Ocean Exploration and Research

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MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

CRUISE EX-16-09: Main Hawaiian Island Shakedown (Mapping)

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1. Introduction

The NOAA Office of Ocean Exploration and Research (OER) 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 mapping shakedown expedition EX-16-09, and to present a summary of the overall mapping results and mapping related cruise activities. A detailed description of the NOAA Ship *Okeanos Explorer's* mapping capabilities is available in the 2016 NOAA Ship *Okeanos Explorer* Survey Readiness Report, available in the NOAA Central Library.

3. Cruise Objectives

EX-16-09 was a telepresence-enabled cruise focused on the testing and calibration of mission sonars, equipment, data management infrastructure, and telepresence capabilities to ensure full preparation of ship and mission systems to support fiscal year 2017 field season operations. The 2017 field season was the third year of the Campaign to Address Pacific monument Science, Technology, and Ocean NEeds (CAPSTONE) effort to collect scientific data in deep water areas of U.S. marine protected areas in the central and western Pacific.

EX-16-09 commenced on December 10, 2016 in Honolulu, HI and concluded on December 16, 2016 in Honolulu, HI. This cruise consisted of 24-hour per day mapping operations, during which the highest priority tasks included:

1. Calibration of five EK60 transducers (18, 38, 70, 120, 200 kHz)
2. Testing and possible calibration of the ship's two ADCPs (38, 300 kHz)
3. Testing of the Underway CTD (UCTD) and expendable bathythermograph (XBT) autolauncher and refining Standard Operating Procedures (SOPs).
4. Confirmation of equipment and data management readiness to conduct three telepresence mapping cruises in FY17.
5. Collecting high quality data within the United States Exclusive Economic Zone (EEZ) in water depths exceeding 200 meters (m).

The complete objectives for this cruise are detailed in the EX-16-09 Project Instructions, which are archived in the NOAA Central Library.

4. Summary of Mapping Results

EX-16-09 mapped 3,695 square kilometers (km^2) of seafloor in the vicinity of the Hawaiian Islands during the 7 days at sea (Figure 1 and Table 1). The vast majority of mapping operations occurred within the U.S. EEZ in depths deeper than 200 m.

