

MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

CRUISE EX-16-05 Leg 2: 2016 Deepwater Exploration of the Marianas

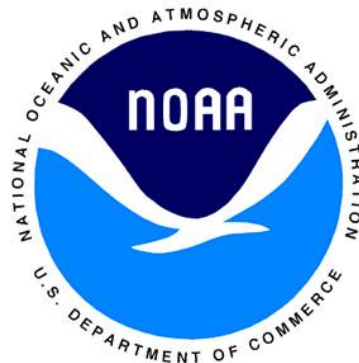
May 20 – June 11, 2016

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1. Introduction



The NOAA Office of Ocean Exploration and Research and the NOAA Ship *Okeanos Explorer*

Commissioned in August 2008, the NOAA Ship *Okeanos Explorer* is the nation's only federal vessel dedicated to ocean exploration. With 95% of the world's oceans left unexplored, the ship's combination of scientific and technological tools uniquely positions it to systematically explore new areas of our largely unknown ocean. These exploration cruises are explicitly designed in collaboration with the broad science community to provide a foundation of publicly accessible baseline data and information to support science and management needs. This baseline information often leads to further more detailed investigations by other parties.

The unique combination of mission capabilities including a high-resolution multibeam sonar deep water remotely operated vehicles, telepresence technology, and integrated data management system quicken the scientific discovery and dissemination process. These systems enable us to identify new targets in real time, dive on those targets shortly after initial detection, and then send this information back to shore for immediate near-real-time collaboration with scientists and experts at Exploration Command Centers around the world. The integrated data management system provide for the quick dissemination of information-rich products to the scientific community. This ensures that discoveries are immediately available to experts in relevant disciplines for research and analysis.

Through the operation and maintenance of the mission capabilities, NOAA's Office of Ocean Exploration and Research (OER) provides the nation with unparalleled capacity to discover and investigate new oceanic regions and phenomena, conduct the basic research required to document discoveries, and seamlessly disseminate data and information-rich products to a multitude of users. OER strives to develop technological solutions and innovative applications to critical problems in undersea exploration and to provide resources for developing, testing, and transitioning solutions to meet these needs.

***Okeanos Explorer* Management – a unique partnership within NOAA**

The *Okeanos Explorer* mode of systematic telepresence-enabled exploration requires a robust shore-based high speed network and infrastructure. The ship is operated, managed and maintained by NOAA's Office of Marine and Aviation Operations, which includes commissioned officers of the NOAA Corps and civilian wage mariners. OER owns and is responsible for operating and managing the cutting-edge ocean exploration systems on the vessel (ROV, mapping and telepresence) and ashore including Exploration Command Centers and terrestrial high speed networks. The ship and shore-based infrastructure combine to be the only federal program dedicated to systematic telepresence-enabled exploration of the planet's largely unknown ocean.

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2. Report Purpose

The purpose of this report is to briefly highlight the mapping data collection and processing methods used during the cruise.

This report focuses on the mapping data collected during exploration expedition EX-16-05 Leg 2. An associated cruise report encompassing overall 2016 exploration efforts by OER in the region, 2016 Deepwater Exploration of the Marianas: EX-16-05 Leg 1 Cruise Report, can be found in the NOAA Central Library.

3. Cruise Objectives

Operations for this cruise included 24 hour per day mapping operations. The expedition commenced in Saipan, Commonwealth of the Northern Marianas, with delayed offshore operations beginning May 29, and concluding in Guam on June 11. Operations used the ship's deep water mapping systems (Kongsberg EM302 multibeam sonar, EK60 split-beam fisheries sonars, and Knudsen 3260 chirp sub-bottom profiler

sonar), and the ship's high-bandwidth satellite connection for daily transfer of incoming data to awaiting shoreside scientists.

Exploration operations for this cruise focused on deep water areas around the Commonwealth of the Northern Mariana Islands (CNMI) and Mariana Trench Marine National Monument (MTMNM). This expedition helped establish a baseline of information in the region to catalyze further exploration, research and management activities.

The detailed objectives for this cruise are provided in EX-16-05 Leg 2 Project Instructions, which are archived in the NOAA Central Library.

3. Summary of Mapping Results

Cruise Maps

Below are two maps showing (1) total bathymetric coverage obtained during the cruise including transit mapping, and (2) focused mapping operations within MTMNM. In all, over 29,000 square kilometers were mapped.

