Ocean Exploration and Research

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MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

CRUISE EX-13-04 Leg 2 Northeast United States Canyons Exploration

Meme Lobecker[1]

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[1]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

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-13-04 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 2013 NOAA Ship *Okeanos Explorer* Survey Readiness Report, available in the NOAA Central Library. A separate cruise report detailing the remotely operated vehicle (ROV) activities of the cruise is also planned to be available in the NOAA Central Library.

3. Cruise Objectives

The objectives for this cruise are fully detailed in the EX-13-04 Leg 2 Project Instructions, which are archived in the NOAA Central Library. Following is a brief summary of objectives as executed, with focus on mapping data acquisition and processing.

EX-13-04 Leg 2 operations commence on July 31, 2013 in New York, NY and conclude on August 17, 2013 in Davisville, RI. Operations included a combination of acoustic seabed, water column, and sub-seafloor mapping; ROV dives; and conductivity temperature depth (CTD) readings and rosette water sampling operations. Strategic mapping objectives included sub-bottom data collection over key features, multibeam data collection over canyon heads requiring coverage development, and multibeam holiday lines completing previous coverage along the continental shelf break. Mapping data collection was planned to occur primarily overnight during transits between ROV dive locations.

4. Summary of Mapping Results

Cruise Overview Map

Ocean Exploration and Research

EX-13-04 Leg 2
Northeast United States Canyons Exploration
Cruise Summary Map

July 31 - August 17, 2013

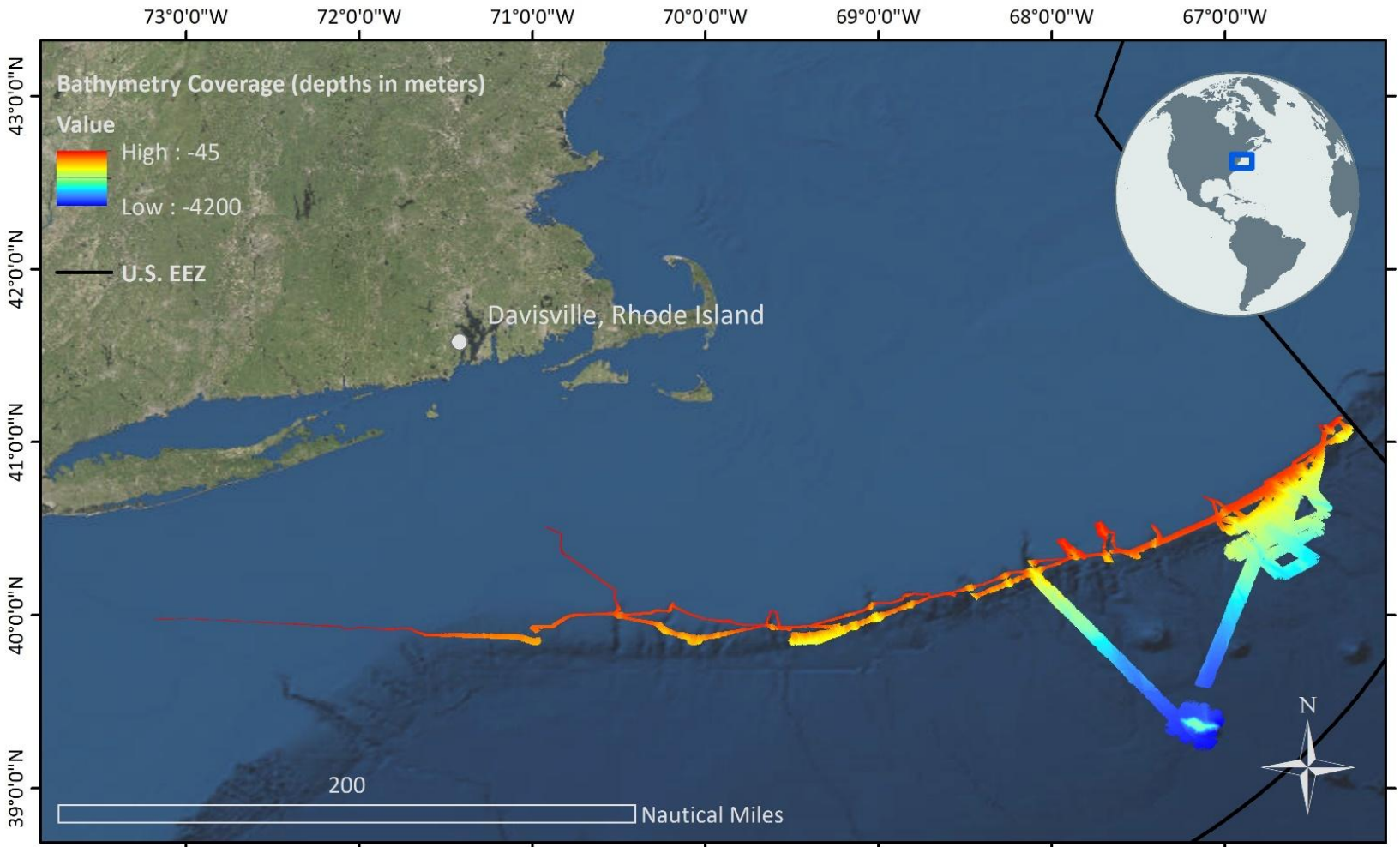

Figure 1. Cruise map showing overall EX-13-04 Leg 2 bathymetry coverage. 50 meter resolution. Generated in ArcMap.

