Ocean Exploration and Research

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MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT

EX-18-04: Dedicated Joint Polar Satellite System (JPSS) Visible Infrared Imaging Radiometer Suite (VIIRS) Ocean Color Calibration/Validation Cruise May 2018 *(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 the EX-18-04 dedicated JPSS VIIRS Ocean Color Calibration/Validation Cruise May 2018. EX-18-04 was unique since it was not planned and executed by NOAA OER. EX-18-04 was planned and lead by NOAA National Environmental, Satellite, Data and Information Service (NESDIS) All OER objectives were secondary to that of the NESDIS team, however opportunistic mapping operations occurred as much as possible in pursuit of the OER *always exploring* concept of operations. This report will present an overall summary of 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, which is available in the NOAA Central Library.

3. Cruise Objectives

A summary of the EX-18-04 cruise objectives as well as the NESDIS technical cruise report can be found here: https://repository.library.noaa.gov/view/noaa/20267. OER exploratory mapping objectives occurred opportunistically and largely during overnight transits.

4. Summary of Mapping Results

EX-18-04 mapped 12,311 square kilometers around Florida and in the Gulf of Mexico during the 10 days-at-sea (Figure 1 and Table 1). 8,480 square kilometers of this area was mapped within the U.S. Exclusive Economic Zone in depths deeper than 200 meters. Multibeam bathymetry data coverage is shown in Figure 1.

