MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

CRUISE EX-16-05 Leg 1: 2016 Deepwater Exploration of the Marianas

April 20 – May 11, 2016

Report Author:
Lindsay McKenna Gray

Report Date: September 14, 2016

NOAA Office of Ocean Exploration and Research
1315 East-West Hwy, SSMC3, #10210
Silver Spring, Maryland 20910

[1]ERT Corp. on long term contract to NOAA Office of Ocean Exploration and Research, [2]NOAA Corps, [3]University of Puerto Rico, Mayaguez, [4]NOAA Atlantic Hydrographic Branch, [5]University Corporation for Atmospheric Research

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 operations systematic telepresence-enabled exploration, requires a robust with 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.

Table of Contents

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 1. The full cruise report, 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 ROV, mapping, telepresence-based remote participation, and CTD rosette operations. The expedition commenced in Santa Rita, Guam with operations beginning on April 20th and concluded in Saipan, CNMI on May 11th. Operations used the ship's deep water mapping systems (Kongsberg EM302 multibeam sonar, EK60 split-beam fisheries sonars, ADCPs, and Knudsen 3260 chirp sub-bottom profiler sonar), NOAA's two-body 6000 m remotely operated vehicle (ROVs *Deep Discoverer* and *Seirios*), CTD rosette, and the ship's high-bandwidth satellite connection for real-time ship to shore communications. ROV dives were conducted during the day to collect high-resolution visual surveys and limited rock and biologic specimen sampling. Mapping operations were conducted during overnight transits and when the ROVs were on deck. CTD casts were conducted to collect more environmental information at sites of interest. Exploration operations for this cruise focused on deep-water areas around

CNMI and the 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 specific objectives for this cruise were defined in EX-16-05 Leg 1 Project Instructions, which are achieved in the NOAA Central Library.

3. Summary of Mapping Results

Cruise Overview Map

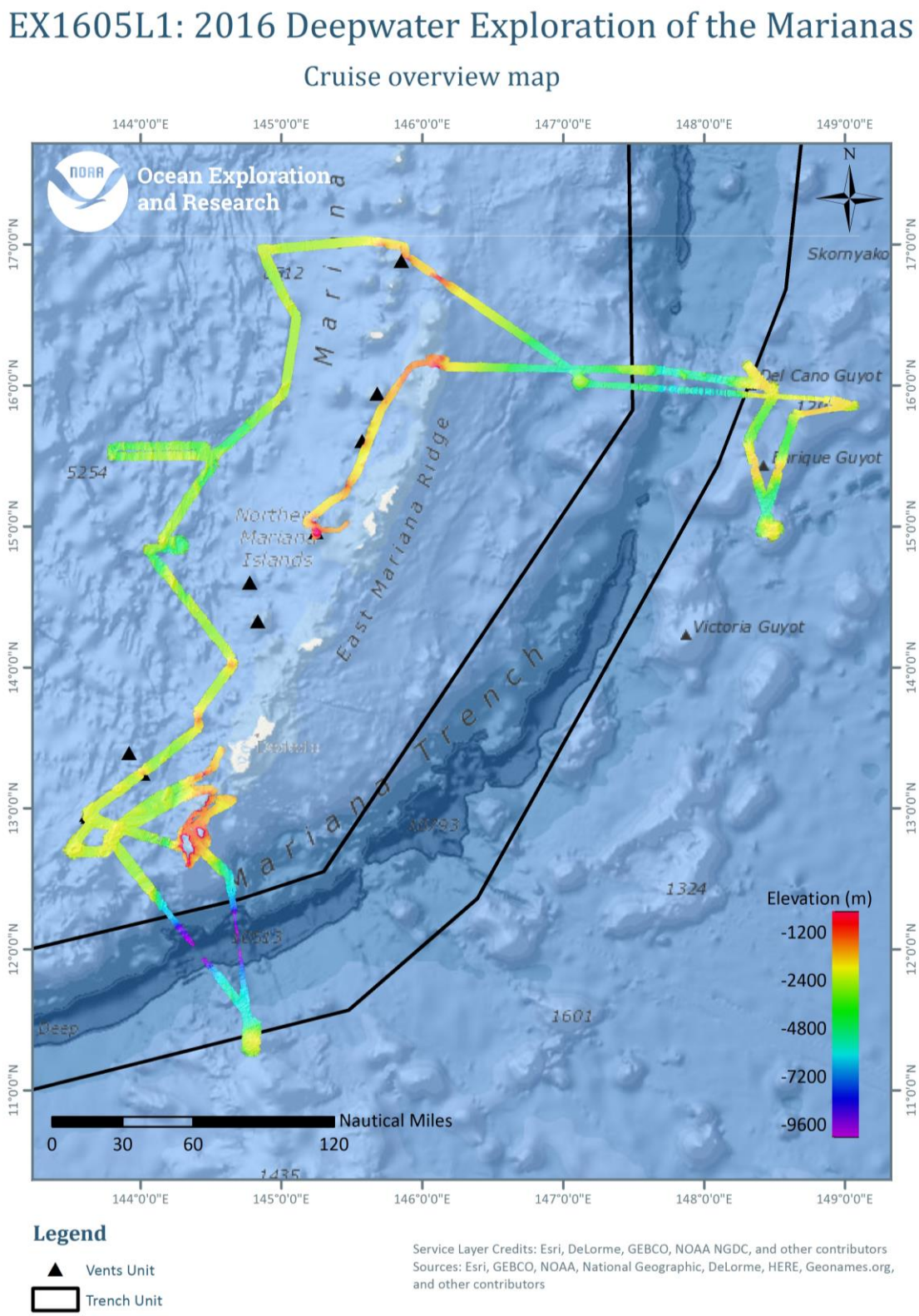

Figure 1.Cruise map showing overall EX-EX-16-05 Leg 1 operations. Generated in ArcMap.

