Ocean Exploration and Research

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MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

CRUISE EX-17-07: Musician Seamounts (*Telepresence 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 utilized throughout the telepresence mapping cruise EX-17-07, 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 2017 NOAA Ship *Okeanos Explorer* Survey Readiness Report, available in the NOAA Central Library.

3. Cruise Objectives

EX-17-07 was conducted in support of the **C**ampaign to **A**ddress **P**acific Monument **S**cience, **T**echnology, and **O**cean **NE**eds (CAPSTONE), a multi-year effort focused on the systematic collection of baseline information in support of scientific and management needs within and in the vicinity of monuments and marine protected areas in the central and western Pacific. This cruise consisted of 24 hour per day mapping operations building off of previous data collected at the Murray Fracture Zone and Musician Seamounts, with the following focused scientific and exploration goals: to provide preliminary mapping data to contribute to a geological understanding of remote areas of the Pacific Ocean, support data collection for the subsequent EX-17-08 ROV dive operations, identify and characterize marine habitats (such as high density deep sea corals and sponge communities), seamounts in the Prime Crust Zone, and collect information on the geologic history of the Central Pacific seamounts, including those relevant to the understanding of plate tectonics and subduction zone biology and geology.

The expedition commenced in Honolulu, Hawaii, on August 8, 2017. Mapping operations utilized the ship's deep water systems (Kongsberg EM 302 multibeam sonar, EK 60 split-beam fisheries sonars, 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 scientists and Explorers-in-Training (internship program) for data processing and interpretation.

The complete objectives for this cruise are detailed in the EX-17-07 Project Instructions, which are archived in the NOAA Central Library.

4. Summary of Mapping Results

EX-17-07 mapped 55,831 square kilometers of seafloor with a focus on the Murray Fracture Zone and the Musician Seamounts during the 24 days-at-sea (Figure 1 and Table 1). See Section 7 for graphics of focused mapping operations.

Cruise Overview Map

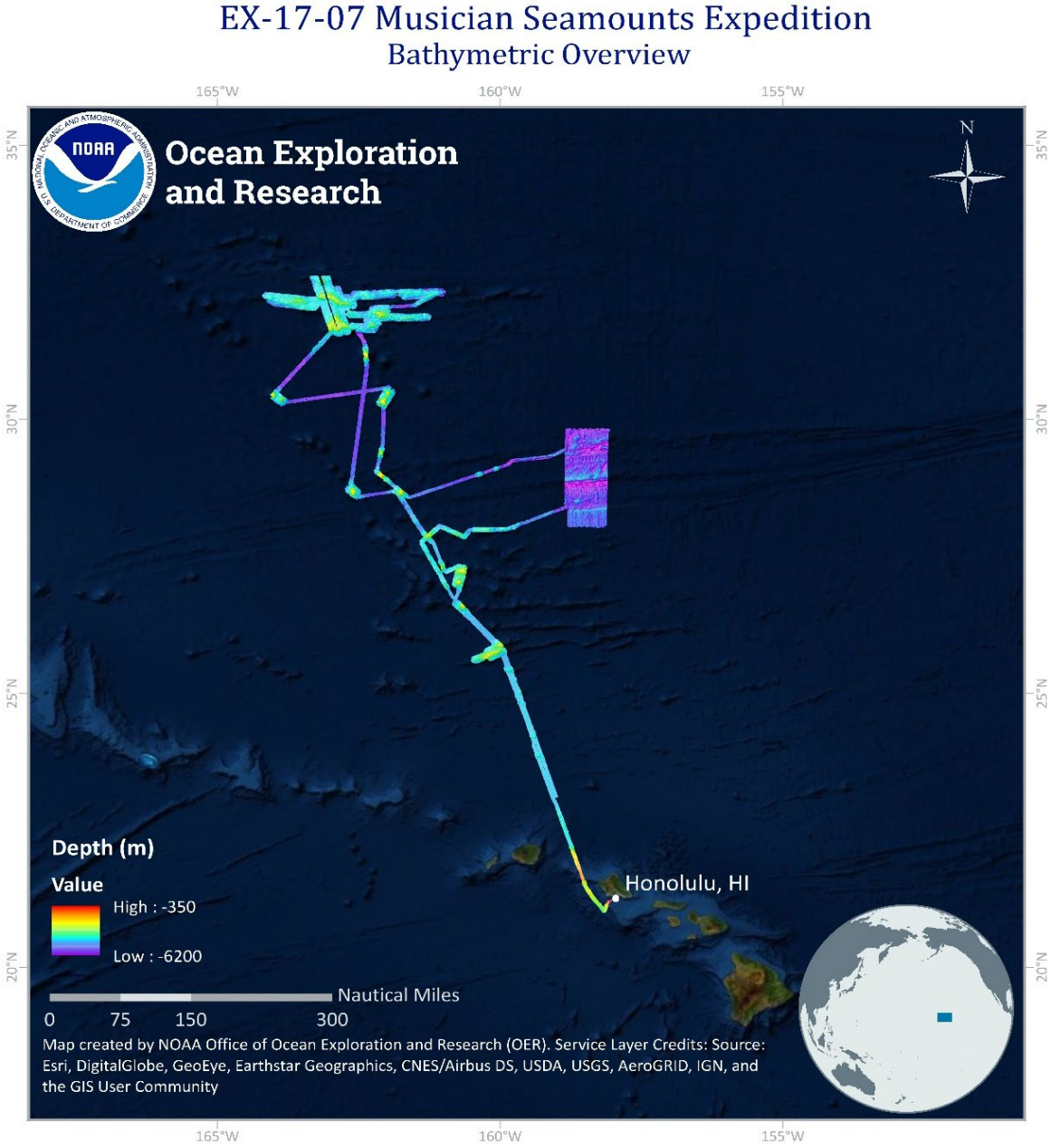

Figure 1. Overview of the bathymetric mapping coverage acquired during the Musician Seamounts expedition (EX-17-07). Image created in ArcMap.

5. Mapping Statistics

Table 1. Summary statistics of ocean mapping work completed during EX-17-07.

Dates of cruise	**August 08 – August 31, 2017**
Ship's draft: **Start of cruise (08/08/2017)** **End of cruise (08/31/2017)**	 **Fore: 15' 3'', Aft STBD: 14' 1.5"** **Fore: 15' 3"; Aft STBD: 14' 1.5"**
Linear kilometers mapped via EM 302	**7,241**
Square kilometers mapped via EM 302	**55,831**
Number / Data Volume of EM3 02 raw bathymetric / bottom backscatter multibeam files (.all)	**663 files/ 34.4 GB**
Number / Data Volume of EM 302 water column multibeam files	**663 files / 125 GB**
Number / Data Volume of EK 60 water column split beam files (.raw)	**203 / 20.1 GB**
Number / Data Volume of sub-bottom sonar files (.segy, .kea, .keb)	**772 / 8.17 GB**
Number of XBT casts	**95**
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 2017 NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report is available in the NOAA Central Library.

