Ocean Exploration and Research

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MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

CRUISE EX-18-05

East Florida and DEEP SEARCH Mapping
Mayport, Florida to Charleston, South Carolina
May 22 – June 06, 2018

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1. Introduction

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

Using the latest tools and technology, OER **explores** previously unknown areas of our deep ocean, making discoveries of scientific, economic, and cultural value. Through live video streams, online coverage, training opportunities, and real-time events, OER allows scientists, resource managers, students, members of the general public, and others to actively **experience** ocean exploration, expanding available expertise, cultivating the next generation of ocean explorers, and engaging the public in exploration activities. From this exploration, OER makes the collected data needed to **understand** our ocean publicly available, so we can maintain the health of our ocean, sustainably manage our marine resources, accelerate our national economy, and build a better appreciation of the value and importance of the ocean in our everyday lives.

Contents

2. Report Purpose

The purpose of this report is to briefly describe the acoustic seafloor and water column mapping data collection and processing methods used during exploration expedition EX-18-05, and to present a summary of the overall mapping results and mapping related cruise activities. A detailed description of the *Okeanos Explorer's* mapping capabilities is available in the 2018 NOAA Ship Okeanos Explorer Survey Readiness Report, available in the NOAA Central Library at https://doi.org/10.25923/4hs3-bq40 (last accessed 10/07/2020).

3. Cruise Objectives

The objectives for this cruise are fully detailed in the EX-18-05 Project Instructions, which are archived in the NOAA Central Library at https://doi.org/10.25923/31rp-wa59 (last accessed 10/01/2020).

Operations commenced in Mayport, Florida on May 22, 2018 and concluded on June 6, 2018 in Charleston, South Carolina. Operations for this cruise included seafloor and water column mapping operations, with shoreside cruise leadership and student participation enabled through telepresence. Mapping operations included 24 hour per day use of the ship's deep water mapping systems (Kongsberg EM302 multibeam sonar, EK60 split-beam fisheries sonars, and Knudsen 3260 chirp sub-bottom profiler sonar), and the ship's high-bandwidth satellite connection for daily transfer of data to awaiting shoreside scientists and Explorers-in-Training.

Mapping areas for this expedition were entirely within U.S. waters offshore from Florida, Georgia, and South Carolina. EX-18-05 was the first official cruise of NOAA Ship *Okeanos Explorer* in support of the Atlantic Seafloor Partnership for Integrated Research and Exploration, or ASPIRE, a major multi-year, multi-national collaborative ocean exploration field program focused on raising collective knowledge and understanding of the North Atlantic Ocean. The goal of ASPIRE is to provide data to inform and support research planning and management decisions in the region, adding to a foundation of publicly accessible baseline data to increase understanding of the North Atlantic Ocean. ASPIRE also provides critical information relevant to emerging blue economy priorities, including sustainable fisheries, offshore energy and marine minerals, coastal and offshore hazards, and marine tourism and recreation. Additional information on ASPIRE can be found at https://oceanexplorer.noaa.gov/explorations/aspire/ (last accessed 10/13/2020). The new data will also support the multi-agency sponsored DEEP Sea Exploration to Advance Research on Coral/Canyon/Cold seep Habitats (DEEP SEARCH) program. Additional information on DEEP SEARCH can be found at

https://oceanexplorer.noaa.gov/explorations/17deepsearch/background/plan/plan.html (lass accessed 10/13/2020).

This expedition was the eighth cruise to successfully utilize telepresence enabled mapping operations on *Okeanos Explorer*. The Expedition Coordinator (EC) for the cruise was based on shore at the Exploration Command Center (ECC) at University of New Hampshire Center for Coastal and Ocean Mapping/Joint Hydrographic Center (UNH CCOM/JHC) with regular and ongoing communications with the ship's Operations Officer and Commanding Officer, and the onboard mapping lead (**Table 1**). The onboard mapping lead was the primary liaison between ship and OER operations and attended all the shipboard daily meetings and provided daily situation reports (SITREPS) to the broader OER *Okeanos* operational team. Google Chat was used for round the clock communication between ship and shore.

Table 1. Mission compliment, shoreside and shipboard.

Position	Location	Role
Expedition Coordinator	Shore	Overall cruise planning and leadership
Onboard Mapping Lead	Ship	Coordinate ship logistics, communication with EC, stand data acquisition watch
Senior Survey Technician	Ship	Stand data collection watch
Mapping Watch Lead	Ship	Stand data collection watch
Explorer in Training	Ship	Cursory cleaning of multibeam data, produce daily gridded products
Explorers in Training (3)	Shore	Clean and log all sonar data, produce value added sonar products, produce summary maps

The screens of the mapping acquisition systems (EM 302, EK 60, SBP etc.) were broadcast 24 hours per day through two live video streams that were monitored by both onboard and onshore mapping scientists. A specially configured laptop enabled remote access to all the sonar acquisition and data processing machines from shore. The raw data from all sonars was transmitted to shore and detailed processing was completed on shore. Automated bathymetric gridding occurred on the ship in order for the onboard team to monitor and ensure adequate seabed coverage.

Expendable bathythermographs (XBTs) in support of multibeam sonar mapping operations were conducted at an interval defined by prevailing oceanographic conditions, and did not exceed 3 hours. All mapping data was fully processed according to OER standard procedures and was archived with the National Centers for Environmental Information (NCEI) within 90 days of the end of the cruise.

4. Summary of Mapping Results

EX-18-05 mapped 16,103 square kilometers of seafloor in the vicinity of Florida, Georgia, and South Carolina during the 16 days at sea (**Figure 1 and Table 2**). 15,937 square kilometers of this area is within the U.S. waters and the U.S. Exclusive Economic Zone (U.S. EEZ) in depths deeper than 200 m. Multibeam bathymetry data coverage from EX-18-05 is shown in **Figure 1**. XBTs were deployed at hourly increments of no more than 3 hours (**Figure 2**).

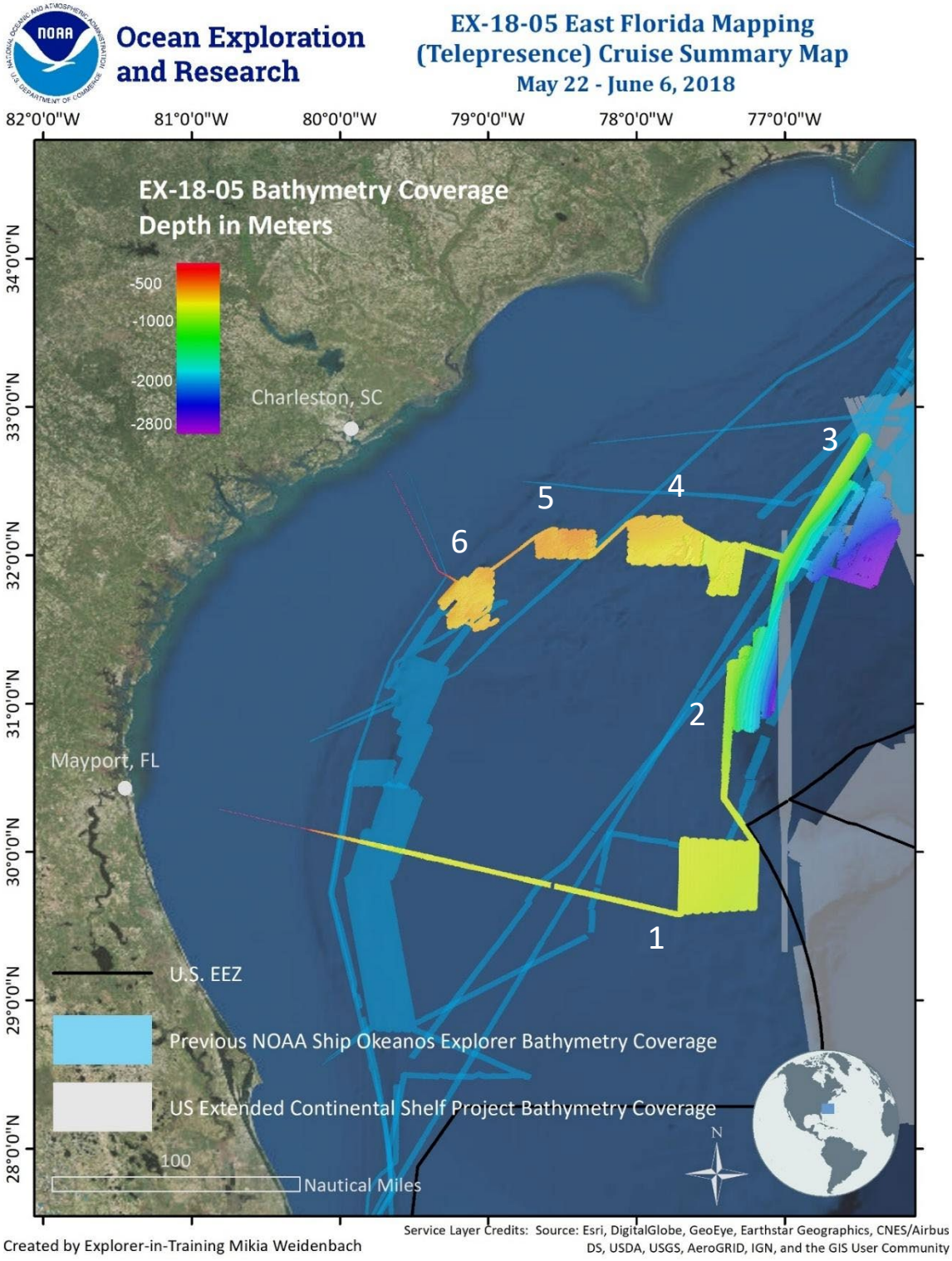

Figure 1. Cruise map showing overall EX-18-05 bathymetry coverage with survey areas 1 – 6 labelled.