Cruise Overview Map

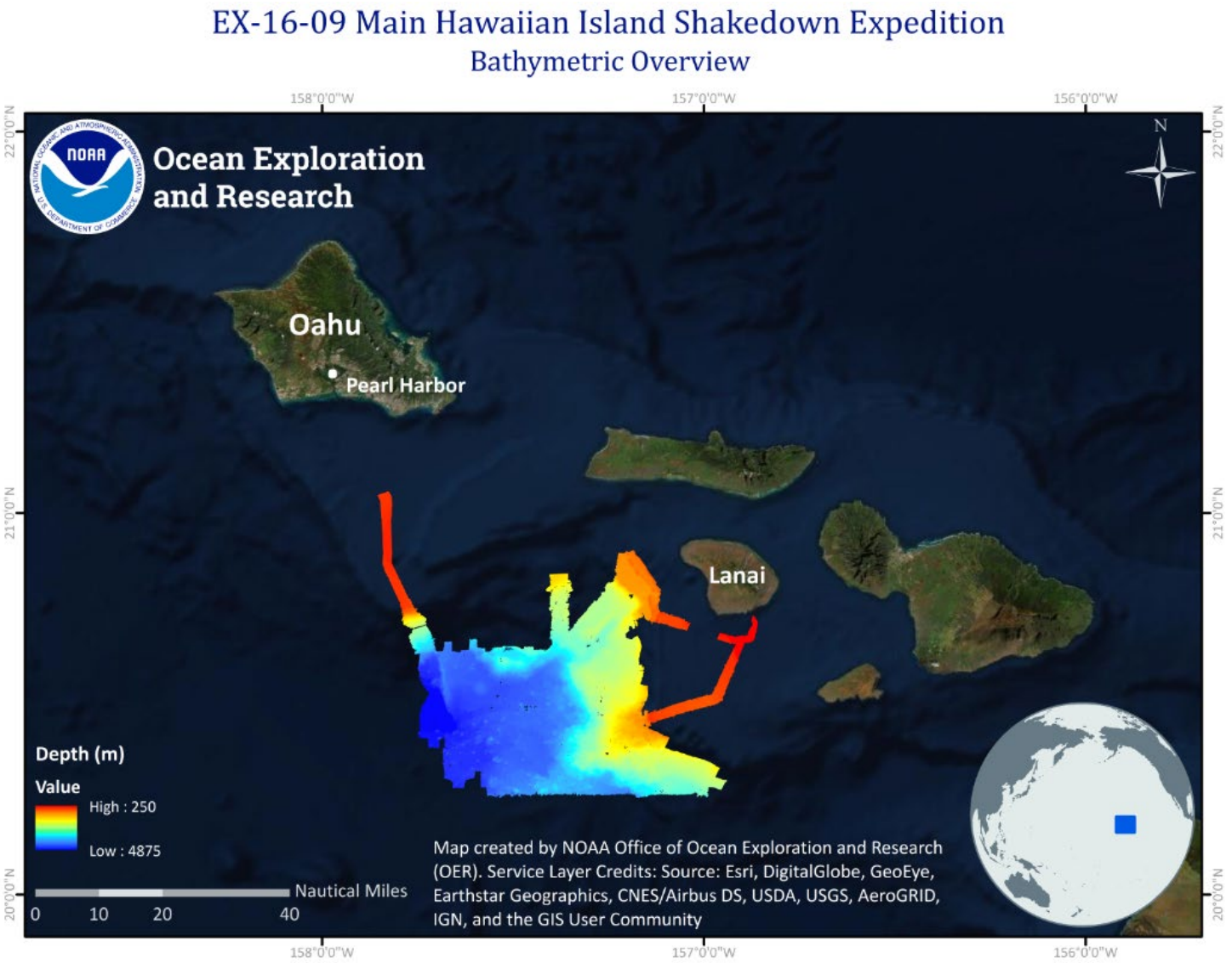

Figure 1. Overview of multibeam bathymetric mapping coverage completed during EX-16-09 in the vicinity of the Hawaiian Islands.

5. Mapping Statistics

Table 1. Summary statistics of ocean mapping work completed during EX-16-09.

Dates of cruise	**December 10-16, 2016**
Linear kilometers of survey with EM 302	**1200**
Square kilometers mapped with EM 302	**3,695**
Square kilometers mapped with EM 302 within U.S. EEZ deeper than 200 meters	**3,693**
Number / data volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)	**135 files / 6.3 GB (some files restricted from public release)**
Number / data volume of EM 302 water column multibeam files	**135 files / 22.5 GB (some files restricted from public release)**
Number / data volume of EK60 water column split-beam files (.raw)	**45 / 4.1 GB**
Number / data volume of sub-bottom sonar files (.segy, .kea, .keb)	**156 / 1.2 GB**
Number of XBT casts	**20**
Number of CTD casts (including test casts)	**1**
Number of UCTD casts	**6**

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 2016 NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report is available in the NOAA Central Library at https://doi.org/10.25923/9vs2-pw48.

Simrad EK60 Split-beam Sonars

The ship had five operational Simrad EK60 split-beam fisheries sonars onboard during the cruise: 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. These sonars were calibrated during this cruise, and calibration values were applied to the EK60 sonars for data collected during EX-16-09 and for the FY2017 field season.

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.

Teledyne ADCPs

The ship utilizes a 38 kHz Teledyne RDI Ocean Surveyor Acoustic Doppler Current Profiler (ADCP), with an approximately 1000 meter range; and a 300 kHz Teledyne RDI Workhorse Mariner ADCP, with an approximately 70 meter range. The ADCPs are typically not run concurrently with the other sonars during mapping operations due to interference issues.

7. Data Acquisition Summary

Mapping operations included data collection via the EM 302 multibeam sonar, EK60 (18, 38, 70, 120, and 200 kHz) split-beam sonars, and the Knudsen 3260 sub-bottom profiler. Data were collected by each sonar concurrently, with the exception of the times calibrations were occurring. Additionally, the ADCPs were briefly run to collect data in bottom tracking mode while in shallow water leaving Pearl Harbor and Lanai in an effort to gather transducer alignment datasets, but otherwise were secured. See the daily cruise log entries in Section 11 below for more detailed information.

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 adjusted to minimize poor data on the outer beams of the swath.

