Ocean Exploration and Research

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MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

EX-14-04 Leg 2: Our Deepwater Backyard: Exploring the Atlantic Canyons and Seamounts *(ROV and VIPs)*

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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 the remotely operated vehicle (ROV) and mapping expedition EX-14-04 Leg 2, 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

EX-14-04 Leg 2 is the second of four 2014 cruises focused on collecting baseline characterization data in poorly understood areas along the New England Seamount chain and US northeast continental shelf canyons. This cruise focused on conducting engineering trials of the ROV, outreach events for very important personnel (VIPs) onboard, and transit and overnight mapping operations.

EX-14-04 Leg 2 commenced in North Kingstown, RI on September 4, 2014 and concluded in Baltimore, MD on September 10, 2014. Mapping operations utilized the ship's deep water systems (Kongsberg EM 302 multibeam sonar, EK 60 split-beam fisheries sonar, and Knudsen 3260 chirp sub-bottom profiler), as well as the ship's high-bandwidth satellite connection for daily transfer of incoming sonar data to shoreside backups.

The complete objectives for this cruise are detailed in the EX-14-04 Legs 2 and 3 Project Instructions, which are archived in the NOAA Central Library.

4. Summary of Mapping Results

EX-14-04 Leg 2 mapped 245 square kilometers of seafloor during the 7 days at sea (Figure 1 and Table 1).