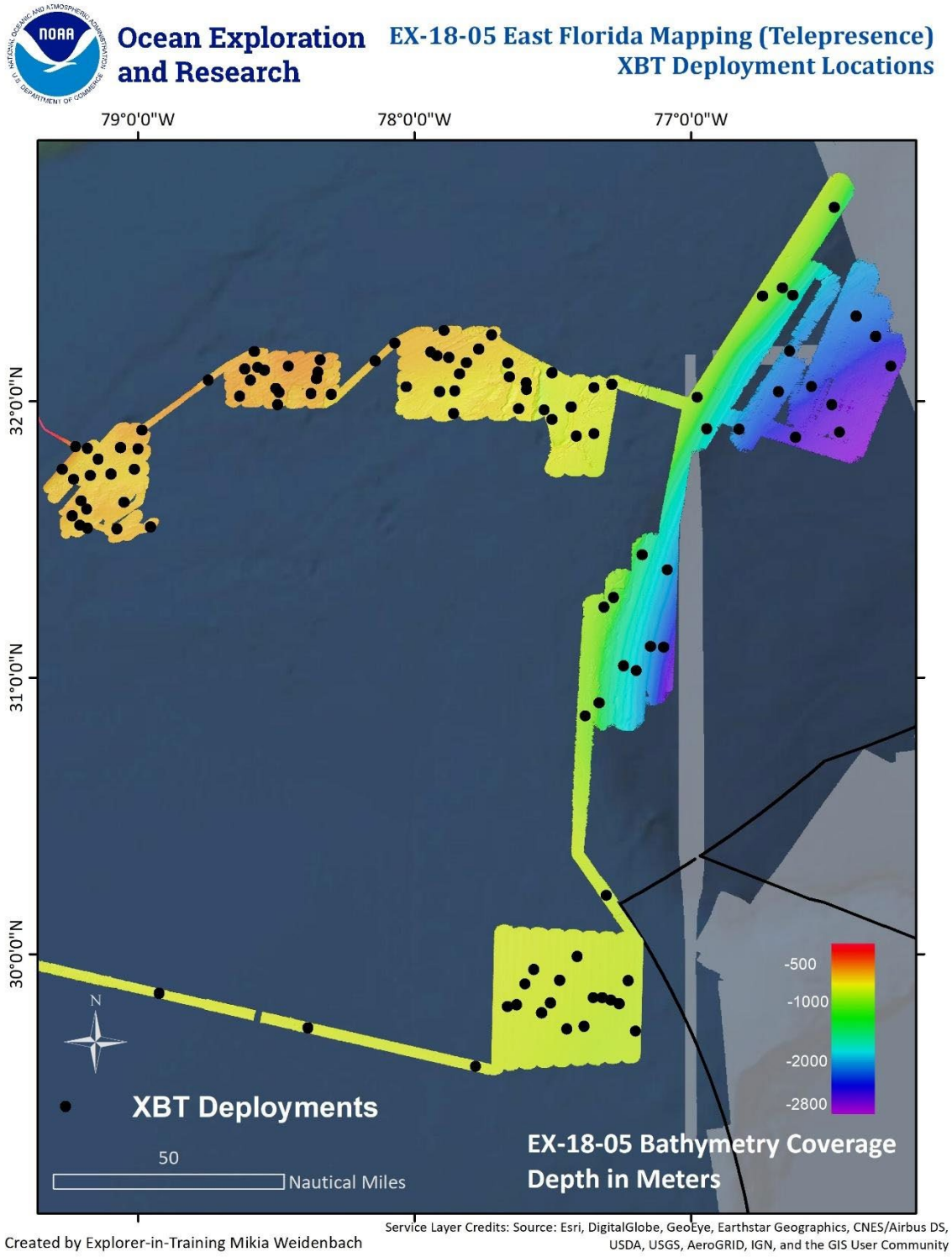

Figure 2. Cruise map showing XBT deployment distribution for EX-18-05.

5. Mapping Statistics

Table 2. Table of mapping summary statistics.

Dates	**May 22 – June 6, 2018**
Linear kilometers of survey with EM302	**4,975**
Square kilometers mapped with EM302	**16,103**
Square kilometers mapped with EM 302 deeper than 200 m within US waters	**15,937**
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files	**832 files / 48.1 GB**
Number / Data Volume of EM 302 water column multibeam files	**828 / 119 GB**
Number / Data Volume of EK 60 water column single beam files	**458 / 10.5 GB**
Number / Data Volume of sub-bottom sonar files	**792 / 2.8 GB**
Number of XBT casts	**112**
Number of CTD casts (including test casts for level of effort tracking)	**3 test casts, files not archived, no valid data**

6. Mapping Sonar Setup

Kongsberg EM 302 Multibeam Sonar

The NOAA Ship *Okeanos Explorer* is equipped with a 30 kHz Kongsberg EM302 multibeam sonar capable of detecting the seafloor in up to 10,000 meters of water and conducting productive mapping operations in 8,000 meters of water. The system generates a 150° beam fan containing up to 432 soundings per ping in waters deeper than 3300 meters. In waters

less than 3300 meters, the system is operated in multi-ping, or dual swath mode, and obtains up to 864 soundings per ping, by detecting two swaths per ping cycle. The multibeam sonar is used to collect seafloor bathymetry, seafloor backscatter, and water column backscatter. Backscatter represents the strength of the acoustic signal reflected from a target, such as the seafloor or bubbles in the water column. The system is calibrated with a multibeam sonar patch test annually and the results are reported in the annual readiness report. The 2018 NOAA Ship Okeanos Explorer Mapping Systems Readiness Report is available in the NOAA Central Library at https://doi.org/10.25923/4hs3-bq40 (last accessed 10/07/2020).

Simrad EK 60 Split-beam Sonars

The ship is equipped with four Kongsberg EK 60 split-beam fisheries sonars, 18, 38, 70, 120, and 200 kHz. The 18 kHz transducer and transmits a 7° beam fan. These sonars are quantitative scientific echosounders calibrated to identify the target strength of water column acoustic reflectors - typically biological scattering layers, fish, or gas bubbles – providing additional information about water column characteristics and anomalies. The EK sonars are calibrated on the annual shakedown cruise, and more often as operational locations require and field season schedule permits. The EK sonars were last calibrated during cruise EX-18-02. The EX-18-02 EK Calibration Report is archived in the NOAA Institutional Repository at https://doi.org/10.25923/6nb5-f816 (last accessed 10/07/2020). During this cruise, the 38 kHz was not used due to interference issues with the 30 kHz multibeam.

Knudsen 3260 Sub-bottom Profiler

Additionally, the ship is equipped with a Knudsen 3260 sub-bottom profiler that produces a frequency-modulated chirp signal with a central frequency of 3.5 kHz. This sonar is used to provide echogram images of shallow geological layers underneath the seafloor to a maximum depth of approximately 80 meters below the seafloor. The sub-bottom profiler is normally operated to provide information about sub-seafloor stratigraphy and features. The data generated by this sonar is fundamental to helping geologists interpret the shallow geology of the seafloor.

Teledyne ADCPs

The ship utilizes a 38 kHz Teledyne RDI Ocean Surveyor Acoustic Doppler Current Profiler (ADCP), with a ~1000 meter range; and a 300 kHz Teledyne RDI Workhorse Mariner ADCP, with a ~70 meter range. The ADCPs gather data prior to ROV deployments in order to assess currents at the dive site in support of safe operations. They are kept running throughout the

ROV dives. The ADCPs are typically not run concurrently with the other sonars due to interference issues and were not run during this cruise.

Survey lines were planned to maximize either bathymetry edge matching of existing data or data gap filling in areas with existing bathymetry coverage. In regions with no existing data, lines were planned to optimize potential exploration discoveries.

Throughout the cruise, multibeam data quality was monitored in real-time by acquisition watch standers. Ship speed was adjusted to maintain data quality as necessary and line spacing was planned to ensure at least ¼ swath width overlap between lines. Cutoff angles in SIS were generally left wide open for maximum exploration data collection, and were adjusted on both the port and starboard side to ensure the best data quality and coverage. Data were corrected for sound velocity in real-time using the Reson SVP-70 data at the sonar head, and profiles from Expendable Bathythermographs (XBTs) that were conducted every 0.5 to 3 hours, or as dictated by local oceanographic conditions.

7. Data Acquisition Summary

Mapping operations included EM 302 multibeam, EK 60 splitbeam, and Knudsen sub-bottom profile data collection. The schedule of operations included 24 hours per day of sonar data collection including during transits between ports and all focused mapping operation areas. EK 60 frequencies collected were 18, 70, 120, and 200 kHz. The EK 60 38 kHz system and both of the ship's Acoustic Doppler Current Profilers were secured due to interference with the EM 302 30 kHz multibeam sonar.

Expendable bathythermographs were collected using Lockheed Martin Deep Blue probes every 1 to 3 hours using a NOAA AOML Automated XBT Launcher, and applied in real time using Seafloor Information Software (SIS). During transit across the shallow continental shelf, Sound Speed Manager's SVP server was utilized. Sound speed at the sonar head was determined using Reson SVP70.

Background data used for exploration mapping included multibeam data collected on previous cruises and downloaded from the NCEI archives, and Sandwell and Smith satellite altimetry bathymetric data.

Tables listing all sonar data and sound velocity data files collected and products created during the cruise are provided as ancillary archived files with the multibeam sonar dataset. Watch logs, weather logs, and watchstander settings checklists are also archived as ancillary files associated with each sonar data type.

Throughout the cruise, multibeam data quality was monitored in realtime by acquisition watchstanders. Ship speed was adjusted to maintain data quality as necessary. Line spacing was planned to ensure 1/4 to 1/3 overlap between lines at all times. Cutoff angles in SIS

were generally left wide open to 70 degrees on port and starboard to collect the widest swaths possible.

Simrad EK60 split-beam water column sonar data and Knudsen sub-bottom data were collected throughout the majority of the cruise, (**Fig. 3, 4**). Data were monitored in real time for quality and were reviewed for seeps.

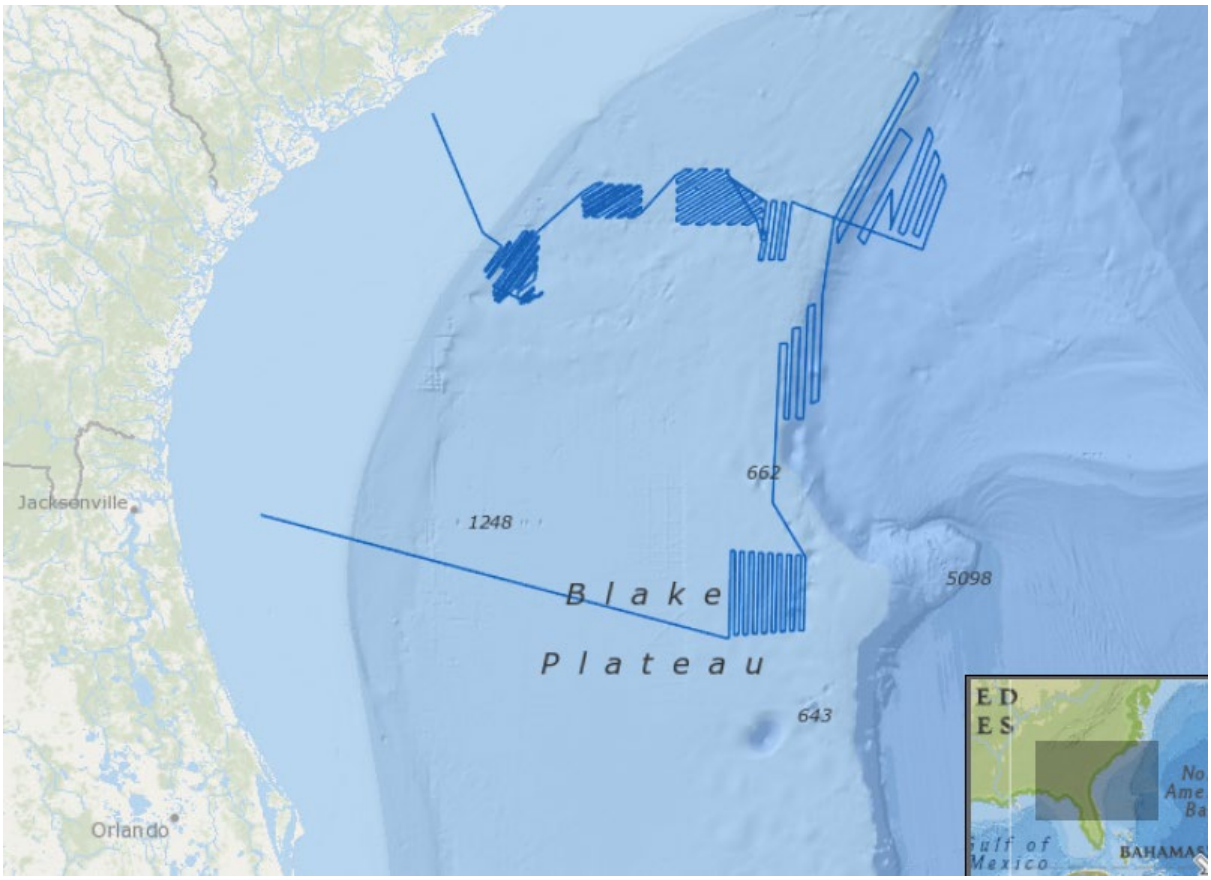

Figure 3. Simrad EK60 split-beam sonar data tracklines (blue) collected during EX-18-05.

