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MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

CRUISE EX-15-05: Transit: Honolulu, HI to Alameda, CA *(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 the mapping expedition EX-15-05, and to present a summary of the overall mapping results and mapping related cruise activities. A detailed description of NOAA Ship *Okeanos Explorer's* mapping capabilities is available in the 2015 NOAA Ship *Okeanos Explorer* Survey Readiness Report, available in the NOAA Central Library at https://doi.org/10.25923/hhvn-7d52 (last accessed 10/04/2020).

3. Cruise Objectives

The primary objective of this cruise was a strategically planned transit from Honolulu, Hawaii to Alameda, California, where the ship underwent drydock repairs. The ship was scheduled to depart Honolulu on October 5, 2015 and arrive in Alameda on October 15, 2015, however sailing was delayed and the cruise dates were October 7 – October 16. In pursuit of the "Always Exploring" and telepresence models, this cruise was used to further test the operational reality of conducting a 24 hour/day mapping transit cruise through the use of telepresence. Using the satellite altimetry-derived bathymetry data published by Sandwell and Smith (Sandwell, 2014) and in consultation with David Sandwell, the transit line was strategically designed to collect deep water bathymetry, sub-bottom, and water column data over previously unmapped areas, including potential seamounts, in close proximity to the well mapped Great Circle Route between the two ports. A team of three expert mapping watchstanders were onboard to collect and minimally process bathymetry data. A 5 megabit per second satellite connection was used to transmit one live stream of the multibeam acquisition screen and to send daily gridded multibeam products to the shoreside data server. OER scientists based at the University of New Hampshire Center for Coastal and Ocean Mapping received the final raw data package when the ship reached shore, and processed raw data into standardized products according to OER's established archival procedures.

The complete objectives for this cruise are detailed in the EX-15-05 Project Instructions, which are archived in the NOAA Central Library and available in the NOAA Institutional Repository at https://doi.org/10.25923/tmhy-fa11 (last accessed 10/09/2020).

4. Summary of Mapping Results

EX-15-05 mapped 15,040 square kilometers of seafloor along a straight line transit between Honolulu, HI and Alameda, CA during the 10 days at sea (**Figure 1 and Table 1**). 2,916 square kilometers of this area was mapped within the U.S. Exclusive Economic Zone and territorial sea in depths deeper than 200 m. Multibeam bathymetry data coverage is shown in **Figure 1**.