Cruise Overview Map

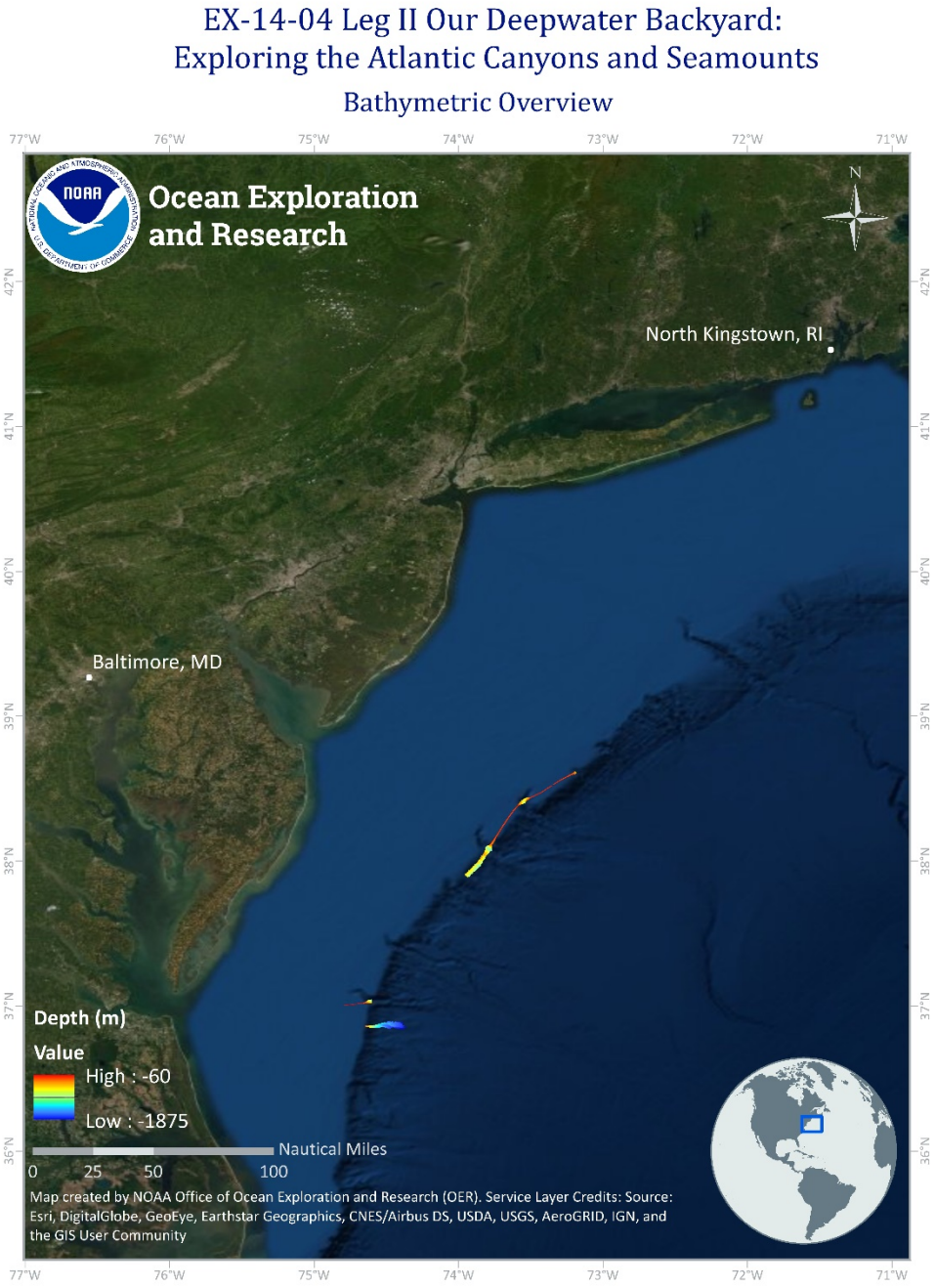

Figure 1. Overview of bathymetric mapping coverage completed during EX-14-04 Leg 2.

5. Mapping Statistics

Table 1. Summary statistics of ocean mapping work completed during EX-14-04 Leg 2.

Dates of cruise	**September 04 – 10, 2014**
Linear kilometers of survey with EM 302	**172**
Square kilometers mapped with EM 302	**245**
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)	**29 files/ 1.9 GB**
Number / Data Volume of EM 302 water column multibeam files	**28 files / 5.12 GB**
Number / Data Volume of EK 60 water column split beam files (.raw)	**22 / 711 MB**
Number / Data Volume of sub-bottom sonar files (.segy, .kea, .keb)	**88 / 568 MB**
Number of XBT casts	**5**
Number of CTD casts (including test casts)	**0**

6. Mapping Sonar Setup

Kongsberg EM 302 Multibeam Sonar

NOAA Ship *Okeanos Explorer* is equipped with a 30 kilohertz (kHz) Kongsberg EM 302 multibeam sonar capable of detecting the seafloor in up to 10,000 meters of water and conducting productive mapping operations in 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 shoaler than 3300 meters the system is operated in 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 data. Backscatter represents the strength of the acoustic signal reflected from a target, such as the seafloor or bubbles in the water column. The system is patch tested annually and the results are reported in the annual readiness report. The 2014 NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report is available in the NOAA Central Library.

Simrad EK60 Split-beam Sonar

The ship operated an 18 kHz Simrad EK60 split-beam fisheries sonar. 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. This sonar was calibrated on the EX-14-02 Leg I cruise, and calibration values from that cruise were applied to the EK sonar for EX-14-04 Leg 2. The 2014 EK 60 Calibration Report is available in the NOAA Central Library.

Knudsen 3260 Sub-bottom Profiler

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 approximately 80 meters below the seafloor. The sub-bottom profiler is normally operated to provide information about sub-seafloor stratigraphy and features. The data generated by this sonar are fundamental to helping geologists interpret the shallow geology of the seafloor.

7. Data Acquisition Summary

Mapping operations included data collection via the EM 302 multibeam sonar, EK 60 split-beam sonar, and Knudsen 3260 sub-bottom profiler. Data were collected by each sonar concurrently during mapping operations.

Survey lines were planned to either maximize edge matching of existing bathymetric data, or to fill data gaps in areas with existing bathymetric coverage. 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 the multibeam acquisition software Seafloor Information System (SIS) were generally left wide open for maximum exploration data collection and routinely adjusted on both the port and starboard side to ensure the best data quality and coverage.

Multibeam data received real time surface sound velocity corrections via the Reson SVP-70 probe at the sonar head, as well as through profiles generated from Expendable Bathythermographs (XBTs) conducted at intervals no greater than 6 hours, as dictated by local oceanographic conditions. Reson sound velocity values were constantly compared against secondary derived sound speed values from the ship's onboard thermosalinograph flow-through system as a quality assurance measure.