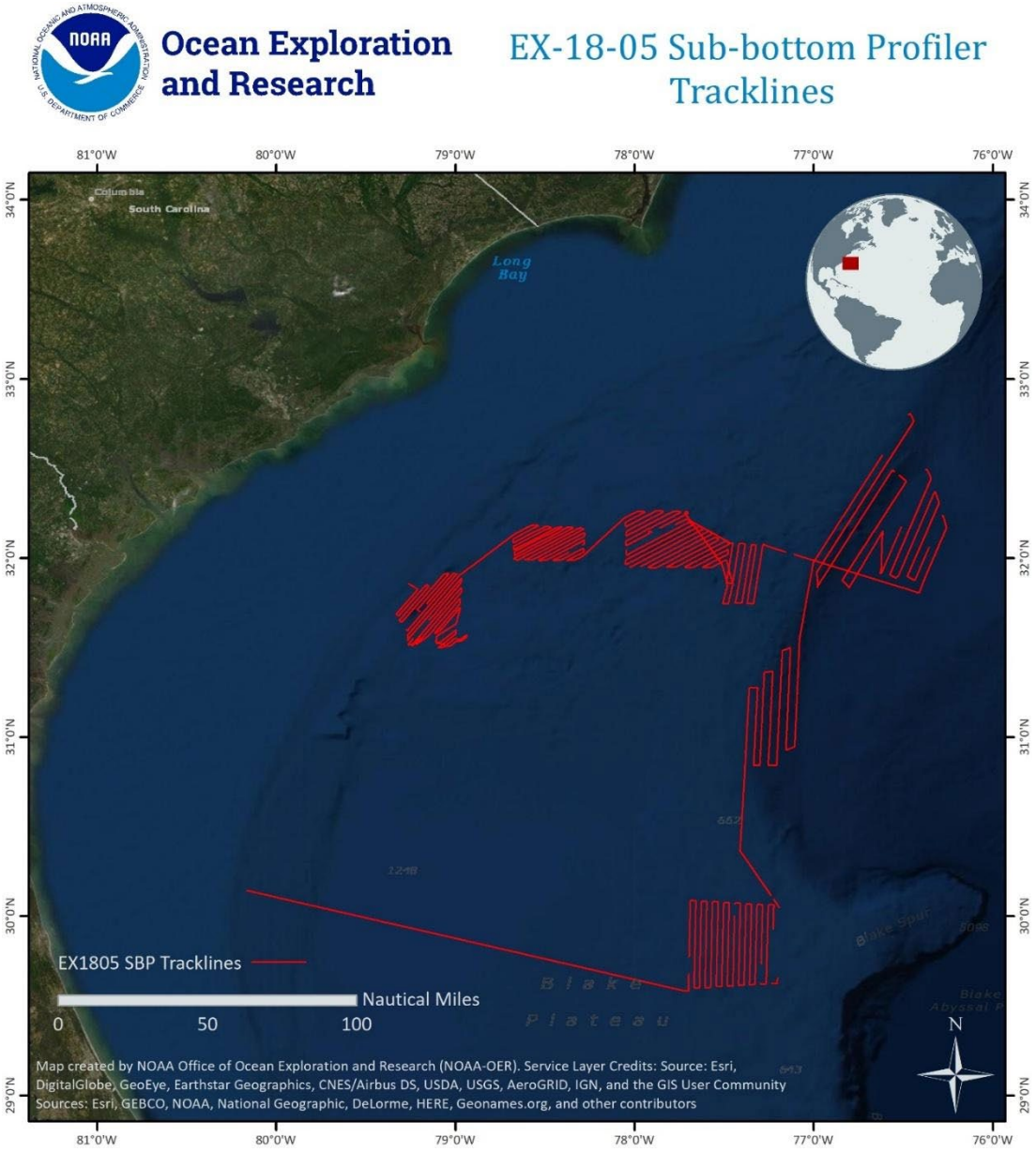

Figure 4. Sub-bottom profiler data tracklines (in red) collected during EX-18-05.

8. Multibeam Sonar Data Quality Assessment and Data Processing

Figure 5 shows the multibeam data processing workflow for this cruise. EM 302 Built-in Self Tests (BISTs) were run throughout the cruise to monitor multibeam sonar system status and are available as ancillary files in the sonar data archives. Raw multibeam bathymetry data files were acquired by SIS, then imported into QPS Qimera multibeam sonar processing data. In Qimera, attitude and navigation data stored in each file were checked, and erroneous soundings were removed using 2-D and 3-D editors. While operating in / near the Gulf

Stream, Qimera's TU Delft Sound Speed Inversion tool was employed to mitigate difficult sound speed conditions caused by highly variable temperature and salinity.

Final bathymetry QC was completed post-cruise onshore at the Center for Coastal and Ocean Mapping at the University of New Hampshire. With the vast majority of surveying completed in deep water, depth measurements were not adjusted for tides, as they are an essentially insignificant percent of the overall water depth. Data cleaning projects were in UTM zone projections for the operations area. Final data products were exported and archived as field geographic WGS84 coordinate reference frame (i.e., unprojected).

Data quality throughout the cruise varied with the seas, on fair weather days the data quality was best and in line with previous field season's performance in terms of swath width and consistent bottom detection. Line spacing and direction were altered as necessary on poor weather days to ensure swath overlap and highest possible data quality. Weather was entered into the weather log every 3 hours to indicate effect of seas on data quality.

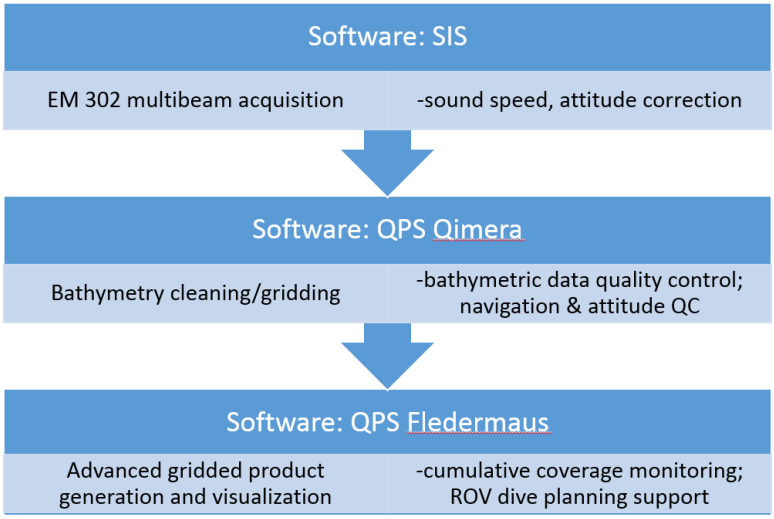

Figure 5. Shipboard multibeam data flow.

Crosslines

Comparing depth values from orthogonal survey lines is a standard hydrographic quality control measure to evaluate the consistency of the multibeam sonar data being collected during a cruise. Crossline analysis was conducted using the Crosscheck Tool in QPS Qimera software. Two crosslines were conducted during the cruise, on June 1 (**Fig. 6**) and June 5 (**Fig. 7**). The details of these cross line comparisons (comparison # 1 and # 2) are provided below.

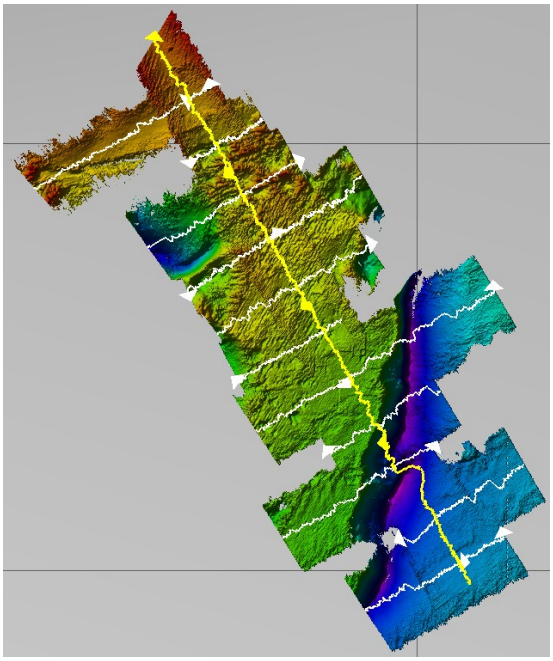

Figure 6. EX-18-05 crossline 1 (shown in yellow) used for comparison against the bathymetric grid generated via orthogonal multibeam survey lines.

For comparison 1 conducted on June 1 in survey area 4, the crossline files were

0538_20180601_110947_EX1805_MB.all
0539_20180601_113949_EX1805_MB.all
0540_20180601_120950_EX1805_MB.all
0541_20180601_123947_EX1805_MB.all
0542_20180601_130948_EX1805_MB.all

and the mainscheme line files were

0463_20180531_051655_EX1805_MB.all
0464_20180531_054653_EX1805_MB.all
0466_20180531_061031_EX1805_MB.all
0482_20180531_131247_EX1805_MB.all
0485_20180531_135926_EX1805_MB.all
0486_20180531_142926_EX1805_MB.all
0497_20180531_193213_EX1805_MB.all
0501_20180531_204904_EX1805_MB.all
0509_20180601_002657_EX1805_MB.all
0510_20180601_004409_EX1805_MB.all
0514_20180601_020119_EX1805_MB.all
0520_20180601_042645_EX1805_MB.all
0523_20180601_053728_EX1805_MB.all

0527_20180601_070516_EX1805_MB.all
0528_20180601_072339_EX1805_MB.all

The results confirm that comparison 1 met International Hydrographic Organization (IHO) Order 2 specifications for data quality.

