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Mapping Data Acquisition and Processing Summary Report

EX-22-03: Puerto Rico Mapping and Deep-Sea Camera Demonstration (Mapping and Tech Demonstration)

San Juan, Puerto Rico to Newport, Rhode Island

April 4-28, 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 the Puerto Rico Mapping and Deep-Sea Camera Demonstration expedition, EX-22-03, and to present a summary of mapping results and operations. A separate report detailing non-mapping operations, including a deep-sea camera demonstration, is archived as a separate expedition report.[1]

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 archived in the NOAA Central Library.[2]

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[3] and also available from the website.[4]

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[1] https://doi.org/10.25923/hd6d-sn86

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

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

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

Expedition Overview

From April 4 - 28, 2022, NOAA Ship *Okeanos Explorer* sailed for NOAA Ocean Exploration's Puerto Rico Mapping and Deep-Sea Camera expedition (EX-22-03). The ship departed from San Juan, Puerto Rico. The mission objectives were two-fold: seafloor mapping in U.S waters offshore of Puerto Rico and testing deep-sea camera systems developed by the Multidisciplinary Instrumentation in Support of Oceanography (MISO) Facility at the Woods Hole Oceanographic Institution (WHOI) for potential integration into future NOAA Ocean Exploration operations. The primary mapping area of the expedition was the Muertos Trough region and surrounding areas in U.S. Caribbean waters around Puerto Rico. Upon completion of mapping in the priority areas, the expedition focused on testing the integrated deep-sea camera and conductivity, temperature, and depth (CTD) system to support several mission objectives through simultaneous imaging and sampling of the water column. In addition, a transit over the 8,000 m deep Puerto Rico Trench was used to test the limits of the new Kongsberg EM 304 MKII multibeam sonar that was installed in 2021. The last portion of the expedition consisted of mapping the high seas and offshore waters of the U.S. East Coast while transiting to the destination of Newport, Rhode Island.

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 supports the National Strategy for Mapping, Exploring, and Characterizing the United States Economic Zone and Seabed 2030.

The complete objectives for this expedition are detailed in "Project Instructions: EX-22-03 Puerto Rico Mapping and Deep-Sea Camera Demonstration (Mapping)", which is archived in the NOAA Central Library.[5]

[5] https://doi.org/10.25923/81bm-3t26

Operational Personnel

EX-22-03 included onboard operational personnel, inclusive of ship's force and mission team, who participated in operational execution (see **Table 1**).

Table 1. EX-22-03 Onboard personnel.

Name	Role	Affiliation	Dates Aboard
Shannon Hoy	Expedition Coordinator	NOAA Ocean Exploration (FW)[1]	4/02 – 4/29
Katharine Egan	Science Coordinator	NOAA Ocean Exploration	4/02 – 4/29
Caitlin Ruby	GIS Lead	NOAA NCEI[2]	4/02 – 4/29
Marshall Swartz	Engineer	WHOI[3]	4/02 – 4/29
Charles Wilkins	Senior Survey Tech	OMAO[4]	4/02 – 4/29
Dan Freitas	Mapping Watch Lead	UCAR[5]	4/02 – 4/29
Marcel Peliks	Mapping Watch Lead	UCAR[5]	4/02 – 4/29
Treyson Gillespie	Mapping Watch Lead	UCAR[5]	4/02 – 4/29
Chris Wright	Data Engineer	GFOE[6]	4/02 – 4/29
Fernando Aragon	Data Engineer	GFOE[6]	4/02 – 4/29
Roland Brian	Video Engineer	GFOE[6]	4/02 – 4/29
Brian Doros	Video Engineer	GFOE[6]	4/02 – 4/29
Liang Wu	Knauss Fellow	NOAA Ocean Exploration	4/02 – 4/29
Cassie Ferrante	Explorer in Training	UCAR[5]	4/02 – 4/29
Paige Hoel	Explorer in Training	UCAR[5]	4/02 – 4/29

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[3]Woods Hole Oceanographic Institution
[4]NOAA Office of Marine and Aviation Operations
[5]University Corporation for Atmospheric Research
[6]The Global Foundation for Ocean Exploration

Summary of Mapping Operations

NOAA Ocean Exploration mapped 44,160 square kilometers (sq km) of seafloor during the 25 days at sea for EX-22-03. Of the 44,160 sq km mapped, 41,766 sq km were deeper than 200 meters (m) and within the U.S. Exclusive Economic Zone and Territorial Sea. Multibeam bathymetry data coverage is shown in **Figure 1.**

