Ocean Exploration and Research

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MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT:

EX-19-05 Leg 1, Deep Connections 2019 (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.

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 the mapping expedition EX-19-05 Leg 1, 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 2019 NOAA Ship *Okeanos Explorer* Survey Readiness Report, available in the NOAA Central Library.

3. Cruise Objectives

EX-19-05 Leg 1 is one of several NOAA Ship *Okeanos Explorer* expeditions conducted from 2018 to 2021 as part of the Deep Connections: Exploring Atlantic Canyons and Seamounts of the U.S. and Canada campaign.

This cruise also contributes 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. 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.

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. 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.

EX-19-05-Leg 1 departed from North Kingstown, Rhode Island on August 6, 2019 and arrived in Halifax, Nova Scotia, Canada on August 20, 2019, for a total of 15 days-at-sea. EX-19-05 Leg 1 operations involved a transit northward, crossing the continental shelf followed by focused ocean mapping operations mostly in deep (> 200 m) Canadian waters off the east coast of Nova Scotia. The cruise conducted 24 hour/day exploratory mapping operations to provide initial characterization of the region, as well as to provide data to support more in-depth exploration with remotely operated vehicles (ROVs) planned for the follow-on EX-19-05 Leg 2 expedition. The complete objectives for this cruise are detailed in the EX-19-05 Leg 1 Project Instructions, which are archived in the NOAA Central Library.

4. Summary of Mapping Results

EX-19-05 Leg 1 collected 18,734 square kilometers (5462 square nautical miles) and 4798 linear kilometers of bathymetry and associated water column data; 37 square kilometers of this area were mapped within the U.S. Exclusive Economic Zone in depths greater than 200 meter (Table 1). Multibeam bathymetry data coverage is shown in Figure 1.