Statistic	Value (depths in meters)

Number of Points of Comparison: 1515691
Grid Cell Size: 25.000
Data Mean: -680.840162
Reference Mean: -682.512457
Mean: 1.672295
Median: 0.343289
Std. Deviation: 5.154932
Data Z - Range: -997.75 -515.36
Ref. Z - Range: -986.48 -517.42
Diff Z - Range: -42.21 50.33
Mean + 2*stddev: 11.982159
Median + 2*stddev: 10.653153
Ord 2 Error Limit: 15.729606
Ord 2 P-Statistic: 0.031838
Ord 2 - # Rejected: 48257
Order 2 Survey ACCEPTED

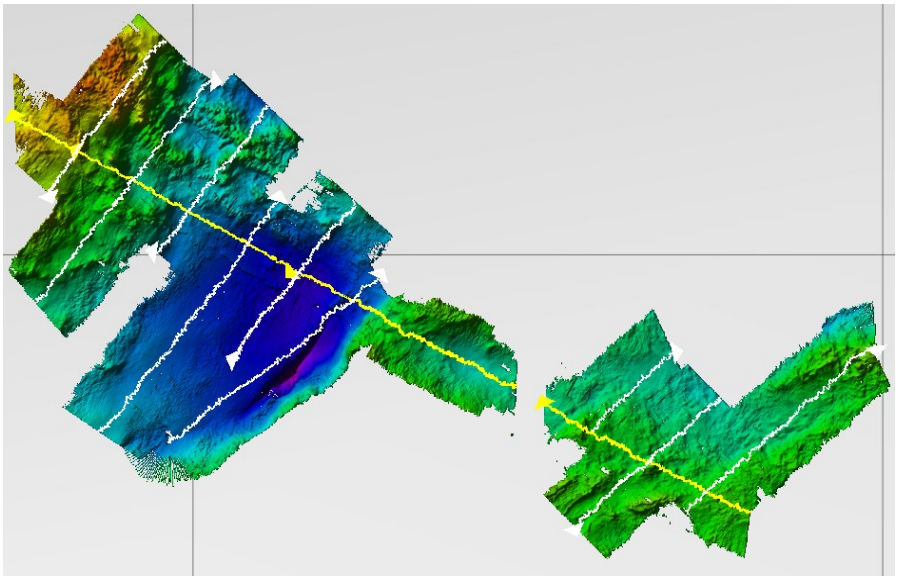

Figure 7. EX-18-05 crossline 2 (shown in yellow) used for comparison against the bathymetric grid generated via orthogonal multibeam survey lines.

For comparison 2, the crossline files were

0772_20180605_102601_EX1805_MB.all
0773_20180605_105559_EX1805_MB.all
0774_20180605_112559_EX1805_MB.all
0775_20180605_115601_EX1805_MB.all

and the mainscheme line files were
0700_20180604_035810_EX1805_MB.all
0705_20180604_045904_EX1805_MB.all
0720_20180604_113423_EX1805_MB.all
0725_20180604_160847_EX1805_MB.all
0737_20180604_213803_EX1805_MB.all
0739_20180604_222239_EX1805_MB.all
0759_20180605_061325_EX1805_MB.all
0764_20180605_074405_EX1805_MB.all
0766_20180605_082523_EX1805_MB.all

The results confirm that comparison 2 met International Hydrographic Organization (IHO) Order 1 specifications for data quality.

Statistic Value (depths in meters)

Number of Points of Comparison: 1058403
Grid Cell Size: 10.000
Data Mean: -477.247629
Reference Mean: -477.550871
Mean: 0.303241
Median: 0.025360
Std. Deviation: 2.964064
Data Z - Range: -555.84 -406.52
Ref. Z - Range: -553.75 -411.31
Diff Z - Range: -17.09 51.19
Mean + 2*stddev: 6.231370
Median + 2*stddev: 5.953489
Ord 1 Error Limit: 6.228263
Ord 1 P-Statistic: 0.046384
Ord 1 - # Rejected: 49093
Order 1 Survey ACCEPTED

Significant sound velocity challenges were encountered due to working in the Gulf Stream, often directly in or adjacent to the main axis of the current. Several methods were employed to mitigate data artifacts, typically refraction in the form of ‘smiles’, from rapidly changing salinity and temperature in the Gulf Stream, including: frequent XBT deployments, post

application of sound velocity profiles, the use of the newly released Qimera TU Delft Tool, and extensive manual ping editing. Despite these efforts, refraction sound velocity artifacts up to 8% of water depth were still present in the final grids (**Figs. 8, 9).** Strong surface currents up to 4 knots also impacted data quality due to severe crabbing required at times to maintain line heading. This can be observed in **Figure 9** at the points of new sound velocity profile application (indicated with white arrows).

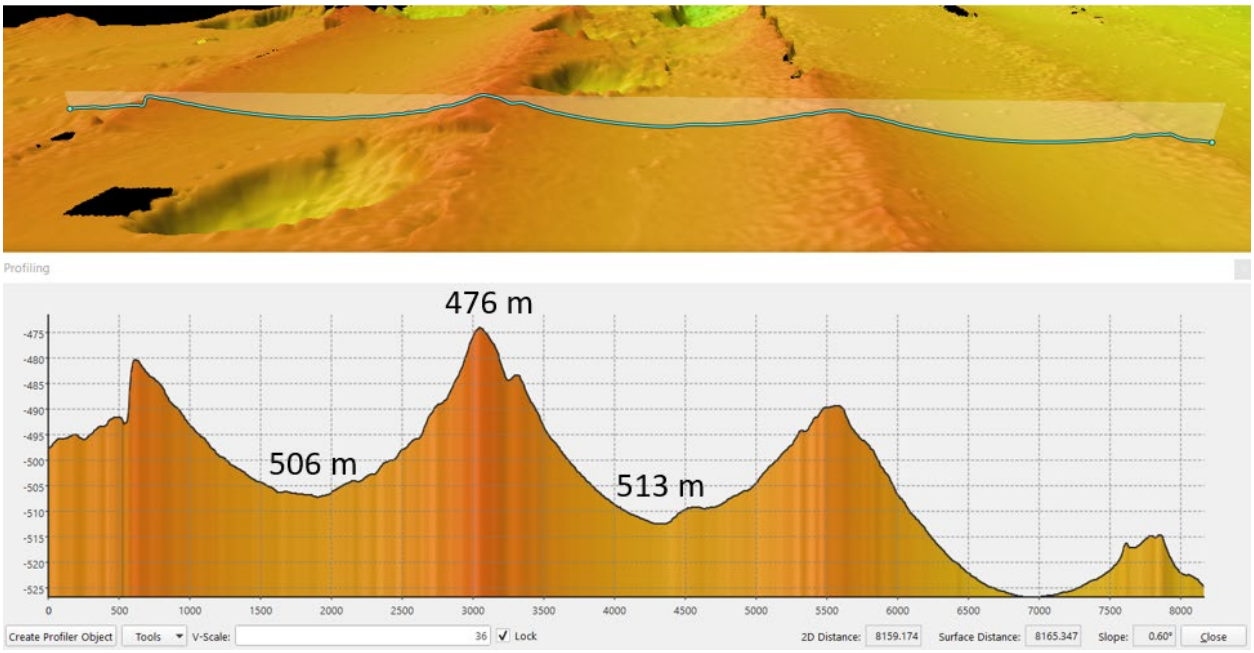

Figure 8. Sound velocity artifacts in survey area 4. Top: oblique view of profile drawn across track over four swath overlaps, with artifacts of magnitude 7.4% of water depth. Bottom: profile in 2D.

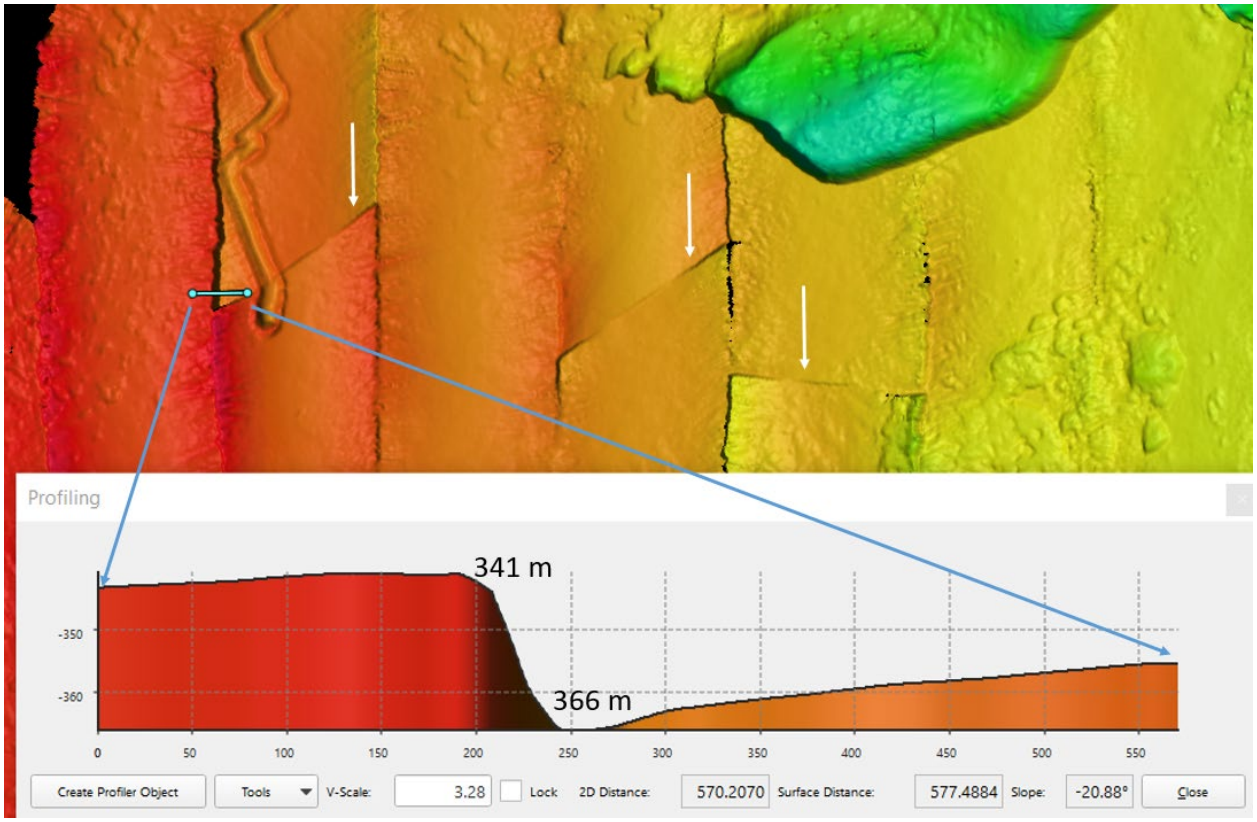

Figure 9. Sound velocity artifacts in survey area 5. Top: Plan view of profile drawn over one swath overlap, with artifacts of magnitude 7.1% of water depth. White arrows indicate application of new sound velocity profiles during data collection, creating immediate across track 'steps', with across track angle also demonstrating severe crab angle of ship course-over-ground vs. heading. Bottom: profile in 2D, connected to relevant grid section by blue arrows.

Survey area 3 was impacted most heavily by heavy seas, with loss of bottom tracking and reduced swath widths (**Fig. 10**).

