Ocean Exploration and Research

doi: 10.25923/kwf4-dp11

MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

CRUISE EX-10-02: ROV Integration, Shakedown, Field Trials

Author: Sam Candio[1]

March 25, 2020

[1]Cherokee Nation Strategic Programs, at NOAA Ocean Exploration and Research

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.

Contents

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 remotely operated vehicle (ROV) integration, shakedown, and field trials encompassed by Legs 1, 2, and 3 that comprised EX-10-02, 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 2010 NOAA Ship *Okeanos Explorer* Survey Readiness Report, available in the NOAA Central Library.

3. Cruise Objectives

EX-10-02 was comprised of three legs focused on the integration of the Institute for Exploration (IFE) ROV Little Hercules and OER camera platform on the *Okeanos Explorer*, as well as subsequent shakedown and field trials associated with the performance of this tandem system. Mapping data were opportunistically collected between ROV operations throughout the expedition, with data acquisition occurring periodically between March 11 and May 11, 2010. Each of the three legs of this expedition commenced and concluded in Honolulu, HI. This report focuses solely on mapping operations conducted throughout this expedition, and does not provide results on the ROV integration and shakedown.

4. Summary of Mapping Results

EX-10-02 mapped 5,134 square kilometers of seafloor off of Hawaii during the combined 31 days-at-sea (Figure 1 and Table 1).