Cruise Overview Map

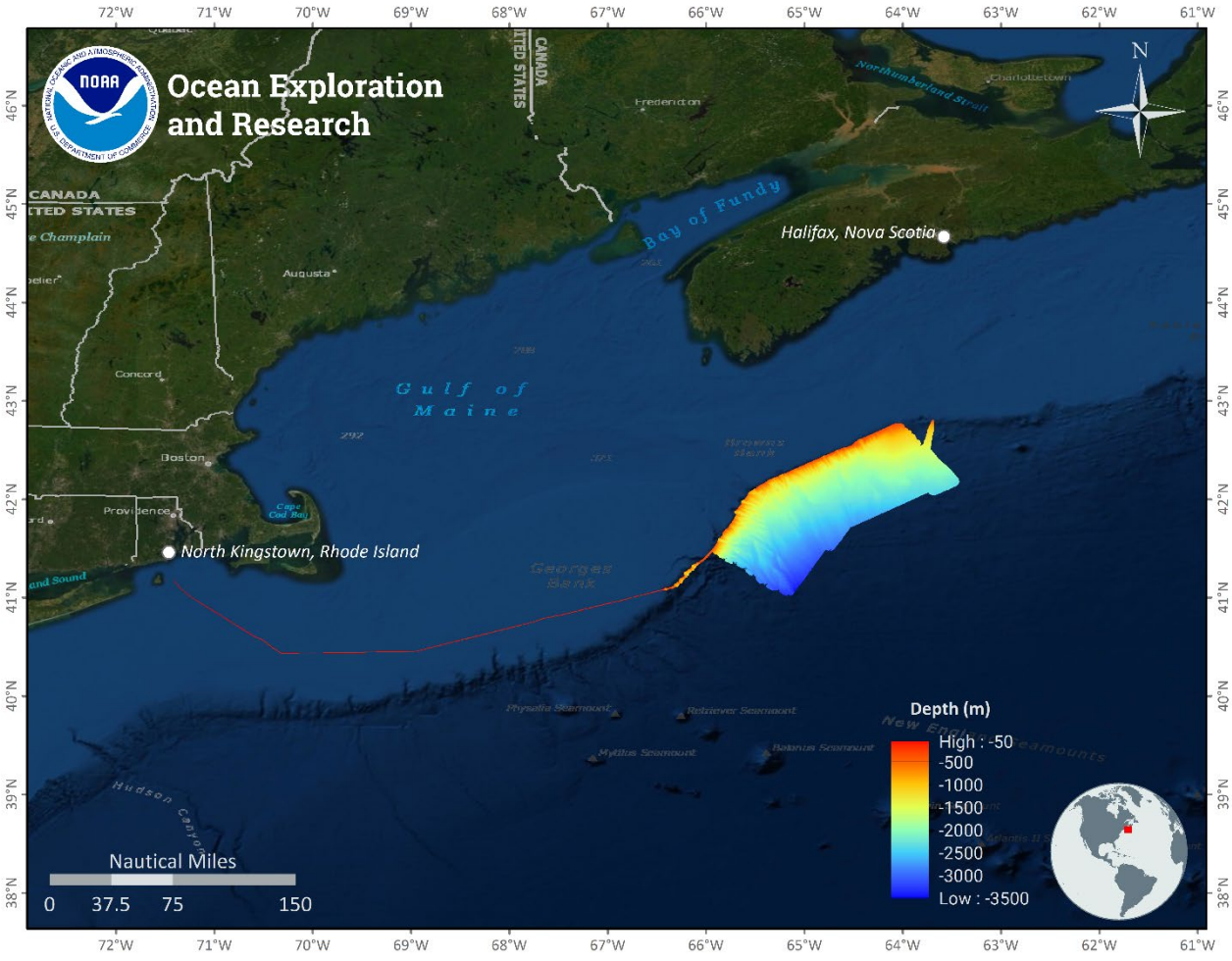

Figure 1. Overview map showing bathymetry mapping coverage completed during the first leg of the 2019 Deep Connections expedition (EX-19-05 Leg 1). Map created by NOAA Office of Ocean Exploration and Research (NOAA-OER), generated in ArcMap.

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. Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors

5. Mapping Statistics

Table 1. Summary statistics of ocean mapping work completed during EX-19-05 Leg 1.

Dates of cruise	August 6 - August 20, 2019
Ship's draft Start of cruise (08/06/2019) End of cruise (08/20/2019)	Fore: 12' 3.5'', Aft STBD: 15' 4" Fore: 14' 8.0"; Aft STBD: 14' 4.5"
Linear kilometers of survey with EM 302	4,798
Square kilometers mapped with EM 302	18,734
Square kilometers mapped with EM 302 in the US EEZ and deeper than 200 meters	37
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)	557 files/ 32.3 GB
Number / Data Volume of EM 302 water column multibeam files	557 files / 99.5 GB
Number / Data Volume of EK 60 water column split beam files (.raw)	659 / 135 GB
Number / Data Volume of sub-bottom sonar files (.segy, .kea, .keb)	698/ 5.2 GB
Number of XBT casts	120
Number of CTD casts (including test casts)	3

6. Mapping Sonar Setup

Kongsberg EM 302 Multibeam Sonar

The 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 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.

Simrad EK 60 Split-beam Sonars

The ship is equipped with five Kongsberg EK split-beam fisheries sonars, 18, 38, 70, 120, and 200 kHz. The 18 kHz transducer and transmits a 7° beam fan. The 38 and 70 kHz were upgraded to wide-band transceivers in 2019. 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. It was determined during the 2019 EK calibrations that the 38 kHz transducer was compromised and therefore data was not collected with the 38 kHz transducer during this expedition.

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 while transiting due to interference issues.

7. Data Acquisition Summary

Mapping operations included EM 302 multibeam sonar, EK 60/80 split-beam (18, 70, 120, and 200 kHz) sonars, and Knudsen 3260 sub-bottom profile data collection.

Survey lines were planned to maximize either bathymetry edge matching of existing data or data gap filling in areas where existing bathymetry coverage existed. 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 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 Acquisition 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. 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 at intervals no greater than 6 hours, or as dictated by local oceanographic conditions (typically around every 2 hours in this region).

Simrad EK 60/80 split-beam water column sonar data were collected during the entire cruise (Figure 2). Primarily the EK 80 70 kHz was run in broadband mode when shallower than 800 meters and in narrowband mode when deeper than 800 meters.

Knudsen 3260 sub-bottom profiler data were also collected during the majority of the cruise. Figure 3 shows where sub-bottom data was collected during EX-19-05 Leg 1.