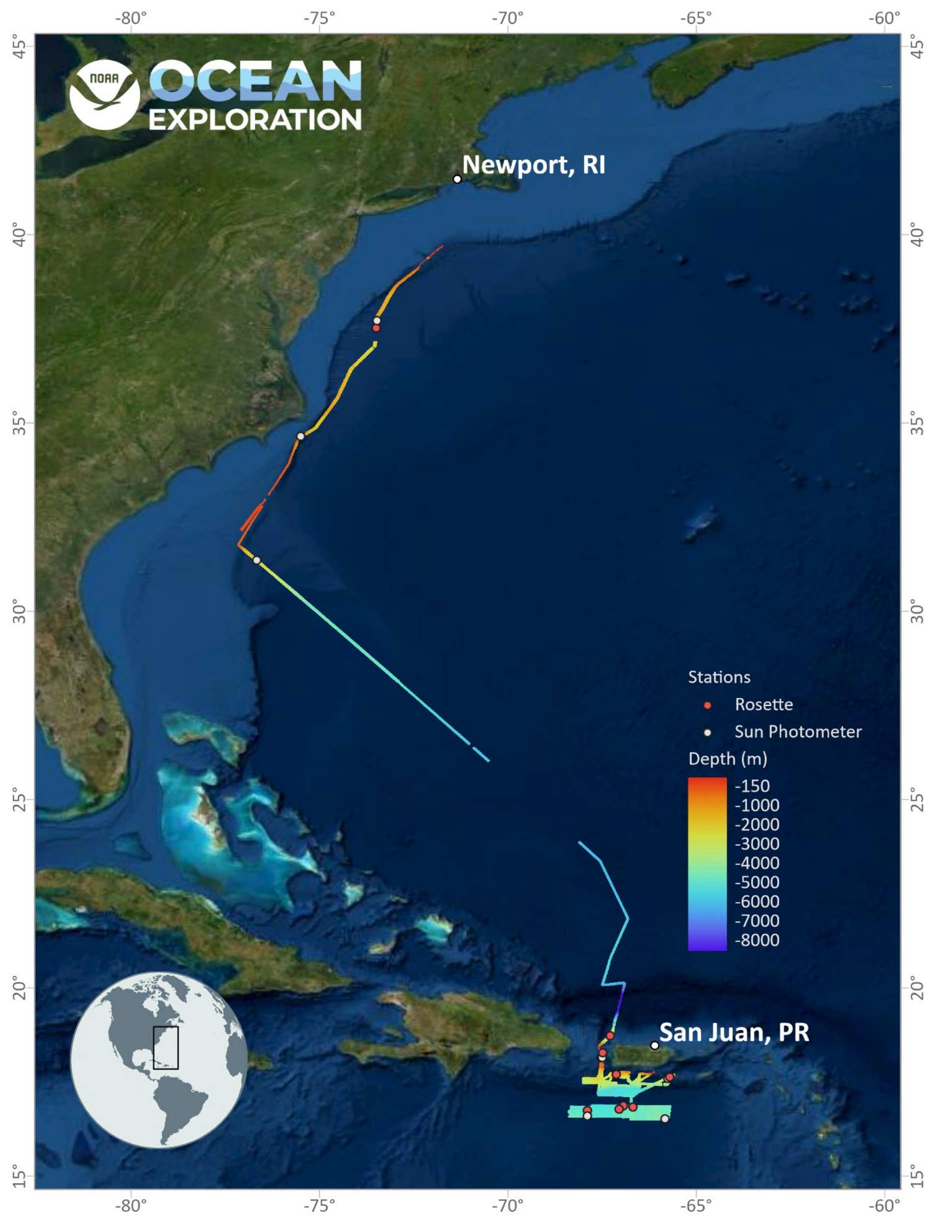

Figure 1. Overview of bathymetric mapping coverage and stations (deep-sea camera casts (red circle) and sun photometer measurements (white circle)) completed during Puerto Rico Mapping and Deep-Sea Camera Demonstration (EX-22-03).

Mapping Statistics

Table 2 provides summary statistics of ocean mapping work during EX-22-03, April 4 - 28, 2022 (UTC).

Table 2. Summary statistics of ocean mapping work during EX-22-03.