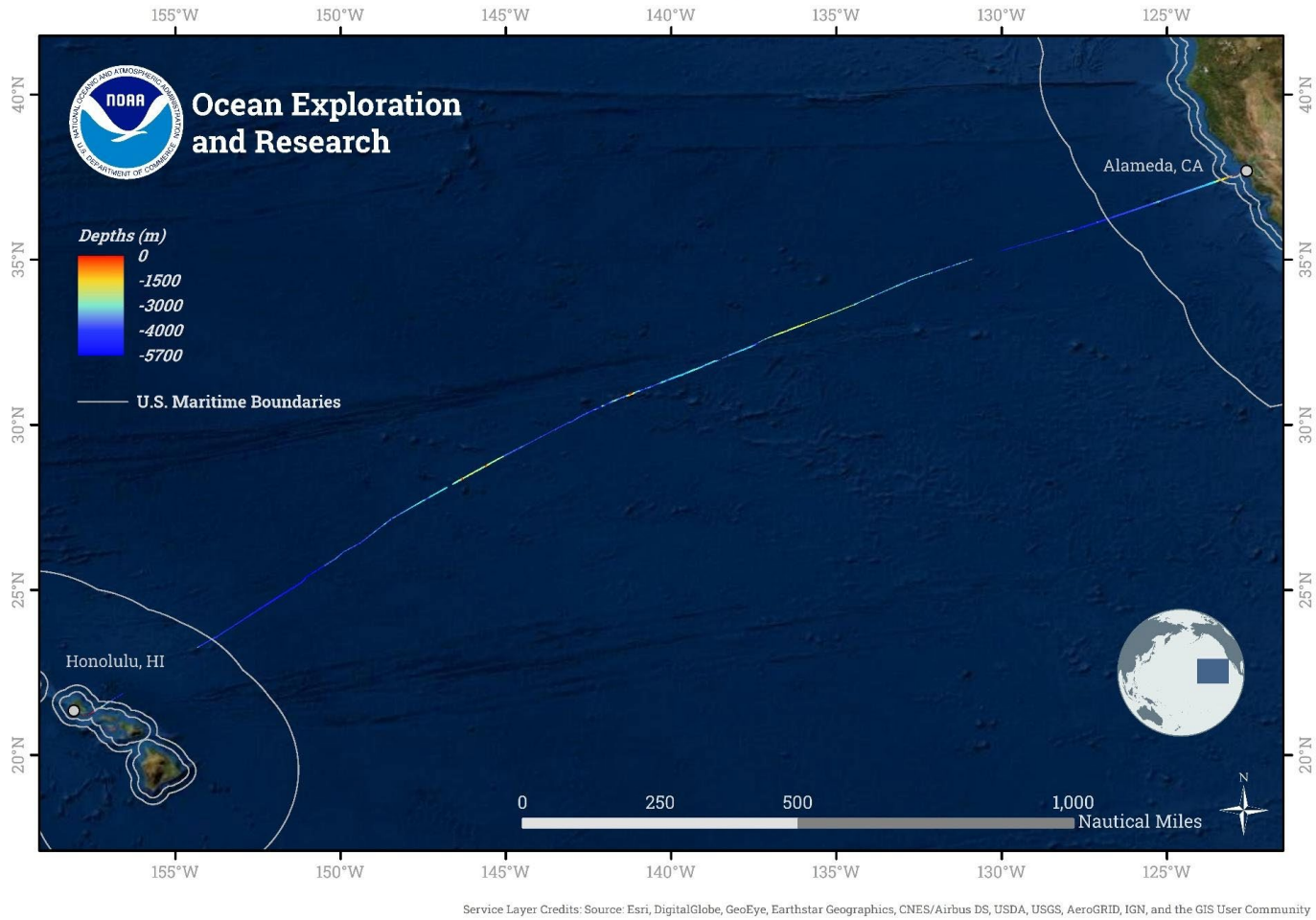

Figure 1. Overview map of bathymetric coverage completed during EX-15-05: Honolulu, HI to Alameda, CA

5. Mapping Statistics

Table 1. Summary statistics of ocean mapping work completed during EX-15-05.

Dates of cruise	**October 7 – October 16, 2015**
Ship's draft: **Start of cruise (10/07/2015)** **End of cruise (10/16/2015)**	**Fore: 15'; Aft : 14' 1.5"** **End of cruise draft unavailable**
Linear kilometers of survey with EM 302	**3,558**
Square kilometers mapped with EM 302	**15,040**
Square kilometers mapped with EM302 within U.S. EEZ deeper than 200 meters	**2,916**
Number / data volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)	**189 files/ 11.8 GB**
Number / data volume of EM 302 water column multibeam files	**189 files / 46.6 GB**
Number / data volume of EK 60 water column split-beam files (.raw)	**422 / 2.9 GB**
Number / data volume of sub-bottom sonar files (.segy, .kea, .keb)	**51 / 2.8 GB**
Number of XBT casts	**26**
Number of CTD casts (including test casts)	**0**

6. Mapping Sonar Setup

Kongsberg EM 302 Multibeam Sonar

NOAA Ship *Okeanos Explorer* is equipped with a 30 kilohertz (kHz) Kongsberg EM 302 multibeam sonar capable of 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 shallower than 3300 meters the system is operated in dual swath mode, and obtains up to 864 soundings per ping by generating two swaths per ping cycle. The multibeam sonar is used to collect seafloor bathymetry, seafloor backscatter, and water column backscatter data. Backscatter represents the strength of the acoustic signal reflected from a target, such as the seafloor or bubbles in the water column. The system is calibrated with a multibeam sonar patch test annually and the results are reported in the annual readiness report. The 2015 NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report is available in the NOAA Central Library at https://doi.org/10.25923/hhvn-7d52 (last accessed 10/04/2020).

Simrad EK60 Split-beam Sonar

The ship operated one 18 kHz Simrad EK60 split-beam sonar. This sonar is a quantitative scientific echosounder 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. This sonar was calibrated on the EX-15-02 Leg 1 cruise, and calibration values from that cruise were applied to the EK sonars for EX-15-05. The 2015 EK60 Calibration Report is forthcoming and will available in the NOAA Central Library and the NOAA Ocean Exploration Institutional Repository.

