Ocean Exploration and Research

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MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT:

EX-17-11, Gulf of Mexico 2017 (ROV & Mapping)

November 29, 2017 to December 21, 2017

Key West, Florida to Pascagoula, Mississippi

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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, and 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 the mapping expedition EX-17-11 Gulf of Mexico 2018, and to present a summary of the overall mapping results and mapping related cruise activities. A separate report titled, 'Cruise Report: EX-17-11, Gulf of Mexico 2017 (ROV& Mapping)' detailing ROV and other science objectives is available from the NOAA Central Library. A detailed description of the NOAA Ship *Okeanos Explorer* mapping capabilities are available in the 2017 NOAA Ship *Okeanos Explorer* Survey Readiness Report, archived in the NOAA Central Library.

3. Cruise Objectives

During EX-17-11 NOAA OER worked with the scientific and management community to characterize unknown and poorly-known areas of the Gulf of Mexico through telepresence-based exploration. Baseline information collected during the cruise will support and catalyze further exploration, research and management activities.

An online summary of all mission objectives be found here: https://oceanexplorer.noaa.gov/okeanos/explorations/ex1711/logs/summary/welcome.html (last accessed April 2020)

The complete objectives for this cruise are detailed in the EX-17-11 Project Instructions, which are archived in the NOAA Central Library here: https://repository.library.noaa.gov/view/noaa/17345 (last accessed April 2020).

4. Summary of Mapping Results

The expedition commenced from Key West, Florida on November 29, 2017 and concluded in Pascagoula, Mississippi on December 21, 2017. EX-17-11 mapped 26,000 square kilometers (km) of seafloor in the Gulf of Mexico during the 22 days-at-sea (Figure 1 and Table 1). 20,514 square kilometers with the U.S. Exclusive Economic Zone (EZZ) deeper than 200 meters (m) were mapped. Multibeam bathymetry data coverage is shown in Figure 1.

Cruise Overview Map

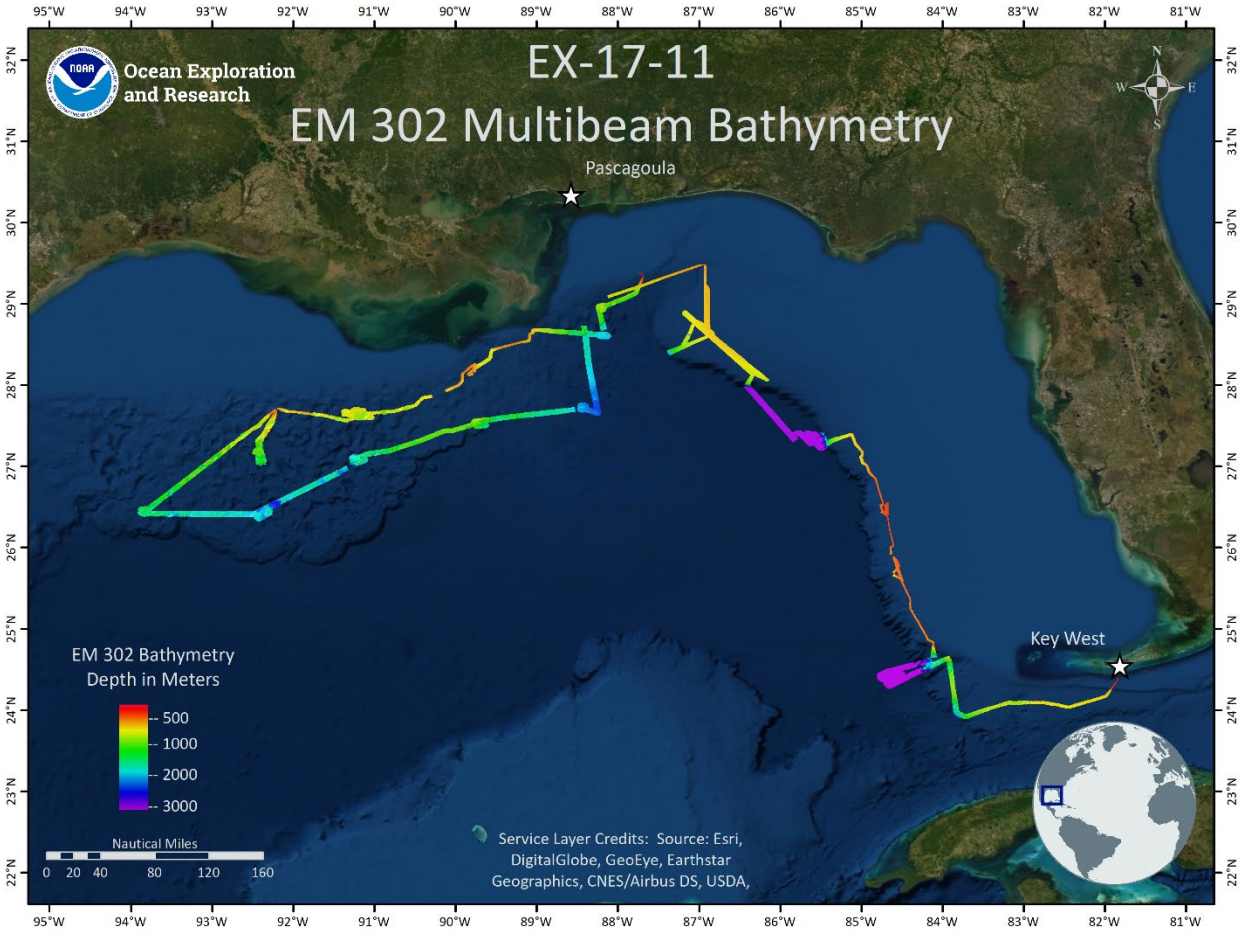

Figure 1. Overview of bathymetric mapping coverage completed during Gulf of Mexico 2017 expedition (EX-17-11).

