

Mapping Data Acquisition and Processing Summary Report

NF-21-06: Exploration Mapping - Blake Plateau

Charleston, South Carolina to Charleston, South Carolina

July 27th – August 5th, 2021

Authors:

Treyson Gillespie¹

¹University Corporation for Atmospheric Research

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NOAA Ocean Exploration
1315 East-West Highway
Silver Spring, MD 20910

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Introduction

NOAA Ocean Exploration is dedicated to exploring the unknown ocean, unlocking its potential through scientific discovery, technological advancements, and data delivery. By working closely with partners across public, private, and academic sectors, we are filling gaps in our basic understanding of the marine environment. This allows us, collectively, to protect ocean health, sustainably manage our marine resources, accelerate our national economy, better understand our changing environment, and enhance appreciation of the importance of the ocean in our everyday lives.

With priority placed on exploration of deep waters and the waters of the U.S. Exclusive Economic Zone, NOAA Ocean Exploration applies the latest tools and technologies to explore previously unknown areas of the ocean, making discoveries of scientific, economic, and cultural value. By making collected data publicly available in increasingly innovative and accessible ways, we provide a unique and centralized national resource of critical ocean information. And, through live exploration video, online resources, training and educational opportunities, and public events, we share the excitement of ocean exploration with people around the world and inspire and engage the next generation of ocean scientists, engineers, and leaders.

Report Purpose

The purpose of this report is to briefly describe the acoustic seafloor, water column, and mapping data collection and processing methods used by NOAA Ocean Exploration on NOAA Ship *Nancy Foster* during Exploration Mapping - Blake Plateau, NF-21-06, and to present a summary of mapping results and mapping-related expedition activities.

For further information about equipment calibration procedures and data acquisition, please contact chiefst.nancy.foster@noaa.gov.

Expedition Overview

This expedition provided exploratory mapping data focused on areas generally deeper than 200 meters (m) in U.S. waters off of the U.S. East Coast and within the Blake Plateau. Mapping priorities included the acquisition of bathymetric and seabed backscatter data to fill coverage gaps in support of the National Ocean Mapping, Exploration, and Characterization (NOMECE) strategy goal to map U.S. waters deeper than 40 m by 2030. This was accomplished through continual 24-hour mapping efforts using the Kongsberg EM 710 multibeam sonar and the EK 60 (38, 120, 200 kilohertz (kHz)) sonars onboard NOAA Ship *Nancy Foster*.

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 will provide 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 and Bureau of Ocean Energy Management, as well as international partners from Canada and Europe. The complete objectives for this expedition are detailed in “Project Instructions: NF-21-06 Blake Plateau (Mapping),” which is archived in the NOAA Central Library.¹

Operational Personnel

NF-21-06 included onboard operational personnel, inclusive of ship’s force and expedition team, who participated in operational execution, and shore-based personnel (who participated remotely via telepresence) (see **Tables 1** and **2**).

Table 1. NF-21-06 Onboard personnel.

Name	Role	Affiliation	Dates Aboard
Treyson Gillespie	Project Operations Lead (offshore)	NOAA Ocean Exploration (UCAR) ¹	07/26 – 08/05
Samantha Martin	Chief Survey Tech	NOAA Ship <i>Nancy Foster</i> ²	07/26 – 08/05
Benjamin Barbee	Survey Tech	NOAA Ship <i>Nancy Foster</i> ²	07/26 – 08/05
LT Pete Gleichoff	Operations Officer	OMAO ³	07/26 – 08/05

¹University Corporation for Atmospheric Research

²Wage Mariners for NOAA Ship *Nancy Foster*

³NOAA Office of Marine and Aviation Operations

Table 2. NF-21-06 Shore-based personnel.

Name	Role	Affiliation
Meme Lobecker	Chief Scientist (onshore)	NOAA Ocean Exploration (CF) ¹

¹Cherokee Federal, at NOAA Ocean Exploration and Research

¹ <https://doi.org/10.25923/nq5j-3s02>

Summary of Mapping Operations

NOAA Ocean Exploration mapped 2539 square kilometers (sq km) of seafloor on the Blake Plateau during the 10 days at sea for NF-21-06. Of the 2539 sq km mapped, 2376 sq km were deeper than 200 m and within the U.S. Exclusive Economic Zone and Territorial Sea. Multibeam bathymetry data coverage for the expedition is shown in **Figure 1**.

