Ocean Exploration and Research

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MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

CRUISE EX-12-04 Exploration: Northeast Canyon and Continental Margins Mapping

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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.

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-12-04, 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 2012 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-12-04 Project Instructions, which are archived in the NOAA Central Library.

Northeast Canyons Mapping

The shelf break of the US North Eastern (NE) region consists of a diverse habitat including more than 70 canyons which range from depths of ~ 100 m to ~ 3500 m. Some of the canyons have only partially been studied and constitute a high priority for exploration and research for several federal and state agencies. OER's previous work on NE canyons includes ''Deep Water Mid-Atlantic Canyon Exploration" in 2011 which focused on Norfolk, Washington, Accomac and Baltimore canyons. Other NOAA programs, including the National Marine Fisheries Service's (NMFS) Northeast Fisheries Science Center (NEFSC) and NMFS Deep Sea Coral Research and Technology Program (DSCRTP) also have interest in understanding the geomorphology and habitat complexity of these canyons. During planning of this expedition, OER engaged NMFS representatives to help identify priority canyons mapping targets. OER also consulted with representatives from the Mid Atlantic Regional Council on the Ocean (MARCO) which includes the states of New York, New Jersey, Delaware, Maryland and Virginia. MARCO seeks to understand and conserve coastal ocean resources. Scientific priorities were identified as building the base layers of the bathymetry, geomorphology and establishing accurate extent of these canyons.

The data collected will build upon previous mapping coverage obtained by *Okeanos Explorer* during cruises EX-11-06 and EX-12-01. Priority areas for EX-12-04 included:

- Spencer Canyon
- Lindenkohl Canyon
- Carteret Canyon
- Hudson Canyon
- Jones Canyon

- Babylon Canyon
- Emery Canyon
- Uchupi Canyon
- Ryan Canyon
- McMaster Canyon
- Block Canyon
- Alvin Canyon
- Atlantis Canyon
- Veatch Canyon
- Hydrographer Canyon
- Oceanographer Canyon
- Filebottom Canyon
- Chebacco Canyon
- Lydonia Canyon

NOAA Ship Ferdinand R. Hassler & NOAA Ship Henry Bigelow Collaboration

NOAA Ship *Ferdinand R. Hassler* and NOAA Ship *Henry B. Bigelow* each conducted cruises complimentary to EX-12-04.

During her June 20 – 27, 2012 cruise, *Hassler* will collect a small patch of Reson 7111 multibeam data over a predetermined area also mapped by *Okeanos Explorer* during EX-12-04. The bottom backscatter collected by the two ships will be compared in order to further understand variations in bottom backscatter data between different sonars.

During her July 3 – 18, 2012 cruise, *Bigelow* will conduct towed camera operations within priority areas defined by NEFSC. Sites will be chosen based on historical data and the results of a habitat suitability model being developed by NEFSC, which will incorporate *Okeanos Explorer* and Hassler multibeam data in priority areas. The primary objective of Tow Camera operations is to image deep sea corals. NEFSC habitat suitability model considers a variety of inputs from different data layers including bathymetry, oceanographic currents data, and historical coral occurrence data. The model predicts areas where corals are expected to occur. The Tow Camera will be used to ground truth the habitat suitability model results.

Ancillary Sonar Data Collection

In addition to multibeam data collection, data acquisition from the EK 60 (18 kHz), and Knudsen 3260 sonars was planned. Recent changes to the trigger-jigger, used for simultaneous operation of sonars, were planned to be tested.

Training

The mapping team was comprised of mix of diverse skill sets and levels of professional experience. The team included two interns, two mapping professional contractors, two staff members from the E/V Nautilus, and one senior level scientist. Interns William Boll and Meredith Meyers were students at Old Dominion University and McDaniel College, respectively. Ash Harris and Gina Brewer, both experienced mapping professionals, were watch leads paired with less experienced watch standers. Nicole Raineault and Roderick McLeod, visiting scientists from the E/V Nautilus, were onboard to gain first order experience with the multibeam sonar operation and multibeam data management. David Packer, a marine ecologist with the NEFSC, was onboard to gain first order experience with the collection and processing of multibeam backscatter data, and further his knowledge of *Okeanos Explorer* and multibeam data in general.