5. Mapping Statistics

Table 1. Summary statistics of ocean mapping work completed during EX-17-11.

Dates of data collection	November 29 – December 21, 2017
Linear km of survey with EM 302	4,600
Square km mapped with EM 302	26,000
Square kilometers mapping with U.S. EZZ deeper than 200m	20,514
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)	413 files/ 33.1 GB (6 files/607 MB Restricted)
Number / Data Volume of EM 302 water column multibeam files	413 files / 87.3 GB (6 Files/ 1.06 GB Restricted)
Number / Data Volume of EK60 water column split-beam files (.raw/.idx)	235 Files/9.2 GB (12 Files/ 391 MB Restricted)
Number / Data Volume of sub-bottom sonar files (.segy, .kea, .keb)	488 Files / 3.97 GB (6 Files/ 104 MB Restricted)
Number of XBT casts	68
Number of CTD casts (including test casts)	1

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 conducting mapping operations in up to 8,000m of water depth. The system generates a 150° beam fan containing up to 432 soundings per ping in waters deeper than 3300m. In waters shallower than 3300m 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. System calibration to determine the angular offsets (Patch Test) is conducted annually and the results are reported in the annual readiness report. The 2017 NOAA Ship *Okeanos Explorer* Survey Readiness Report at the time of writing this report was planned for archival in the NOAA Central Library.

Simrad EK6 Split-beam Sonars

The ship operated four Simrad EK60 split-beam fisheries sonars: 18 kHz, 38 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-17-11. The 2016 EK60 Calibration Report is planned for archival 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 ~1000m range; and a 300 kHz Teledyne RDI Workhorse Mariner ADCP, with a ~70m 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 during mapping operations due to interference issues.

7. Data Acquisition Summary

Mapping operations included data collection using the EM 302 multibeam sonar, EK60 split-beam (18, 38, 70, 120, and 200 kHz) sonars, and Knudsen 3260 sub-bottom profiler. Data were collected by each sonar concurrently during the transits

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. EX-17-11 when possible included focused overnight mapping of the ROV dive location.

Select data from December 9, 2017 were collected using Underwater Cultural Heritage (UCH) protocols and have not been cleared for public access by OER. Individuals wishing to access these files can contact ncei.info@noaa.gov.

Figure 2 shows a map of location of sonar anomalies, typically thought to be bubble plumes/cold water seeps, which were geo-picked from the EM 302 water column data. Some of these are new locations and some confirmed historical seep locations.EX-17-11 mapping operations when possible included focused overnight mapping of the ROV dive location, examples are shown in Figures 3 and 4 for Dives 14 and 16 respectively.

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 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 secondarily derived sound speed values from the ship's onboard thermosalinograph flow-through system as a quality assurance measure.

