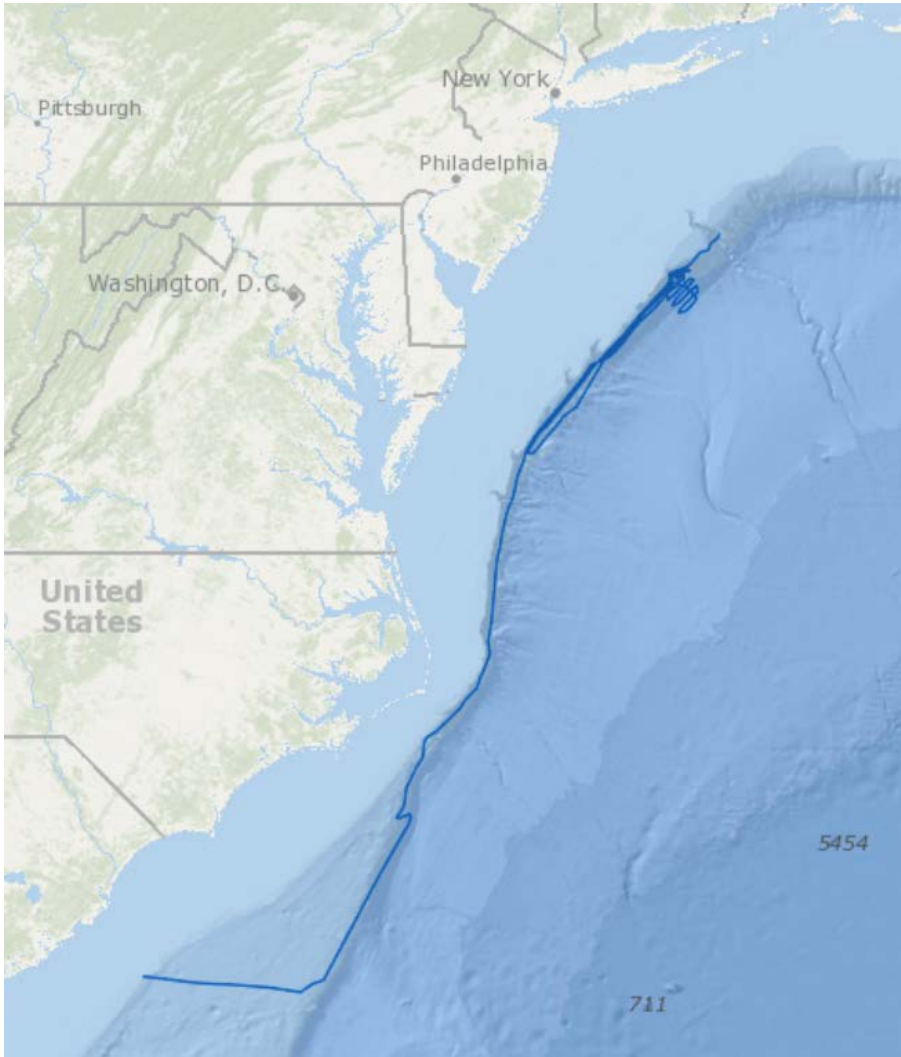


Figure 4. Screenshot of Simrad EK 60 18 kHz split-beam sonar data tracklines in blue collected during EX-12-01.

Knudsen 3260 sub-bottom profiler data were collected briefly for system verification purposes only. The screenshot below shows data holdings in www.ncei.noaa.gov (last accessed 4 April 2019).