Simrad EK 60 Split-beam Sonars

The ship operated four Simrad EK 60 split-beam fisheries sonars: 18 kHz, 70 kHz, 120 kHz, and 200 kHz. These sonars are quantitative scientific echosounders 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. These sonars were calibrated on the EX-16-09 cruise, and calibration values from that cruise were applied to the EK sonars for EX-17-07. The 2017 EK 60 & EK 80 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.

Teledyne ADCPs

The ship utilizes a 38 kHz Teledyne RDI Ocean Surveyor Acoustic Doppler Current Profiler (ADCP), with a ~1000 meter range; and a 300 kHz Teledyne RDI Workhorse Mariner ADCP, with a ~70 meter range. The ADCPs gather data prior to ROV deployments in order to assess

currents at the dive site in support of safe operations. They are kept running throughout the ROV dives. The ADCPs are typically not run concurrently with the other sonars while transiting due to interference issues.

7. Data Acquisition Summary

Mapping operations included data collection via the EM 302 multibeam sonar, EK 60 split-beam (18, 70, 122, and 200 kHz) sonars, and Knudsen 3260 sub-bottom profiler. Data were collected by each sonar concurrently during 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. Focused mapping operations were conducted over the northern Musician Seamounts (Figure 2), Mussorgsky Seamount (Figure 3), Debussy Seamount (Figure 4), Paganini Seamount (Figure 5), Murray Fracture Zone (Figure 6), Sibelius Seamount (Figure 7), and Schumann Seamount (Figure 8).

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 Acquisition 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 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 surface 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 and Knudsen 3260 sub-bottom profiler data were also collected throughout the majority of the cruise. Data were monitored in real time for quality but were not post-processed.

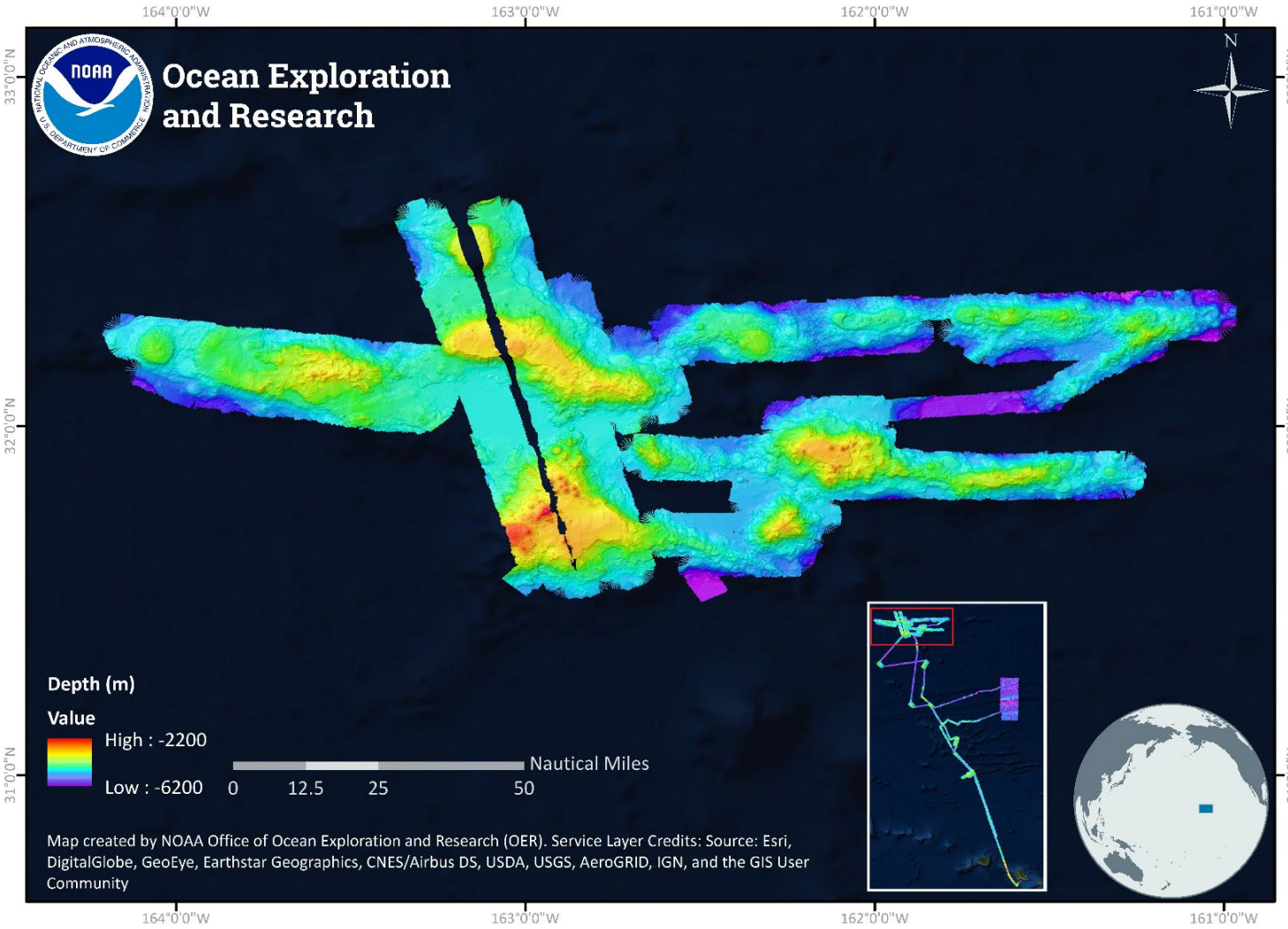

Figure 2. Focus map displaying a 60-meter resolution grid generated from bathymetric data collected over the northern Musician Seamounts. Image created in ArcMap.

