

MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT:

EX-17-10, Canal Transit and Gulf of Mexico Mapping (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.



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2. Report Purpose

The purpose of this report is to briefly describe the acoustic seafloor and water column mapping data collection and processing methods used during exploration expedition EX-17-10, 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-17-10 commenced on November 15, 2017 in Panama City, Panama and concluded on November 22, 2017 in Key West, Florida. The primary goals of the cruise were the following:

1. Move the ship from operational areas in the Pacific Ocean to the Atlantic Ocean via transiting northward through the Panama Canal;
2. Collect ocean mapping data continuously wherever permitted;
3. Test the UnderwayCTD equipment under normal surveying conditions.

Multibeam, split-beam, sub-bottom profiler sonar mapping operations were conducted 24 hours a day throughout the cruise, except within foreign waters that had not provided marine scientific research permits by the time of the cruise (Colombia). Expendable bathythermograph (XBT) sound velocity casts in support of multibeam sonar mapping operations were conducted as needed to ensure high quality multibeam sonar data, with no interval between casts exceeding 6 hours. Multibeam data were fully processed according to standard onboard procedures and archived at the National Centers for Environmental Information.

The specific objectives for this cruise were defined in the EX-17-10 Project Instructions, which are archived in the NOAA Central Library and available at this link:

<https://repository.library.noaa.gov/view/noaa/17237>.

4. Summary of Mapping Results

Multibeam mapping operations for EX-17-10 covered an area of 14,029 square kilometers of seafloor over a linear ship track distance of approximately 2,200 kilometers. Multibeam bathymetry data coverage is shown in Figure 1.

