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Mapping Data Acquisition and Processing Summary Report

EX-22-02: Caribbean Mapping (Mapping)

Puerto Rico and Caribbean Sea

Key West, Florida to San Juan, Puerto Rico

March 10-28, 2022

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Introduction

NOAA Ocean Exploration is the only federal program dedicated to exploring our deep ocean, closing prominent gaps in our basic understanding of U.S. deep waters and the seafloor and delivering the ocean information needed to strengthen the economy, health, and security of our nation.

Using the latest tools and technology, NOAA Ocean Exploration 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, NOAA Ocean Exploration 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, NOAA Ocean Exploration 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.

Report Purpose

The purpose of this report is to briefly describe the acoustic seafloor, water column, and subseafloor mapping data collection and processing methods used by NOAA Ocean Exploration on NOAA Ship *Okeanos Explorer* during Caribbean Mapping, EX-22-02, and to present a summary of mapping results and mapping-related expedition activities.

A detailed description of *Okeanos Explorer's* mapping equipment and capabilities is available in the "NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report 2022," which is (or will be) archived in the NOAA Central Library.[1]

For further information about general equipment calibration procedures, data acquisition, processing, reporting, and archiving, see the "NOAA Ocean Exploration Deepwater Exploration Mapping Procedures Manual V1," which is archived in the NOAA Central Library[2] and also available from the website.[3]

[1] https://doi.org/10.25923/g2ep-ae34

[2] https://doi.org/10.25923/jw71-ga98

[3] https://oceanexplorer.noaa.gov/data/publications/mapping-procedures.html

Expedition Overview

EX-22-02 (March 10-28, 2022) carried out focused operations in U.S. waters south of Puerto Rico. Operations included the use of the ship's deepwater mapping systems (Kongsberg EM 304 multibeam sonar, EK60/EK80 split-beam sonars, Knudsen 3260 Chirp sub-bottom profiler, and Teledyne acoustic Doppler current profilers), expendable bathythermograph (XBTs) in support of multibeam sonar mapping operations, and a high-bandwidth satellite connection for continuous ship-to-shore communications. Operations focused on exploring deep waters (greater than 200 m) in U.S. waters south of Puerto Rico, in partnership with the MesoAmerican-Caribbean Sea Hydrographic Commission (MACHC).

Atlantic U.S. deep-sea exploration contributes to NOAA's Atlantic Seafloor Partnership for Integrated Research and Exploration (ASPIRE), a major multi-year, multi-national, collaborative ocean exploration campaign focused on raising our collective knowledge and understanding of the North Atlantic Ocean. Building on previous work in the North Atlantic, including the 2011-2014 Atlantic Canyons Undersea Mapping Expeditions (ACUMEN), NOAA's ASPIRE campaign provides data to inform research planning and management decisions in the region, by broadening both the geographic focus to include more of the U.S. Atlantic and Canada, and the scope of partnerships to include U.S. federal agencies, such as U.S. Geological Survey (USGS) and Bureau of Ocean Energy Management (BOEM), as well as international partners from Canada and Europe. ASPIRE will support the National Strategy for Mapping, Exploring, and Characterizing the United States Economic Zone[4] and Seabed 2030.

The complete objectives for this expedition are detailed in "Project Instructions: EX-22-02, Caribbean Mapping (Mapping)," which is archived in the NOAA Central Library.[5]

Operational Personnel

EX-22-02 included onboard operational personnel, inclusive of ship's force and mission team, who participated in operational execution (see **Table 1**), and shore-based personnel (who participated remotely via telepresence) (see **Tables 1** and **2**).

[4] https://www.noaa.gov/nomec

[5] https://doi.org/10.25923/7cf3-ky80

Table 1. EX-22-02 Onboard personnel.

Name	Role	Affiliation	Dates Aboard
Thomas Morrow	Expedition Coordinator	NOAA Ocean Exploration (Fedwriters)[1]	03/8-03/30
Sam Candio	Mapping Watch Lead	NOAA Ocean Exploration (STC)[2]	03/8-03/22
Treyson Gillespie	Mapping Watch Lead	UCAR[3]	03/8-03/18
Danielle Warren	Senior Survey Tech	OMAO[4]	03/8-03/30
LTJG Hunter Brendel	Operations Officer	OMAO[4]	03/8-03/30
Kathrin Bayer	Explorer-in-Training	UCAR[3]	03/8-03/30
Daryin Medley	Explorer-in-Training	UCAR[3]	03/8-03/30
Henry Arndt	Explorer-in-Training	UCAR[3]	03/8-03/30
Chris Wright	Data Engineer	GFOE[5]	03/8-03/30
Andy Lister	Data Engineer	GFOE[5]	03/8-03/30
Caitlin Bailey	Videographer	GFOE[5]	03/8-03/30
Anna Sagatov	Videographer	GFOE[5]	03/8-03/30
Roland Brian	Telepresence Engineer	GFOE[5]	03/8-03/30
Robert Knott	Telepresence Engineer	GFOE[5]	03/8-03/30

[1]Fedwriters
[2]Science and Technology Corporation
[3]University Corporation for Atmospheric Research
[4]NOAA Office of Marine and Aviation Operations
[5]The Global Foundation for Ocean Exploration

Table 2. EX-22-02 Shore-based personnel.