EK 60 / EK 80 Data Collection Tracklines

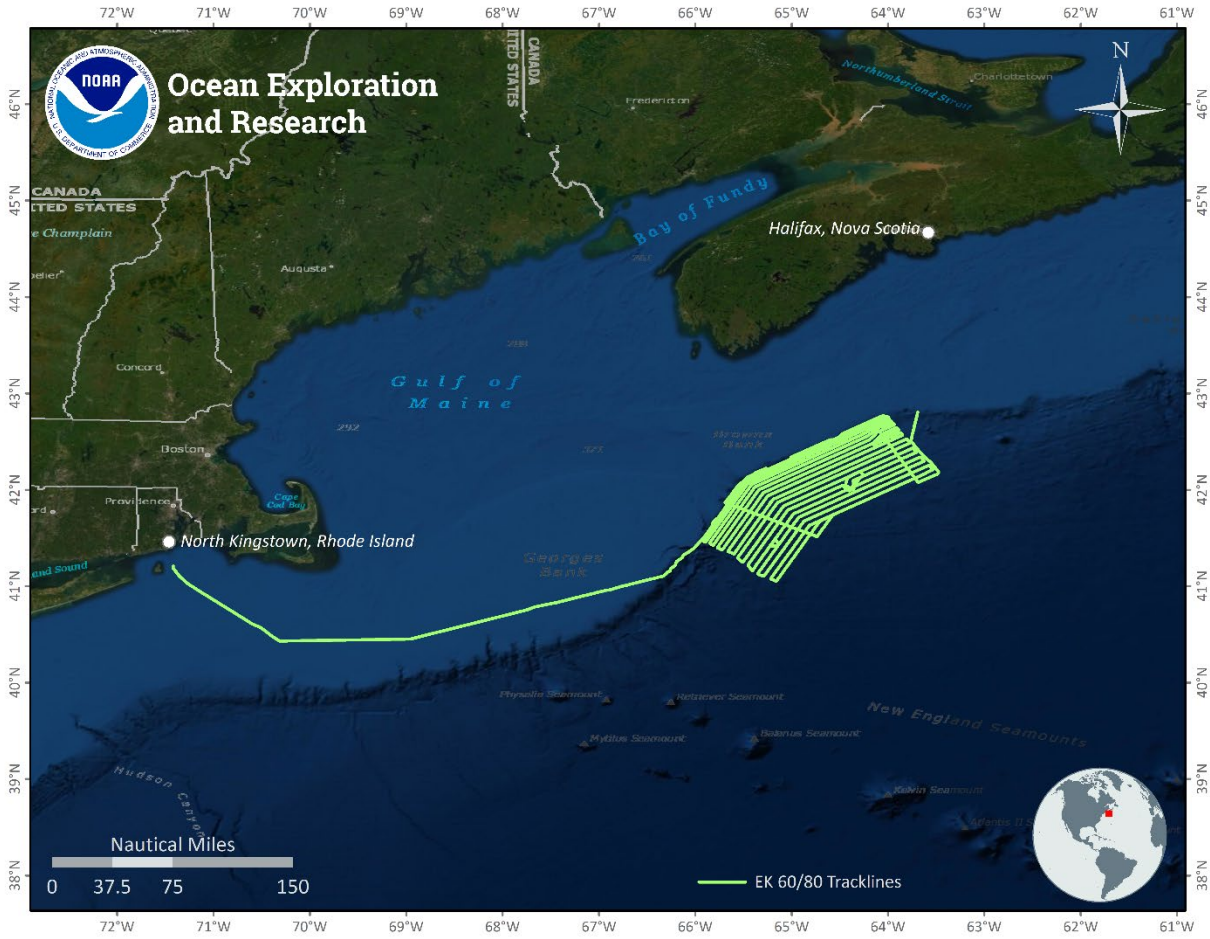

Figure 2. Overview showing tracklines of Simrad EK 60/80 split-beam sonar data (in green) collected during the first leg of the 2019 Deep Connections expedition (EX-19-05 Leg 1). Map created by NOAA Office of Ocean Exploration and Research (NOAA-OER), generated in ArcMap.

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. Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors

Knudsen Sub-bottom Profiler Data Collection Tracklines

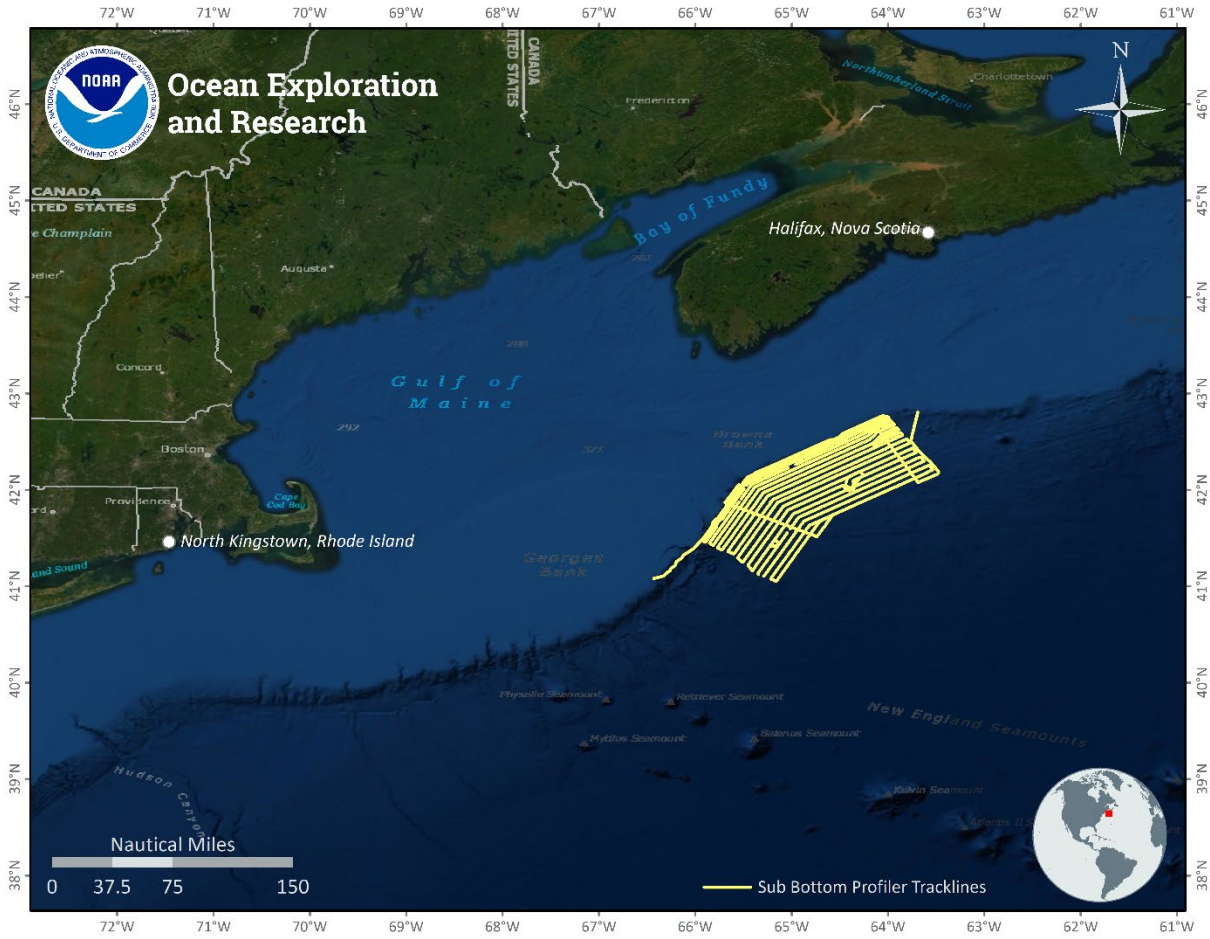

Figure 3. Overview showing tracklines of Knudsen sub-bottom profiler data (in yellow) collected during the first leg of the 2019 Deep Connections expedition (EX-19-05 Leg 1). Map created by NOAA Office of Ocean Exploration and Research (NOAA-OER), generated in ArcMap.

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. Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors

8. Multibeam Sonar Data Quality Assessment and Data Processing

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 (Figure 4). Raw multibeam bathymetry data files were acquired by SIS, then imported into QPS Qimera for processing the multibeam sonar 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. Gridded digital terrain models were created 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.

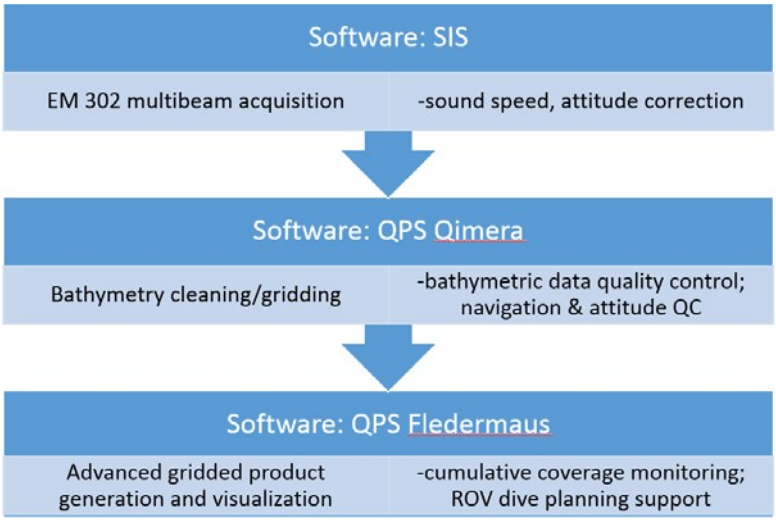

Figure 4. Shipboard multibeam data flow.