Cruise Overview Map

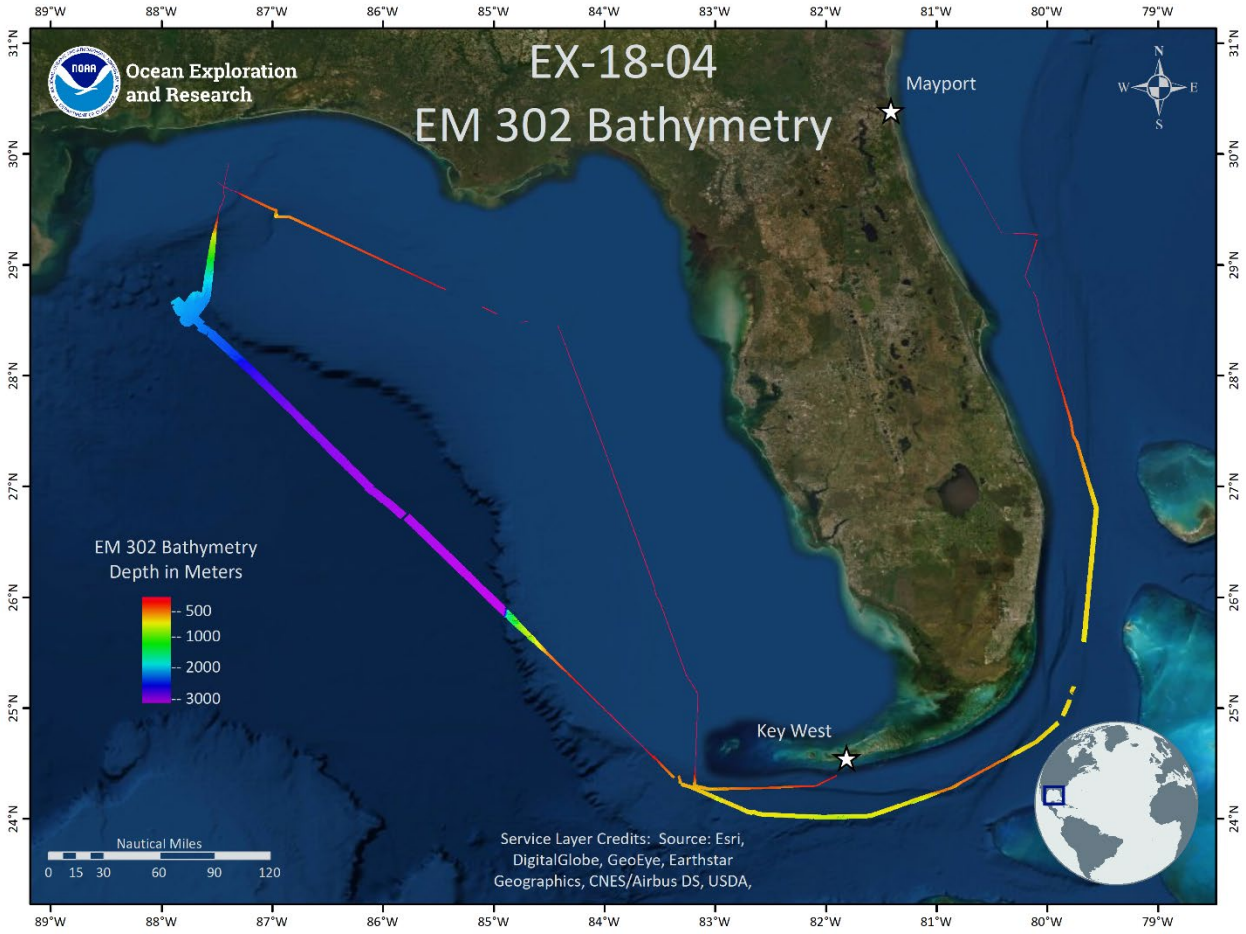

Figure 1. Overview of bathymetric mapping coverage completed during Dedicated JPSS VIIRS Ocean Color Calibration/Validation Cruise May (EX-18-04).

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5. Mapping Statistics

Table 1. Summary statistics of ocean mapping work completed during EX-18-04.

Dates of data collection	May 9 – May 18, 2018
Linear kilometers of survey with EM 302	2,703
Square kilometers mapped with EM 302	12,311
Square kilometers mapped with EM 302 within U.S. EEZ deeper than 200m	8,480
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)	200 files/ 34.9 GB
Number / Data Volume of EM 302 water column multibeam files	200 files / 80.8 GB
Number / Data Volume of EK60 water column split-beam files (.raw)	81 / 4.28 GB
Number / Data Volume of sub-bottom sonar files (.segy, .kea, .keb)	168 / 1.35 GB
Number of XBT casts	32
Number of CTD casts (including test casts)	17

6. Mapping Sonar Setup

Kongsberg EM 302 Multibeam Sonar

NOAA Ship *Okeanos Explorer* is equipped with a 30 kilohertz (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 shallower than 3300 meters the system is operated in dual swath mode, and obtains up to 864 soundings per ping by generating two swaths per ping cycle. The multibeam sonar is used to collect seafloor bathymetry, seafloor backscatter, and water column backscatter data. 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 here: https://doi.org/10.25923/4hs3-bq40

Simrad EK6 Split-beam Sonars

The ship operated four Simrad EK60 split-beam fisheries sonars: 18 kHz, 70 kHz, 120 kHz, and 200 kHz. 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-18-04. The 2018 EK60 & 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 normally operated to provide information about sub-seafloor stratigraphy and features. The data generated by this sonar are 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 during mapping operations due to interference issues.

7. Data Acquisition Summary

Mapping operations included data collection via the EM 302 multibeam sonar, EK60 split-beam (18, 70, 120, and 200 kHz) sonars, and Knudsen 3260 sub-bottom profiler. Data were collected by each sonar concurrently during the transits

Survey lines were planned to either maximize edge matching of existing bathymetric data, or to fill data gaps in areas with existing bathymetric coverage. In regions with no existing data, lines were planned to optimize potential exploration discoveries. EX-18-04 mapping data is largely transit mapping data except for a couple of survey lines southwest of De Soto Canyon in the Gulf of Mexico.

Throughout the cruise, multibeam data quality was monitored in real time by acquisition watchstanders. 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 the multibeam acquisition software Seafloor Information System (SIS) were generally left wide open for maximum exploration data collection and routinely adjusted on both the port and starboard side to ensure the best data quality and coverage.