Cruise Overview Map

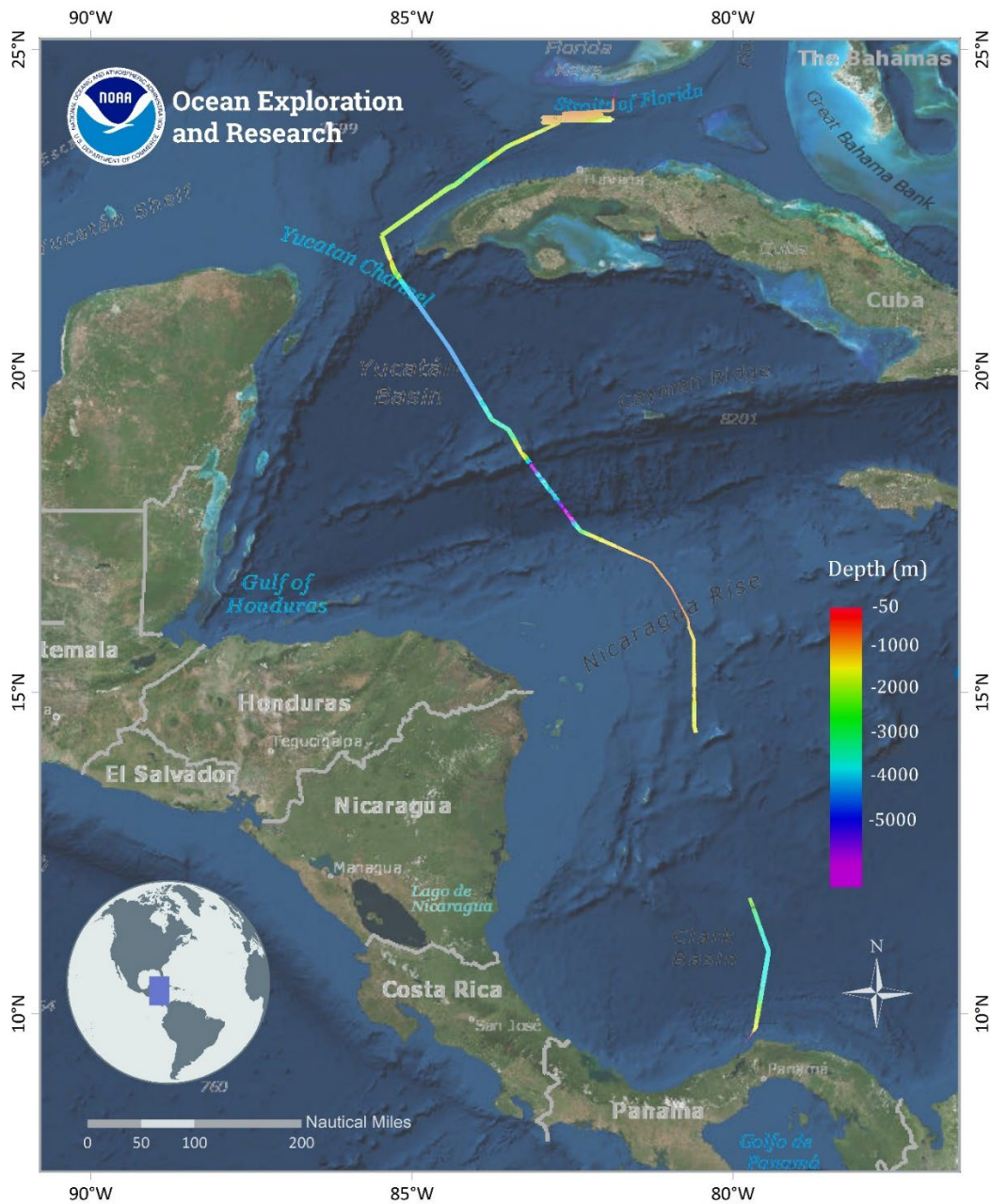


Figure 1. Cruise map showing EX-17-10 multibeam bathymetry coverage.

Transit mapping was focused on adding coverage to seamounts and ridge features whenever possible. Edge matching mapping was also done on older previously collected multibeam sonar coverage available through the NCEI archives. Background data used to plan exploration mapping included all multibeam data in the project area archived with the National Center for Environmental Information (NCEI) as gridded using NCEI’s Auto Grid online tool.

New EM302 multibeam, split-beam EK60, and sub-bottom profiling data were collected within Panamanian, Nicaraguan, Honduran, Cuban, and U.S. waters during the cruise. Colombia did not approve NOAA’s marine scientific research permit request and thus no mapping data were collected within Colombian waters. ADCP data were collected within shallow areas in Panama after the ship transited the Panama Canal and headed north. The ADCP was secured while surveying with other sonars to avoid interference.

All of the data collected during the cruise was single line transit data except for a focused survey in U.S. waters within the Straits of Florida. This survey filled a substantial gap in publicly available multibeam data coverage of this area just north of the maritime boundary with Cuba (Figure 2).

