Ocean Exploration and Research

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MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT:

EX-17-08, Musicians Seamounts (ROV & Mapping)

September 06, 2017 to September 30, 2017

Honolulu, Hawaii to Honolulu, Hawaii

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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, and 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 mapping expedition EX-17-08 Musicians Seamounts and to present a summary of the overall mapping results and mapping related cruise activities. A separate report titled, 'Cruise Report: EX-17-08, Musicians Seamounts (ROV & Mapping)' detailing ROV and other science objectives is available from the NOAA Central Library. A detailed description of the NOAA Ship *Okeanos Explorer's* mapping capabilities, '2017 NOAA Ship *Okeanos Explorer* Survey Readiness Report' is available in the NOAA Central Library.

3. Cruise Objectives

The Musicians Seamounts expedition addressed science themes and priority areas put forward by scientists and managers from NOAA, management agencies in the region, and the ocean science community. NOAA OER priorities for the expedition included a combination of science, education, outreach, and open data objectives that will support management decisions at multiple levels

This expedition was part of the three-year Campaign to Address the Pacific monument Science, Technology, and Ocean NEeds (CAPSTONE) (last accessed April 2020), an initiative to collect deepwater baseline information to support science and management decisions in and around U.S. marine protected areas (MPAs) in the central and western Pacific.

An online summary of all mission objectives be found here: https://oceanexplorer.noaa.gov/okeanos/explorations/ex1708/logs/summary/welcome.html (last accessed April 2020)

The complete objectives for this cruise are detailed in the EX-17-08 Project Instructions, which are archived in the NOAA Central Library here: https://repository.library.noaa.gov/view/noaa/17238 (last accessed April 2020)

4. Summary of Mapping Results

The expedition commenced from Honolulu, Hawaii on September 6, 2017 and concluded in Honolulu, Hawaii on September 30, 2017. EX-17-08 mapped 30,603 square kilometers (km) of seafloor during the 25 days-at-sea (Figure 1 and Table 1).

Cruise Overview Map

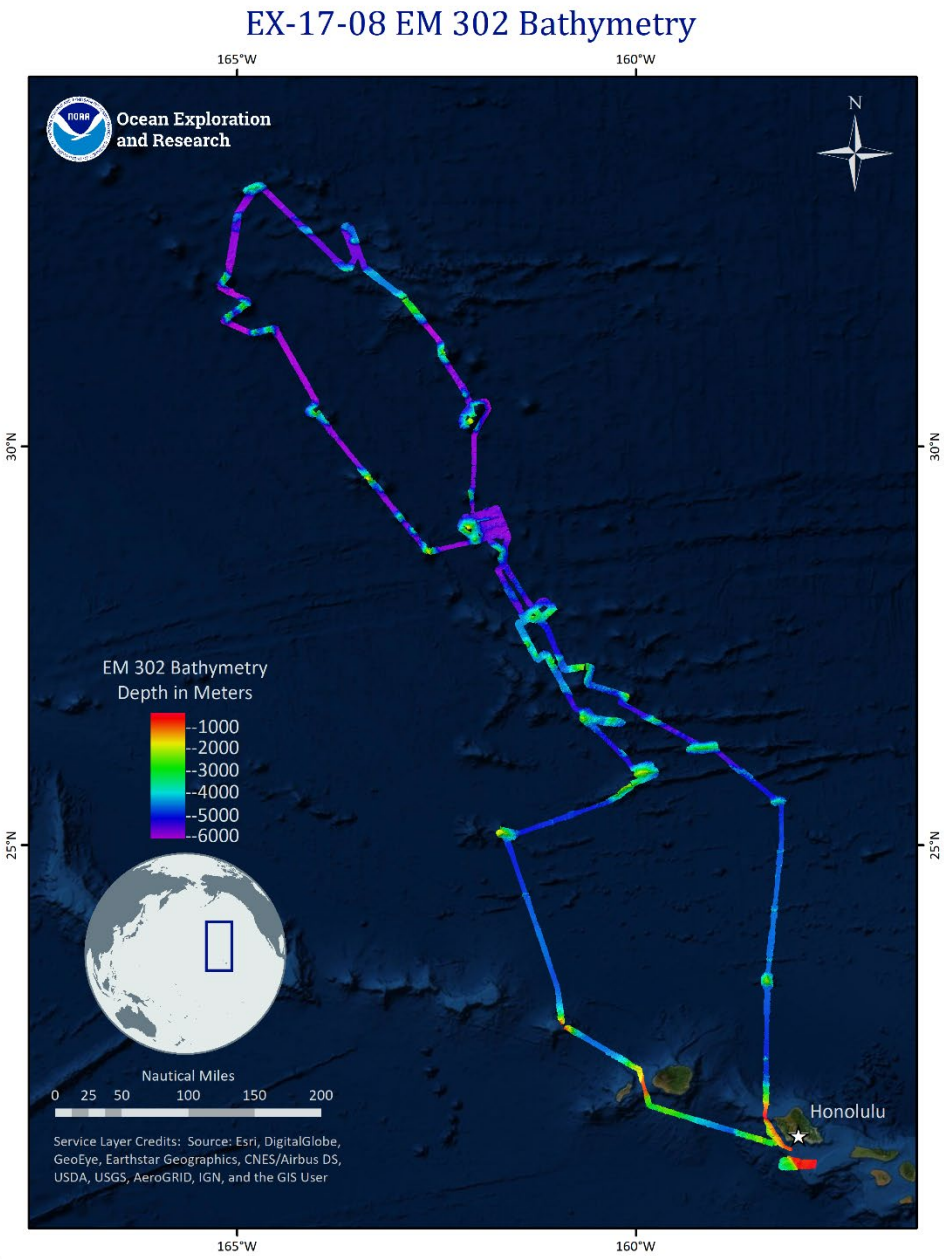

Figure 1. Overview of bathymetric mapping coverage completed during the Musicians Seamounts expedition (EX-17-08).