Multibeam data received real time surface sound velocity corrections via the Reson SVP-70 probe at the sonar head, as well as through profiles generated from Expendable Bathythermographs (XBTs) conducted at intervals no greater than 6 hours, as dictated by local oceanographic conditions. Reson sound velocity 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 cruise. Data were monitored in real time for quality but were not post-processed. Figure 2 shows the EK60 data collected during EX-18-04.

Knudsen 3260 sub-bottom profiler data were also collected during the majority of the cruise. Figure 3 shows where sub-bottom data were collected during EX-18-04.

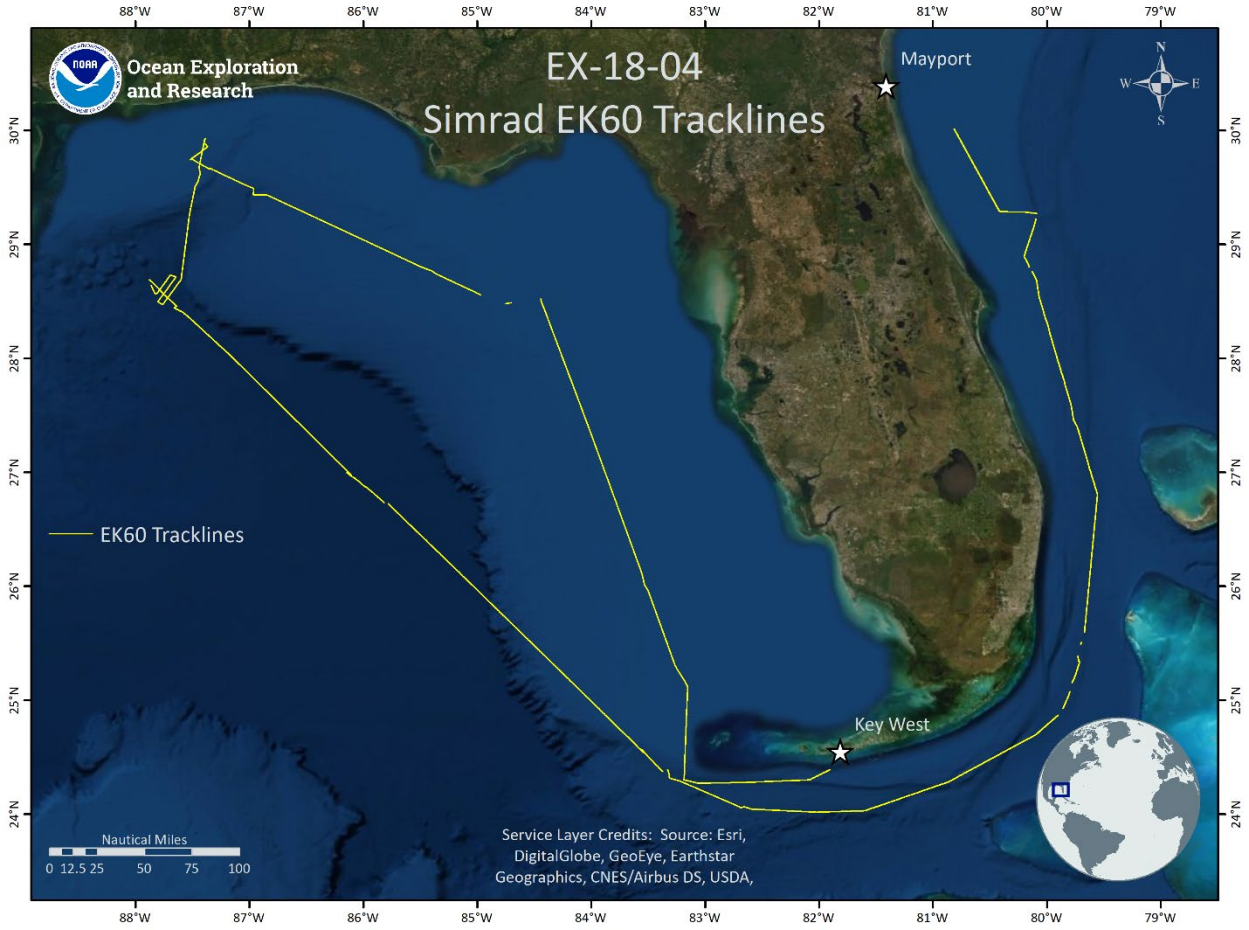

Figure 2. Simrad EK60 split-beam sonar data tracklines (in yellow) collected during EX-18-04.