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 on data collected during EX-19-05 Leg 1 using the Cross Check Tool in QPS Qimera software (Figure 4). Mainscheme lines in this analysis included lines 0077, 0081, 0082, 0127, 0138, 0200, 0243, 0247, 0282, 0286, 0287, and 0343. Crosslines are 0464 - 0471 from 8/19/19. This check was conducted in an area with variable sound velocity, and therefore represents challenging survey conditions encountered during the cruise. The results from the crossline comparison are in Table 2 below. These results show that, even with the effect of the highly dynamic oceanographic conditions experienced during EX-19-05 Leg 1, the data collected still meets International Hydrographic Organization (IHO) Order 2 data quality requirements.

Table 2. Statistics provided from QPS Qimera software Cross Check Tool, with depth values reported in meters.

Number of Points	5690632	**Ref. Z – Range**	-2110.62 : -456.87
Data Mean	-1196.05	**Diff Z – Range**	-20.25 : 22.55
Reference Mean	-1195.64	**Mean + 2*stddev**	4.34
Mean	-0.41	**Median + 2*stddev**	5.07
Median	1.15	**Ord 2 Error Limit**	27.517876
Std. Deviation	1.96	**Ord 2 P-Statistic**	0.000003
Data Z – Range	-2113.59 : -455.78	**Ord 2 - # Rejected**	15
		ORDER 2	ACCEPTED

EM 302 Patch Test

A multibeam patch test was conducted over the Pascagoula Dome in the northern Gulf of Mexico on May 13, 2019 during cruise EX-19-02, using the same location as the EX-18-02 patch test. In addition to the patch test, a speed noise test was performed on the EM 302. The full procedures and results are described in the 2019 *Okeanos Explorer* Survey Readiness Report.

EK 60/80 Calibration

EK 60 and EK 80 calibrations were conducted in the Gulf of Mexico in March 2019, west of Key West, Florida. The 18 kHz, 70 kHz, 120 kHz, and 200 kHz sonars were successfully calibrated in continuous wave mode (CW). The 70 kHz sonar has a wide band transceiver (WBT) and was calibrated for both CW and frequency-modulated (FM) pulses. During the calibration, the 38 kHz transducer showed impedance issues and was not able to be calibrated. Complete details about the EK 60/80 calibrations are described in the EX-19-02 EK Calibration Report archived at the NOAA Central Library.

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-19-05 Leg 1 project instructions which is available in the NOAA Central Library.

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 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 (TRU)
- Multibeam WCD review log if data were reviewed for presence of seeps in QPS Fledermaus MidWater

EM 302 water column data are available in the NCEI Water Column Sonar Archives: https://www.ngdc.noaa.gov/maps/water_column_sonar/index.html (last accessed 12/11/2019).

Sub-bottom data, supporting data, and informational logs are available in the NCEI Data Archives accessible at https://www.ngdc.noaa.gov/ (last accessed 12/11/2019).

EM 302 bathymetry data, supporting informational logs, and ancillary files are available in the NCEI Data Archives accessible at https://www.ngdc.noaa.gov/ (last accessed 12/11/2019).

10. Cruise Calendar

All times listed are local ship time, which was -4 hours from UTC

August 2019

Sun	Mon	Tues	Wed	Thur	Fri	Sat
4 Mission Personnel arrive in North Kingstown, RI Mobilization begins.	5 Mobilization continues.	6 Depart North Kingstown, RI. Transit to main survey area.	7 Continued transiting. Arrived at priority survey area at 20:00.	8 Continue surveying main survey area: the canyons off the coast of New England and Canada. Performed Shallow conductivity-temperature-depth (CTD) cast.	9 Continue surveying main survey area: the canyons off the coast of New England and Canada.	10 Continue surveying main survey area: the canyons off the coast of New England and Canada.
11 Continue surveying main survey area: the canyons off the coast of New England and Canada.	12 Continue surveying main survey area: the canyons off the coast of New England and Canada.	13 Continue surveying main survey area: the canyons off the coast of New England and Canada.	14 Continue surveying main survey area: the canyons off the coast of New England and Canada.	15 Continue surveying main survey area: the canyons off the coast of New England and Canada.	16 Continue surveying main survey area: the canyons off the coast of New England and Canada.	17 Continue surveying main survey area: the canyons off the coast of New England and Canada. Performed Deep CTD cast.
18 Finished surveying main survey area. Began collecting crosslines.	19 Finished crosslines and began transiting to Halifax, Canada.	20 Arrive in Halifax, Canada. Began demobilization.	21 All mission personnel depart ship.	22	23	24