5. Mapping Statistics

Table 1. Summary statistics of ocean mapping work completed during EX-17-08.

Dates of data collection	September 6 to September 30, 2017
Linear km of survey with EM 302	5,069
Square km mapped with EM 302	30,603
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)	482 files/ 22.1 GB
Number / Data Volume of EM 302 water column multibeam files	482 files / 79.9 GB
Number / Data Volume of EK60 water column split-beam files (.raw)	208 Files/ 13 GB
Number / Data Volume of sub-bottom sonar files (.segy, .kea, .keb)	488 Files / 4.78 GB
Number of XBT casts	36
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 conducting mapping operations in up to 8,000m of water depth. The system generates a 150° beam fan containing up to 432 soundings per ping in waters deeper than 3300m. In waters shallower than 3300m 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. System calibration to determine

the angular offsets (Patch Test) is conducted annually and the results are reported in the annual readiness report. The 2017 NOAA Ship *Okeanos Explorer* Survey Readiness Report available in the NOAA Central Library.

Simrad EK6 Split-beam Sonars

The ship operated four Simrad EK60 split-beam fisheries sonars: 18 kHz, 38 kHz, 70 kHz, 120 kHz, 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 on the EX-16-09 cruise, and calibration values from that cruise were applied to the EK sonars for EX-17-08. The 2016 EK60 Calibration Report is planned for archival in the NOAA Central Library.

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 geology of the seafloor.

Teledyne ADCPs

The ship utilizes a 38 kHz Teledyne RDI Ocean Surveyor Acoustic Doppler Current Profiler (ADCP), with a ~1000m range; and a 300 kHz Teledyne RDI Workhorse Mariner ADCP, with a ~70m range. The ADCPs gather data prior to ROV deployments in order to assess currents at the dive site in support of safe operations. They are kept running throughout the ROV dives. 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 using the EM 302 multibeam sonar, EK60 split-beam (18, 38, 70, 120, and 200 kHz) sonars, and Knudsen 3260 sub-bottom profiler. Data were collected by each sonar concurrently during the transits.

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. EX-17-08 when possible included focused overnight mapping of the ROV dive location.

Figures 2 and 3 are examples of focused overnight mapping in preparation of the following ROV dives. Much of the data collected on EX-17-08 was the first focused mapping data collected over these remote seafloor features. Figure 4 is an example of strategic mapping data collected over seafloor features of interest during transits between ROV dive sites. Figure 5 is an example of edge matching between EX-17-07 and EX-17-08. EX-17-07 was the previous dedicated mapping cruise to the Musicians Seamounts.

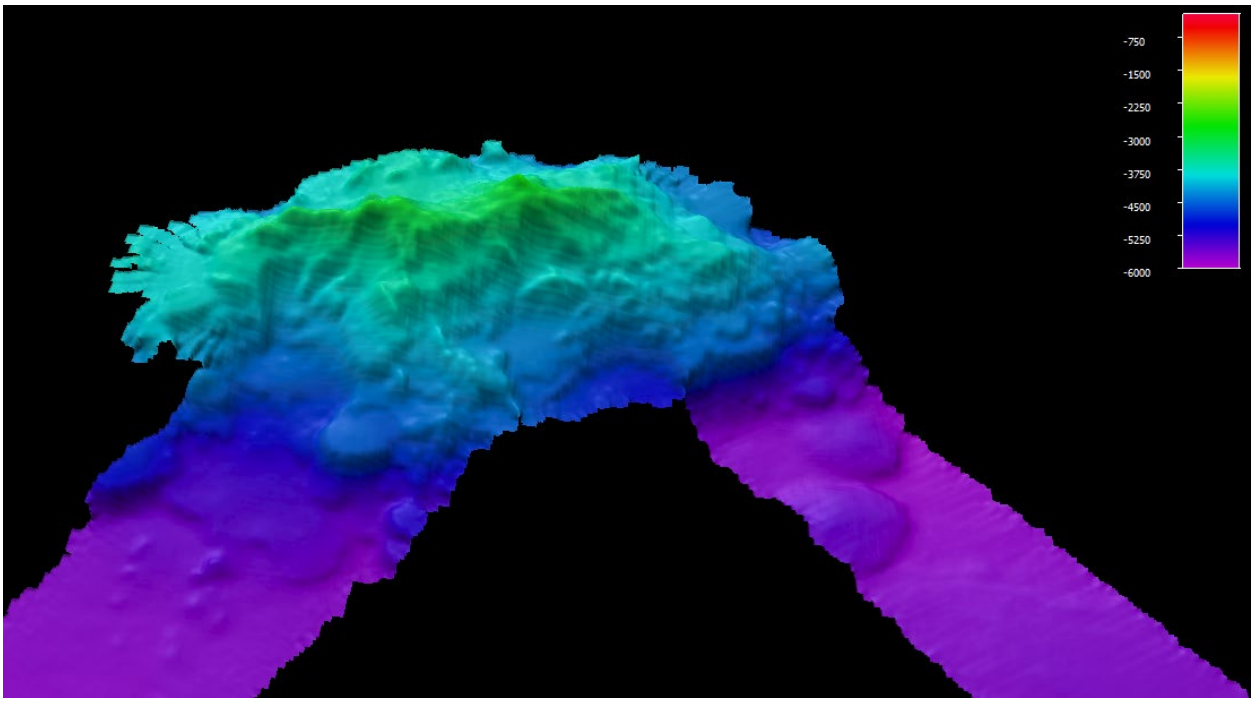

Figure 2. EM 302 data collected over Shostakovich Seamount for Dive 10. Vertical exaggeration 3x, 80m cell size, depth in meters.