Telepresence Operations

Telepresence objectives for the cruise included testing and refining ship-to-shore communications and operations procedures. This included the transfer of daily multibeam products to shore and two telepresence live interactions. On June 6, a question and answer session occurred between Meme Lobecker on the ship and student SCUBAnauts at the Silver Spring Exploration Command Center, hosted by NOAA OER personnel Fred Gorrell, Kelley Elliott, and Kyle Carothers. On June 8, onboard mapping personnel took turns answering questions from shoreside participants including OER personnel at the Pacific Environmental Marine Laboratory from 2100-0100.

4. Summary of Mapping Results

Cruise Overview Map

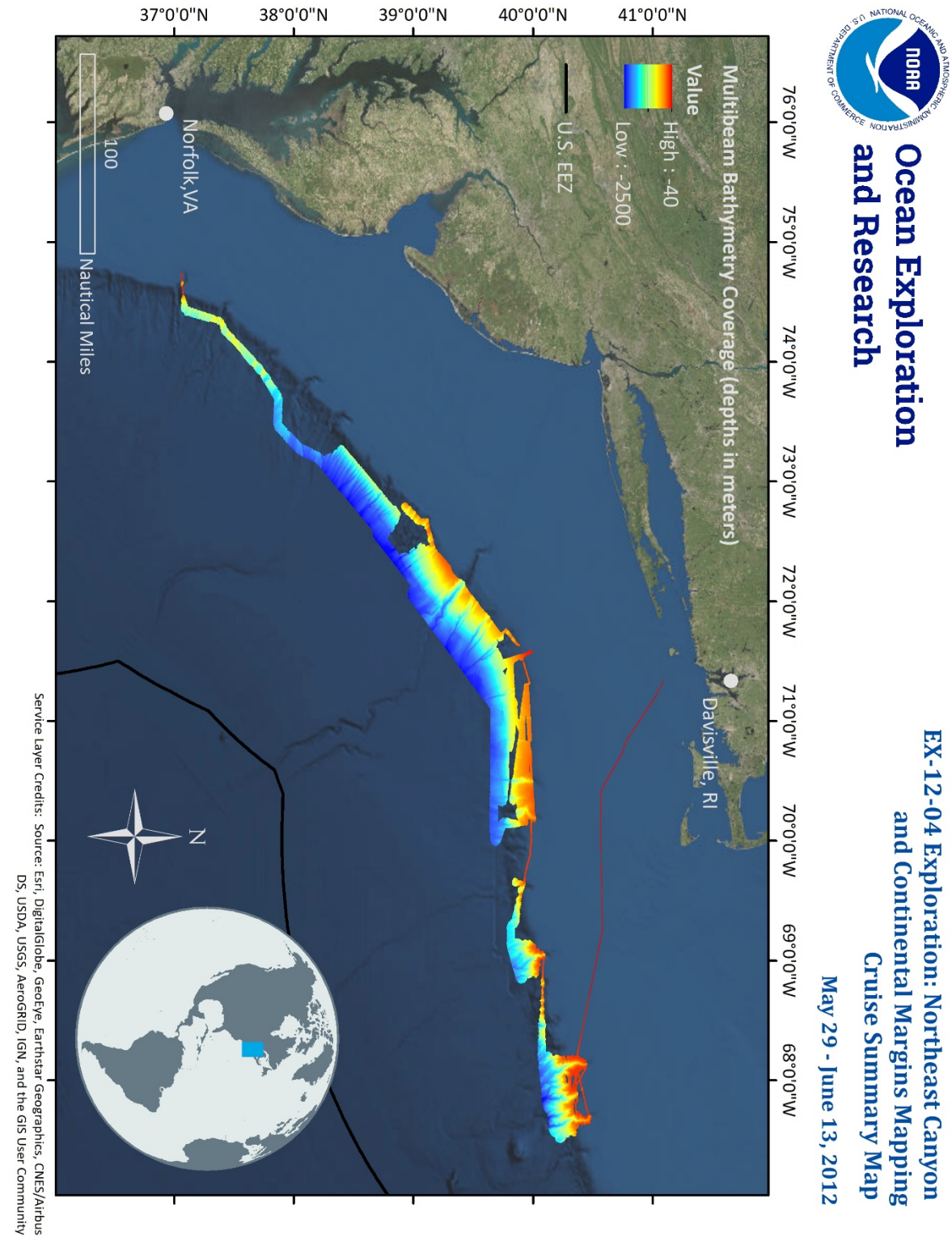

Figure 1. Cruise map showing overall EX-12-04 bathymetry coverage. Generated in ArcMap.

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5. Mapping Statistics

Dates of cruise	**Mary 29 – June 13, 2012**
Ship's draft Start of cruise **End of cruise**	**Fore: 15' 8", Aft: 14' 8"** **Fore: 14' 8"; Aft: 14' 6.5"**
Linear kilometers of survey with EM 302	**5,806**
Square kilometers mapped with EM 302	**15,906**
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)	**342 files/ 41.2 GB**
Number / Data Volume of EM 302 water column multibeam files	**342 files / 97.1 GB**
Number / Data Volume of EK 60 water column split beam files (.raw)	**381 / 6.27 GB**
Number / Data Volume of sub-bottom sonar files (.segy, .kea, .keb)	**210 / 3.8 GB**
Number of XBT casts	**116**
Number of CTD casts (including test casts)	**0**

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. 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

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 with existing bathymetry 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 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 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, or as dictated by local oceanographic conditions.

Multibeam backscatter data quality was also closely monitored in real-time, as this data type will be used in habitat characterization models by NEFSC and MARCO. The ping mode in SIS was held in 'deep' mode for the entire cruise in order to maintain consistent backscatter data.

Line plans were designed to run parallel to the continental slope. Due to the historical occurrence of 'omega artifacts' in older multibeam data when running lines directly up canyons, canyon survey lines were designed perpendicular to canyons. It was not known whether the EM 302 is susceptible to this artifact, however there was no significant impact to overall cruise timing to run the lines cross canyon.

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).

