doi: 10.25923/yrb6-5n89

Cruise Report: EX-13-04 Legs 1 & 2 Northeast U.S. Canyons Expedition 2013 (ROV and Mapping)

Northwest Atlantic

Leg 1: North Kingstown, RI, to New York, NY
(08, July, 2013 - 25, July, 2013)

Leg 2: North Kingstown, RI, to North Kingstown, RI
(31, July, 2013 - 17, August, 2013)

Contributors:
Kimberly Galvez, Cherokee Federal/NOAA Office of Ocean Exploration and Research (OER)
Kelley Elliott, Expedition Manager, Expedition Coordinator for Leg 1, NOAA OER
LTJG Brian Kennedy, Expedition Coordinator for Leg 2, NOAA OER
Andrea Quattrini, Science Lead for Leg 1, University Corporation for Atmospheric Research (UCAR)/Temple University
Brendan Roark, Science Lead for Leg 1, UCAR/Texas A&M University
Tim Shank, Shore-side Science Lead for Leg 1, Woods Hole Oceanographic Institution (WHOI)
Amanda Demopolous, Science Lead for Leg 2, U.S. Geological Survey (USGS)
Martha Nizinski, Science Lead for Leg 2, NOAA National Marine Fisheries Service (NMFS)
Meme Lobecker, Mapping Lead for Leg 1, ERT, Inc./NOAA OER
Adam Skarke, Mapping Lead for Leg 2, ERT, Inc./NOAA OER
Jason Chaytor, Shore Scientist, USGS

March 30, 2021

Office of Ocean Exploration and Research, NOAA
1315 East-West Hwy, SSMC3 RM 10210
Silver Spring, MD 20910

Abstract

Northeast U.S. Canyons Expedition 2013 (EX-13-04 Legs 1 & 2) was a combined mapping and ROV expedition to the canyons, inter-canyons, and seamounts of the Northwest Atlantic that took place between July 8 and August 17, 2013. Operations during this 36-day at sea expedition included a combination of remotely operated vehicle (ROV) dives in support of community, regional, OER internal, and OER partner priorities as well as exploratory mapping operations targeting areas containing no or poor-quality modern mapping data. There were 31 ROV dives conducted from depths of 500 m to 3,271 m, for a total of over 195 hours of bottom time, at 10 primary (named) canyons, two minor canyons, Mytilus seamount, and inter-canyon areas—including five U.S. Geological Survey (USGS) marine hazard sites and four hydrocarbon seep sites. In addition, 19 CTD casts were conducted, and sonar mapping surveyed 14,641 square kilometers of seafloor. Exploration of the canyon system determined the canyons to be hot spots for biodiversity, revealing deep-sea coral and sponge habitats at every canyon, range extensions of fauna not previously known to occur in the area, and suspected new species. Three new cold seeps and associated chemosynthetic communities were discovered and investigated during the expedition. This report contains summaries of the operations, including mapping operations, outreach activities, and a cruise schedule. All data associated with this expedition have been archived and are publicly available through the NOAA Archives.

This report can be cited as follows:

Galvez, K., Elliott, K., Kennedy, B., Quattrini, A., Roark, B., Shank, T., Demopolous, A., Nizinski, M., Lobecker, E., Skarke, A., Chaytor, J. (2013). Cruise Report: EX-13-04 Legs 1 & 2, Northeast U.S. Canyons Expedition 2013 (ROV and Mapping). Office of Ocean Exploration and Research, Office of Oceanic & Atmospheric Research, NOAA, Silver Spring, MD 20910. OER Expedition Rep. 13-04. doi: 10.25923/yrb6-5n89

For further information, direct inquiries to:

NOAA Office of Ocean Exploration and Research
1315 East-West Hwy, SSMC3 RM 10210
Silver Spring, MD 20910
Phone: 301-734-1014
Email: oceanexplorer@noaa.gov

Table of Contents

Tables

Figures

1. Introduction

By leading national efforts to explore the ocean and make ocean exploration more accessible, the NOAA Office of Ocean Exploration and Research (OER) is filling gaps in basic understanding of deep waters and the seafloor, providing deep-ocean data, information, and awareness. Exploration within the U.S. Exclusive Economic Zone (EEZ) and international waters as part of Seabed 2030 efforts to produce a bathymetric map of the world ocean floor by 2030 and the OER goals to explore U.S. waters supports key NOAA, national, and international goals to better understand and manage the ocean and its resources.

Using the latest tools and technology, OER explores unknown areas of the deep ocean. NOAA Ship *Okeanos Explorer* is one such tool. Working in close collaboration with government agencies, academic institutions, and other partners, OER conducts deep-sea exploration expeditions using advanced technologies on *Okeanos Explorer*, mapping and characterizing areas of the ocean that have not yet been explored. Collected data about deep waters and the seafloor—and the resources they hold—establishes a foundation of information and fills gaps in the unknown.

All data collected during *Okeanos Explorer* expeditions adhere to federal open-access data standards and are publicly available shortly after an expedition ends. This ensures the delivery of reliable scientific data needed to identify, understand, and manage key elements of the ocean environment.

Exploring, mapping, and characterizing the U.S. EEZ are necessary for a systematic and efficient approach to advancing the development of ocean resources, promoting the protection of the marine environment, and accelerating the economy, health, and security of our nation. As the only federal program dedicated to ocean exploration, OER is uniquely situated to lead partners in delivering critical deep-ocean information to managers, decision makers, scientists, and the public, leveraging federal investments to meet national priorities.

2. Expedition Overview

From 08, July, 2013 – 17, August, 2013, OER and partners conducted a two-part, telepresence-enabled ocean exploration expedition on *Okeanos Explorer* to collect critical baseline information and improve knowledge about unexplored and poorly understood deepwater areas offshore the Northeast U.S. The *Northeast U.S. Canyons Expedition 2013* (EX-13-04 Legs 1 & 2) focused primarily on Northeast U.S. canyons and inter-canyon areas. EX-13-04 Leg 1 operations focused on the submarine canyons along the U.S. continental margin that runs from Pennsylvania to Massachusetts, and EX-13-04 Leg 2 conducted operations in the Northeast U.S. canyons along the shelf break and one of the New England Seamounts. Preceding expeditions in this region include the *Atlantic Canyons Undersea Mapping Expeditions 2012* (ACUMEN) *campaign* (https://oceanexplorer.noaa.gov/okeanos/explorations/acumen12/summary/welcome.html, *last accessed March 05, 2021*) including NOAA Ships *Okeanos Explorer*, *Ferdinand Hassler, Nancy Foster,* and *Henry B. Bigelow*. As such, the *Northeast U.S. Canyons Expedition 2013* effort was designed to provide timely, actionable information to support decision-making based on reliable and authoritative science. Like other expeditions, it also served as an opportunity for the nation to highlight the uniqueness and importance of deep-water environments.

2.1 Rationale for Exploration

Considerable investigations of a few Northeast U.S. canyons were conducted in the 1960s-80s, however little work has been conducted in recent decades using the latest technologies. Recent investigations of Northeast U.S. canyons using remotely operated vehicles (ROVs) and tow-camera systems have revealed that deep-sea coral and chemosynthetic communities occur in these canyon systems, but the full extent of their distribution and community structure is still unknown. Many areas within this region, including seamounts, remain completely unexplored within the U.S. EEZ.

To define the operating area for this expedition, NOAA collaborated with the scientific and management communities to assess the exploration needs and data gaps in unknown and poorly known areas of the Northeastern U.S. continental margin. The May 2011 NOAA Workshop on Systematic Telepresence-Enabled Exploration in the Atlantic Basin (https://oceanexplorer.noaa.gov/about/what-we-do/media/atl-basin-workshop-2011-summary.pdf, *last accessed March 05, 2021*) identified canyons and seamounts as priority areas for systematic ocean exploration. The 2012 series of five ACUMEN cruises including NOAA Ships *Nancy Foster*, *Henry B. Bigelow*, *Ronald H. Brown*, and *Ferdinand R. Hassler*, and two subsequent *Okeanos Explorer* cruises, gathered baseline information on deepwater canyons off the Northeastern U.S. seaboard, mapping along the continental shelf and slope from Virginia to the northeastern boundary of the U.S. EEZ. These mapping operations provide the basis for preliminary target selection. Operating areas were further refined based on priority area input from other NOAA programs and the management community and was part of a series of expeditions that contributed to ACUMEN.

Data and information from this expedition will help to improve scientific understanding of the deep-ocean habitats of the U.S. continental margin and the connections between communities throughout the Atlantic Basin. It will also inform deep-sea management plans for habitat areas of particular concern (HAPCs), marine protected areas (MPAs), and U.S. National Marine

Sanctuaries; support local scientists and managers seeking to understand and manage deep-sea resources; and stimulate subsequent exploration, research, and management activities.

2.2 Objectives

NOAA priorities for the *Northeast U.S. Canyons Expedition 2013* included a combination of science, education, outreach, and data management objectives. They were:

- Explore the diversity of benthic habitats and features (e.g. canyons, seamounts, landslides, deep-sea corals, seeps);
- Engage a broad spectrum of the scientific community and public in telepresence-based exploration;
- Provide a foundation of publicly-accessible data and information products to spur further exploration, research, and management activities;
- Complete the ACUMEN mapping effort which focused on surveying the deepwater canyons along the break of the continental shelf between Virginia and New England;
- Ground truth acoustic seep data and characterize associated habitat; and
- Test and refine operating procedures and products.

3. Participants

EX-13-04 Legs 1 & 2 included onboard mission personnel as well as shore-based science personnel who participated remotely via telepresence technology. See **Tables 1**, **2**, and **3** for lists of onboard and shore-based personnel who supported EX-13-04 Legs 1 & 2.

Table 1. EX-13-04 Legs 1 & 2 onboard mission team personnel.