Name	Role	Affiliation
Shannon Hoy	Cloud Coordinator	NOAA Ocean Exploration (Fedwriters)
Kevin Jerram	Cloud Contractor	UCAR[3]
Treyson Gillespie	Cloud Contractor	UCAR[3]

Summary of Mapping Operations

NOAA Ocean Exploration mapped 18,580 square kilometers (sq km) of seafloor during the 21 days at sea for EX-22-02. Of the 18,580 sq km mapped, 18,033 sq km was deeper than 200 meters (m) and within the U.S. Exclusive Economic Zone and Territorial Sea. Multibeam bathymetry data coverage are shown in **Figure 1** and **Figure 2.**

Figure 1. Overview of bathymetric mapping coverage completed during Caribbean Mapping (EX-22-02).

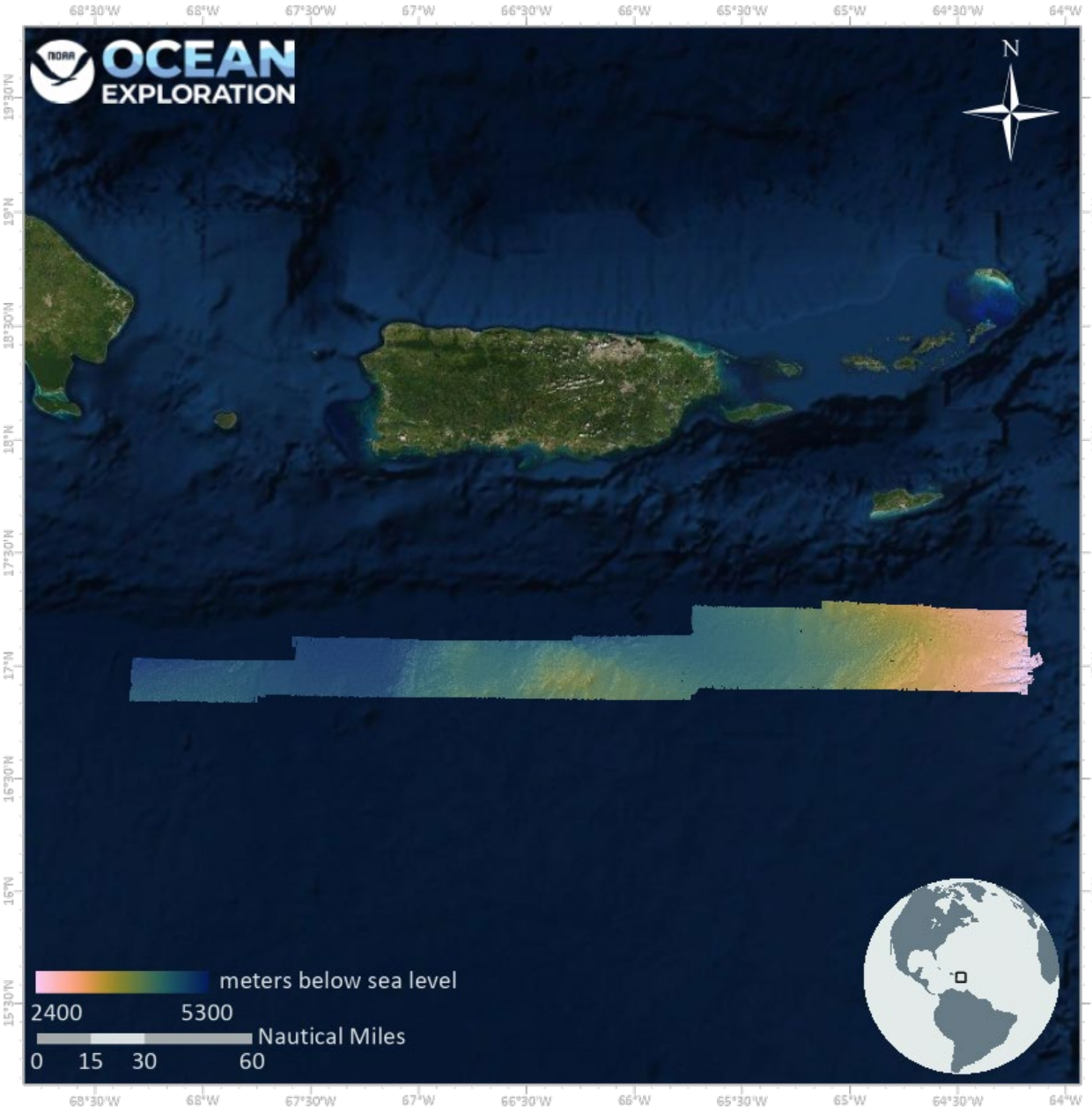

Figure 2. Detailed new mapping coverage completed in the US EEZ during Caribbean Mapping (EX-22-02).

Mapping Statistics

Table 3 provides summary statistics of ocean mapping work during EX-22-02 [March 10-28, 2022] (UTC).

Table 3. Summary statistics of ocean mapping work during EX-22-02.