4. Mapping Statistics

Dates	April 20 to May 11, 2016
Line kilometers of survey with EM302	3600
Square kilometers mapped with EM302	19,600
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files	451 files/ 21.3 GB
Number / Data Volume of EM 302 water column multibeam files	451 files / 69.6 GB
Number / Data Volume of EK 60 water column singlebeam files	1317 files / 27 GB
Number / Data Volume of subbottom sonar files	355 files / 3.6 GB
Number of XBT casts	20
Number of CTD casts (including test casts)	3

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 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. The 18 kHz transducer and transmits a 7° beam fan.

Additionally the ship is equipped with a Knudsen 3260 subbottom profiler, the transducer produces a 3.5 kHz chirp signal. 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.

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 overnight transit mapping and mapping whenever the ROV was on deck. Lines 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. Just under 20,000 square kilometers of seafloor were maped, this includes data from six sites that are included in the Vents Unit of the Mariana Trench Marine National Monument (MTMNT).

During normal mapping operation data was collected with the EM302, EK60s, and subbottom profiler. During daytime ROV operations, the 38 and 300 kHz ADCPs were turned on. The EM302 and EK60s timed out during transits over the deepest sections of the Mariana Trench.

The 38 kHz ADCP was always turned off for general mapping operations, however the 300 kHz was initially run with the other mapping sonars. However, a noticeable interference in the outer

beams of the EM302 from the 300 kHz ADCP became apparent to watchstanders seven days into the cruise. The interference was tested in Medium, Deep, Very Deep, and Extra Deep depth modes with CW, Mix, and FM transmit modes. The interference pattern was noticeable in all modes, so for subsequent mapping the 300 kHz ADCP was turned off. This interference could be related to the depth mode of the EM302 and the number of sectors the multibeam is using, and/or the bandwidths and filters applied to each sector.

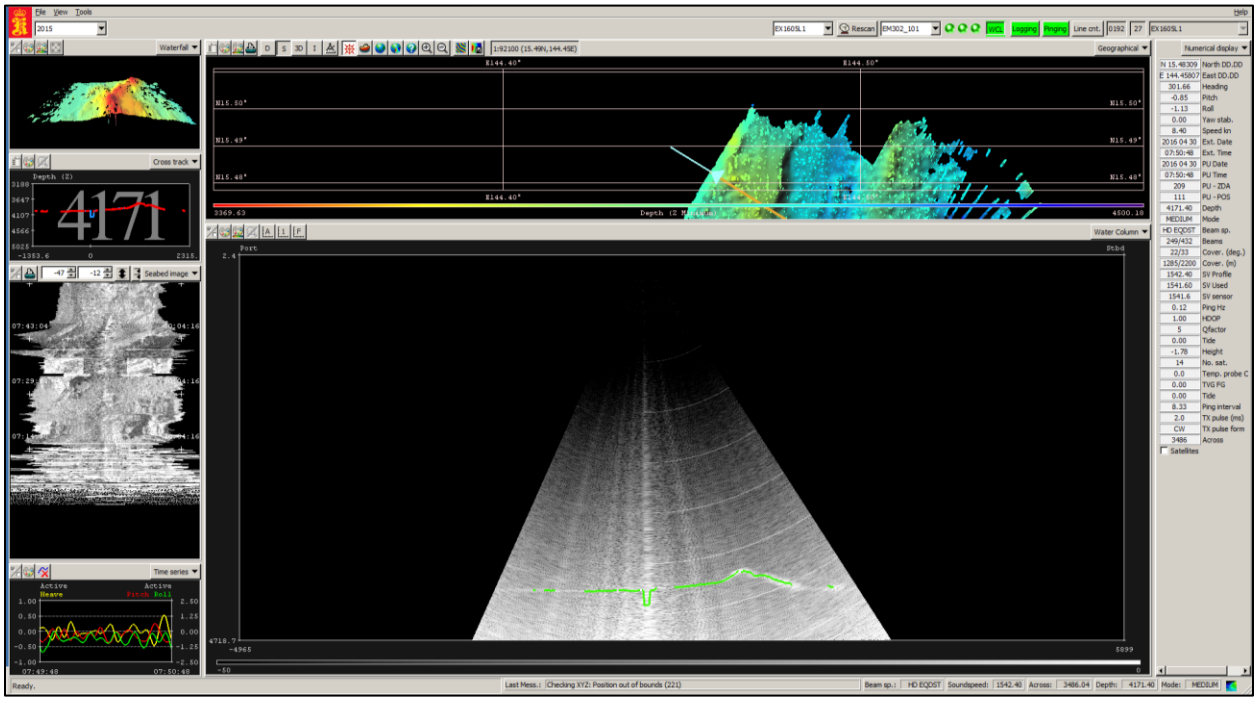

Figure 2. Interference pattern visible in the EM302 water column when the sonar is in Medium depth mode and CW transmit mode. The interference is more prominent on the starboard side.