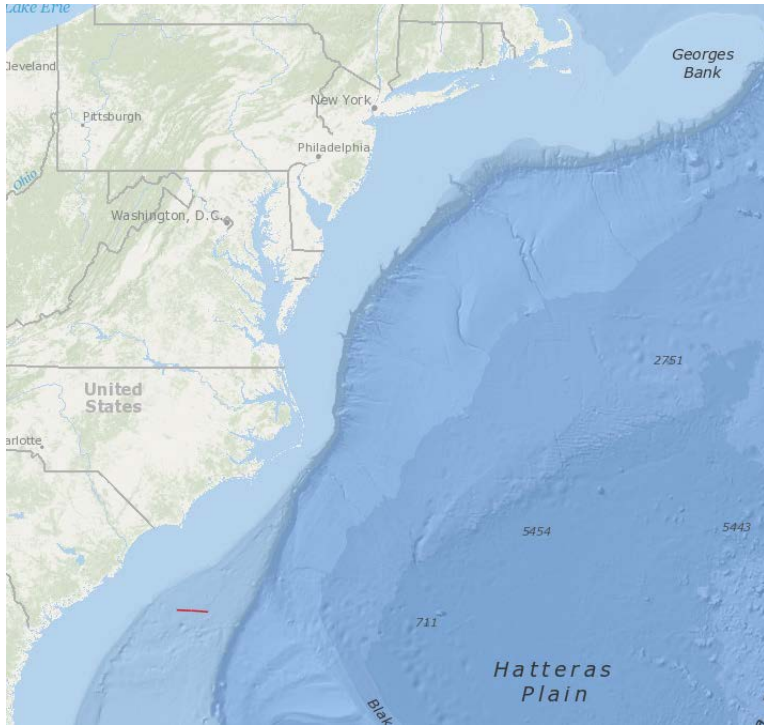


Figure 5. Screenshot of sub-bottom profiler data tracklines in red collected during EX-12-01 (off the coast of South Carolina).

8. Multibeam Sonar Data Quality Assessment and Data Processing

EM 302 Built-in Self Tests (BISTs) were run throughout the cruise to monitor multibeam sonar system status and are available as ancillary files in the sonar data archives. 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 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.

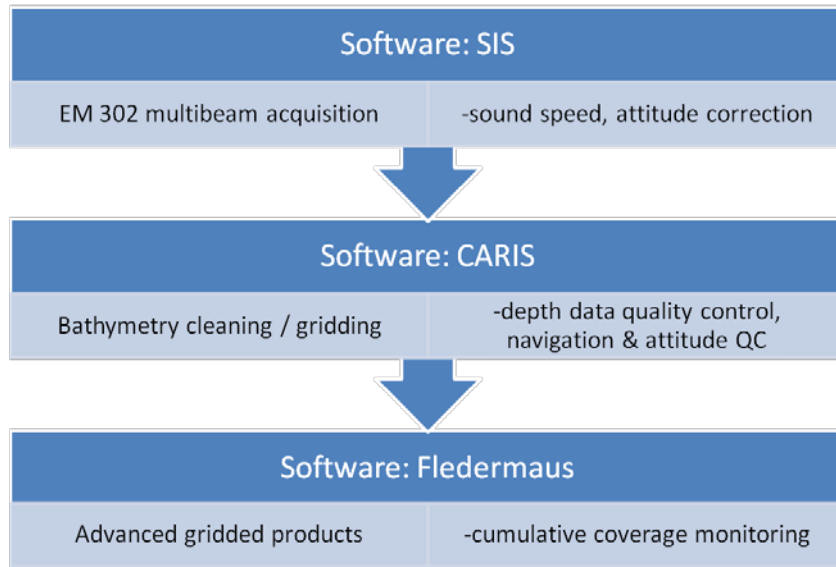


Figure 16. Shipboard multibeam data flow.

Crosslines

Comparing depth values from orthogonal survey lines is a standard hydrographic quality control measure to evaluate the consistency of the multibeam sonar data being collected during a cruise. Crossline analysis was conducted using the Crosscheck Tool in QPS Qimera software.

The mainscheme crosslines were:

0008_20120215_152137_EX1201_MB.all
 0009_20120215_172143_EX1201_MB.all
 0010_20120215_205419_EX1201_MB.all
 0012_20120216_000150_EX1201_MB.all
 0013_20120216_014354_EX1201_MB.all
 0014_20120216_042853_EX1201_MB.all
 0016_20120216_061658_EX1201_MB.all

The crossline was:

0020_20120216_095620_EX1201_MB.all

The statistical results are below, with depth (z) values in meters.