Simrad EK 60 split-beam water column sonar data were collected throughout the majority of the cruise. Data were monitored in real time for quality but were not post-processed.

Knudsen 3260 sub-bottom profiler data were also collected during the majority of the cruise.

8. Multibeam Sonar Data Quality Assessment and Data Processing

Figure 2 shows the multibeam data processing workflow for this cruise. 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 in SIS, then imported into CARIS HIPS for processing. In CARIS, the attitude and navigation data stored in each file were checked, and erroneous soundings were removed using Swath Editor and Subset Editor. 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. Data cleaning projects were in UTM zone projections for the operations area. Final data products were exported and archived as field geographic WGS84 coordinate reference frame (i.e., unprojected).

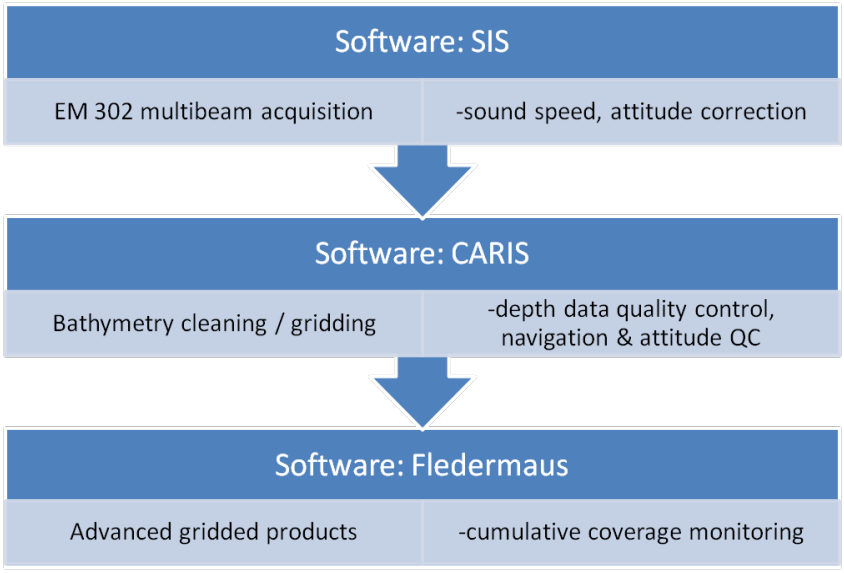

Figure 2. Shipboard multibeam data processing workflow.

Crosslines

Comparing depth values from orthogonal survey lines is a standard hydrographic quality control measure to evaluate the consistency of the multibeam sonar data collected during a cruise. A crossline was run on September 8 as shown in Figure 3. A crossline analysis was completed using the Crosscheck Tool in QPS Qimera software to verify that the survey meets the requirements for an International Hydrographic Order 1 survey. The results are shown below.

Crossline file:

0026_20140908_224339_EX1404L2.all

Mainscheme line files:

0014_20140908_195750_EX1404L2.all

0017_20140908_202446_EX1404L2.all

0018_20140908_203853_EX1404L2.all

Statistic	Value
Number of points of comparison	216,859
Grid Cell Size	50.00
Difference Mean	-0.512
Difference Median	-0.215
Difference Std. Dev	4.224
Difference Range	[-130.27, 88.58]
Mean + 2*Stddev	8.959
Median + 2*Stddev	8.662
Data Mean	-1555.869
Reference Mean	-1555.357

Data Z-Range	[-1748.18, -1364.15]
Reference Z-Range	[-1741.30, -1368.28]
Order 1 Error Limit	20.226
Order 1 # Rejected	840
Order 1 P-Statistic	0.0039
Order 1 Survey	**ACCEPTED**