Name (First, Last)	Title	Affiliation
Leg 1		
Kelley Elliott	Expedition Coordinator	NOAA OER (Acentia, LLC.)
Andrea Quattrini	Science Lead	Temple University/University Corporation for Atmospheric Research (UCAR)
Brendan Roark	Science Lead	Texas A&M University/UCAR
Elizabeth "Meme" Lobecker	Mapping Lead	NOAA OER (ERT, Inc.)
Jared Drewniak	Video Lead	NOAA OER (ERT, Inc.)

Webb Pinner	Telepresence/Data Lead	NOAA OER (Acentia, LLC)
Brian Bingham	ROV Team Lead	UCAR
Dave Wright	ROV Engineering Team	UCAR
Bobby Mohr	ROV Engineering Team	UCAR
Jeffery Lanning	ROV Engineering Team	UCAR
Karl McLetchie	ROV Engineering Team	UCAR
Anthony Sylvester	ROV Engineering Team	UCAR
Joshua Carlson	ROV Engineering Team	UCAR
Tom Kok	ROV Engineering Team	UCAR
Jeff Williams	ROV Engineering Team	UCAR
Roland Brian	Telepresence/Video Engineer	UCAR
Art Howard	Video Editor	UCAR
Brendan Reser	Telepresence/Data Manager	NOAA National Coastal Data Development Center (NCDDC) Design Guide Implementation Team (DGIT)
Kasey Cantwell	Web Coordinator	NOAA OER (Acentia, LLC.)
Leg 2		
LTJG Brian Kennedy	Expedition Coordinator	NOAA OER
Amanda Demopolous	Science Lead	U.S. Geological Survey (USGS)
Martha Nizinski	Science Lead	NOAA National Marine Fisheries Service (NMFS)
Adam Skarke	Mapping Lead	NOAA OER (ERT, Inc.)
Jared Drewniak	Video Lead	NOAA OER (ERT, Inc.)

Webb Pinner	Telepresence/Data Lead	NOAA OER (Acentia, LLC)
Dave Lovalvo	ROV Team Lead	NOAA OER (ERT, Inc.)
Dave Wright	ROV Engineering Team	UCAR
Bobby Mohr	ROV Engineering Team	UCAR
Jeff Williams	ROV Engineering Team	UCAR
Karl McLetchie	ROV Engineering Team	UCAR
Tom Kok	ROV Engineering Team	UCAR
Joshua Carlson	ROV Engineering Team	UCAR
Chris Ritter	ROV Engineering Team	UCAR
Jeffery Lanning	ROV Engineering Team	UCAR
Jeffrey Delmerico	ROV Engineering Team	UCAR
Roland Brian	Video Engineer	UCAR
Tara Smithee	Video Editor	UCAR

Table 2. EX-13-04 Legs 1 & 2 shore-based operations personnel.

Name (First, Last)	Affiliation	Position
Catalina Martinez	NOAA OER	Rhode Island Regional Manager
Kasey Cantwell	NOAA OER	Shore-side operations coordinator; Web coordinator for Leg 1
Steve Damas	UCAR	Inner Space Center (ISC) Video Engineer
Emily Crum	NOAA OER	Web coordinator for Leg 2

Table 3. EX-13-04 Legs 1 & 2 shore-based science participants.

Name (First, Last)	Email	Affiliation
Leg 1		
Bernie Ball	bernieb@duke.edu	Duke University
Eleanor Bors	ekbors@gmail.com	Woods Hole Oceanographic Institute (WHOI)

Sandra Brooke	sbrooke@fsu.edu	Florida State University
Daniel Brothers	dbrothers@usgs.gov	USGS
Robert Carney	rcarne1@lsu.edu	Louisiana State University
Jason Chaytor	jchaytor@usgs.gov	USGS
Walter Cho	waltercho@pointloma.edu	Gordon University
Eric Cordes	ecordes@temple.edu	Temple University
Katherine Coykendall	dcoykendall@usgs.gov	USGS
Amanda Demopoulos	ademopoulos@usgs.gov	USGS
Peter Etnoiyer	Peter.Etnoyer@noaa.gov	NOAA
Holly Fowle	holly.a.fowle@noaa.gov	Temple University
Scott France	france@louisiana.edu	University of Louisiana Lafayette
Peter Girguis	pgirguis@oeb.harvard.edu	Harvard University
Steve Gittings	steve.gittings@noaa.gov	NOAA
Santiago Herrera	sherrera@whoi.edu	WHOI
Taylor Heyl	theyl@whoi.edu	WHOI
Shannon Hoy	shannon.hoy@noaa.gov	USGS
Christina Kellogg	ckellogg@usgs.gov	USGS
Brian Kinlan	brian.kinlan@noaa.gov	NOAA
Jay Lunden	jlunden@temple.edu	Temple University
Anabel Martinez		WHOI
Kerry McCulloch	mcculloc@uoregon.edu	WHOI/University of Oregon
Zach McKelvey		Duke University
Lenaick Menot	lenaick.menot@ifremer.fr	L'Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER)
Jon Moore	jmoore@fau.edu	Florida Atlantic University
Cheryl Morrison	cmorrison@usgs.gov	USGS
Jennifer NcClain Counts	jmcclaincounts@usgs.gov	USGS
Martha Nizinski	nizinski@si.edu	NOAA
Sophie Plouviez	sophie.plouviez@duke.edu	Duke University
Shirley Pomponi	spomponi@fau.edu	Florida Atlantic University
Andrea Quattrini	andrea.quattrini@temple.edu	Temple University
David Ritter		Michigan State University
Matt Rittinghouse	matthew.rittinghouse@noaa.gov	NOAA
Brendan Roark	broark@geos.tamu.edu	Texas A&M University
Steve Ross	rosss@uncw.edu	University of North Carolina Wilmington
Stephen Roth		NOAA
Carolyn Ruppel	cruppel@usgs.gov	USGS
Enrique Salgato		NOAA
Tim Shank	tshank@whoi.edu	WHOI
Megumi Shimuzu	shimizum@uncw.edu	University of North Carolina Wilmington
Adam Skarke	Adam.Skarke@noaa.gov	NOAA OER

Brad Stevens	bgstevens@umes.edu	University Maryland Eastern Shore (UMES)
Dave Stevens		NOAA
Uri Ten Brink	utenbrink@usgs.gov	USGS
AJ Turner	aj.turner@noaa.gov	NOAA
Inge Van Den Beld	Inge.van.den.Beld@ifremer.fr	IFREMER
Cindy Van Dover	clv3@duke.edu	Duke University
Mike Vecchione	VecchioneM@si.edu	NOAA NMFS
Les Watling	watling@hawaii.edu	University of Hawaiʻi at Mānoa
Kelly Williams	williamsk@allegheny.edu	WHOI
Leg 2		
Peter Auster	peter.auster@uconn.edu	University of Connecticut
Jamie Austin	jamie@ig.utexas.edu	University of Texas Institute for Geophysics (UTIG)
Amy Baco-Taylor	abacotaylor@fsu.edu	Florida State University
Bernie Ball	bernieb@duke.edu	Duke University
Eleanor Bors	ekbors@gmail.com	WHOI
Robert Carney	rcarne1@lsu.edu	Louisiana State University
Jason Chaytor	jchaytor@usgs.gov	USGS
Dwight Coleman	dcoleman@uri.edu	URI ISC
Erik Cordes	ecordes@temple.edu	Temple University
Katherine Coykendall	dcoykendall@usgs.gov	USGS
Steve Damas		UCAR
Peter Etnoyer	Peter.Etnoyer@noaa.gov	NOAA
Scott France	france@louisiana.edu	University of Louisiana Lafayette
Erick Geiger	egeiger@udel.edu	University of Delaware
Santiago Herrera	sherrera@whoi.edu	WHOI
Taylor Heyl	theyl@whoi.edu	WHOI
Christina Kellogg	ckellogg@usgs.gov	USGS
Morgan Kilgour	morgan.kilgour@uconn.edu	University of Connecticut
Brian Kinlan	brian.kinlan@noaa.gov	NOAA NMFS
Elizabeth Lobecker	Elizabeth.Lobecker@noaa.gov	NOAA OER
Jay Lunden	jlunden@temple.edu	Temple University
Christopher Mah	brisinga@gmail.com	Smithsonian Institution
Kerry McCulloch	mcculloc@uoregon.edu	WHOI/University of Oregon

Nicola Morgan	nbmorgan11@yahoo.com	Florida State University
Cheryl Morrison	cmorrison@usgs.gov	USGS
Andrea Quattrini	andrea.quattrini@temple.edu	Temple University
Brendan Reser		NOAA OER
Thomas Ritter	thomas.ritter@msu.montana.edu	Montana State University
Matt Rittinghouse	matthew.rittinghouse@noaa.gov	NOAA
Brendan Roark	broark@geos.tamu.edu	Texas A&M University
Esprit Saucier	heestand.saucier@louisiana.edu	University Louisiana Lafayette
Tim Shank	tshank@whoi.edu	WHOI
Clara Smart	clarajsmart@gmail.com	University of Rhode Island (URI)
Brad Stevens	bgstevens@umes.edu	UMES
AJ Turner	aj.turner@noaa.gov	NOAA
Michael Vecchione	VecchioneM@si.edu	NOAA NMFS
Rhian Waller	rhian.waller@maine.edu	University of Maine
Les Watling	watling@hawaii.edu	University of Hawaiʻi at Mānoa
Kelly Williams	williamsk@allegheny.edu	Allegheny College

4. Methodology

To accomplish its objectives, EX-13-04 Legs 1 & 2 used:

- Dual-bodied ROV system (ROVs *Deep Discoverer* and *Seirios*) to conduct daytime seafloor and water column surveys to help further characterize the deepwater fauna and geology of the region.
- Sonar systems (Kongsberg EM 302 multibeam sonar, Knudsen 3260 sub-bottom profiler, and Simrad EK60 split-beam sonars) to conduct mapping operations at night and when the ROVs were on deck.
- Sea-Bird Electronics (SBE) 9/11+ CTD rosette with SBE 32 carousel and in situ sensors.
- A high-bandwidth satellite connection to provide real-time ship-to-shore communications (telepresence).