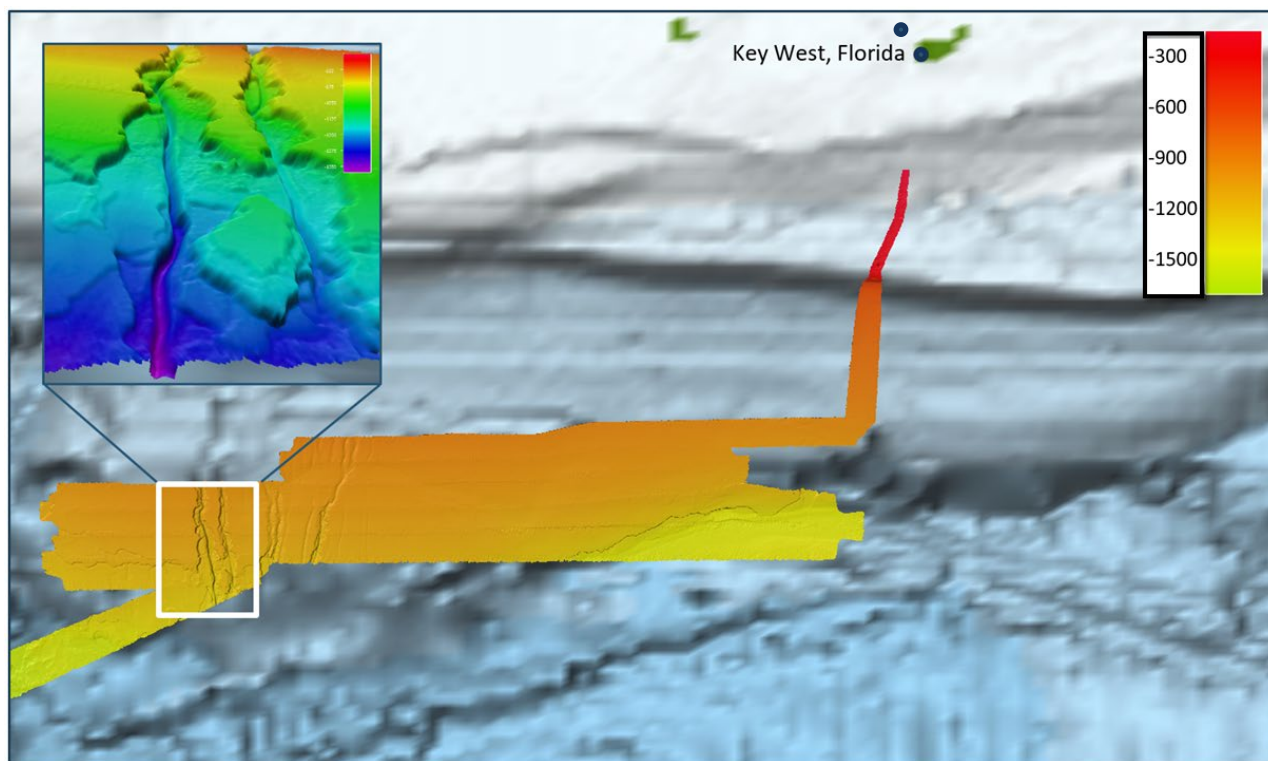


Figure 2. Oblique view image of the focused survey area completed during the cruise within U.S. waters in the Florida Straits. Note the distinct channel features in the western portion of the survey (inset). Image made in QPS Fledermaus software, 6x vertical exaggeration, depth scale is in meters.

5. Mapping Statistics

| | |
|---|------------------------------------|
| Dates | November 15 – November 22, 2017 |
| Linear kilometers of survey with EM302 | 2,200 |
| Square kilometers mapped with EM302 | 14,029 |
| Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files | 148 files / 11.6 GB |
| Number / Data Volume of EM 302 water column multibeam files | 148 files / 35.59 GB |
| Number / Data Volume of EK 60 water column singlebeam files | 30 files / 2.96 GB |
| Number / Data Volume of sub-bottom sonar files | 153 files / 2.11 GB |
| Number of XBT casts | 26 |
| Number of CTD casts (including test casts) | 0 |

6. Mapping Sonar Setup

Kongsberg EM302 Multibeam Sonar

The NOAA Ship *Okeanos Explorer* is equipped with a 30 kHz Kongsberg EM 302 multibeam sonar capable of mapping the seafloor to depths of up to 8000 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 (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 some target, whether 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.



Kongsberg EK 60 Split-beam Sonars

The ship is also equipped with five Kongsberg EK 60 split-beam fisheries sonars: 18, 38, 70, 120, 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. The 38 kHz EK60 sonar was not run on this cruise because it interferes with the multibeam sonar and was also not properly calibrated, and later deemed damaged. These sonars were calibrated on the EX-16-09 cruise, and calibration values from that cruise were applied to the EK sonars for EX-17-10.

Knudsen 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 during mapping operations due to interference issues.

7. Data Acquisition Summary

Mapping operations included EM 302 multibeam, EK 60 split-beam, Knudsen sub-bottom profile, and ADCP data collection. The schedule of operations included 24 hr/day mapping work, except within the Panama Canal and within Colombian waters. In regions with no existing data, exploration transit lines were planned to optimize potential discoveries. Approximately 14,029 square kilometers of seafloor were mapped by the multibeam sonar over the course of the cruise.