EX-16-05 Leg 2 2016 Deepwater Exploration of the Marianas

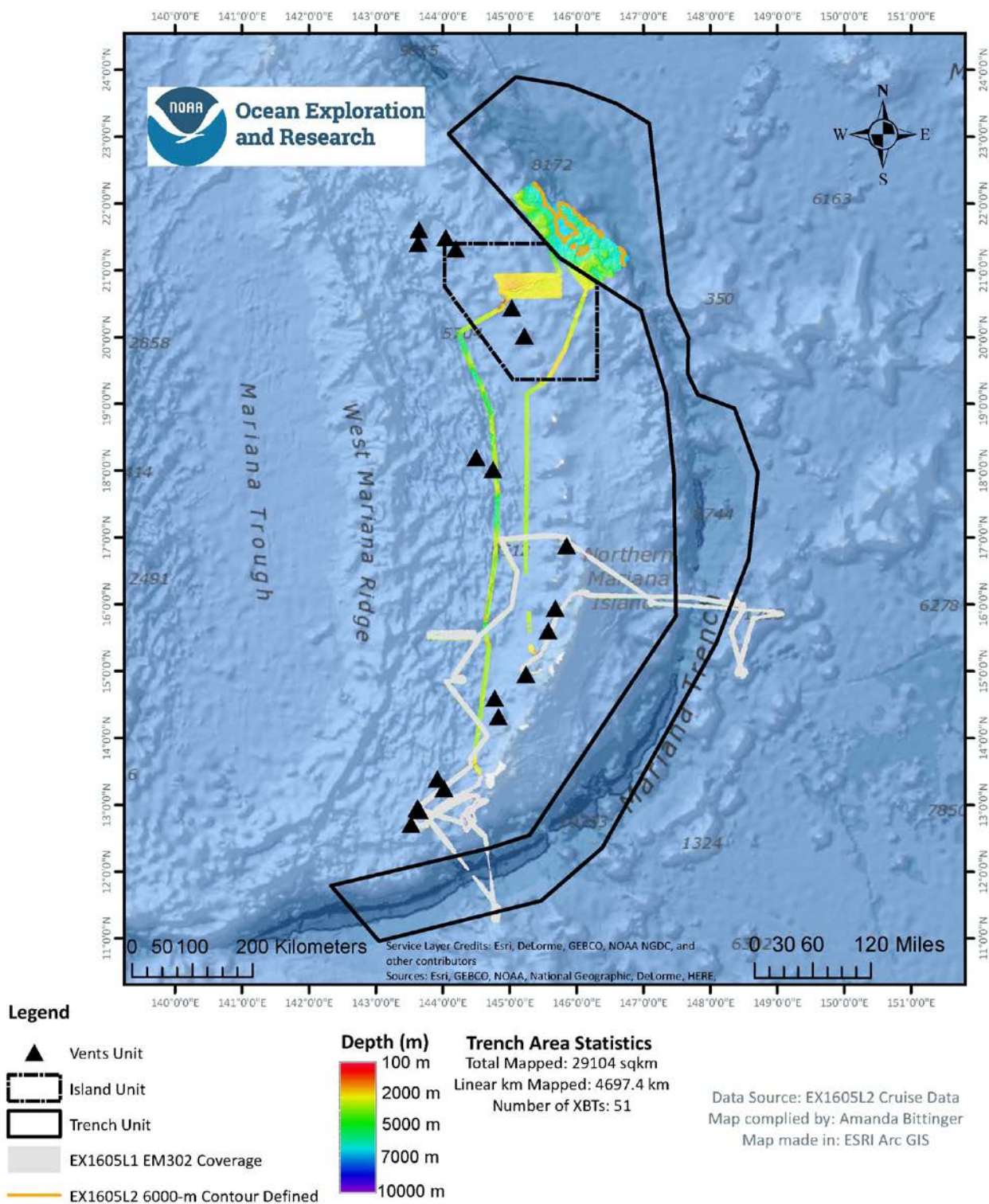


Figure 1. Cruise map showing overall EX-16-05 Leg 2 operations.