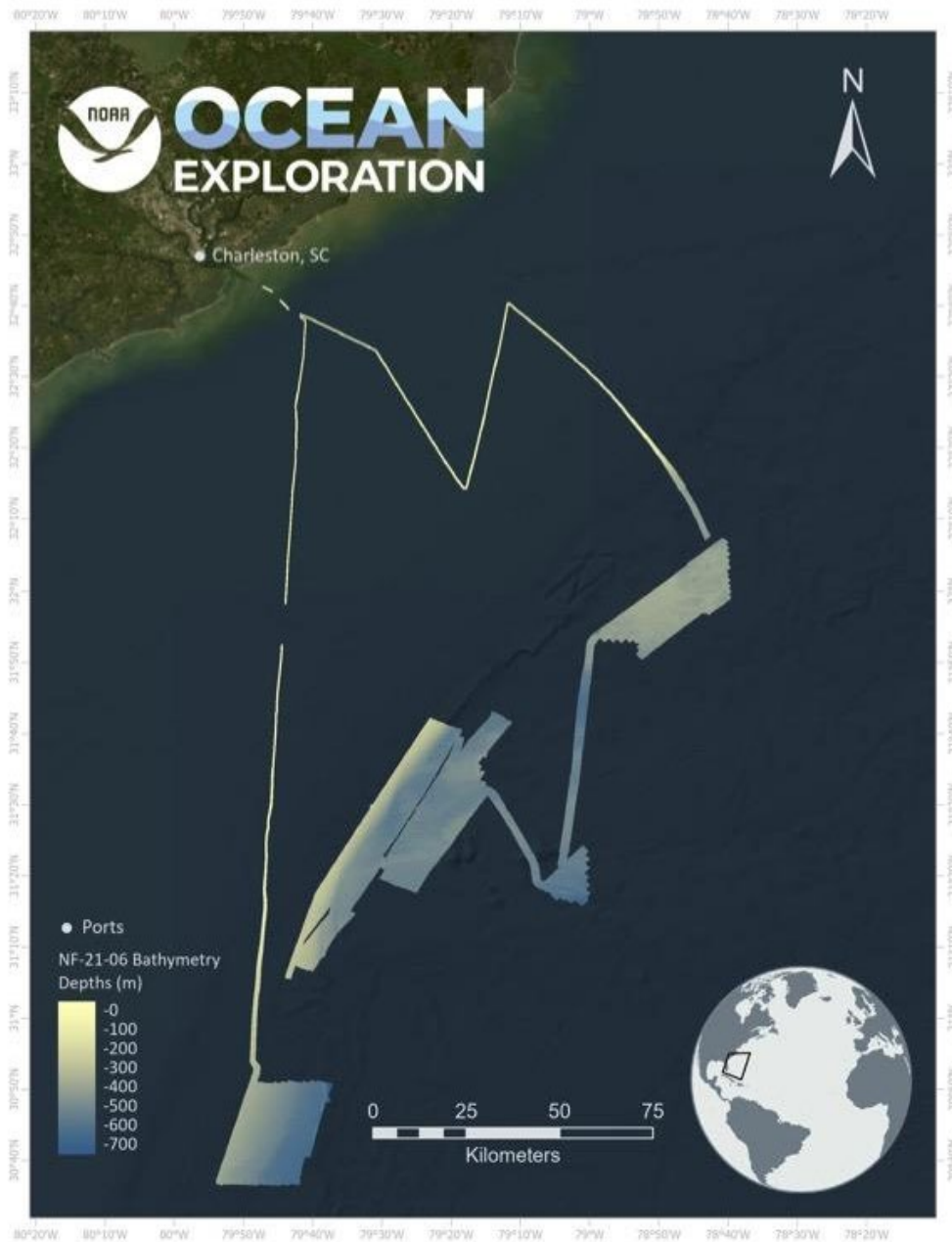


Figure 1. Overview of bathymetric mapping coverage completed during Exploration Mapping - Blake Plateau (NF-21-06).

Mapping Statistics

Table 3 provides summary statistics of ocean mapping work during NF-21-06 from July 27th to August 5th, 2021 (UTC).