Statistic	Value
Ship's draft*: Start of expedition (03/10/2022) End of expedition (03/28/2022)	 Fwd: 15'10.5", Aft Port: 15'11", Aft Stbd: 15' 9" Fwd: 14' 7.5", Aft Port: 16' 5", Aft Stbd: 15' 11"
Linear kilometers of survey with EM 304	8,398 km
Square kilometers mapped with EM 304	18,580 km^2
Square kilometers mapped with EM 304 within U.S. waters deeper than 200 m	18,033 km^2
Number/data volume of EM 304 raw multibeam files (.kmall)	336 files/41.9 GB
Number/data volume of EM 304 water column multibeam files (.kmwcd)	335 files/92.5GB
Number/data volume of EK60/EK80 water column split-beam files (.raw)	318/74.6 GB
Number/data volume of sub-bottom sonar files (.segy, .kea, .keb)	90/0.7 GB
Number of expendable bathythermograph (XBT) casts	73
Number of conductivity, temperature, depth profiler (CTD) casts (including test casts)	1

*Prior to EX-21-01, and as a result of the full marine survey completed during the 2020/2021 drydock, it was determined that the draft markers on the bow are referenced to the bottom of the original hull, and not the base of the sonar blister on the fairing which is 16.5" lower, requiring that a +16.5" offset be applied to the draft measurements. The measurements listed in Table 3 reflect the +16.5" offset.

Mapping Sonar Setup

Kongsberg EM 304 Multibeam Sonar

NOAA Ship *Okeanos Explorer* is equipped with a 26 kilohertz (kHz) Kongsberg EM 304 MKII multibeam sonar, capable of detecting the seafloor in up to 10,000 m of water and conducting productive mapping operations in up to 8,000 m of water. The nominal transmit (TX) alongtrack

beamwidth is 0.5°, and the nominal receive (RX) acrosstrack beamwidth is 1.0°. The system generates a 140° beam fan (70° port/70° starboard maximum angles), containing 512 beams with up to 800 soundings per ping cycle when in high-density mode. In waters shallower than approximately 3,300 m the system is able to operate in dual-swath mode, where one nominal ping cycle includes two swaths, resulting in up to 1,600 soundings. The multibeam sonar is used to collect seafloor bathymetry, seafloor backscatter, and water column backscatter.

Simrad EK60/EK80 Split-Beam Sonars

The ship is equipped with a suite of Simrad EK60/EK80 split-beam fisheries sonars: 18 kHz (EK60), 38 kHz (EK80), 70 kHz (EK80), 120 kHz (EK60), and 200 kHz (EK60). These systems 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. In 2019, the 38 and 70 kHz transceivers were replaced with broadband units (WBTs). WBTs use frequency modulation to acquire higher resolution water column data allowing for the detection of finer features, improved depth capability without loss of range resolution, and support of broadband frequency response of targets.

As of May 2022, the Simrad EK60/80 sonars have not been calibrated for data collected during the 2022 field season. The intention is for the sonars to be calibrated during an upcoming expedition. Once calibrated, this report will be updated to reflect the calibration, and the calibration files (including calibration report) will be added to the data archive.

Knudsen 3260 Sub-Bottom Profiler

The ship is equipped with a Knudsen 3260 sub-bottom profiler (SBP) 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 m below the seafloor. The sub-bottom profiler is operated to provide information about sub-seafloor stratigraphy and features.

Teledyne Acoustic Doppler Current Profilers

Two acoustic Doppler current profilers (ADCPs), a Teledyne Workhorse Mariner (300 kHz) and a Teledyne Ocean Surveyor (38 kHz), are installed on the ship. Depending on environmental conditions, the 300 kHz system provides ocean current data to approximately 70 m deep, and the 38 kHz system provides data to approximately 1,200 m deep. The 38 kHz system is capable of collecting data in narrowband and broadband frequency ranges. The ADCPs gather data prior to remotely operated vehicle (ROV) and conductivity, temperature, depth profiler (CTD)

deployments in order to assess currents in support of safe operations. The ADCPs are typically not run concurrently with the other sonars during mapping operations due to issues of interference.

Data Acquisition Summary

Following port departure, data were collected with the ADCPs until the sea buoy was reached, at which point the ADCPs were secured. Then, data acquisition began with the EM 304, EK60/EK80 (18, 38, 70, 120, and 200 kHz), and the Knudsen 3260 sub-bottom profiler, with these sonars running concurrently using a Kongsberg Synchronization Unit (K-Sync). During CTD operations, the EM 304 multibeam and Knudsen sub-bottom profiler were secured to allow for the 300 kHz ADCP and the entire suite of EK split-beam sonars to acquire data. Data were not collected while transiting through Bahamas and Turks and Caicos Islands Exclusive Economic Zones.

Multibeam survey lines were planned to maximize either edge-matching of existing bathymetric data or data gap filling in areas with existing bathymetric coverage. In regions with no existing data, lines were optimized for potential discoveries and to complete relatively large contiguous areas to support interpretation of features from bathymetry and backscatter.

Throughout the expedition, multibeam data quality was monitored in real time by acquisition watchstanders. Ship speed was adjusted to maintain data quality and sounding density as necessary, and line spacing was planned to ensure one-quarter to one-third swath-width overlap between lines, depending on the environmental conditions and impact on the quality of the outer swath regions. Angles were generally left open (70°/70°) during transits to maximize data collection and were adjusted on both the port and starboard sides to ensure the best data quality and coverage. If outer beams were returning obviously spurious soundings (e.g., due to attenuation or low grazing angle), beam angles were gradually reduced and monitored closely until a high-quality swath was obtained. Within the primary mapping region south of Puerto Rico, due to sea state and depth limitations, best swath coverage was consistently within angles of 35-22°.