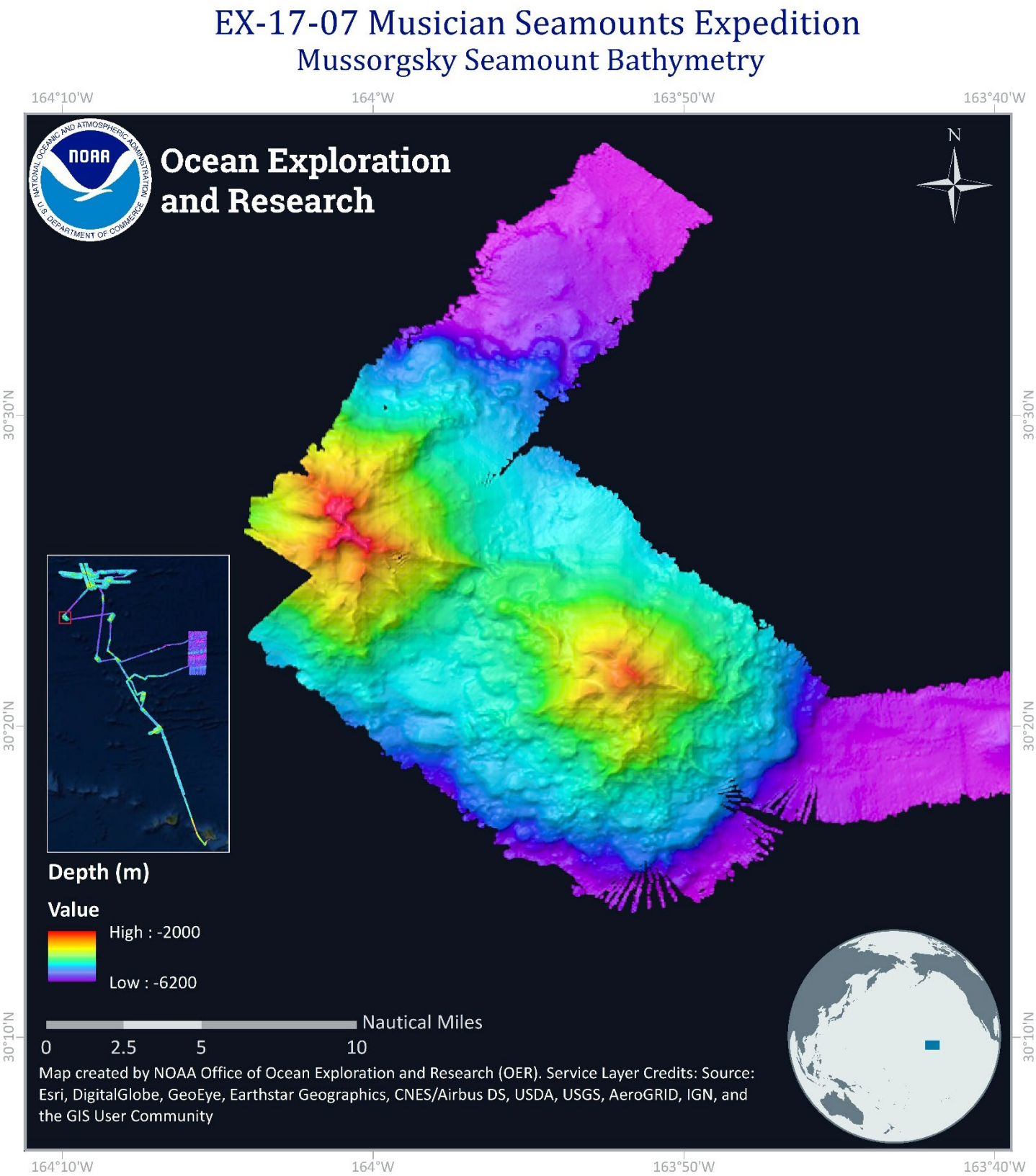

Figure 3. Focus map displaying a 60-meter resolution grid generated from bathymetric data collected over the Mussorgsky Seamount. Image created in ArcMap.

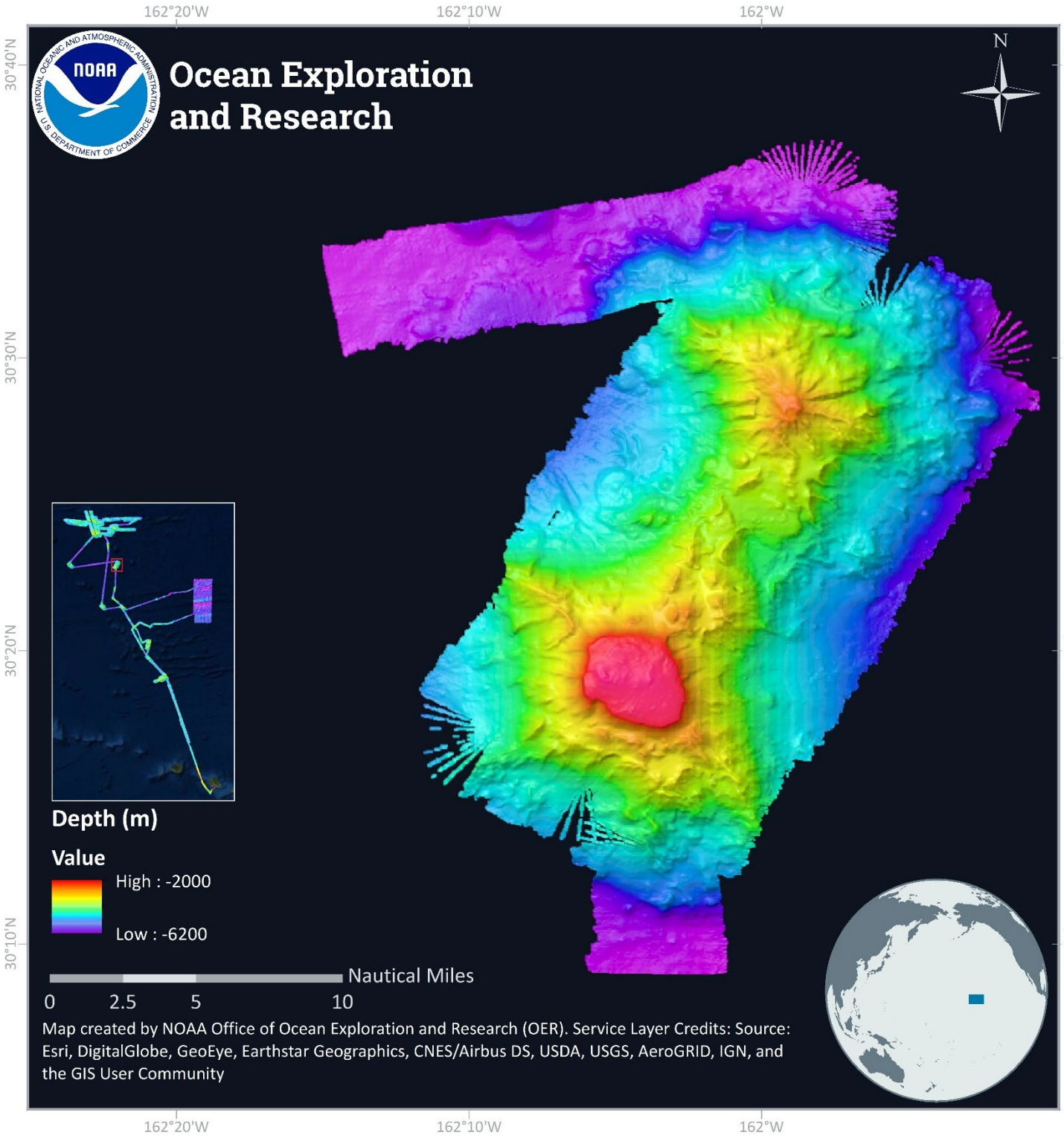

Figure 4. Focus map displaying a 60-meter resolution grid generated from bathymetric data collected over the Debussy Seamount. Image created in ArcMap.