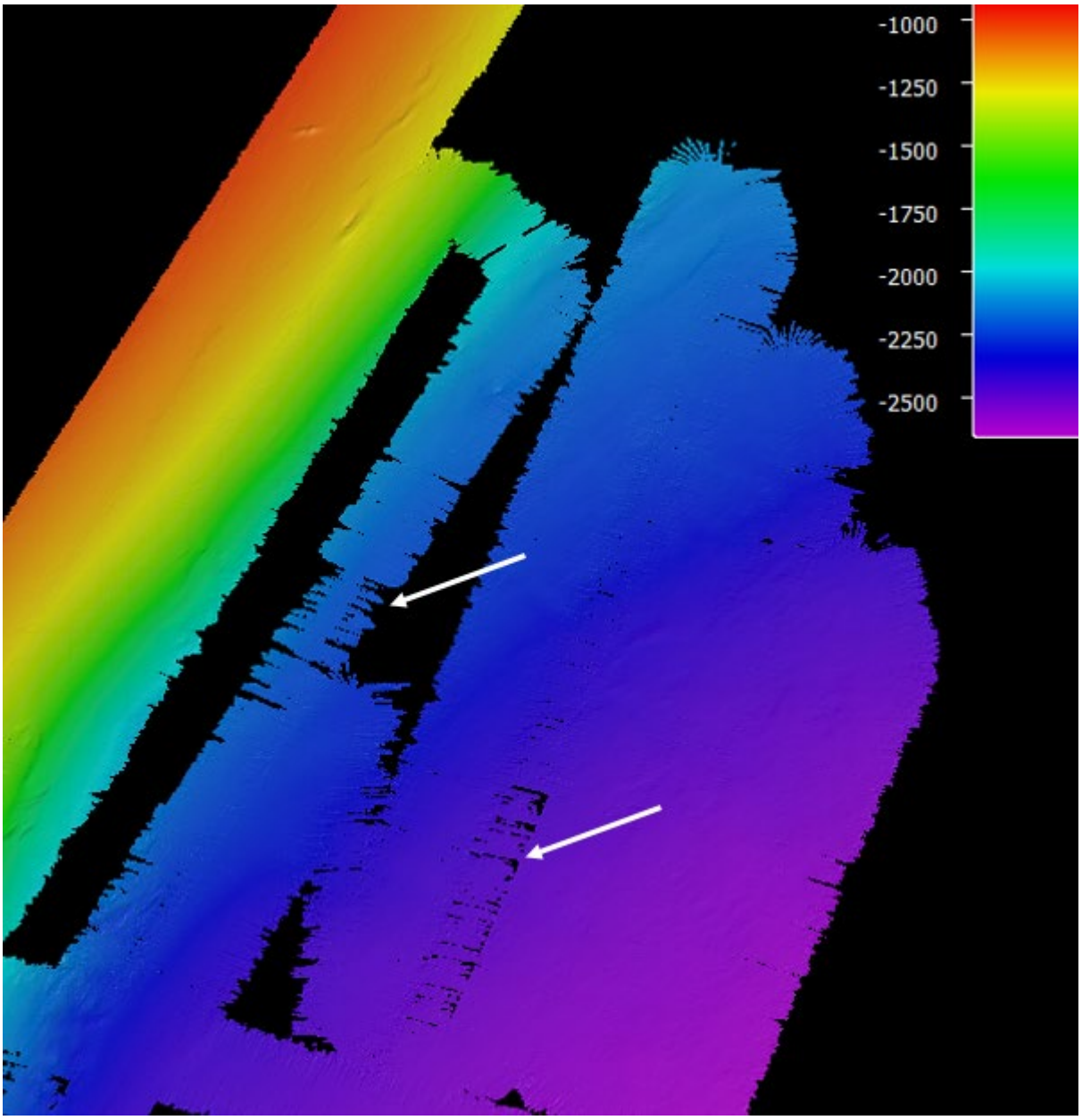

Figure 10. Plan view of survey area 3 with white arrows indicating loss of bottom tracking due to heavy seas. Color depth bar in meters.

EM 302 Patch Test

A multibeam patch test was conducted during EX-18-02. The results are briefly described in the mapping data report for that cruise, as well as in the 2018 *Okeanos Explorer* Survey Readiness Report available at https://doi.org/10.25923/4hs3-bq40 (last accessed 10/07/2020).

9. Data Archival Procedures

All mapping data collected by the NOAA Ship *Okeanos Explorer* are archived and publically available within 90 days of the end of each cruise via the National Centers for Environmental Information (NCEI) online archives. The complete data management plan (which describes the raw and processed data formats produced for this cruise) is available as an appendix in the EX-18-05 project instructions which is available in the NOAA Central Library at https://doi.org/10.25923/31rp-wa59 (last accessed 10/01/2020).

Ancillary and supporting files are archived with the sonar datasets. These include:

EM 302 Multibeam bathymetry and bottom backscatter dataset:

- Mapping watch stander log
- Weather log
- Sound velocity profile log
- Multibeam acquisition and processing log
- Built-In-System-Tests (BISTs)
- Processor Unit Parameters
- Text files of telnet sessions on the EM 302 transceiver unit

Simrad EK split-beam water column dataset:

- Mapping watch stander log
- Weather log
- EK data log

Knudsen 3260 Sub-bottom Profiler dataset:

- Mapping watch stander log
- Weather log
- Sub-bottom data log

EM 302 Multibeam water column dataset:

- Mapping watch stander log
- Weather log
- Sound velocity profile log
- Multibeam acquisition and processing log
- Built-In-System-Tests (BISTs)
- Processor Unit Parameters

- Text files of telnet sessions on the EM 302 transceiver unit
- MB WCD review log if data were reviewed for presence of seeps in Fledermaus MidWater

All sonar data collected during EX-18-05 are available through www.ncei.noaa.gov (last accessed 10/07/2020).

10. Cruise Calendar

May 2018						
Sun	Mon	Tues	Wed	Thur	Fri	Sat
	20 Mission personnel arrive to ship and to UNH.	21 Introductory meetings and training on ship and at UNH.	22 Depart Mayport, FL for survey working grounds.	23 24 hour mapping survey area 1.	24 24 hour mapping survey area 1.	25 Complete area survey 1, transit to survey area 2.
26 24 hour mapping survey area 2.	27 Complete survey area 2, commence survey area 3.	28 24 hour mapping survey area 3.	29 Complete survey area 3, commence survey area 4.	30 24 hour mapping survey area 4 near main axis of Gulf Stream.	31 24 hour mapping survey area 4 near main axis of Gulf Stream.	
June 2018						
						1 Complete survey area 4, transit to survey area 5.
2 Commence survey area 5.	3 Complete survey area 5, commence survey area 6.	4 Continue survey area 6.	5 Complete survey area 6.	6 Arrive port Charleston, SC.	7 Mission personnel disembark.	

11. Daily Cruise Log Entries

Generated from the daily expedition situation reports. All times listed are in local ship time which was Eastern Standard Time (-4 hours from Coordinated Universal Time (UTC). Activities for both ship and shore teams are provided.

May 20, 2018
SHIP: Mission personnel arrive to ship in Mayport, FL, and settle into staterooms. XBT probes for EX1805 and EX1806 were loaded by ship force into survey storage.

SHORE: Two of three EiTs arrived to Durham NH on 5/20; one EiT is delayed until 5/22. Introduction training was conducted including OER programmatic background, data collection, data processing, and data management goals, onboard technology, EiT expectations, UNH Center for Coastal and Ocean Mapping / Joint Hydrographic Center building tour, IT and building security logins.

May 21, 2018
SHIP: Introductory trainings were held for mission personnel new to the ship and mapping operations, including ship safety tour and orientation, mapping watchstander roles and responsibilities, cruise objectives, and ship scientific equipment.

SHORE: Onshore EC led a teleconference call to review the project instructions with onboard ship and mission personnel. Introductory sonar processing software training continued.

May 22, 2018
SHIP: The ship departed the pier from Mayport, FL at 1100 and began mapping operations at the end of the traffic lanes en route to survey Area 1. The EM302 was energized, pinged and logged without issue. EM302 *.all files are created at 30-minute intervals to improve processing in shallow water. Water column data (*.wcd) collection was inadvertently not enabled for the first four multibeam files so there are four fewer *.wcd files for the cruise than *.all files. SIS was reconfigured to acquire *.wcd starting with line file 0004. EK 60 frequencies 12, 70, 120 and 200 kHz are pinging and logging successfully. The EK 38 kHz is not run due to interference with the multibeam. Knudsen sub-bottom pinging and logging commenced at ~200m of depth. Data quality is good on all sonars.

ADCP's will not be used on this cruise unless advised by the onshore EC. Sun photometer measurements will be acquired as weather permits.

A Qimera project was created for basic multibeam data processing for coverage checks and daily product creation. The automatic import and gridding function of Qimera will be utilized.

SHORE: Three live feeds are coming to shore showing EM302, Knudsen/EK split screen, and Hypack showing survey lines progress. The UNH RTS unit is connected to the control room stations.

May 23, 2018
SHIP: Twenty-four hour mapping operations in survey Area 1. Daily products are being generated by night watch lead and submitted for data transfer to shore. RTS bridge communication training was held. An Ops Meeting was held at 1430. The temperature in the ship is about 6 degrees higher than normal today. CME is aware and troubleshooting the

issue. Offshore EiTs are lightly processing multibeam data in Qimera to prepare it for daily products and watch leads are QC'ing data processing. The augmenting senior survey technician is getting up to speed on sonar acquisition procedures.

"OKEX" alpha was added to the UNH RTS intercom panel via coordination with the URI-HUB. A detailed training session was conducted with Bridge personnel on the RTS intercom, video router & Pelco camera controller on the bridge to prepare for remote access communications later in the week.

SHORE: Training of EiTs continued with Qimera bathymetry cleaning and gridding, sub-bottom data processing, EK and EM 302 water column review, and log keeping. EiT profiles for the OER website were discussed. The third EiT started today after experiencing two days of travel challenges and missing the first two days of orientation.

May 24, 2018

SHIP: Twenty-four hour mapping operations continue in Area 1. Estimated completion of Area 1 is tomorrow at 1630. The EM302 data has consistent sound velocity artifacts. AXBTs are conducted every 2-3 hours to minimize "smiles." EK60 and Knudsen data quality is good.

SHORE:
EiTs took control of Qimera bathymetry editing and gridding, Knudsen image and navigation processing, EK and EM 302 water column data review, and processing log keeping for all sonars. Watchstanding situational awareness training continued. Live video feeds were stable all day.

May 25, 2018

SHIP: Area 1 was successfully completed at 1700. Transit mapping at 10 knots continued toward Area 2.

EiTs continue to process data onboard to generate daily products and learn processing procedures and different data cleaning techniques.

SHORE:
EiTs are keeping up with normal data processing routines. Staggered watches started after three days of group training. The ECC is manned from 0700 to 2000. Survey area 1 advanced data products are in development including high res grid, draped mosaic, and slope bathymetry. Survey area 1 was quite benign, with two very small outcrop features and some interesting terrain as we transited out of NE corner the area to survey area 2.

Remote watchstanding was tested for a few hours. EM302, Knudsen, and EK were controlled from shore. Communications between survey and UNH, and bridge and UNH were carried out on OKEX party line. An SOP was developed at UNH for connecting to Virtual Private Network / Remote Desktop Protocol.

May 26, 2018

SHIP: Area 2 continues to be mapped for full coverage north of the Blake Spur. EM302 data quality has improved in Area 2 with regard to sound velocity artifacts. PU Sensor error for attitude datagrams less than 90% from COM2 is still sporadic. Message services are being saved every few days to document. EK60 and Knudsen data are also high quality.

SHORE:
Onshore EiT shifts continued through the weekend. Live video feeds continue to provide excellent onshore situational awareness.

May 27, 2018
SHIP: Area 2 survey operations were completed. Area 3 survey operations began at 0215 and will continue in this area for approximately 48 hours. Maximum speed with three engines online in a southerly direction is 7.5 knots. Survey lines seen in the Hypack screen broadcast are variably spaced due to previous coverage of overlapping geotiffs that are not shown, because they prevent charted depths from being visible. Minimal sound velocity artifacts in Area 3. Data on all sonars deteriorated about 1630 due to weather. Seas 5-7 feet. Winds 20-25 knots.