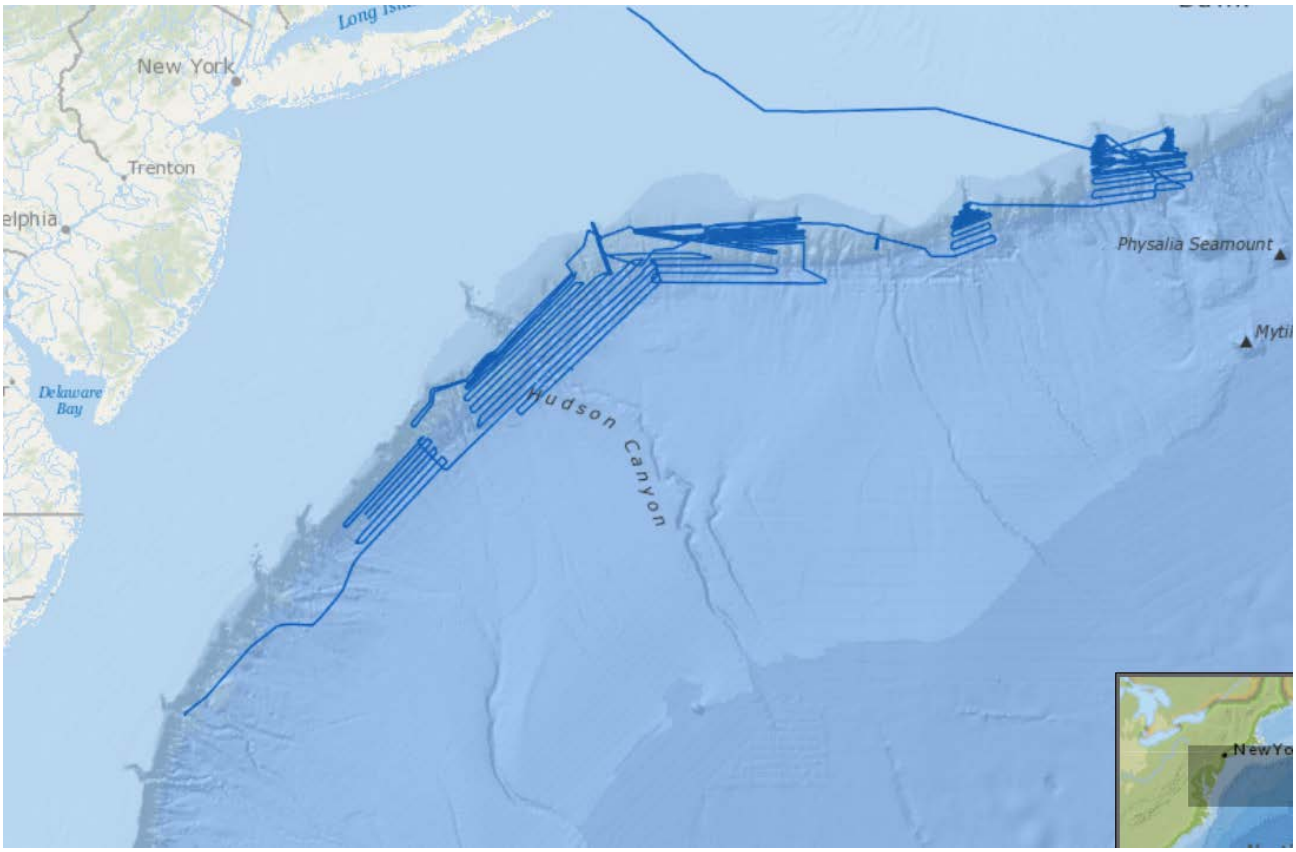

Figure 2. Screenshot of Simrad EK 60 18 kHz split-beam sonar data track lines in blue collected during EX-12-04.

Knudsen 3260 sub-bottom profiler data were collected daily from 1000 – 18000 local ship time. Data were monitored in real-time for quality, but the steep sides of canyons provided significant challenges, and data quality suffered. It was not always possible to keep the range gates set to appropriate values to accommodate rapidly changing depths as the ship traversed steep canyon walls. Seabed penetration along the canyons was relatively small. Data were not post-processed. The screenshot below shows data holdings in www.ncei.noaa.gov (last accessed 4 April 2019).