Statistic	Value
Ship's draft*: Start of expedition (04/04/2022) End of expedition (04/28/2022)	 Fore: 15' 10.5''; Aft STBD: 15' 9"; Aft Port: 15' 10" Fore: 15' 10.5"; Aft STBD: 15' 5"; Aft Port: 16' 2"
Linear kilometers of survey with EM 304	3,838
Square kilometers mapped with EM 304	44,160
Square kilometers mapped with EM 304 within U.S. waters deeper than 200 m	41,766
Number/data volume of EM 304 raw multibeam files (.kmall)	577 files/69.5 GB
Number/data volume of EM 304 water column multibeam files (.kmwcd)	574 files/171 GB
Number/data volume of EK60/EK80 water column split-beam files (.raw)	664/130 GB
Number/data volume of sub-bottom sonar files (.segy, .kea, .keb)	771/3.5 GB
Number of expendable bathythermograph (XBT) casts	128
Number of conductivity, temperature, depth profiler (CTD) casts (including test casts)	10**

*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.

** See the associated expedition report for more information about the deep-sea camera stations. The CTD data were not applied to the mapping data.

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.

Due to schedule constraints, the EK60/EK80s were not calibrated during the annual shakedown. The 200, 120, 70, and 38 kHz were successfully calibrated during a following expedition, EX-22-04. At the time of writing this report the 18 kHz has not been calibrated. Any calibration reports produced throughout the field season will be added to the 2022 Readiness Report as supporting documents.[6]

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

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

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

Standard data acquisition included 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 deep-sea camera operations, the EM 304 multibeam and Knudsen sub-bottom profiler were secured to allow for the ADCPs and the entire suite of EK split-beam sonars to acquire data.

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 the 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 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.

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);

application of roll, pitch, and heave motion corrections obtained by the POS MV 320 V5 inertial position and orientation system. Throughout this expedition the POS MV 320 V5 was set as the primary positioning and attitude system. 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). Surface sound speed values collected from the Teledyne Reson SVP-70 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, including during deep-sea camera casts. Data were collected using standard settings (as detailed in the mapping procedures manual). 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.

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; SVP Crossfade (60 seconds)" 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 2** shows the onboard multibeam data processing workflow.

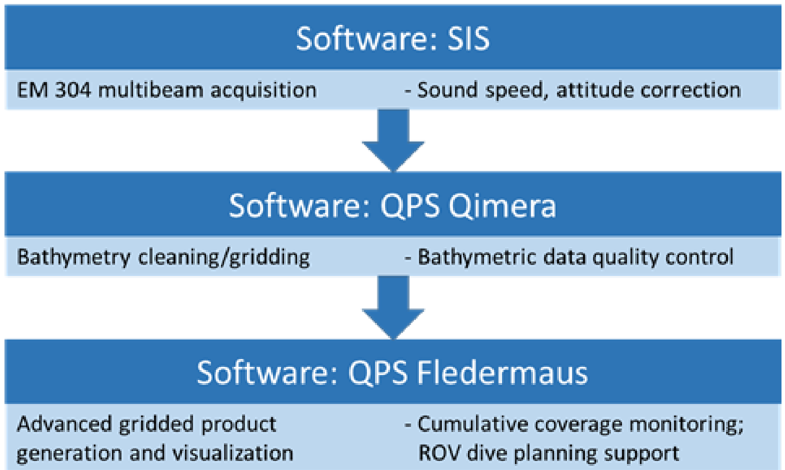

Figure 2. Shipboard multibeam data processing workflow.

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 were 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 April 12, 2022, as shown in **Figure 3**, and the results are presented in **Table 3**.

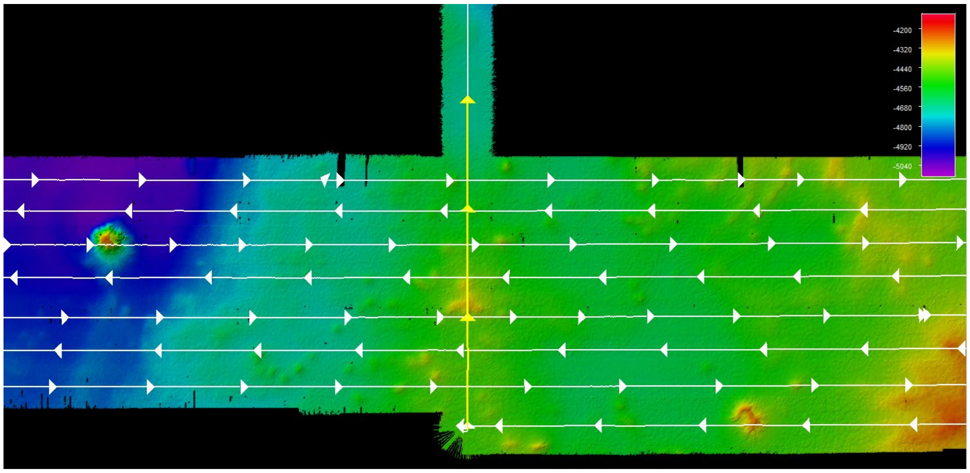

Figure 3. EX-22-03 crossline (shown in yellow) used for comparison against the bathymetric grid generated via orthogonal multibeam survey lines.