No sun photometer measurements have been done to date due to weather.

AXBT settings have been added to the 4 hour watchlead equipment settings checklist.

The Mapping Team night watch is learning and experimenting with the Qimera TU Delft Sound Speed Inversion tool and creating an SOP for future use.

SHORE:
Onshore EiTs continue to keep up with EK, EM302, and SBP data review and processing. Weekend shifts are going well. Area 1 and 2 Fledermaus scene files were created by EiTs and contain the following layers: high res bathy, bathy-derived slope, and draped bottom backscatter mosaics.

May 28, 2018
SHIP: Area 3 survey operations continue. Data on all sonars is still poor in a southerly direction due to weather. Engines at 160 RPMs making 7 knots in a southerly direction. Seas 5-8 feet. Winds steady 20-25 knots. Weather is expected to calm down Wednesday. New line plans were received from the Onshore EC for Area 4 to accommodate for various sea states.

The AXBT is working well. It is keeping mapping personnel from going outside to launch individual XBTs in rough weather; and maintaining a solid time schedule for XBT's without missing any due to rough weather.

SHORE:

EiT's continued normal weekend data processing watches. Data onshore is caught up after a few snags from the previous 1-2 days thanks to onboard data and mapping team excellent communications with EiTs.

May 29, 2018
SHIP: Area 3 survey operations continued throughout the day and completed at 1445. Transit mapping speeds to Area 4 average 9-9.5 knots at 165 RPMS. Area 4 survey line plans were altered for weather conditions into an eastern block at 010° and a western block at 125°. Area 4 was started at approximately 2145. Coverage is good. Data quality is improving on all sonars. Sea states are reducing and expected to be good on Thursday.

SHORE:
Area 3 Fledermaus project is being created with layers: 30m bathy, bathy-derived slope, draped bottom backscatter.

All SBP data continues to be processed into jpg and nav lines. All water column files (EK and EM302) continues to be reviewed for anomalies, with none found yet.

May 30, 2018
SHIP: Area 4 survey operations continue. The eastern section was completed this morning at approximately 1030. Speeds varied from 7.5 to 9 knots in the north-direction and 6.5 to 8 knots in the southeast to north east direction. The western section of lines (heading 305°) experienced crab angles of 23 to 25 degrees, which caused a change in the line plan direction to be with the Gulf Stream (heading 060°). Currents of 3 to 4 knots are slowing the ship speed in the southwestern direction. Sound velocity casts are being taken on a 2-3 hour basis and back-applied in post processing if required to improve soundings. Eddies can be seen real-time in the thermosalinograph and surface sound speed displays. Weather related data artifacts are significantly reduced. Seas 3 to 5 feet, winds 8 knots.

A long liner fishing vessel in the eastern area of Area 4 caused a deviation in line plan during the morning. The remaining lines will be picked up if time allows.

The ADEON hydrophone deployment "SAV" was traversed overnight.

SHORE:
Remote desktop (RD) to EM302 and Knudsen/EK was utilized. On the ship, the EK computer is already connected to the Knudsen via remote desktop, and it was found this causes the display onshore through RD to be too slow for use. Once we closed the 'remote' EK remote desktop on the ship, the connection to the Knudsen was excellent with only a couple second delay between mouse action onshore and impact to take effect on the ship. Good communication with ship personnel is required because when shore RD's in, the ship sees a blue screen on that computer.

EiTs worked on final maps in ESRI. They also learned how to make adjustments to bottom backscatter mosaics in FMGT.

The processed SBP files were shared with USGS partner scientists via the UPLOAD folder on the Okeanos FTP.

May 31, 2018
SHIP: Area 4 survey operations continue at 6 knots in a southwest direction and 9 knots in a northeast direction. Area 4 expected completion is Friday about 2000.

SHORE: Data quality is starting to degrade as main axis of Gulf Stream is approached. XBT are conducted every 2 hours. Onboard EiT crated an SOP for a new Qimera tool (TU Delft) that flattens out SVP artifacts. This will be used during final QC of on onshore files after initial cleaning is done by EiTs. The first static map of Area 2 was created. Processed SBP files were shared with USGS. Processed bathy was shared with OER planners for EX1806 for entire cruise so far.

June 1, 2018
SHIP: Early in the morning the remaining Area 4 western segments delayed from long liners were acquired and a crossline was done to transit to the far end of Area 4 to work on the last corner of mapping. Area 4 was completed at 2330. Transit mapping to Area 5 followed.

The night watch has completed the SOP for the Qimera TU Delft Sound Velocity Inversion Tool, which is used to reduce the sound velocity artifacts in data and products. The SOP is being used to process data onboard where appropriate for testing and training purposes. The SOP highlights changes in standard deviation in data after use.

SHORE: One EiT had to depart early today due to scheduling conflicts, he could not stay for the cruise extension due to earlier commitment to another internship. He will continue to work on his online EIT profile and send in next few days.

Remaining 2 EiTs are expected to be able to keep up with same processing routine, since they have been coming up to speed for the last two weeks.

Onboard survey progress is going well, despite slow survey speeds and severe SVP artifacts due to Gulf Stream. DEEP SEARCH mapping areas commenced in evening of 5/19 and should be fully or near fully completed on time. Progress was communicated to DEEP SEARCH scientists.

June 2, 2018
SHIP: Transit mapping continued to Area 5. Area 5 survey operations began at 0245 and continued through the day. Sound velocity artifacts are increasing in Area 5. Profiles are being taken closer to 2 hours to mitigate artifacts. Line plans were adjusted to accommodate shallower than charted depths. Ship speed in the southwest direction is 5 to 5.5 knots.

SHORE: EiTs continue to keep up with onshore data processing. The Qimera SVP correction tool is not currently available on CCOM ECC computers but is available on mapping leads' laptop due to temporary differences in licensing, and will be utilized during data QC.

June 3, 2018
SHIP: Area 5 survey operations completed at 1600. Sound velocity variations are less in the northwestern area off the shoal. Transit mapping to Area 6 followed at 5 knots opposing the Gulf Stream and survey operations began at 2000.

SHORE:
Onshore EiTs continue to gain new data processing skills. Bridge and onboard team are working very closely to drive coverage as needed to get adequate overlap in depths shallower than anticipated depths.

The onshore and offshore Qimera projects both became corrupt around the same time. The onshore fix was to remove the latest dynamic grid which was corrupting the project. The offshore solution was to start a new project.

A zig zag feature at least 6 km long was mapped. In consultation with UNH, USGS, College of Charleston, and University of South Carolina scientists, is thought to potentially an iceberg scour. It is likely too deep and wide to be a trawl or anchor scar.

June 4, 2018
SHIP: Area 6 survey operations continue in the Gulf Stream area. Speeds have increased slightingly in the southwestern direction to 6.5 knots. Sound velocity artifacts are reduced. Data processors are using the TU Delft SV Inversion tool to minimize artifacts seen in the daily products.

The 38kHz ADCP was energized prior to CTD testing. Currents were approximately 3.7 to 4.1 knots at the southern end of Area 6.

Data package QC has been started for data up until now and the initial transfer of mapping data to the external hard drive has been completed. The new GFOE managed computers have USB 3.0 connections, so transfer of several hundred gigabits of data to the external drive only took approximately an hour instead of over six hours.

SHORE: EiTs continued to keep up with ping editing, sub-bottom jpg/nav generation, and water column review. Sound velocity artifacts are present due to vicinity of main axis of Gulf Stream. No water column anomalies were found.

June 5 & 6, 2018
SHIP: Continued Area 6 survey operations. Survey speeds increased as lines progressed away from the Gulf Stream. Transit mapping began at 2400 inbound to Charleston. The World Ocean Atlas 2009 / Sound Speed Manager server was used for sound velocity casts for

transit. Data was logged to the sea buoy, and then pinging was secured. Arrival to the pier in Charleston, SC was approximately 1030 June 6, 2018.

SHORE: Remote watchstanding testing occurred, with an XBT launched from the AXBT (viewed on camera from shore) software using EXCTD1 computer, remote control of SBP and EM302.

The onboard cruise wrap up meeting was held between ship and shore. The complete list of cruise objectives were reviewed. All major mapping areas were fully completed or completed within ~95% of planned coverage. Onshore situational awareness was steady due to excellent shipboard support of data transfer and live feed continuity. Ship was able to complete MOB training and partial small boat training. Compliments were given to onboard mission and ship crew for excellent communication and execution of project instructions. Progress was made in remote watchstanding, and it was determined that short 2-day mock watchstanding test period would continue to test more robustly, improve standard protocols and work through operational requirements without introducing risk to important data collection.

12. References

The following references are available in the NOAA Institutional Repository. The EX-18-05 Project Instructions can be obtained from the NOAA Central Library at https://doi.org/10.25923/31rp-wa59 (last accessed 10/07/2020). The EX-18-05 Data Management Plan is an appendix of the project instructions.

The 2018 NOAA Ship Okeanos Explorer Survey Readiness Report can be obtained in the NOAA Central Library at https://doi.org/10.25923/4hs3-bq40 (last accessed 10/07/2020).

The EX-18-02 EK60 Calibration Report can be obtained in the NOAA Central Library at https://doi.org/10.25923/6nb5-f816 (last accessed 10/07/2020).

Sub-bottom data, supporting data, and informational logs are available by contacting the NCEI Geophysical Data Archives at https://www.ngdc.noaa.gov/ (last accessed 10/07/2020).

EM 302 bathymetry and water column data and EK water column data, supporting informational logs, and ancillary files are available in the NCEI Data Archives accessible at https://www.ngdc.noaa.gov/ (last accessed 10/07/2020).

The oceanographic dataset containing the meteorological and oceanographic data collected during this cruise is available at https://doi.org/10.25921/51yt-b051 (last accessed 10/07/2020). The surface sound speed and thermosalinograph datasets can be found here.

The following was used for reference throughout the cruise:

Sandwell, D. T., and W. H. F. Smith, Global marine gravity from retracked Geosat and ERS-1 altimetry: Ridge Segmentation versus spreading rate, J. Geophys. Res., 114, B01411, doi:10.1029/2008JB006008, 2009.

Various NOAA Nautical Charts.

13. Appendix

Intern Products

An important component of telemapping cruises is the onshore training opportunities for Explorers-in-Training. The following maps were created during the cruise by two interns who were new to the sonar technology and data processing techniques used by OER. The following series of maps (**Figs. 11 – 16**) results from turning raw sounding data into cleaned bathymetric surfaces, and then using those surfaces to create summary maps of each focus survey area.

