

MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT:

EX-18-06, Windows to the Deep 2018 (ROV & Mapping)

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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.



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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-18-06, 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. A full description of Remotely Operated Vehicle (ROV) operations and sample collections completed during the cruise is available in a separate Expedition Report available in the NOAA Central Library with the title “*Cruise Report EX-18-06 Windows to the Deep 2018 (ROV & Mapping).*”

3. Cruise Objectives

The EX-18-06 expedition was a 20-day expedition that started in Charleston, SC on June 13, 2018, and ended in Norfolk, VA on July 2, 2018. The deep water areas offshore Florida, Georgia, South Carolina, and North Carolina are some of the least explored areas along the U.S. East Coast. The primary objective of the expedition was to survey this region to provide baseline information to support management and science needs. The complete objectives for this cruise were defined in the [EX-18-06 Project Instructions](#), which are archived in the NOAA Central Library at [doi:10.25923/rz5x-k707](https://doi.org/10.25923/rz5x-k707).

EX-18-06 was one of several NOAA Ship *Okeanos Explorer* expeditions from 2018 to 2021 planned to contribute to NOAA’s Atlantic Seafloor Partnership for Integrated Research and Exploration (ASPIRE), a major multi-year, multi-national, collaborative ocean exploration program focused on raising our collective knowledge and understanding of the North Atlantic Ocean. The North Atlantic Ocean plays a pivotal role to humankind, providing biological and geological resources, ecosystem services such as seafood production and climate regulation, and a route for trade and travel between Europe and the Americas. However, we have only begun to understand the North Atlantic Ocean’s ecosystems, resources and oceanography, as much about the seabed bathymetry, geology, mineralogy, and trans-Atlantic connectivity of biological communities remains unknown. With the signing of the Galway Statement on Atlantic Ocean Cooperation by the European Union, Canada and the U.S., and the Atlantic Ocean Research Alliance’s deep-sea science and exploration efforts, there is significant momentum within the international community to cooperate on integrated exploration and research 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 (USGS) and Bureau of Ocean Energy Management (BOEM), as well as international partners from Canada and Europe.

From May 22 through July 2, 2018, NOAA and partners conducted a two-part, telepresence-enabled ocean exploration expedition on NOAA Ship *Okeanos Explorer* to collect critical baseline information about unknown and poorly understood deep water areas of the Southeastern United States. Summary results from the first cruise of the expedition (EX-18-05) are provided in a separate mapping data report entitled “*Windows to the Deep 2018: Exploration of the Southeast U.S. Continental Margin (Mapping)*” available in the NOAA Central Library.

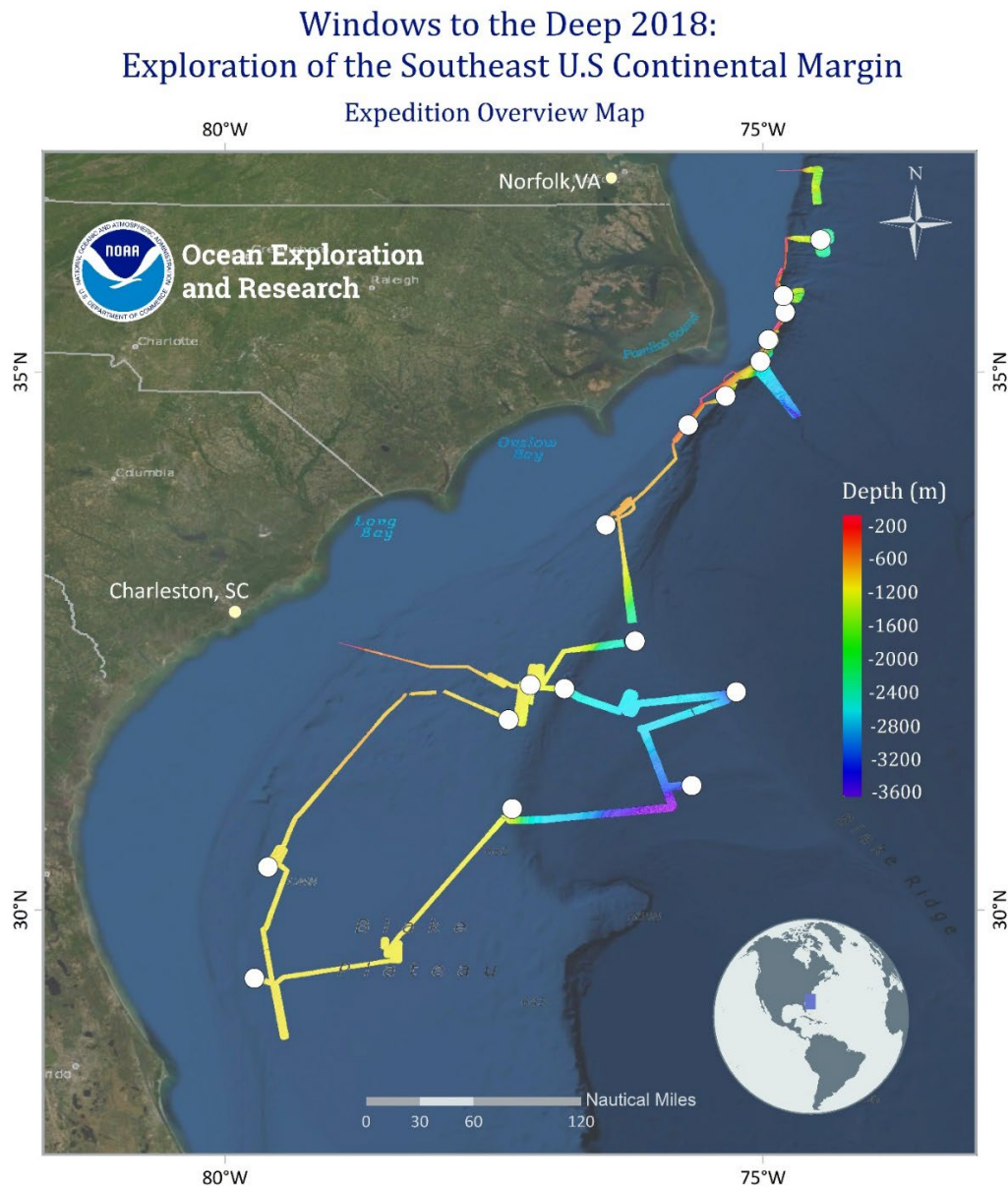
During the Windows to the Deep 2018 expedition, at-sea and shore-based science teams worked together to map the seafloor and utilized remotely-operated vehicles (ROVs) to observe many of these sites for the first time. The expedition addressed science themes and priorities put forward by scientists and managers from NOAA, management agencies in the region, and the ocean science community. NOAA priorities for the expedition included a combination of science, education, outreach, and open data objectives:

- Acquire data on deep water habitats in the southeast U.S. continental margin to support priority science and management needs
- Identify, map, and explore the diversity and distribution of benthic habitats, including fish habitats, deep-sea coral and sponge communities, chemosynthetic communities, and biological communities that colonize or aggregate around shipwrecks
- Investigate biogeographic patterns of deep-sea ecosystems and connectivity across the southeast U.S. continental margin for use in broader comparisons of deep water habitats throughout the Atlantic Basin
- Map, survey, and sample geologic features within the southeast U.S. continental margin to better understand the geological context of the region and improve knowledge of past and potential future geohazards
- Explore U.S. maritime heritage by identifying and investigating sonar anomalies as well as characterizing shipwrecks
- Collect high-resolution bathymetry in areas with no (or low-quality) sonar data
- Acquire a foundation of ROV, sonar, and oceanographic data to better understand the characteristics of the water column and the fauna that live there
- Engage a broad spectrum of the scientific community and public in telepresence-based exploration and provide a foundation of publicly accessible data and information products to spur further exploration, research, and management activities

4. Summary of Mapping Results

Multibeam mapping operations for EX-18-06 covered an area of 13,608 square kilometers of seafloor over a linear ship track distance of approximately 3,764 kilometers (Table 1). Multibeam bathymetry data coverage is shown in Figure 1, along with the locations of the ROV dives completed during the cruise.

Cruise Overview Map



Overview map showing seafloor bathymetry mapping coverage and ROV dives (white circles) completed during the EX-18-06 expedition. Map created by NOAA Office of Ocean Exploration and Research (NOAA-OER). Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 1. Cruise map showing overall EX-18-06 multibeam bathymetry coverage and the location of ROV dives (white dots) completed during the expedition.

5. Mapping Statistics

Table 1. Summary statistics of ocean mapping work completed during EX-18-06.

Dates of cruise	June 13, 2018 – July 2, 2018
Linear kilometers of survey with EM 302	3,764
Square kilometers mapped with EM 302	13,608
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)	591 files/ 32.8 GB
Number / Data Volume of EM 302 water column multibeam files	591 files / 84.7 GB
Number / Data Volume of EK 60 water column split beam files (.raw)	167 files / 8.5 GB
Number / Data Volume of sub-bottom sonar files (.seg, .kea, .keb)	771 files / 2.95 GB
Number of XBT casts	95
Number of CTD casts (including test casts)	0

6. Mapping Sonar Setup

The following sonars were operated during the cruise:

Kongsberg EM 302 Multibeam Sonar

The NOAA Ship *Okeanos Explorer* is equipped with a 30 kHz Kongsberg EM 302 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 patch tested 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.

Simrad EK 60 Split-beam Sonars

NOAA Ship *Okeanos Explorer* is equipped with five EK 60 split-beam sonar transducers operated at frequencies of 18, 38, 70, 120 and 200 kHz. These sonars were used continuously (aside from the 38 kHz

which interfered with the multibeam during mapping operations and also has a compromised, uncalibrated transducer) throughout the cruise during both overnight mapping operations and daytime ROV operations. These sonars are quantitative scientific echosounders calibrated to identify the target strength of water column acoustic reflectors - typically biological scattering layers, fish, or gas bubbles – providing additional information about water column characteristics and anomalies. These sonars were calibrated on the EX-18-02 cruise, and calibration values from that cruise were applied to the EK sonars for EX-18-06. The 2018 EK Calibration Report (<https://doi.org/10.25923/6nb5-f816>) is available in the NOAA Central Library.

Knudsen 3260 Sub-bottom Profiler

The ship is equipped with a Knudsen 3260 sub-bottom profiler that produces a frequency-modulated chirp signal with a central frequency of 3.5 kHz. This sonar is used to provide echogram images of shallow geological layers underneath the seafloor to a maximum depth of approximately 80 meters below the seafloor. The sub-bottom profiler is 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 Acoustic Doppler Current Profiler (ADCP)

The ship utilized a 38 kHz Teledyne RDI Ocean Surveyor ADCP, with a ~900 meter range. ADCP data were gathered data prior to ROV deployments in order to assess currents at the dive site in support of safe operations. The ADCP was kept running throughout the ROV dives. The ADCP is not typically run concurrently with the other sonars while transiting due to interference issues. This sonar collected data until June 28, 2018 on this cruise, at which time it ceased to operate normally.