Knudsen 3260 Sub-bottom Profiler

The ship is equipped with a Knudsen 3260 sub-bottom profiler that produces a frequency-modulated chirp signal with a central frequency of 3.5 kHz. This sonar is used to provide echogram images of shallow geological layers underneath the seafloor to a maximum depth of approximately 80 meters below the seafloor. The sub-bottom

profiler is normally operated to provide information about sub-seafloor stratigraphy and features. The data generated by this sonar are fundamental to helping geologists interpret the shallow geology of the seafloor.

7. Data Acquisition Summary

Mapping operations included data collection via the EM 302 multibeam sonar, EK 60 split-beam 18 kHz sonar, and the Knudsen 3260 sub-bottom profiler. Data were collected by each sonar concurrently during the transit.

The transit line was 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, waypoints were planned to optimize potential exploration discoveries.

Throughout the cruise multibeam data quality was monitored in real time by acquisition watchstanders. Ship speed was adjusted to maintain data quality as necessary, and line spacing was planned to ensure at least ¼ swath width overlap with preexisting data. Cutoff angles in the multibeam acquisition software Seafloor Information System (SIS) were generally left wide open for maximum exploration data collection and routinely adjusted on both the port and starboard side to ensure the best data quality and coverage.

Multibeam data received real time surface sound velocity corrections via the Reson SVP-70 probe at the sonar head, as well as through profiles generated from Expendable Bathythermographs (XBTs) conducted at intervals no greater than 6 hours, as dictated by local oceanographic conditions. Reson sound velocity values were constantly compared against secondarily derived sound speed values from the ship's onboard thermosalinograph flow-through system as a quality assurance measure.

Simrad EK60 split-beam water column sonar data were collected throughout the majority of the cruise. Data were monitored in real time for quality but were not post-processed. **Figure 2** shows the EK60 data collected during EX-15-05.

Knudsen 3260 sub-bottom profiler data were also collected during the majority of the cruise. **Figure 3** shows where sub-bottom data were collected during EX-15-05.