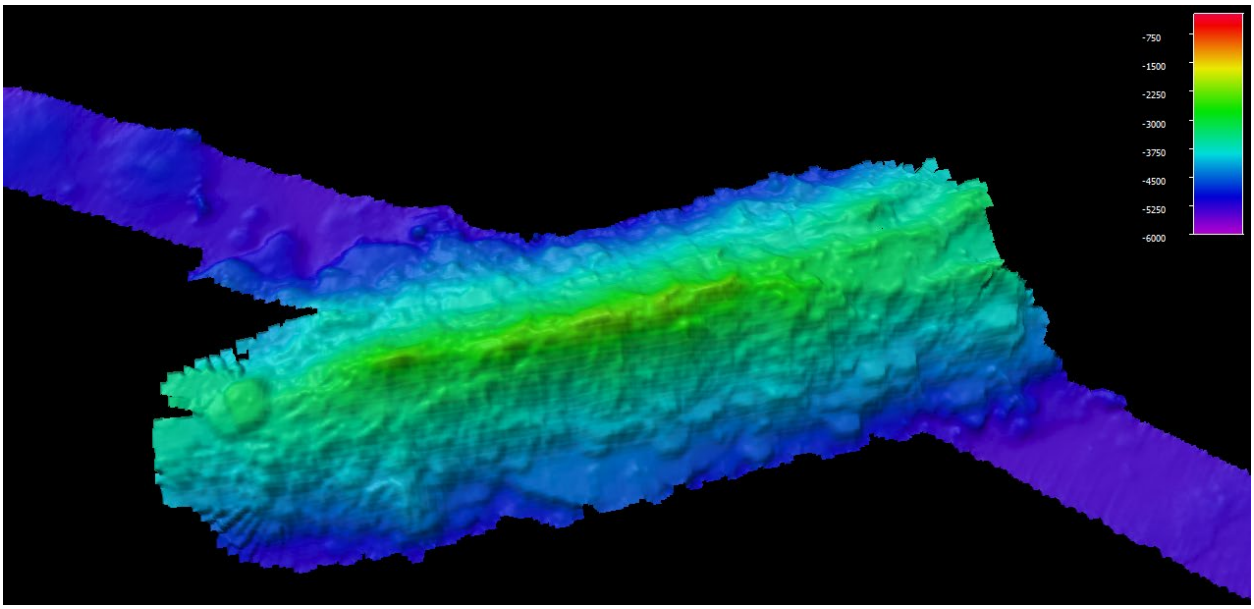

Figure 3. EM 302 data collected over Beethoven Ridge for Dive 03. Vertical exaggeration 3x, 80m cell size, depth in meters.