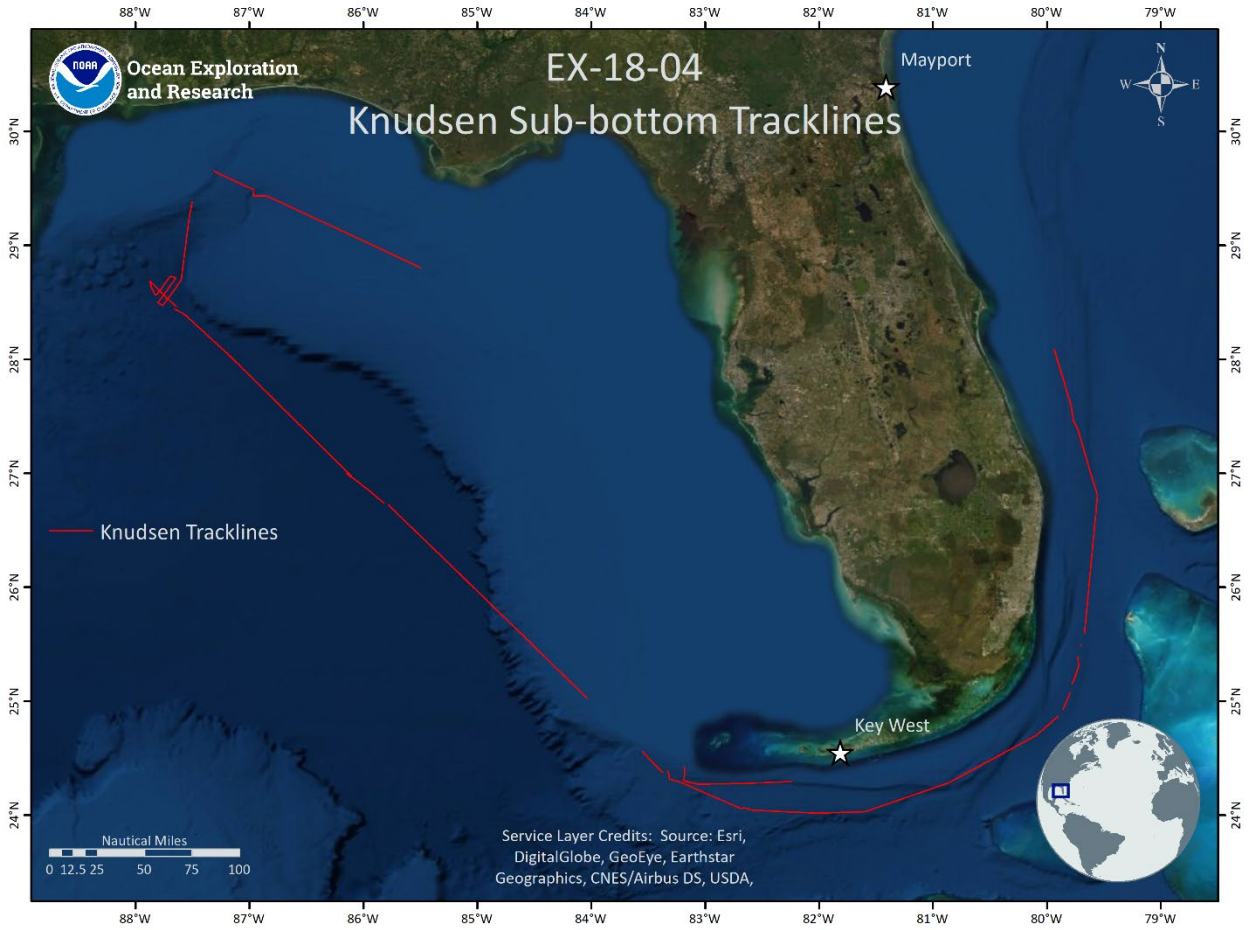

Figure 3. Sub-bottom profiler data tracklines (in red) collected during EX-18-04.