7. Data Acquisition Summary

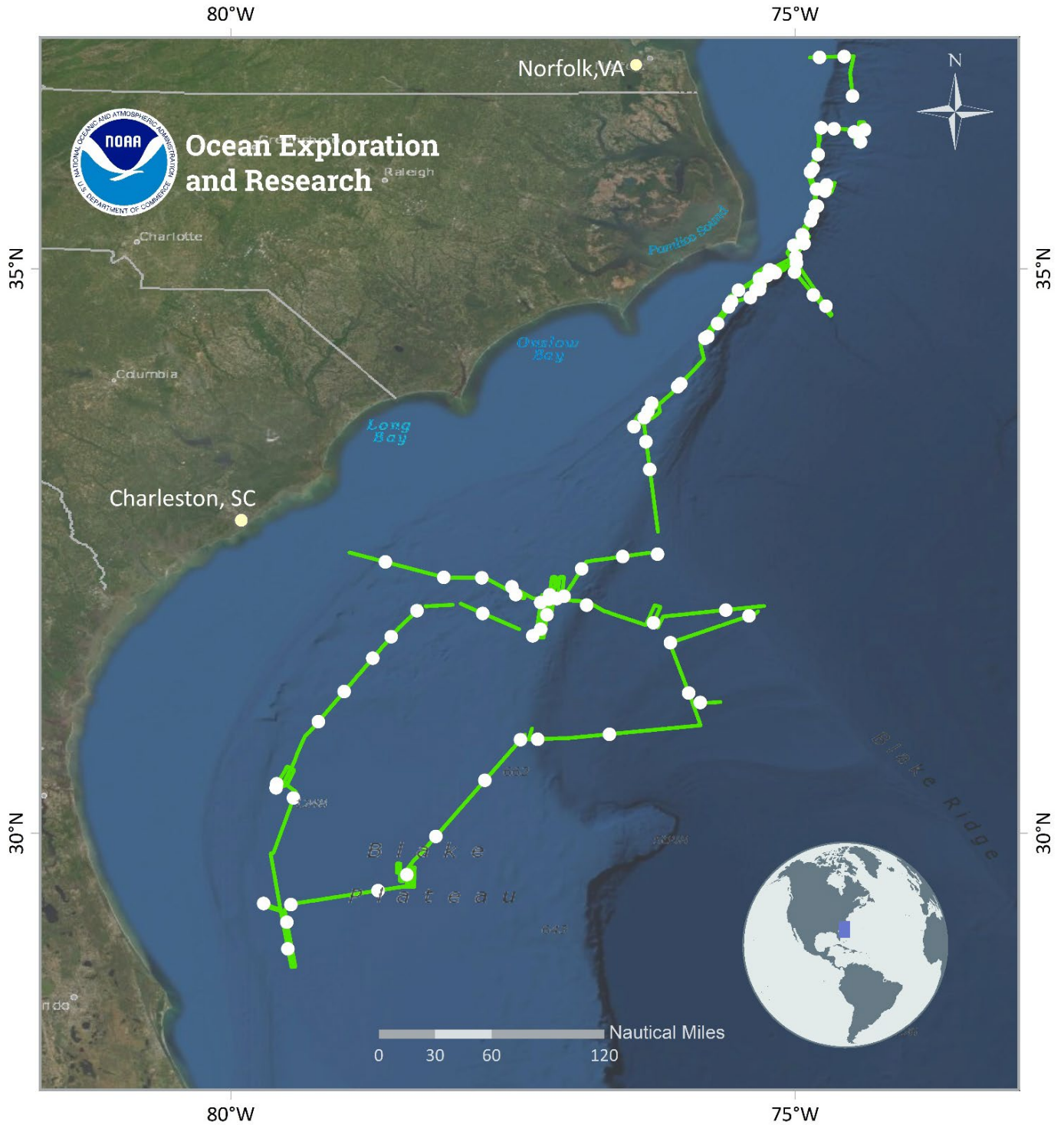
Mapping operations included EM 302 multibeam, EK 60 split-beam, and Knudsen sub-bottom profile data collection. Survey lines were planned to maximize either bathymetry edge matching of existing data or data gap filling in areas with existing bathymetry coverage. In regions with no existing data, lines 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 one-quarter to one-third 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 during focused survey operations 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. Reson sound velocity values were constantly compared against secondary derived sound speed values from the ship's onboard thermosalinograph flow-through system as a quality assurance measure. Expendable Bathythermographs (XBTs) were conducted every 1 to 4 hours (as governed by dynamic oceanographic conditions) to provide

temperature profiles of the water column in order to calculate sound velocity profiles. These profiles are used while surveying with the multibeam sonar in order to properly account for sound speed changes and ensure the most accurate bathymetry data possible. In total there were 95 XBT casts taken as part of the mapping survey.

Simrad EK 60 split-beam water column sonar data were collected continuously during the cruise, while transit mapping and during ROV dive operations. Knudsen 3260 sub-bottom profiler data were collected constantly throughout the cruise, except during ROV dives. EK60 and sub-bottom data were monitored in real time for quality during the cruise but were not post-processed. Data collection tracklines for the EM 302 multibeam, EK60, and sub-bottom profiler sonars, along with the location of XBT casts, are shown in Figure 2.





Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 2. Cruise map showing XBT cast locations (white) and sonar acquisition tracklines (green) for the EM 302 multibeam, EK60 split-beam, and sub-bottom profiler sonars completed during EX-18-06.

8. Multibeam Sonar Data Quality Assessment and Data Processing

Figure 3 shows the multibeam data processing workflow for this cruise. EM 302 Built-in Self Tests (BISTs) were run at the beginning and ending of 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. Erroneous soundings were removed using 2-D, 3-D, and spline filtering editing tools in Qimera. Gridded digital terrain models were exported utilizing QPS Fledermaus software and posted to the ship's ftp site for daily transfer to shore. Final bathymetry QC was completed post-cruise onshore at the Center for Coastal and Ocean Mapping at the University of New Hampshire. With the vast majority of surveying completed in deep water, depth measurements were not adjusted for tides, as they are an essentially insignificant percent of the overall water depth. Data cleaning projects were in UTM zone projections for the operations area. Final data products were exported and archived as field geographic WGS84 coordinate reference frame (i.e., un-projected).

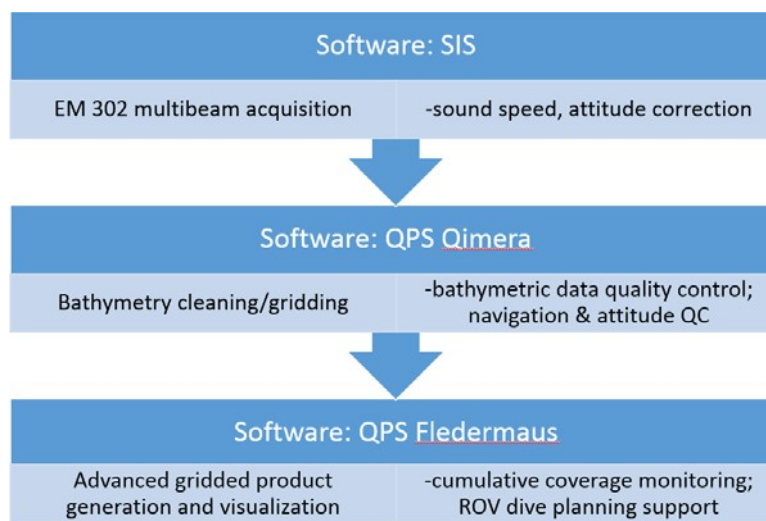


Figure 3. Shipboard multibeam data processing workflow.

Crosslines

Comparing depth values from orthogonal survey lines is a standard hydrographic quality control measure to evaluate the consistency of the multibeam sonar data collected during a cruise. A crossline was run on November 2, 2018 as shown in Figure 4. Crossline analysis was completed using the Crosscheck Tool in QPS Qimera software, and the results shown below indicate the survey meets the requirements for an International Hydrographic Order 1 survey.

Crossline file:

0277_20180622_013943_EX1806_MB.all

Main scheme line file:

0029_20180614_072446_EX1806_MB.all

Depths listed ("Z") are in meters.

<u>Statistic</u>	<u>Value</u>
Number of points of comparison	183,975
Grid Cell Size	30
Difference Mean	0.547
Difference Median	-0.022
Difference Std. Dev	3.472
Difference Range	[-11.023, 21.842]
Mean + 2*Stddev	7.492
Median + 2*Stddev	6.967
Data Mean	-864.235
Reference Mean	-864.782
Data Z-Range	[-910.606, -826.506]
Reference Z-Range	[-906.759, -835.823]
Order 1 Error Limit	11.2533
Order 1 # Rejected	1898
Order 1 P-Statistic	0.0103166
Order 1 Survey	ACCEPTED