All data collected by NOAA must be covered by a data management plan to ensure they are archived and publicly accessible. The data management plan for EX-13-04 Legs 1 & 2 is in Appendix A.

4.1 ROV Seafloor Surveys

ROV dive operations supported the expedition objectives in Section 2.2, and included high-resolution visual surveys of seafloor and water column habitats as well as geological and biological sampling. During each dive, the ROVs descended to the seafloor and then moved from waypoint to waypoint, documenting the geology and biology of the area. Each ROV dive was approximately 7-11 hours long, conditions and logistics permitting. Dives were primarily conducted during the day (operations described in detail by Quattrini et al. (2015) and Kennedy et al. (2019)). Additional information about the general process of site selection, collaborative dive planning, scientific equipment on the ROVs, and the approach to benthic exploration used on *Okeanos Explorer* can be found in Quattrini et al. (2015) and Cantwell et al. (2020). The operating model for OER's *Okeanos Explorer* cruises is based on telepresence-enabled participation whereby the small at-sea science team is augmented by a significantly larger shore-based science team located around the world. Additional information about the operating model and how OER conducts community-driven exploration can be found in Cantwell et al. (2020).

Onboard and shore-based scientists identified each encountered organism to the lowest taxon possible based on data available during real-time assessment. Additionally, they provided geological interpretations of the observed substrate throughout each ROV seafloor survey.

For water column exploration, a series of transects were performed during either vehicle descent before reaching the seafloor or ascent following the completion of the benthic/seafloor exploration. Transects primarily targeted the deep scattering layer and the waters directly above and below it. Specific transect depths were decided each day during ROV descent through an evaluation of the Simrad EK60 data; ROV conductivity, temperature, depth (CTD) data; and the acoustically determined position of the deep scattering layer.

4.2 Sampling Operations

A survey of opportunity was conducted in partnership with NOAA Northeast Fisheries Science Center (NEFSC) with water samples collected by CTD rosette casts at various locations. For more information and samples/data collected by the NEFSC, please contact Jon Hare (jon.hare@noaa.gov).

No other samples were collected during EX-13-04.

4.3 Acoustic Operations

Acoustic operations included Kongsberg EM 302 multibeam, Simrad EK60 split-beam, and Knudsen sub-bottom profiler data collection (Lobecker et al., 2015 and Lobecker, 2015). The schedule of mapping operations included overnight transits and whenever the ROVs were on deck. Lines were planned to maximize edge matching of existing data or filling of data gaps in areas with incomplete bathymetry coverage. In regions with no existing data, exploration transit lines were planned to optimize potential discoveries. Targeted mapping operations were conducted in the vicinity of the (1) Northeast U.S. continental margin and (2) New England Seamount Chain.

4.3.1 Multibeam Sonar (Kongsberg EM 302)

Multibeam seafloor mapping data were collected using the Kongsberg EM 302 sonar, which operates at a frequency of 30 kilohertz (kHz). Multibeam mapping operations were conducted during all overnight transits between ROV dive sites. Multibeam data quality was monitored in real time by acquisition watchstanders. Ship speed was adjusted to maintain data quality as necessary.

Whenever possible, transits were designed to maximize coverage over seafloor areas with no previous high-resolution mapping data. In these focus areas, line spacing was generally planned to ensure 30% overlap between lines at all times. Cutoff angles in the Seafloor Information System (SIS) software were generally adjusted on both the port and starboard sides to ensure the best balance between data quality and coverage. Overnight surveys were also completed in areas that were previously mapped with a lower-resolution multibeam sonar system.

Additionally, multibeam mapping operations were conducted directly over planned ROV dive sites to collect seafloor mapping data to help refine dive plans. These operations collected data on seafloor depth (bathymetry), seafloor acoustic reflectivity (seafloor backscatter), and water column reflectivity (water column backscatter).

Background data used to guide exploratory multibeam mapping operations included the 2012 ACUMEN cruises, and *Okeanos Explorer* cruises EX-13-02, EX-13-03, which gathered baseline information on deepwater canyons off the Northeastern U.S. seaboard, mapping along the continental shelf and slope from North Carolina to the northeastern boundary of the U.S. EEZ. Some dive planning and mapping operations were conducted using bathymetric grids created using all available bathymetry archived at NOAA's National Centers for Environmental Information (NCEI) and their AutoGrid tool.

4.3.2 Sub-Bottom Profiler (Knudsen Chirp 3260)

The primary purpose of the Knudsen Chirp 3260 (3.5 kHz) sonar is to image sediment layers underneath the seafloor to a maximum depth of about 80 m below the seafloor, depending on the specific sound velocity of the substrate. The sub-bottom profiler was operated simultaneously with the multibeam sonar during mapping operations to provide supplemental information about the sedimentary features underlying the seafloor.

4.3.3 Split-beam Sonars (Simrad EK60)

At the time of this expedition, *Okeanos Explorer* was equipped with three split-beam transducers (Simrad EK60 general purpose transceivers, 18 kHz).

This sonar was used continuously throughout EX-13-04 Legs 1 & 2, during both overnight mapping operations and daytime ROV operations. The sonar provided calibrated target strength measurements of water column features such as dense biological layers and schools of fish. This sonar also helped detect gaseous seeps on the seafloor. EK60 data were also used during midwater transects of ROV dives to detect the depth of the deep scattering layers, which are aggregations of biological organisms in the water column.

4.3.4 Expendable Bathythermograph (XBT) Systems

Expendable bathythermographs (XBTs) were collected every six hours and applied in real time using SIS. Sound speed at the sonar head was determined using sound speed from a flow-through thermosalinograph (TSG).

4.4 Conductivity, Temperature, and Depth (CTD)

CTD measurements were collected by two different methods — via CTD rosette casts and an integrated CTD system on the ROVs. The ROV system recorded CTD and associated sensors on every dive. CTD rosette casts were conducted at the conclusion of every ROV dive to profile the water column and to collect water samples, using a SBE Model 9/11+ CTD, installed in a 24-position rosette frame with a SBE-32 carousel. At the time of this expedition, there were 24-2.5L Niskin bottles capable of collecting water samples. The SBE 9+ underwater unit has a depth capability of 6,800 m and a dual conductivity/temperature sensor pair.

Additional sensors installed on the CTD frame include: light scattering spectroscopy (LSS), dissolved oxygen (DO), oxygen reduction potential (ORP), and an altimeter.

4.5 Sun Photometer Measurements

OER gathers limited at-sea measurements aboard *Okeanos Explorer* to support a NASA-led, long-term research effort that assesses marine aerosols. As time allowed on cloud-free days, onboard personnel collected georeferenced sun photometer measurements for the Maritime Aerosol Network (MAN) component of the Aerosol Robotic Network (AERONET). AERONET is a network of sun photometers that measures atmospheric aerosol properties around the world.

MAN complements AERONET by conducting sun photometer measurements on ships of opportunity to monitor aerosol properties over the global ocean.

4.6 Eventlog

During ROV dives, participating researchers communicate between ship and shore using the Eventlog. The Eventlog is a persistent chat room where all comments, discussions, and requests are logged and provided a UTC timestamp that can later be correlated to the operations, location, and data feeds collected by the ship. The chat server facilitates the first-order annotation of cruise activities, serving as a digital version of scientists' daily logs and enabling input from multiple users. Eventlog users were encouraged to use "dive codes", which are three-to-five letter shorthand codes that are used to standardize and speed the recording of observations in the Eventlog. The dive codes were copy and pasted into the Eventlog every morning, and can be found online and are included in Appendix B.

5. Clearances and Permits

Pursuant to the National Environmental Policy Act (NEPA), OER is required to include in its planning and decision-making processes appropriate and careful consideration of the potential environmental consequences of actions it proposes to fund, authorize, and/or conduct. The Companion Manual for NOAA Administrative Order 216-6A (https://www.nepa.noaa.gov/docs/NOAA-NAO-216-6A-Companion-Manual-03012018.pdf, *last accessed March 05, 2021*) describes the agency's specific procedures for NEPA compliance.

An environmental review memorandum was completed for NOAA Ship Okeanos Explorer expeditions EX-13-04 Legs 1 & 2 in accordance with Section 4 of the companion manual. Based upon this review, a categorical exclusion was determined to be the appropriate level of NEPA analysis necessary, as no extraordinary circumstances existed that required the preparation of an environmental assessment or environmental impact statement. The categorical exclusion memo can be found in Appendix C of this report. OER is preparing a programmatic environmental assessment to cover future expeditions.

The expedition was conducted prior to the establishment of the Northeast Canyons and Seamounts Marine National Monument off the Northeast U.S. coast and the Frank R. Lautenberg Deep-Sea Coral Protection Area off the Mid-Atlantic U.S. coast. As such no permits or letter of Acknowledgement were sought or required at the time of this expedition. The expedition did not involve any other monuments, sanctuaries, or protected areas in the vicinity. No geological or biological samples were collected during EX-13-04 Legs 1 & 2.

6. Schedule and Map

EX-13-04 Legs 1 & 2 was a total of 36 days at sea, between July 8, 2013, and August 17, 2013. EX-13-04 Leg 1 departed from North Kingstown, RI, on July 8, 2013, and returned to port in New York, NY, on July 25, 2013. EX-13-04 Leg 2 departed from North Kingstown, RI, on July 31, 2013, and returned to port in North Kingstown, RI, on August 17, 2013. See **Table 4** for a day-by-day breakdown of EX-13-04 Legs 1 & 2. There were 31 dives achieved during EX-13-04 Legs 1 & 2 (see **Table 7** for details). Some dives were cancelled due to weather. See **Figure 1** for a map showing collected bathymetry and ROV dive sites for EX-13-04 Leg 1 and **Figure 2** for EX-13-04 Leg 2's bathymetry collected and key operational areas.