11. Daily Cruise Log Entries

Generated from the daily expedition situation reports. All times listed are in local ship time (-4 hours from UTC)

August 04
Once the mission team settled in we turned on the EM 302 topside unit (TRU) to warm up prior to the ping test scheduled for tomorrow. We also confirmed that the POS configuration settings post firmware update matched the previous settings from EX-19-02. The only difference found was that the Heave Bandwidth was set to 8 seconds rather than 14. We have left the Heave Bandwidth set to 8 seconds, as we expect rougher seas.

August 05
Mapping computers had all Windows updates completed. New projects were set up for each sonar and the transit line was provided to the Bridge in preparation for tomorrow's departure.

27 boxes of XBTs were loaded onboard the ship (324 probes).

August 06
We began our transit to our mapping priority area at 14:00. We started pinging with the EM 302 and EKs once we departed the sea buoy.

While starting up the Qimera project, we noticed that the license files for QPS on MBPROC1 had uninstalled (reason for this is unknown at this time). MBPROC2 and MBPROC3 still had their licenses installed. It took running License Manager as an administrator to activate the softlock license on MBPROC1. QPS software on MBPROC1 is functioning at this time.

We will be manually setting the Qimera project to UTM Zone 20 N as the main survey lies entirely within 20 N and only the transit lies within 19 N. This way we can benefit from all the files being in the same project.

Seafloor Mosaic Display (SMD) was not receiving the datagram from the EM 302. Troubleshooting revealed that one number of the IP address on the Datagram Distribution was incorrect. This was fixed and SMD is now working properly.

As we are transiting in these shallow waters (less than 80 meters for the next 27 hours) we will be utilizing synthetic casts retrieved from World Ocean Atlas version 2012 (WOA13) via Sound Speed Manager. We will be manually retrieving and exporting them (rather than using the server) to increase feasibility/understandability of logging and archiving.

There were a few instances of keyboard-video-mouse system (KVM) issues, specifically with "sticking keys" on MBPROC2. Brian has fixed the issue each time and there were no further issues overnight.

August 07
The data is of good quality as we transit across the heads of the canyons. We attempted to use the 'auto' phase tracking for the sub-bottom, however it was not stable and we returned to setting phases manually.

MBPROC2 froze last night while using Qimera. This was not a KVM issue but rather the computer freezing, requiring a hard restart. Similar issues were reported during EX-19-03 Leg 2. The Global Foundation for Ocean Exploration's (GFOE) data team is fervently working to identify the issue.

August 08
Data is looking good except for blowouts caused by bubble wash due to the rough seas.

A shallow CTD cast was conducted to maintain functionality. A deeper CTD cast is planned on the 17th of August to continue optimization.

The Ocean Surveyor 38 kHz was taken out of external sync mode (1,1) and set to internally trigger. This should fix the issue reported by the University of Hawaii's Data Acquisition System (UHDAS) by having the ADCP synced and running in both narrow and broadband mode. At this time there is no operational reason to externally trigger the ADCP OS 38.

SIS stopped gridding data below 1000 meters. The data was still present, however not displayed. We began a new survey with a 64 X 64 and 50 m cell size. The issue is no longer present.

A new Qimera project was made for the main survey area in a troubleshooting attempt to alleviate the crashing of the MBPROCs. We created this project locally on MBPROC1. No crashes were observed overnight.

The POS navigation status dropped from Marinestar DGPS to 'CA' for 15 - 30 minutes. The position light was also red. Our position accuracy for that interval was on the order of 2 meters for X and Y and 5 meters for Z. It then returned to Marinestar VBS with accuracies of approximately .4 meters for X and Y and .6 meters for Z.

August 09
Data quality is looking good. As we are mapping near the canyon heads, we are occasionally having to divert for fishing traffic. We have been able to fill in all data gaps that were caused by altering course.

Sound velocity has been extremely variable in this region, to the point that the surface sound speed from the Reson SV probe and the current XBT cast will differ enough to prompt a warning in SIS within 10 minutes of the XBT cast. See images below that show the highly variable surface sound speed (Figure 5 and 6).