Due to a malfunction in the Reson SVP-70 probe at the sonar hear, multibeam data were unable to receive real time surface sound velocity corrections from this probe per normal operations. Surface sound velocity data were instead derived from CTD data obtained via the ships flow through thermosalinograph (TSG). A component of the onboard scientific seawater system, the TSG collects temperature and conductivity readings, and derives salinity and sound velocity in realtime. The value is computed by the system and provided directly to the multibeam Hydrographic Workstation. The TSG is normally used as a quality control comparison check on the sound speed directly measured by the Reson SVP-70 probe, but also provides usable data in the case that the Reson probe is malfunctioning. No sound velocity artifacts in the data were observed, suggesting that this method of correcting for sound speed at the sonar transducer face of the multibeam was sufficient for this cruise.

Simrad EK60 split-beam water column sonar data were collected during mapping operations (Figure 2). Data were monitored in real time for quality but were not post-processed. Knudsen 3260 sub-bottom profiler data were also collected throughout the majority of the cruise (Figure 3).

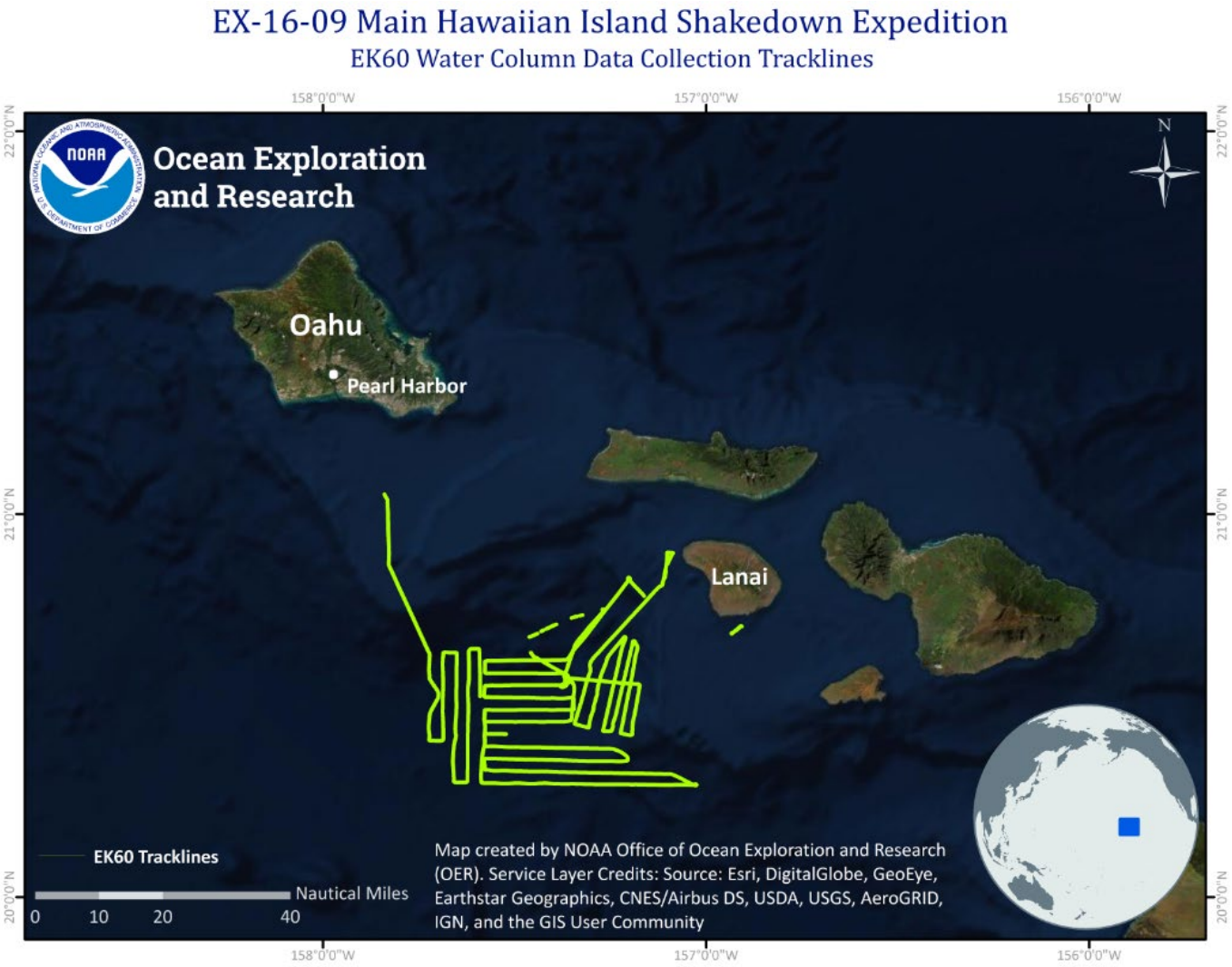

Figure 2. Simrad EK60 split-beam sonar data tracklines (in green) collected during EX-16-09. Calibration data excluded from figure.