Real-time corrections to the data upon acquisition included: continuous application of surface sound speed obtained with a hull-mounted Reson SV-70 probe, application of water column sound speed profiles obtained with Sippican Deep Blue Expendable Bathythermographs (XBTs) and/or Seabird CTD 9/11, and application of roll, pitch, and heave motion corrections obtained with POS MV 320 version 5 inertial motion unit. No tidal corrections were applied to the raw or processed data. Sound speed profiles were conducted every four hours or more frequently as dictated by local oceanographic conditions (typically every two hours when operating near currents). Reson sound speed 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/EK80 split-beam water column sonar data were collected throughout the majority of the expedition. Data were monitored in real time for quality but were not post-processed.

Knudsen 3260 sub-bottom profiler data were also collected during the majority of the expedition. **Figure 3** shows where sub-bottom data were collected during EX-22-02.

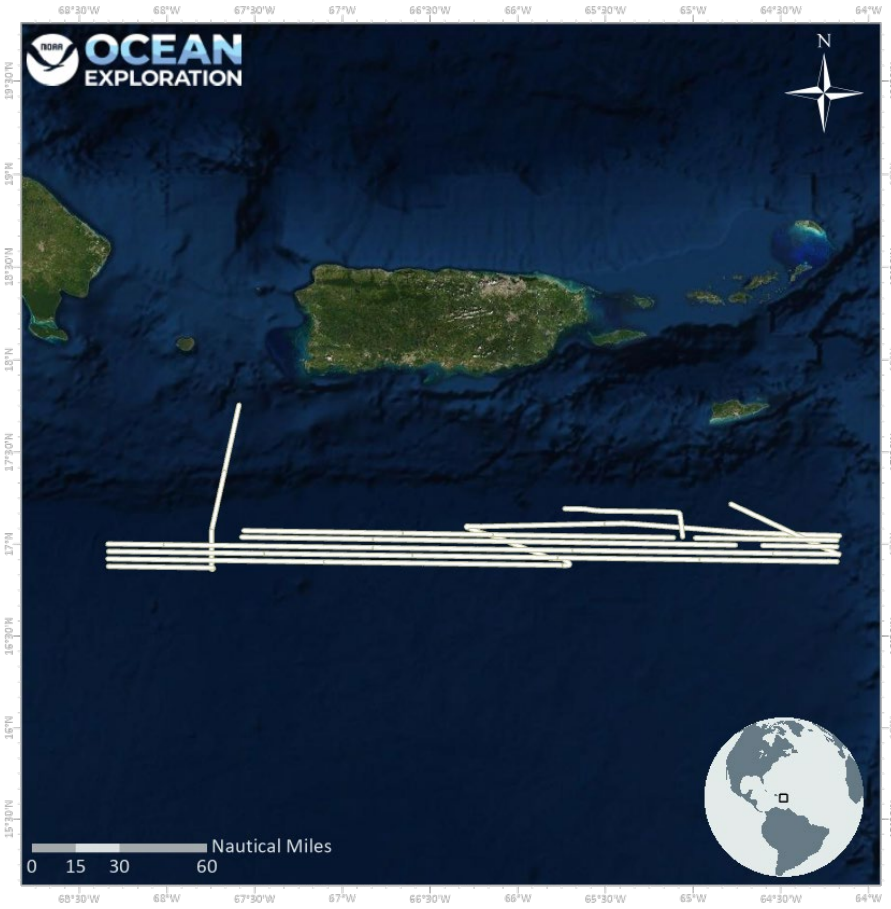

Figure 3. Sub-bottom profiler data collection tracklines (in white) collected during EX-22-02.

Multibeam Sonar Bathymetric Data Processing and Quality Assessment

The bathymetry data were generated using a Kongsberg EM 304 MKII multibeam system, and recorded using Kongsberg's Seafloor Information System (SIS) software as *.kmall files. Collocated to the bathymetric data, bottom backscatter data were collected and stored within

the *.kmall files, both as beam averaged backscatter values, and as full time series values (snippets) within each beam. Water column backscatter data were recorded separately within *.kmwcd files.

The full-resolution multibeam .kmall files (Level-00 data) were imported into QPS Qimera, and then processed and cleaned of noise and artifacts. Outlier soundings were removed using multiple methods including automatic filtering and/or manual cleaning with the swath and subset editing tools. The default sound speed scheduling method used was "Nearest-in-Time." If another method was implemented, it will be noted in the associated log. Gridded digital terrain models were created using the weighted moving average algorithm and were exported in multiple formats using QPS Fledermaus software. Daily bathymetric surfaces were created and sent to shore. **Figure 4** shows the onboard multibeam data processing workflow.

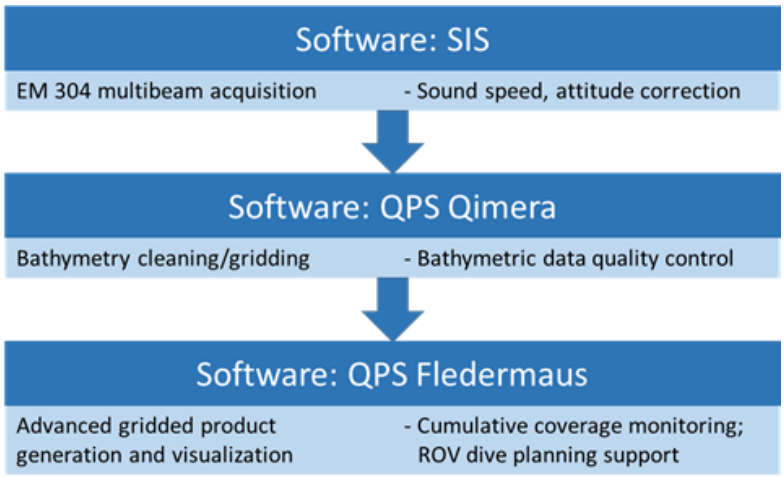

Figure 4. Shipboard multibeam data processing workflow.