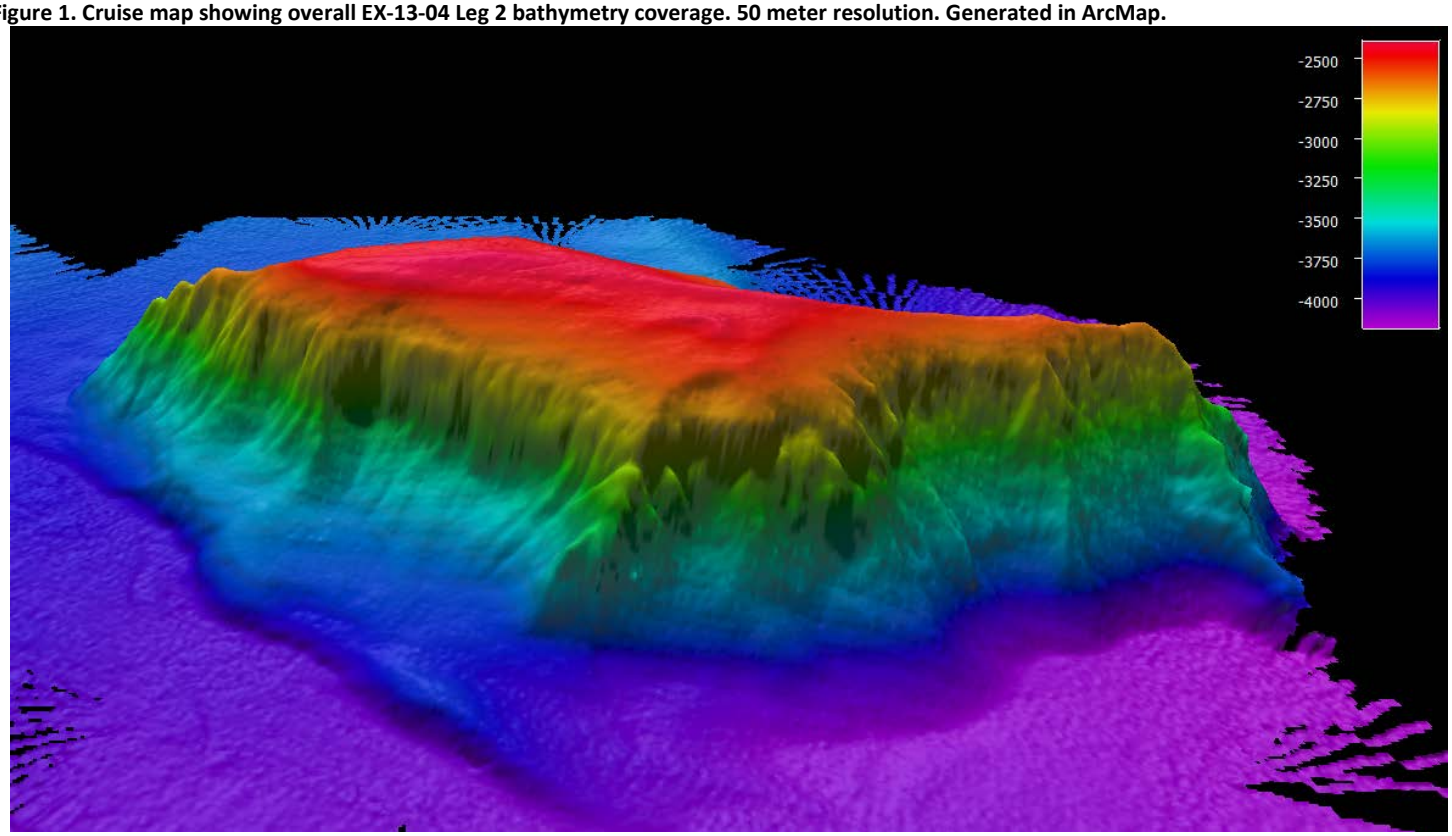

Figure 2. Screenshot of perspective view looking northward showing bathymetry data collected Mytilus Seamount. 50 meter resolution. Generated in QPS Fledermaus. Vertical exaggeration 3. Color depth bar units in meters.

