Ocean Exploration and Research

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MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

CRUISE EX-17-09: Eastern Pacific Mapping *(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.

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2. Report Purpose

The purpose of this report is to briefly describe the acoustic seafloor and water-column data collection and processing methods utilized throughout mapping expedition EX-17-09, 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

The primary objective for this cruise was 24 hour per day seafloor mapping while transiting between Honolulu, Hawaii and Balboa, Panama; including a several hundred nautical mile section along the Clarion-Clipperton Fracture Zone. The secondary objective was operational testing of a newly developed nitrogen (N2) sensor funded by an OER grant to the University of Washington Applied Physics Lab. Ten CTD casts were conducted to measure the biologically produced excess nitrogen in the Eastern Tropical North Pacific (ETNP) Oxygen Minimum Zone (OMZ).

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), and the ship's high-bandwidth satellite connection for daily transfer of incoming sonar data to shoreside backups. All data processing was completed on the vessel.

Exploration operations for this cruise focused on the Clarion-Clipperton Fracture Zone to better understand the evolution of plate tectonics, specifically large multi-segment fracture zones and former oceanic transform faults, in the area. This expedition helped establish a baseline of information in the region to catalyze further exploration, research and management activities.

The detailed objectives and rational for exploration and mapping areas addressed during this cruise are provided in EX-17-09 Project Instructions, available in the NOAA Central Library.

4. Summary of Mapping Results

EX-17-09 mapped 54,653 square kilometers of seafloor while transiting between Honolulu, Hawaii and Balboa, Panama, with additional focused mapping along the shelf break east of the Panama traffic separation scheme (Figure 1 and Table 1).