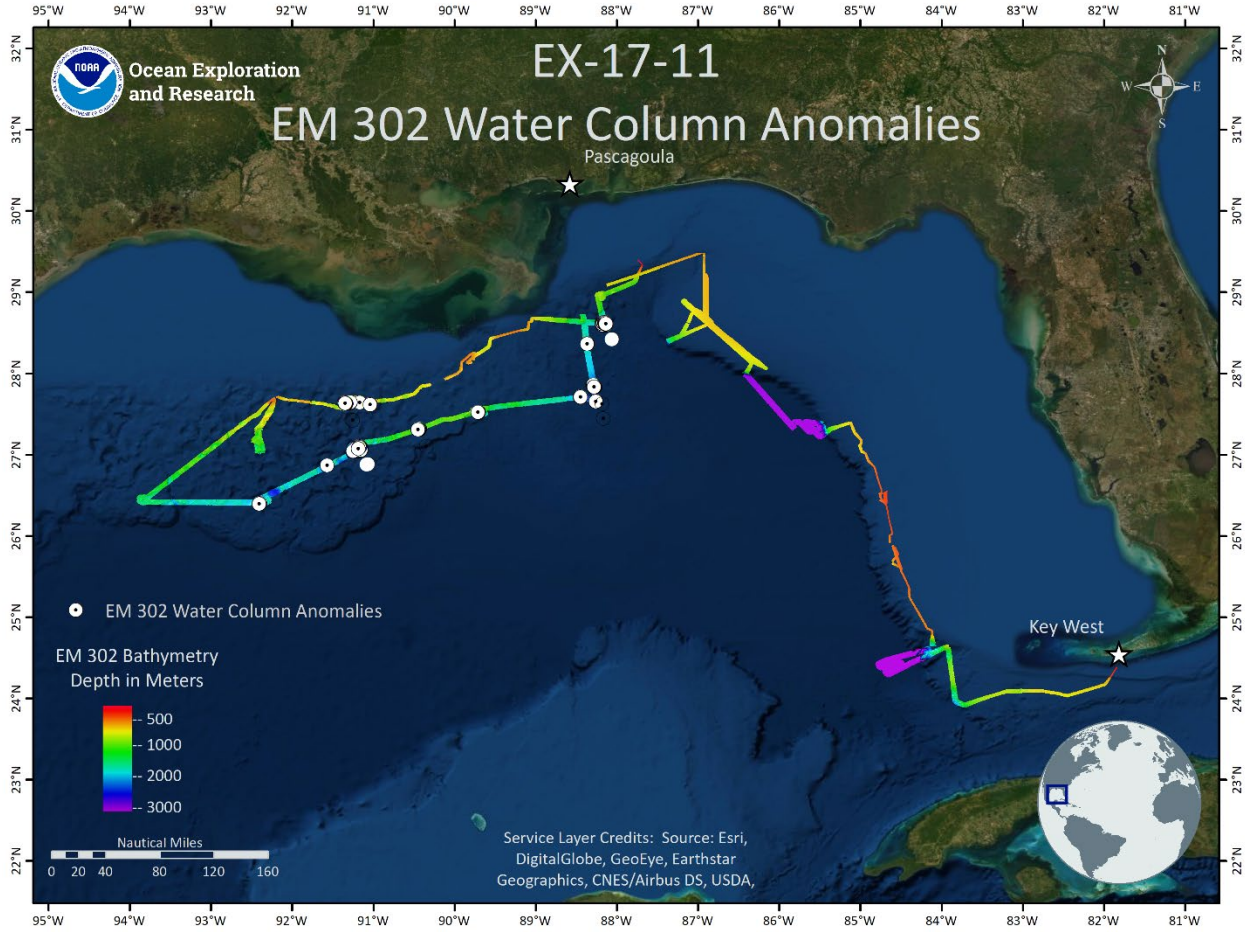

Figure 2. Locations of EM 302 water column anomalies from EX-17-11. These are typically thought to be cold water seeps/bubble plumes.

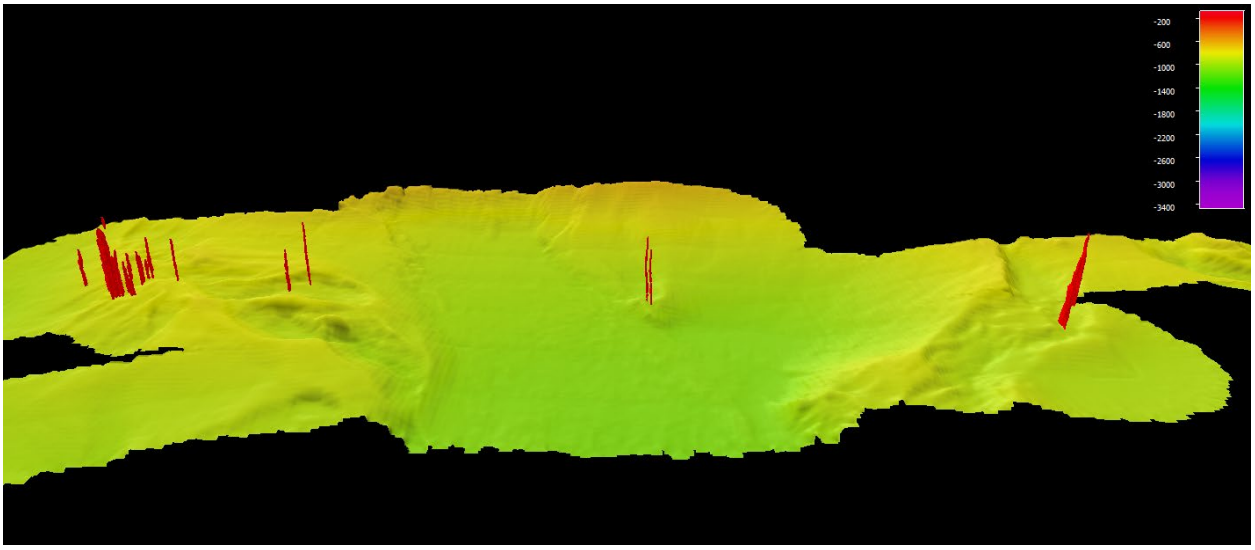

Figure 3. Example of overnight focused mapping over a ROV dive site with water column anomalies identified in the EM 302 data. From Dive 14, 'Penchant Basin.' Vertical exaggeration 3x, 60m cell size, depth in meters.