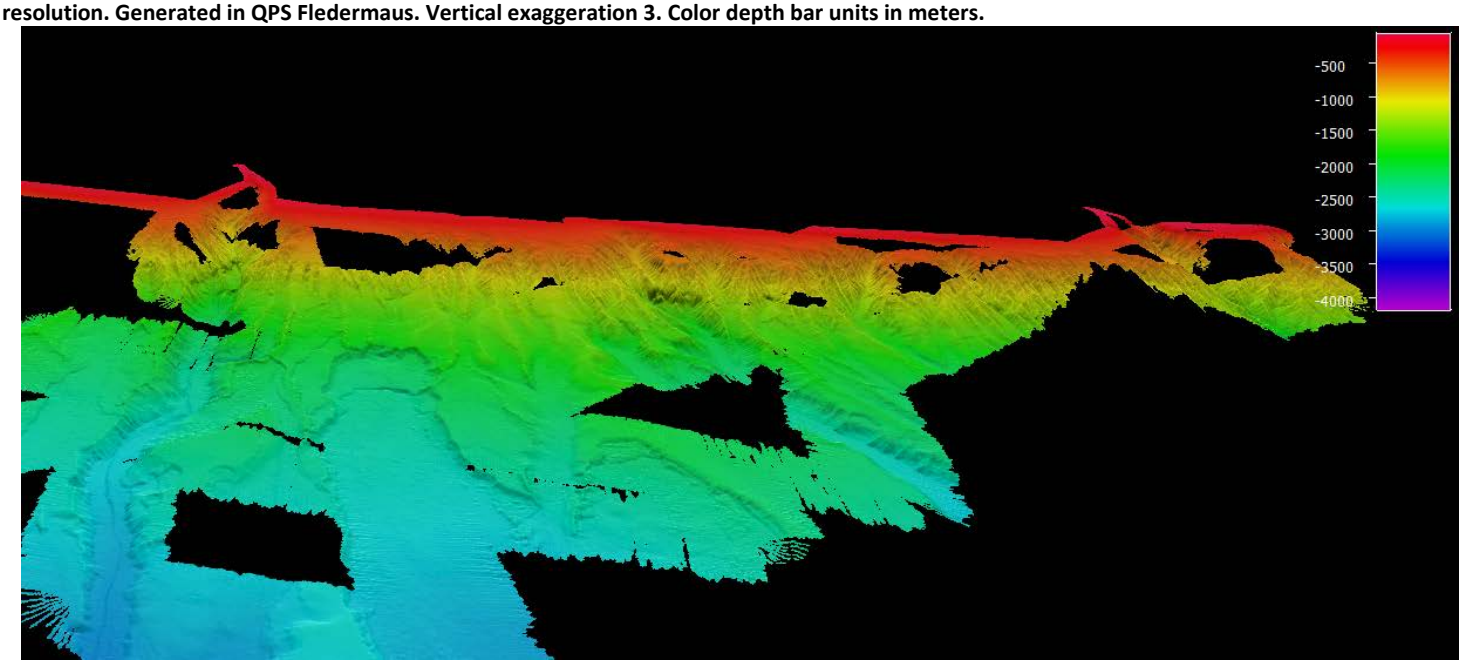

Figure 3. Screenshot of perspective view looking westward showing bathymetry holiday fill lines and shoal side development collected over several canyons and slump features along the United States Atlantic continental shelf break. 50 meter resolution. Generated in QPS Fledermaus. Vertical exaggeration 3. Color depth bar units in meters.

5. Mapping Statistics

Dates of cruise	**July 31 – August 17, 2013**
Ship's draft Start of cruise **End of cruise**	**Fore: 15' 2", Aft: 13' 10"** **Fore: 14' 9"; Aft: 13' 8.5"**
Linear kilometers of survey with EM 302	**2,720**
Square kilometers mapped with EM 302	**6,774**
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)	**286 files/ 29 GB**
Number / Data Volume of EM 302 water column multibeam files (.wcd)	**286 files / 91 GB**
Number / Data Volume of EK 60 water column split beam files (.raw)	**109 / 4.9 MB**
Number / Data Volume of sub-bottom sonar files (.segy, .kea, .keb)	**73 / 149 MB**
Number of XBT casts (.edf)	**82**
Number of ship's CTD casts (including test casts) (.hex)	**7**

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 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 less than 3300 meters, the system is operated in multi-ping, or dual swath mode, and obtains up to 864 soundings per ping, by detecting 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.

Simrad EK 60 Split-Beam Sonar

The ship is also equipped with one Simrad EK 60 split-beam fisheries sonar. The 18 kHz transducer 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 3260 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 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 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 3260 sub-bottom profile data collection.

Survey lines were planned to maximize either bathymetry edge matching of existing data or data gap filling in areas with existing bathymetry coverage. In regions with no existing data, lines were planned to optimize potential exploration discoveries. Data was primarily collected overnight between ROV dives.

Throughout the cruise, multibeam data quality was monitored in real-time by acquisition watch standers. 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 (70 – 75 degrees on each side) 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 real-time using the Reson SVP-70 data at the sonar head, and profiles from Expendable Bathythermographs (XBTs) that were conducted every 2 to 4 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. Data were monitored in real time for quality but were not post-processed. 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 track lines in blue collected during EX-13-04 Leg 2.

Knudsen 3260 sub-bottom profiler data were collected as much as possible but generally not overnight due to interior space noise levels and potential impact on crew rest. Data were monitored in real-time for quality. Data were not post-processed. The screenshot below shows data holdings in www.ncei.noaa.gov (last accessed 4 April 2019).