On shore, the Mapping Team performed a final quality check of the data using QPS Qimera and Fledermaus software. This involved additional fine cleaning of soundings and minimization of residual artifacts from sound speed biases and field-cleaning errors. Depth values were compared from orthogonal lines (crosslines) to evaluate the consistency of the multibeam sonar data collected during the expedition.

A crossline analysis was completed using the Crosscheck Tool in QPS Qimera software to evaluate the data against the Order 1 S-44 standards set by the International Hydrographic Organization (IHO, 2008).

Each line of cleaned full resolution data was exported to a *.gsf file (Level-01 data). The processed and cleaned files were used to create a static surface in QPS Qimera. This final surface was re-projected into the field geographic WGS84 reference frame in QPS Fledermaus software and saved as a .sd file for archiving. Using QPS Fledermaus, this *.sd bathymetric grid

file was then exported into ASCII XYZ text file (*.xyz), color *.tif, floating point *.tif, and Google Earth *.kmz file formats. The *.gsf files were used to create daily backscatter mosaics using QPS FMGT. All products maintain horizontal referencing to WGS84 (G1762) and vertical referencing to the assumed mean waterline. There is a complete accounting of each individually archived multibeam data file and of each bathymetric surface product in the multibeam data acquisition and processing logs archived with the dataset.

Crossline Analysis

A crossline was run on March 27,2022, as shown in **Figure 5**, and the results are presented in **Table 4**.

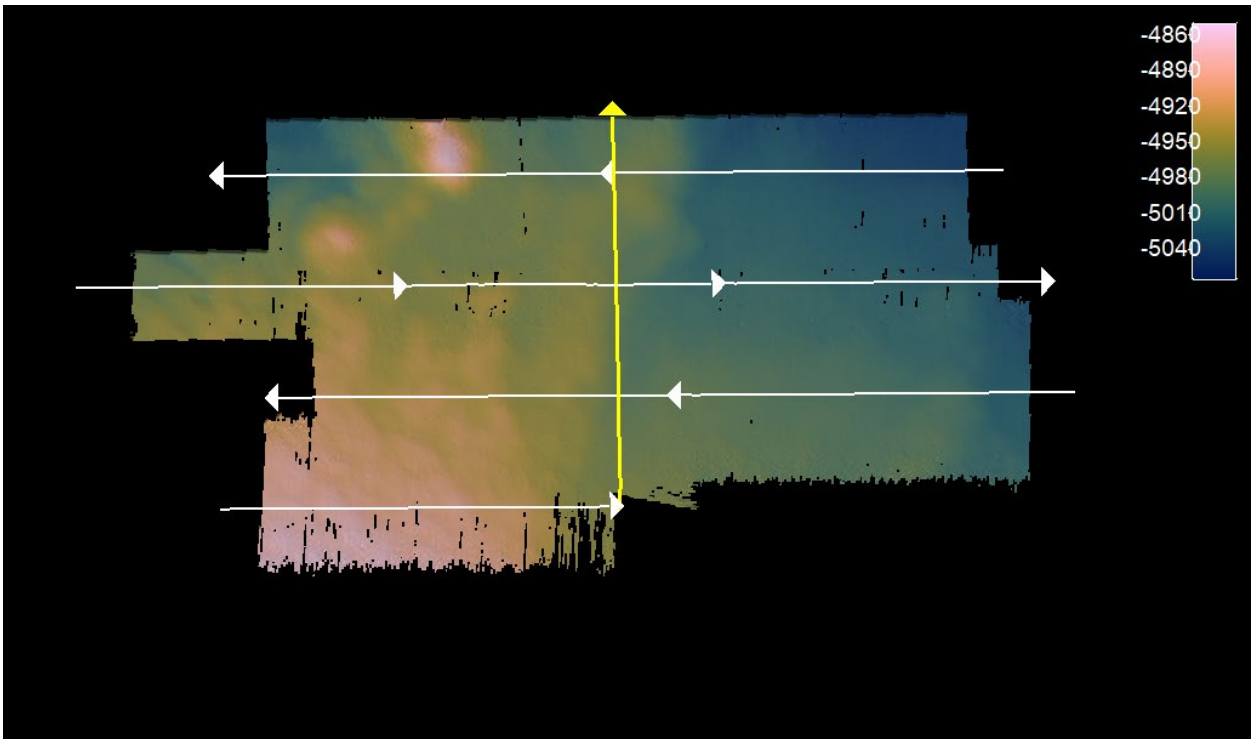

Figure 5. EX-22-02 crossline (shown in yellow) used for comparison against the bathymetric grid generated via orthogonal multibeam survey lines. Survey surface displayed as depth in meters.

Crossline file: 0329_20220327_082511_EX2201_MB.kmall

Mainscheme line files:

0237_20220324_005533_EX2201_MB.kmall
0238_20220324_015533_EX2201_MB.kmall
0248_20220324_091750_EX2201_MB.kmall
0249_20220324_101750_EX2201_MB.kmall
0250_20220324_111750_EX2201_MB.kmall

0316_20220326_224209_EX2201_MB.kmall
0317_20220326_234209_EX2201_MB.kmall
0326_20220327_070953_EX2201_MB.kmall

Table 4. Crosscheck results.