8. Multibeam Sonar Data Quality Assessment and Data Processing

Figure 4 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 in SIS, then imported into QPS Qimera for processing. In Qimera, the attitude and navigation data stored in each file were checked, and erroneous soundings were removed using 2-D and 3-D editors. 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., unprojected).

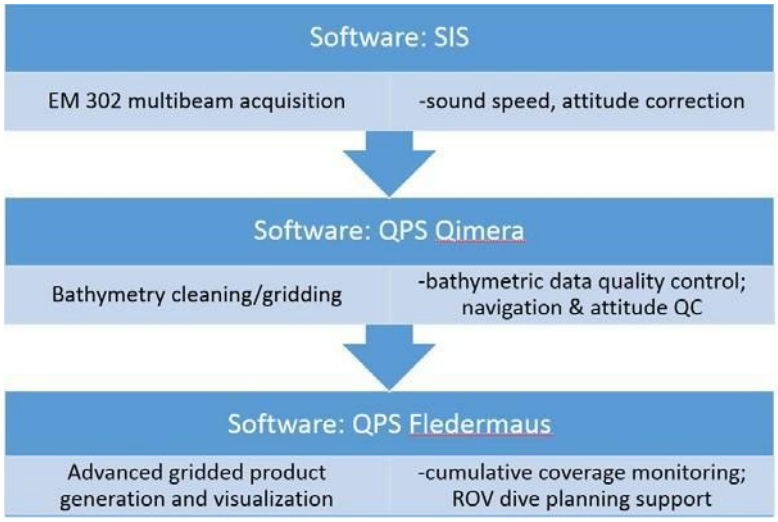

Figure 4. Shipboard multibeam data processing workflow.

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 July 7, 2018 as shown in Figure 5. Crossline analysis was completed using the Crosscheck Tool in QPS Qimera software to evaluate if the survey meets the requirements for an International Hydrographic Order 1 survey. The results are shown below.

Crossline file:

0095_20180513_171855_EX1804_MB.all

Mainscheme line files:

0082_20180513_071102_EX1804_MB.all

0084_20180513_082613_EX1804_MB.all

0086_20180513_084809_EX1804_MB.all

Statistic	Value (in meters)
Number of points of comparison	170077
Grid Cell Size	65
Difference Mean	0.557619
Difference Median	-0.512218
Difference Std. Dev	3.225207
Difference Range	[-24.82, 23.86]
Mean + 2*Stddev	7.008033
Median + 2*Stddev	6.630079
Data Mean	-2403.106715
Reference Mean	-2403.664333
Data Z-Range	[-2452.88, -2356.70]
Reference Z-Range	[-2450.28, -2366.19]
Order 1 Error Limit	31.251637
Order 1 # Rejected	0
Order 1 P-Statistic	0.00
Order 1 Survey	**ACCEPTED**