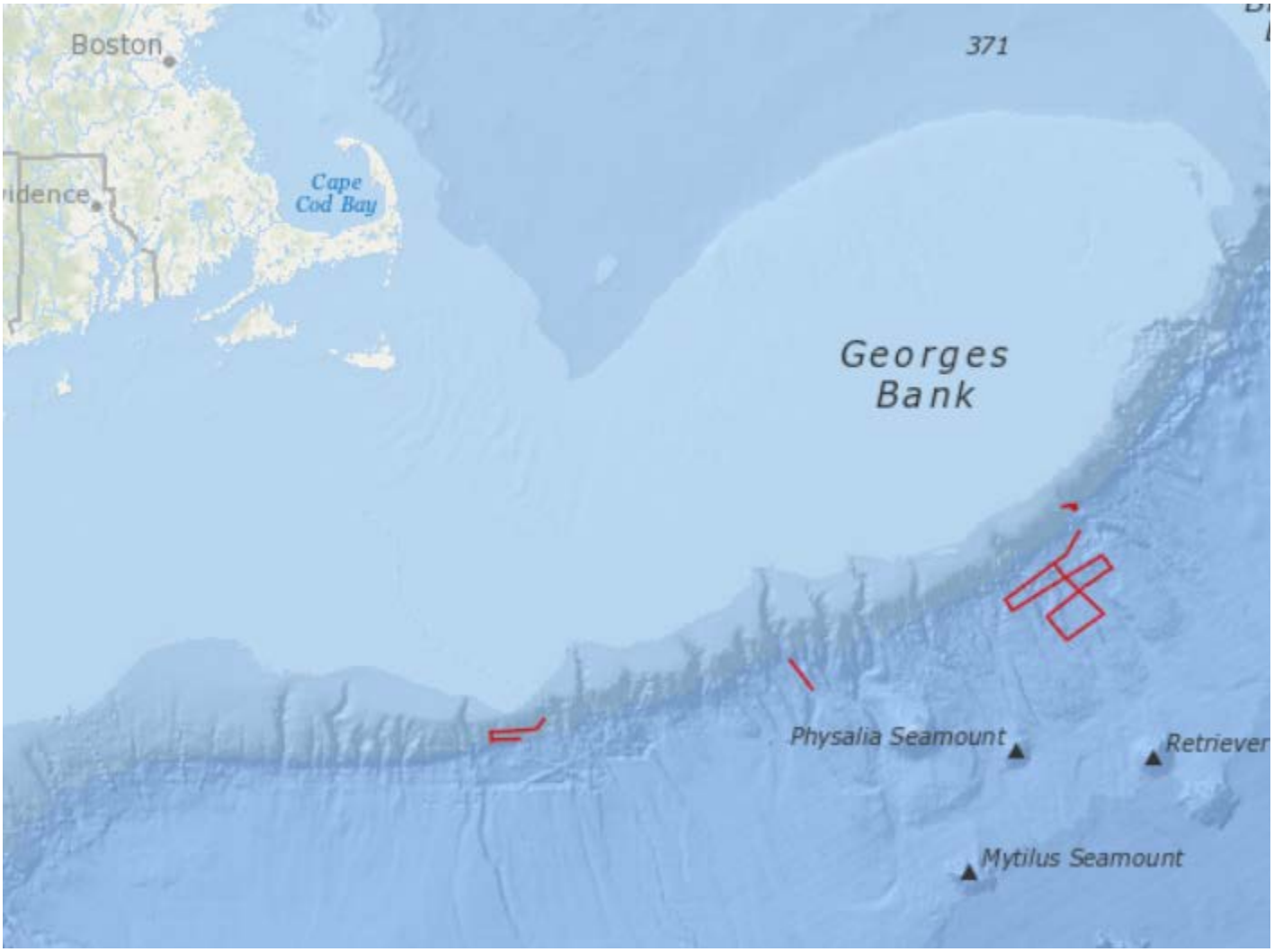

Figure 5. Screenshot of sub-bottom profiler data track lines in red collected during EX-13-04 Leg 2.