Crossline files: 0153_20220412_001732.kmall - 0155_20220412_021732.kmall
Mainscheme line files: 0000_20220405_123906_EX2203_MB.kmall - 0163_20220412_072122_EX2203_MB.kmall

Table 3. Crosscheck results.

Statistic	Value
Number of points of comparison	773916
Grid cell size (m)	100.00
Difference mean (m)	-8.618340
Difference median (m)	-7.333085
Difference standard deviation (m)	6.093057
Difference range (m)	[-64.32, 214.82]
Mean + 2* standard deviation (m)	20.804453
Median + 2* standard deviation (m)	19.519199
Data mean (m)	-4538.074034
Reference mean (m)	-4529.455694
Data z-range (m)	[-4717.38, -4232.13]
Reference z-range (m)	[-4705.61, -4315.58]
Order 1 error limit (m)	58.885048
Order 1 # rejected	6
Order 1 p-statistic	0.000008
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 4 provides a list of the acquisition and processing software versions that were used during EX-22-03.

Table 4. Versions of acquisition and processing software used during EX-22-03.

Software	Purpose	Version
SIS	EM 304	5.7.0 5.9.3 (after 04/22/2022)
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	2.4.8
FMGT	Backscatter	7.10.1
FMMidwater	Water Column	7.9.4
Sound Speed Manager	Sound Velocity Profiles	2022.1.0
NRCan (SegJp2)	Sub-bottom	1.0
Fledermaus 7	Visualization/Data Analysis	7.8.12

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-22-03, 2022 Puerto Rico Mapping and Deep-sea Camera Demonstration”, 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 5-9** 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 5. 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 6. 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, processing unit parameters, recorded telnet sessions	.xlsm, .xlsx, .txt

Table 7. 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 8. 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 9. 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 and in Google Earth format, any associated calibration files	.xlsm, .xlsx, .shp, .kml, .cal, .xml, .pdf

All sonar data are permanently discoverable within the NCEI archives[7] and searchable through the Ocean Exploration Digital Atlas,[8] 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 10**. For any challenges accessing data, send an inquiry to NCEI,[9] or contact the Ocean Exploration Mapping Team.[10]

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

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

[9] ncei.info@noaa.gov

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

Table 10. Locations of data collected during EX-22-03 (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 (Kmalls) 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

Table 11. EX-22-03 schedule.

Date (UTC)	Activity
03/29	WHOI mission personnel arrived to begin mobilization of the deep-sea camera system.
03/30	Mobilization of the deep-sea camera system continued.
03/31	Mobilization of the deep-sea camera system continued.
04/01	Mobilization of the deep-sea camera system continued.
04/02	The remaining mission personnel moved aboard the ship.
04/03	Mobilization of remaining mission systems was completed.
04/04	Departed San Juan, Puerto Rico, and transited to priority mapping area south of Puerto Rico.
04/05	Survey operations begin. First rosette test cast to 100m (ROS01).
04/06	Mapping in priority area south of Puerto Rico.
04/07	Mapping in priority area. Second rosette test cast to 50m (ROS02).
04/08	Mapping in priority area. ROS03 deployment to 1000m.
04/09	Mapping in priority area.
04/10	Mapping in priority area.
04/11	ROS04 deployment to 1545m. Mapping to fill gaps south of Puerto Rico.
04/12	ROS05 deployment to 1004m. Mapping to fill gaps south of Puerto Rico.
04/13	Mapping to fill gaps in NCEI data south of Puerto Rico.
04/14	Mapping to fill gaps in NCEI data south of Puerto Rico.
04/15	Two camera deployments (ROS06 and ROS07) including one towed. Mapping to fill gaps south of Puerto Rico.
04/16	Mapping to fill gaps south of Puerto Rico. ROS08 deployment.
04/17	ROS09 deployment to 475m, towed for 300m.
04/18	Mapping to fill gaps south of Puerto Rico, begin transit to north of Puerto Rico.