Table 3. Summary statistics of ocean mapping work during NF-21-06.

Statistic	Value
Ship's draft*: Start of expedition (07/27/2021)	Fore: 10' 9"; Aft STBD: 10' 11"; Aft Port: 10' 11
Linear kilometers of survey with EM 710	218.9 km
Square kilometers mapped with EM 710	2,539 km ²
Square kilometers mapped with EM 710 within U.S. waters deeper than 200 m	2,376 km ²
Number/data volume of EM 710 raw multibeam files (.kmall)	211 files / 33.7 GB
Number/data volume of EM 710 water column multibeam files (.kmwcd)	194 files / 180 GB
Number/data volume of EK60 water column split-beam files (.raw)	149 files / 6.39 GB
Number of underway conductivity, temperature, depth profiler (UCTD) and Rapid Sound Velocity Profiler (RSVP) casts	78

Mapping Sonar Setup

Kongsberg EM 710 Multibeam Sonar

NOAA Ship *Nancy Foster* is equipped with a 40-100 kHz Kongsberg EM 710 multibeam sonar, capable of detecting the seafloor in up to 2,800 meters of water. The nominal transmit (TX) alongtrack beamwidth is 0.5° and the nominal receive (RX) acrosstrack beamwidth is 1.0°. The system can generate a 140° beam fan (70° port/70° starboard maximum angles), containing 256 beams. The multibeam sonar is used to collect seafloor bathymetry, seafloor backscatter, and water column backscatter.

Simrad EK60 Split-Beam Sonars

The ship is equipped with a suite of Simrad EK60 split-beam fisheries sonars: 38, 120 , and 200 kHz. These systems are quantitative scientific echosounders that can be calibrated to identify the target strength of water column acoustic reflectors, typically biological scattering layers, fish, or gas bubbles, providing additional information about water column characteristics and anomalies.

These sonars were calibrated during expedition NF-21-04 and those calibration values were applied to the EK sonars for NF-21-06.

Teledyne Acoustic Doppler Current Profilers

An acoustic Doppler current profiler (ADCP), Teledyne Ocean Surveyor (38 kHz), is installed on the ship. Depending on environmental conditions, 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.

Data Acquisition Summary

Survey operations included the EM 710 and EK60 (38, 120, and 200 kHz) sonars, with these sonars running concurrently using the EK60's synchronization mode, with the EM 710 set as the master. The synchronization delay was manually adjusted based on water depth to minimize acoustic interference across the sonars.

Multibeam survey lines were planned to maximize either edge-matching of existing bathymetric data or data gap infill of areas with existing bathymetric coverage. In regions with no existing data, lines were planned to optimize 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. Angles in Kongsberg's Seafloor Information Systems (SIS) software 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.

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 Teledyne Ocean Sciences Underway CTD and Valeport RapidPro sound velocity profiler, 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 less 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 split-beam water column sonar data were collected throughout the majority of the expedition. EK60 data were monitored in real-time for quality but were not post-processed.

Bathymetric Data Processing and Quality Assessment

The bathymetry data were generated using a Kongsberg EM 710 multibeam system, and recorded using SIS software as *.all files. Collocated to the bathymetric data, bottom backscatter data were collected and stored within the *.all 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 *.wcd files.

The full-resolution multibeam .all 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 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 processing log. Gridded digital terrain models were created using the weighted moving average algorithm and were exported in multiple formats using QPS Fledermaus software. **Figure 2** shows the onboard multibeam data processing workflow.

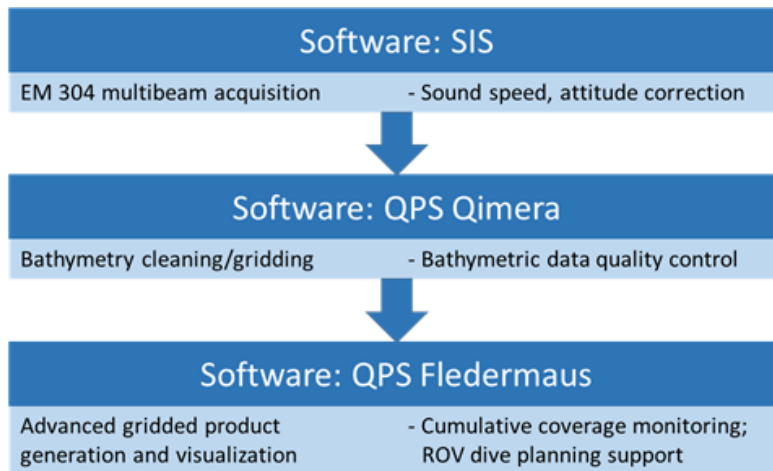


Figure 2. Shipboard multibeam data processing workflow (right).