Throughout the cruise, multibeam data quality was monitored in real-time by acquisition watchstanders. Ship speed for much of the cruise (9-10 knots) was faster than is typical for the

ship while conducting mapping (8-9 knots) in order to ensure an on-time arrival in Key West. Typical survey speeds of 8-9 knots were maintained during the focused survey in the Florida Straits at the end of the cruise. Cutoff angles in SIS were generally adjusted on both the port and starboard side to ensure the best data quality and coverage. Sound velocity bias was noted in the outer beams of the multibeam swath during the focused survey in the U.S. EEZ – probably due to the dynamic nature of the Gulf Stream as it moves through that region.

On EX-17-10, the 38 kHz ADCP was not used due to a suspected leak in the transducer. The 300 kHz system was run only while transiting through the Bahia de Manzanillo in Panama after transiting through the Panama Canal and while transiting through shallow waters on the final approach to Key West, Florida. The system was run in these areas without any other scientific sonars on to avoid interference, and was run in bottom tracking mode to collect data useful for confirming that the angular offset values in the system configuration are still accurate.

8. Multibeam Sonar Data Quality Assessment and Data Processing

Figure 3 shows the multibeam data processing workflow for this cruise. EM 302 Built-in Self Tests (BISTs) were run at the beginning and ending of 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 QPS Qimera multibeam sonar processing data. Erroneous soundings were removed using 2-D, 3-D, and spline filtering editing tools in Qimera. 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., un-projected).

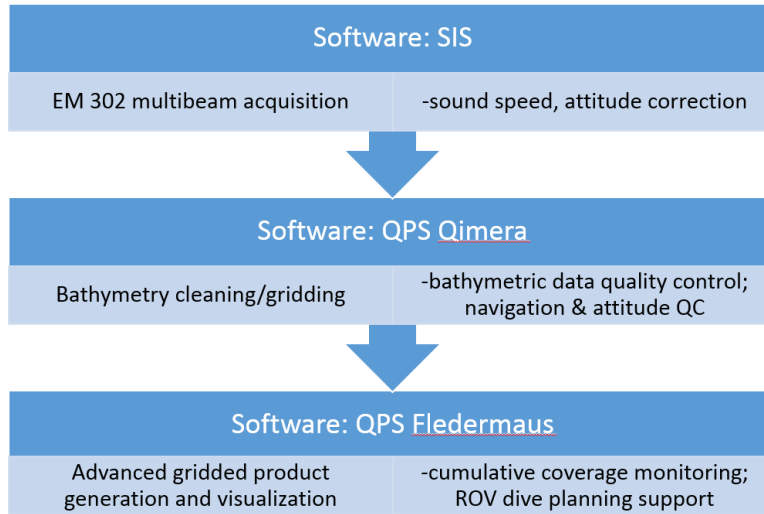


Figure 3. Shipboard multibeam data flow.

Crosslines

Comparing depth values from orthogonal survey lines is a standard hydrographic quality control measure to evaluate the consistency of the multibeam sonar data collected during a cruise. A crossline was run on November 21, 2017 as shown in Figure 4. Crossline analysis was completed using the Crosscheck Tool in QPS Qimera software and confirmed the data meets the requirements for an International Hydrographic Order 1 survey. The results are shown below.

Crossline file:

0105_20171121_024808_EX1710_MB.all

Mainscheme line file:

0107_20171121_033927_EX1710_MB.all

The results showed data quality sufficient for an International Hydrographic Organization Order 1 survey. Depths listed (“Z”) are in meters.

| <u>Statistic</u> | <u>Value</u> |
|--------------------------------|-----------------|
| Number of points of comparison | 111,529 |
| Grid Cell Size | 25 m |
| Difference Mean | 0.45 m |
| Difference Median | 0.16 m |
| Difference Std. Dev | 6.31 m |
| Difference Range | [-57.67, 44.59] |
| Mean + 2*Stddev | 13.07 |
| Median + 2*Stddev | 12.78 |

| | |
|-----------------------|---------------------|
| Data Mean | -1170.48 |
| Reference Mean | -1170.93 |
| Data Z-Range | [-1328.41 -1062.88] |
| Reference Z-Range | [-1320.35 -1064.48] |
| Order 1 Error Limit | 15.230 |
| Order 1 # Rejected | 3309 |
| Order 1 P-Statistic | 0.0297 |
| Order 1 Survey | ACCEPTED |