Mapping was conducted around Santa Rosa reef and the north side of Farallon De Medinilla to try to capture the 400 m contour for NOAA partners at the National Marine Fisheries Service. The 400 m contour is an indicator of essential fish habitat.

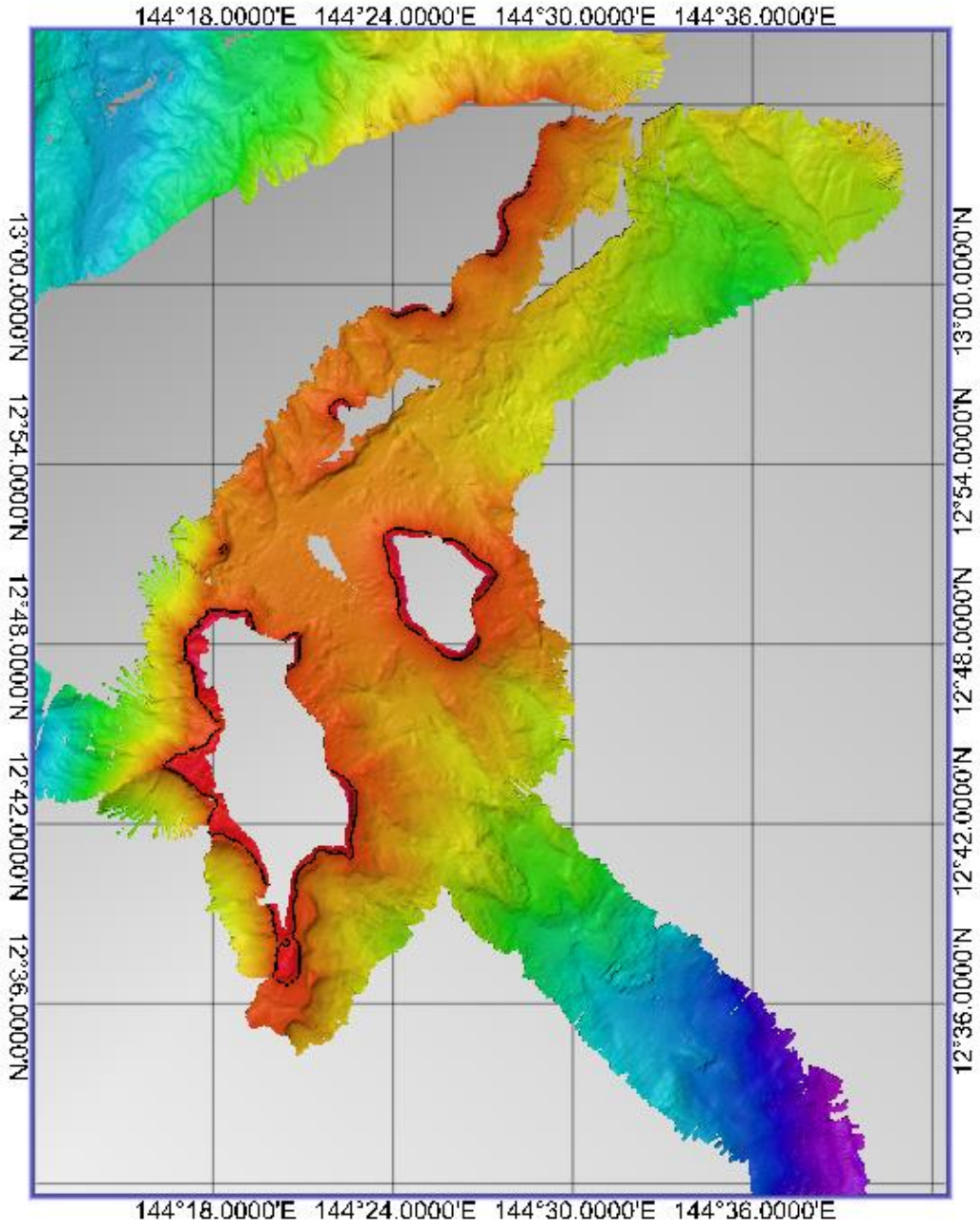

Figure 3. Bathymetry collected around Santa Rosa reef, 400 m contour shown in black.

One of the ROV dives was on a site of active black-smoker hydrothermal vents at a depth of 3,300 m. Following the dive, several mapping passes were made over the active venting. There was a clear and repeated signature in the 18 kHz EK60 from the black smokers.

A repeated and detailed survey was conducted over Esmerelda Crater, with focus on collecting high quality EK60 data over this active underwater volcano. Well defined scattering layers were visible in all four EK60 frequencies. One water column anomaly, consistent with gas seepage,

was detected on one pass, however the anomaly was not detect on subsequent passes over the same area.