Date (UTC)	Activity
04/19	ROS10 to 1480m, towed approximately 450m. Begin transit mapping north to EEZ boundary.
04/20	Mapping the EEZ of Puerto Rico and the Dominican Republic.
04/21	Transit mapping to the Blake Plateau.
04/22	Transit mapping to the Blake Plateau.
04/23	Transit mapping to the Blake Plateau.
04/24	Mapping on the Blake Plateau.
04/25	Transit mapping on the Blake Plateau.
04/26	Transit mapping and CTD verification (ROS11).
04/27	Transit mapping. Held station in port overnight due to weather.
04/28	Arrival in Newport, Rhode Island.
04/29	Mission personnel depart.

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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).

Mobilization

The expedition coordinator received information that the planned mapping area for EX-22-03 was recently mapped by the R/V Armstrong (within the last month). The expedition coordinator worked to amend plans to continue mapping south of Puerto Rico, picking up where EX-22-02 concluded. The expedition coordinator corresponded with the shore team to ensure that new operations remained in compliance with permits.

All QPS software was updated to the newest version. Sound speed manager was also updated.

April 4

All surveys were set up after departing port. During the transit from port, ADCP data were attempted, however, the WH300 would not start and likely relates to the issues seen at the beginning of the season. The expedition coordinator reached out to UHDAS for further troubleshooting guidance.

The initial built-in-systems-test (BIST) of the EM 304 revealed that the SIS and/or processing unit (PU) software is out of date. The expedition coordinator contacted Kongsberg to receive installation files that are planned to be installed during the Newport inport. The EM 304, EK60/80, and Knudsen are operating normally.

April 5

Mapping continued south of Puerto Rico, conditions remain fair for data quality.

The WH300 was still unable to start up and not available for deep-sea camera operations. The Chief ET (CET) and Senior Survey Technician (SST) are investigating connections and the expedition coordinator is corresponding with UHDAS.

After resuming survey operations following the deep-sea camera dunk test, SIS restarted without warning. The mapping team will monitor for recurring behavior.

SIS and Sound Speed Manager (SSM) occasionally lose communication and the machines must be restarted for SSM to successfully receive datagrams.

April 6

Mapping continues in the priority area.

QPS is having some strange GUI errors where it looks like there is no data in the grid when that is not the case. The expedition coordinator has reached out to QPS.

The EKs were not getting position information due to an incorrect baud rate set for the POS MV per SOP. This has been fixed and the SOPs have been updated.

The Seapath has been cycling through “Safe”, “Caution,” and “Unsafe” modes and the skyplot shows that satellite constellations are not being received during the “Caution” and “Unsafe” instances. SIS is warning that Attitude 1 is “BAD” during these times, but this does not affect the data since the POS is set as the primary attitude and positioning sensor. The system was restarted but the issue returned almost immediately. One suspected reason is that the unit shows that the Marinestar subscription for the Seapath test has expired (though the unit should function without the correctors). Kongsberg requested an extension and the issue temporarily abated, however it returned later in the evening. Around 2030 the ship took a hard turn and the positioning feed completely dropped out (which could be coincidental) and was unable to be recovered. The CET, SST, and expedition coordinator are in communication with Kongsberg for troubleshooting but suspect an issue with a physical connection to an antenna.

One small kmall file is missing from the network and the local computer, the EC is investigating the cause.

UHDAS flagged that the UHDAS server clock was 14-15 seconds ahead of the GGA timestamps from the POS MV and the GP170. The CET rebooted the server which corrected the issue and will monitor for drift.

April 7

Continued mapping with favorable conditions.

The multibeam and EK 80 kHz were showing about 100 m difference in depth. The water column sound speed in EK80 was changed from “Calculated” to “Manual” and updated to the harmonic sound speed from the most recent XBT cast. The two are now within 10m of each other.

Relevant SOPs have been updated.

The Seapath is back online after a hard restart. More work to investigate the termination of the antennas is planned for Newport.

April 8

Mapping continues. The team is working on SOPs, including creating a Sound Speed Profile "Quick Guide."

The WH300 worked when setting up for the deep-sea camera station, the cause of the return of functionality is unknown, and the CET and SST continue to investigate.

April 9

SIS crashed again without warning. Hopefully, the new versions that will be installed prior to the next mission will fix this behavior.