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

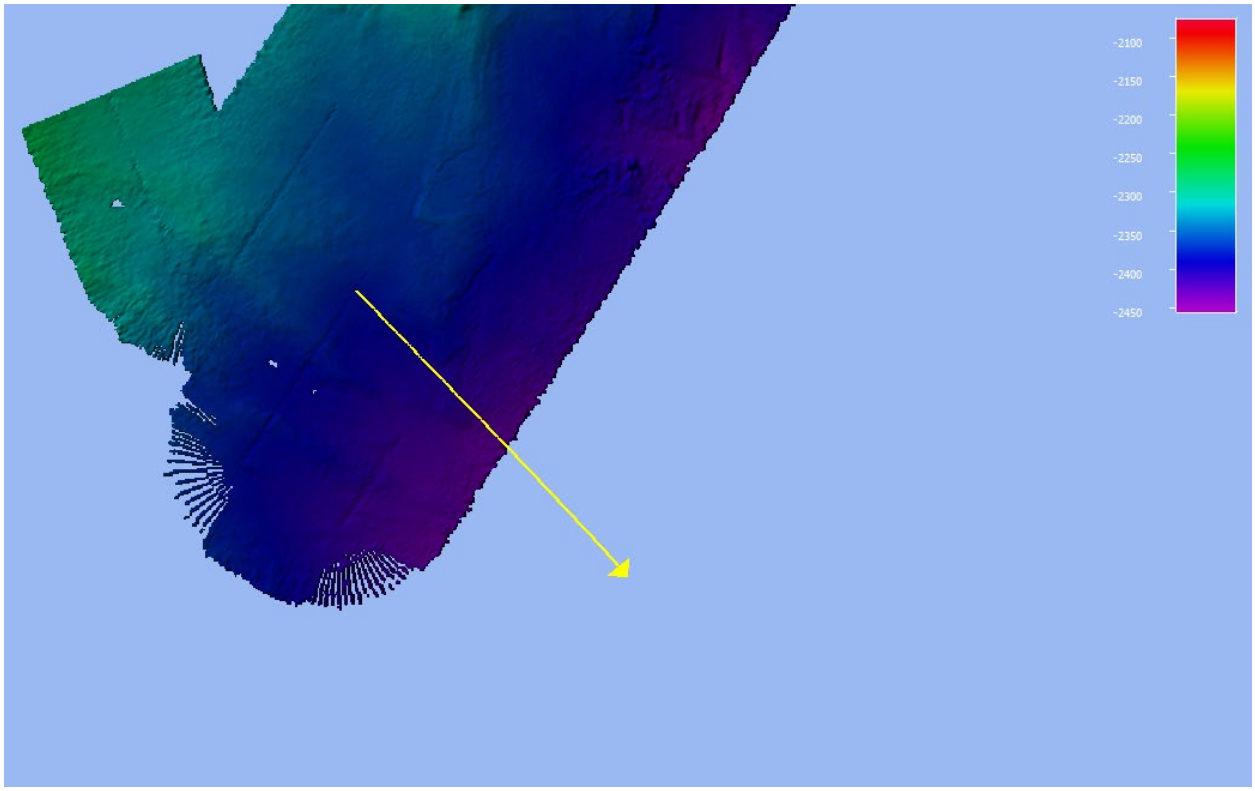

Figure 5. EX-18-04 crossline (shown in yellow) used for comparison against the bathymetric grid generated via orthogonal multibeam survey lines. Depth in meters, 4x vertical exaggeration, 65 meter cell size.

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. 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 (TRU)

Simrad EK60 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 (TRU)
- Multibeam water column data review log if data were reviewed for presence of seeps in Fledermaus MidWater or QPS Qimera

All sonar data is permanently discoverable at https://www.ngdc.noaa.gov/ (last accessed April 2020).

At the time of writing this report, EM 302 and EK60 water column data, supporting data, and informational logs were be available in the NCEI Water Column Sonar Archives: https://www.ngdc.noaa.gov/maps/water_column_sonar/index.html (last accessed April 2020).

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-18-04 Knudsen 3260 sub-bottom raw and processed data.

EM 302 bathymetry data, supporting informational logs, and ancillary files were/will be available in the NCEI Data Archives accessible at https://maps.ngdc.noaa.gov/viewers/bathymetry/ (last accessed April 2020)

10. Cruise Calendar

All times listed are local ship time, -5 hours from UTC

May 2018

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		8 Mobilization, Key West, Florida	9 Depart Key West, NESDIS Sampling, overnight transit mapping	10 Transit Mapping	11 NESDIS sampling and transit mapping	12 NESDIS sampling, transit mapping
13 NESDIS sampling and transit mapping	14 NESDIS sampling and transit mapping	15 NESDIS sampling and transit mapping	16 NESDIS sampling and transit mapping	17 NESDIS sampling and transit mapping	18 Arrive Mayport Florida Naval Station, demobilization	19

11. Daily Cruise Log Entries

Generated from the daily expedition situation reports. All times listed are in local ship time (-5 hours from UTC)