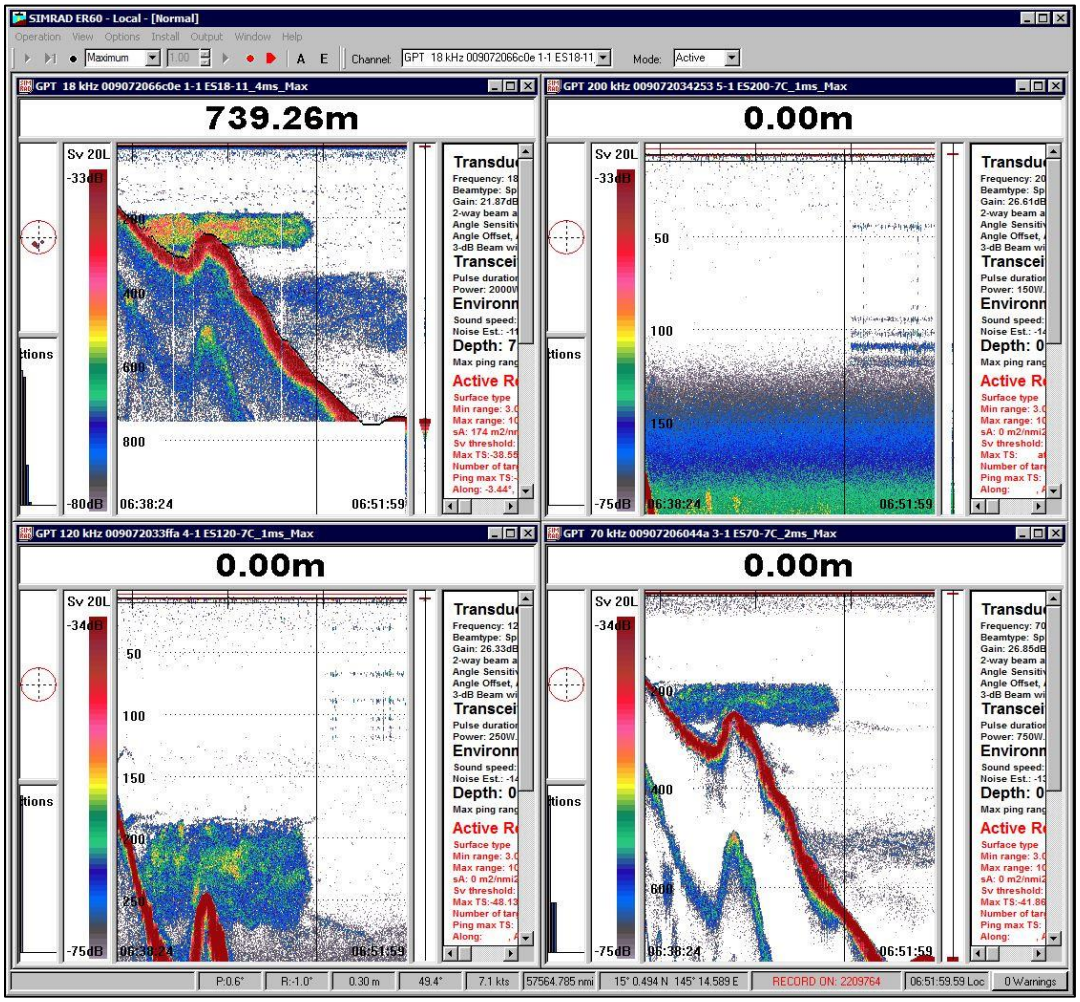

Figure 4. Scattering layer over Esmerelda Crater, the layer is visible over all four frequencies.

Closer to Tinian and Saipan, focused surveys were conducted nearshore for underwater archeology purposes.

Expendable bathythermographs were collected once an evening 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). There were a few days in the middle of the cruise where the pump on the TSG was broken, so the last known salinity data was used to calculate sound speed from the XBT profile data. Sound speed throughout the water column was very consistent throughout the cruise, so the broken pump had no adverse effects on data quality.

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. Some dive planning was conducted using bathymetry grids created using all available bathymetry achieved with NCEI using NCEI's Auto Grid online tool.

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 were focused surveying was conducted, line spacing planned to ensure ¼ to ½ 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.