Figure 3. Knudsen 3260 sub-bottom profiler data tracklines (in red) collected during EX-16-09.

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 Seafloor Information System (SIS), then imported into QPS Qimera software for processing. In Qimera, 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 File Transfer Protocol (FTP) site for daily transfer to shore. Final bathymetry quality control (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. The coordinate system for the data cleaning projects was set to the appropriate Universal Transverse Mercator (UTM) zone for the operational area. Final data products were exported and archived as field geographic WGS84 coordinate reference frame (i.e., unprojected).

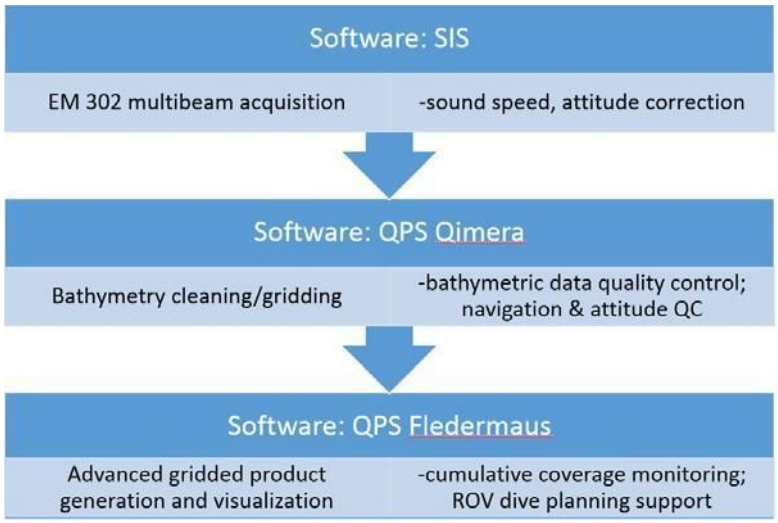

Figure 4. Shipboard multibeam data processing workflow.

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 December 12, 2016 as shown in Figure 5. 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:

0038_20161212_142457_EX1609.all

Mainscheme line files:

0020_20161212_043919_EX1609_MB.all

0023_20161212_055407_EX1609_MB.all

0026_20161212_074624_EX1609_MB.all

0029_20161212_100813_EX1609_MB.all

0033_20161212_115912_EX1609_MB.all

Statistic	Value (depths in meters)
Number of points of comparison	3131213
Grid Cell Size	100
Difference Mean	-0.298
Difference Median	-0.131
Difference Std. Dev	7.132
Difference Range	[-50.31, 50.11]
Mean + 2*Stddev	14.562
Median + 2*Stddev	14.396
Data Mean	-2413.982

Reference Mean	-2413.684
Data Z-Range	[-3398.43, -1971.88]
Reference Z-Range	[-3394.96, -1982.24]
Order 1 Error Limit	31.382
Order 1 # Rejected	685
Order 1 P-Statistic	0.002187
Order 1 Survey	ACCEPTED

These results confirm that the data collected meet International Hydrographic Organization (IHO) Order 1 specifications for data quality.