Cruise Overview Map

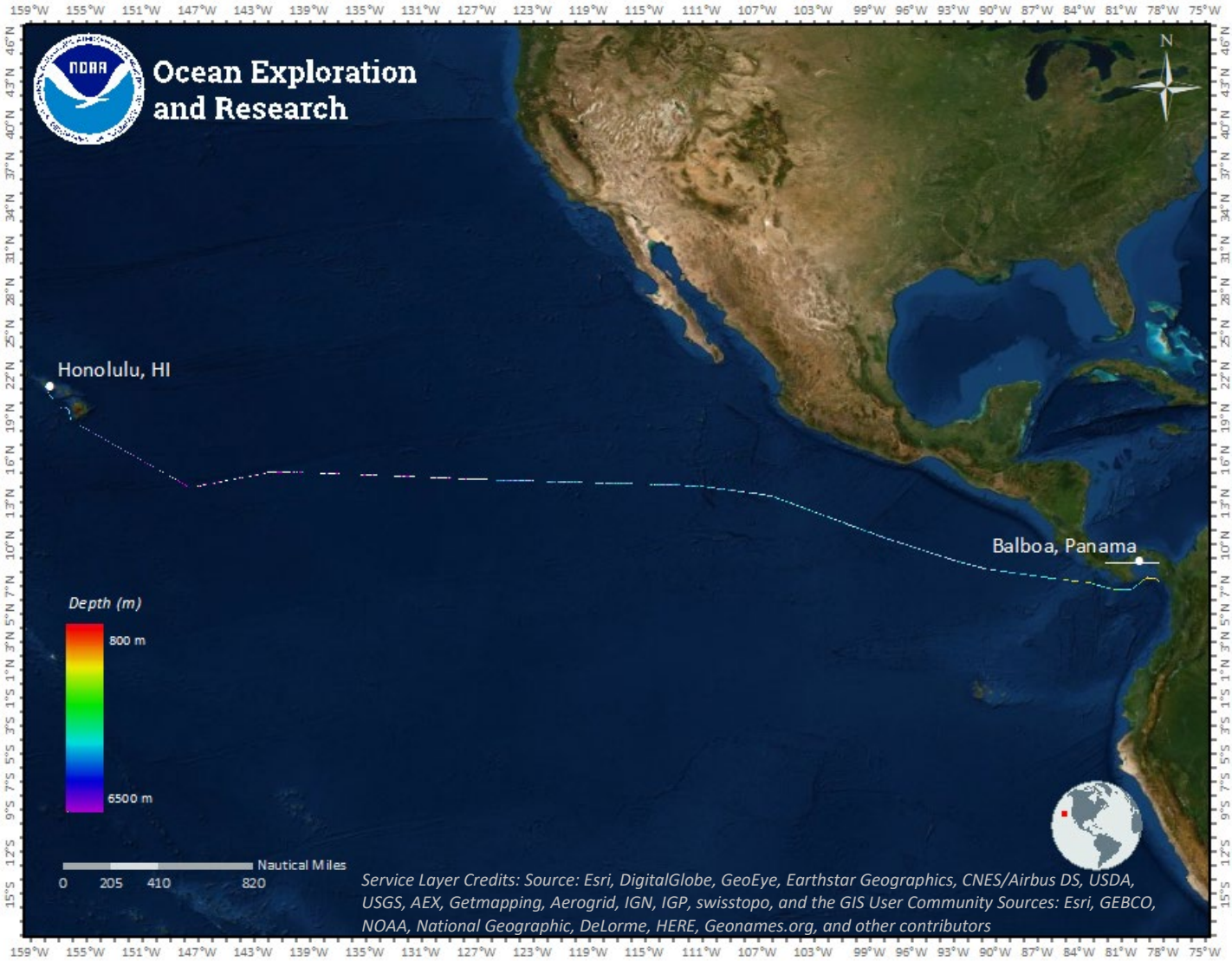

Figure 1. Overview map showing bathymetric mapping coverage completed during the Eastern Pacific Mapping expedition (EX-17-09). Map created by NOAA Office of Ocean Exploration and Research, generated in ArcMap.

5. Mapping Statistics

Table 1. Summary statistics of ocean mapping work completed during EX-17-09.

Dates of cruise	**October 16, 2017 – November 11, 2017**
Ship's draft: **Start of cruise (10/16/2017)** **End of cruise (11/11/2017)**	 **Fore: 15' 2'', Aft STBD: 14' 4"** **Fore: 15' 1.5"; Aft STBD: 13' 11.5"**
Linear kilometers of survey with EM 302	**9,407**
Square kilometers mapped with EM 302	**63,884**
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)	**608 files/ 39.2 GB**
Number / Data Volume of EM 302 water column multibeam files	**608 files / 135 GB**
Number / Data Volume of EK 60 water column split beam files (.raw)	**86 / 11 GB**
Number / Data Volume of sub-bottom sonar files (.segy, .kea, .keb)	**457 / 7.6 GB**
Number of XBT casts	**87**
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 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 multi-ping, or dual swath mode, and obtains up to 864 soundings per ping by detecting two swaths per ping cycle. The multibeam sonar is used to collect seafloor bathymetry, seafloor backscatter, and water column backscatter data. Backscatter represents the strength of the acoustic signal reflected from a target, such as the seafloor or bubbles in the water column.

Simrad EK 60 Split-beam Sonars

The ship is equipped with five Kongsberg EK 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.

Knudsen 3260 Sub-bottom Profiler

Additionally, the ship is equipped with a Knudsen 3260 sub-bottom profiler that produces a frequency-modulated chirp signal with a central frequency of 3.5 kHz. This sonar is used to provide echogram images of shallow geological layers underneath the seafloor to a maximum depth of approximately 80 meters below the seafloor. The sub-bottom profiler is normally operated to provide information about sub-seafloor stratigraphy and features. The data generated by this sonar 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, 38, 70, 122, and 200 kHz) sonars, and Knudsen 3260 sub-bottom profiler. Data were collected by each sonar concurrently during the transits. During CTD operations, the EM 302 multibeam and Knudson sub-bottom profiler were secured to allow for the 300 kHz ADCP and the entire suite of EK 60 split beam sonars to acquire data. Screen grabs of the EK 60 data window were taken following each cast.

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 along approximately 338 nautical miles of the Clarion Clipperton Fracture Zone before diverting to the new course towards Panama. Due to extreme weather conditions, data collected between October 16 and October 24 are relatively poor, with the exception of data collected in the lee of the island of Hawaii.

Throughout the cruise, multibeam data quality was monitored in real time by acquisition watchstanders. Ship speed was adjusted as necessary to maintain sufficient data quality, with general transit speeds of 10 knots and survey speeds of 8.5 to 9 knots. During this expedition, winds approaching 40 knots and seas up to 18 feet limited the planned speeds, and the RPMs were adjusted for optimal safe passage. Throughout acquisition the cutoff angles in the multibeam acquisition software, Seafloor Information System (SIS), were generally left wide open to allow for the maximization of exploration data collection and were routinely adjusted on both the port and starboard side to ensure optimal 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.