Table 4. EX-13-04 Legs 1 & 2 schedule

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
07/07 Mobilization at North Kingstown, RI	**07/08** EX Departure for Leg 1 Transit and overnight mapping operations	**07/09** Dive 01: USGS Hazard 3 CTD rosette cast Overnight mapping operations	**07/10** Dive 02: USGS Hazard 4 Overnight mapping operations	**07/11** Dive 03: New England Seep 3 CTD rosette cast Overnight mapping operations	**07/12** Dive 04: New England Seep 2 CTD rosette cast Overnight mapping operations	**07/13** Dive 05: Hydrographer Mid1 CTD rosette cast Overnight mapping operations
07/14 Dive 06: Hydrographer Canyon—Shallow 2 CTD rosette cast Overnight mapping operations	**07/15** Dive 07: Atlantis Canyon—Mid 1 CTD rosette cast Overnight Mapping Operations	**07/16** Dive 08: Atlantis Canyon Deep CTD rosette cast Overnight Mapping Operations	**07/17** Dive 09: Alvin Canyon—Shallow 1 CTD rosette cast Overnight Mapping Operations	**07/18** Dive 10: Alvin Canyon—Mid 2 CTD rosette cast Overnight Mapping Operations	**07/19** Dive 11: Block Canyon—Mid 2 CTD rosette cast Overnight mapping operations	**07/20** Dive 12: USGS Hazards 2 Overnight mapping operations
07/21 Dive 13: New England Seep 1 Overnight mapping operations	**07/22** Dive 14: Block Deep Overnight Mapping operations	**07/23** Dive 15: Block Shallow 1 CTD rosette cast Overnight mapping operations	**07/24** Dive 16: Gauntlet Minor Overnight Mapping Operations	**07/25** Transit to New York, NY	**07/26**	**07/27**

07/28	**07/29**	**07/30** Mobilization at North Kingstown, RI	**07/31** EX Departure for Leg 2 Overnight mapping operations	**08/01** Dive 01: USGS Hazards 1 Overnight mapping operations	**08/02** Dive 02: Minor Canyon area near Shallop Canyon CTD rosette cast Overnight mapping operations	**08/03** Dive 03: Oceanographer Canyon 1 CTD rosette cast Overnight mapping operations
08/04 Dive 04: Mytilus Seamount North Overnight mapping operations	**08/05** Dive 05: Mytilus Seamount South Overnight mapping operations	**08/06** Dive 06: Nygren Mid Deep CTD rosette cast Overnight mapping operations	**08/07** Dive 07: Heezen Canyon Deep CTD rosette cast Overnight mapping operations	**08/08** Dive 08: Nygren Canyon Shallow Overnight mapping operations	**08/09** Dive 09: Heezen Canyon Shallow CTD rosette cast Overnight mapping operations	**08/10** Dive cancelled due to weather Transit mapping
08/11 Dive 10: Nygren/Heezen Intercanyon Water column survey CTD rosette cast Overnight mapping operations	**08/12** Dive 11: Lydonia Powell intercanyon CTD rosette cast Overnight mapping operations	**08/13** Dive 12: Lydonia Canyon Overnight mapping operations	**08/14** Dive 13: Oceanographer Canyon 2 Water column survey CTD rosette cast Overnight mapping operations	**08/15** Dive 14: Welker Canyon Overnight mapping operations	**08/16** Dive 15: USGS Hazard 5 Overnight mapping operations	**08/17** Arrival: North Kingstown, RI

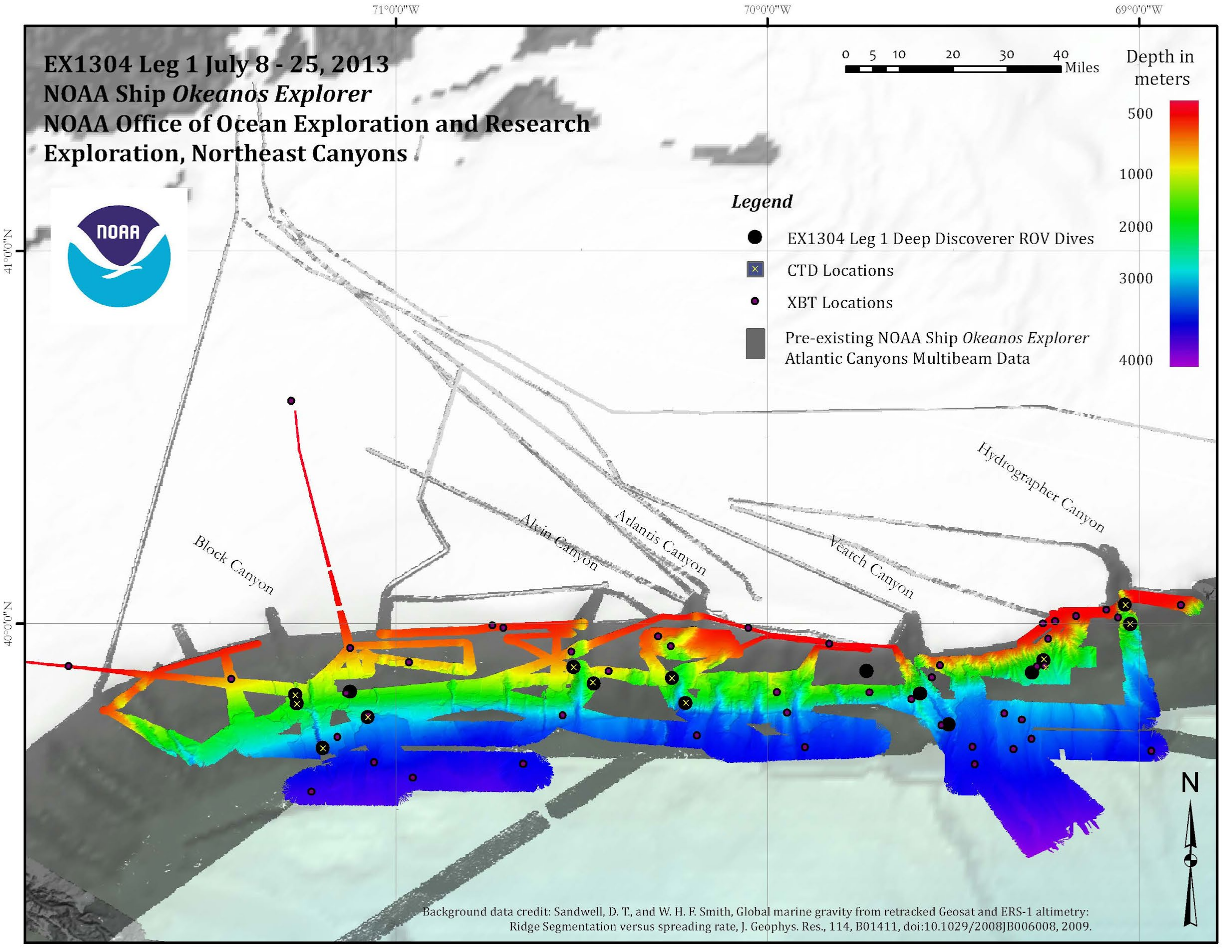

Figure 1. Map showing EX-13-04 Leg 1 bathymetry data collected and locations of ROV dive sites.

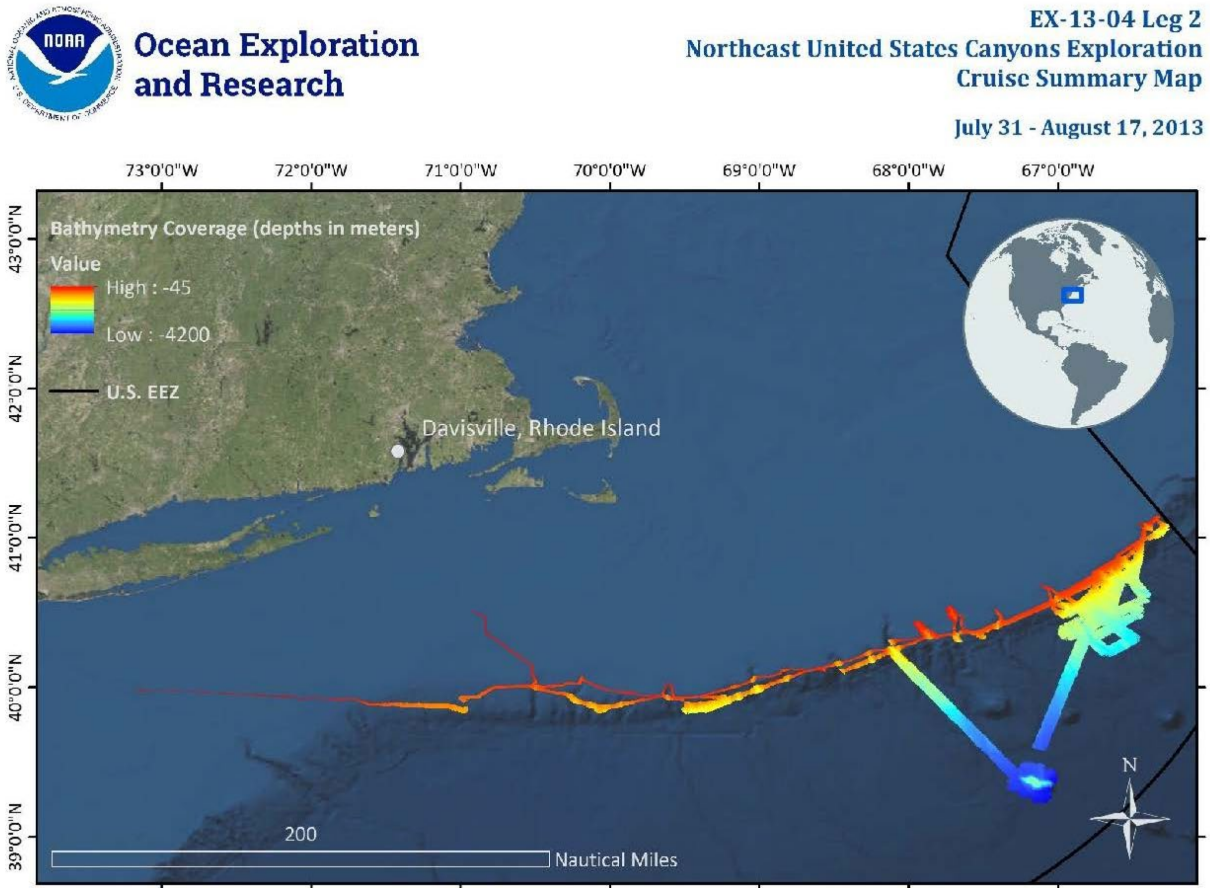

Figure 2. Map showing EX-13-04 Leg 2 bathymetry data collected and key operational areas.