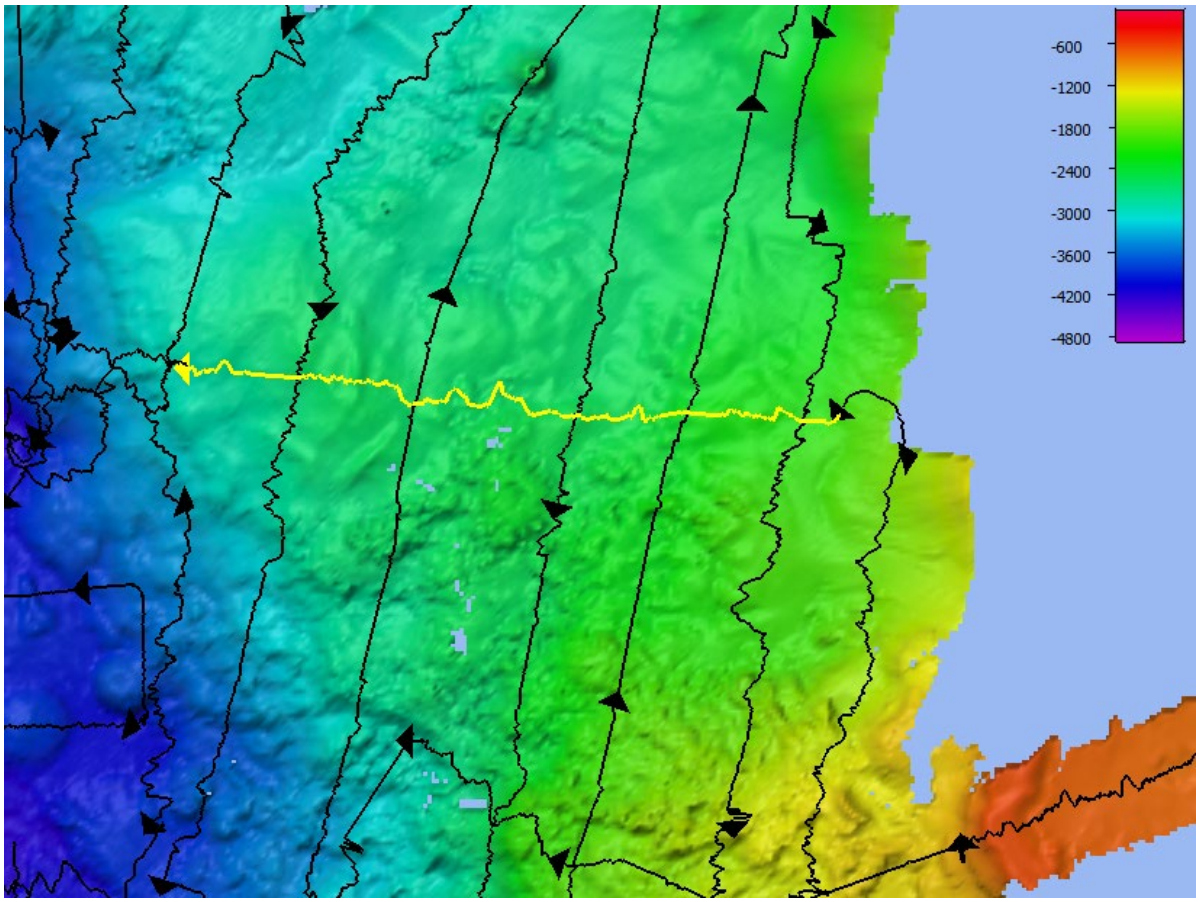

Figure 5. EX-16-09 crossline (shown in yellow) used for comparison against the bathymetric grid generated via orthogonal multibeam survey lines.

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 available as an appendix in the EX-16-09 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 watchstander log
- Weather log
- Sound velocity profile log
- Multibeam acquisition and processing log

Simrad EK split-beam water column dataset:

- Mapping watchstander log
- Weather log

Knudsen 3260 Sub-bottom Profiler dataset:

- Mapping watchstander log
- Weather log

EM 302 Multibeam water column dataset:

- Mapping watchstander log
- Weather log
- Sound velocity profile log
- Multibeam acquisition and processing log

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

EM 302 and EK60 water column data, supporting data, and informational logs are available in the NCEI Water Column Sonar Archives:

- EM 302 water column data can be found here: doi: 10.7289/V5D798NG
- EK60 water column data can be found here: doi: 10.7289/V5J101D6

Sub-bottom data, supporting data, and informational logs are available in the NCEI Trackline Geophysical Data portal at https://maps.ngdc.noaa.gov/viewers/geophysics/ (last accessed 4/8/2020). For assistance in accessing sub-bottom profiler data, send an inquiry to ncei.info@noaa.gov requesting access to EX-16-09 Knudsen 3260 sub-bottom profiler raw and processed data.

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 4/8/2020).

10. Cruise Calendar

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

December 2016

Sun	Mon	Tues	Wed	Thur	Fri	Sat
						10 Start of cruise. Ship underway from Honolulu, HI. Mapping systems were energized and tested.
11 Small boat transfer in Lanai. EK60 calibrations commenced. ADCP testing. Overnight mapping operations.	12 EK60 calibrations continued during daylight hours. Overnight mapping operations.	13 EK60 operations continued during daylight hours. Overnight mapping operations.	14 Small boat transfer in Lanai. UCTD testing occurred during mapping operations.	15 UCTD and XBT Autolauncher testing occurred during mapping operations. CTD cast conducted.	16 Ship pulled in to port in Honolulu, HI. End of cruise.	