Ancillary University of Washington CTD Project

A federal funding opportunity project was hosted onboard during this cruise. CTD operations were conducted by a team of two scientists from the University of Massachusetts at Dartmouth (UMD) and the University of Washington (UW), using a CTD provided by the UW that was integrated into the ship's CTD cable. A separate UW CTD laptop was used to monitor data input/output during operations. No ship's computers were utilized for CTD operations. The maximum depth of all CTD casts was approximately 600m. Depth and hold times from 12 to 18 minutes were determined from the descent, and profiles were conducted during the ascent. Each CTD operation spanned approximately 4 hours. Data acquired during these CTD operations will be archived separately from the standard OER sonar datasets.

Water samples were retrieved following each cast once the CTD was secured on deck. CTD locations were as follows: two outside of the OMZ western boundary, six within the OMZ, and two outside of the western boundary of the OMZ.

Due to predicted late arrival times to Panama resulting from extremely poor weathers conditions, following CTD#2 on October 22, 2017, the ship diverted from the planned Clarion Fracture Zone route to a course of 089 towards CTD location #8 at approximately 15.11342 N, 142.07241 W, crossing the OMZ on a different transect than initially planned. CTD operations were suspended after CTD#2 until ample time was recovered to arrive in Panama on schedule. CTD operations resumed with CTD#3 approximately 190 nm past the western boundary of the OMZ. CTDs were then conducted once every 24 hours. The CTD cast plan was revised by the onshore CTD team to fit the new transit trackline, maintaining the spacing across the OMZ. A revised location of the eastern boundary was used for CTD#8 to mitigate the loss of the CTD#3 location on the western boundary.

8. Multibeam Sonar Data Quality Assessment and Data Processing

Figure 2 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 by SIS, then imported into QPS Qimera for processing the multibeam sonar data. In Qimera, attitude and navigation data stored in each file were checked, and erroneous soundings were removed using 2-D and 3-D editors. Data quality throughout the cruise varied with the weather conditions, as discussed above in Section 6. Weather was entered hourly into the Bridge Weather Log, and a copy of this log is available in the ancillary files archived with the multibeam data.

Gridded digital terrain models were created 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.

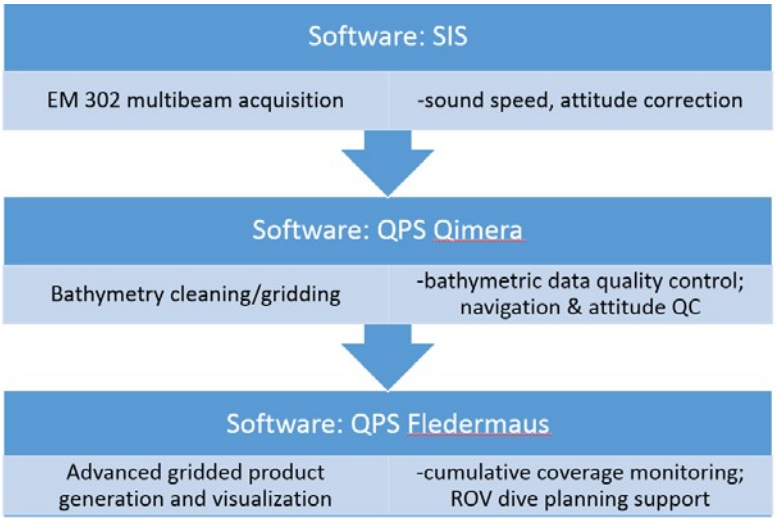

Figure 2. Shipboard multibeam data flow.

EM 302 Patch Test

A multibeam patch test was conducted southwest of Oahu, HI on July 8, 2017 (during EX-17-06). In addition to the patch test, a speed noise test was performed on the EM 302. The full procedures and results are described in the 2017 *Okeanos Explorer* Survey Readiness Report.

9. Data Archival Procedures

All mapping data collected by the NOAA Ship *Okeanos Explorer* are archived and publicly available within 90 days of the end of each cruise via the National Centers for Environmental Information (NCEI) online archives. The complete data management plan (which describes the raw and processed data formats produced for this cruise) is provided in the EX-17-09 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 WCD 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 12/17/2019).

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 12/17/2019).

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 12/17/2019).