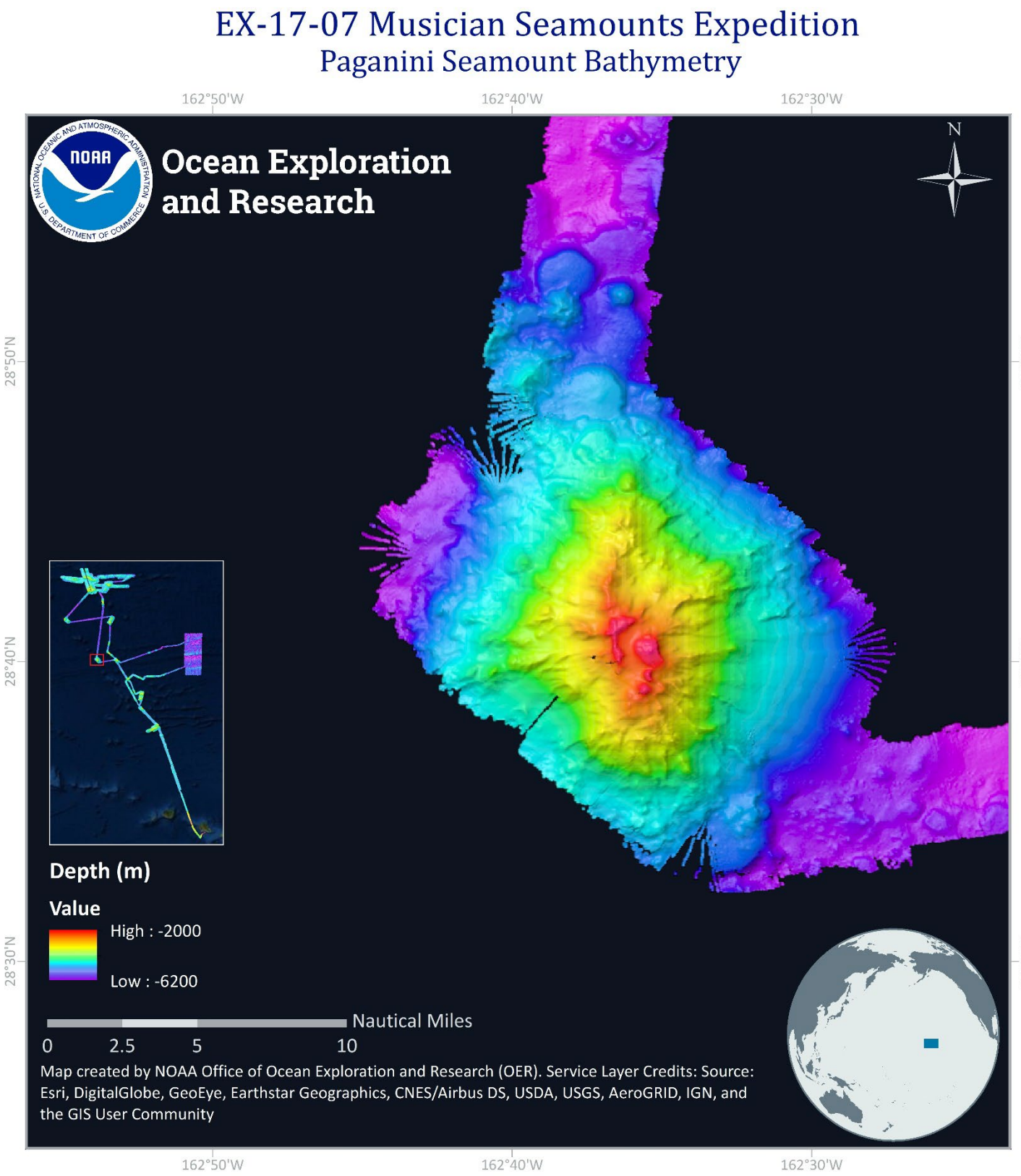

Figure 5. Focus map displaying a 60-meter resolution grid generated from bathymetric data collected over the Paganini Seamount. Image created in ArcMap.