11. Daily Cruise Log Entries

Generated from the daily expedition situation reports. All times listed are local ship time, which was -10 hours from UTC

December 10, 2016

The ship departed the pier at 0900 and practiced touch-and-go maneuvers on the pier for officer training. A last-minute addition to the cruise was to bring a dynamic positioning (DP) technician from Kongsberg out for 24 hours to work on the DP system. This work became a top priority objective of the first day. The ship departed Pearl Harbor at 1300 and began transiting to the planned EK60 calibration area off the west coast of Lanai. Mapping testing work included ADCP testing, initial testing of the EM 302 multibeam system, and running the EK60s.

The ADCPs were run in bottom tracking mode leaving Pearl Harbor to gather alignment datasets. The same issue occurred that was encountered during the EX-16-08 cruise with the UHDAS computer ("ADCP Logging" on the KVM) stopping any video output signal when the KVM transmitter is power cycled. To fix this, the Secure Shell (SSH) protocol is used in the Putty program on a Windows machine to send the UHDAS machine a command to send a video output signal. A short SOP is being written for this issue (which is a bug). Otherwise, ADCP systems are working normally.

No sonars were operated while transiting through Penguin Banks in the Hawaiian Humpback Whale National Marine Sanctuary, and speed was held to 8.5 knots. Whales were spotted several times during the transit, but not in close proximity to the ship.

After leaving the sanctuary, the EM 302 was tested. The remote start switch was reversed from its usual orientation – the transmit-receive unit (TRU) was on when the button was out, and TRU off when button was in. This issue was resolved, but the first few BIST tests had TX32 board errors. After re-booting the TRU all BISTs passed. While the sonar was pinging, telnet errors on one TX32 board kept coming up even though all BISTs had passed and the system was operating. The survey technician (ST) re-seated the problematic board and re-booted the TRU to eliminate the error.

December 11, 2016

The day commenced with a small boat transfer to a port in Lanai to drop the Kongsberg DP representative off so he could fly to Honolulu. The ship then transited 1.5 hours to the EK60 calibration area west of Lanai. Wind, sea state, and currents were all favorable for calibration.

The EK60 equipment was deployed, and the Simrad technician ran the software calibration module while other mission personnel operated the downriggers via radio. The set up for the EK60 calibration went quickly at first, but then one of the lines seemed to get stuck near the front of the hull. It was eventually freed, and the calibration work proceeded quickly forward after that. All of the EK transducers (except for the old 18 kHz) are clustered together, making calibration of different transducers fairly easy since the calibration sphere under the ship can be found quickly. The 18 kHz location requires completely different downrigger positions, and it can be tricky to locate the sphere. Calibrations are being completed for the longest pulse lengths of each transducer since this is the setting we collect data with. All higher frequency calibrations were completed today except for the 120 kHz, which had to be stopped late in the afternoon due to an incoming squall and the ship drifting towards Lanai.

The ADCPs were briefly run in bottom tracking mode while leaving shallow water near the port and out to the EK60 calibration site.

Overnight mapping gathered multibeam and sub-bottom data and focused on implementing the new Qimera software to process multibeam data.

December 12, 2016

All daylight hours today were spent on EK60 calibration work. Currents today were stronger, at 1-1.5 knots, which made finding the calibration sphere in the sonar beam under the ship more difficult. The sphere also attracted fish, which interfere with good target strength measurements. We finished calibration work on the 70 and 38 kHz transducers today. The only transducer remaining for tomorrow morning is the 18 kHz. We expect to finish this in the morning and spend the afternoon on UCTD operations. Overnight mapping operations focused on surveying a deep area west of Lanai to shakedown the multibeam, EK60s, and sub-bottom profiler.

EK60 calibrations today were fairly challenging and time-consuming, but ultimately successful with good results. The 38 kHz transducer had not had a sea acceptance test fully

completed since the GPT (transceiver) unit had been sent back to Kongsberg for repair after it was found to be faulty during EX-16-01 tests. The system was behaving strangely today, and the Simrad technician took apart part of the GPT and transducer cable to check connections and switch wires. This work improved the results and allowed for a successful calibration.