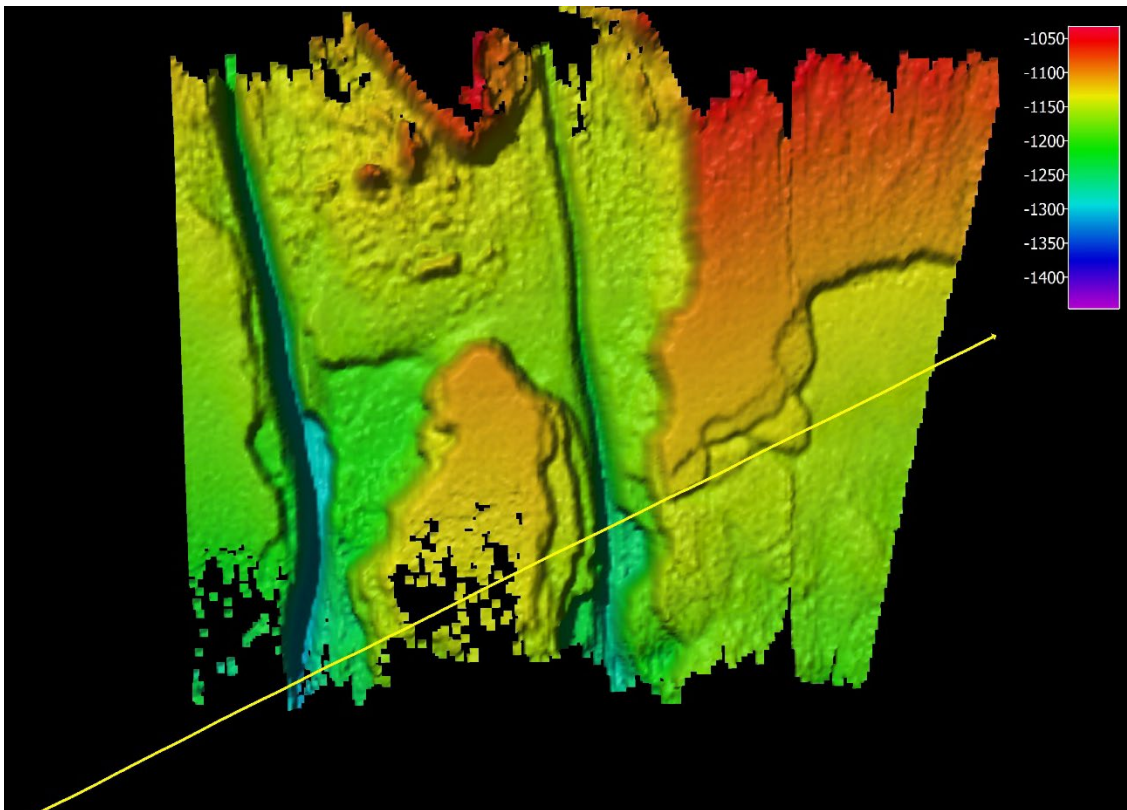


Figure 4. EX-17-10 crossline (shown in yellow) used for comparison against the bathymetric grid generated from the mainscheme line. Depth scale shown is in meters.

9. Data Archival Procedures

All mapping data collected by *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-17-10 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

Simrad EK 60 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
- Multibeam water column data review log identifying files with potential seeps

Sub-bottom data, supporting data, and informational logs are available in the NCEI Data Archives accessible at <https://www.ngdc.noaa.gov/> (last accessed 1/9/2020).

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 1/9/2020).

EM 302 and EK 60 water column data, supporting informational logs, and ancillary files are available in the NCEI Data Archives accessible at <https://www.ngdc.noaa.gov/mgg/wcd/> (last accessed 1/9/2020).