Cruise Overview Map

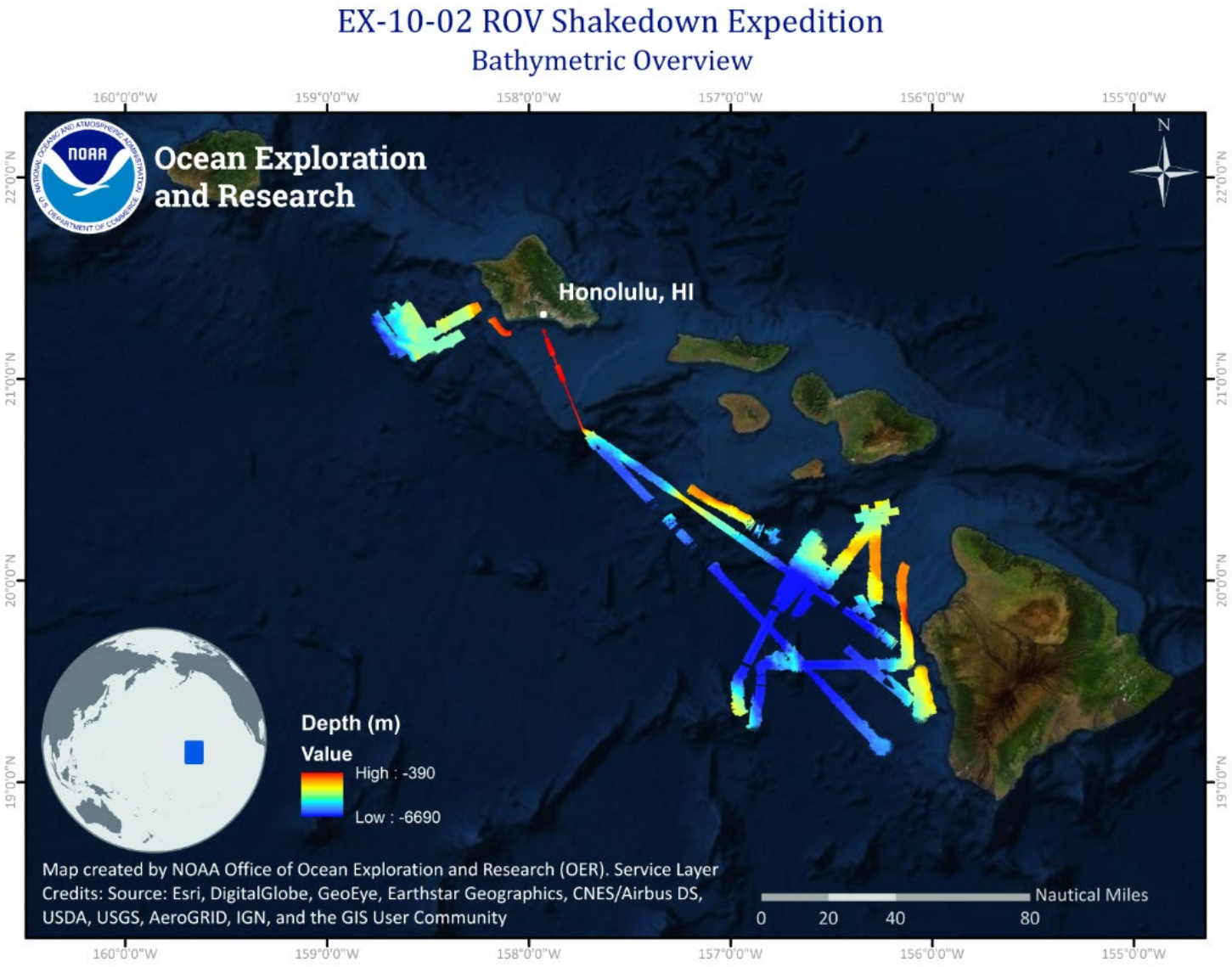

Figure 1. Overview of bathymetric mapping coverage completed during the ROV Shakedown expedition (EX-10-02 Legs 1-3).

5. Mapping Statistics

Table 1. Summary statistics of ocean mapping work completed during EX-10-02.

Dates of data collection	March 11, 17, 19-21, 2010 April 30 – May 3, 2010 May 10–11, 2010
Linear kilometers of survey with EM 302	1,122.7
Square kilometers mapped with EM 302	5,134
Number / data volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)	107 files/ 7.7 GB
Number / data volume of EM 302 water column multibeam files	11 files / 1.78 GB
Number / data volume of EK60 water column split beam files (.raw)	0 / 0 GB
Number / data volume of sub-bottom sonar files (.segy, .kea, .keb)	0 / 0 GB
Number of XBT casts	11
Number of CTD casts (including test casts)	1

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 shoaler 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 patch tested annually and the results are reported in the annual readiness report. The 2010 NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report is available in the NOAA Central Library.

7. Data Acquisition Summary

Mapping operations consisted of data collection via the EM 302 multibeam sonar.

Data collection occurred opportunistically between ROV dive operations. 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.

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 between lines. 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 secondary derived sound speed values from the ship's onboard thermosalinograph flow-through system as a quality assurance measure.

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 in SIS, then imported into CARIS HIPS for processing. In CARIS, the attitude and navigation data stored in each file were checked, and erroneous soundings were removed using Swath Editor and Subset Editor. 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).

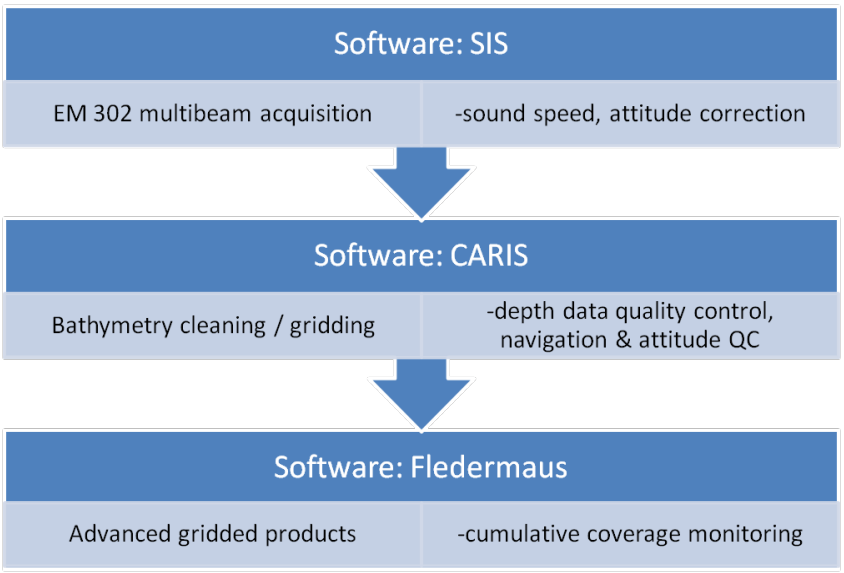

Figure 2. Shipboard multibeam data processing workflow.