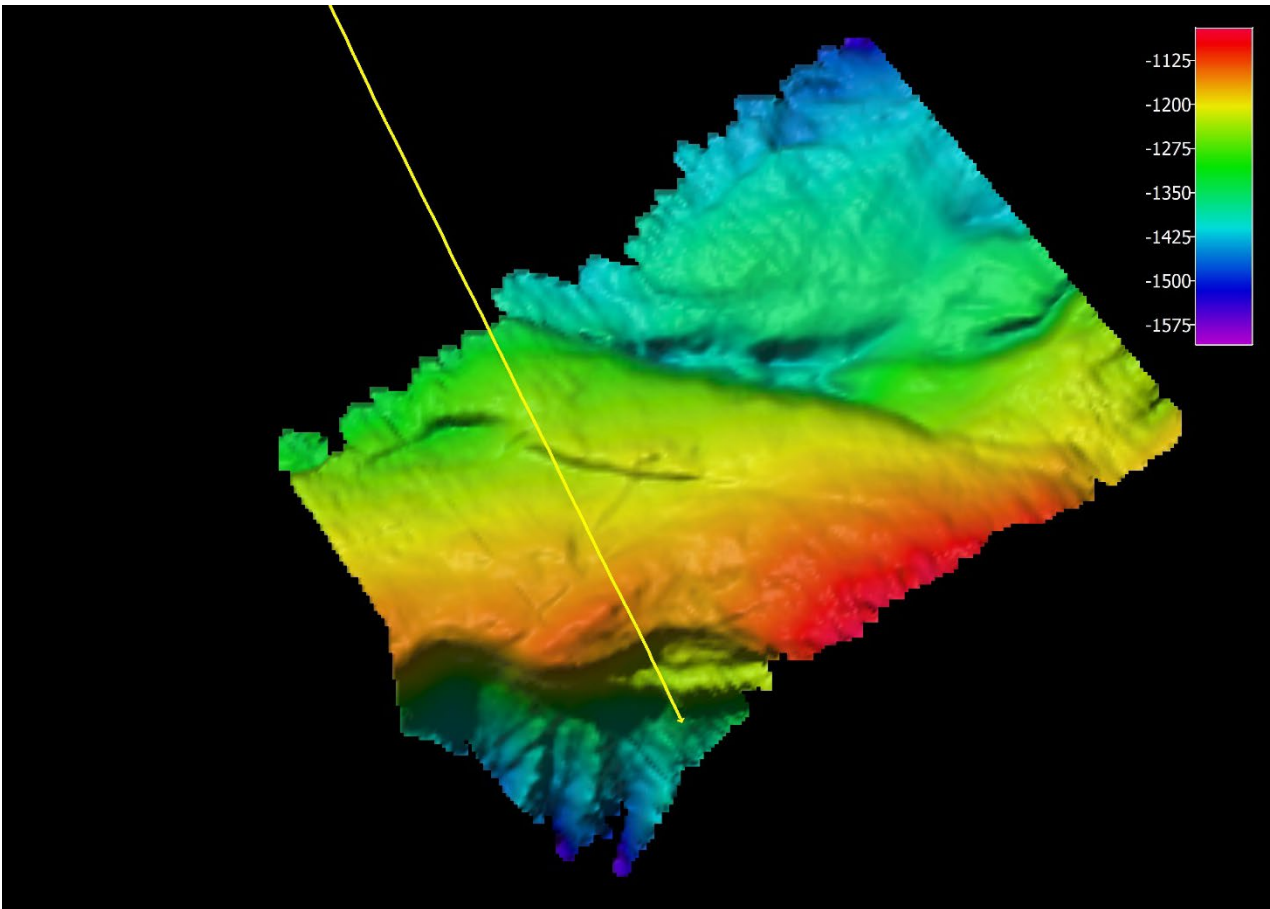


Figure 4. EX-18-06 crossline (shown in yellow) used for comparison against the bathymetric grid generated via an orthogonal multibeam survey line.

9. Data Archival Procedures

All mapping data collected by the NOAA Ship *Okeanos Explorer* are archived and publicly available within 90 days of the end of each cruise via the National Centers for Environmental Information (NCEI) online archives. The complete data management plan (which describes the raw and processed data formats produced for this cruise) is available as an appendix in the EX-18-06 project instructions available in the NOAA Central Library at [doi:10.25923/rz5x-k707](https://doi.org/10.25923/rz5x-k707). 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

Simrad EK 60 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
- Multibeam water column data review log identifying files with potential seeps

All sonar data is permanently discoverable at <https://www.ngdc.noaa.gov/>

At the time of writing this report:

Sub-bottom data, supporting data, and informational logs will be available in the NCEI Data Archives accessible at <https://www.ngdc.noaa.gov/>. For any challenges accessing SBP data, send an inquiry to ncei.info@noaa.gov requesting access to EX-18-06 Knudsen 3260 sub-bottom raw and processed data.

EM 302 bathymetry data, supporting informational logs, and ancillary files are available in the NCEI Data Archives accessible at <https://maps.ngdc.noaa.gov/viewers/bathymetry/> (last accessed 2/18/2020).

EM 302 and EK 60/80 water column data, supporting informational logs, and ancillary files are available in the NCEI Data Archives accessible at <https://www.ngdc.noaa.gov/mgg/wcd/> (last accessed 2/18/2020).

10. Cruise Calendar

All times listed are local ship time, which was Eastern Daylight Time (-4 hours from UTC)

June/July 2018

Sun	Mon	Tues	Wed	Thur	Fri	Sat
	11 (June) Sailing delayed until 6/12. Pre-cruise meeting @1400.	12 Fueling @ 1930 -2400 Sailing delayed until 6/13.	13 <i>Okeanos</i> Departs Charleston, SC at 0930. Transit mapping to first dive site.	14 Dive 1: Blake Escarpment North	15 Dive 2: Blake Ridge and Midwater	16 Dive 3: Giant Bedforms
17 Dive 4: Blake Escarpment South	18 Dive canceled - all day mapping.	19 Dive 5: Stetson Mesa South	20 Dive 6: Stetson Mesa North	21 Dive 7: Savannah Banks	22 Dive 8: Richardson Scarp	23 Dive 9: Blake Ridge Wreck
24 Dive 10: Cape Fear	25 Dive 11: Pamlico Shallow	26 Dive 12: Pamlico Deep	27 Dive 13: Rocky Reef	28 Dive 14: Hatteras Canyon	29 Dive 15: Keller Canyon and Midwater	30 Dive 16: Pea Island
1 (July) Dive 17: Currituck	2 <i>Okeanos</i> docks in Norfolk, VA. End of cruise.					



11. Daily Cruise Log Entries

Generated from the daily expedition situation reports. All times listed are local ship time, which was Eastern Daylight Time (-4 hours from UTC)

June 13, 2018

Made dive plan products for dives 1 and 2. Loaded up XBT autolauncher and reviewed Standard Operating Procedures (SOPs). Began survey operations after lunch when we reached 50m water depths. All sonars running well and data quality is very good. Adding coverage to Area 4 from the previous cruise (EX-18-05) before proceeding to the dive site. Began normal night mapping watch schedule with augmenting Survey Tech (ST) Allen and Watch Lead Jerram.