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 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.

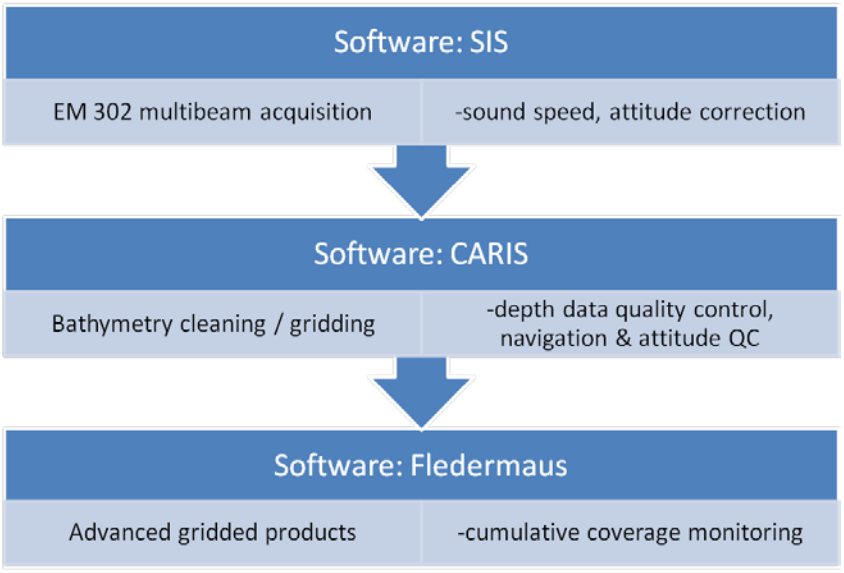

Figure 16. Shipboard multibeam data flow.