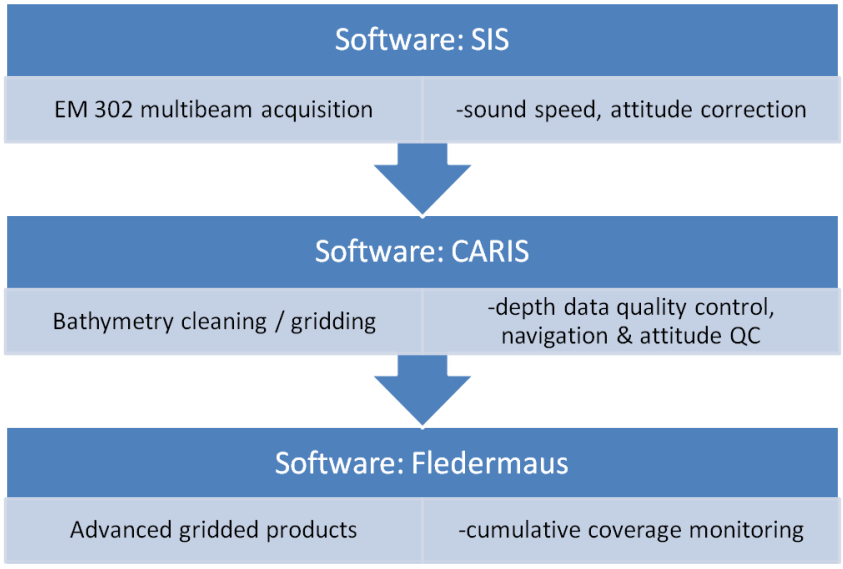

Figure 5. Shipboard multibeam data flow.

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.

Crosslines

Crossline analysis was conducted using surface differencing in Caris. Two reference surfaces were computed, the first using multibeam lines 0118 and 0114, run in the E/W direction. The second using line 0128 oriented N/S, Figure 6. The two surfaces were differenced, and statistics were computed based on the differences. The attribute value bin sized used for the differencing was 1 m.

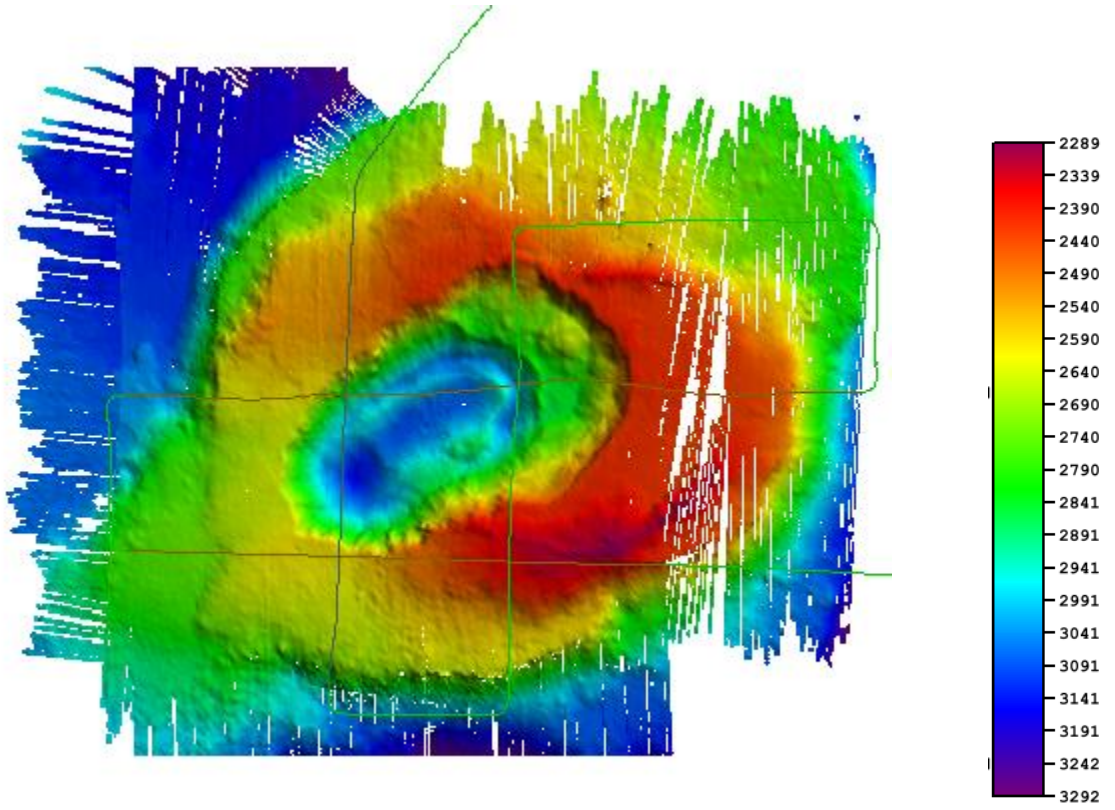

Figure 6. Reference surface used in cross-line analysis. Lines used for analysis are shown in brown. Depths are in meters.