10. Cruise Calendar

All times listed are local ship time, which was -4 hours from UTC

November 2017

| Sun | Mon | Tues | Wed | Thur | Fri | Sat |
|--|--|--|---|---|--|---|
| 12 | 13 | 14 | 15 Start of cruise. Depart Panama City, Panama. Overnight transit of Panama Canal. | 16 Left Panama Canal and transited north in Panamanian and Columbian waters. | 17 Transited north through Columbian and Nicaraguan waters. | 18 Transited north through Nicaraguan and Honduran waters. |
| 19 Transited north through Honduran and Cuban waters. | 20 Completed mapping in Cuban waters. Tested Underway CTD. | 21 Focused mapping survey southwest of Key West, Florida. | 22 Completed focused mapping survey. Arrived in port to Key West at 0800. | 23 | 24 | 25 |

11. Daily Cruise Log Entries

Generated from the daily expedition situation reports. All times listed are in local ship time, which was Eastern Standard Time (-5 hours from UTC)

November 15, 2017

The ship departed the pier in Panama City at 2100 and transited through the Panama Canal overnight. The pre-departure checklist items were taken care of today, including setting up all sonar systems for data acquisition and finalizing Hypack planning projects. Qimera was updated on both MBPROC2 and MBPROC3 machines to the latest version – this should address an issue that was causing unreasonable delays when loading new raw lines into the project.



November 16, 2017

The ship successfully transited the Panama Canal overnight without any problems. Many mission personnel stayed up late to see the locks, and many crew and officers worked a very long day to enable the transit. Mapping operations began at approximately 0600 and continued until 2040 when we reached the Exclusive Economic Zone (EEZ) boundary between Panama and Colombia. Transit through Colombian waters continued into the night but without any data collection since the marine scientific research permit was not approved.

The sonars all started well today after completing the canal transit. Leaving the multibeam transceiver unit (TRU) on during the several days of in-port time appeared to avoid the initial start-up issues experienced recently on other cruises. The ADCP was set to log in passive mode (no pinging, but logging position and heading feeds). All sonars were secured and all SCS sensors disabled prior to the ship entering Colombian waters. SCS was set to continue logging ship position and heading to ensure that shiptracker knows where the ship is and the navigation track of the vessel is recorded. The night watch was released since there was no overnight mapping to do without permits.

November 17, 2017

The ship transited overnight and part of the day through Colombian waters – no data was collected due to lack of diplomatic clearance. Once the ship was outside 12 nm from Serrana Cay, we entered Nicaraguan waters and resumed data collection at approximately 1300. Weather was sunny with moderate north wind and mild sea state. Drills were completed today. The sonars all began working without incident once data collection resumed. Multibeam water column data and sub-bottom data are being processed in addition to the typical multibeam bathymetry. The Explorer-in-Training students continue their training on the ship.

The UnderwayCTD stand was setup up by SST Wilkins and he mounted the winch to the stand in anticipation of testing in Honduran waters tomorrow (weather permitting). We plan to test the mechanical components – especially the winch which was repaired at the factory and has not been tested since.

November 18, 2017

Exploratory transit mapping was completed in Nicaraguan waters then continued all day in Honduran waters. Sea state was moderate and data quality was good. All sonars are working normally and data quality has been good overall. Sea state picked up today, but was still good for surveying. UnderwayCTD (UCTD) testing was postponed due to heavy rolls from the sea state picking up and the required heading of the ship – this makes the initial setup of the heavy winch risky. We are planning a tour of engineering spaces for new personnel. The data collection permit for Cuba was approved. We plan to arrive in Cuba at approximately 0400

11/19. There will be some time on 11/21 in US waters for a small focused survey of unmapped area in the Straits of Florida.

November 19, 2017

Exploratory transit mapping was completed in Honduran waters overnight, then the ship crossed into Cuban waters around 0600 and continued mapping work. Sea state and winds were mild all day and data quality was excellent. Mapping in Cuba will continue tomorrow. The UCTD was tested today without significant problems. Most of the day was spent doing transit mapping in Cuban waters. All sonars are working normally and data quality was excellent today. We are using one Qimera project for the whole cruise (cruise track is mostly in UTM17N, with some in UTM16N). Qimera software was updated before the cruise to the latest version (1.5.6) and has been working with no crashes, long processing delays, or warnings. Students are expanding their skill sets and working on mid-water, sub-bottom, and seafloor backscatter mosaic processing projects. Sun photometer measurements have been occurring every couple of hours when the view to the sun has been free of clouds.