On shore, a final quality check of the data using QPS Qimera and Fledermaus software was performed. 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 overlapping 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 software. 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

Crosslines were run across each priority mapping area, as shown in **Figure 3**, and the results are presented in **Tables 4**.

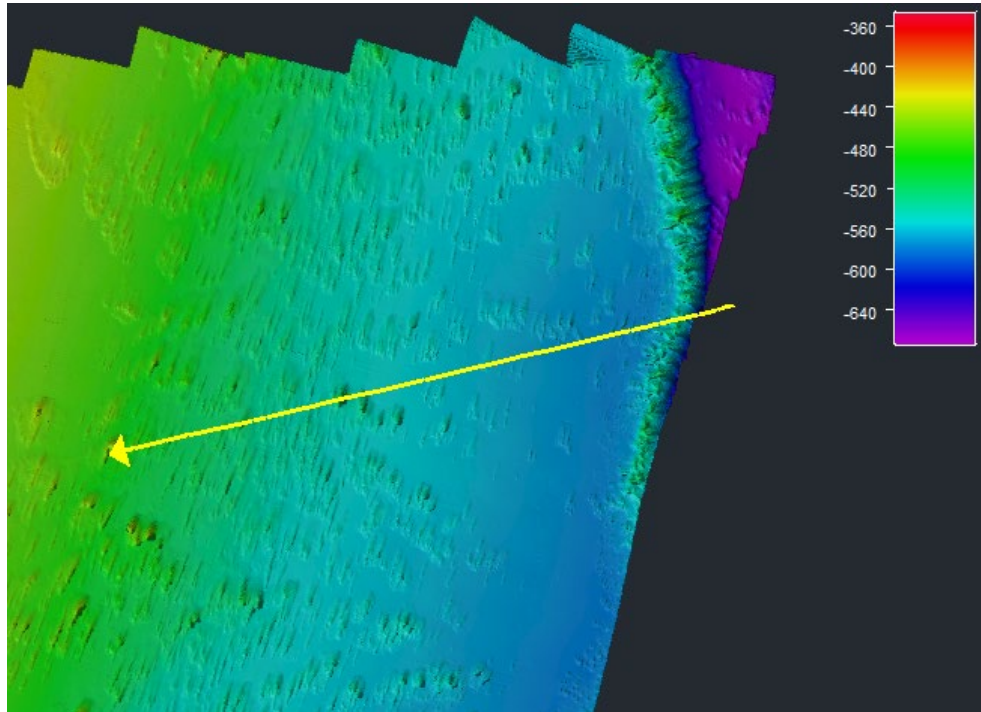


Figure 3. NF-21-06 crossline (shown in yellow) used for comparison against the bathymetric grid generated for Priority Mapping Area 1 via overlapping multibeam survey lines.

Crossline file:

- 0051_20210729_121953_NancyFoster_EM710.gsf

Mainscheme line files:

- 0035_20210728_224340_NancyFoster_EM710.gsf
- 0039_20210729_020912_NancyFoster_EM710.gsf
- 0040_20210729_032025_NancyFoster_EM710.gsf
- 0044_20210729_063310_NancyFoster_EM710.gsf
- 0045_20210729_073950_NancyFoster_EM710.gsf
- 0050_20210729_113145_NancyFoster_EM710.gsf

Table 4. Priority Mapping Area 1 Crosscheck results.

Statistic	Value
Number of points of comparison	550,199
Grid cell size (m)	15.00
Difference mean (m)	0.283
Difference median (m)	0.208
Difference standard deviation (m)	1.073
Difference range (m)	[-10.844, 14.930]
Mean + 2* standard deviation (m)	2.428
Median + 2* standard deviation (m)	2.353
Data mean (m)	-545.468
Reference mean (m)	-545.752
Data z-range (m)	[-651.745, -465.021]
Reference z-range (m)	[-649.293, -466.468]
Order 1 error limit (m)	7.11237
Order 1 # rejected	88
Order 1 p-statistic	.000159942
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 NF-21-06.