The Simrad technician set up the EK80 software to enable better synchronization of the 38 kHz EK60 transducer so that is does not interfere with the multibeam (which are normally not run concurrently). Now all five EK60 frequencies, the EM 302, and the sub-bottom profiler can all be run without major interference observed.

Overnight mapping gathered multibeam, EK60, and sub-bottom data, and focused on utilizing the new Qimera software to process multibeam data. Fledermaus software has been updated to the latest version, and Qimera fully installed on MBPROC machines. All multibeam data are being processed in Qimera, and the SOP and workflow procedures are being updated. A daily product was posted on the FTP site today – fully processed using Qimera.

The ST has been focusing attention on the XBT autolauncher. The loading cap tension hardware has been adjusted, electrical connections are further waterproofed, and the Engineering Department has assisted in building an improved mount to extend the launcher further off the railing. The Chief Electronics Technician (CET) wants to test the launcher in its current location and focus on making sure the electronics and software work before focusing on moving it to a new potential location between the wirecam and the A-frame. Further testing and evaluation will occur it at its current location on the far starboard side of the stern.

The Reson sound velocity probe (on the hull near the multibeam transmit transducer) is still not working. Commercial divers cleaned and replaced the probe during the one day in-port period between EX-16-08 and EX-16-09. The CET still cannot get data or signals from it. He is trying to find a cable to test the removed probe in a bucket of water and troubleshoot the electronic communications. No progress to date. The Thermosalinograph (TSG) flow through system is being used as the primary means to provide the sound speed at the multibeam transducer face to the SIS multibeam acquisition computer.

The multibeam is running well, but swath widths today were not as wide as is typical for the system (even compared to last week). This may be an issue with background noise or the specific terrain/sediments we are working in today, but it is something to monitor. Swath widths achieved are 1-2 km less than expected in water depths of 3500 and deeper (i.e. widths of 5000-6000 m when 7000 m is expected).

December 13

The daylight hours today were spent again on EK60 calibration work. The initial area in which the 18 kHz transducer calibration was attempted had winds and currents working in opposition to each other, and it was hard to control the sphere to consistently locate it within the beam. The gear was removed from the water and the ship steamed an hour to the south side of Lanai within several miles of shore, to get in the lee of the island from the strong north wind. This area worked well, and the calibration was successfully completed with excellent results (i.e. low root mean square values).

Since the ship was located very close to the harbor where the visiting Kongsberg Engineer was to be dropped off, a late afternoon small boat transfer was prepared to get him to shore early and save transit time tomorrow. The winds shifted direction within the following 30 minutes, however, and a steady 20 knot wind with gusts to 36 knots made the operation too high risk and forced the postponement of the transfer.

The XBT autolauncher was put onto an improved mounting bracket today that significantly extends it aft with greatly improved clearance over the stern railing. It is mounted in the original position at the starboard corner of the stern and we are currently not planning to try to relocate it closer to the A-frame.

The multibeam ran well for evening operations with normal swath widths, allowing for the survey of a sizeable area off the west coast of Lanai. The SVP probe is still not currently functional.

The sub-bottom profiler is operating normally.

December 14

A small boat transfer was completed right after breakfast to drop the Simrad Engineer to port on Lanai. The ship then steamed south, gathering ADCP data to validate the new sonar transducer alignment angles calculated by the University of Hawaii (UH) based on data collected during the past two weeks. The ship then headed west into deeper waters to shakedown the UnderwayCTD

(UCTD). Some initial issues with the line tangling were experienced, followed by shorter successful casts with both the dummy probe and the sound velocity probe. Longer casts will be tested tomorrow. Seas were 3-4' today.

All of the new EK60 calibration results have been applied to the EK80 software used to run all five of the EK60 sonars simultaneously. The synchronization settings in this interface are keeping the 38 kHz EK60 and the 30 kHz EM 302 from interfering with each other.

The XBT autolauncher was not tested further today since focus shifted to the UCTD. The CET set up an external Bluetooth antenna that can be magnetically mounted right outside the wetlab exterior door to communicate with the UCTD sound velocity probe. The probe's Bluetooth signal was able to reach this antenna, with sound velocity casts able to be immediately downloaded as soon as the probe was back on deck.