Statistic	Value
Number of points of comparison	2,158,049
Grid cell size (m)	100.00
Difference mean (m)	0.097
Difference median (m)	0.173
Difference standard deviation (m)	3.261
Difference range (m)	[-39.320, 30.613]
Mean + 2* standard deviation (m)	6.620
Median + 2* standard deviation (m)	6.696
Data mean (m)	-4972.934
Reference mean (m)	-4973.031
Data z-range (m)	[-5070.759, -4841.677]
Reference z-range (m)	[-5062.837, -4851.829]
Order 1 error limit (m)	64.6513
Order 1 # rejected	0
Order 1 p-statistic	0
Order 1 survey	ACCEPTED

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

Acquisition and Processing Software

Table 5 provides a list of the acquisition and processing software versions that were used during EX-22-02.

Table 5. Versions of acquisition and processing software used during EX-22-02.

Software	Purpose	Version
SIS	EM 304	5.7.0
EK80	EK suite	2.0.0
EchoControl	Knudsen	4.09
UHDAS	ADCPs	14.04
AMVERSEAS	Autolaunch XBT	9.3
WinMK22	XBT	3.0.2
K-Sync	Synchronization	1.9.0
Qimera	Bathymetry	2.4.7
FMGT	Backscatter	7.9.5
FMMidwater	Water Column	7.9.3
Sound Speed Manager	Sound Speed Profiles	2022.1.6
NRCan (SegJp2)	Sub-bottom	1.0
Fledermaus 7	Visualization/Data Analysis	7.8.11
ArcGIS Pro	Visualization/Figures	2.9.3

Data Archiving Procedures

All mapping data collected by NOAA Ocean Exploration on *Okeanos Explorer* are archived and publicly available within 90 days of the end of each expedition 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 expedition) is available as an appendix in the "Project Instructions: EX-22-02, Caribbean Mapping (Mapping)," which is archived in the NOAA Central Library. For each data type, raw data (Level 00), processed data (Level 01), derived products (Level 02), and ancillary files may be available, depending on the dataset and the level of staffing for the expedition. **Tables 6-10** describe the data archived for each dataset. For further information about proprietary software and freeware that can handle

the varying data types, refer to the "NOAA OER Deepwater Exploration Mapping Procedures Manual."

Table 6. EM 304 bathymetry and seabed backscatter dataset.

Level	Description	File Type
Level 00	Raw multibeam files (in native sonar format) that include both raw bathymetry and backscatter (horizontal referencing = WGS84)	.kmall
Level 01	Processed multibeam files in generic sensor format that include bathymetry and backscatter (horizontal referencing = WGS84)	.gsf
Level 02	Gridded multibeam data and backscatter mosaics (horizontal referencing = WGS84)	.xyz, .tif, .tif (floating point GeoTIFF), .kmz, .sd, .scene
Ancillary files	Mapping watchstander log, weather log, sound speed profile log, multibeam acquisition and processing log, backscatter correction file, built-in self test logs, processing unit parameters, telnet session records	.xlsm, .xlsx, .txt

Table 7. EM 304 water column backscatter dataset.

Level	Description	File Type
Level 00	Raw multibeam files (in native sonar format) that include water column backscatter (horizontal referencing = WGS84)	.kmwcd
Level 01	n/a	n/a
Level 02	QPS Fledermaus objects such as beam fan, beam line, volume and/or track line; produced if time and staffing allows (horizontal referencing = WGS84)	.sd, .scene
Ancillary files	Mapping watchstander log, weather log, sound speed profile log, multibeam acquisition and processing log, water column data log, built-in self test logs,	.xlsm, .xlsx, .txt

	processing unit parameters, recorded telnet sessions	

Table 8. EK60/EK80 split-beam echosounder dataset.

Level	Description	File Type
Level 00	Raw water column files provided in native sensor format (horizontal referencing = WGS84)	.raw, .idx
Level 01	n/a	n/a
Level 02	n/a	n/a
Ancillary files	Mapping watchstander log, weather log, EK data log, EK calibration report, calibration files and the raw files used for calibration	.xlsm, .xlsx, .txt, .pdf, .xml, .raw, .idx

Table 9. Knudsen 3260 sub-bottom profiler dataset.

Level	Description	File Type
Level 00	Raw sub-bottom files provided in native sonar format (horizontal referencing = WGS84)	.sgy, .kea, .keb
Level 01	Raw sub-bottom files converted to images and shapefiles of the tracklines; produced as time and staffing levels allow	.jpg, .shp
Level 02	n/a	n/a
Ancillary files	Mapping watchstander log, weather log, sub-bottom profiler data log	.xlsm, .xlsx

Table 10. Sound speed profiles dataset.