7. Results[1]

Metrics for the EX-13-04 Legs 1 & 2 expedition's major exploration and scientific accomplishments are summarized in **Table 5** and **Table 6**. More detailed results are presented in the subsections that follow.

Table 5. Summary of exploration metrics for EX-13-04 Legs 1 & 2.

Exploration Metrics	Totals
Leg 1	
Days at sea	18
Linear km mapped by EM 302	2,705
Square km covered by EM 302	7,567

[1] If you are unable to access the results noted here, contact ex.expeditioncoordinator@noaa.gov.

Square km covered by EM 302 in U.S. EEZ	7,331
Vessel CTD casts	12
XBT casts	48
ROV dives	16
ROV dives in U.S. EEZ	16
Maximum ROV seafloor depth (m)	2,135
Minimum ROV seafloor depth (m)	563
Total time on bottom (hh:mm:ss)	96:20:21
Total ROV time (hh:mm:ss)	136:41:47
Leg 2	
Days at sea	18
Linear km mapped by EM 302	2,720
Square km covered by EM 302	7,074
Square km covered by EM 302 in U.S. EEZ	6,671
Vessel CTD casts	7
XBT casts	82
ROV dives	15
ROV dives in U.S. EEZ	15
Maximum ROV seafloor depth (m)	3,271
Minimum ROV seafloor depth (m)	899
Total time on bottom (hh:mm:ss)	99:22:20
Total ROV time (hh:mm:ss)	128:32:01

Table 6. Summary of scientific metrics for EX-13-04 Legs 1 & 2. Rows 1-4 are also included in the following ROV Dive Summary **Table 7** as Sci. Met. 1-4.

Scientific Metrics	Totals
1) Dives during which living corals and sponges were observed	26
2) Dives during which chemosynthetic communities were observed	4
3) Dives during which active seeps/vents were observed	4

4) Dives during which diverse benthic communities were observed	31
Total biological or geological samples	0
Actively participating scientists, students, and resource managers	71

7.1 ROV Survey Results

The maximum depths explored during the 16 ROV surveys for EX-13-04 Leg 1 was 2,135 m, and for the 15 ROV surveys for EX-13-04 Leg 2 was 3,271 m. During the 16 dives, the ROVs spent a total of nearly 137 hours on the bottom for EX-13-04 Leg 1, while the ROVs spent a total of nearly 128 hours on the bottom over 15 dives for EX-13-04 Leg 2 (see **Table 5** for more cumulative results). See **Table 7** for dive-specific information for each of the dives.

Table 7. Summary information for the 16 ROV dives conducted during EX-13-04 Legs 1 & 2. **Table 6** "Scientific Metrics" contains the definitions for Sci. Met. 1-4.

Date (yyyy mmdd)	Dive #	Site Name	On Bottom Latitude (dm)	On Bottom Longitude (dm)	Max Depth (m)	Dive Duration (hh:mm:ss)	Bottom Time (hh:mm:ss)	Sci. Met. 1	Sci. Met. 2	Sci. Met. 3	Sci. Met. 4
Leg 1											
20130709	1	USGS Hazard 3	39° 44.912'N	71° 4.521' W	1880	08:16:03	05:14:50	Yes	No	No	Yes
20130710	2	USGS Hazard 4	39° 52.331'N	69° 43.990'W	608	08:01:23	06:51:50	No	No	No	Yes
20130711	3	New England Seep 3	39° 54.063'N	69° 15.435'W	1139	07:52:34	06:11:05	No	Yes	Yes	Yes
20130712	4	New England Seep 2	39° 52.087'N	69° 17.248'W	1476.1	07:50:23	06:04:21	No	Yes	Yes	Yes
20130713	5	Hydrographer Mid 1	39° 59.941'N	69° 01.404' W	1422.7	07:38:52	05:44:51	Yes	No	No	Yes
20130714	6	Hydrographer Canyon—Shallow 2	40° 03.012'N	69° 02.244' W	908.3	07:32:44	06:51:27	Yes	No	No	Yes
20130715	7	Atlantis Canyon—Mid 1	39° 51.167'N	70° 15.370 W	1105.6	08:05:37	06:54:32	Yes	No	No	Yes

20130716	8	Atlantis Deep	39° 47.184’N	70° 13.228' W	1793.9	08:01:48	05:47:42	Yes	No	No	Yes
20130717	9	Alvin Canyon—Shallow 1	39° 52.993'N	70° 31.299' W	926.9	06:59:52	05:47:27	Yes	No	No	Yes
20130718	10	Alvin Canyon—Mid 2	39° 50.323'N	70° 28.026' W	1109.6	07:36:33	06:37:44	Yes	No	No	Yes
20130719	11	Block Canyon—Mid 2	39° 50.323'N	70° 28.026' W	1351.0	07:28:53	05:42:00	Yes	No	No	Yes
20130720	12	USGS Hazards 2	39° 43.72'N	69° 30.698'W	2026.9	07:40:21	05:46:11	Yes	No	No	Yes
20130721	13	New England Seep 1	39° 48.301'N	69° 35.654'W	1423.2	08:42:47	06:53:30	Yes	Yes	Yes	Yes
20130722	14	Block Deep	39° 39.939'N	71° 11.798' W	2135.2	19:57:34	04:46:36	Yes	No	No	Yes
20130723	15	Block Shallow 1	39.80811° N	71.27022° W	1137.7	07:45:41	06:45:38	Yes	No	No	Yes
20130724	16	Gauntlet Minor	39.81678° N	71.123355°W	1121.1	07:19:42	4:20:37	Yes	No	No	Yes
Leg 2											
20130801	1	USGS Hazards 1	39° 52.573'N	70° 58.735'W	784.1	08:00:30	07:01:29	No	No	No	Yes
20130802	2	Minor Canyon Near Shallop Canyon	39°55.977'N	69° 13.582'W	1139.8	07:11:59	05:34:25	Yes	No	No	Yes
20130803	3	Oceanographer Canyon 1	40°15.105'N	68° 7.338'W	1239.3	08:07:07	06:34:59	Yes	No	No	Yes
20130804	4	Mytilus Seamount North	39°23.200'N	67° 8.553'W	3271.4	10:06:49	06:25:56	Yes	No	No	Yes
20130805	5	Mytilus Seamount South	39°21.337'N	67° 12.444'W	3262.3	10:34:04	07:04:29	Yes	No	No	Yes

20130806	6	Nygren Mid Deep	40°43.624'N	66° 39.644'W	1590.4	08:09:40	06:24:57	Yes	Yes	Yes	Yes
20130807	7	Heezen Canyon Deep	41° 1.879'N	66° 19.632'W	1723.4	07:59:56	06:06:39	Yes	No	No	Yes
20130808	8	Nygren Canyon Shallow	40°45.050'N	66° 40.616'W	914.6	08:18:33	07:18:53	Yes	No	No	Yes
20130809	9	Heezen Canyon Shallow	41° 3.872'N	66° 23.274'W	925.9	08:13:28	06:35:42	Yes	No	No	Yes
20130811	10	Nygren/Heezen Intercanyon	40°51.678'N	66°32.622'W	824.3	08:09:35	07:13:26	Yes	No	No	Yes
20130812	11	Lydonia Powell intercanyon	40°20.984'N	67° 32.154'W	662.8	08:13:45	07:32:07	Yes	No	No	Yes
20130813	12	Lydonia Canyon	40.30305 N	67.6761 W	1238.9	08:14:10	06:23:59	Yes	No	No	Yes
20130814	13	Oceanographer Canyon 2	40°17.343'N	68° 7.092'W	1247.6	08:09:37	06:44:47	Yes	No	No	Yes
20130815	14	Welker Canyon	40° 5.501'N	68° 28.362'W	1445.4	10:48:26	05:08:35	Yes	No	No	Yes
20130816	15	USGS Hazard 5	39°51.320'N	70° 3.966'W	899.3	08:14:22	07:11:57	No	No	No	Yes

7.1.1 Accessing ROV Data

All data collected and stored follows the Data Management Plan (Gottfried, 2013) found in Appendix A.

OER Digital Atlas

ROV data from EX-13-04 Legs 1 & 2 are archived at NCEI and available through OER's Digital Atlas (https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm, *last accessed March 05, 2021*).