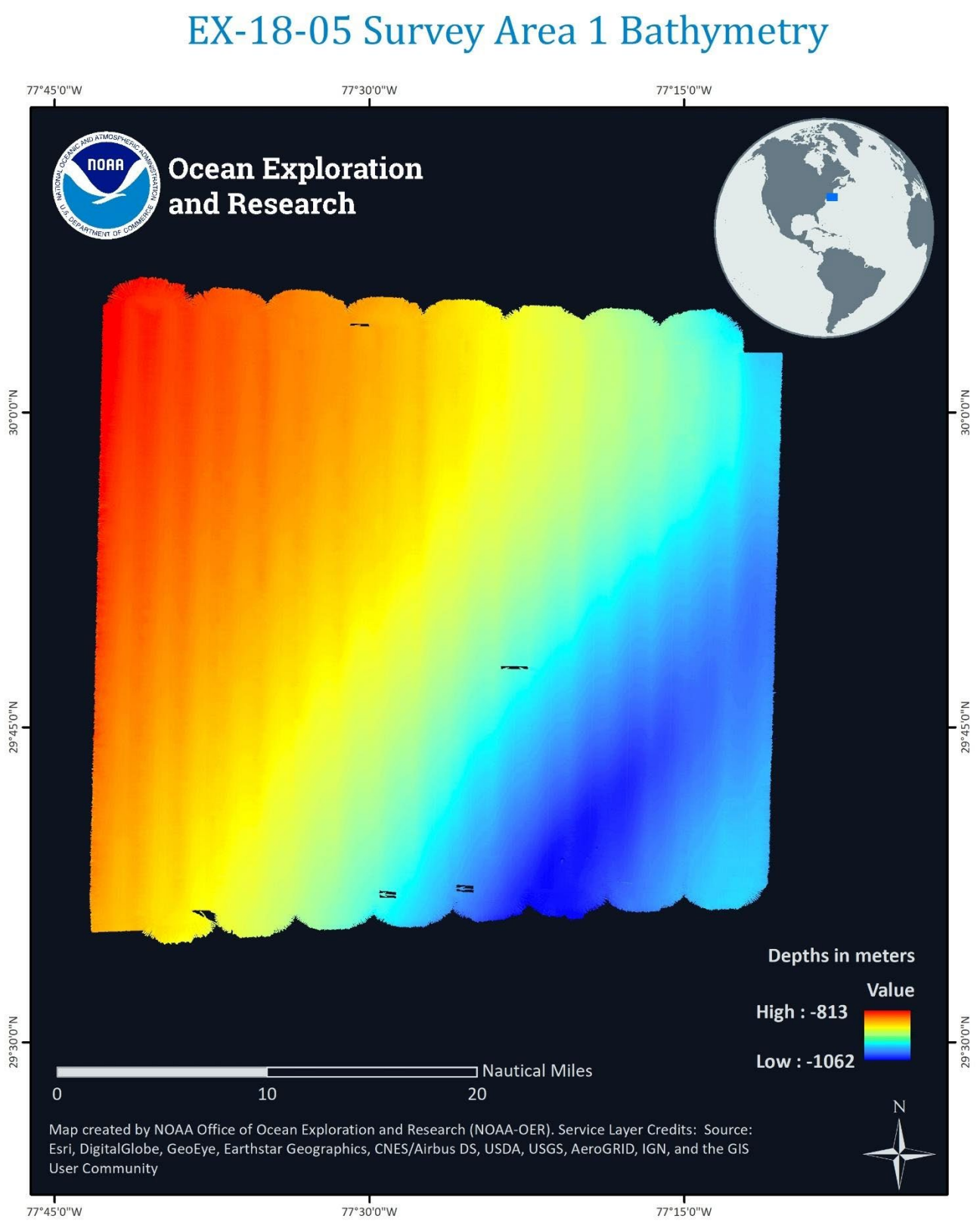

Figure 11. Focus map of 20 meter resolution gridded bathymetry collected at Area 1.

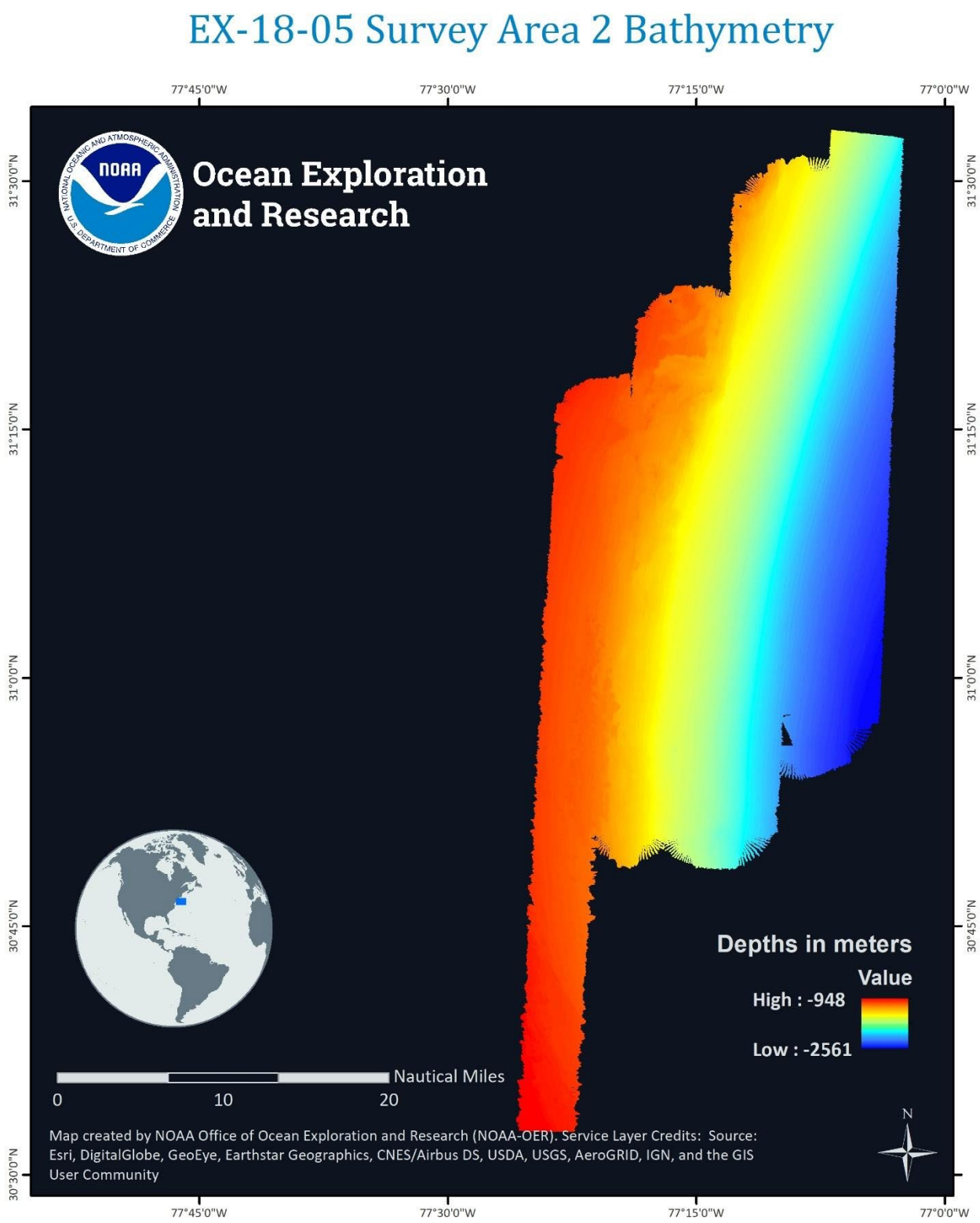

Figure 12. Focus map of 30 meter resolution gridded bathymetry collected at Area 2.

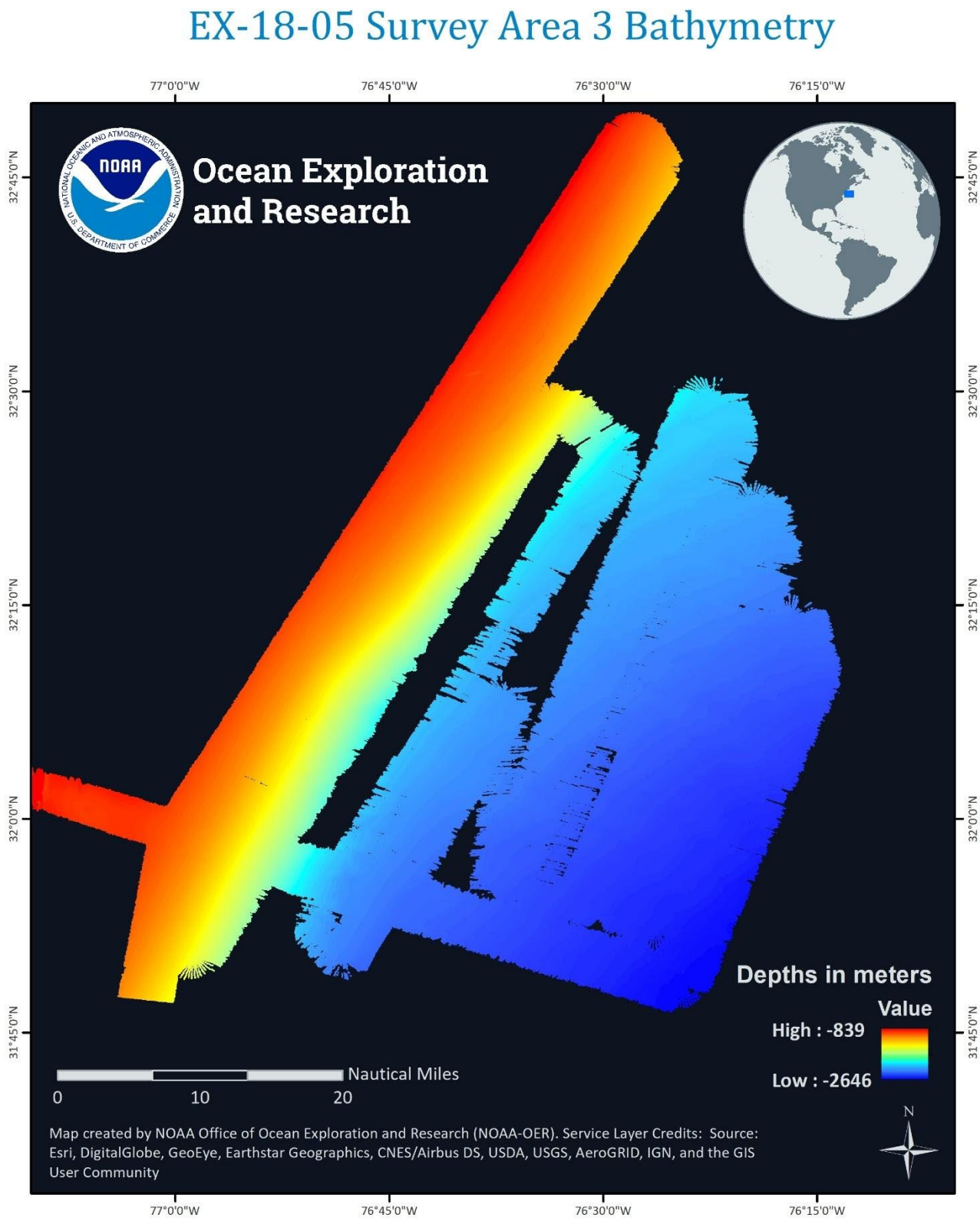

Figure 13. Focus map of 35 meter resolution gridded bathymetry collected at Area 3.