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. Two crosslines were run during the cruise.

The first was run on August 4. The crossline file was 0041; the mainscheme lines were files 0048, 0050, 0053, 0056, and 0059. The Crosscheck results against the requirements for an International Hydrographic Order 1 survey are shown below, with depth values (z) in meters.

Number of Points of Comparison 239036
Data Mean -3354.537595
Reference Mean -3358.407649
Mean 3.870053
Median 174.858396
Standard Deviation (stddev) 29.348034
Data Z – Range -4480.66, -2155.57
Reference Z – Range -4895.46, -2386.01
Difference Z – Range -577.46, -1014.22
Mean + 2*stddev 62.566121
Median + 2*stddev 233.554463

Order 1 Error Limit 43.662163
Order 1 P-Statistic 0.038701
Order 1 - # Rejected 9251
Order 1 Survey ACCEPTED

The second was run on August 11. The crossline file was 0167; the mainscheme lines were files 0156, 0159, 0162, 0165. The Crosscheck results against the requirements for an International Hydrographic Order 1 survey are shown below, with depth values (z) in meters.

Number of Points of Comparison 450047
Data Mean -2426.694338
Reference Mean -2425.948386
Mean -0.745952
Median -969.099432
Standard Deviation 60.113085
Data Z – Range -5696.11 -1829.66
Reference Z – Range -2959.19 -1807.56
Difference Z – Range -2848.93 940.33
Mean + 2*stddev 120.972123
Median + 2*stddev 1089.325603
Order 1 Error Limit 31.541292
Order 1 P-Statistic 0.024086
Order 1 - # Rejected 10840
Order 1 Survey ACCEPTED

EM 302 Patch Test

A multibeam patch test was conducted during EX-13-01. The results are briefly described in the mapping data report for that cruise, as well as in the 2013 *Okeanos Explorer* Survey Readiness Report.

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-13-04 Leg 2 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

Simrad EK split-beam water column dataset:

- Mapping watch stander log
- Weather log
- EK data log

Knudsen 3260 Sub-bottom Profiler dataset:

- Mapping watch stander log
- Weather log
- Sub-bottom data log

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/V5WW7FKS

EK 60 data http://doi.org/10.7289/V5XW4GQ5

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

July 2013						
Sun	Mon	Tues	Wed	Thur	Fri	Sat
			31. Depart dock from Manhattan, NY, NY. Transit exploration mapping towards ROV dive site 1.			
August 2013						
				1. Survey operations commence 1730 immediately after ROV recovery.	2. CTD cast then mapping immediately after ROV recovery.	3. CTD cast then mapping immediately after ROV recovery.
4. Mapping immediately after ROV recovery.	5. Mapping immediately after ROV recovery.	6. CTD cast then mapping immediately after ROV recovery.	7. CTD cast then mapping immediately after ROV recovery.	8. Mapping immediately after ROV recovery.	9. CTD cast then mapping immediately after ROV recovery.	10. ROV dive cancelled. Continuous mapping data collection.
11. CTD cast then mapping immediately after ROV	12. CTD cast then mapping immediately	13. CTD cast then mapping immediately	14. CTD cast then mapping immediately after ROV recovery.	15. Mapping immediately after ROV recovery.	16. Mapping immediately after ROV recovery. Commence	17. Arrive port Davisville Rhode Island.

recovery.	after ROV recovery.	after ROV recovery.			transit to port.	

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 Universal Coordinated Time (UTC)).

July 31

EX-13-04 Leg 2 survey operations commenced at 1500 EDT. Multibeam and split-beam sonar data were collected continuously while in transit between New York Harbor and the first ROV dive location. Multibeam sonar data quality was high with consistent bottom detection and wide swath width.