The UCTD deck equipment was fully installed today. Today was the first day the system had been tested since warranty replacement of the motor clutch on the winch. Three shallow casts with the dummy probe were completed without line on the tailspool. No knots occurred in the line, but the winding tension on the winch was occasionally drifting out of specifications after casts. We checked line tension after each cast and calibrated back to spec as needed, since we believe this was the cause of earlier problems with the system. The loop splice showed some wear after 3-4 casts, so we replaced it with a new splice. We did one fourth deeper cast with a low amount of line loaded onto the tailspool rewinder. This cast worked well with no entanglements, and only a half pound of tension loss on the winch rewinder following the cast. Next steps are to conduct deeper casts with more and more line wound onto the tailspool to confirm system is working right. Only after successful full-depth casts with the dummy probe with the maximum amount of line on the tailspool, will we consider using the actual data probes.

A tour of engineering spaces for new personnel is planned for tomorrow at 1500. There will be some time on 11/21 in US waters for a small focused survey of unmapped area in the Straits of Florida.

November 20, 2017

Exploratory transit mapping was completed in Cuban waters today at 2215. Sea state and winds were rougher than yesterday but still mild and data quality was very good. We will be completing a small focused survey in U.S. waters southwest of Key West (near the EEZ boundary) for the rest of the cruise prior to pulling into port Wednesday morning. Surveying work in Cuba went smoothly with most of the data being in areas lacking publicly accessible



multibeam coverage. We did a few small diversions to adjust for traffic in the area. SIS is having intermittent display issues where the geographic display grid doesn't show data for a few minutes – no data is actually lost during these transient events. We are up to date on all data processing. Sun photometer measurements have been occurring every couple of hours when the sun has been cloud free.

The UCTD was further tested in the afternoon. The winch did not maintain the correct tension between casts. The UCTD failed the full depth cast, with two bad knots in the line on retrieval – no equipment was lost. We are cleaning and putting away the system tomorrow and will have follow up discussions on the system's future later. A tour of engineering spaces for new personnel was completed today.

November 21, 2017

The whole day was spent conducting a focused mapping survey of a 1,000 square kilometer area southwest of Key West, Florida. Seas were mild and weather was pleasant. We are scheduled to arrive at the sea buoy at 0600 and at the pier by 0800 on 11/22. We should clear customs by 1000. Mapping effort was spent on a large gap in multibeam coverage on the gently sloping shelf at depths around 1000m. The shelf is incised with some dramatic channel features. The Gulf Stream made for challenging sound velocity changes and the outer beams of the swaths were showing more issues than normal, so XBT casts were increased to every 2-3 hours. We had to avoid some substantial longline fishing gear in the evening that interrupted our mapping plan, but ultimately with no major impacts. We tested an XBT gun that was suspected of potentially being faulty from two bad casts on the previous cruise – it performed normally and was put back in active rotation. Mapping work will continue overnight until we get to the sea buoy. The UCTD was cleaned and put away today.

November 22, 2017

Final day of EX-17-10. The ship completed the focused mapping survey southwest of Key West overnight and arrived at the sea buoy at 0600. The ship was tied up to the pier by 0800. Overnight mapping went well with good data quality. Minor outer beam sound velocity artifacts are present in the survey due to highly variable sound velocity conditions in the survey area associated with the Gulf Stream. The survey revealed interesting very distinctive channels on the seafloor and a dramatic "blue hole" depression in the seafloor (similar to features we have mapped on shallow shelf areas on the east side of Florida). All sonars were turned off except for the EM 302 TRU which was left powered on to stay ready for EX-17-11.



12. References

The 2017 Mapping Systems Survey Readiness Report can be obtained by contacting NOAA Ship *Okeanos Explorer* at oar.oer.exmappingteam@noaa.gov.

The following data were used as background data during the cruise:

- 1) National Center for Environmental Information (NCEI) Autogrid Multibeam Bathymetry Data Web Mapping Tool. <https://www.ngdc.noaa.gov/maps/autogrid/>
- 2) [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.](#)