May 8

A hull dive was completed. The following is a description of the EK60 38 kHz resulting from the dive:
During our hull inspection we noticed that on the EK-60 Transducer Suite, the ES38-B 38kHz had some of the rubber gasket protruding from between the sensor and the hull. The gasket had about 0.5 to 1 inch of material protruding for about 240 degrees around the sensor. The remaining area was either not protruding or had been torn off or dislodged at some previous time. There was some small algal growth on the gasket suggesting it may not be that recent. Due to the clarity of the water on the last dive we were able to get a better view of the sensors and that is how we noticed this.

New surveys and file paths were set up for the EM 302, Knudsen and EK60. Data management structure for EX-18-04 has been created.

EM 302 failed first BIST post-hull dive. Power was cycled to the TRU and second BIST was a full pass.

May 9

EM 302, EK60s and Knudsen all powered on and began acquiring data normally. Knudsen will not be run in shallow (<100m) of water. Multibeam was left pinging during sampling for depth. Will likely leave on during NESDIS sampling.

May 10

Due to shallow water depths (< 100m), synthetic profiles for sound velocity will be downloaded through Sound Speed Manager and pushed to the multibeam in real-time. Bowing of the outer beams is present but we do not want to use XBTs in such shallow conditions.

The EM 302 is dropping pings every so often. Will monitor when we get to deeper areas.

Survey continues to aid the NESDIS in drafting line plans and understanding ship location.

May 11

Shallow water mapping continues.

The multibeam was dropping pings. A closer examination of the telnet showed timeouts on TX boards. BIST was a full pass but there remained errors in telnet and issues with the data. TRU power was cycled over 4 times and Ethernet cords were adjusted over the course of 2 hours. TRU came back online normally and another BIST was passed. Ping dropouts have ceased and data looks excellent.

THE EM 302 message showed a timeout error. This is likely related to the previously reported dropped pings issue.

May 12

Data quality looks good and ship is moving into deeper waters. XBTs are being performed every 2-3 hours as the ship operates near shore.

EM 302 TRU troubleshooting has been successful and TX timeout errors have ceased. OER mapping continues to facilitate transit planning between science and the bridge.

Drop-dead dates and times were calculated for our transit to Jacksonville on the opposite side of Florida. Mapping has provided line plans in accordance with operational needs. Lines are located in areas that do not contain existing multibeam data.

EX-18-05 planning materials are being sent to the ship and placed on the network. EX-18-05 mapping data structure has been setup.

May 13

All data looks good. EM 302 dropouts have ceased and errors in the telnet are no longer present. Mapping continues to assist with ship track planning.

Shallow water data processing is nearly complete.

May 14

No updates to report. Mapping continues.

May 15

The timeout errors from the TRU are back in telnet. Mapping team may decide to restart TRU if data quality becomes an issue. Mapping continues to aid NESDIS team in calculating time and distance for transits. OER and GFOE also continue to help troubleshoot connectivity issues and data access issues.

May 16

Mapping team spent 4 hours troubleshooting the multibeam timeout errors. After wire fidgeting, reseating of BSP and TX boards, the timeout errors are gone, and the data look excellent. Kongsberg support assisted in these efforts.

May 17
Transit mapping, no further updates.

May 18
Arrive Mayport Naval Station, demobilization. Systems secured and data package complete.

12. References

NOAA Office of Ocean Exploration and Research, 2018. The 2018 NOAA Ship *Okeanos Explorer* Survey Readiness Report NOAA: https://doi.org/10.25923/4hs3-bq40.

NOAA Office of Ocean Exploration and Research, 2018.The 2018 EK60 Calibration Report can be obtained in the NOAA Central Library here: https://doi.org/10.25923/6nb5-f816. Last accessed April 2020.

NOAA Nautical Charts: https://www.charts.noaa.gov/InteractiveCatalog/nrnc.shtml. Last accessed April 2020.

NOAA Autogrid: https://www.ngdc.noaa.gov/maps/autogrid/, last accessed April 2020.

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