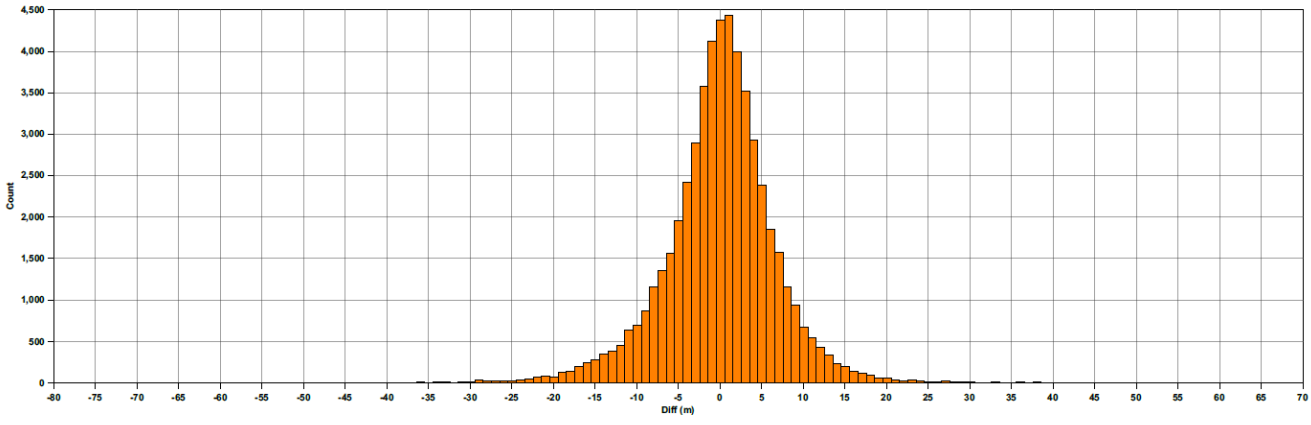

Figure 7. Difference histogram. The water depth of the cross-line analysis ranged from 2200 m to 3300 m. Statistics of the differencing are shown below.

Statistics
Minimum: -77.3 m
Maximum: 67.4 m
Mean: -0 m
Area: N/A
Standard Deviation: 7 m
Total count: 54,287

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 processes data formats produced for this cruise is available as an appendix in the project instructions.

9. Cruise Calendar.

All times listed are in local. Local ship time was +12 hours from UTC.

April / May 2016						
Sun	**Mon**	**Tues**	**Wed**	**Thur**	**Fri**	**Sat**
		19 Mission personal arrive	20 Depart Guam, mapping ops commenced outside of Guam harbor, evening CTD conducted	21 Daytime ROV dive, evening mapping	22 Daytime ROV dive, evening mapping	23 Daytime ROV dive, evening mapping
24 Daytime ROV dive, overnight ROV recovery with ADCPs on, no bathymetry mapping conducted	25 Daytime and evening transit mapping	26 Morning CTD ops, daytime ROV dive, evening mapping	27 Morning CTD ops, daytime ROV dive, evening mapping	28 Daytime ROV dive, evening mapping	29 Daytime ROV dive, evening mapping	30 Daytime ROV dive, evening mapping
1 Daytime ROV dive, evening mapping	2 Daytime ROV dive, evening mapping	3 Daytime ROV dive, evening mapping	4 Daytime ROV dive, evening mapping focused on subbottom lines	5 Daytime ROV dive, evening mapping focused on subbottom lines	6 Daytime ROV dive, evening mapping focused on subbottom lines	7 Daytime ROV dive, evening mapping
8 Daytime ROV dive, evening mapping	9 Daytime ROV dive, evening mapping focused on water column	10 Daytime ROV dive, evening mapping focused on Underwater Cultural Heritage (UCH)	11 Morning UCH mapping, pulled into port in Saipan	12 Demod	13 Mission personnel depart	14

10. Daily Cruise Log

All times listed are local ship time.

April 20-21
NOAA Ship *Okeanos Explorer* departed Guam at approximately 1000 to commence the 2016 Deepwater Exploration of the Marianas Expedition. Mapping operations were started once we departed Guam harbor and continued en route to Fina Nagu Caldera A where CTD operations were conducted. An electrical failure occurred during CTD Pogo operations, and mapping operations were conducted overnight. Mission personnel spent the day getting familiar with ship systems and operations, and preparing for the first ROV dives.

April 22
Continued overnight mapping around the Santa Rosa reef, to try to capture the 400m contour. The ship was not comfortable mapping anywhere there was not existing multibeam bathymetry due to shallow reef pinnacles that might not be charted. We did not capture the 400m contour all the way around the reef but will attempt to fill in more portions of the unmapped area tonight. Data quality was good on all sonars. Overnight mapping around the Santa Rosa reef continued. Data quality was high on all sonars. We continued to map the 400m contour for NOAA fisheries. We weren't able to trace the entire contour, but we did map a significant portion of the contour, see attached image. New watch-standers are up to speed on mapping procedures and daily products are being made and pushed to shore. XBTs are only being collected once a night because no sound speed artifacts are being detected. Casts will be conducted more frequently if needed.

April 23
During overnight mapping to the next dive site, Enigma Seamount, we crossed over the Mariana Trench. The EK60s timed out due to the deep depths so we did not run the EK60s in water deeper than ~6000m. Over the trench we transited 8-9 knots and the EM302 had a difficult time tracking bottom, but the deepest depth we measured was ~9,825m. Once we arrived at Enigma Seamount we mapped two-thirds of the seamount before arriving on the dive site in the morning. The new Enigma Seamount grid was compared to a grid made compiled by NCEI Auto-Grid using EM122 data collected by the Navy in 2010. At the dive location, depths between the two surveys were within 0.04% of water depth. Data quality was good on all sonars in depths <5000m. We got the Backscatter Mosicing software running and ran it all night. We have been routinely collecting ADCP data on both the 38 and 300 kHz ADCPs during the ROV dives.

April 24
No mapping operations. ROV recovery extended into the early morning hours of 4/25. Following recovery, the ship remained on station in DP until 1600 to enable the deck department and engineering team to safely disassemble, assess and reassemble the flag sheave.