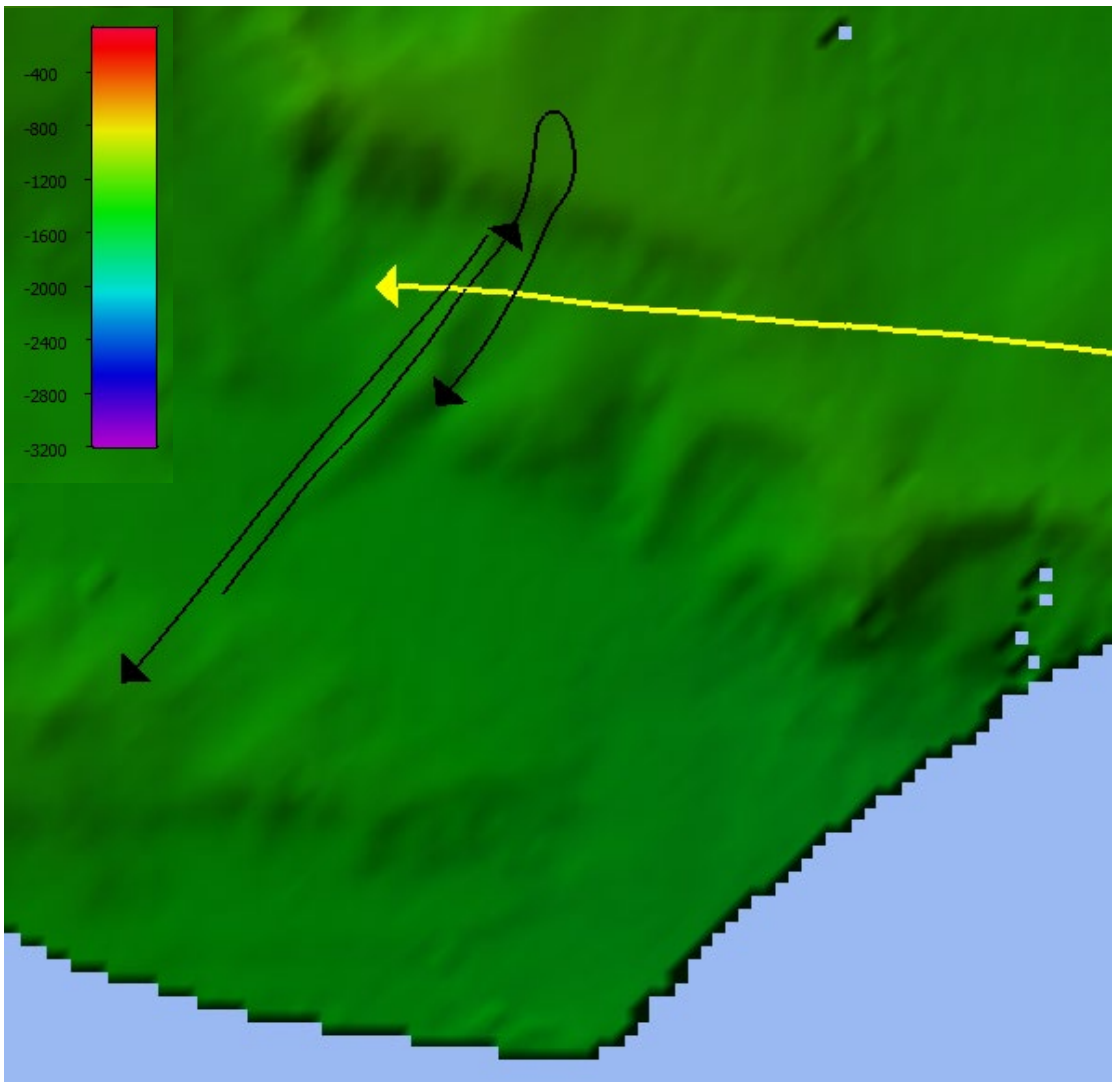

Figure 3. EX-14-04 Leg2 crossline (shown in yellow) used for comparison against the 50-meter bathymetric grid generated via orthogonal multibeam survey lines.

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 EX-14-04 Leg 2 and 3 project instructions, 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:

- Sound velocity profile log
- Multibeam acquisition and processing log

Simrad EK split-beam water column dataset:

- EK data log

Knudsen 3260 Sub-bottom Profiler dataset:

- Sub-bottom data log

EM 302 Multibeam water column dataset:

- Sound velocity profile log
- Multibeam acquisition and processing log
- Multibeam water column data review log if data were reviewed for presence of seeps in Fledermaus MidWater

All sonar data is permanently discoverable at https://maps.ngdc.noaa.gov/viewers/bathymetry/.