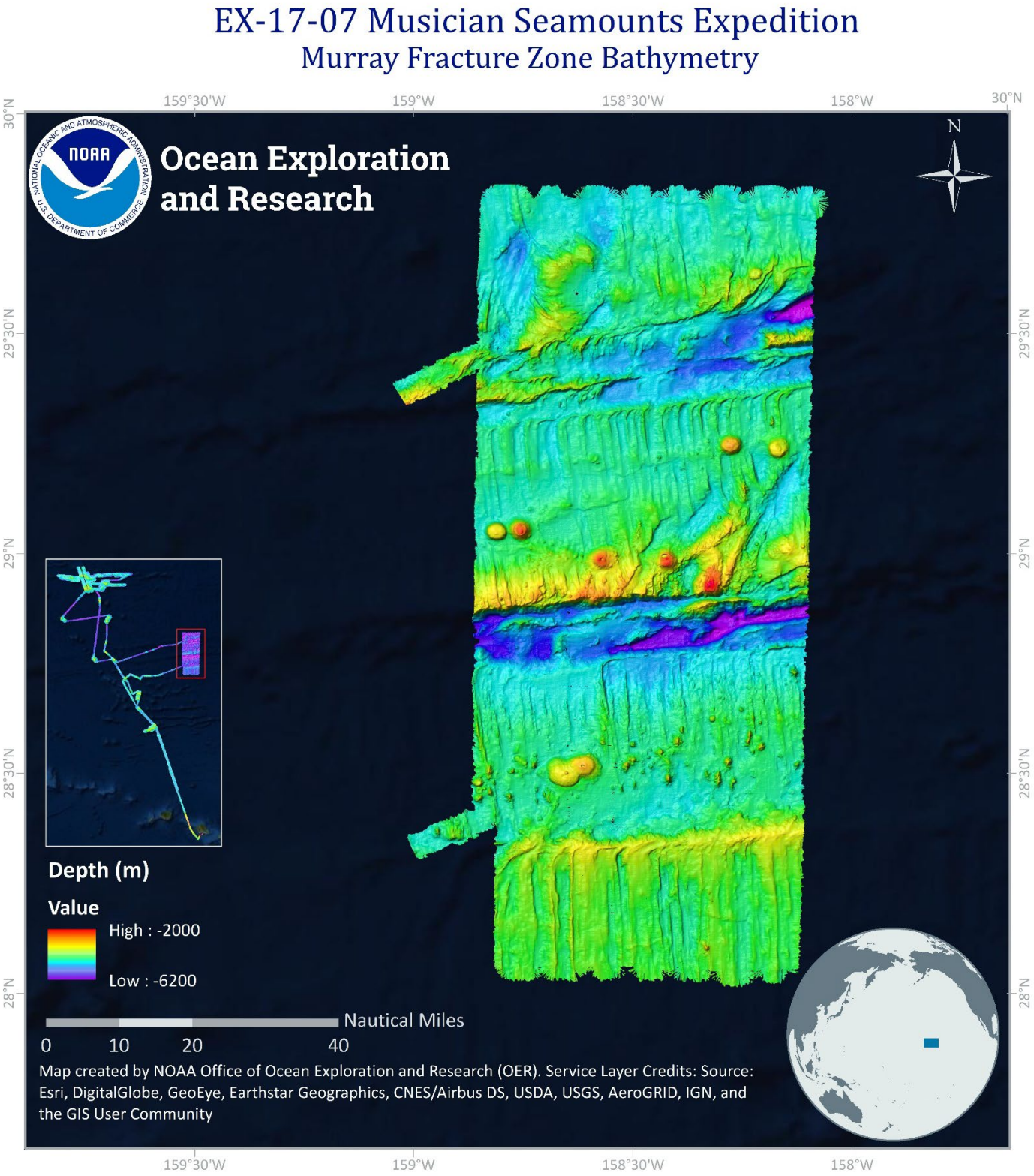

Figure 6. Focus map displaying a 75-meter resolution grid generated from bathymetric data collected over the Murray Fracture Zone. Image created in ArcMap.

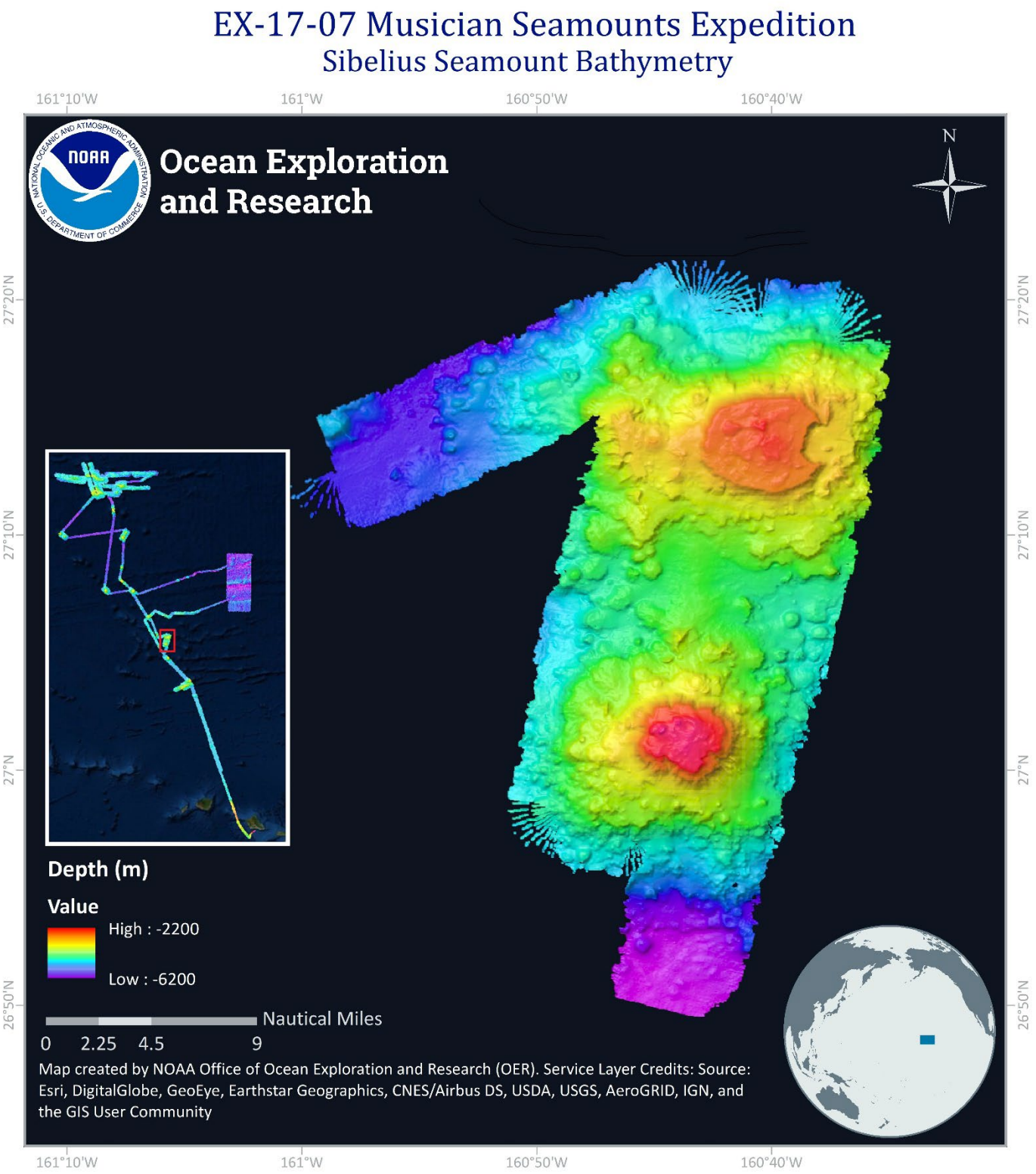

Figure 7. Focus map displaying a 60-meter resolution grid generated from bathymetric data collected over the Sibelius Seamount. Image created in ArcMap.