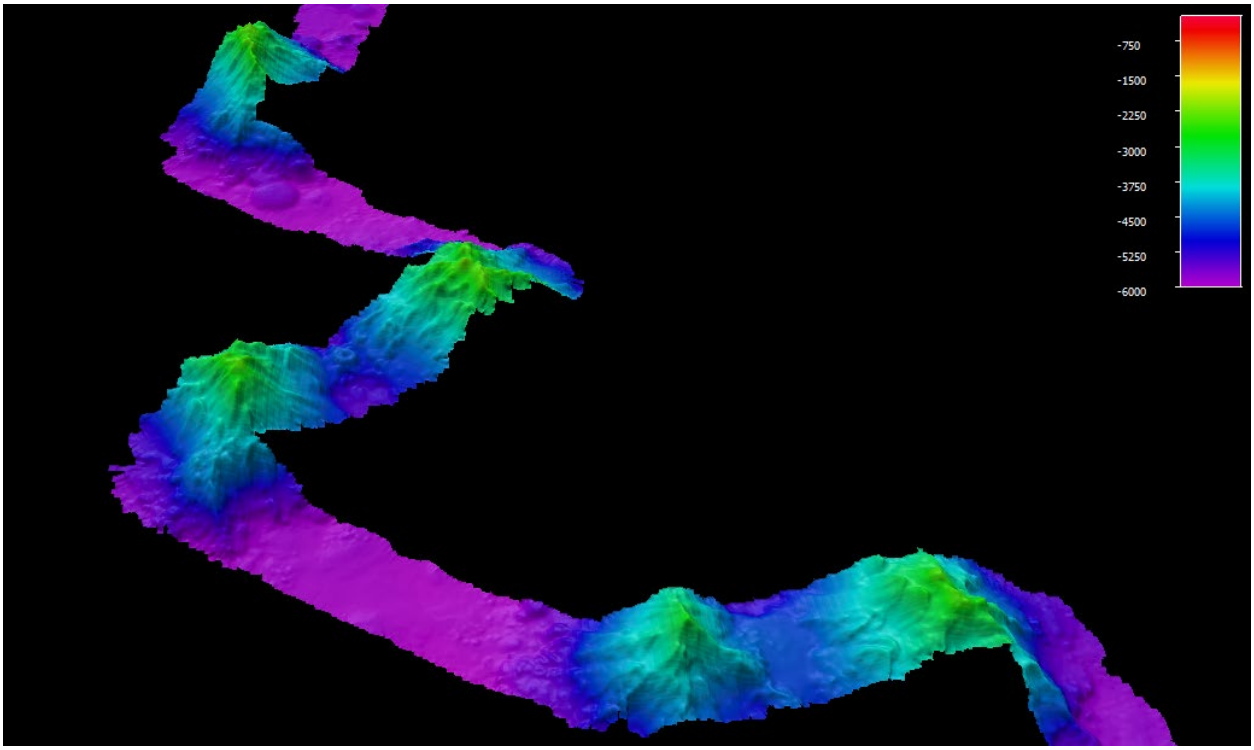

Figure 4. EM 302 data transit data collected over Mahler, Stravinsky, Hammerstein and other unnamed seamounts. Transit mapping line targeted seafloor features of interest. Vertical exaggeration 3x, 80m cell size, depth in meters.

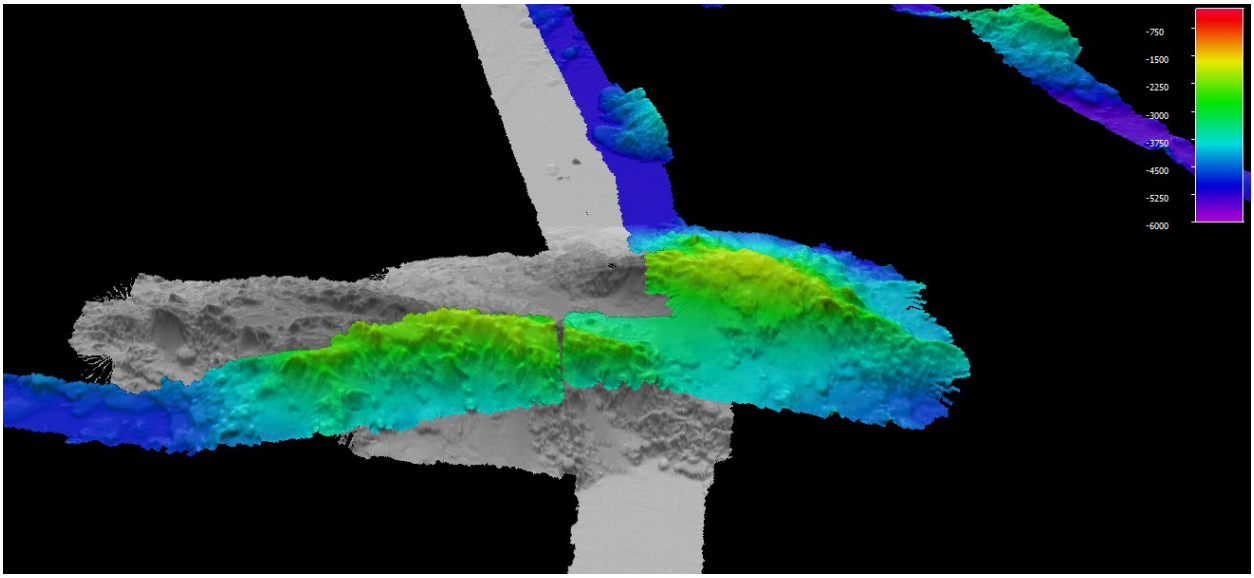

Figure 5. EM 302 data over Schuman Seamount and the west edge of Blackfin Ridge from EX-17-07 in grey with EX-17-08 data in rainbow. EX-17-08 mapping operations when possible edged matched date from EX-17-07. Vertical exaggeration 3x, 80m cell size, depth in meters.

Throughout the cruise, multibeam data quality was monitored in real time by acquisition watch standers. 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 Sound Velocity Probe (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. Sound velocity profiles were also generated from the ROV CTD sensors at the end of each dive. 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 6 shows the EK60 data collected during EX-17-08. The 38 kHz EK60 was only turned on during ROV dives.

Knudsen 3260 sub-bottom profiler data were also collected during the majority of the cruise. Figure 7 shows where sub-bottom data were collected during EX-17-08.