Level	Description	File Type
Level 00	Raw profile data for any XBT or CTD cast	.txt, .hex, .cnv
Level 01	Processed sound speed profiles created for multibeam data acquisition	.asvp
Level 02	n/a	n/a
Ancillary Files	Mapping watchstander log, sound speed profile log, profile locations as a shapefile	.xlsm, .xlsx, .shp, .kml, .cal, .xml, .pdf

	and in Google Earth format, any associated calibration files	

All sonar data is permanently discoverable within the NCEI archives[6] and searchable through the Ocean Exploration Digital Atlas,[7] which provides access to all of the data collected during an expedition. The locations for specific data types (at the time of writing this report) are detailed in **Table 11**. For any challenges accessing data, send an inquiry to NCEI,[8] or contact the Ocean Exploration Expedition Coordinators.[9]

[6] https://www.ngdc.noaa.gov/

[7] https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm

[8] ncei.info@noaa.gov

[9] oar.oer.exmappingteam@noaa.gov

Table 11. Locations of data collected during EX-22-02 (at the time of writing this report).

Data Type	Description	Location
EM 304 bathymetry and backscatter data	EM 304 bathymetric and backscatter data, supporting informational logs, and ancillary files are available through the NCEI Bathymetry Data Viewer	https://www.ncei.noaa.gov/maps/bathymetry/ Request raw sonar data (*.kmall) from ncei.info@noaa.gov with oer.info.mgmt@noaa.gov cc'd POSPac and BS correction files can be requested from oar.oer.exmappingteam@noaa.gov
Water column data (EM 304 and EK60/EK80)	EM 304 and EK60/EK80 water column data, supporting data, and informational logs are available through the NCEI Water Column Sonar Data Viewer	https://www.ncei.noaa.gov/maps/water-column-sonar/
Knudsen 3260 sub-bottom profiler data	Sub-bottom data, supporting data, and informational logs are available in the NCEI data archives	https://www.ncei.noaa.gov/maps/trackline-geophysics/
Sound speed profiles	Ancillary sound speed profiles are available along with all mapping data per expedition in the NCEI data archives, or within the oceanographic archive for the expedition.	https://www.ncei.noaa.gov/maps/bathymetry/ or through the oceanographic archives at: https://www.ncei.noaa.gov/
Reports	Reports are archived in the NOAA Central Library's Ocean Exploration Program (OEP) institutional repository	NOAA Central Library home: https://library.noaa.gov/ OEP institutional repository: https://repository.library.noaa.gov/cbrowse?pid=noaa%3A4&parentId=noaa%3A4

Expedition Schedule

The expedition schedule is available in **Table 12** and additional details from daily logs are presented in **Appendix A**.

Table 12. EX-22-02 schedule.

Date (UTC)	Activity
03/08	Mission personnel began to arrive in Cape Canaveral, FL.
03/08	Mobilization began and more mission personnel arrived.
03/09	Mobilization finished.
03/10	Departed Key West. Began transiting to mapping target region. Sonars secured after leaving US EEZ.
03/14	Entered Dominican Republic waters and resumed mapping operations.
03/16	Arrived at primary mapping target region, mapping continued.
03/18	Diverted to St. Croix for small boat operations, resumed mapping after returning to target region.
03/22	Diverted to St. Croix for small boat operations, mechanical (no data) CTD test carried out before resuming mapping operations.
03/25	Diverted mapping lines to fill holidays.
03/27	Performed crosscheck and started transit to San Juan, Puerto Rico, and secured sonars over pre-existing coverage.
03/28	Arrived San Juan, Puerto Rico, began demobilization.

References

Candio, S; Morrow, T; Hoy, S; Wilkins, C; Copeland, A. 2022. NOAA Ship *Okeanos Explorer* Mapping Systems Readiness Report. Office of Ocean Exploration and Research, Office of Oceanic and Atmospheric Research, NOAA, Silver Spring, MD 20910. https://doi.org/10.25923/g2ep-ae34

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Appendix A: Daily Log Entries

The following entries were excerpted from each of the daily expedition situation reports provided by the onboard team to the onshore support team, and therefore are somewhat informal in language. These are included to provide situational awareness for future users of the data collected during this expedition. All times are in local ship time (-4 hours from UTC).

March 04-07

In port at Key West, FL. No updates, all survey equipment secured.

March 08-09

Alongside preparations continued for departure on 10 March. No updates, all survey equipment secured while in port. Request for ping test alongside denied due to divers in the water. Science team loaded and secured equipment for upcoming EX-22-03 expedition.

March 10

Ping tested after clearing the channel. Knudsen sonar did not successfully ping test, but waters were less than 1000 m and this is a known problem when at transit speeds in shallow water. Troubleshooted and restarted the Knudsen system, confirmed configuration, will ping test again when in deeper water at survey speeds and resume troubleshooting. Confirmed preparations to secure sonars prior to leaving U. S. waters. Explorers-in-Traning (EiTs) attended orientation, learned how to set up acquisition parameters, monitor and adjust sonars during transit.

March 11

Continued training EiTs on mapping data cleaning and processing. Despite caution, EiTs continue to over-clean data with reckless enthusiasm. Will continue to advise and cleaning enthusiasm is expected to reach a tempered steady state once 24-hour mapping operations begin. Sonars still secure, no data collected in Bahamas EEZ. Preparations started for EK calibration upon arrival at first science station, but expected weather patterns do not favor calm conditions required to properly calibrate systems. Exploring alternative scheduling options and considering revised line plans to account for wind and wave direction.

March 12

Transit training for EiTs continues. Derived a complete training data set from a previous expedition to illustrate processing workflow for Knudsen and water column data. Sonars are still secure for transit through the Bahamas.

March 13

Sonars still secure for transit.

March 14

Knudsen issues continue, unable to ping. Planned to trace cable and troubleshoot physical connections with transducer array tomorrow. Started data collection late in the day after troubleshooting with Knudsen. Multibeam and EK sonars functioning as expected. Transit data quality limited by sea conditions.