Table 5. Versions of acquisition and processing software used during NF-21-06.

Software	Purpose	Version
SIS	EM 710	4.3.2
EK80	EK suite	1.12.4
Qimera	Bathymetry	2.3.1
FMGT	Backscatter	7.9.5
FMMidwater	Water Column	7.9.3
Sound Speed Manager	Sound Velocity Profiles	2021.2.0
Fledermaus 8	Visualization/Data Analysis	8.3.1

Data Archiving Procedures

All mapping data collected by NOAA Ocean Exploration on NOAA Ship *Nancy Foster* were archived and are publicly available 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 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 710 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)	.all
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 710 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)	.wcd
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 8. EK38/EK120/EK200 split-beam echosounder dataset.

Level	Description	File Type
Level 00	Raw water column files provided in native sensor format (horizontal referencing = WGS84)	.raw, .idx
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. 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
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 is permanently discoverable within the NCEI archives² and searchable through the Ocean Exploration Data Atlas,³ 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,⁴ or contact the Ocean Exploration Mapping Team.⁵

² <https://www.ngdc.noaa.gov/>

³ <https://www.ncei.noaa.gov/maps/ocean-exploration-data-atlas/>

⁴ ncei.info@noaa.gov

⁵ oar.oer.exmappingteam@noaa.gov

Table 10. Locations of data collected during NF-21-06 (at the time of writing this report).

Data Type	Description	Location
EM 710 bathymetry and backscatter data	EM 710 bathymetry and backscatter data, supporting informational logs, and ancillary files are available through the NCEI Bathymetry Data Viewer	https://maps.ngdc.noaa.gov/viewers/bathymetry/
Water column data (EM 710 and EK60)	EM 710 and EK60 water column data, supporting data, and informational logs are available through the NCEI Water Column Sonar Data Viewer	https://www.ngdc.noaa.gov/maps/water_column_sonar/index.html
Sound speed profiles	Ancillary sound speed profiles are made available along with all mapping data per expedition in the NCEI data archives, or within the oceanographic archive for the expedition.	https://maps.ngdc.noaa.gov/viewers/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/browse?pid=noaa%3A4&parentId=noaa%3A4

Expedition Schedule

Table 11. NF-21-06 schedule

Date (UTC)	Activity
7/19 – 7/25	Expedition personnel sheltered in place at home.
7/26	Expedition personnel arrived to ship and began lodging onboard.
7/27	First day underway. Departed Charleston, SC in the morning. Transit mapping was performed during route to operational areas after passing sea buoy. Arrived to first survey area in the evening. Safety drills, including donning of survival suits were performed.
7/28-8/4	Focused mapping operations on the Blake Plateau.
8/5	Transit mapping to Charleston, SC was performed. Arrived at Charleston, SC sea buoy in the morning. Final data package assembled and two copies carried off ship on separate hard drives. Expedition personnel departed ship.

References

Hoy, S., Lobecker, E., Candio, S., Sowers, D., Froelich, G., Jerram, K., Medley, R., Malik, M., Copeland, A., Cantwell, K., Wilkins, C., and Maxon, A. (2020). Deepwater Exploration Mapping Procedures Manual. Office of Ocean Exploration and Research, Office of Oceanic and Atmospheric Research, NOAA, Silver Spring, MD 20910. <https://doi.org/10.25923/iw71-ga98>

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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 (-5 hours from UTC).

July 26th

Initial set up of data management files/systems and vessel familiarization were completed. Wifi/Network access was established, and a basic test map in Qimera was created using old bathymetry data to ensure the correct activation of softlock key.

The weather was slightly overcast with light showers.

July 27th

An initial dockside BIST test was performed using the EM710 (NF2106_EM710_DOCKSIDE_BIST_DN208.txt). Departed the Federal Law Enforcement Training Center (FLETC) in Charleston, SC at approximately 12:45 PM. Once past the sea buoy, the EM710 sonar and EK (38, 120, 200 kHz) sonars were turned on and logging/pinging was initiated for transit.