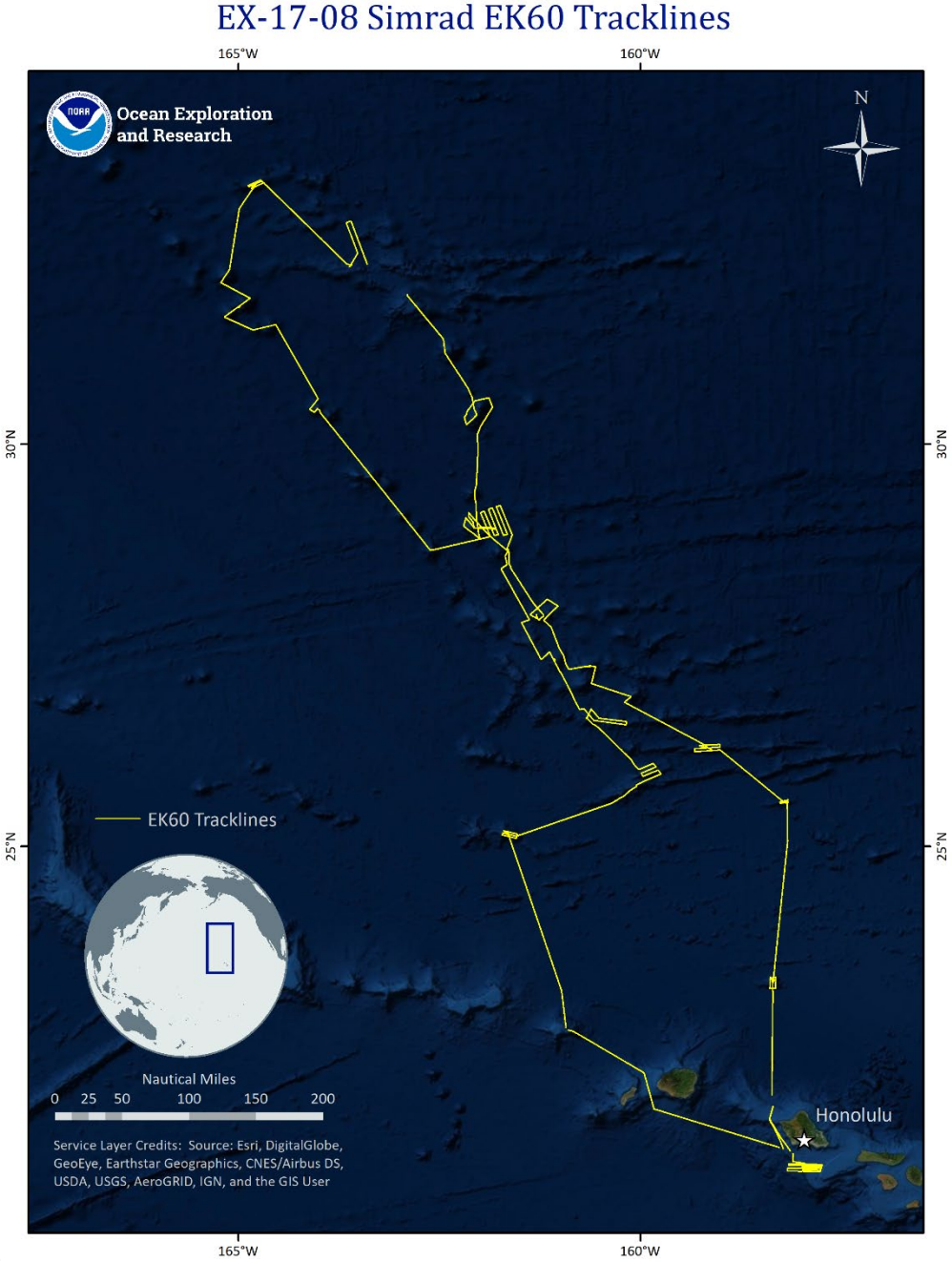

Figure 6. Simrad EK60 split-beam sonar data tracklines (in yellow) collected during EX-17-08.