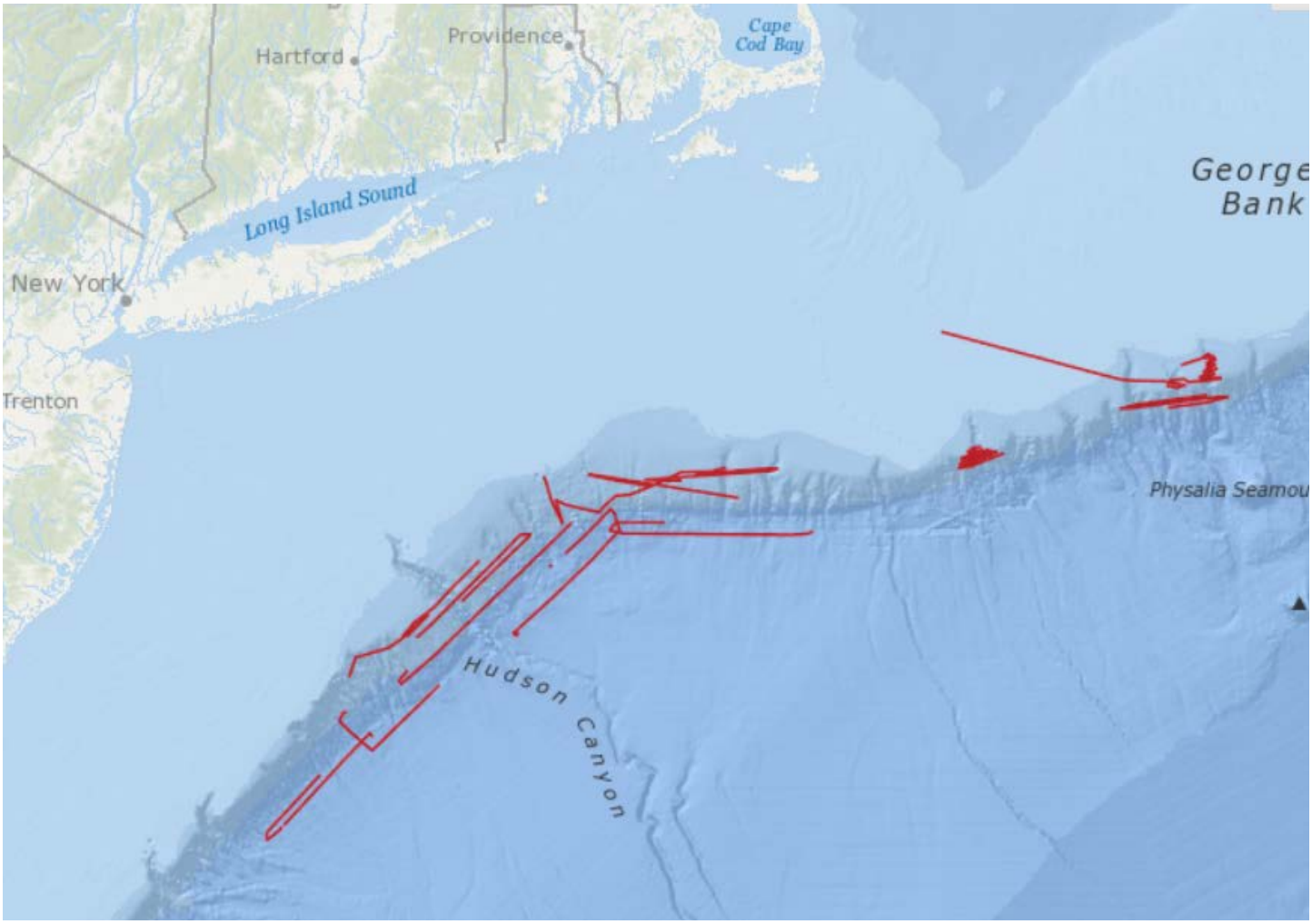

Figure 3. Screenshot of sub-bottom profiler data track lines in red collected during EX-12-04.

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.

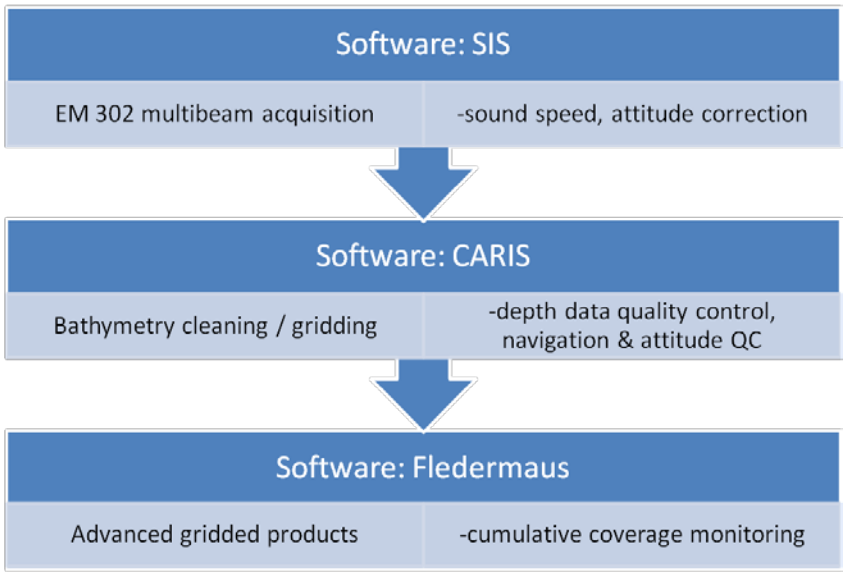

Figure 16. Shipboard multibeam data flow.