June 14, 2018

Survey mapping overnight went smoothly, with coverage added to EX-18-05 data and an on-time arrival at the dive site. Multibeam processing is up to date. After dive recovery, the multibeam had a problem with the warning that it was not receiving PPS, which is the GPS time signal to the transceiver unit. We checked the POSMV feed and it was working normally. We rebooted SIS first, but then had to reboot the TRU to fix the problem. After that the multibeam performed normally. Data quality is very good. Sound velocity is much less variable where we now are. AXBTs (auto launcher XBTs) are working great.

June 15, 2018

Overnight mapping filled a small remaining gap in a priority mapping box from EX-18-05 between the northern Blake Escarpment and Blake Ridge. Sonars are all working well and data quality remains very good. We ran the EK60s and 38 kHz ADCP throughout the ROV dive to inform the mid-water exploration on ascent. Screenshots of CTD data and EK60 echograms were sent to shore. We tested the workflow to use ROV CTD data for sound velocity profiles (SVPs) for the multibeam. Used SBEData software to convert .hex file to .cnv, then imported into Sound Speed Manager for editing and exported as .asvp files to SIS. Compared these profiles to AXBT casts and there was excellent agreement. We will use this for the rest of the cruise and type up a one page SOP. The engineers replaced a faulty valve in the thermosalinograph (TSG) today during the ROV dive. However, a new leak from the TSG piping was discovered and was leaking above the electric pump motor. The leak was patched, but there was not enough cure time before surveying needed it turned back on. Pipe still leaks, so TSG secured overnight until the leak can get a better fix tomorrow. Evaluated a shipwreck target provided by NOAA Ship *Henry Bigelow*. The wreck appears to be in about 80 meters of water so outside our normal operating parameters, and we do not plan to dive on it.

June 16, 2018

Overnight mapping went smoothly and sonar quality was excellent, with some very nice sub-bottom data collected. Despite valiant efforts twice by the engineers, the TSG pipes still have pinhole leaks and the TSG was secured again today. Another fix will be attempted tomorrow, but a more complete fix may be needed after the cruise in port. The area we are now in has fairly stable salinity, but this will change in a few days and we hope the TSG can be operational by then to support mapping. We are still working out the best way to get ROV CTDs into a format usable by the multibeam for sound velocity profiles - they are not



working as expected in Sound Speed Manager so some tech support will be sought on Monday. Daily gridded bathymetry products are being made and pushed to shore.

June 17, 2018

Overnight surveying operations finished the edge matching line with the extended continental shelf (ECS) data near Blake Ridge, then transited over unmapped areas to the dive site, mapping interesting bedform features along the way. Survey supported mid-water exploration work by running the EK60 sonars and sending screenshots of the echograms to shoreside scientists. The engineers are still working on the TSG as there are still small leaks, so the system has remained secured. Data quality is very good and the night watch is keeping up with cleaning the multibeam data. AXBTs are working great. Took some sun photometer measurements. Late night generator issues led to needing to make a survey plan near tomorrow's dive site in case the dive does not happen. Delivered plan to the bridge for early morning mapping.

June 18, 2018

Mapping Lead Sowers relieved the night watch at breakfast, and stood watch throughout the day to cover mapping operations due to the cancelled dive. Mapped a box around the planned "Knolls" dive site and re-mapped the knoll feature we planned to dive on as well as numerous others scattered around an otherwise flat seafloor. The features ended up being quite interesting with distinct North-South ridges - these would make a good dive target if we get back to this area next year. At 1330 we departed on a transit west toward the Stetson South dive site. The multibeam had transient but consistent dropouts of the attitude data feed, and separately from the PPS time feed - both from the POSMV. Impact on overall data quality is minor (sporadic bad pings), but we are troubleshooting with onboard engineers from Global Foundation for Ocean Exploration (GFOE). This may be a Marinestar issue beyond our control that could come and go - the same issue was reported on EX-18-05. The TSG repair held today and it was turned back on. We are mapping overnight to edge match Stetson data collected on EX-14-03 in a fascinating area. After reviewing the latest model output from the Real-Time Ocean Forecast System (RTOFS) currents model, we abandoned our preferred dive site on Stetson south and planned one to the east, as well as another contingency even further east. Planned dive options for Stetson north.

June 19, 2018

Overnight mapping went very well, with some great new data on Stetson Mesa on the eastern edge of our large coverage there from EX-14-03. The new sound speed inversion tool in Qimera worked great on reducing sound velocity artifacts. Sea state is very calm and data quality is very good. The multibeam needed two TX36 boards to be re-seated prior to working yesterday, but today all BIST tests passed right away. We continued to have the intermittent loss of GPS time leading to erratic bad pings once in a while. We checked the connections on the back of the POSMV and they appeared tight. However just this little check caused a short loss of primary GNSS receiver feed to the POS, suggesting a poor connection with the primary POS antenna and the POSMV unit - we will try a new connector when we can without interrupting operations. TSG is still working. Overnight mapping continues to edge map coverage along Stetson Mesa over interesting terrain.