EX-16-05 Leg 2 2016 Deepwater Exploration of the Marianas Monument Areas

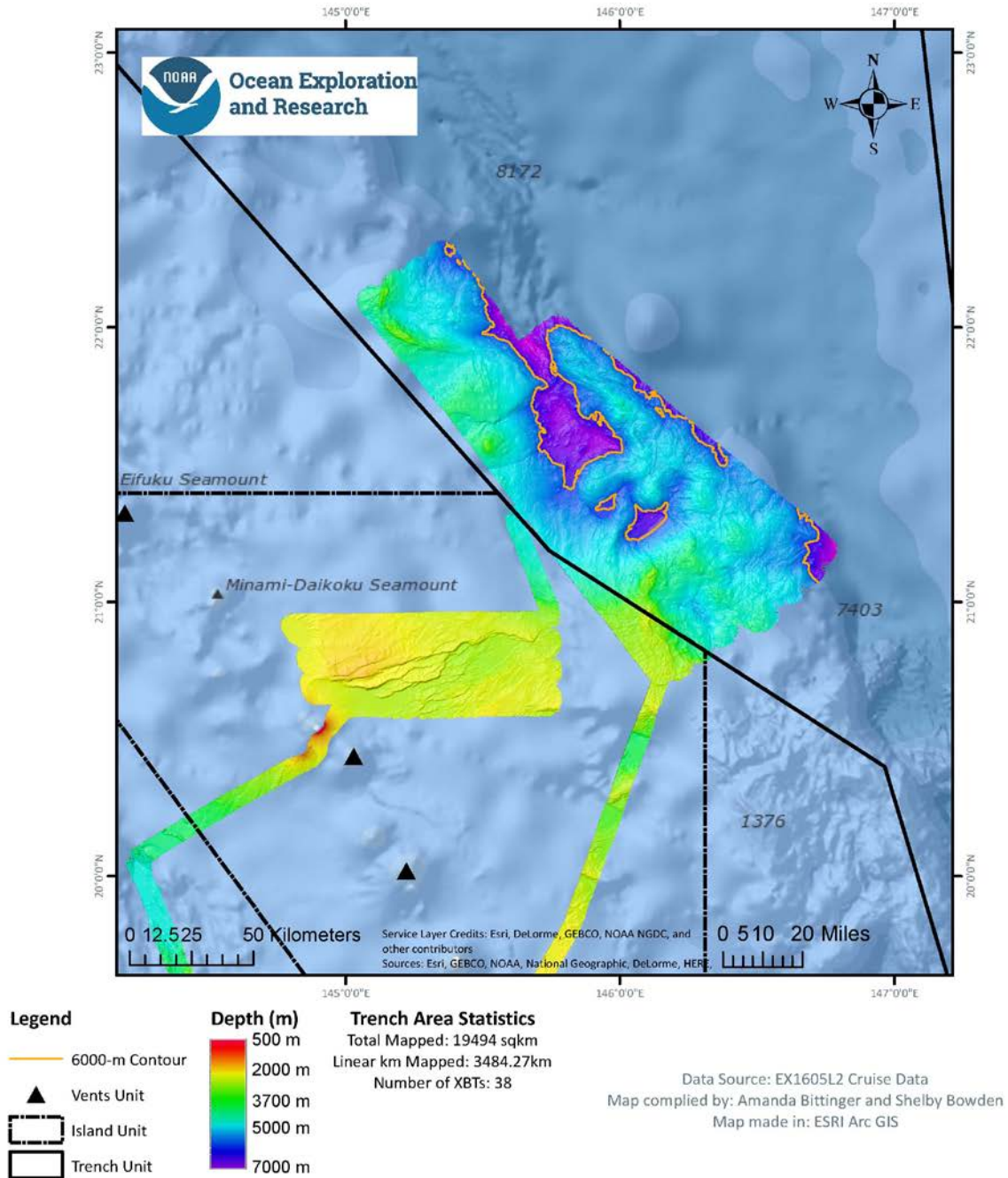


Figure 2. Cruise map showing focused mapping operations within Marianas Trench Marine National Monument.

4. Mapping Statistics

Dates of data collection	May 30 to June 11, 2016
Line kilometers of survey	4697
Square kilometers mapped	29,104
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files	347 files/ 18.9 GB
Number / Data Volume of EM 302 water column multibeam files	347 files / 70.0 GB
Number / Data Volume of EK 60 water column singlebeam files	414 files / 29.7 GB
Number / Data Volume of subbottom sonar files	1032 files / 3.03 GB
Number of XBT casts	52
Number of CTD casts (including test casts)	0
Beginning draft	Fwd: 14'10" Aft: 14'3-1/4"
Ending draft	FWD: 13'9" AFT: 14" 3-1/4"

5. Mapping Sonar Setup

The NOAA Ship *Okeanos Explorer* is equipped with a 30 kHz Kongsberg EM 302 multibeam sonar capable of mapping the seafloor in 0 to 8000 meters of water. The system generates up to a 150° beam fan containing up to 432 soundings per ping in waters deeper than 3000 meters. In waters less than 3000 meters, the system is operated in multiping, or dual swath mode, and obtains up to 864 soundings per ping, by generating two swaths per ping cycle.