To access these data, click on the Search tab, for ROV data pertaining to EX-13-04 Leg 1 enter "EX1304L1" in the Enter Search Text field, and click Search. Click on the point that represents

EX-13-04 Leg 1 to access data options. For ROV data pertaining to EX-13-04 Leg 2 enter "EX1304L2" in the Enter Search Text field, and click Search. Click on the point that represents EX-13-04 Leg 2 to access data options. In the pop-up window, select the ROV Data Access tab for links to the ROV dive data, which is organized by dive.

ROV Dive Summaries

Individual ROV dive summaries for EX-13-04 Legs 1 & 2 and associated ROV dive data are archived at NCEI and available through the OER Digital Atlas. EX1304 Leg 1 can be found here https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm?cruiseNum=EX1304L1 *(last accessed March 05, 2021)* and Leg 2 can be found here https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm?cruiseNum=EX1304L2 *(last accessed March 05, 2021)*. The dive summary can be accessed by clicking on the ROV Data Access tab, then clicking "Open" next to the dive summary needed.[2]

ROV Dive Video

To search, preview, and download the dive videos for *Okeanos Explorer*, go to the OER Video Portal (https://www.nodc.noaa.gov/oer/video/, *last accessed March 05, 2021*).

7.2 Sampling Operations Results

No geological or biological samples were collected during EX-13-04 Legs 1 & 2. Information regarding water samples collected and analyses by NOAA NEFSC can be accessed using this link: https://www.ncei.noaa.gov/metadata/geoportal/rest/metadata/item/gov.noaa.nodc%3A0127524/html, *last accessed March 05, 2021*.

7.3 Acoustic Operations Results

During EX-13-04 Legs 1 & 2, multibeam mapping operations results included 5,425.6 linear kilometers (km) mapped and 14,641 km^2 covered (14,002 km^2 of these in the U.S. EEZ). Additional information about the mapping conducted during EX-13-04, including data quality assessments, is in the EX-13-04 Leg 1 and EX-13-04 Leg 2 mapping data reports (Lobecker et al., 2015 and Lobecker, 2019).

7.3.1 Acoustic Operations Data Access

Multibeam Sonar (Kongsberg EM 302)

The multibeam dataset for the expedition is archived at NCEI and accessible through their Bathymetric Data Viewer (https://maps.ngdc.noaa.gov/viewers/bathymetry/, *last accessed*

[2] ROV dive summaries are typically available 90 days after an ROV cruise. For access in the interim, contact ex.expeditioncoordinator@noaa.gov.

March 05, 2021). To access these data, click on the Search Bathymetric Surveys button, select "NOAA Ship Okeanos Explorer" from the Platform Name dropdown menu, and "EX1304L1" from the Survey ID dropdown menu for EX-13-04 Leg 1 and/or "EX1304L2" from the Survey ID dropdown menu for EX-13-04 Leg 2. Click OK, and the ship track for the cruise will appear on the map. Click the ship track for options to download data.

Sub-bottom Profiler (Knudsen Chirp 3260)

The sub-bottom profiler was not run during any of EX-13-04 Legs 1 & 2 ROV dive operations, but generally was operated during multibeam mapping operations. These data are archived at NCEI and accessible through their Trackline Geophysical Data Viewer (https://maps.ngdc.noaa.gov/viewers/geophysics/, *last accessed March 05, 2021*). To access these data, select "Subbottom Profile" under Marine Surveys and click on Search Marine Surveys. In the pop-up window, select "EX1304_1" for EX-13-04 Leg 1 or "EX1304_2" for EX-13-04 Leg 2 in the Filter by Survey IDs dropdown menu. Click OK, and the ship track for the cruise will appear on the map. Click the ship track for options to download data.

Split-beam Sonars (Simrad EK60)

EK60 water column data for EX-13-04 are archived at NCEI and available through their Water Column Sonar Data Viewer (https://www.ngdc.noaa.gov/maps/water_column_sonar/index.html, *last accessed March 05, 2021*). To access these data, click on the Additional Filters button, deselect "All" next to Survey ID, and select "EX1304L1" for EX-13-04 Leg 1 or "EX1304L2" for EX-13-04 Leg 2 from the Survey ID list. Click OK, and the ship track for the cruise will appear on the map. Click on the ship track for options to download data.

7.4 Conductivity, Temperature, and Depth (CTD) Measurements

CTD profile data from EX-13-04 are archived at NCEI and available through OER's Digital Atlas (https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm, *last accessed March 05, 2021*). To access these data, click on the Search tab, enter "EX1304L1" for EX-13-04 Leg 1 or "EX1304L2" for EX-13-04 Leg 2 in the Enter Search Text field, and click Search. Click on the point that represents EX-13-04 Leg 1 or EX-13-04 Leg 2 to access data options. In the pop-up window, select the Data Access tab for a link to download the CTD profile data. Data for nutrient analysis data (conducted by NEFSC) on the water samples during CTD casts are included in the CTD profile data link.

ROV CTD data can be found with the dive summary data pages. For data from EX-13-04 Leg 1 use link: https://www.ncei.noaa.gov/waf/okeanos-rov-cruises/EX-13-04l1/, *last accessed March 05, 2021*. For data from EX-13-04 Leg 2 use link: https://www.ncei.noaa.gov/waf/okeanos-rov-cruises/EX-13-04l2/, *last accessed March 05, 2021*.

7.5 Sun Photometer Measurements

Sun photometer measurements are available through NASA's MAN (https://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.html, *last accessed March 05, 2021*). Access these data by searching the table for "2013," "Okeanos Explorer," and "North Atlantic Ocean." Click on the links to download the data. (Note: There may be more than one entry for *Okeanos Explorer* in a region in a given year.)

7.6 Engagement

The *Northeast U.S. Canyons Expedition 2013* expedition engaged with audiences around the world, opening a window of understanding into the deep sea. Live video feeds from OER's new 6,000-meter ROV *Deep Discoverer* (D2), interactions with aquaria and learning centers, and online coverage allowed the public to join the dives and virtually explore the ocean. The live video feeds received approximately 670,000 visits during the course of the expedition, and the online website coverage received approximately 142,000 visits.

8. Summary of EX-13-04 Leg 1

From July 8-25, 2013, the first leg of the *Northeast U.S. Canyons Expedition 2013* explored diverse habitats and geological settings of the deep canyons region off the Northeast U.S. ROV D2 completed 16 dives to depths ranging from 500 to 2,135 m along the continental slope of the Northeast U.S. Three exploratory ROV dives were conducted in Block Canyon and two dives were conducted each in Hydrographer, Alvin, and Atlantis Canyons. In addition, the ROV documented geological features and ecosystems in three priority sites considered to be geohazard areas by the USGS Hazards group, three hydrocarbon seep areas, and one unnamed minor canyon. Additional scientific analysis of this expedition (EX1304L1 and EX1304L2) can be found in Quattrini et al. (2015) and Brumley et al. (2018) and a summary can be found in Chase (2018).

8.1 Canyon Biology and Geology

Exploration of the canyons at depths ranging from ~650 to 2,135 m revealed that they are likely more dynamic, both geologically and biologically, than previously thought (Valentine, 1987). Specifically, each dive documented different biological and geological features along both the east and west walls in various locations within each canyon. While exploration of the deepwater canyon systems revealed that the community composition and distribution of benthic fauna were related to both depth and substrate type, wall failures and breaches were recognized as having a high potential for yielding unstable habitat for the establishment of hard-bottom communities (Quattrini et al., 2015). Numerous observations of fallen or dislodged octocoral and scleractinian colonies were made at the base of the vertical canyon walls.

Lithologies exposed along the walls of Atlantis, Alvin and Block Canyons—as well as the unnamed canyon between Block and Alvin Canyons—were relatively similar along the upper slope section between depths of ~800 to 1,400 m. Based on the depth interval, projections from seismic reflection and well data, and surface texture, these lithologies were most likely Late Cretaceous to Early Eocene chalks, limestones-calcareous mudstones/siltstones, and porcellanites. The deeper dive (Dive 14) in Block Canyon intersected a Pliocene-Pleistocene sediment wedge, with lithologies dominated by mudstones and siltstones. Mudstones and siltstone lithologies were encountered along the walls of Hydrographer Canyon, but the age of these units is currently unknown. Rock debris at the base of steep walls was encountered in all canyons, although the strength of the wall lithologies strongly controlled their distribution, extent, and morphology. Extensive debris aprons, with large blocks, were present at the base of the walls in Hydrographer Canyon (Dive 05) and the deep Block Canyon (Dive 14), while tabular slabs and smaller debris were common in Alvin, Atlantis and the upper slope of Block Canyon.

Initial impressions of the Northeast canyon system also revealed that these canyons are hotspots for biodiversity, putatively hosting more than 25 species of corals, more than seven species of sponges, more than 30 species of fishes, and dozens of crustacean (e.g., crabs, lobsters, barnacles, shrimp), cephalopod (squids and octopus), and echinoderm species (e.g. starfish, sea urchins, sea cucumbers). Dominant sessile fauna in the canyons included *Desmophyllum* sp., *Solenosmilia variabilis, Paramuricea* sp., *Paragorgia arborea, Anthothela* sp., bamboo corals (Isididae), numerous species of sponges (Hexactinellidae and Demospongidae) and limid bivalves. Dominant fishes included cutthroat eels (Synaphobranchidae), rattails (Macrouridae), skates (Rajiidae), black dogfish (*Centroscyllium fabricii),* and witch flounder (*Glyptocephalus cynoglossus).* In addition, numerous fauna were observed that were not previously known to occur in the area, including species of crabs (e.g., lithodid king crabs) and corals (e.g., *Metallogorgia* cf. *melanotrichos* with a brittle star associate *Ophiocreas* cf. *oedipus)*. Also of note, *Lophelia pertusa* was observed in Hydrographer Canyon at a depth of 867 m. Several observations of young organisms and eggs were observed, including octopus eggs, bobtail squid eggs, egg cases from catsharks and skates, and small coral colonies indicative of relatively recent recruitment to the canyons (particularly in Hydrographer Canyon).