EM 302 water column data are available in the NCEI Water Column Sonar Archives: https://www.ngdc.noaa.gov/maps/water_column_sonar/index.html (last accessed 02/03/2020).

- EK 60 water column data can be found directly here: doi:10.7289/V5V40S50
- EM 302 water column data can be found directly here: doi:10.7289/V5DZ0690

Sub-bottom data, supporting data, and informational logs are available in the NCEI Trackline Geophysical Data portal at https://maps.ngdc.noaa.gov/viewers/geophysics/

(last accessed 02/03/2020). For assistance in accessing SBP data, send an inquiry to ncei.info@noaa.gov requesting access to EX-14-04 Leg 2 Knudsen 3260 sub-bottom raw and processed data.

EM 302 bathymetry data, supporting informational logs, and ancillary files are available in the NCEI Data Archives accessible at https://maps.ngdc.noaa.gov/viewers/bathymetry/(last accessed 02/03/2020).

10. Cruise Calendar

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

September 2014

Sun	Mon	Tues	Wed	Thur	Fri	Sat
				4 Departed Rhode Island. Transit to first ROV dive site.	5 Overnight and transit mapping between ROV dive sites.	6 Transit mapping.
7 Transit mapping. VIP demonstrations.	8 Transit mapping to ROV site.	9 VIPs return to shore. Ship preparations for Star Spangled Spectacular event.	10 Ship alongside in Baltimore.			

11. Daily Cruise Log Entries

Generated from the daily expedition situation reports. All times listed are in local ship time (-5 hours from UTC)

September 4

The ship departed from Rhode Island towards the first dive site. Several initial Built-in Self Tests (BISTs) of the EM 302 had partial failures due to being unable to connect to over half of the TX36 boards. After two full system restarts of the transmit-receive unit (TRU) and EM 302 computer, tightening the 220v power cables, and letting the system warm up for 10 minutes, the first fully successful BIST was run. For several hours a routine of pinging, cease pinging, running a BIST was conducted, with all BISTs passing and all pinging resulting in good bottom detection (in shallow water). Kongsberg has 4 refurbished TX36 boards available, which will need to be installed in the TRU in Baltimore, and the removed boards returned to Kongsberg. A larger overhaul of the system over the winter is likely, potentially replacing all 24 TX 36 boards and their subrack.

September 5

The EM 302 ran well after two reboots of the TRU and computer. The initial BIST after the first boot failed, all subsequent BISTs after the second reboot passed, and the system ran well in 150-800 meters of water. The EK 60 and sub-bottom profiler were run in the evening and are performing well.

September 6

The EM 302 booted cleanly and passed all BISTs after warming up for 15 minutes. Data were collected during the transit to shore for VIP pickup, including over canyon heads of the Baltimore and Norfolk Canyons. Heading calibration lines to test the POS MV antenna reseating were unable to be run due to a transformer fire that necessitated the transit directly to shore.

September 7

The EM 302 ran as the ship transited from shore to the dive site at Norfolk Canyon. The TRU was powered up for approximately 2 hours prior to running a BIST. The BIST passed, and pinging was successful including the starting and stopping of pinging three times. An additional BIST was run upon reaching the dive site, and all tests passed with the exception

of RX noise due to ultra-short baseline (USBL) interference. Mapping systems were demonstrated to onboard VIPs.

September 8

Mapping data were collected in the vicinity of the third dive site. Mapping systems were demonstrated to onboard VIPs.

September 9

The VIPs were returned to shore, and the ship began preparations for its involvement in the Star Spangled Spectacular.

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.

The EX-14-04 Leg 2 and 3 Project Instructions can be obtained from the NOAA Central Library. The EX-14-04 Leg 2 and 3 Data Management Plan is an appendix of the project instructions.

The EX-14-02 EK 60 Calibration Report can be obtained in the NOAA Central Library or by contacting the NOAA OER mapping team at oar.oer.exmappingteam@noaa.gov