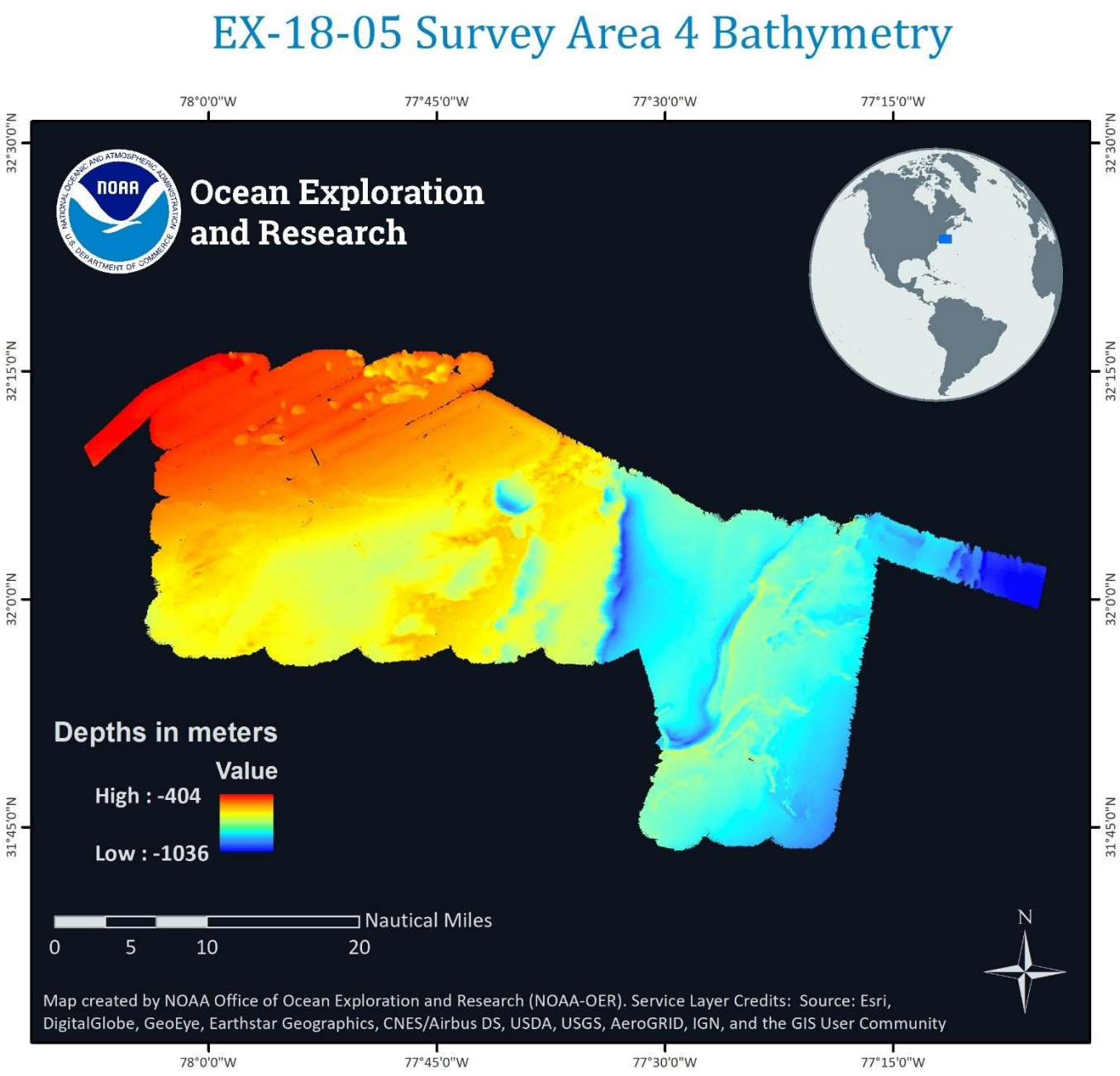

Figure 14. Focus map of 15 meter resolution gridded bathymetry collected at Area 4.

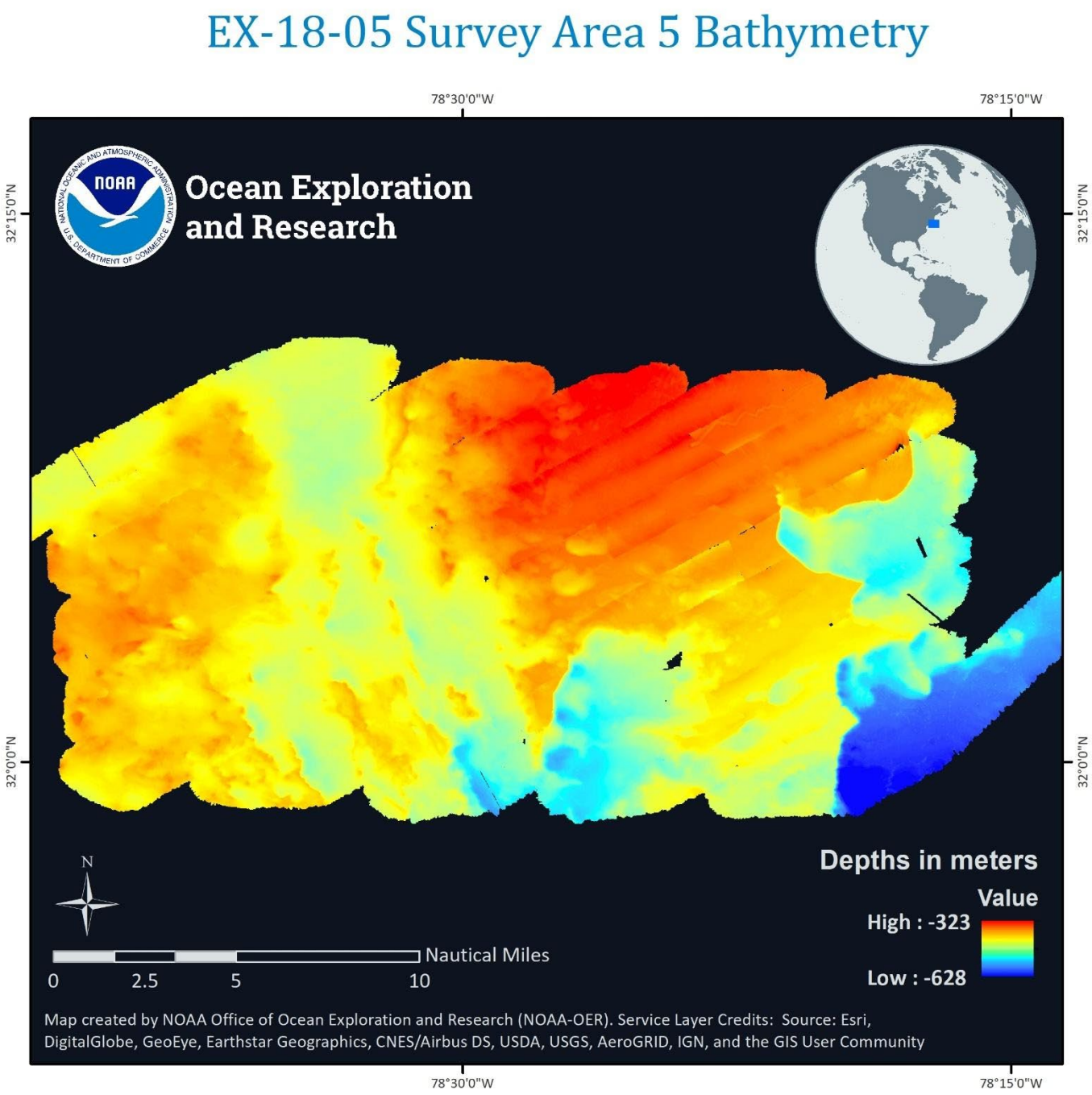

Figure 15. Focus map of 15 meter resolution gridded bathymetry collected at Area 5.

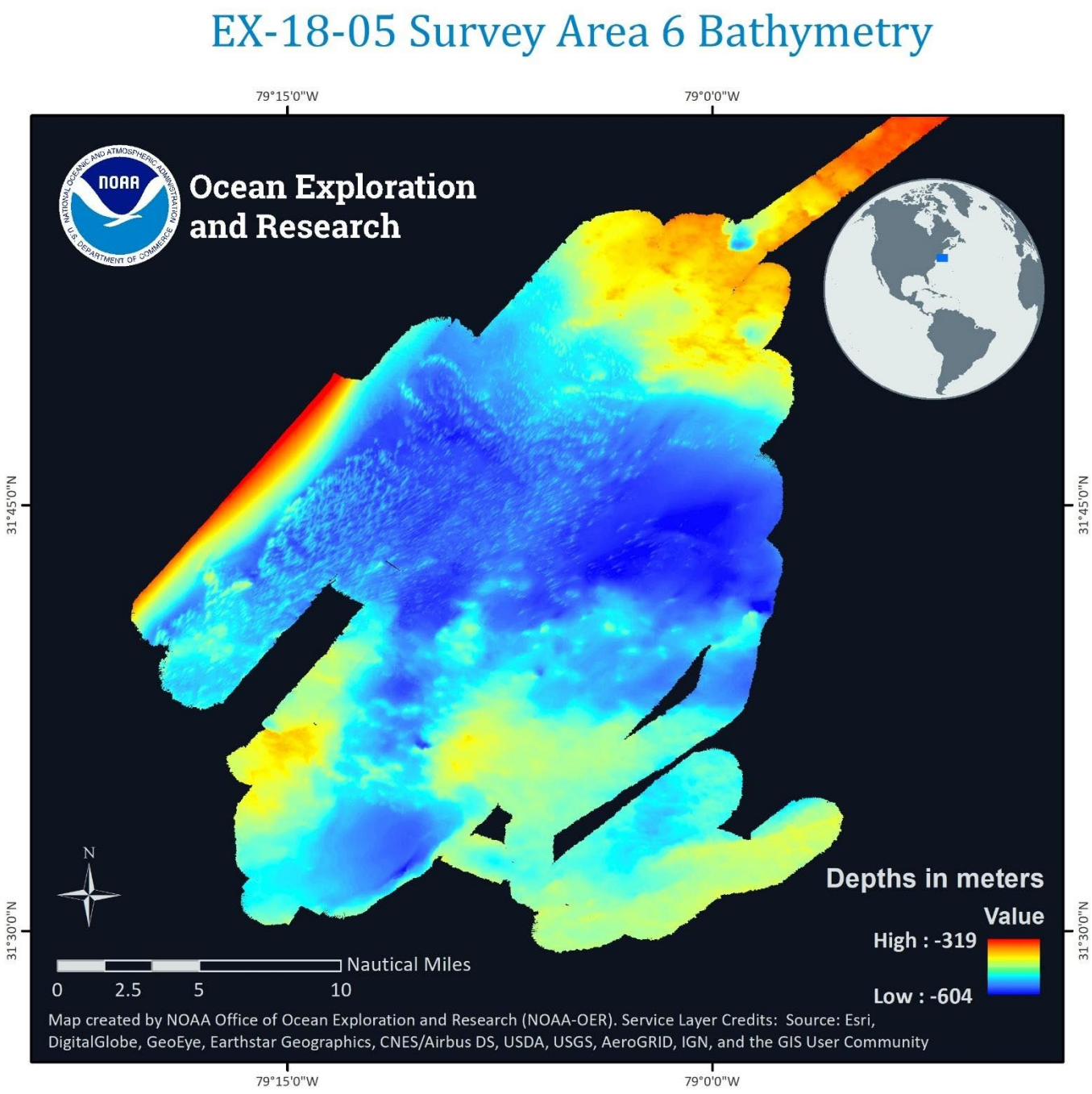

Figure 16. Focus map of 10 meter resolution gridded bathymetry collected at Area 6.