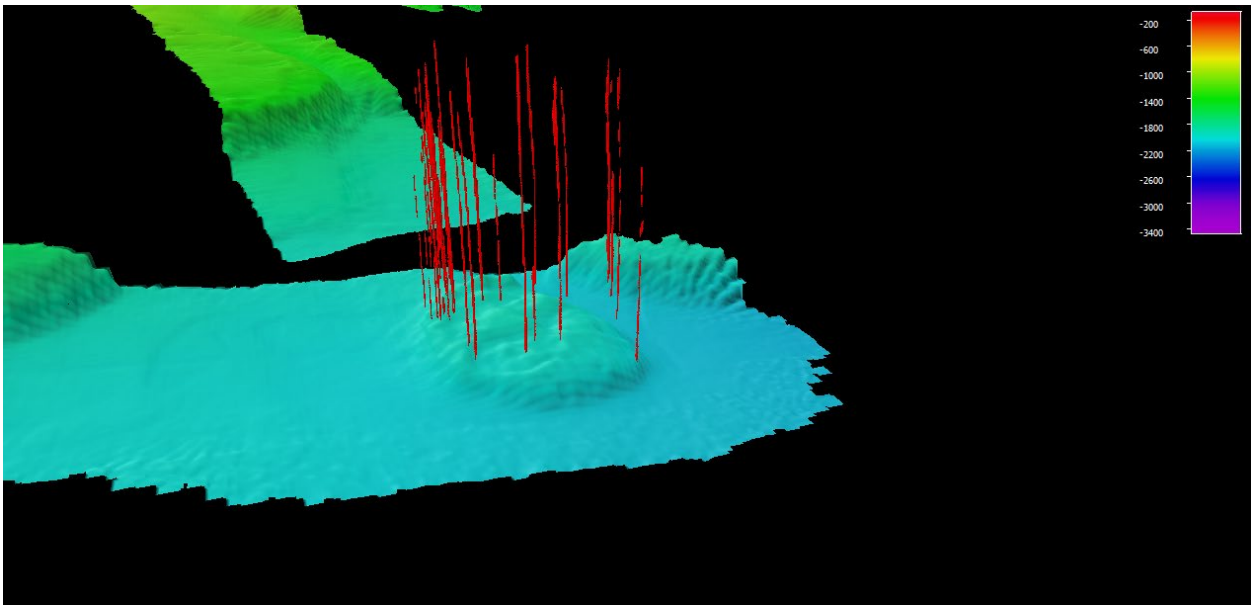

Figure 4. Example of overnight focused mapping over a ROV dive site with water column anomalies identified in the EM 302 data. From Dive 16, 'Dauphin Dome.' Vertical exaggeration 3x, 60m cell size, depth in meters.

Simrad EK60 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. Figure 5 shows the EK60 data collected during EX-17-11. The 38 kHz EK60 was only turned on during ROV dives.

Knudsen 3260 sub-bottom profiler data were also collected during the majority of the cruise. Figure 6 shows where sub-bottom data were collected during EX-17-11.