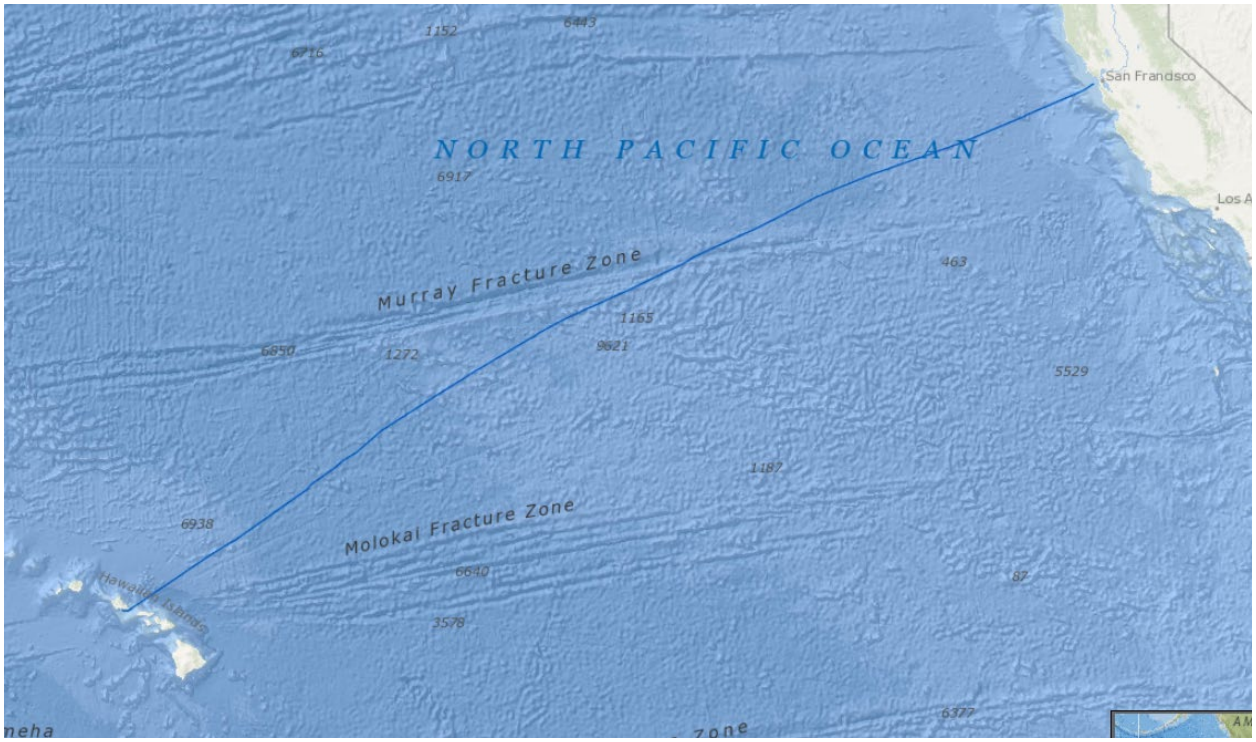

Figure 2. Simrad EK60 split-beam sonar data tracklines (in blue) collected during EX-15-05.

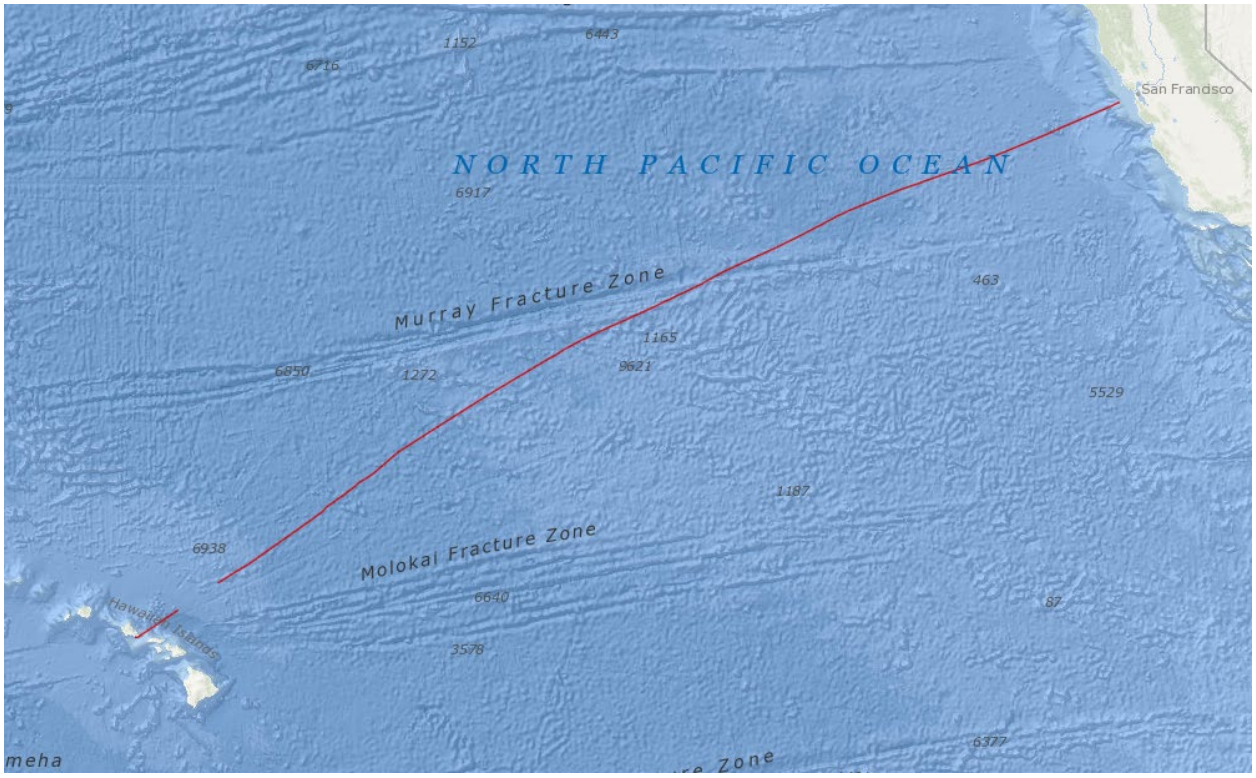

Figure 3.Sub-bottom profiler data tracklines (in red) collected during EX-15-05.