August 1

Survey operations commenced at 1730 EDT immediately after ROV recovery. Multibeam and split-beam sonar data were collected continuously while in transit to the next ROV dive location. Mapping operations were focused on filling data holidays and expanding existing *Okeanos Explorer* bathymetric coverage in the area. Multibeam sonar data quality was high with consistent bottom detection and wide swath width.

August 2

A CTD cast was conducted after the ROV was recovered. Mapping commenced once the CTD was on deck at 1900 EDT. Multibeam and split-beam sonar data were collected continuously while in transit to the next ROV dive location. Sub-bottom profiler data were collected from 1900 to 2200 EDT. Mapping operations were focused on sub-bottom profiling priorities identified by partner scientists and filling multibeam coverage holidays and expanding existing coverage in the area. Multibeam sonar data quality was high with consistent bottom detection and wide swath width.

August 3

A CTD cast was conducted after the ROV was recovered. Mapping commenced once the CTD was on deck at 1930 EDT. Multibeam and split-beam sonar data were collected continuously while in transit to the next ROV dive location. Sub-bottom profiler data were collected from 1900 to 2200 EDT. Mapping operations were focused on sub-bottom profiling priorities identified by partner scientists and on filling multibeam coverage holidays and expanding existing coverage in the area. Multibeam sonar data quality was high with consistent bottom detection and wide swath width.

August 4

Survey operations commenced at 2030 EDT Immediately after ROV recovery. Multibeam and split-beam data were collected continuously as a focused survey of Mytilus Seamount was conducted. Multibeam sonar data quality was high with consistent bottom detection and wide swath width.

August 5

Survey operations commenced at 2000 EDT immediately after ROV recovery. Multibeam and split-beam data were collected continuously while in transit between Mytilus Seamount and Nygren Canyon. Multibeam sonar data quality was high with consistent bottom detection and wide swath width.

August 6

On August, 5 the EM302 multibeam sonar failed a built in self-test (BIST) after start up, recording no power (0 volts) to all transmit boards. After a reboot of the transmit/receive unit (TRU) SIS software was unable to fully connect to the TRU. After two subsequent reboots of the TRU, acquisition computer, and SIS software, SIS connected to the TRU, passed a BIST and functioned as expected. Multibeam mapping operations were interrupted from approximately 2000 to 2200 EDT. The cause of the initial failure is unclear and further investigation is ongoing.

Immediately after recovery of the ROV a CTD cast to a depth of 1580 meters was conducted. Following the CTD cast, survey operations commenced at 2000 EDT. Multibeam and split-beam data were collected continuously while in transit between Nygren Canyon and Heezen Canyon. Sub-bottom profile data were collected from 2000 to 2200 EDT. Initial mapping operations were focused on characterizing the water column, seafloor, and stratigraphy proximal to the newly discovered seep. Subsequent mapping efforts focused on sub-bottom profiling priorities identified by partner scientists and on filling data holidays as well as expanding existing EX bathymetric coverage in the area. Multibeam bathymetric data quality is high, with consistent bottom detection and wide swath coverage.

August 7

Immediately after recovery of the ROV a CTD cast to a depth of 1660 meters was conducted. Following the CTD cast, survey operations commenced at 2000 EDT. Multibeam and split-beam data were collected continuously while in transit between Heezen Canyon and Nygren Canyon. Mapping operations focused on filling data holidays as well as expanding existing EX bathymetric coverage in the area. Multibeam bathymetric data quality is high, with consistent bottom detection and wide swath coverage.

August 8

Immediately after recovery of the ROV, survey operations commenced at 2000 EDT. Multibeam and split-beam data were collected continuously while in transit between Nygren Canyon and Heezen Canyon. Sub-bottom profile data were collected from 2000 to 2200 EDT. Initial mapping operations were focused on characterizing the water column, seafloor, and stratigraphy proximal to the newly discovered seep. Subsequent mapping efforts focused on sub-bottom profiling priorities identified by partner scientists and on filling data holidays as well as expanding existing EX bathymetric coverage in the area. Multibeam bathymetric data quality is high, with consistent bottom detection and wide swath coverage.