The ship is also equipped with four Kongsberg EK 60 split beam fisheries sonars, 18, 70, 120, and 200 kHz.

Additionally the ship is equipped with a Knudsen 3260 subbottom profiler, which produces a 3.5 kHz chirp signal and is capable of penetrating the seabed up to 80 meters, depending on water depth and seabed type.

A 38kHz Teledyne RDI Ocean Surveyor Acoustic Doppler Current Profiler (ADCP), with a ~1000 m range, and a 300 kHz Teledyne RDI Workhorse Mariner ADCP, with a ~70 m range, is also onboard but was not operated this cruise due to interference with other sonars.

6. Data Acquisition Summary

Mapping operations included EM 302 multibeam, EK 60 singlebeam, Knudsen subbottom profile, and ADCP data collection. The schedule of operations included 24 hour per day sonar data collection. Transit lines to and from the working grounds were planned to maximize either edge matching of existing data or data gap filling in areas where existing bathymetry coverage existed. In regions with no existing data, exploration transit lines were planned to optimize potential discoveries.

During normal mapping operation data was collected with the EM302, EK60s, and subbottom profiler.

Expendable bathythermographs were collected every six hours and applied in real time using Seafloor Information Software (SIS). Sound speed at the sonar head was determined using a Reson SVP-70 probe and the thermosalinograph (TSG).

Background data used for exploration mapping included multibeam data collected on previous Okeanos Explorer cruises, the R/V *Falkor*, the Extended Continental Shelf project, and Sandwell and Smith satellite altimetry bathymetric data.

Tables listing all sonar data and sound velocity data files collected and products created during the cruise are provided as ancillary archived files.

Throughout the cruise, multibeam data quality was monitored in realtime by acquisition watchstanders. Ship speed was adjusted to maintain data quality as necessary. Most of the mapping was conducted along transit lines, however in places where focused surveying was conducted, line spacing planned to ensure $\frac{1}{4}$ to $\frac{1}{2}$ overlap between lines at all times. Cutoff angles in SIS were generally adjusted on both the port and starboard side to ensure the best data quality and coverage.

7. Sonar Data Quality Assessment and Data Processing

EM 302 Multibeam Bathymetry Data

Raw multibeam bathymetry data files were acquired by SIS, and were imported into CARIS. In CARIS, attitude and navigation data stored in each file were checked, and erroneous soundings were removed using CARIS Swath Editor and Subset Editor. Data quality throughout the cruise was very high, with wide swath widths of up to 5 times water depth, including up to 9.4 kilometer swaths. The figure below illustrates the overall multibeam data acquisition and processing flow.

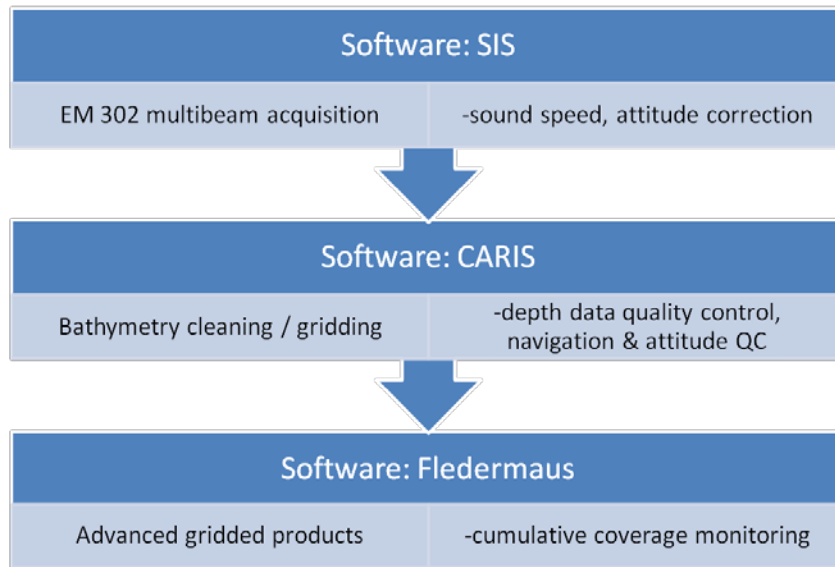


Figure 3. Shipboard multibeam data flow.