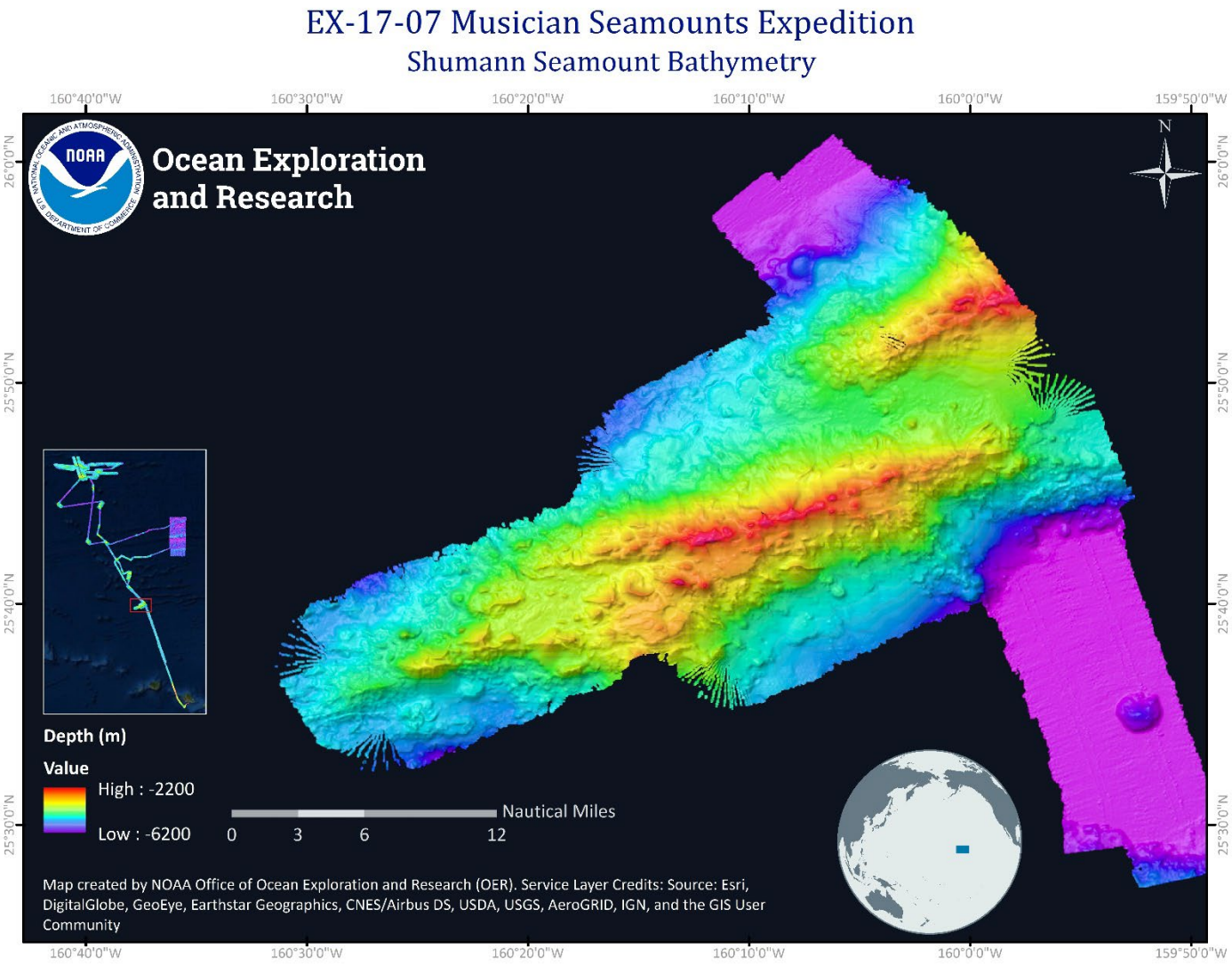

Figure 8. Focus map displaying a 60-meter resolution grid generated from bathymetric data collected over the Schumann Seamount. Image created in ArcMap.

8. Multibeam Sonar Data Quality Assessment and Data Processing

Figure 9 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 QPS Qimera for processing. In Qimera, the attitude and navigation data stored in each file were checked, and erroneous soundings were removed using 2-D and 3-D editors. Gridded digital terrain models were exported utilizing QPS Fledermaus software 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. 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).

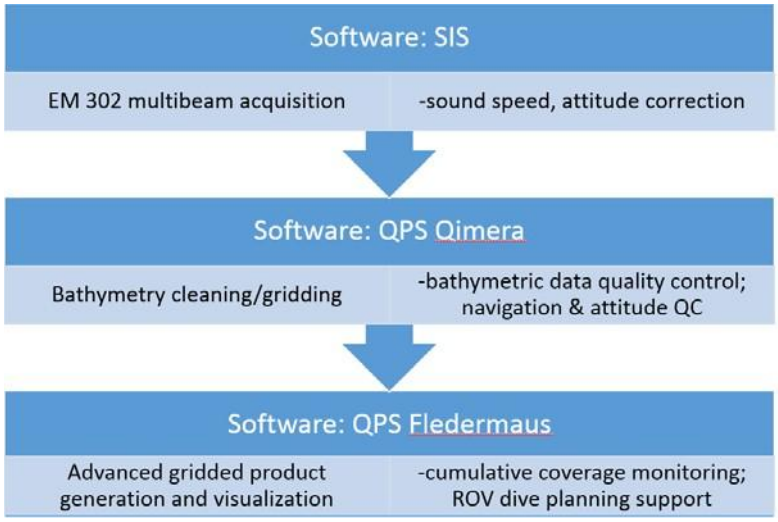

Figure 9. Shipboard multibeam data processing workflow.

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. Crosslines were run on August 19, 2017 as shown in Figure 10. Crossline analysis was completed using the Crosscheck Tool in QPS Qimera software. The results are shown below and confirm that the data collected meet International Hydrographic Organization (IHO) Order 1 specifications for data quality.

Crossline files:

0269_20170819_155025_EX1707_MB

0270_20170819_165022_EX1707_MB

0271_20170819_175025_EX1707_MB

0272_20170819_185025_EX1707_MB

0273_20170819_195020_EX1707_MB

Statistic	Value ("z" depths in meters)
Number of points of comparison	544,821
Grid Cell Size	100 m
Difference Mean	-0.250
Difference Median	-0.661
Difference Std. Dev	5.851
Difference Range	[-112.66, 161.86]
Mean + 2*Stddev	11.952
Median + 2*Stddev	12.363
Data Mean	-5663.535
Reference Mean	-5663.285
Data Z-Range	[-6046.25, -5148.46]
Reference Z-Range	[-6032.17, -5159.02]
Order 1 Error Limit	73.624
Order 1 # Rejected	126
Order 1 P-Statistic	0.000231
Order 1 Survey	**ACCEPTED**