Crosslines

Comparing depth values from orthogonal survey lines is a standard hydrographic quality control measure to evaluate the consistency of the multibeam sonar data collected during a cruise. A crossline was run on March 27, as shown in Figure 3. Crossline analysis was completed using the Crosscheck Tool in QPS Qimera software to evaluate the data against standards set by the International Hydrographic Organization. The results are shown below.

Crossline file:

0026_20100327_052538_EX.all

Main scheme line files:

0028_20100502_070113_EX.all

0033_20100502_094943_EX.all

0034_20100502_154653_EX.all

0035_20100502_164245_EX.all

Statistic	Value (depths in meters)
Number of points of comparison	136,015
Grid Cell Size	100.000
Difference Mean	-3.356
Difference Median	-0.436
Difference Std. Dev	11.326
Difference Range	[-192.98, 142.34]
Mean + 2*Stddev	26.009
Median + 2*Stddev	23.089
Data Mean	-4781.671
Reference Mean	-4778.314

Data Z-Range	[-4968.63, -3931.89]
Reference Z-Range	[-4812.90, -3967.67]
Order 1 Error Limit	62.12
Order 1 # Rejected	412
Order 1 P-Statistic	0.03
Order 1 Survey	**ACCEPTED**

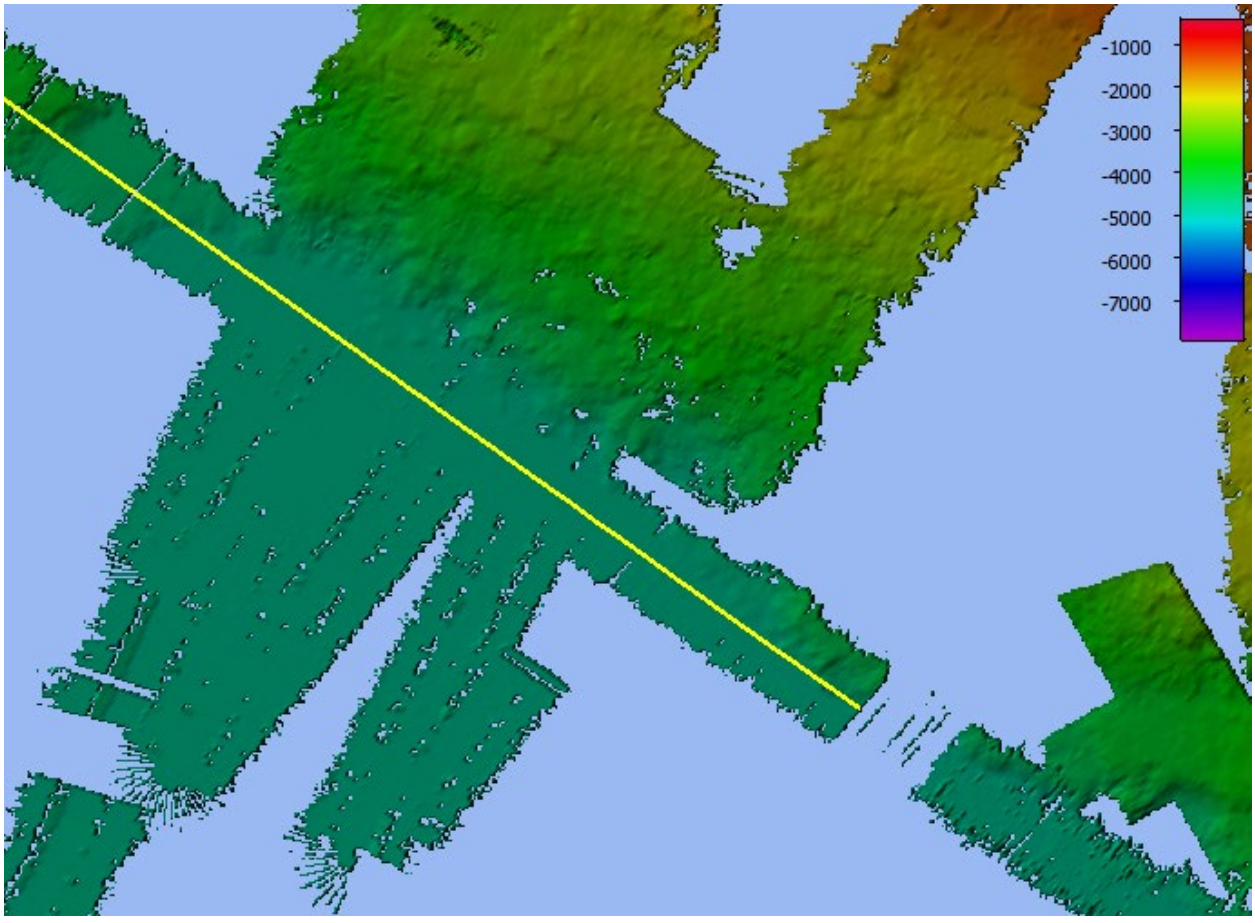

Figure 3. EX-10-02 crossline (shown in yellow) used for comparison against the bathymetric grid generated via orthogonal multibeam survey lines.

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 contained within the Project Instructions for this cruise which will be available in the NOAA Central Library. Ancillary and supporting files are archived with the sonar datasets.

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

At the time of writing this report,

EM 302 water column data, supporting data, and informational logs are available in the NCEI Water Column Sonar Archives at http://doi.org/10.7289/V5VT1Q23 and

https://www.ngdc.noaa.gov/maps/water_column_sonar/index.html (last accessed 03/22/2020).

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 03/22/2020).

11. Daily Cruise Log Entries

Generated from the daily expedition situation reports. Only days on which mapping data were collected are included in this log. All times listed are in local ship time (-10 hours from UTC)

March 11
Limited mapping data were collected during the transit back to Ford Island, Hawaii. Heavy seas throughout the transit led to relatively poor data quality.

March 17
Mapping data were collected during the transit to the first dive site in the lee of the Big Island. EM 302 data were collected while the system was run in auto in order to conduct data acquisition tests. The team is working on integrating the multibeam data into the ship's Scientific Computer System (SCS). Data are now being collected and plotted from the ROV's conductivity temperature depth (CTD).