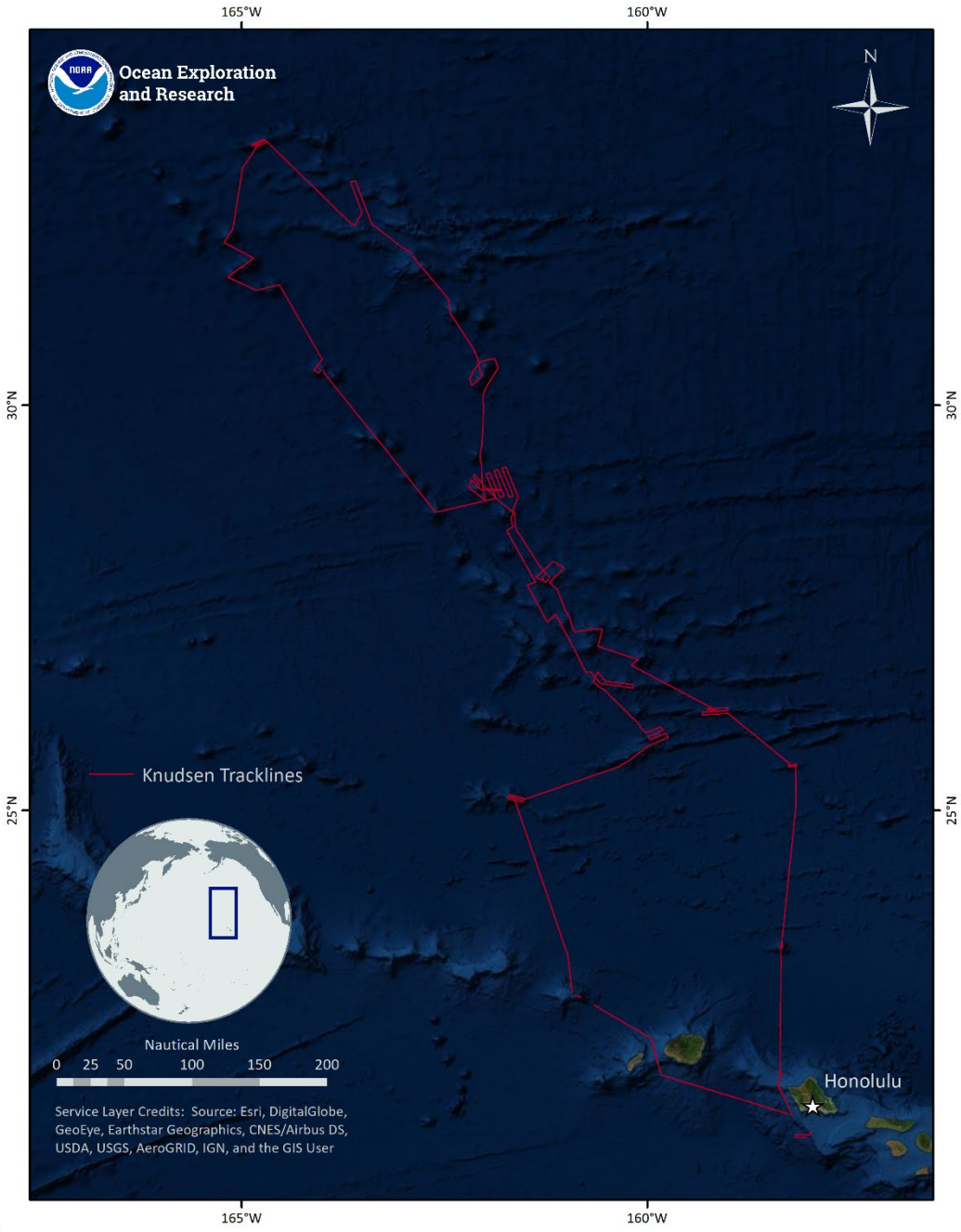

Figure 7. Sub-bottom profiler data tracklines (in red) collected during EX-17-08.

8. Multibeam Sonar Data Quality Assessment and Data Processing

Figure 8 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 QPS Qimera for processing. In Qimera, the attitude and navigation data stored in each file were checked, and erroneous soundings were removed using 2D and 3D 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).

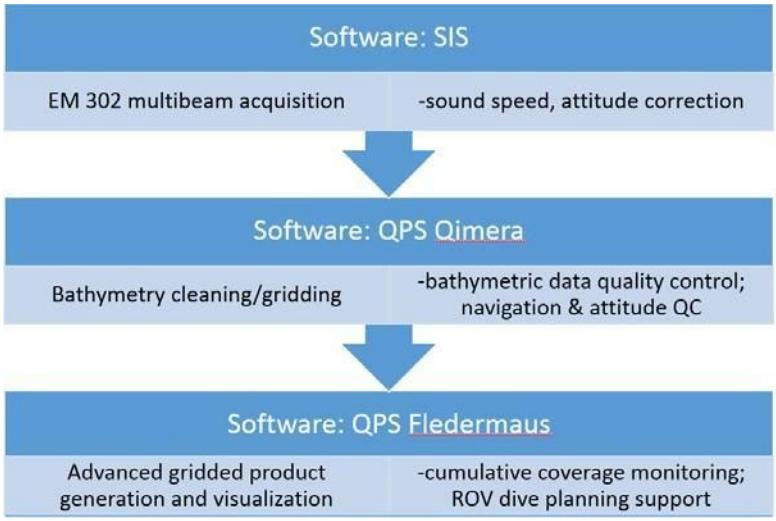

Figure 8. Shipboard multibeam data processing workflow.

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 September 20, 2017 as shown in Figure 9. Crossline analysis was completed using the Crosscheck Tool in QPS Qimera software to evaluate if the survey meets the requirements for an International Hydrographic Order 1 survey. The results are shown below.

<u>Crossline file:</u>

0297_20170920_143244_EX1708_MB.all

Mainscheme line files:

0293_20170920_122457_EX1708_MB.all

0288_20170920_085348_EX1708_MB.all

Statistic	Value (in meters)
Number of points of comparison	148506
Grid Cell Size	80
Difference Mean	4.383824
Difference Median	2.522064
Difference Std. Dev	9.929385
Difference Range	[-68.39, 111.06]
Mean + 2*Stddev	24.242594
Median + 2*Stddev	22.380834
Data Mean	-5183.531561
Reference Mean	-5187.915385
Data Z-Range	[-5560.98, -4583.54]
Reference Z-Range	[-5552.63, -4609.09]
Order 1 Error Limit	67.444756
Order 1 # Rejected	275
Order 1 P-Statistic	0.001852
Order 1 Survey	**ACCEPTED**