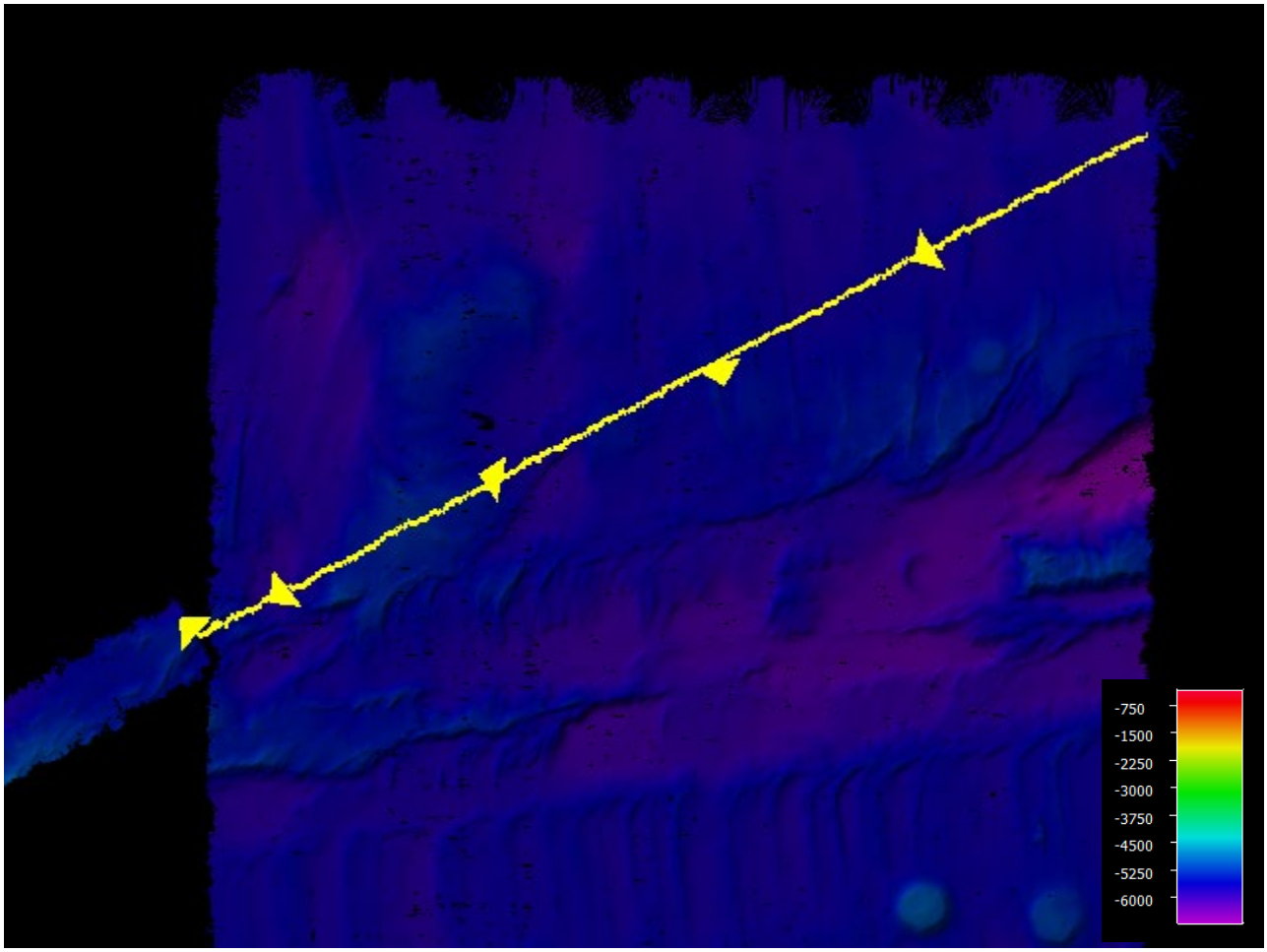

Figure 10. EX-17-07 crosslines (shown in yellow) used for comparison against the bathymetric grid generated via orthogonal multibeam survey lines. Image created in Fledermaus, color depth bar in meters.

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-17-07 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:

- 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 (TRU)

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 (TRU)
- Multibeam water column data review log if data were reviewed for presence of seeps in Fledermaus MidWater

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 12/23/2019).

Sub-bottom data, supporting data, and informational logs are available in the NCEI Data Archives accessible at https://maps.ngdc.noaa.gov/viewers/geophysics/ (last accessed 12/23/2019).

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 12/23/2019).

10. Cruise Calendar

All times listed are local ship time, -10 hours from UTC

August 2017

Sun	Mon	Tues	Wed	Thur	Fri	Sat
6 Mission personnel arrive in Honolulu, HI.	7 Training and vessel familiarization for mapping team.	8 Ship departed Ford Island at 1630. Transit to S28 search area and northward.	9 Transit mapping.	10 Focused mapping at Blackfin Ridge.	11 Focused mapping at Yatsuhashi and Murray Fracture Zone.	12 Focused mapping at the Murray Fracture Zone.
13 Focused mapping at the Murray Fracture Zone.	14 Focused mapping at the Murray Fracture Zone.	15 Focused mapping at the Murray Fracture Zone.	16 Focused mapping at the Murray Fracture Zone.	17 Focused mapping at the Murray Fracture Zone.	18 Focused mapping at the Murray Fracture Zone.	19 Focused mapping at the Murray Fracture Zone completed. En route to Mozart Seamount.
20 Focused mapping at the Debussy Seamount.	21 Focused mapping at the Mussorgsky Seamount.	22 Focused mapping at the western side of North Ridge.	23 Focused mapping in the western and central North Ridge.	24 Focused mapping in the center line plan at North Ridge.	25 Focused mapping at North Ridge (east).	26 Focused mapping at North Ridge (east).
27 Transit mapping south toward Paganini Seamount. Fast rescue boat deployment and recovery drills.	28 Focused mapping at Paganini Seamount and transit mapping over dive sites.	29 Transit mapping of dive site areas, and focused mapping at the Sibelius Seamount.	30 Transit mapping to Riverside.	31 Focused mapping over Riverside. PH buoy at 0600. Docked at Pier F9 on Ford Island.	1 Mapping personnel depart the ship.	2

11. Daily Cruise Log Entries

Generated from the daily expedition situation reports. All times listed are in local ship time (-10 hours from UTC).

August 6
Mission personnel arrive to the ship in Honolulu, Hawaii.

August 7
Prepare ship and survey plans for departure. HYPACK project and alternative line plans were created. A conference call was held with all offshore and onshore mapping personnel at 1000.

August 8
A safety induction meeting was held for all new personnel at 1230. The ship got underway at 1630 from Ford Island. Transit mapping commenced at the PH buoy. An XBT was conducted; and multibeam, EK 60, and sub-bottom data were acquired. The S28 search line was run at 6 knots for approximately 1.5 hours before the EM 302 malfunctioned with variable TX board connection errors. EK 60 and Knudsen SBP were changed to external ping mode while the EM 302 was troubleshot. Troubleshooting continued throughout the night.

August 9
The ship continued to transit map north toward Blackfin Ridge using the EK 60 and Knudsen. The EM 302 was fixed at approximately 1000, at which time all sonars were changed to internal pinging. A transit speed of 10.5 knots was maintained through the day. The OER Team Meeting was held at 0900. Drills occurred at 1300.

August 10
Focused mapping over Blackfin Ridge. Ship speed was reduced to 8.5 to 9 knots for mapping operations, and swath coverage was approximately 9000m in 2500m of water. Upon completion of Blackfin Ridge speed was increased to 10 to 11 knots.