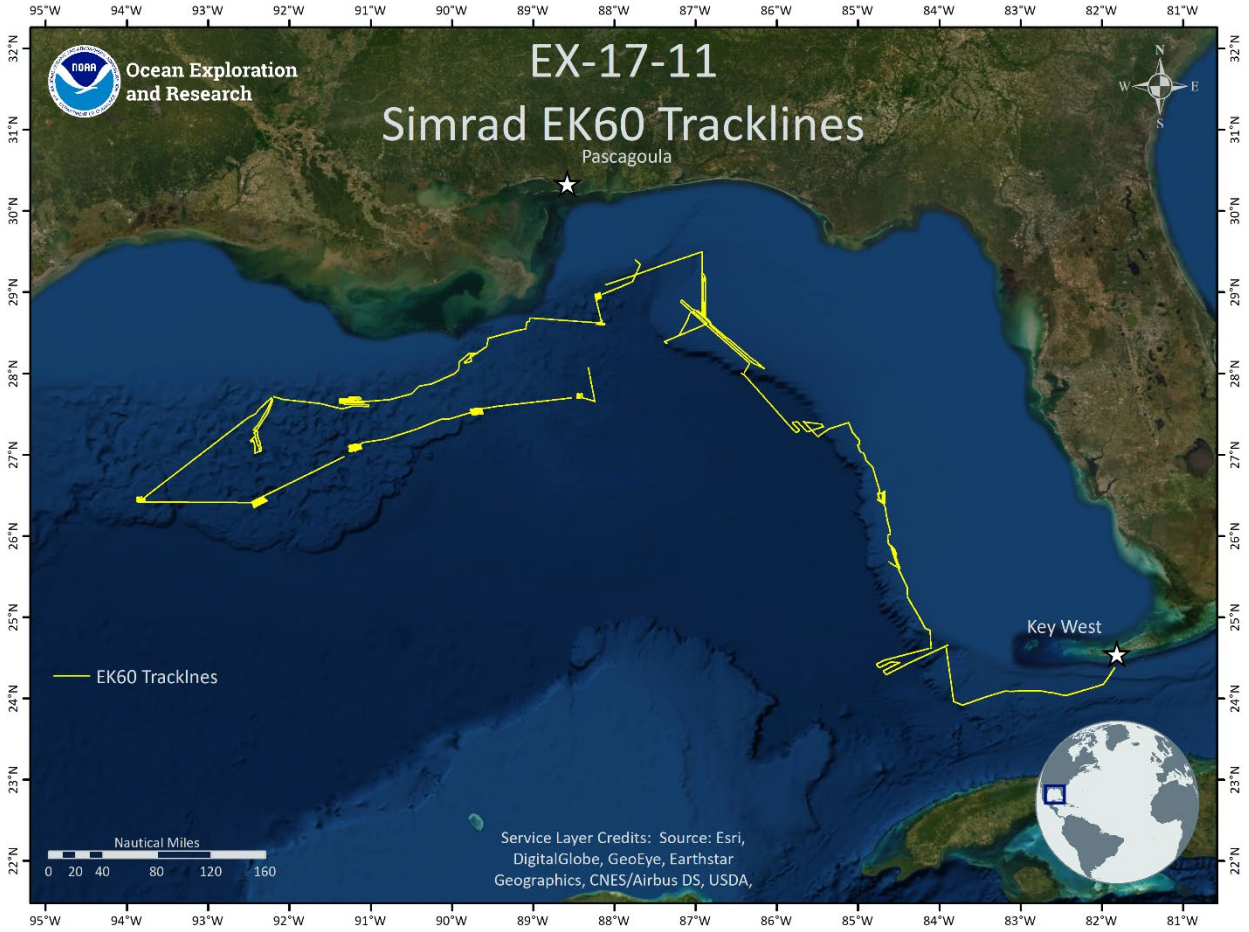

Figure 5. Simrad EK60 split-beam sonar data tracklines (in yellow) collected during EX-17-11.

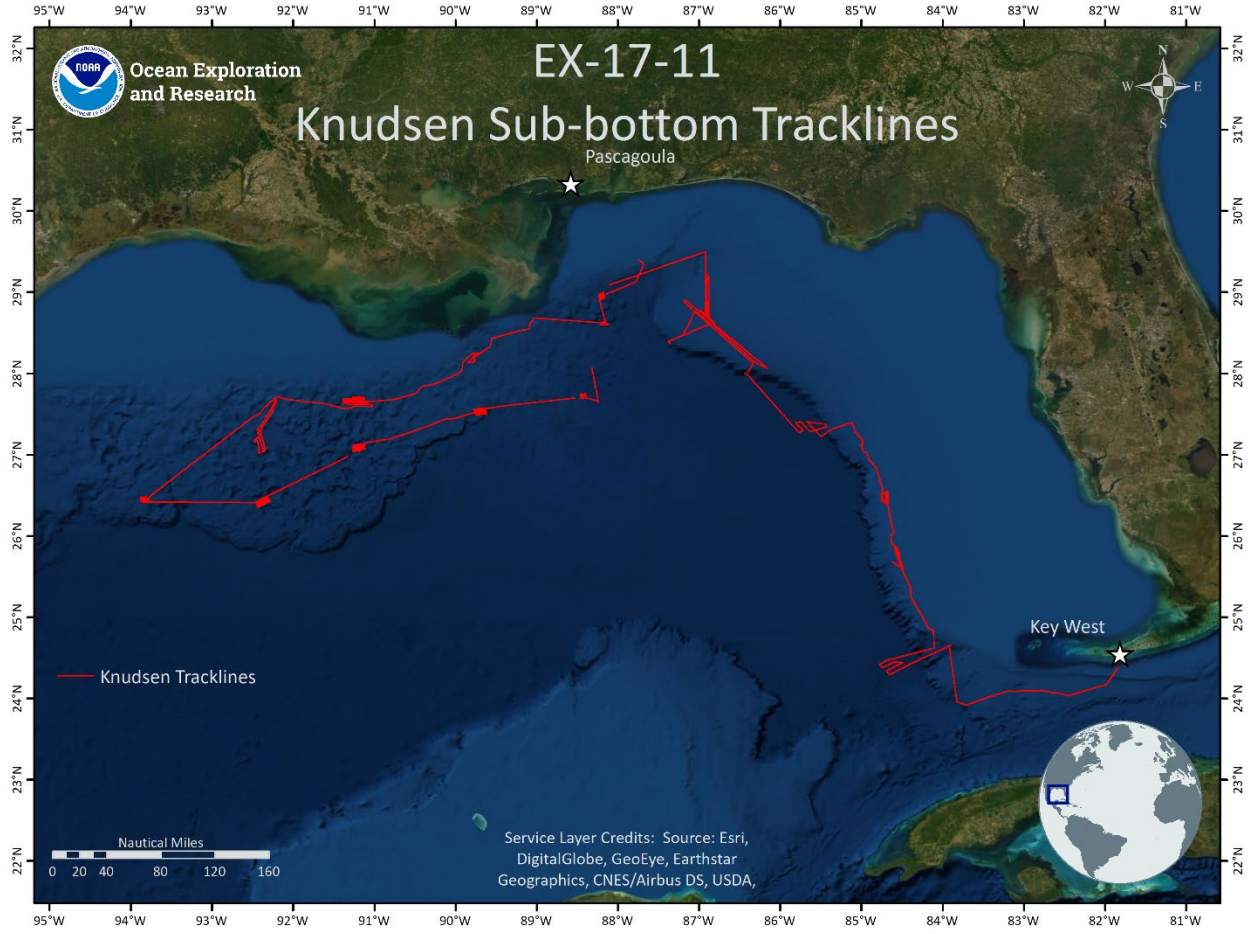

Figure 6. Sub-bottom profiler data tracklines (in red) collected during EX-17-11.

8. Multibeam Sonar Data Quality Assessment and Data Processing

Figure 7 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 2D and 3D 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).