EM 302 Multibeam Water Column Backscatter Data Processing

Water column data was reviewed daily throughout the cruise to examine for the presence of seeps and other water column anomalies. No anomalies were identified.

EM 302 Built In System Tests (BISTs)

BISTs were run throughout the cruise to monitor multibeam sonar system status and are available as ancillary files in the sonar data archives.

8. 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 raw and processed data formats produced for this cruise is provided as an ancillary file with the dataset hosted by NCEI.

Sub-bottom data, supporting data, and informational logs are available in the NCEI Data Archives accessible at <https://www.ngdc.noaa.gov/> (last accessed 6/26/2019).

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 6/26/2019).

EK split-beam data is available in the NCEI Data Archives at <http://doi.org/10.7289/V5BG2M6X>.

EM 302 water column data is available in NCEI Data Archives at <http://doi.org/10.7289/V56Q1VFR>.

9. Cruise Calendar

All times listed are in local. Local ship time was +10 hours from UTC.

May / June 2016						
Sun	Mon	Tues	Wed	Thurs	Fri	Sat
			May 18 Mission personnel arrive to ship, alongside in port of Saipan	19 Mission personnel training and orientation	20 Mission personnel training and orientation	21 Alongside port of Saipan
22 Alongside port of Saipan	23 Alongside port of Saipan	24 Alongside port of Saipan	25 Alongside port of Saipan	26 Alongside port of Saipan	27 Alongside port of Saipan	28 Alongside port of Saipan
29 Alongside port of Saipan, Old Man By the Sea beach cleanup	30 Depart Port of Saipan for survey working grounds in northern area of MTMNM. Commenced Transit mapping.	31 Continue exploration transit to working grounds	June 1 Arrive survey working grounds in northern area of MTMNM, commence survey	2 Continue survey of MTMNM	3 Continue survey of MTMNM	4 Continue survey of MTMNM
5 Continue survey of MTMNM	6 Continue survey of MTMNM	7 Continue survey of MTMNM	8 Continue survey of MTMNM	9 Complete survey operations within MTMNM, commence exploration transit to Guam	10 Continue exploration transit to Guam	11 Mapping secured; Arrive Guam, U.S. Navy Base
12 In port, Guam	13 EX-16-05 Leg 2 mission personnel depart ship					

10. Daily Cruise Log

All times listed are local ship time, which was +10 hours from UTC.

May 18, 2016

The ship was alongside at the port of Saipan, with all mission personnel onboard. Training and ship orientation for Explorers in Training occurred. The sailing board has been delayed due to safe manning requirement in engineering department.

May 19, 2016

The ship was alongside at the port of Saipan. Departure is delayed as repairs for a leak in the hull into a void space are evaluated by NOAA and American Bureau of Shipping inspectors. Training and orientation of new mission personnel continued, including Fledermaus, Caris, ESRI ArcMap.

May 20-29, 2015

The ship was alongside at port of Saipan as plans for repairing the void space hole continue to develop. Training and orientation of new mission personnel continued. Data from previous cruises EX-16-05 Leg 1 and EX-16-04 was processed to inform ROV dive planning by shoreside based science and management partners for EX-16-05 Leg 3 and EX-16-06. Survey department SOPs were updated. A beach cleanup at Old Man By The Sea Beach was conducted, resulting in removal of over 200 pounds of plastic waste from the remote beach.

May 30, 2016

The ship departed port of Saipan for the survey working grounds in the northern portion of CNMI waters, within MTMNM Trench and Isles Units. Transit mapping was conducted at 10-11 kts and used the most direct route over existing data gaps in order to arrive to the working grounds as soon as possible, with predicted arrival early morning June 1. Watchstander training commenced. The EM 302 failed several BISTs while alongside. Two TX36 boards that were consistently failing were reseated and the system booted up cleanly initially, worked for an hour or so, then started losing attitude, and data/time data. The attitude feed on comport 2 to the EM302 failed several times and the EM 302 stopped pinging. EM 302 TX36 boards in slots 0 and 1 were swapped with each other and this appeared to solve the issue.

May 31, 2016

Exploration mapping transit continued over previously unmapped areas en route to the working grounds in the northern area of the CNMI EEZ / Mariana Trench Marine National Monument. Transit mapping was conducted at 10-11 kts and used the most direct route over existing data gaps in order to arrive to the working grounds as soon as possible.

June 1, 2016

The first 12 hour line in the MTMNM was completed. Data quality was high in fair weather.