The UCTD was carefully set up and line tension on the winch calibrated to the manufacturer's specifications. The first UCTD cast today used the tailspool rewinder attached to the dummy probe. The majority of the cast sequence went as expected, however, the end of the line did have two areas that were in tangled masses. Untangling these loops was time consuming and is the same type of problem experienced last year. After straightening and re-spooling the line, short conservative casts without any line on the tailspool were attempted – all of which went normally. The problem is most likely a combination of the line spiraling on the dummy probe (since it lacks stabilizer fins) and the interaction of this twisted line with the line coming off the tailspool during a deep cast. Testing then switched to using the real sound velocity probe since it does not seem to twist the line like the dummy probe, while still using short lengths of line on the tailspool until as the team works up to the ability to take deeper casts. The vessel speed was also halved to put less strain on the line during testing work. Further testing will continue tomorrow.

The multibeam daily product Standard Operating Procedure (SOP) was updated to reflect changes associated with using Qimera software instead of Caris. For now, the final daily product suite will remain in the WGS84 field geographic (unprojected) format to make it easy for external users. The projected interim sd objects and geotiffs that Qimera directly exports will be saved and used onboard in HYPACK and ArcMap.

After causing significant concern last night, network connectivity losses did not appear to be a problem today. The CET has a theory about old network switches potentially being part of this problem.

December 15

Overnight mapping operations continued building upon the large continuous survey of a deep ocean area west/southwest of Lanai. Network connectivity was normal last night. Daylight hours were mostly dedicated to further testing of the UCTD and XBT autolauncher while continuing the multibeam survey.

The UCTD system's sound velocity probe (SV probe) is working as expected, collecting good casts and automatically downloading the data via Bluetooth to the CTD computer. The CTD probe (a completely separate probe than the SV probe) was unable to communicate with the computer since it was not sending a Bluetooth signal. This was initially thought to be due to a poor battery charge, but the issue persisted after fully recharging the battery. This probe has not been used in the water before. Technical assistance has been requested from Teledyne.

Through conducting numerous tests of how line tension from the winch changed while winding line onto the system's tailspool, it was noted that immediately after calibrating the winch's line tension and loading just 50m of spool, the winch tension would drop down a pound of resistance. This means that as the line is wound onto the tailspool, it is not getting put on at a consistent tension. According to Teledyne, the proper tension is very important in making sure the line comes off correctly during probe decent. Therefore, the winch system is not performing as it is supposed to, and the tailspool should not be used until this issue can be resolved. All components of the UCTD gear were cleaned and stowed until further work can be continued on EX-17-01.

The XBT autolauncher is now operational, but a few refinements are needed. The software is capable of enabling on demand remote casts, keeping all personnel inside for the cast. Wind must be in a favorable orientation (just like for a handheld launch) to avoid having the XBT wire getting blown into contact with the ship which will terminate the cast due to electrical shorting. The current navigational feed is not being recognized by the software, so some additional troubleshooting is needed to fix that – but the hardware and software have been confirmed to work as intended.

A CTD cast was completed to 1500 m at 1300 today. This was directly compared with an expendable bathythermograph (XBT) cast from the XBT autolauncher. The CTD cast and XBT

were nearly identical in the upper regions of the thermocline, with a minor 2 m/s offset in deeper portions. The CTD cast was valuable practice for the crew and ST in its own right.

The Qimera workflow and SOPs are updated and are ready to support the multibeam processing needs for FY17.

The end of cruise meeting with CO, OPS, PS Sowers, and PS White was held today. The core important cruise objectives were accomplished. All of the sonar systems are working well and ready to perform. Some of the lower priority cruise objectives were not able to be finished (due to technical challenges, personnel, and timing constraints), but can be integrated with objectives for ongoing mapping cruises in 2017.

Mapping operations continued through the night during the transit back to Honolulu. The ship is scheduled to get into port at approximately 0830 tomorrow.

December 16

Overnight mapping operations continued through the transit back to Honolulu. The ship moored to Pier F-10 on Ford Island at 0900. Demobilization occurred.

12. References

The 2016 NOAA Ship *Okeanos Explorer* Survey Readiness Report can be obtained in the NOAA Central Library at https://doi.org/10.25923/9vs2-pw48.

The EX-16-09 Project Instructions can be obtained from the NOAA Central Library at https://repository.library.noaa.gov/view/noaa/13526. The EX-16-09 Data Management Plan is an appendix of the project instructions.

NOAA Nautical Charts

Various datasets downloaded from the NCEI archives via NOAA AutoChart.