8.2 USGS Hazards Sites

ROV D2 visited three sites (Dives 01, 02, and 12) prioritized by the USGS to examine the geological formation, character, and potential instability of the seafloor, estimate relative timing of landslide events, and determine whether these areas pose a hazard to tsunami generation. Information gathered during ROV dives have added to previous research testing hypotheses about the stability of scarp and canyon features and the potential for using surface morphology to estimate the relative age of landslide features, especially debris piles that are well expressed in geophysical data (Chaytor et al., 2012). One dive (USGS Hazards 4) was focused on investigating pockmark features along the upper slope that may be evidence of shallow fluid/gas release. No evidence of recent fluid/gas expulsion was noted in the pockmarks traversed.

Benthic fauna observed at these sites were species typically associated with soft substrata. Fauna included red crabs (*Chaceon* cf. *quinquedens*), sea pens (pennatulaceans), brittle stars (ophiuroids), sea urchins, and sea cucumbers (holothurians). At the USGS Hazard 4 site, hundreds of red crabs were observed and a discarded crab trap was noted. At the USGS Hazards 2 site, thousands of brittle stars were observed, denoting a productive area in the canyon system.

8.3 New England Seep Sites

ROV D2 surveyed two unexplored areas where water column anomalies (bubble streams rising from the seafloor) were found with multibeam sonar (see below) to determine if methane and associated chemosynthetic communities were present. An additional site, which was surveyed on the engineering shakedown cruise EX-13-02, was also re-surveyed during this leg. All three of these exploration dives revealed living chemosynthetic communities, e.g., beds of *Bathymodiolus* mussels, which hosted at least 10 species, including gastropod snails, polychaete worms, and shrimp associated with hydrocarbon seepage. On two of the dives to seep areas (New England Seeps 1 and 2), ROV D2 imaged methane bubbling directly through sediments on the seafloor. At New England Seeps 2 and 3, methane hydrates were observed, confirming that the processes that lock methane into ice occur in canyon areas in this region of the NW Atlantic. These cold seep areas were extensive (more than 100 meters in length). Of note at New England Seep 1, numerous size classes of *Bathymodiolus* sp. mussels were evident, including thousands of small individuals.

8.4 Mapping and Other Operations

Throughout the cruise, previously collected multibeam data (as part of ACUMEN) were used to plan all ROV dives. Gridded bathymetry data were viewed in collaboration with the onshore science team, and dive tracks were planned and plotted in 3D and shared with the team.

Each night, the survey department conducted mapping operations. Though much of the area explored was mapped during previous cruises, more than 7,500 km^2 were mapped during EX-13-04 Leg 1, including: canyon areas where gaps existed in previous multibeam data, areas where previously collected bottom backscatter data quality was poor, new data collection along shallow areas of the continental margin to further build multibeam data coverage, and confirmation of the locations of several previously detected gas plumes (Skarke et al., 2014). At least one site (Dive 03), where sonar data discovered gas plumes in the 2012 water column data, revealed that precise locations previously showing bubble release were no longer actively releasing bubbles, and that new locations in the local vicinity were now showing active plumes.

Additionally, sub-bottom data were acquired and CTD casts were conducted in every canyon. Water samples were collected at the following depths: near bottom, 500, 250, 200, 150, 100, 50, 30, 20, 10 m, and at the surface to support a piggyback project by NOAA NEFSC for nutrient analysis.

9. Summary of EX-13-04 Leg 2

From July 31 to August 16, the second leg of the *Northeast U.S. Canyons Expedition 2013* cruise continued exploration of the geomorphology and benthic ecology of deep-sea canyons and Mytilus Seamount along the Northeast U.S. Atlantic margin. During EX-13-04 Leg 2, ROV D2 surveyed the area extending between Alvin and Block Canyons in the west and Heezen Canyon (eastern limit of the U.S. EEZ) to the east (**Figure 2**). Fifteen dives, ranging in depth from 490 to 3,271 m were completed at five named canyons (Nygren, Heezen, Oceanographer, Lydonia, and Welker), one minor canyon (unnamed near Shallop Canyon), two inter-canyon sites, two USGS geohazards targets, and Mytilus Seamount (**Table 7**). Additional scientific analysis of this expedition (EX1304L1 and EX1304L2) can be found in Quattrini et al., 2015.

Many of the ROV dives conducted represented the first exploration and visual examination of this region. The submarine canyons investigated were diverse and dramatic environments, with no two canyons appearing to be exactly alike, in terms of lithology or biology. Overall, the team expanded scientific understanding of the spatial distributions, both geographic and bathymetric, of species along the continental margin and slope, including observations of species not previously known from the region and species once considered rare.

9.1 Canyon Biology and Geology

While the canyons explored on EX-13-04 Leg 1 were mostly Eocene/Cretaceous in origin, with heavily eroded carbonates, canyons visited on EX-13-04 Leg 2 were composed of a high diversity of lithologies. Some rock surfaces were so heavily encrusted with manganese-iron coating that it was difficult to obtain a complete description of rock composition. Lydonia Canyon was composed of a chalky material, but confirmation of rock type would require a physical sample. Heezen Canyon was composed mostly of mudstone. Given the presence of numerous large colonies of *Paragorgia arborea* and other octocorals, it was apparent that the slope stability of Heezen Canyon was high, at least approximately several hundred years. However, the presence of large, displaced blocks indicated that this area experiences long-term erosional processes. The extensive manganese coating on the rock features observed at Nygren Canyon suggested that the steep features observed here have longer-term strength and stability. In contrast, Oceanographer Canyon contained an extensive debris apron and talus slopes, indicating this area likely experiences continuous shedding, making it a less suitable habitat for slow-growing encrusting fauna. While numerous species of corals were observed in Oceanographer Canyon, most individuals were of similar size, suggesting periodic recruitment events follow shedding episodes. However, further examination of the dive video, in concert with known age estimates for the deep-sea corals, are needed to advance scientific understanding of the slope stability and frequency of shedding events for this region.

Overall, preliminary observations indicated that this region supports a high diversity of fauna and habitat types. Initial estimates of species include at least 40 species of corals and 40 species of fishes. Additionally, numerous species of sponges (glass, demosponges, and encrusting types), crustaceans (squat lobsters, crabs [*Chaceon* sp., *Cancer* sp.], shrimps, euphausiids, hermit crabs, amphipods, barnacles), cephalopods (squid: *Brachioteuthis* sp., *Chiroteuthis* sp., *Illex* sp., *Mastigoteuthis* sp., bobtail squid, and various octopuses), echinoderms (sea stars: brisingids, *Hymenaster* sp., *Pythonaster* sp., *Evolplosoma* sp., *Pteraster* sp., *Chondraster giganteus*; various ophiuroids, crinoids, urchins, and holothurians), and other invertebrates (e.g., salps, siphonophores, aplacophorans, bivalves), were observed throughout the dives. Large unicellular xenophyophores were documented both on the sediment-covered seafloor and on the steep walls of Mytilus Seamount. Overall, exploration of this region advanced scientific understanding of species distributions and occurrences, including expanded ranges for certain species (Quattrini et al, 2015). But many questions remain. For example, little is known about connectivity of species found among the canyons examined.

During this expedition, two dives (Dives 04 and 05) were dedicated to the exploration of Mytilus Seamount, the least explored seamount of the New England Seamount Chain, thus representing the most comprehensive exploration of this seamount to date. While there was no opportunity to explore the top of the seamount, the sediment drape was likely composed of carbonate material, suggesting the seamount may be capped in limestone. Mytilus Seamount is volcanic in origin, and the dives revealed a steep and rugged topography on the north side, whereas the south slope was gentler and contained a thicker sediment drape, possibly resulting from a landslide (Duncan, 1984). While the areas examined on the north and south sides had very different topography, similar faunal assemblages were observed on both sides of the seamount. The large, smooth basalt rock features were colonized by sponges and corals; holothurians and ophiuroids were present on the sedimented ledges. No scleractinian corals were observed on either dive, but several species of bamboo corals and other octocorals were noted. Overall, few fish were present, including macrourids, ophidiids, synaphobranchids, halosaurs, *Antimora* sp., *Bathychaunax* sp., and *Bathysaurus* sp. Seamounts are reputed to be dynamic and diverse environments for marine fauna (Shank, 2010). These dives enhanced scientific understanding of the distribution of species on and among seamounts as well as the faunal relationships between seamounts and submarine canyons (Quattrini et al., 2015).

The expedition yielded rare observations of predation, parasitism, and reproduction. Acts of predation included squid eating fish, fish eating squid and fish, fish captured by anemones and corals, and sea stars and sea urchins eating coral polyps. In situ observations of parasitism are very rare, and several different types of crustacean ectoparasites attached to fishes were noted during this expedition. These included copepods and Gnathiidae and Cymothoidae isopods. Lastly, regarding reproduction, squids and red crabs mating, fish egg masses on corals and boulders, coiled pink egg mass (possibly from a nudibranch) on a boulder, and shark egg cases attached to octocoral branches were observed. Finally, evidence of anthropogenic influence was apparent in all of the canyons surveyed; in particular, several instances of discarded fishing gear were documented in the unnamed minor canyon (Dive 02).

9.2 USGS Hazards Sites

Two dives (Dives 01 and 15) were conducted at USGS marine geohazard targets to investigate submarine landslide debris fields and scarps. These areas had not been explored previously and were examined to ascertain the potential for tsunami generation, including assessing the instability of the seafloor and other potential hazards. The team anticipated that the age of the landslide material might be estimated, based on the characteristic encrusting mineralogy and fauna. Examination of the thick sediment drape—in some places > 30 cm thick—and little exposed rock suggested that the landslides were old, relict features.