10. Cruise Calendar

All times listed are local ship time, which began as -10 hours from UTC and shifted 1 hour every 4 to 5 days as the ship transited eastward.

October/November 2017

Sun	Mon	Tues	Wed	Thur	Fri	Sat
14-15 Mission personnel arrive to Honolulu, HI and prepare for cruise.	16 Ship departs Ford Island at 0900.	17 Transit mapping.	18 Transit mapping.	19 Transit mapping and CTD test cast #1 (failed).	20 Transit mapping along Clarion Fracture Zone (CFZ). CTD test cast #2	21 Transit mapping along CFZ. CTD cast #1 (+1 hr to -9 UTC)
22 Transit mapping along CFZ. CTD cast #2. Redirect transit eastward to Panama due to weather.	23 Transit mapping toward CTD site #7.	24 Revised transit mapping toward CTD site #8.	25 Transit mapping. Crossed OMZ boundary at 1600. (+1 hr to -8 UTC)	26 Transit mapping. CTD cast #3.	27 Transit mapping. CTD cast #4.	28 Transit mapping. CTD cast #5.
29 Transit mapping. CTD cast #6. (+1 hr to -7 UTC)	30 Transit mapping. CTD cast #7.	31 Transit mapping. CTD cast #8 at the OMZ border.	1 Transit mapping.	2 Transit mapping. CTD cast #9.	3 Transit mapping.	4 Transit mapping. CTD cast #10.
5 Transit mapping. CTD swap out. (+1 hr to -6 UTC)	6 Transit mapping.	7 Transit mapping.	8 Transit mapping. Ship's CTD test cast.	9 Focused mapping along shelf break east of the Panama traffic separation scheme.	10 Arrive to anchorage outside entrance to Panama at 1800	11 Arrival to Balboa Panama, Rodman Pier at 1000. (+1 hr to -5 UTC)

11. Daily Cruise Log Entries

All times listed are local ship time, which began as -10 hours from UTC and shifted 1 hour every 4 to 5 days as the ship transited eastward.

October 14
Mission personnel arrive to the ship in Honolulu, Hawaii.

October 15
Prepare ship and survey plans for departure. Hypack projects for the transit across multiple UTM zones were created. In lieu of a conference call, the mapping team convened to review the plan and talking points from the Onshore Expedition Coordinator.

October 16
The ship got underway at 0900 from Ford Island, Pearl Harbor, HI. A safety introduction meeting was held for all new personnel at 1000. Transit mapping commenced at the PH buoy. An XBT was conducted, and multibeam, EK 60 and sub-bottom data were acquired. EM 302 connection issues occurred at approximately 1830 in the evening and were resolved within a few hours. Weather: 7 ft seas and 20 kt winds out of the harbor.

October 17
The ship continued to transit map in a southeastern direction along the south side of the Hawaiian Islands with continued delays from high seas (12 to 15, occ 18 ft.) and strong winds (30 to 40 kts). Data quality is extremely poor with several lost pings across all sonars.

October 18
The ship continued to transit map in a southeastern direction along the south side of the Hawaiian Islands with continued delays from high seas and strong winds. The tentatively scheduled test CTD cast was canceled due to the confused sea state. Data quality remains poor with frequent lost pings across all sonars.

October 19
The ship continued to transit map in a southeastern direction with continued delays from high seas and strong winds. The tentatively scheduled cast was attempted, however a communications failure occurred, causing the CTD to require re-termination; and it was canceled. Data quality remains poor, but is improving with slightly reduced sea states to 12 feet and winds to 25 knots.

October 20
Transit mapping continued southeast to the Clarion Fracture Zone (CFZ). Data quality increased to moderate for approximately 24 hours as the sea states reduced to 6 to 8 feet and the winds reduced to 18 knots. An almost continuous alongtrack swath was 6400m wide in 5300m of water.

CTD test cast #2 was partially successful in that it descended to 610m and ascended at 30m/min stopping in 100m intervals to fire bottles and allow sensors to adjust. The bottles did not close tightly, therefore they did

not hold water. The oxygen and fluorometer sensors did not perform as expected. The new nitrogen sensor worked.