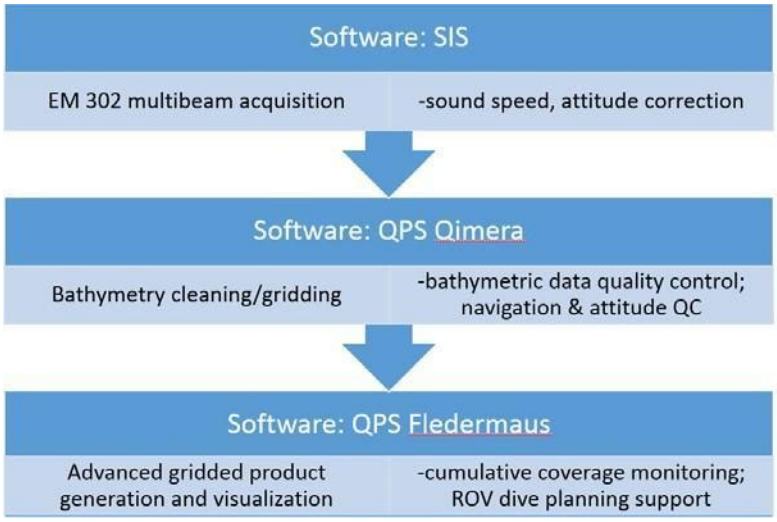

Figure 7. Shipboard multibeam data processing workflow.

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 December 14, 2017 as shown in Figure 8. Crossline analysis was completed using the Crosscheck Tool in QPS Qimera software to evaluate if the survey meets the requirements for an International Hydrographic Order 1 survey. The results are shown below.

Crossline file:

0287_20171214_100047_EX1711b_MB.all

Mainscheme line files:

0279_20171214_070009_EX1711b_MB.all

0281_20171214_080014_EX1711b_MB.all

0283_20171214_084826_EX1711b_MB.all

Statistic	Value (in meters)
Number of points of comparison	158614
Grid Cell Size	45
Difference Mean	-0.385612
Difference Median	-0.689780

Difference Std. Dev	3.244456
Difference Range	[-37.42, 23.56]
Mean + 2*Stddev	6.874524
Median + 2*Stddev	7.178691
Data Mean	-1588.354458
Reference Mean	-1587.968846
Data Z-Range	[-1698.08, -1390.40]
Reference Z-Range	[-1690.06, -1392.17]
Order 1 Error Limit	20.649649
Order 1 # Rejected	15
Order 1 P-Statistic	0.000095
Order 1 Survey	**ACCEPTED**

These results confirm that the data collected meet International Hydrographic Organization (IHO) Order 1 specifications for data quality.

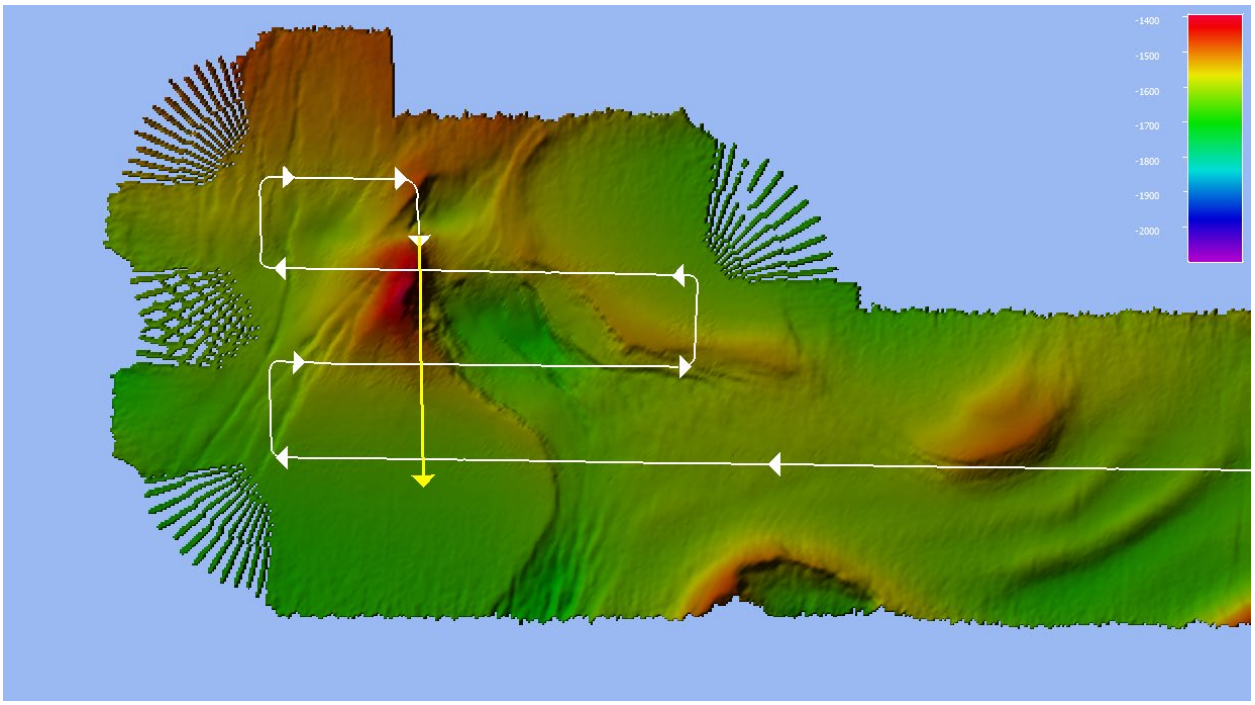

Figure 8. EX-17-11 crossline (shown in yellow) used for comparison against the bathymetric grid generated via orthogonal multibeam survey lines.