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.

A crossline was run on May 31. Crossline analysis was completed using Qimera Crosscheck, and the results against the requirements for an International Hydrographic Order 1 survey are shown below. The crossline file was line 0033; the mainscheme lines were lines 0009, 0011, 0016, 0017, 0019, 0024, and 0026. Depth (z) values are in meters.

248834 # Number of Points of Comparison
-1927.913817 # Data Mean
-1926.841173 # Reference Mean
-1.072644 # Mean
41.078596 # Median
7.875415 # Std. Deviation
-2377.92 -1223.54 # Data Z – Range
-2378.70 -1231.32 # Ref. Z – Range
-230.03 291.81 # Diff Z – Range
16.823475 # Mean + 2*stddev
56.829427 # Median + 2*stddev
25.053925 # Ord 1 Error Limit
0.008078 # Ord 1 P-Statistic

2010 # Ord 1 - # Rejected
1 **# Order 1 Survey ACCEPTED**

EM 302 Patch Test

A multibeam patch test was conducted during EX-12-01. The results are briefly described in the mapping data report for that cruise, as well as in the 2012 *Okeanos Explorer* Survey Readiness Report.

Nadir Gaps

Nadir gaps were observed in 270 meters of water and shallower due to forcing SIS into Deep mode. As stated previously, the ping mode held at Deep throughout the entire cruise to maintain consistent bottom backscatter data quality. The exact cause of these nadir gaps is unknown at this time, but the overall impact to the total dataset was small.

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-12-04 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/V5HQ3WWJ

EK 60 data http://doi.org/10.7289/V5K935HD

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

May 2012						
Sun	Mon	Tues	Wed	Thur	Fri	Sat
27 Mission personnel arrives to the ship in Norfolk, VA	28 Mission team training.	29 Depart dock, commence mapping operations.	30 Continue mapping operations.	31 Continue mapping operations.	1 Continue mapping operations.	2 Continue mapping operations.
June 2012						
3 Continue mapping operations.	4 Continue mapping operations.	5 Continue mapping operations.	6 Continue mapping operations.	7 Continue mapping operations.	8 Continue mapping operations.	9 Continue mapping operations.
10 Continue mapping operations.	11 Continue mapping operations.	12 Continue mapping operations.	13 Continue mapping through the morning until reaching Narragansett Bay sea buoy at 0930. Ship alongside Quonset Pier 1400.	14 In port, North Kingstown, RI. Mission personnel departed 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))

May 24, 2012
An in port outreach event, including ship tours, occurred in Norfolk, VA with regional scientists and representatives from MARCO and VA Sea Grant.

May 27, 2012
Mapping mission and science personnel arrive to the ship, including Dave Packer, Roderick McLeod, Meredith Meyers, William Boll, Ash Harris, Gina Brewer, and Meme Lobecker.

May 28, 2012
Final mapping mission personnel Nicole Raineault arrives to ship. Mapping personnel received training on mapping systems and control room equipment. The cruise plan was reviewed. Watch stander roles were reviewed.

May 29, 2012
The ship departed from the NOAA facility in Norfolk, VA at 1040. New mission personnel training continued throughout the day. Survey operations commenced in the evening.
Sonar data commenced at 1911 in 80 meters of water. Upon reaching the continental shelf break, the ship turned north and followed a transit line adjacent to previous EX multibeam coverage. XBTs are collected every 2-3 hours.

The initial BIST tests run on the EM302 showed poor results, with many tests failing. The TRU was restarted and all tests passed. The sonar has been performing well.

May 30, 2012
Mapping of the southernmost MARCO summary priority area continued. This area includes Spencer, Lindenkohl, and Carteret Canyons. Multibeam bathymetry and bottom backscatter data quality are excellent. The SIS computer has not required restarting. During EX-12-03, this computer required frequent restarting due to apparent memory allocation errors.