253869 # Number of Points of Comparison
 -1490.692319 # Data Mean

-1490.717234 # Reference Mean
 0.024916 # Mean
 -2.937221 # Median
 6.335483 # Std. Deviation
 -1888.01 -959.57 # Data Z – Range
 -1880.98 -947.35 # Ref. Z – Range
 -65.99 57.23 # Diff Z – Range
 12.695882 # Mean + 2*stddev
 15.608187 # Median + 2*stddev
 19.385773 # Ord 1 Error Limit
 0.019234 # Ord 1 P-Statistic
 4883 # Ord 1 - # Rejected
Order 1 Survey ACCEPTED

EM 302 Patch Test

A multibeam patch test was conducted over Veatch Canyon southeast of Rhode Island. The patch test was run with the previous year’s transducer offsets applied. The results of the patch test were analyzed in both SIS Calibration Mode and with the CARIS Calibration Tool. The offsets were determined to have not changed from previous years’ patch test results.

The navigation time error and pitch biases were determined by running a single line in opposite directions at two speeds over a section of Veatch Canyon with slopes of up to 30°. It was determined there is no timing offset present in the navigation and timing system. The pitch offset was confirmed to be -0.0725.

The roll bias was determined by running a single line at the same speed over a flat area in 2075 meters of water in opposite directions. It was confirmed that there is no roll offset in the installation.

The heading bias was determined by running a pair of parallel lines offset from each other by 3.5 kilometers. The lines each ensonified the steep sides of Veatch Canyon in their outer beams. The lines were run in the same direction and at the same speed across the canyon. It was confirmed that there is no heading offset in the installation.

9. Data Archival Procedures

All mapping data collected by the NOAA Ship *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 the raw and processed data formats

produced for this cruise) is available as an appendix in the 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 watchstander 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

Simrad EK split-beam water column dataset:

- Mapping watchstander log
- Weather log
- EK data log

Knudsen 3260 Sub-bottom Profiler dataset:

- Mapping watchstander log
- Weather log
- Sub-bottom data log

EM 302 Multibeam water column dataset:

- Mapping watchstander 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/V5VT1Q1N>

EK 60 data <http://doi.org/10.7289/V50K26HX>

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

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

February 2012						
Sun	Mon	Tues	Wed	Thur	Fri	Sat
	13 Alongside in Davisville, RI. Divers inspected ship hull and sonar installation.	14 Departed Davisville, RI.	15 Commenced patch test.	16 Completed patch test. Block, Ryan, and McMaster Canyons mapping.	17 Transit to Toms Canyon.	18 Toms, Berkley, and Hendrickson Canyons mapping
19 Toms, Berkley, and Hendrickson Canyons mapping.	20 Transit mapping to SC along shelf break.	21 Transit mapping to SC along break.	22 Transit mapping to Charleston, SC over the shelf. All sonars secured at 2130.	23 Arrived at Charleston sea buoy ~ 0400.	24 Mission crew departs 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 Daylight Savings Time (EDT) (-4 hours from Coordinated Universal Time (UTC))

Feb 13, 2012

The ship is alongside at the port Davisville, RI. The EM 302 multibeam sonar has passed a BIST and is functioning as expected in alongside test. The EX60 singlebeam sonar is showing full functionality in alongside testing. The XBT system is fully operational and passed its standard testing protocol.

Mission personnel were assigned watches and trained in control room and XBT cast procedures as well as multibeam acquisition, and processing.

Divers conducting maintenance on the EX seachests recorded video of the EM 302 transducers which indicates that they are substantially free of biofouling. The minimal biofouling that was observed on the transducers was weakly attached algae, which is expected to wash off when the ship is underway. It was noted that the Belzona fairing compound around the transducers is in serviceable condition but will likely need to be replaced the next time the ship is in dry dock.

Feb 14, 2012

At 1510 the EX departed the Port of Davisville, RI bound for the Atlantic, and at approximately 1700 it cleared the Narragansett Bay sea buoy. Multibeam data collection commenced at approximately 1900 in 40 meters of water. Initial mapping watches have focused on training mission personnel in control room operations as well as the acquisition of multibeam data and sound velocity profiles.

Multibeam bathymetry data quality is high, with consistent bottom detection swath coverage. Due to observed water mass variability, XBT profiles are being collected every three hours, or more often as required in shallow water survey areas. However, sound velocity artifacts continue to be observed in the data due to shallow water and frequently changing water mass. The EX is presently mapping the continental shelf southeast of Rhode Island.