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-17-11 project instructions, available in the NOAA Central Library here: https://repository.library.noaa.gov/view/noaa/17345 (last accessed April 2020). 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 EK60 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 or QPS Qimera

All sonar data is permanently discoverable at https://www.ngdc.noaa.gov/ (last accessed April 2020).

At the time of writing this report, EM 302 and EK60 water column data, supporting data, and informational logs were available in the NCEI Water Column Sonar Archives: https://www.ngdc.noaa.gov/maps/water_column_sonar/index.html (last accessed April 2020). The Digital Object Identifier (DOI) for EX-17-11 EM 302 water column data is: http://doi.org/10.7289/V5W957HS (last accessed April 2020) and the DOI for EK60 data is: http://doi.org/10.7289/V54T6GN6 (last accessed April 2020).

Sub-bottom data, supporting data, and informational logs will be available in the NCEI Data Archives accessible at https://www.ngdc.noaa.gov/ (last accessed April 2020). For any challenges accessing SBP data, send an inquiry to ncei.info@noaa.gov requesting access to EX-17-11 Knudsen 3260 sub-bottom raw and processed data.

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

10. Cruise Calendar

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

November - December 2017

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			28 Mobilization	29 Depart Key West, Florida	30 Dive 01, overnight mapping	December 01 Dive 02, overnight mapping
02 Dive 03, overnight mapping	03 Dive 04, overnight mapping	04 Dive 05, overnight mapping	05 Dive 06, overnight mapping	06 Dive cancelled, 24/hour mapping	07 Dive cancelled, 24/hour mapping operations	08 24/hour transit mapping
09 Dive 07, UCH, overnight mapping	10 Dive 08, overnight mapping	11 Dive 09, overnight mapping	12 Dive 10, overnight mapping	13 Dive 11, overnight mapping	14 Dive 12, overnight mapping	15 Cancelled dive, 24/hour mapping
16 Dive 13, overnight mapping	17 Dive 14, overnight mapping	18 Dive 15, overnight mapping	19 Dive 16, overnight mapping	20 Dive 17, transit mapping	21 Arrive, Pascagoula, Mississippi, demobilization	22

11. Daily Cruise Log Entries

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

November 28

Mobilization, Key West, Florida.

November 29

The EM 302 Transmit Receive Unit (TR was left on for the short in port between EX-17-11 and EX-17-10 and the first Built-in Self-test (BIST) passed. The Knudsen came online fine. The EK60s needed a power cycle - the software was not registering the 18 kHz. It may have been a loose ethernet. Mapping yesterday went well with excellent data quality even at high speeds (10+kts). Likely this was due to shallow depths, hard substrate and calm conditions. Training and orientation continues for Augmenting Survey Technician (AST) currently focused on acquisition. XBTs are being done every 3-4 hours.

November 30

Dive 01. Mapping operations continued swimmingly overnight with swaths of 2x depth in roughly 3500m of water. All systems functioned normally. The ADCP was turned to acquisition last night close to Dive 02 location to attain surface current speed while the EM 302 was running with little effect. The first round of MB daily products have been sent ashore using the new file format. Yesterday we ran a cross track line of EX data over varying depths starting at 24.64511N -83.9200407W and ending at 24.41901N -84.411179W.

December 01

Dive 02. Mapping operations continued smoothly overnight. Since operations are in shallow (<400m) of water, the Knudsen was secured and then started when the ship transited through deeper waters. The onboard team is investigating a discrepancy in sound speed, a little over 1 meter/second, between the Reson SVP and the thermosalinograph (TSG). Now that the ship is well into UTM 16N, we will start new Qimera and Hypack projects post-dive.

December 02

Dive 03. Mapping continued overnight in shallow waters (<400m) edge matching existing data. Knudsen was run all night with good returns. Survey lines where run over historical seep sites. No seeps where seen in the EM 302 water column or EK60s. All systems continue to function normally, with larger than expected swaths. AST is working on the TSG/Reson discrepancy by examining past sound velocity figures. Watch lead (WL) is processing water column overnight.

December 03

Dive04. Edge matching continued overnight in relatively shallow waters (<400m) until early in the morning the ship transit to map some gaps in the abyssal plain. All systems continue to function well. EK60 screenshots were sent to shore for mid water dive planning. We have prepared survey areas in case of poor weather later in the week. Dive 06 will be the first dive using the new Bureau of Ocean Energy Management (BOEM) seismic data set (last accessed April 2020).

December 04

Dive 05 Mapping operations continued last night targeting gaps in the abyssal plain of Gulf of Mexico (GoMex). At approximately 22:30 local time last night an error appeared after a rapid on/off pinging change on the telnet and pinging stopped despite Pining being turned on, "No Attitude...No Doppler Velocity." All position data was feeding fine into the sensors and Scientific Computing System (SCS). SIS was restarted, then the acquisition computer was restarted, the same error appeared - all BISTs past. Mapping power cycled the TRU and then brought up SIS and the error went away. During the midwater portion of Dive 05 as the ROVs got shallower, the 38 kHz began tracking the vehicles as the bottom. Since they were in the Deep Scattering Layer (DSL), bottom tracking was turned off so the onshore team could see the DSL.