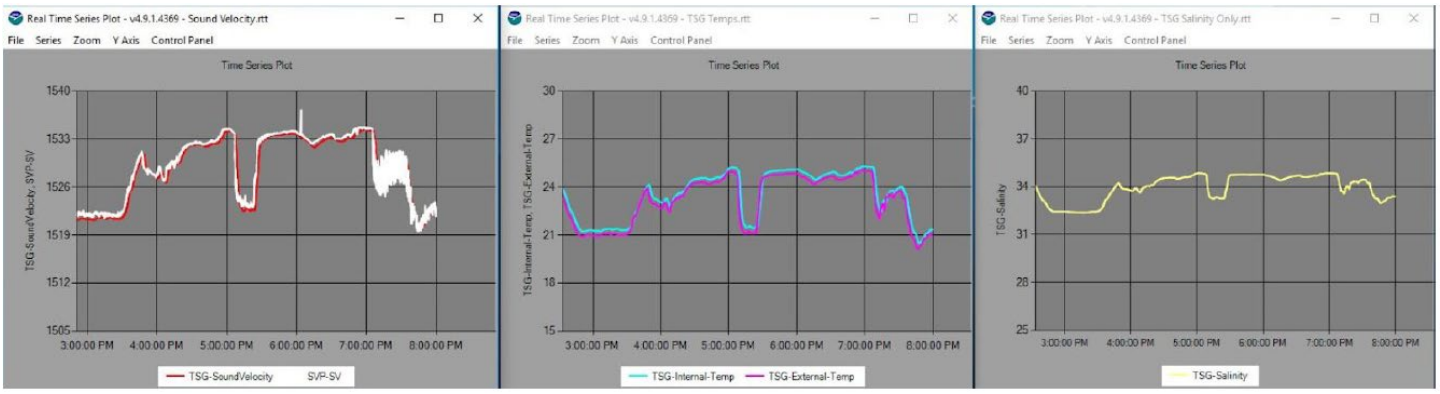

Figure 5: SCS Display showing the surface sound speed from the TSG and Reson Sound Velocity Probe (left), Temperature (mid), and Salinity (right) over the course of 5 hours.

The location of the ocean currents from August 7th show that we are operating in an area with many eddies coming off the Gulf Stream (Figure 6).