April 10

SIS lost communication to sonar. Pinging was still active in K-Control, but K-Sync repeatedly put EM 304 into Standby Mode. Issue resolved with PU restart, computer restart, and resuming typical system setup K-Sync.

A significant cross-track error has been observed in Hypack, it is minimal at the edges of the UTM zone and grows towards the center of the UTM zone (up to 500 m). After pursuing numerous troubleshooting steps (including installing Hypack 2022), the matter remains unresolved. The expedition coordinator has reached out to Hypack for support.

April 11

Seapath acquisition is now accessible via the keyboard-video-mouse (KVM) system.

April 12

The EKs are unable to ping faster than 7.5 seconds, which is greatly slowing down the ping cycle of the multibeam in shallower waters. The EC and team have investigated all known methods for improving the ping cycle, but have yet to determine the cause. Troubleshooting will continue.

The EC has submitted a ticket to QPS regarding the display issues in Qimera 2.4.6 and 2.4.7. These issues are completely hindering processing and the team has had to revert back to 2.4.1 which has known issues with exporting GSFs.

April 13

Mapping continued closing gaps in bathymetric coverage in the NCEI archives. Weather conditions are poor, but data quality is fair (especially when traveling westward).

April 14

Mapping continued closing gaps in bathymetric coverage in the NCEI archives. Weather conditions are poor, but data quality is fair (especially when traveling westward).

April 15

SIS crashed without warning following the deep-sea camera station. After restarting the PU, data quality was poor and the waterfall display showed high ambient noise. The PU was again restarted and the data quality returned to expected levels.

The source of the EK long ping was discovered. After isolating each EK by iteratively uninstalling each transceiver, the issue was isolated to the EK 38 kHz. The EC uninstalled and reinstalled the 38 kHz transceiver and normal ping cycles resumed.

The EC (with the help of GFOE) was able to set up the live position of the rosette coming into Fledermaus. This situational awareness was invaluable during the towing operation.

April 16

SIS crashes continue, especially soon after restarting the processing unit.

All processing is up-to-date, including reviewing the EM 304 water column for seeps.

April 17

SIS crashed again without warning after startup.

Seeps were observed in the EK data while crossing the Mona Passage.

April 18

Conditions were suboptimal for data quality.

April 19

Following the rosette cast, mapping operations focused on mapping the EEZ border of Puerto Rico and the Dominican Republic. Data quality is fair due to rough seas.

QPS released a new version of Qimera (2.4.8) to address bugs flagged last week. The new version has been installed and the mapping team will be evaluating its functionality tomorrow.

April 20

All systems are operating as expected.

April 21

The mapping team attempted to update SIS to the newest version (5.9.3). After updating, SIS would not start and hung up at the initializing graphical user interface (GUI) step. The EC reached out to Kongsberg and performed numerous troubleshooting steps, including rolling back the SIS version, all with no success.

Kongsberg Norway plans to remote in at 0200 to determine and fix the issues.

April 22

Troubleshooting with Kongsberg Norway was successful and we were able to get SIS up and running. The culprit ended up being that the driver for the graphics card for the hydrographic workstation was too out of date. We are now running SIS 9.5.3 and everything seems functional except for displaying the 'depth tail.'

Transit mapping continues, the seas are following and the data quality is good.

April 23

Transit mapping continues and all systems are operating normally.

April 24

Transit mapping continues, the seas have abated and data quality is good. XBT frequency has increased to mitigate the Gulf Stream.

April 25

Transit mapping continues. All systems operating as expected.

April 26

Transit mapping continues and data quality is good.

A 2300m cast was conducted using the reintegrated ship CTD rosette, SBE 9plus sensor suite, and all 10L Niskin bottles. During descent, specific focus was taken between the 1000-1100m depths, where the WHOI Drop Cam setup had intermittent telemetry interruptions during its last two casts. No similar interruptions occurred during this cast, nor were any physical flaws noticed on the cable wind by the observer at the winch. All Niskin bottles fired and continue to properly retain water. An issue to note, one of the sensor suite's two SBE 4 Conductivity sensors was found to be improperly functioning during pre-cast deck tests, and subsequently not utilized for this cast. Since there is still one integrated Conductivity sensor on the unit, this is not necessarily a show-stopper. If/when needed, a Conductivity sensor can be taken off the recently calibrated spare CTD suite that will be on board from Newport onward.

April 27

Preliminary data prep and quality assurance on mapping specific data as all ingest for mapping has been stopped. Minor cleanup thus far, but no major issues to report.

No other issues to report, currently all data systems are operating as expected.