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

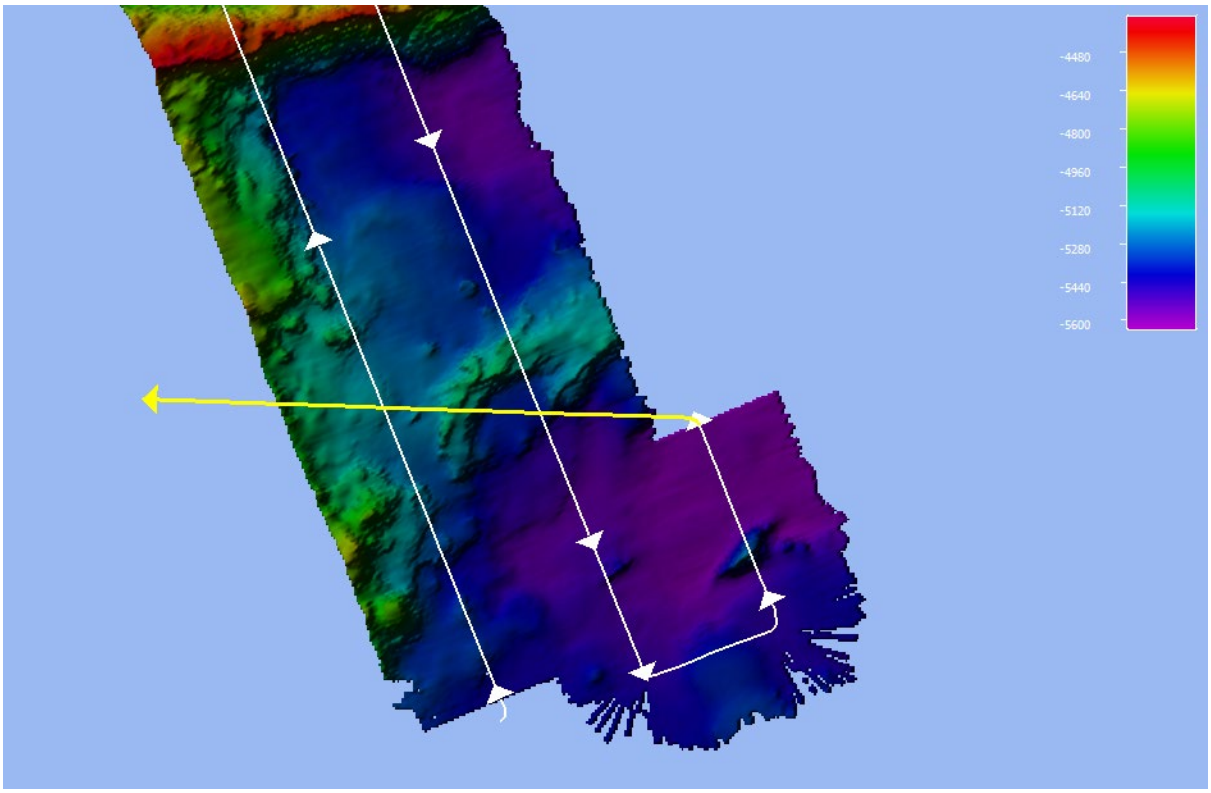

Figure 9. EX-17-08 crossline (shown in yellow) used for comparison against the bathymetric grid generated via orthogonal multibeam survey lines.

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-17-08 project instructions, available in the NOAA Central Library here: https://repository.library.noaa.gov/view/noaa/17238 (last accessed April 2020). 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)
- Processor Unit Parameters
- Text files of telnet sessions on the EM 302 transceiver unit (TRU)

Simrad EK60 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
- Built-In-System-Tests (BISTs)
- Processor Unit Parameters
- Text files of telnet sessions on the EM 302 transceiver unit (TRU)
- Multibeam water column data review log if data were reviewed for presence of seeps in Fledermaus MidWater or QPS Qimera

All sonar data is permanently discoverable at https://www.ngdc.noaa.gov/ (last accessed April 2020).

At the time of writing this report, EM 302 and EK60 water column data, supporting data, and informational logs were available in the NCEI Water Column Sonar Archives: https://www.ngdc.noaa.gov/maps/water_column_sonar/index.html (last accessed April 2020). The Digital Object Identifier (DOI) for EX-17-08 EM 302 water column data is: http://doi.org/10.7289/V5J101G3 (last accessed April 2020) and the DOI for EK60 data is: http://doi.org/10.7289/V5NS0S64(last accessed April 2020).

Sub-bottom data, supporting data, and informational logs will be available in the NCEI Data Archives accessible at https://www.ngdc.noaa.gov/ (last accessed April 2020). For any challenges accessing SBP data, send an inquiry to ncei.info@noaa.gov requesting access to EX-17-08 Knudsen 3260 sub-bottom raw and processed data.

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

10. Cruise Calendar

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

September 2017

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			06 Depart Honolulu, Hawaii, transit mapping	07 Dive 01. Transit mapping	08 Dive 02, overnight transit mapping	09 Dive 03, overnight transit mapping
10 Dive 04, overnight transit mapping	11 Dive 05,overnight transit mapping	12 Dive cancelled (weather), 24 hour mapping	13 Dive 06/07, overnight transit mapping	14 Dive 08, overnight transit mapping	15 Dive 09, overnight transit mapping	16 Dive 10, overnight transit mapping
17 Dive 11, overnight transit mapping	18 Dive 12, overnight transit mapping	19 Dive 13, overnight transit mapping	20 Dive 14, overnight transit mapping	21 Dive 15, overnight transit mapping	22 Dive 16, overnight transit mapping	23 Dive 17, overnight transit mapping
24 Dive 18, overnight transit mapping	25 Dive 19, overnight transit mapping	26 Dive 20, overnight transit mapping	27 Dive cancelled (mechanical issues/ship), 24 hour mapping	28 Dive 21, overnight transit mapping	29 Dive 22, overnight transit mapping	30 Arrive, Honolulu, Hawaii. Demobilization

11. Daily Cruise Log Entries

Generated from the daily expedition situation reports. All times listed are in local ship time (-10 hours from UTC)

September 6

Qimera was updated to the latest version, 1.5.4. In accordance with guidance from QPS, Fledermaus was also updated to the latest version 7.7.7.6. The POS MV was disconnected from the network switch and had to be reconnected. The EM 302 had a little trouble on startup, but the ethernet connections to Transmit (TX) boards were adjusted and the second iteration was fine. Data quality is excellent, even with speedy transits (>10 kn [knot]). All other systems are functioning as expected. Daily products will start being produced today, 07/06. A targeted Underwater Cultural Heritage (UCH) mapping line was run yesterday and the backscatter mosaic images were sent offshore to identify potential targets. Sub-bottom naming will now be generated with a time and date stamp to generate unique file names. The Data Team is making sure these are being accepted by the sync scrips. Drives were De-fragmented and computers were restarted in-port.

September 7

All systems are functioning as expected. The EK60s are recording through the ROV Dives. Scene files are being created for each dive. Data continues to look excellent. LTJG Brasher continues to train with Survey in the evenings.

September 8

First built-in self-test (BIST) passed upon recovery after Dive 01. Initial data quality was weak due to sea state, but improved overnight. Early morning mapping of today's dive site revealed finer scale features on the ridge top. Overnight transit speeds continue to be 10-11kn.