May 31, 2012
Mapping of the west section of MARCO summary priority #2 was completed. This area includes Spencer, Lindenkohl, and Carteret Canyons. Multibeam bathymetry and bottom backscatter data quality were excellent. A crossline was run in this area.

Mapping of MARCO summary priority #3 commenced.

Dave Packer, onboard mission scientist from NEFSC, began analyzing multibeam backscatter data in preparation for *Henry Bigelow* cruise in July.

June 1, 2012
Mapping of the west section of MARCO summary priority #3 (center black polygon) continued. This area includes Hudson, Jones, Babylon, Uchipi, Ryan, McMaster, and Block Canyons. Multibeam bathymetry and bottom backscatter data quality remain excellent.

XBTs are conducted every 2-3 hours. Despite this, outer beams are affected by sound velocity artifacts, suspected due to Gulf Stream water and eddies. Multibeam overlap is 30-50% to account for sound velocity artifacts in outer beams.

June 2, 2012
Mapping of the west section of MARCO summary priority #3 continued. Multibeam bathymetry and bottom backscatter data quality remain excellent.

June 3, 2012
Mapping of the west section of MARCO summary priority #3 continued. This area includes Hudson, Jones, Babylon, Uchipi, Ryan, McMaster, and Block Canyons. Multibeam bathymetry and bottom backscatter data quality remain excellent.

June 4, 2012
Mapping of MARCO priority summary polygon #3 was completed.

The main cooling fan in the mission uninterruptable power supply (UPS) failed at 1430. The UPS is running in maintenance bypass mode until the fan can be replaced in port.

In the evening, the seas increased to 7-9 feet, and winds increased to 30 knots. Multibeam data quality degraded during transit to the sonar comparison area.

June 5, 2012
Mapping of MARCO priority summary polygon #1 commenced. This area includes Alvin and Atlantis Canyons, as well as a few smaller canyons. Multibeam and bottom backscatter data quality were very poor in the morning due to heavy seas. Reciprocal lines were rerun to collect higher quality data. The poor weather continued until the late afternoon, and the seas laid down in the early evening.

The UPS is running in maintenance bypass mode until the fan can be replaced in port. As a result, the ship cannot exceed 160 RPMs in order to avoid transient power spikes. An APC technician is scheduled for June 13.

June 6, 2012
Mapping of the west section of MARCO summary priority #1 and NEFSC priority #7 continued. This area includes Alvin and Atlantis Canyons, as well as a few smaller canyons. Multibeam and bottom backscatter data quality were high. Numerous lobster pots were encountered on inshore lines, creating difficulty in obtaining 100% bottom coverage in shallower lines.

A telepresence interaction with Silver Spring ECC occurred. Student SCUBAnauts were at the SS ECC with Fred Gorrell, Kelley Elliott, and Kyle Carothers.

June 7, 2012
Mapping of the west section of MARCO summary priority #1 and NEFSC priority #7 continued. This area includes Alvin and Atlantis Canyons, as well as a few smaller canyons. Multibeam and bottom backscatter data quality were high. Numerous lobster pots were encountered on inshore lines, creating difficulty in obtaining 100% bottom coverage in shallower lines.

Engineering and ET departments are monitoring ship's power for stability. Safety drills (fire/emergency, abandon ship) were held.

June 8, 2012
Mapping of the west section of MARCO summary priority #1 and NEFSC priority #7 was completed. This area includes Alvin and Atlantis Canyons, as well as a few smaller canyons. Multibeam and bottom backscatter data quality were high. Numerous lobster pots were encountered on inshore lines, creating difficulty in obtaining 100% bottom coverage in shallower lines. Buoys and high fliers marking strings of lobster pots were observed throughout the area.

The *Hassler-Okeanos* bottom backscatter data comparison area was surveyed.