June 20, 2018

Overnight transit mapping went smoothly, adding coverage to EX-14-03 data on Stetson Mesa. Sonar data quality remained strong. The multibeam passed all BISTs first try. To address the sporadic POSMV clock dropout issue we have decided to wait until the last morning of the cruise. At that time ship's Chief Electronics Technician Peperato will put a completely new connector onto the end of the primary POSMV antenna cable for a better connection with the POSMV deck unit. Also, we will switch all of the serial cables from the POS that are in an older serial hub to a brand new unit already set up by GFOE. The old hub is on the floor of the rack room and not well protected, the new unit is safely mounted directly above the POS deck unit. We believe this will fix the dropouts, but don't want to do until the end of the cruise to avoid disruptions to this critical data feed for both ROV and mapping. Also planned for the last day of the cruise is some quick testing of the new serial ports for the ADCP unit, since several ports have failed. This work is being done in coordination with our ADCP partners at the University of Hawaii (UH). We believe we fixed the issue with the daily products today thanks to work/testing by Watch Lead Jerram. Daily Gulf Stream forecast models are being put into Hypack to help guide ROV dive operations.

June 21, 2018

Overnight mapping operations completed a long transit from the Stetson North dive site to the preferred dive at Savannah Banks, with some significant coverage of unmapped terrain. We mapped as possible as we moved to the second and third dive site options. A geologist from the College of Charleston has been processing our sub-bottom data from the cruise and is very interested in the mound features. He requested low speed lines over dive sites as possible. We will try to do post dive surveys as time/operations allow. Overnight survey lines are planned for an unmapped area just east of coverage obtained in EX-18-05 in the Richardson Hills area for overnight mapping. Tonight is a "map and dive" situation where we will pick a good scarp feature to dive on based on what is mapped overnight. This needed to be done to stay out of strong Gulf Stream currents. Sea state picked up a bit today, data quality is still good.

June 22, 2018

Last night's mapping filled in an empty space in the eastern portion of Richardson Hills. The multibeam data had a quick initial cleaning and an excellent dive site was located with a steep scarp over 100 meters tall with slopes up to about 40 degrees. Dynamic Positioning (DP) testing occurred right after ROV recovery. Mapping took this slow transit time window to do a sub-bottom survey over the scarp upon which the ROV dove today. This dataset was requested by a geologist from the College of Charleston whenever possible. We collected the line at 2-3 knots. Overnight mapping will continue mapping the scarp feature to the north, then head to the Blake Ridge Wreck area. Underwater Cultural Heritage (UCH) procedures are being reviewed for tomorrow's dive, and ST Allen will be sequestering the SCS files and turning off the video feed of the back row.

June 23, 2018

Overnight mapping involved gathering additional data to the north of Richardson Hills that finished the escarpment we were mapping, then a transit to the Blake Ridge Wreck site. UCH protocols were followed for mapping data with all sonar data files near the dive site put in restricted folders. Sonars are operating normally, minus the periodic POSMV feed dropouts to the multibeam that we plan to fix at the end of the cruise. The mapping operations for tonight will map an unknown area near Cape Fear north of a known *Lophelia pertusa* mound site.



June 24, 2018

Overnight mapping completed a transit northward and mapping a small survey box of unexplored area offshore of Cape Fear near the edge of the continental shelf. The satellite-derived bathymetry grid showed some bumps there, but it turned out to be smooth gently sloping seafloor with no features of interest to offer dive potential. We mapped to the edge of the *Lophelia* mound that was the backup dive site. After the dive we ran a slow sub-bottom profiler line over the mounds as requested by onshore scientists (to better understand the underlying geologic features) while the ship did some dynamic positioning (DP) testing maneuvers. Tonight's mapping is another long transit followed by several areas of surveying for potential wrecks given to us as UCH possibilities by the Monitor National Marine Sanctuary. We will be doing very slow lines with a tight swath and manually set power mode to obtain high resolution and quality backscatter. Data from today will be examined by the night watch then the Mapping Lead in the morning. Sound velocity refraction on the outer beams is a challenging multibeam cleaning task (as expected in this area in the middle of the Gulf Stream). XBTs are being done roughly every 2 hours.

June 25, 2018

Overnight mapping for possible UCH targets went smoothly last night, with one possibility identified but nothing very definitive. We processed backscatter data and shared files and interpretations with onshore archeologists. We have a meeting with them tomorrow morning to review data and decide on any potential dive targets for Wednesday. The primary positions provided have not yet yielded results in their immediate vicinity. We continue to look tonight expanding out from the main area and also catching a possible location 16 miles to the north. The occasional position dropouts on the multibeam only affect one ping - which is fine for the bathymetry but leaves an ugly gap in the backscatter. We will definitely be trying to fix this issue as a top priority on the last day of mapping. We completely turned off all sonars today prior to the scuba diving operations. All sonars came back on without any problems.

June 26, 2018

Last night was the second night of mapping operations with a primary focus on searching for potential UCH wrecks in the vicinity of the Pamlico Canyon area. After a thorough review of the backscatter and bathymetry data, one target was identified as having potential. A scene file was made with all of the relevant data, sent to onshore scientists, and discussed via a conference call arranged. We all agreed that the target from the first night of surveying (that we stumbled upon during a transit) was the best target and have planned to dive on it tomorrow. Given the cancelled dive at Pamlico Deep, we spent the morning mapping in transit to the backup dive site at an inter-canyon area south of Pamlico Canyon. The ADCP sonar was not getting good detections of currents this morning (very low "percent good"). After shutting down UHDAS control software and power cycling the OS38 deck unit it worked better and we were able to use it for pre-dive evaluation of currents. This happened earlier in the week and may be a sign of a trend in decreasing reliability. The other sonars are working well. The AXBT has been very useful for overnight mapping, with several lighting storms occurring during the week that would have prevented someone from going out to do a manual cast.