September 9

The EK60s were run during today's dive and the mapping team noticed a very deep (~150m off the bottom) scattering layer that dissipated later in the dive. Screenshots were distributed to OER water column experts. The Graphical User Interface (GUI) for the OS38 ADCP was added back today and the deck unit was powered on. It will not be activated without further consideration from the mapping team. ROV CTD was used as the first Sound Velocity Profile (SVP) profile post dive. SIS Helmsman Display is being used to effectively monitor arrival and transit times. Data quality continues to be excellent. The EK60 38kHz is being recorded during the dives. During Aft-Con training the team experimented with running the WH300 with the EM302. First BIST after the dive passed. Sun photometer readings are being taken as permissible during the day.

September 10

Data continues to look excellent. All systems functioning normally. EK60 and ROV CTD screenshots were shared with water column folks on shore for midwater transect planning.

September 11
Overnight mapping data looks good and transit speeds continue to be >10kn. During the transit mapping team took the opportunity to run the WH300 coincident with the EM302 over flat abyssal floor. Mapping team is edge-matching EX-17-07 data during transits. The 38 kHz EK60 is being recorded during dives.

September 12
With the cancelled dive mapping team planned lines to fill in data around Liszt Seamount and to add coverage to Debussy Seamount. Survey data is being heavily affected by sea state. The data layers produced by the EX-17-07 onshore EiTs are being used in dive planning calls. The EK60s came up with an error that they lost connection to the General Purpose Transceivers (GPT). Power was cycled to the GPTs and the software was restarted; all seemed fine after. Mapping Team had a positive interaction with representatives from the Korean Hydrographic Branch at the Silver Spring Exploration Command Center (ECC).

From the Senior Survey Technician (SST): The SeaBird rosette frame delivered from Marine Operations Center-Pacific (MOC-P) was pressure washed and inspected for any defects, of which there are few and innocuous. The SBE-32 water sampling pylon from Marine Operations Center-Pacific Islands (MOC-PI) was installed with new, greased fasteners; no complications. Tomorrow the SBE-9 CTD will be installed and cables connected, followed by the PMEL altimeter, General Oceanics 2.5L Niskin bottles, and distributed stabilization weights. When assembly is finished, the protective cover will be placed over the unit while the painting of the CTD deck is completed.

September 13
With the calming seas the data continues to improve. Mapping team is edge-matching EX-17-07 as ship head's further north, northwest. All systems functioning normally.

September 14
All systems functioning as expected. SIS did need a restart when a large grid (>30MB) was brought in as a background layer. Still seems unclear at exactly what size it freezes. Post dive BIST all passed.

September 15
Transit mapping, all systems functioning normally.

September 16
Transit mapping, all systems functionally normally.

September 17
Data quality is high even with fast (>10 kn) transits. All systems functioning normally.

September 18
Data quality remains good. All systems functioning as expected. Screenshots of EK60 and ROV CTD are being sent to shore on days when ROV midwater work is planned.

September 19
Transit mapping. All systems functioning as expected.

September 20
Transit mapping. All systems functioning as expected.

September 21
No technical issues.

September 22
Failed BIST after dive. SIS froze, crashed and was restart. Another BIST Failed. SIS was closed, power was cycled to the Transmit Receive Unit (TRU), telnet and SIS were restarted with a successful BIST.

From SST regarding ship's CTD hardware. Full assembly and communication linkage of all components, either previously aboard or procured from other sources. (Save for the Altimeter, which was not necessary at this time. Twice successful deck-tests, with all bottles firing sequentially. Successful bottle firing just below the surface of the water, with visual confirmation. Successful 1000m test cast, with all bottles fired, as well as viable CTD data. The bottles hold water samples just fine.

September 23
Data quality is good.

September 24
Transit mapping, no issues to report.

September 25
Transit mapping, no issues to report.

September 26
Fast transits down to Middle Bank still allowed for good coverage. All systems functioning well.

September 27

With the cancelled dive at Ka'ula, the team has gone to 24 hour operations. For the transit to Oahu, data looks good. Team is preparing data for the UCH dives. Tonight mapping team plans to run lines for backscatter calibrations.

September 28
Systems are prepared for UCH work. Scientific Computing System (SCS) has been made restricted, as well as the data on-board, and ADCP mailers. Mapping team continued to process data for UCH work. Overnight we will run lines east of Penguin Bank to improve existing data as suggested by folks on shore.

September 29
Overnight transit mapping.

September 30
Arrive Honolulu, Hawaii, demobilization.

12. References

NOAA Office of Ocean Exploration and Research, 2017. The 2017 NOAA Ship *Okeanos Explorer* Survey Readiness Report NOAA is available at the NOAA Central Library or by emailing oar.oer.exmappingteam@noaa.gov.

NOAA Office of Ocean Exploration and Research, 2017. EX-17-08 Project Instructions: https://repository.library.noaa.gov/view/noaa/17238 (last accessed April 2020). The EX-17-08 Data Management Plan is an appendix of the project instructions.

NOAA Office of Ocean Exploration and Research, 2016. The 2016 EK60 Calibration Report can be obtained by contacting oar.oer.exmappingteam@noaa.gov.

NOAA Nautical Charts, 2020: https://www.charts.noaa.gov/InteractiveCatalog/nrnc.shtml, (last accessed April 2020)

NOAA Autogrid, 2020: https://www.ngdc.noaa.gov/maps/autogrid/, last accessed April 2020

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