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8. Multibeam Sonar Data Quality Assessment and Data Processing

Figure 4 shows the multibeam data processing workflow for this cruise. EM 302 Built-in Self Tests (BISTs) were run throughout the cruise to monitor multibeam sonar system status and are available as ancillary files in the sonar data archives. Raw multibeam bathymetry data files were acquired in SIS, then imported into CARIS for processing. In CARIS, the attitude and navigation data stored in each file were checked, and erroneous soundings were removed using 2-D and 3-D editors. Gridded digital terrain models were exported utilizing QPS Fledermaus software and posted to the ship's ftp site for daily transfer to shore. Final bathymetry QC was completed post-cruise onshore at the Center for Coastal and Ocean Mapping at the University of New Hampshire. With the vast majority of surveying completed in deep water, depth measurements were not adjusted for tides, as they are an essentially insignificant percent of the overall water depth. Data cleaning projects were in UTM zone projections for the operations area. Final data products were exported and archived as field geographic WGS84 coordinate reference frame (i.e., unprojected).

Heavy seas impacted data quality throughout the cruise. Notes are provided in the daily cruise log section of this report, and sonar settings adjustments are provided in the watch log which is available with the sonar datasets.

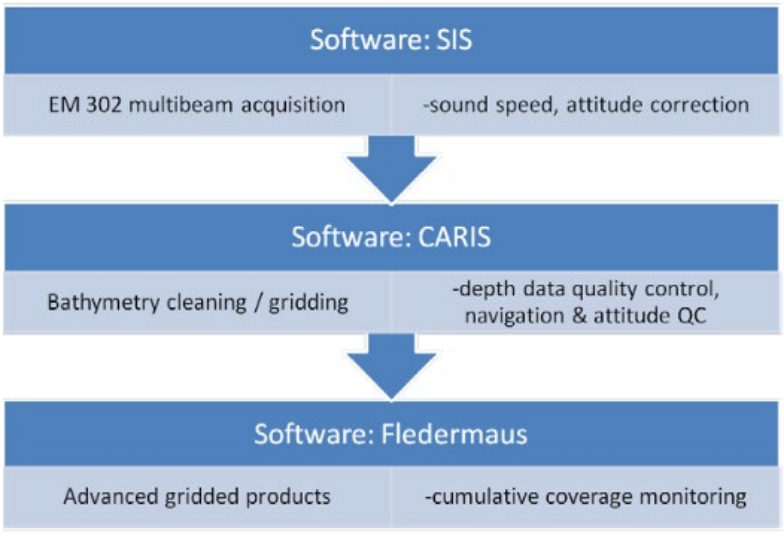

Figure 4. Multibeam data processing flow.

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. There were no crosslines conducted during this straight line transit cruise, however crossline data and analysis conducted on September 24, 2015 during the previous cruise EX-15-04 Leg 4 showed the data met International Hydrographic Organization Order 2 survey requirements for water deeper than 200 m. Those results are available at the NOAA Central Library in the EX-15-04 Leg 4 Mapping Data Acquisition and Processing Summary Report at https://doi.org/10.25923/7wp7-9f42 (last accessed 10/3/2020).

9. Data Archival Procedures

All mapping data collected by the NOAA Ship *Okeanos Explorer* are archived and publicly available within 90 days of the end of each cruise via the National Centers for Environmental Information (NCEI) online archives. The complete data management plan (which describes the raw and processed data formats produced for this cruise) is available as an appendix in the EX-15-05 project instructions, available in the NOAA Central Library at https://doi.org/10.25923/tmhy-fa11. 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)

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

All sonar data are permanently discoverable at https://www.ngdc.noaa.gov/

EM 302 and EK 60 water column data, supporting data, and informational logs are available in the NCEI Water Column Sonar Archives:

https://www.ngdc.noaa.gov/maps/water_column_sonar/index.html (last accessed 10/03/2020), specifically:

- The EM 302 water column backscatter files are available at http://doi.org/10.7289/V56T0JMX (last accessed 10/03/2020).
- The EK 60 water column files are available at http://doi.org/10.7289/V5N29TX4 (last accessed 10/03/2020).