June 27, 2018

Last night's mapping operations involved edge matching along the edge of the continental shelf while transiting south to the suspected wreck site we mapped two days prior. Two additional mapping passes



were done over the site. Early morning data processing involved updating bathymetry grids for the dive site, selecting water column data that had high backscatter returns as potential wreck detections, and consulting with the ROV team on a safe approach to the potential UCH site. Tonight's mapping will start with shallow edge mapping, then map the midsections of the inter-canyon areas between Pamlico Canyon and Hatteras Canyon. This area was never previously mapped by *Okeanos*. The synthesis grids for this region of the canyon show a distinct and ugly artifact from stitching together ECS data with *Okeanos* data with a poor edge match. We will fix this issue tonight with new coverage, as well as a similar issue at the head of the canyons. A new pass over the planned dive site at Hatteras Canyon will also be completed, including checking to see if we can find the seep reported there by USGS.

June 28, 2018

Last night's mapping completed edge mapping along the edge of the shelf, then a few lines over the inter-canyons between Pamlico and Hatteras Canyons. A line was also run directly up Hatteras Canyon, revealing an extremely narrow incised portion of the channel not apparently visible in other existing surveys of the canyon. It is not clear at this time if this feature has been there and just not been mapped in that much detail before, or if it has changed since the last time EX surveyed it. Tonight's mapping is focused on getting a high quality survey completed at the heads of canyons and along the edge of the shelf between Hatteras and Keller Canyons. We are utilizing data provided to us from USGS to dive in Keller Canyon as it is a good 25m resolution survey. The ADCP would not collect any useful data today. UH confirmed that it was non-functional based on the data mailers that they received every day. This means that the ship is now without any working ADCP to support ROV operations. Replacement (likely) or repair is not possible until drydock.

June 29, 2018

Overnight mapping focused on improving data coverage and quality at the heads of the canyons north and south of Keller Canyon. All mapping sonars operating normally, except for the periodic dropouts on the multibeam. Tonight's mapping is focusing on the heads of the canyons around the "Pea Island" canyon we are diving on tomorrow, high resolution lines down Pea Canyon, and gap filling of a deeper area not covered by *Okeanos* multibeam (or any other good data). Supported midwater dives with EK60 data and sending screenshots of the ROV CTD plots to shore. Planned the final two dives with the onshore/onboard science team.

June 30, 2018

Last night we conducted edge mapping at the heads of canyons and filling a deeper gap in EX canyon coverage east of the dive site at "Pea Island." We have been obtaining coverage over dive sites either before or after dives, which was desired by USGS. We have been closely collaborating with USGS on data sharing and dive planning, and we will also be gathering some high priority sub-bottom profile lines over the major Currituck landslide feature overnight. The weather is exceptionally calm and data quality is very good. We sent a help ticket to Kongsberg to get ideas on fixing our dropout issue on the occasional EM 302 pings. We prepared a detailed document of the problem with examples, and sent along the most recent BIST test results. We would like to at least rule out the TRU, while still planning to improve the primary POS antenna connection and improving the serial hub for the multibeam computer tomorrow after the dive. Sound velocity at the top of the canyons fluctuates dramatically, and we have been doing frequent XBTs and lots of re-working of sound velocity profiles to address issues with overlapping line offsets. We have



not had processing time to look at much water column data, but have seen some seep evidence in the multibeam. The ADCP was completely turned off today as recommended by UH.

July 1, 2018

Last night we mapped along the top edge of the canyons then did a few slow lines over the Currituck landslide feature to optimize sub-bottom data at the request of USGS - ending at the toe of the feature for the dive site. Tonight we are re-mapping seeps discovered several years ago by OER, which will provide another snapshot of seep activity in this area. This will be followed by a direct transit to the sea buoy at the entrance to Norfolk. The mission team replaced the serial hub for the EM 302 computer that has feeds from the TSG and SCS. The old hub was on the floor of the rack room and was in poor condition. The new hub is securely mounted to the top of the hydrographic workstation computer and labeled. This improvement had no impact on the dropouts observed on the multibeam. The replacement of the POS primary antenna connector will happen in port. We have had no further insights yet from Kongsberg support. GFOE is planning to move the POSView software from the ArcGIS computer to a dedicated POSMV computer (as originally planned when the GFOE network transition occurred). This will free up the ArcGIS machine for use on the next cruise.

July 2, 2018

Mapping sonars were secured last night close to midnight when we reached 50m on the continental shelf prior to transiting towards the sea buoy. Qimera data processing continues this morning. We are preparing the mapping data package and copying to hard drive to bring back to shore. Sun photometer data will be downloaded today and sent to NASA. Cleaning and organizing of survey and lab space will be completed today, and conduct a tour for Virginia Sea Grant this afternoon.

12. References

The 2018 NOAA Ship *Okeanos Explorer* Survey Readiness Report can be obtained in the NOAA Central Library or by contacting the NOAA OER mapping team at oar.oer.exmappingteam@noaa.gov.

The EX-18-06 Project Instructions can be obtained from the NOAA Central Library at [doi:10.25923/rz5x-k707](https://doi.org/10.25923/rz5x-k707). The EX-18-06 Data Management Plan is an appendix of the project instructions.

The following data were used as background data throughout the expedition:

- Tozer, B. , D. T. Sandwell, W. H. F. Smith, C. Olson, J. R. Beale, and P. Wessel, Global bathymetry and topography at 15 arc seconds: SRTM15+, Accepted Earth and Space Science, August 3, 2019. <https://doi.org/10.1029/2019EA000658>
- NOAA Nautical Charts
- Various datasets downloaded from the NCEI archives via NOAA AutoChart.