Transit went underway as expected with minor tech issues. Expected to begin survey of priority mapping area 1 tomorrow (07/27/2021) at approximately 0100 hours.

July 28th

Arrived on station and began mapping operations for priority mapping area 1 at approximately 07:30 UTC. Switched from World Ocean Atlas (WOA) synthetic SVP files to conducting UCTD and RSVP casts for sound velocity profiling. EM710 was put into DEEP mode at start of working grounds.

The ship experienced a POS MV dropout at 13:07 UTC. Reacquired line at 14:08 UTC. Dropout consistent with other POS MV dropouts across fleet simultaneously. Waited for POS MV system to cycle back online before continuing operations.

Debris was spotted in the water, ship broke line at 17:45 UTC, reacquired line at 18:14 UTC after retrieval of debris.

Mapping efforts continue normally at roughly 8 knots with little disruption. Data quality is good with 1-2 ft seas and 11 knot winds.

Tomorrow will continue mapping efforts for priority mapping area 1 before conducting cross-lines and proceeding to mapping area 2.

July 29th

Survey of priority mapping area 1 continued through the morning. Executed partial cross line before experiencing POS MV drop out at approximately 13:04 UTC. Abandoned cross lines for priority mapping area 1 and began transit to priority mapping area 2. Reacquired POS MV during transit to priority mapping area 2 (approx. 14:00 UTC) and began logging transit data until arrival on station at approximately 14:45 UTC.

Mapping efforts continue in priority mapping area 2. Data quality is good and weather is favorable with 1 – 2 ft. seas and winds between 4-9 knots.

Tomorrow will continue survey of priority mapping area 2.

July 30th

Survey of priority mapping area 2 continued today. No lines were broken and no POS MV drops were experienced. Data quality is good and weather is favorable with 1-2 ft. seas and 4-9 knot winds.

Tomorrow will continue mapping efforts of priority mapping area 2, followed by cross lines of priority mapping area 2, and transit to priority mapping area 3. Mapping efforts in priority mapping area 3 will begin once on station.

July 31st

Completed mapping efforts in priority mapping area 2 with two cross lines. Transited to priority mapping area 3 and began survey of priority mapping area 3. Broke line at beginning of polygon for engine maintenance for approximately 1 ½ hours, reacquired line and continued survey. Mapping efforts continue in this polygon.

Data quality is good, though some interference from EK sonars are noted in deeper portions of the survey. Weather has picked up some, but is still suitable for survey. Waves are a reasonable 2 – 4 ft. with winds between 17 and 23 knots.

Tomorrow will continue survey of priority mapping area 3.

August 1st

Completed mapping efforts in priority mapping area 3. Collected cross line data and filled areas of poor data density due to deteriorating weather conditions and main engine servicing (Only 1 of 2 Z-drives operable at the moment). EK's secured so as to limit interference with multibeam bathymetry collection due to weather (and lack of K-sync device to help with timing). Weather has picked up some with 22-27 knot winds and waves of between 3-5 ft. Will continue singlebeam collection when possible.

Tomorrow will transit to priority mapping area 4 and begin mapping efforts in the area.

August 2nd

Began transit to mapping area 4 after filling in areas of poor data density in priority mapping area 3. Mapping efforts began in mapping area 4 in the southwestern most corner of the polygon. Once polygon was completed, ship transited to northern most section of polygon to begin further mapping efforts in the area. Weather has settled some and data quality has improved with 1-3 ft. seas, and winds between 9 and 20 knots throughout the day. EK sonars are actively logging data again.

Tomorrow will continue mapping efforts in mapping area 4.

August 3rd

Mapping efforts continued in mapping area 4 until the arrival of inclement weather. Attempted to collect data as scattered storm systems passed by the vessel. CO made decision to head back into port, after checking weather reports, for vessel and crew safety. Winds ranged from 13 - 28 knots and waves were between 3 - 5 ft.

Will continue to transit back to Charleston anchorage until arrival at FLETC. Tomorrow will include data management tasks and copying of data to hard drives for shipping and transport.

August 4th

Arrived into inner anchorage of Charleston harbor at approximately 7 AM (EST). Collected multibeam transit data until the Charleston sea buoy. Data management and finalization of logs/deliverables completed today. Will continue to moor in inner anchorage until moving to pier at FLETC at approximately 7 AM (EST).