Sub-bottom data, supporting data, and informational logs are discoverable through the NCEI Trackline Geophysical Data portal at https://maps.ngdc.noaa.gov/viewers/geophysics/ (last accessed 10/03/2020).

EM 302 bathymetry data, supporting informational logs, and ancillary files are available in the NCEI Data Archives accessible at https://maps.ngdc.noaa.gov/viewers/bathymetry/(last accessed 10/03/2020).

10. Cruise Calendar

All times listed are local ship time, -7 hours from UTC

October 2015

Sun	Mon	Tues	Wed	Thur	Fri	Sat
			7 Depart pier Ford Island, Honolulu, HI to commence transit to Alameda, CA	8 Continue transit to Alameda, CA.	9 Continue transit to Alameda, CA.	10 Continue transit to Alameda, CA.
11 Continue transit to Alameda, CA.	12 Continue transit to Alameda, CA.	13 Continue transit to Alameda, CA.	14 Continue transit to Alameda, CA. EM 302 secured in heavy weather.	15 Continue transit to Alameda, CA.	16 Sonars secured in 50 m water near San Francisco Bay. Ship alongside Alameda, CA in afternoon.	

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11. Daily Cruise Log Entries

Generated from the daily expedition situation reports. All times listed are in local ship time (-7 hours from UTC)

October 7

The ship departed the pier at Ford Island, Honolulu, HI to commence transit to Alameda, CA. The mapping department energized the sonars at the sea buoy and began data collection. Logging on all sonars was secured for 45 minutes during man overboard drills at 1230.

Overnight, the EM 302 lost bottom tracking due to heavy weather and was secured. Prior to securing the EM 302, settings for filters, maximum swath angles, and power settings were adjusted in an attempt to detect the seafloor through the sea surface noise. These settings were key throughout the cruise when dealing with the heavy seas encountered during transit. All settings changes are logged in the mapping watchstander log archived as an ancillary file with the EM 302 dataset.

October 8

The ship lost ship-shore instant messaging capabilities for several hours through the Pidgin system login failure.

Several BISTs failed prior to resuming data collection with the EM 302, and the EM 302 would not ping. SIS was showing red status lamps on the PPS and POS. Troubleshooting including reseating boards in the TRU and several TRU and SIS restarts. Data collection resumed in the afternoon after several hours of troubleshooting.

October 9

Heavy seas continued, resulting in lower quality multibeam data. EM 302 swath angles were reduced in an attempt to eliminate low quality data in outer beams.

October 10 – 13

Seas laid down and data quality was relatively higher. Swath widths for multibeam are in the 2800 – 4500 m range, with fast ship transit speed, slightly elevated seas, and a less acoustically reflective bottom.

October 14

In heavy weather, the EM 302 lost and was unable to recover bottom tracking, and was secured overnight for approximately 4 hours. Data acquisition with the EK and sub-bottom continued.

October 15
EM 302 data collection resumed in the morning with improved sea conditions.

October 16
Mapping data collection continued until 1230 when 50 m water depth was reached approaching San Francisco Bay, at which point all sonars were secured from survey. A BIST was run and all tests passed. The ship was pierside in Alameda, CA in the late afternoon.

12. References

OER, 2015. The 2015 NOAA Ship *Okeanos Explorer* Survey Readiness Report can be obtained in the NOAA Central Library at https://doi.org/10.25923/hhvn-7d52 (last accessed 10/04/2020).

OER, 2015. The EX-15-05 Project Instructions can be obtained in the NOAA Central Library athttps://doi.org/10.25923/tmhy-fa1 (last accessed 10/09/2020). TheEX-15-05 Data Management Plan is an appendix of the project instructions.

The EX-15-05 EK60 Calibration Report is forthcoming and will be available in the NOAA Central Library and NOAA Ocean Exploration Institutional Repository.

Sandwell, D. T., R. D. Müller, W. H. F. Smith, E. Garcia, R. Francis, New global marine gravity model from CryoSat-2 and Jason-1 reveals buried tectonic structure, Science, Vol. 346, no. 6205, pp. 65-67, doi: 10.1126/science.1258213, 2014.

NOAA Nautical Charts

Various datasets downloaded from the NCEI archives via NOAA AutoChart.