April 25
We continue to collect ADCP data during ROV dives, and had the ADCPs recording all yesterday while we maintained position for the winch repair. Overnight we mapped a straight transit line to the next CTD launch location, Fina Nagu Caldera C. The ship had to maintain higher speeds (9-9.5 kts) to get on station in time, so data over the Mariana Trench was poor. The EM302 did not track bottom deeper than 9,501 m. The 18 and 70 kHz EK60s were set to passive mode in the trench because they were timing out. Once we moved to waters shallower than 6000 m, tracking

improved on all the sonars. Data quality was fair in >5000m of water (due to high speed) and good in waters shallower than 5000m. Several passes were made over the Fina Nagu Caldera D dive site with the EM302, as we arrived on station earlier than expected because CTD operations were aborted mid-cast.

April 26

We mapped over the Toto caldera last night, which is a known area of active venting and also part of the MTNMN Vents Unit. This was a mapping suggestion made by Bob Stern during the post-dive call. We made several passes over the caldera at 6-7 knots. Watch standers monitored the EM302 and 18kHz EK60 for water column anomalies. No anomalies were visible in the water column. On our way to Fina Nagu caldera C we had planned to map over 3 other vent units, however we were not able to make fast enough speed to map over them and get on station in time for the CTD cast. Data quality on all sonars was high.

April 27

Overnight mapping focused on the Santa Rosa north box. It was a long transit to get to the priority mapping area so we only have time for 2 lines inside the box. There was no existing bathymetry over the area we mapped, so mapping proceeded very carefully since there are shallow reefs in the area. We did not quite capture the 400m contour, but got close with most of the 600m contour. The EM302, EK60s, and Knusden were run during overnight mapping and data quality was high.

April 28

Overnight mapping focused on the Santa Rosa north box. It was a long transit to get to the priority mapping area so we only have time for 2 lines inside the box. There was no existing bathymetry over the area we mapped, so mapping proceeded very carefully since there are shallow reefs in the area. We did not quite capture the 400m contour, but got close with most of the 600m contour. The EM302, EK60s, and Knusden were run during overnight mapping and data quality was high.

April 29

Overnight we mapped to the next dive site. On the way we were able to map over 3 monument trench units. No anomalies were noted in the water column over these sites. Once we arrived at the dive site we mapped a portion of the NW Guam Seamount. Data quality was high on all the sonars. Overnight, the watch-lead was able to do some interference testing with the ADCPs while seas were quite calm. Interference was noted with the 38 kHz, but no interference was noted with the 300 kHz. The 38 kHz will have to be put on a sync with the other sonars if we want to run it simultaneously. Augmenting ST worked on updating the CTD SOP since the new SST arriving at the ship will not get any overlap with an existing ST. Today we learned that the TSG pump has failed. This is a part that is maintained by the ship and requires regular monitoring and maintenance; it needs to be replaced every year or so. While a spare part resides onboard that is not intended for the TSG pump but could be used, we are opting not to use it in case it is needed for Leg 2 mapping operations. This part is composed of copper instead of stainless steel and would not hold up for long. Sea surface salinity has remained relatively constant this cruise, so the survey department will pull the salinity reading from the vehicles CTD sensor after ROV dives to calibrate the sound speed.

April 30

We mapped two long lines during the overnight mapping operations in an area where there was no existing multibeam bathymetry. Data quality on all sonars was good, considering the depths, >4000m. We did some more testing with the 300 kHz ADCP and were seeing interference in the outer most sectors in the deepest two ping modes. We will continue to test the interference when we are in shallower water. The engineers fixed the TSG pump, so that was turned on last night. The ship is still planning to secure a spare pump in Saipan.

May 1
Mapped a transit line to the next dive site that was requested by Bill Chadwick. We edge matched some existing EM302 Falkor data, and it appears that we may have mapped a boundary of the back arc area. The data quality on all sonars was high. Watch standers continue to work on SOPs, backscatter processing, and ST Potts is taking some time to train the new Ops officer, LTJG Colohan, in preparation for the new SST.

May 2
After the dive on the hydrothermal vents, we mapped over the first vent with all sonars except the ADCPs. We saw a clear signal in the EK60. (Note, the noise in the middle that's over the entire water column is a turn.) We did 4 passes over the first vent, and then moved 100 m to the east and did 2 passes over the third waypoint vent. The signal we saw in the data was consistent and repeatable with each pass. We calculated that the theoretical beam footprint of the EK60 at the depth of the vents was 560 m across, this means we were capturing all the black smokers we saw on the dive with each pass. It is possibly the anomaly is caused by temperature and/or particulate scattering.