December 05

Dive06. Mapping continued smoothly overnight. All systems are functioning normally. Mapping staff is reviewing water column data. Processing and dive scenes are up to date. These was an observed difference between the planned ROV route planned on BOEM seismic bathy. Essentially there was a feature in the BOEM bathy that did exist when the ROVs approached it. It did not exist in the multibeam bathy either. The area was particularly steep and deep and some discrepancy was expected. Moving forward the onboard team will be more meticulous when considering the seismic data in area with similar relief. The depths themselves were accurate.

December 06

With today's dive cancelled survey switched to 24/hour mapping operations. Mapping will focus effort on an area south/south east of DeSoto canyon as requested by regional partners. During the day swaths were large, but overnight coverage and data quality deteriorated. Line spacing also decreased. AST began training on processing EM 302 data this evening. Processing and acquisition are all caught-up.

December 07

With increased seas and wind, the ship broke off survey lines and ran to the north for better conditions and ride. Early in the afternoon Mapping Lead (ML) developed a line plan to run north into the swells and south to sail down the swells to get good data in at least one direction. Data quality heading north is poor, if existent at all. Data quality moving south is okay but does reflect current conditions. While up on the shelf we have been observing

"smiles" in the bottom trace and appearing in the point cloud. These sound velocity (SV) artifacts are present despite the frequency of XBTs and are thought to be a result of shallow, flat conditions (500-700m depth) nearer landmass. At approximately 1900 (CST) ship time the on board team observed consistent interference in the EM 302 and the EK60s. Inquiries around the ship concluded nothing has changed.

December 08

Data quality was poor all day due to sea state. Mapping is performing XBTs every 3 hours, but bowing in the bottom trace (sound speed artifacts) still exists. The onboard team continues to troubleshoot the interference which has become intermittent but has remained despite a 70 nautical mile (nm) transit.

December 09

Dive 07. ADCP and SCS mailers were secured for the UCH dive. Data quality has been improving since as the seas calm and the ship heads east. The onboard team is still observing some interference in the MB and EKs, although it is not as pronounced as it was.

December 10

Dive 08. Data quality continued to improve overnight. On board team continues to monitor sonars for interference which is now intermittent. All systems functioning normally.

December 11

Dive 09. Overnight transit and dive site mapping continues to go well. Mapping team is processing water column data and ML is providing backscatter for morning dive site refinements. Systems are functioning normally.

December 12

Dive 10. Water column and backscatter processing continues and dive tracks are being refined in the morning based on overnight mapping. Screenshots of suspicious interference have been sent to mapping team.

December 13

Dive 11. All systems continue to function normally. ADCP and SCS mailers have been secured overnight.

December 14

Dive 12. Continuing to trouble shoot the interference in the EK60s

December 15

Cancelled dive due to weather, 24/hour mapping. Collected data as possible given conditions over all data quality was fair to poor depending on heading.

December 16

Dive 13. Collected transit mapping overnight as well as a couple lines over the dive site to get updated backscatter and check for water column anomalies. Troubleshooting of inference in the EK60s and MBES continues.

December 17

Dive 14. After some weekend observations, the signal/intensity of the interference does switch (the signal becomes louder) when the EM 302 goes from "Deep 1" to "Deep 2" going from 900m to about 1100m in depth. Mapping forced it into "Very Deep," and the signal in the shallow water EKs changes, but is still very much present. The interference in the EKs is intermittent and appears/disappears without changing any acquisition parameters on the ship. There are other troubleshooting items, such as the status of the Trigger Jigger that are being considered. The Electronic Technicians (ETs) also checked the grounded on the EKs and found no fault.

December 18

Dive 15. Conducted transit mapping transit to the next dive site then completed several tightly spaced lives over the new days dive site to allow for bubble detection and to get good backscatter to help with dive planning.

December 19

Dive 16. Missions/Survey had a discussion with ship team to review interference status. The most pressing takeaway is while the ship has spare Trigger Jiggers, none are programmed. This means if the current Trigger Jigger fails, there are none ready for a hot swap. Programming and testing them can be difficult - possibly something to think about for a shakedown cruise. The interference itself remains unpredictable and intermittent. Last night survey ran tight (150m-200m) EK60 survey lines over active seep areas. After, the ship completed lines over Horne Dome dive site and 27 sonar plume anomaly locations were loaded into the ROV Hypack.

December 20

Dive 17. Conducted transit mapping until the ship entered shallow water.

December 21

Arrival Pascagoula, Mississippi. Data transfer package has been completed. Summary Map and summary statistics have been delivered to Expedition Coordinator. All sonars have been secured and power shut-off. The acquisition tablet has been placed in the top blue Vidmar. XBTs have been restocked from survey stores. Final daily products have been placed in the FTP folder. Chief ET re-terminated the EM 302 cable into the Trigger Jigger. Dry lab, Wet Lab and back row of control room have been cleaned.

12. References

NOAA Office of Ocean Exploration and Research, 2017. The 2017 NOAA Ship *Okeanos Explorer* Survey Readiness Report NOAA is available at the NOAA Central Library or from contacting oar.oer.exmappingteam@noaa.gov.

NOAA Office of Ocean Exploration and Research, 2017. EX-17-11 Project Instructions: https://repository.library.noaa.gov/view/noaa/17345 (last accessed April 2020). The EX-17-11 Data Management Plan is an appendix of the project instructions.

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