October 21
Transit mapping continued along the CFZ. CTD cast #1 was held at approximate position 14 36.2447 N, 144 33.0680 W. The CTD descended to 605m was held at depth for 10 minutes. For each 100m meters of ascent the CTD was held at depth for 10 minutes. Bottles successfully fired at each depth on the ascent. Water sampling was completed after the CTD was secured on deck and the ship resumed the trackline paralleling the fracture zone. Water sampling continued after the CTD was on deck. Sonar data quality was poor. Sea states are 8 feet and winds 20 to 25 knots.

Time change (+1 hour) to -9 hours from UTC.

October 22
Transit mapping continued along the CFZ. Due to continuous delays from weather the ship turned in an easterly direction to transit at a more direct heading to Panama, bypassing the rest of the planned CFZ mapping line. CTD casts were put on hold until ample time has been made up in transit for them to resume. Data quality was poor with many lost pings and alongtrack gaps due to sea and wind states. Winds 20 to 25 knots sustained and seas 8 to 16 feet.

CTD cast #2 was completed to 605m successfully at approximate location 15 04.7082 N, 142 03.2337 W. This was the second test cast outside the OMZ.

October 23
Transit mapping continued eastward on a course of 092T toward the revised destination of CTD station #8. Data quality on all sonars is moderate to poor. EM 302 alongtrack ping loss was reduced, but swath widths remain narrow. Swath widths are 4000m in 4700m of water. Seas were 6 to 8 feet and winds were 17 knots.

October 24
Transit mapping continued eastward with CTD operations on hold. The CTD plan was revised by shoreside CTD science team to accommodate weather conditions. EM 302 sonar data quality was moderate with 4000m swaths in 4700m of water. EK 60 is still noisy but the Knudsen data has improved considerably.

October 25
Continued transiting eastward while mapping on all sonars (EM 302, EK 60, Knudsen, passive data collection with ADCP for University of Hawaii ADCP group testing). CTD operations were on hold until Oct 26 due to lost transit time from poor weather. Applanix POS-MV issues occurred when the Marinestar system did not automatically switch satellite frequencies. About 1.5 hours of data do not contain satellite correctors, affected files are noted in the multibeam processing log. CET Blessing manually configured the POS-MV to a different Applanix suggested frequency to regain GPS satellite correctors. In Panama, he will retest the auto-configure option.

Telepresence video routers required a reset from shore due to system glitches.

Time change (+1 hour) to -8 hours from UTC.

October 26
Continued to transit map to CTD station #3 through the OMZ. At 1230 CTD operation commenced at approximate location 14.64904 N, 127.75090 W, with a maximum depth of 600m. Sonar data quality is the best it has been since the beginning of the cruise with 9100m swaths in 4600m of water.

October 27
Continued transit mapping to CTD station #4 through the OMZ at 9 knots. At 1230 CTD operations commenced at approximate location 14.54771 N, 124.75025 W, with a maximum depth of 600m. Sonar data quality is good with 9000m swaths in 4400m of water. Sea state and winds are 4 feet and 10 knots.

October 28
Continued transit mapping at 165 RPMs to CTD station #5. At 1230 CTD operations commenced at approximate location 14.43933 N, 121.43373 W. The max depth was 600m, with stops at 500m, 400m, 325m, 200m, 135m, 100m, 75m and the surface.

EM 302, EK 60 and Knudsen data quality is good. EM 302 swaths of 8500m in 4300m of water. The surface biological layers are quite prominent in separation in the EK 60 data.

October 29
Transit mapping continues to CTD station #6 at approximate location 14.35481 N, 118.03772 W The max depth of the cast was 600m with stops at 600m, 500m, 400m, 315m, and 200m for 15 minutes; and 115m, 80m, 65m and 10m for 18 minutes.

EM 302, EK 60 and Knudsen data quality is good. EM 302 swaths of 8600m in 4100m of water.

Time change (+1 hour) to -7 hours from UTC.

October 30
Continued transit mapping to CTD station #7 at approximate location 14.26267 N, 114.73987 W. The max depth of the cast was 600m with stops at 600m, 500m, 400m, 285m, 200m, 110m, 70m, 40m and 10m.

EM 302, EK 60 and Knudsen data quality is good. EM 302 swaths of 9000m in 4100m of water.

October 31
Continued transit mapping to CTD station #8 at approximate location 14.15941 N, 111.31217 W. The max depth of the cast was 600m with stops at 600m, 500m, 400m and 290m for 15 minutes; and 95m, 50m, 30m and 10m for 18 minutes. CTD#8 was moved to the eastern boundary of the OMZ polygon provided.