June 2, 2016

Focused mapping exploration with EM 302, subbottom, and EK60 sonars continued. Data quality was moderate to high in 4-6 ft. Swath widths of up to 8km in ~3500m water were achieved with the EM 302.

June 3, 2016

Focused mapping exploration with EM 302, subbottom, and EK60 sonars continued. Data quality was moderate to high in 4-6 ft. A successful Reddit Ask Us Anything session was conducted with onboard EC/Mapping Lead, the entire mapping team, and other onshore expedition coordinators/managers.

June 4, 5, & 6, 2016

Focused mapping exploration with EM 302, subbottom, and EK60 sonars continued, with high data quality and all equipment functioning normally. Current survey efforts are focused on mapping the 6000m contour line on one section of the northwestern wall of the Mariana Trench. The seafloor appears to be very acoustically reflective, resulting in the EM 302 achieving wide swath widths of 6000-8000 meters in these depths. The subbottom is not

penetrating the seabed, presumably because there is little soft sediment cover and the seabed is so reflective.

June 7, 2016

Survey efforts focused on developing the 6000m contour and mud volcano exploration areas near the northwestern wall of the Mariana Trench were completed. The seafloor continues to appear to be very acoustically reflective, resulting in the EM 302 achieving wide swath widths of 6000-8000 meters in these depths. With exceptions over small, deep, sediment filled basins, the subbottom did not penetrate the seabed in this region, presumably because there is little soft sediment cover and the seabed is acoustically reflective.

A crossline was conducted while transiting to the next survey area, the ridge feature extending eastward from the volcanic arc. Data quality was high at the ridge feature, with up to 7600 meter swath coverage in 2000-2500 meters of water.

June 8, 2016

Focused mapping exploration of the ridge feature extending eastward from the volcanic arc with the EM 302, subbottom, and EK60 sonars continued. Data quality was high in calm seas with little wind. The seafloor continues to appear to be very acoustically reflective, resulting in the EM 302 achieving wide swath widths of 6000-7000 meters in these depths. The subbottom data indicates there is up to ~20 m sediment cover in this region.

A successful live audio/video interaction was conducted at 2pm local time with EC and Roy Adsit of CNMI Public School System in Saipan, with 12 teachers from an AP Teacher workshop.

June 9, 2016

Focused mapping exploration of an area extending eastward from the volcanic arc near Farrallon de Pajaros was completed. Focused mapping exploration with EM 302, subbottom, and EK60 sonars continued, with high data quality and all equipment functioning normally. The seafloor continues to appear to be very acoustically reflective, resulting in the EM 302 achieving wide swath widths of 6000-7000 meters in these depths. The subbottom data indicates there is up to ~20 m sediment cover in this region. The feature we were mapping, which looked to be a likely ridge in the satellite altimetry data, was revealed to not be a ridge but in fact as series of faults and scarps, possibly from uplifting in the region.

A successful tri-ship Google Hangout with *Okeanos*, *Falkor*, and *Nautilus* was conducted for World Oceans Day.

Transit to Guam commenced. The transit line will collect new data over historical low-resolution data over a back arc axis, and will complement recent 2015 *Falkor* data over this axis further to the south. The ship is scheduled to be at pier U2 at the Guam Navy Base.

June 10, 2016

Transit to Guam continued, with data quality remaining high.

June 11, 2016

The sea buoy was reached in the late morning, sonars were secured, and the ship stood by for its 1100 berthing window. The ship was alongside at pier U2 at the Guam Navy Base at ~ 1200.

11. References

Ancillary data files are archived with the sonar dataset in the NCEI archives and/or in the NOAA Central Library as supporting files. These include:

EM 302 Processing Parameters in use during the cruise

EM 302 Built In System Test (BIST) Results

Tables of Data File Logs

Daily Watchstander Log

Weather Log

2016 Okeanos Explorer Mapping Systems Readiness Report can be obtained at (<http://doi.org/10.7289/V5FT8J2Z>).

EX-16-05 Leg 2 project instructions, available in the NOAA Institutional Repository.

The following data was used as background data throughout the cruise:

- 1) 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.
- 2) NOAA Nautical Charts in S-57 format.
- 3) Mariana regional bathymetry compilation compiled and provided to NOAA OER by Daniel Scheirer, USGS.
- 4) R/V Falkor 2015 Mariana expedition data provided by William Chadwick, NOAA Pacific Environmental Marine Laboratory (PMEL).
- 5) AUV Sentry data compiled and provided by Susan Merle, NOAA PMEL.