May 3-4
The last two nights of mapping were primarily straight transits to the next dive sites. On May 3-4 we were able to map the summit of the mud volcano prior to the dive. No water column anomalies were noted in the EM302 or the EK60s. Data quality hovered between good to fair as the sea state picked up and our heading was not ideal for the wind and wave direction. The transit to Pigafetta Guyot (May4-5) was quite slow, as transit direction was directly into the prevailing surface current and wind. The ship barely made 8 knots all evening. We arrived on the dive site over an hour late, so we were not able to map the ridge prior to the dive. Due to deteriorating weather and running into the currents and wind, the sonar data quality was fair, with many drop outs due to heavy pitching and induced bubble sweep down. We did force the EM302 into a deeper ping mode, and that seemed to help track the bottom, but resulted in a narrower swath than expected for the depths we were mapping in. No XBT was conducted the evening of May 4-5 due to rough sea conditions. The water around this area is well mixed, so there was no negative impact from not taking an XBT.

May 5, 6, 7
Overnight mapping in all three guyot areas focused on transiting to the next dive site and also collecting good subbottom over the middle of the guyots. Before Pigafetta, Enrique and Del Cano we were able to map the dive site in the morning, improving upon the 100 m grid we used to plan. Seas were still somewhat heavy, so data quality was dependent on what direction we were transiting. Into the seas (easterly) the data quality was poor, with a following sea and the

seas a beam that data quality improved. Watch-standers worked on SOPs and processing backscatter when mapping operations got slow.

May 8, 9, 10

After the FDM dive on 5/8, we mapped an area directly north of the dive site that was requested by Chris Kelley. After the focused mapping was complete we conducted transit mapping to the Esmerelda Bank dive target. Data on all three sonars was good. After the Esmerelda Bank dive we mapped over the Esmerelda Crater all night. There was a distinct layer in the EK60 sonars, visible on all four frequencies, but best on the 18, 70, and 120 kHz. The layer was about 120 m thick, from ~200 to 320 m deep, and had strong scatters. The layer was most visible around the rim. On one pass we saw a distinct anomaly in the multibeam, and 18, 70, and 120 kHz EK60s that looked like a plume. We later made 6 additional passes over the site but did not see the plume again in any sonar. We suspected a temperature anomaly based on the fact we were diving over a volcano, and we were shallower than the max depth of the XBTs so we conducted 7 XBTs and were able to map a thermocline that closely correlated to the layers we saw in the EK60. We collected subbottom over the crater on only one pass, then secured the Knudsen.

May 11

Overnight mapping focused on a cultural heritage site over suspected downed WWII era B-29 planes on the west side of Tinian. We conducted a tight grid over a search area focusing on backscatter. The seafloor in the search area was covered in dense coral with high backscatter returns, so it was very difficult to make out any cultural features. We also did some survey lines to the east of Saipan and Tinian where little to no mapping data existed before coming into port in the morning. Data quality was good on the west side of the islands but deteriorated on the east side due to the swell direction. We turned off the subbottom for some of the night mapping due to poor data quality. All the sonars were secured before heading into port.

11. References

The 2016 Survey Readiness Report can be obtained by contacting NOAA Ship *Okeanos Explorer* at oar.oer.exmappingteam@noaa.gov.

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

1) Sandwell, D. T., and W. H. F. Smith, Global marine gravity from retrackedGeosat 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.

14. Appendices

Ancillary data files are archived with the sonar dataset. These include:

Project Instructions

EM 302 Processing Parameters in use during the cruise

EM 302 Built In System Test (BIST) Results

Tables of Multibeam Data File Logs

Daily Watchstander Log

Weather Log

Appendix A: Acronyms

AERONET – Aerosols Robotic Network
AHB – Atlantic Hydrographic Branch
ASCII – American Standard Code for Information Interchange
AUV - autonomous underwater vehicle
BIST – built in system test
CDR – Commander
CO – Commanding Officer
CTD – conductivity, temperature, depth
dB - decibel
DNP – do not process
EEZ - Exclusive Economic Zone
ERT – Earth Resources Technology Corp.
ET – Electronics Technician
EX – NOAA Ship Okeanos Explorer
FM – frequency modulated / modulation
FTP – file transfer protocol
FV - free vehicle
GB - gigabytes(s)
KB - kilobytes(s)
kHz – kilohertz
km – kilometer
kts – knots
LT – Lieutenant
LSS - light scattering sensor
m - meters
MAN – Maritime Aerosols Network
MB – multibeam sonar
MB – megabytes(s)
ms – millisecond
MTMNM - Mariana Trench Marine National Monument
NASA – National Aeronautics and Space Agency
NCDDC – National Coastal Data Development Center
NCEI - National Center for Environmental Intelligence
NCCOS - National Centers for Coastal Ocean Science
NGDC – National Geophysical Data Center
NMEA – National Marine Electronics Association
NOAA – National Oceanic and Atmospheric Administration
NODC – National Oceanographic Data Center
OER – NOAA Office of Ocean Exploration and Research
OMAO – NOAA Office of Marine and Aviation Operations
OPS – Operations Officer
PRT - Puerto Rico Trench
ROV – remotely operated vehicle
SBP – subbottom profiler
SCS – scientific computer system

SIS – Seafloor Information System
SST - Senior Survey Technician
SVP – sound velocity profile
TRU – transceiver unit
TSG - thermosalinograph
TX – transmit
UCAR - University Corporation for Atmospheric Research
UPRM - University of Puerto Rico, Mayaguez
USGS – United States Geological Survey
W - watt
XBT – expendable bathythermograph
XO – Executive Officer