EM 302, EK 60 and Knudsen data quality is good. EM 302 swaths of 8200m in 2500m of water over the Einstein Seamount north-northwest of the Clipperton Island EEZ.

November 1

Continued 24-hour transit mapping. No CTD operations were held. EM 302, EK 60 and Knudsen data quality is good. EM 302 swaths of 8900m in 3800m of water.

The TSG was cleaned due to a discrepancy between the TSG sensor and the CTD sensor.

November 2
Transit mapping continued to CTD station #9 at approximate location 12.73187 N, 104.13902 W. The max depth of the cast was 600m with stops at 600m, 500m, 400m, 300m, 200m, 125m, 75m, 45m, 35m and 10m.

EM 302, EK 60 and Knudsen data quality is good. EM 302 swaths of 8800m in 3000m of water.

November 3
Twenty-four hour transit mapping continued at 165 RPMs. Plans for re-integration of the ship's CTD system were discussed at the Ops meeting.

EM 302, EK 60 and Knudsen data quality is good. EM 302 swaths of 8000m in 3500m of water.

November 4
Continued transit mapping to CTD station #10 at approximate location 10.24342 N, 97.33207 W. The max depth of the cast was 600m with stops at 600m, 500m, 400m, 300m, 200m, 150m, 100m, 50m and 10m.

EM 302, EK 60 and Knudsen data quality is good. EM 302 swaths of 8200m in 4000m of water.

After cleaning the TSG sensor, it did not come into alignment with the CTD, however data improved. The TSG sensor was swapped out with a spare after SST Wilkins and CST White noticed a leak from cleaning. The sensor had a two-year-old calibration and will be sent back for re-calibration and repair. The updated TSG sensor values are consistent with CTD values.

November 5
Transit mapping continued to Panama. EM 302 swaths of 8200m in 3500m of water traversing several small features in the last 24 hours.

Demobilization of UW CTD and re-integration of ship's CTD began.

Time change (+1 hour) to -6 hours from UTC

November 6
Continue transit mapping to Panama. At approximately 1530 the ship crossed into the Costa Rican EEZ. All sonars and SCS data (except position) were secured due to lack of permits.

EM 302, EK 60 and Knudsen data quality is good. EM 302 swaths of 8000m in 3400m of water.

November 7

Continuing to transit map via Costa Rican waters. EM 302, EK 60 and Knudsen data quality is good. EM 302 swaths of 8200m in 2600m of water.

CTD Scientist Andrew Reed gave a broadcast video satellite phone outreach event to 30 students from Jane Adams Middle School in Seattle.

November 8
The ship crossed into Panamanian waters at 0245 continuing to transit map. The ship's CTD re-integration test cast took place at 1230. The max depth of the cast was 1750m. The altimeter was tested. Three bottles were successfully fired at depth and held water. The wire was greased by the deck team on ascent. Mapping continued after the CTD test cast paralleling and to the east of the traffic separation scheme.

EM 302, EK 60 and Knudsen data quality is good. EM 302 swaths of 8000m in 3000m of water; and swaths of 6100m in 2500m of water.

November 9
Focused mapping along the shelf break in waters over 200 meters with a variable spaced line plan to accommodate changes in depth along the shelf. Lots of dolphins were sighted in the area.

November 10
Focused mapping along the shelf break in waters over 200 meters continued until 0600 when the ship broke off line to resume transit to the anchorage for an 1800 arrival time.

Sound velocity "frown" artifacts can be seen in the shelf break data. Additional XBTS were taken in attempt to mitigate data artifacts. There were several dolphin sightings and fishing boats over the night watch.

November 11
The ship was inbound at 0900. Arrival to Balboa Panama, Rodman Piers at 1000. Science party will depart today to stay in hotels. EiT will depart on Tuesday morning. Follow-on personnel have hotel rooms until the 13th and 14th.

Time change (+1 hour) to -5 hours from UTC at the pier.

12. Acknowledgements

The crew of the NOAA Ship *Okeanos Explorer* provided excellent support in the execution of the offshore mission. In particular, OER would like to acknowledge Senior Survey technician Charlie Wilkins and visiting Chief Survey Technician Phil White for their dedication to the nitrogen sensor CTD project.

13. References

The following data were used as background data throughout the expedition:

- 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
- Various datasets downloaded from the NCEI archives via NOAA AutoChart.