August 11
Focused mapping over Yatsuhashi area at 8.5 to 9 knots. Transit to Murray Fracture Zone at 10 knots. Began Murray Fracture Zone mapping on the line plan azimuth of 357. Contingency plans were created in the event of inclement weather on azimuths of 022 and 090. TSG pipe repairs were completed with less than one hour of downtime to the TSG.

August 12
Focused mapping in the Murray Fracture Zone at survey speed. EM 302 is showing some random COM1 (position) and COM2 (attitude) drop outs a few times a day. Little data is lost due to the drops outs. SIS message service TXT files are being saved daily. Weather is good.

August 13
Focused mapping in the Murray Fracture Zone at survey speed. An engine protocol was instated to optimize fuel consumption during the day. If survey speed can be made using two engines the third engine will be shut down during the day and started in the evening so that if needed additional RPMs are available at night without the need for a call-out. Weather has deteriorated to 5 to 8 feet seas and 15 to 20 knot winds.

August 14
Focused mapping in the Murray Fracture Zone at survey speed. Weather is slightly improved. Static feedback from RTS in the online video feed. All mics muted onboard.

August 15
Focused mapping on the Murray Fracture Zone at survey speed. Weather deteriorated in the northern direction last night. Line plans were shifted to port 300 meters and line spacing was reduced to 4700 meters (m) from 5000 m to improve coverage overlap due to weather conditions. EM 302 swaths are 5900m wide in 5700 m of water, however in deeper water swaths are reducing to as much as 20 degrees on either side.

August 16
Focused mapping in the Murray Fracture Zone continues. Reduced line spacing remains good for coverage with regard to weather and deeper depths up to 6500 m. The engineering department tested the bow and stern thrusters in the morning while underway at zero RPMs. The testing did not have an impact on the ship's heading or data quality. Drills were held at approximately 1300. Explorers in Training are keeping up with data cleaning and daily products with assistance from the Watch Leads when needed.

August 17
Focused mapping in the Murray Fracture Zone. EM 302 swaths continue to be between 6300-7300 m wide in depths over 5500 m to 6500 m.

Free File Sync software was loaded onto the SCS Client1 computer for cruise data package transfer. The low speed internet connection was down today.

August 18
Focused mapping in the Murray Fracture Zone. The EM 302 experienced ping mode changes while in manual mode without watchstander intervention. Data gaps were filled on the following line.

August 19
Focused mapping in the Murray Fracture Zone was completed. Transit mapping at 10 knots continued to new coverage areas enroute to Mozart seamount. A crossline was completed across the northern Murray Fracture Zone. The EM 302 has had intermittent COM dropouts for the last several days. Message services are being saved daily to record the events.

August 20
Focused mapping over the Musician Seamounts at 8.5 to 9 knots with 10 knot transits between seamounts. EM 302 swaths of up to 9200 m along the slope of Debussy Seamount in 4700 m of water at nadir. Debussy Seamount focused mapping was completed.

CTD computer is running very slowly on start-up and restarts. Last night the computer required several restarts to resume navigation and MK21 software connections. Several MK21 communication losses occurred during casts over the last couple days. The software is canceling casts (<500 m) without warning about once in a 24-hour period. New XBT launchers have been switched in, however connection issues continue.

August 21
Transit mapping to Mussorgsky Seamount occurred at 10 knots. Due to wide swaths for the Mussorgsky survey area a small portion of the adjacent seamount was added to the line plan. Mussorgsky was completed and transit mapping to North Ridge resumed at approximately 1800.

August 22
Focused mapping at the western side of the North Ridge line plan. EM 302 swaths up to 9600 m were observed in this area. Weather conditions and sea states were optimal.

The southern transit was revised to include seamounts Paganini and Sibelius for the next cruise. Line miles were removed from the eastern North Ridge line plan.

August 23
Focused mapping at North Ridge continued. The western section was completed and the center section was started. The line spacing was increased to 6000 m in the center section for optimum coverage.

August 24
Continued focused mapping at North Ridge (center). Line plans were reduced to less than 4500 m coverage at Wagner Seamount and extended to the eastern terminus of Rossini Seamount. Original line directions were flipped and the eastern line plan was started in the north, working from Rossini to Bizet. EM 302 swaths are 8800m wide in 4700 m of water. Data quality is excellent as optimal weather conditions continue.

The shoreside team notified the ship of a “No Broadcast” issue. The NOAA NOC later reported that the video broadcast was interrupted by a terrestrial circuit issue from a higher level outage where a fiber cable was damaged by fire. The broadcast was back to a nominal state at 0100 UTC.

August 25
Focused mapping continued at North Ridge (east) using 6000 m (Shubert Seamount) and 7000m line spacing (Bizet Seamount). EM 302 swaths up to 9700 m were recorded. Data quality remains outstanding.

A steering casualty drill was held at 1300.

August 26
Focused mapping continued at North Ridge (east). Data quality, coverage and weather remain optimal. The Qimera project was running slower than normal with significant import lags from the "Checking line solutions for SVP usage after import" processing bar. Data processing options were explored to minimize impact to get the project running smoother. The shoreside team sent a help desk ticket into QPS.

A Man-Over-Board drill was held in the afternoon.

August 27
Focused mapping at the North Ridge (east) area was completed at 1030. Transit mapping toward Paganini Seamount at 10 knots was reduced to 3 knots for 2.5 hours for small boat deployment and recovery drills. Transit speed resumed after completion of small boat drills. EM 302 swaths were 8500m while transiting in 3200 m of water.

August 28
Focused mapping at Paganini was completed. Transit mapping toward Mozart Seamount continued at 10 knots. One pass was made over Mozart Seamount. The trackline was revised to include one pass over additional dive sites.

August 29
Transit mapping over additional EX-17-08 dive sites (5, 15, 16 and 17) were completed and focused mapping over Sibelius seamount was completed. An additional 3 hours of transit mapping was done in the area of Blackfin Ridge to extend coverage and utilize additional time gained from a faster transit speed.

FTP uploading of SD files was unsuccessful, therefore mosaics and static surfaces smaller than 25MB were emailed to the onshore team. The Qimera project is still experiencing slower than normal processing speeds.

August 30
Transit mapping continued south to the Riverside investigation line that was previously missed on departure due to the EM 302 failure. Wind speeds increased to about 20 knots.

August 31
The Riverside investigation was completed in the early morning at 6 knots. The ship reached the PH buoy at 0600 for preparations to transit Pearl Harbor docking at pier F-9. The ship was pier side at 0830. The live broadcast was disabled. Daily products were produced and uploaded to the FTP.

September 1
Visiting mapping personnel depart the ship.

12. References

The 2017 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-17-07 Project Instructions can be obtained from the NOAA Central Library. The EX-17-07 Data Management Plan is an appendix of the project instructions.

EX-17-07 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