Feb 15, 2012

At approximately 0700 the EX arrived at the northern boundary of the patch test survey area in the vicinity of Veatch Canyon. At 0830 a CTD cast was conducted followed immediately by the commencement of the EM 302 sonar patch test. At approximately 1545 a second CTD cast was conducted at the deeper southern boundary of the patch test area. The first phase of the patch test concluded at 2200 and the time delay, as well as pitch calibration offsets, were subsequently calculated. Both values exhibited no change from the 2011 patch test results and accordingly, no offset changes were applied.

Continuous multibeam data collection is being conducted as part of the patch test procedure. Multibeam bathymetry data quality is high, with consistent bottom detection and wide swath coverage. Due to



significant observed variability in sea water salinity and temperature, XBT profiles are being collected every three hours, or less as dictated by physical oceanographic conditions.

Feb 16, 2012

At approximately 0900 the patch test survey was completed and the heading and roll offsets were calculated. Both values exhibited no change from the 2011 patch test results and accordingly, no offset modifications were applied. After the conclusion of the patch test the EX joined the canyon trackline and proceeded to the west along the continental shelf break. At approximately 2130 the EX departed the canyon trackline and commenced a focused survey over Block, Ryan, and McMaster Canyons.

The EX is presently mapping the continental shelf break approximately 90 miles south of Block Island, Rhode Island. Focused survey mapping of Block, Ryan, and McMaster Canyons continues.

Feb 17, 2012

The 1000 forecast indicated that gale force conditions were expected in the EX planned operating area for Sunday through Monday. Accordingly, the focused survey area over Block, Ryan, and McMaster Canyons was concluded early and the ship proceeded to the south along the canyon track line, with the intention of being south of Cape Hatteras by early on Sunday. Transit mapping was conducted along the canyon track line for the remainder of the day as the ship traveled south. While transiting the EK 60 split-beam sonar was powered up. It appears to be fully operational and data quality is good.

Feb 18, 2012

At the 0800 safety meeting, the latest forecast showed that the predicted storm tracks had evolved significantly from the previous day. The new forecast indicated that the most prudent course of action would be to remain north of Cape Hatteras through Monday (2/20). Accordingly, at 1148 the EX turned 180° and proceeded back to the northeast one swath width offshore of the canyon trackline. At approximately 2030 the EX departed the canyon trackline and commenced a focused survey over Toms, Berkley, and Hendrickson Canyons.

Feb 19, 2012

The EX conducted a focused survey over Toms, Berkley, and Hendrickson Canyons through 1930. At the conclusion of the survey the ship rejoined the canyon trackline and proceeded to the southwest at approximately 10 knots. The ships transit speed may be slowed overnight in order to allow a strong low pressure system over the Carolina Capes to move seaward of the planned trackline.

Feb 20, 2012

The EX proceeded to the south-southwest along the canyon trackline through the day. Early in the day the EX passed to the west of a substantial low pressure system and experienced gale force conditions which

diminished into the afternoon and evening hours. The Knudsen sub-bottom profiler was operated continuously between 1000 and 1600 and is fully functional.

Feb 21, 2012

The EX proceeded to the south-southwest along the canyon trackline through the day. Winds and sea state abated through the day but were locally higher in the Gulf Stream. The EX is presently mapping the continental shelf break approximately 190 kilometers east of Cape Romain, South Carolina.

Feb 22, 2012

The EX departed the shelf break canyon line at approximately 0500 and turned to the west-southwest towards Charleston, SC. The EX spent the remainder of the day crossing the shelf and is expected to arrive at the Charleston Harbor sea buoy at approximately 0400 on 2/23. Winds and sea state abated through the day but were locally higher near storms. At 2130 all sonars were secured for the remainder of the cruise due to shallow water and rapidly degrading data quality.

Feb 23, 2012

The EX arrived at the Charleston sea buoy at approximately 0400 and was alongside at port of Charleston Union Pier Terminal at approximately 0900. All data processing was completed and all cruise data were copied to OER drives.

12. References

The 2012 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.

The EX-12-01 Project Instructions can be obtained from the NOAA Central Library. The EX-12-01 Data Management Plan is an appendix of the project instructions.

EM 302 water column data <http://doi.org/10.7289/V5VT1Q1N>

EK 60 data <http://doi.org/10.7289/V50K26HX>

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

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