March 15

Knudsen issues ongoing, requested engineering access to transducer array junction box to verify integrity of the TX cable from the Knudsen unit. Other engineering priorities are currently taking precedence. Continued multibeam mapping across Puerto Rican EEZ. Weather conditions are yielding poor quality data, despite best efforts. Considering alternatives for augmenting the data, likely will extend overlap on inverse lines to maximize coverage quality. SIS is not currently showing historical data grid, will troubleshoot during next coverage overlap to minimize data gaps in new collections.

March 16

Continued troubleshooting Knudsen chirp sonar. After establishing safe enclosed space, ventured into Knudsen transmitter junction box area and checked connection from the rack room. Tested voltages across TX cable and determined no failure in the TX cable. Pulled Knudsen unit from rack and disassembled, per troubleshooting instructions. Found one MOSFET board bad due to a fried resistor. Replaced with spare of unknown age and condition, but apparently in original packaging and assumed to be in working condition. Re-assembled and tested, still no ping. Disassembled and re-seated MOSFET boards as a precaution, still no pings transmitting. Documented voltages from troubleshooting and assembled a service email for Knudsen along with photographs of the damaged MOSFET board. ET ordered parts to repair MOSFET board. Restarted SIS during a turn and cleared the grid cache, SIS is now showing a grid of historical data. Continued mapping lines, westerly lines (in the direction of waves) are considerably improved in quality over easterly lines.

March 17

Email sent to Knudsen regarding ping transmission issues, relayed testing information for MOSFET boards, standard troubleshooting voltages. Mapping operations continue with data quality dependent on ship orientation. Anticipating improved sea conditions early next week.

March 18

Knudsen service request was answered, they requested verification of voltage troubleshooting, and asked ET to pull the system to verify voltages along with the troubleshooting document. Mapping operations continue through medevac transit. Line plan adjusted for return from medevac transit. Watchstanding schedule adjusted for change in personnel, EiTs are prepared to stand short unsupervised watches to cover gaps. CTD cast tentatively scheduled for Monday morning.

March 19

Continued testing Knudsen sonar - swapped transmit ports on the pickup module with no change in function (though a useful way to test the whole transmit relay), suggesting that the USB Processor board was faulty. Found a spare USB processor card and swapped. Knudsen now behaving, resumed pinging and started logging data. Mapping operations continue.

March 20

Troubleshot file naming/scripting issues with DATA team. Knudsen data is transmitting and processing properly. Successfully tested remote watchstander capabilities, with onshore watchstander holding watch concurrent with an EiT onboard for 4 hours. Mapping operations continue with no major disruptions. Multibeam data quality and ping density has improved after some tuning of ping triggers, removing the need for two groups in K-Sync.

March 21

Continued mapping with high quality results. Watchstander remote support successfully tested again with two participants. Mapping operations temporarily suspended for small boat operations to investigate floating objects around midday. AXBT launcher malfunctioned around 1800. Troubleshooting with support from AOML for several hours suggested a problem with the MK21 ethernet board. Attempts to connect the hand launcher were unsuccessful, used synthetic casts until we got a response from Lockheed Martin.

March 22

Continued mapping, breaking lines for transit outside of the mapping area. Mapping resumed after CTD cast, upon returning to the mapping region. AXBT launcher is still offline, using world ocean atlas (WOA) synthetic profiles for sound speed. Troubleshooting efforts for the MK21

unit continue. Reseating all plugs enabled communication with the MK21 unit, but the unit cannot communicate with loaded XBT probes. Various recombinations of the switches between hand launcher and the MK21 interface yielded the same communication issue, suggesting the problem is with the MK21 unit. Lockheed Martin contact (Sippican is no longer in business) recommends uploading a new firmware to resolve a recurring error where the MK21 system believes it is in PROGRAM mode instead of RUN mode. The toggle for PROGRAM/RUN mode is an internal jumper across two of three pins on the board. Upon inspection we confirmed the jumper is in the RUN configuration and was not in the PROGRAM configuration. We are currently awaiting the new firmware from Lockheed Martin.

March 23

Firmware downloaded from Lockheed Martin for the MK21 was uploaded after pulling the unit from the rack and moving the jumper to PROGRAM mode. Upon reboot with the jumper returned to the RUN position, the unit was functioning normally. AXBT launcher and XBTs working normally. The spare MK21 unit is still scheduled to arrive in Puerto Rico and will be kept on board. Mapping continues, with reduced data quality due to sea conditions. Telepresence support continues with a few minor interruptions in connectivity.

March 24

Mapping continues with data quality dependent on survey direction. Remote watchstanding continues to function adequately, though streaming resolution has added some challenges - remote watchstanders report reading instrumentation numbers is sometimes challenging.

March 25

Mapping operations continue, following a route planned to add coverage over several holidays in the existing data. Conditions and data quality vary with weather direction. No additional updates.

March 26

After completing holiday coverage, we resumed mapping on east-west lines, building coverage to the south. Cross-track line has been planned to cross existing data once the ship turns to head north and into port. Remote watchstanding continues to be effective for augmenting onboard personnel.

March 27

Turned at 0400 to perform a cross-line and began transit to San Juan. Sonars secured once we reached shallow waters and began navigating through previous coverage. Post-processing and QA/QC work continues through transit.

March 28

Arrival in San Juan, Puerto Rico.