August 9

Immediately after recovery of the ROV a CTD cast to a depth of 925 meters was conducted. Following the CTD cast, survey operations commenced at 1930 EDT. Multibeam and split-beam data were collected continuously while in transit between Heezen Canyon and the location of the first inter-canyon dive. Mapping operations focused on filling bathymetric data holidays as well as expanding existing EX bathymetric coverage in the area. Multibeam bathymetric data quality is high, with consistent bottom detection and wide swath coverage.

August 10

Due to the cancelation of the ROV dive, mapping operations were conducted continuously throughout the day. Sub-bottom profile data were collected from 0800 to 2200 EDT and these operations focused on geological priorities identified by partner scientists. Concurrent and subsequent multibeam mapping operations focused on filling data holidays as well as expanding existing EX bathymetric coverage in the area. Multibeam bathymetric data quality is high, with consistent bottom detection and wide swath coverage.

August 11

Immediately after recovery of the ROV a CTD cast to a depth of 840 meters was conducted. Following the CTD cast, survey operations commenced at 1930 EDT. Multibeam and split-beam data were collected continuously while in transit between the first and second inter-canyon dive locations. Mapping operations focused on filling bathymetric data holidays as well as expanding existing EX bathymetric coverage in the area. Multibeam bathymetric data quality is high, with consistent bottom detection and wide swath coverage.

August 12

Immediately after recovery of the ROV a CTD cast to a depth of 640 meters was conducted. Following the CTD cast, survey operations commenced at 1930 EDT. Multibeam and split-beam data were collected continuously while in transit between the second inter-canyon dive location and Lydonia Canyon. Mapping operations focused on filling bathymetric data holidays as well as expanding existing EX bathymetric coverage in the vicinity of Powell and

Lydonia Canyons. Multibeam bathymetric data quality is high, with consistent bottom detection and wide swath coverage.

August 13

Immediately after recovery of the ROV a CTD cast was attempted but ultimately canceled due to lightning being observed in the area. The start of survey operations was delayed because observed lighting precluded the collection of a local sound velocity profile by CTD or XBT. After local weather cleared, survey operations commenced at 0500 EDT. In total we lost 8 hours of survey time waiting for the lightning to clear in order to take an XBT. Multibeam and split-beam data were collected continuously while in transit between Lydonia Canyon and Oceanographer Canyon. Mapping operations focused on filling bathymetric data holidays as well as expanding existing EX bathymetric coverage in the area. Multibeam bathymetric data quality is high, with consistent bottom detection and wide swath coverage.

August 14

Immediately after recovery of the ROV a CTD cast to a depth of 1220 meters was conducted. Following the CTD cast, survey operations commenced at 1930 EDT. Multibeam and split-beam data were collected continuously while in transit between the Oceanographer Canyon and Welker Canyon dive locations. Mapping operations focused on filling bathymetric data holidays as well as expanding existing EX bathymetric coverage in the area. Multibeam bathymetric data quality is high, with consistent bottom detection and wide swath coverage.

August 15

Mapping operations commenced at approximately 2000 EDT immediately following the recovery of the ROV. Multibeam and split-beam data were collected continuously while in transit between the Welker Canyon and the USGS site 5 dive locations. Mapping operations focused on filling bathymetric data holidays as well as expanding existing EX bathymetric coverage in the area. Multibeam bathymetric data quality is high, with consistent bottom detection and wide swath coverage.

August 16

Mapping operations commenced at approximately 1700 EDT immediately following the recovery of the ROV. Multibeam and split-beam data were collected until 0000 EDT while in transit between the dive location and towards port in Narragansett Bay. Mapping operations focused on filling bathymetric data holidays as well as expanding existing EX bathymetric coverage in the area. Multibeam bathymetric data quality is high, with consistent bottom detection and wide swath coverage.

August 17

Transit mapping towards port ceased at 0000 EDT in approximately 100 meters of water, mapping systems were secured, and the final mapping data package was assembled. Ship arrived in port in late morning.

12. References

The 2013 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-13-04 Leg 2 Project Instructions can be obtained from the NOAA Central Library. The EX-13-04 Leg 2 Data Management Plan is an appendix of the project instructions.

EM 302 water column data http://doi.org/10.7289/V5WW7FKS

EK 60 data http://doi.org/10.7289/V5XW4GQ5

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