March 19
Three multibeam lines were run to compare the application of sound velocity profiles from the CTD and XBT. Due predicted deterioration of weather over the next 24 hours, the ship will remain close to Kona for tomorrow's dive.

March 20
A drift test was conducted with the EM 302 to evaluate sonar performance. Lines were run at 4, 6, and 8 knots, with one half hour line run while drifting without the use of bow thrusters.

March 21
Limited testing of the EM 302 was conducted running reciprocal lines over the same area of the seafloor.

April 30
EM 302 testing occurred with Kongsberg representatives aboard to investigate the degraded data quality that is exacerbated by poor weather conditions.

May 1
Multibeam testing continued, focusing on known problem depths of 2400 meters (m) to 3200 m. The installation of new transmit boards appears to have resolved many of the data quality issues previously experienced. Issues are still present in depths exceeding 4800 m, which the Kongsberg representative is continuing to troubleshoot.

May 2
Deep water testing continued throughout the day. It has been determined that slower ship speeds during acquisition increases the swath coverage incrementally. Excessive side lobe noise has been observed while collecting data in flat, deep areas for an extended period of time.

A patch test was run in the evening with the newly installed transmit boards to verify the angular offsets of the sonar installation. The pitch offset was adjusted from -0.07 to -0.08 degrees.

May 3
Data were collected during the transit back to Honolulu in deep water to monitor multibeam performance. Data quality was good throughout the transit.

May 10
Test data were collected overnight to determine the optimal SIS settings for deep water. Testing methods targeted the effect of vessel speed on swath coverage.

May 11
Data testing continued in the early morning prior to the ship's return to Honolulu, HI. The mapping team is determining further testing necessary during the upcoming transit to Guam.

12. References

The 2010 NOAA Ship *Okeanos Explorer* Survey Readiness Report can be obtained in the NOAA Central Library https://doi.org/10.25923/4qq0-bc52 .at

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

Tozer, B. , D. T. Sandwell, W. H. F. Smith, C. Olson, J. R. Beale, and P. Wessel, Global bathymetry and topography at 15 arc seconds: SRTM15+, Accepted Earth and Space Science, August 3, 2019. https://doi.org/10.1029/2019EA000658

NOAA Nautical Charts

Various datasets downloaded from the NCEI archives via NOAA AutoChart.