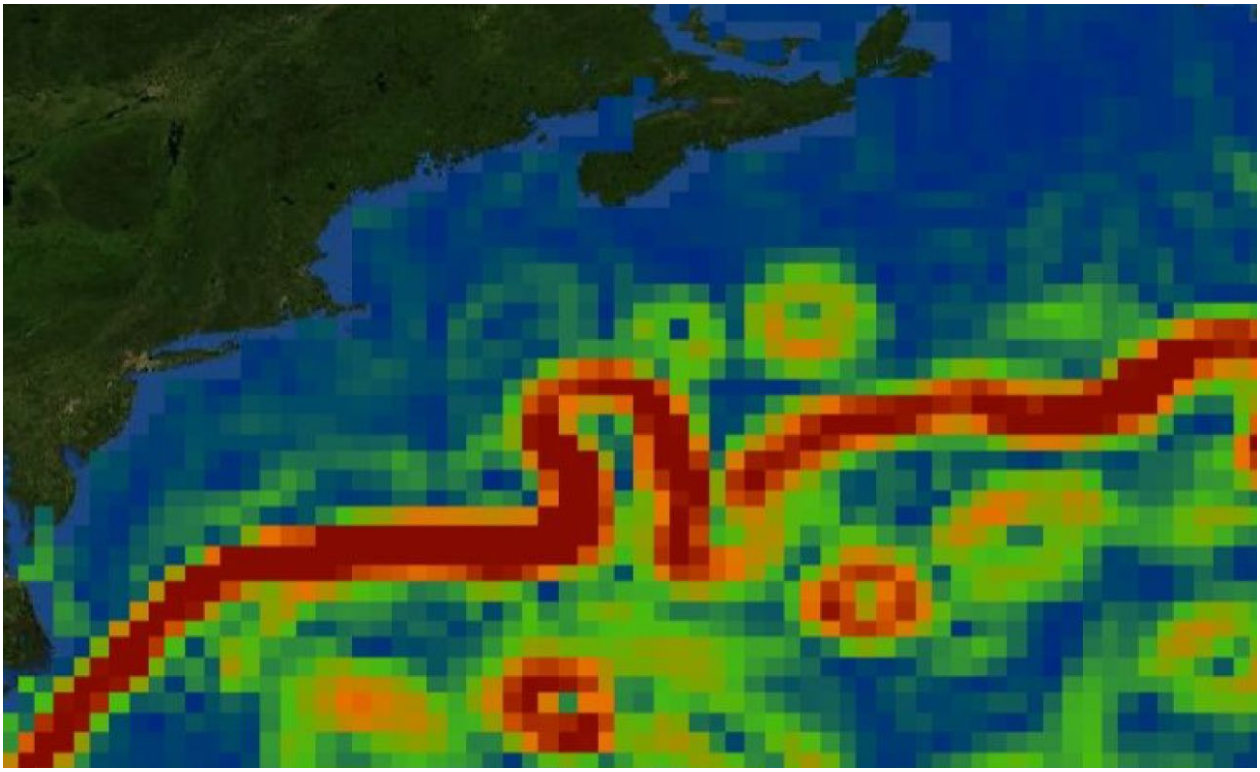

Figure 6: The Gulf Stream on August 7th retrieved from NASA's State of the Ocean tool: https://podaac-tools.jpl.nasa.gov/soto/ .

We have been taking XBTs as needed, but at times it is not operational feasible to keep up with this dynamic environment. To compensate, we are planning lines with enough overlap to aid post processing of the bathymetry data.

We experienced another POS drop to “CA” status today for 15 minutes. The dropout today and the dropout yesterday occurred in different locations of our survey area. More troubleshooting is needed to understand the source of these positioning dropouts.

August 10
We are still experiencing extensive dynamic surface sound speed and performing XBT casts as needed, resulting data quality is good.

The POS experienced another drop out around 20:00. We are continuing to look into this issue.

MBPROC1 crashed again while cleaning in the Qimera project. The cause of the MBPROCs crashing has yet to be established.

August 11
Data quality is good as we continue performing our systematic survey. The surface sound speed is still highly dynamic.

August 12
We looked further into the POS dropouts that have consistently occurred over the past few days. By looking into the GGA strings recorded by SCS, we witnessed that the number of satellites is instantly dropping from ~30 to ~8 for about 26 minutes every day, 4 minutes earlier each day. We have contacted Applanix and a Geodesy expert from the Center for Coastal and Ocean Mapping to find some answers.

We had issues deactivating QPS license files due to not being able to connect to the license server. GFOE worked to resolve the issue.

The GFOE data team created a clone of one of the MBPROCs using a Windows 10 operating system to see if upgrading to the new OS alleviates the reported MBPROC crashes. We will test out using this computer over the next couple of days. This computer, named MBPROC4, is located on the GFOE-AUTH4 computer listed in the KVM.

August 13
We restarted the POS this morning in a troubleshooting attempt to fix the daily POS dropout. This did not fix the issue and dropout was observed at the expected time, 4 minutes earlier than the previous day. We recorded a POSpac file that we will send to Applanix for further analysis.

August 14
The data is looking good except for occasional sector blowouts; we hope to cover these with crosslines.

We did not witness the positioning dropout today and our status changed from MarineStar DGPS to MarineStar GNSS G2 (which we have yet to achieve this cruise). This occurred after Applanix reached out to Fugro to discuss our subscription status. We assume that when we updated the firmware of our POSMV, a disconnect occurred between our unit and our MarineStar subscription. We will continue to monitor to ensure the issue does not return.

We have been utilizing the new MBPROC4 to test functionality with Windows 10 OS. QPS Qimera and Fledermaus functioning well, and there have been no issues, such as the frequently seen crashes on MBPROC1 and2.

August 15
Data looks good and there were no POS dropouts witnessed today.

August 16
Data is looking good; interference witnessed occasionally overnight.

August 17
Data continues to look good as we finish our main survey area, we began our first crossline overnight.

Prior to the deep CTD cast (~2000 m) the ship's Senior Survey Technician (SST) and Chief Electronics Technician (CET) swapped the conductivity sensor out with the spare sensor in storage. At ~ 200 meters voltage spiking occurred and the CTD was brought back on deck and the cable was swapped out. The CTD was redeployed and all was successful. Water sampling bottles fired successfully.

August 18
Data looks good as we perform our crosslines. Mission personnel worked on updating SOPs.

August 19
Crossline data quality is good, and we will perform a crossline analysis tomorrow.

August 20
We began finalizing data package.

12. References

The 2019 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-19-05 Leg 1 Project Instructions can be obtained from the NOAA Central Library. The EX-19-05 Leg 1 Data Management Plan is an appendix of the project instructions.
https://repository.library.noaa.gov/view/noaa/22030

EX-19-02 EK 60 / 80 Calibration Report can be obtained in the NOAA Central Library at https://doi.org/10.25923/wzk7-6d52 or by contacting the NOAA OER mapping team at oar.oer.exmappingteam@noaa.gov