Throughout the day, several racing boats in the "Clipper Around the World Race" (en route from New York City to Halifax, Nova Scotia) were encountered while surveying the area, as well as numerous pleasure and fishing vessels.

In the late evening, transit to NEFSC priority area #5 (Veatch Canyon) commenced.

A telepresence interaction with OER personnel at PMEL took place. Mapping personnel took turns answering questions from shore from 2100-0100.

June 9, 2012
Continuation of EX-12-01 mapping of NEFSC priority #5 (Veatch Canyon) occurred. Multibeam bathymetry and bottom backscatter data quality were high. Buoys and high fliers marking strings of lobster pots were observed throughout the area. The area was unfortunately reached at night, making fishing gear difficult to see, and as a result most of the planned lines were not able to be run.

Mapping of NEFSC priority # 8 (Hydrographer Canyon) was partially completed. The shoalest depths recorded in the canyon thalweg were ~600 meters before transit began to higher priority NEFSC areas# 4 (Oceanographer Canyon), #6 (Gilbert Canyon), and #3 (Lydonia Canyon) to the east. Multibeam bathymetry and bottom backscatter data quality were high. Lobster pot buoys were noted throughout the area.

June 10, 2012
Mapping of NEFSC priority areas#3 (Lydonia Canyon), #4 (Oceanographer Canyon), and #6 (Gilbert Canyon) commenced. Multibeam bathymetry and bottom backscatter data quality were high. Buoys and high fliers marking strings of lobster pots were observed throughout the area. Numerous fishing vessels were observed over Oceanographer Canyon, and required frequent deviation from planned track lines. Multibeam overlap is 30-50% to account for sound velocity artifacts in outer beams. Swath coverage angles are generally set to +/-70°, and occasionally +/-65°.

June 11, 2012
Mapping of NEFSC priority areas #3 (Lydonia Canyon), #4 (Oceanographer Canyon), and #6 (Gilbert Canyon) continued. Multibeam bathymetry and bottom backscatter data quality were high. Buoys and occasional high fliers marking strings of lobster pots were observed throughout the area.

Throughout the day, mapping efforts focused on defining the 500 meter contour along the thalweg of Lydonia Canyon, and obtaining shallow coverage along the top of the canyons to ~250 meters depth. In the evening, the ship moved offshore to map the offshore portion of Lydonia Canyon and avoid the heaviest concentrations of fishing gear near the canyon heads.

June 12, 2012
In the morning, the thermosalinograph pump was secured in the dry lab when a pin hole leak was found in a custom stainless t-fitting located in the bow thruster room. During the inport, the engineers will patch the hole with non-metalic epoxy as a temporary solution. It is believed by engineering that this patch will last

through the remainder of the 2012 field season. The engineering department will leave it up to the chief marine engineer, returning later this week, to decide to replace the T-fitting and with what material (stainless or PVC). The importance of this sensor for mapping and other scientific data has been reiterated.

June 13, 2012
Mapping continued until reaching the Narragansett Bay sea buoy at 0930. The ship reached the dock in Davisville, RI at 1400. The mapping department worked on wrapping up data and projects from the cruise.

The mission UPS cooling fan was replaced and the UPS is fully operational.
The TSG remains secured until the pin hole leak in the T joint is repaired and possibly replaced.

Dave Packer, onboard NEFSC ecologist, has successfully processed all EM 302 bottom backscatter data using Fledermaus FMGT. Cumulative EX-11-06, EX-12-01, and EX-12-04 EM 302 bathy and bottom backscatter products were generated in preparation for NOAA Ship *Henry Bigelow* cruise (July). Dave will take copies with him, and copies will be sent to OER mapping lead Mashkoor Malik in preparation for his sailing on the *Bigelow* cruise.

June 14, 2012
Mission personnel departed the ship.

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-12-04 Project Instructions can be obtained from the NOAA Central Library. The EX-12-04 Data Management Plan is an appendix of the project instructions.

EM 302 water column data http://doi.org/10.7289/V5HQ3WWJ

EK 60 data http://doi.org/10.7289/V5K935HD

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