9.3 New England Seep Sites

Of particular note was the unexpected discovery of a seep in Nygren Canyon. Although the discovery of other newly documented seeps along the coast of the Northeastern U.S. were predicted from unique backscatter and multibeam data (Skarke et al., 2014), no such acoustic data suggested the presence of this seep. This area was characterized by extensive exposed carbonate rock and patches of bacterial mat. Nestled within cracks in the rock were chemosynthetic *Bathymodiolus* sp. mussels, Serpulidae and Polynoidae polychaetes, and various gastropods. Light, white fluffy material was easily disturbed from the site. Similar material, possibly microbial in origin, also was observed at the seeps explored near Veatch and Nantucket Canyons. Further comparisons of all recently discovered seep communities will enable better understanding of the biodiversity and ecology of chemosynthetic environments found along the Atlantic margin.

9.4 Mapping and Other Operations

Additional activities conducted during the expedition included multibeam mapping, sub-bottom profiling, and CTD casts during non-ROV operations. These data expanded the seafloor mapping database and scientific knowledge of the oceanographic conditions in the surrounding environments.

Exploration and data collection during this expedition has greatly enhanced understanding of the geomorphology, biodiversity, and ecology of the northeast canyons along the Northern U.S. Atlantic margin. Specifically, canyons represent dynamic environments, supporting diverse species assemblages—the composition of which are a function of depth, slope stability, and location within the canyon. It is apparent that the underlying foundation and geological structure are important factors influencing the faunal composition within the canyons. However, the relationship between canyon geomorphology, the role of inter-canyon areas, and faunal biodiversity and ecology are still not fully understood. The observations and information gathered on both legs of the expedition will inspire future interdisciplinary research in the region and elsewhere.

10. References

Brumley, K. J., Maschmeyer, C. J., and Mitchell, G. A. (2018). Categorizing Submarine Cold Seeps by Geomorphology and Acoustic Response Utilizing Publicly Available Multibeam Echo Sounder and Remotely Operated Vehicle Datasets. In *AGU Fall Meeting Abstracts*, vol. 2018, pp. OS24C-05. Retrieved March 2021 https://ui.adsabs.harvard.edu/abs/2018AGUFMOS24C..05B/abstract

Cantwell, K., Kennedy, B.R.C., Malik, M., Suhre, K.P. Medley, R. Lobecker, E., Hoy, S., Adams, C., Dornback, M., and Cromwell, M. (2020). The Explorer Model: Lessons from 10 Years of Community-led Ocean Exploration and Open Data. J*ournal of Ocean Technology, 15*(3)*,* pp. 67-76. Retrieved January 2021 https://www.thejot.net/articlepreview/?show_article_preview=1187

Chase, A. (2014). The Atlantic's Deep Sea Treasures: Discoveries From A New Frontier of Ocean Exploration. *NRDC, 12*(IB:14-11-C). Retrieved March 2021 https://assets.nrdc.org/sites/default/files/atlantic-deep-sea-treasures-IB.pdf

Chaytor, J.D., Twichell, D.C. and ten Brink, U.S. (2012) A Reevaluation of the Munson-Nygren-Retriever Submarine Landslide Complex, Georges Bank Lower Slope, Western North Atlantic, *Submarine Mass Movements and Their Consequences*, pp. 135-146.

Springer Netherlands, Dordrecht. Retrieved March 2021 doi.org/10.1007/978-94-007-2162-3_12

Duncan, R. A. (1984). Age progressive volcanism in the New England Seamounts and the opening of the central Atlantic Ocean. *Journal of Geophysical Research: Solid Earth, 89*(B12), 9980-9990. doi.org/10.1029/JB089iB12p09980

Gottfried, S. (2013). Data Management Plan, EX1304: Northeast U.S. Canyons Exploration. NOAA Institutional Repository. Office of Ocean Exploration and Research, Office of Oceanic and Atmospheric Research, NOAA, Silver Spring, MD 20910. Retrieved January 2021 https://repository.library.noaa.gov/view/noaa/10535

Lobecker, E., Elliott, K., Gallant, L.T., Jacklyn, J., Conway, R.E., & Raymond, A. (2015). Mapping data acquisition and processing summary report: Cruise EX-13-04 Leg 1, exploration, NE canyons, July 8 - 25, 2013. NOAA Institutional Repository. Office of Ocean Exploration and Research, Office of Oceanic and Atmospheric Research, NOAA, Silver Spring, MD 20910. doi.org/10.7289/V5VD6WFV

Lobecker, M. (2019). Mapping Data Acquisition and Processing Summary Report, Cruise EX-13-04 Leg 2, Northeast United States Canyons Exploration. NOAA Institutional Repository. Office of Ocean Exploration and Research, Office of Oceanic and Atmospheric Research, NOAA, Silver Spring, MD 20910. doi.org/10.25923/canx-e417

National Oceanic and Atmospheric Administration (2011). Workshop Summary: NOAA Workshop on Systematic Telepresence-Enabled Exploration in the Atlantic Basin, May 10-11, 2011, Narragansett, RI. Office of Ocean Exploration and Research, Office of Oceanic and Atmospheric Research, NOAA, Silver Spring, MD 20910. Retrieved from: https://oceanexplorer.noaa.gov/about/what-we-do/media/atl-basin-workshop-2011-summary.pdf

Quattrini, A.M., Nizinski, M.S., Chaytor, J.D., Demopoulos, A.W.J., Roark, E.B., France, S.C., Moore, J.A., Heyl, T., Auster, P.J., Kinlan, B., Ruppel, C., Elliott, K.P., Kennedy, B.R.C., Loebecker, E., Skarke, A., & Shank, T.M. (2015). Exploration of the Canyon-Incised Continental Margin of the Northeastern United States Reveals Dynamic Habitats and Diverse Communities. *PLoS One*, *10*(10). doi: 10.1371/journal.pone.0139904

Shank, T. (2010). Spotlight 4: New England and Corner Rise Seamounts. Oceanography, 23. doi:10.5670/oceanog.2010.76

Skarke, A., Ruppel, C., Kodis, M., Brothers, D., & Lobecker, E. (2014). Widespread methane leakage from the sea floor on the northern US Atlantic Margin. *Nature Geoscience, advanced online publication*. doi:10.1038/ngeo2232

Valentine, P. C. (1987). The shelf-slope transition; canyon and upper slope sedimentary processes on the southern margin of Georges Bank (1782). Retrieved from *U.S. Geological Survey Bulletin 1782*: http://pubs.er.usgs.gov/publication/b1782

11. Appendices

Appendix A: Data Management Plan

OKEANOS EXPLORER

EX1304: NORTHEAST U.S. CANYONS EXPLORATION
DATA MANAGEMENT PLAN

OCEAN EXPLORATION & RESEARCH

Document Purpose
This document is an addendum to the overarching Okeanos Explorer FY13 Data Management Plan (EX_FY13_DMP.pdf) and is specific to the EX-13-04 mission entitled "Northeast U.S. Canyons Exploration" For more detailed information on the data management effort for the Okeanos Explorer in FY13, please refer to that document.

General Description of the Data to be Managed
EX1304 will employ the new 6,000 meter ROV and the camera sled Seirios to explore some targeted areas in the Northeast U.S. Canyons over two legs: July 8-25 and July 31-August 17. 24-hour operations, including multibeam mapping, ROV operations, and CTD/rosette deployment will be conducted. All data will be fully processed according to OER standard onboard procedures and will be archived with the NOAA National Data Centers. Data management procedures are fully documented in the data management plan for the *Okeanos Explorer* for the FY13 field season (EX_FY13_DMP.pdf)

- Name of Dataset
  - : "EX1304: Northeast U.S. Canyons Exploration"
- Mission Specific Keywords:
  - Place Specific:
    - New England Seamount Chain
    - Western North Atlantic Ocean
    - Mytilus Seamount
    - Block Canyon
    - Alvin Canyon
    - Atlantis Canyon
    - Hydrographer Canyon
    - Veatch Canyon
    - Oceanographer Canyon
    - Lydonia Canyon
    - Powell Canyon
    - Munson Canyon
    - Nygren Canyon
    - Heezen Canyon
    - Chebacco Canyon
  - Theme Specific:
    - Multibeam
    - Multibeam sonar
    - Multi-beam sonar
    - Sub-bottom profile
    - Mapping survey
    - Multibeam backscatter

- Water column backscatter
- Singlebeam sonar
- Singe beam sonar
- Single-beam sonar
- Sub-bottom profile mapping
- ACUMEN
- Atlantic Canyons Undersea Mapping Expedition
- Extended Continental Shelf
- ECS
- Continental shelf mapping
- USGS Marine Hazards
- Gas seeps
- Landslide features
- Deep sea corals
- Underwater cultural heritage
- Deep Discoverer
- Seirios

- Summary Description:

EX-13-04 efforts complement and continue the 2012 Atlantic Canyons Undersea Mapping Expeditions (ACUMEN). The 2012 series of five ACUMEN cruises (NOAA Ships *Okeanos Explorer, Ferdinand Hassler and Henry B. Bigelow*), and two *Okeanos Explorer* cruises since then gathered baseline information on deep water canyons off the northeastern U.S. seaboard, mapping along the continental shelf and slope from Virginia to the northeastern boundary of the U.S. Exclusive Economic Zone (EEZ). These mapping operations provide the basis for preliminary target selection, and enable EX-13-04 Legs I and II to commence the next steps in systematic ocean exploration, investigating deep water areas in and along the northeast canyons off the U.S. East Coast.

- Temporal Bounds:
  - Leg I: July 8 – July 25, 2013
  - Leg II: July 31 – August 17, 2013
- Spatial Bounds:
  - Northern: 41.5
  - Southern: 39
  - Western: -72
  - Eastern: -66
- Data Type Collections for Preservation/Stewardship:
  - Underwater Video – capture of full-resolution underwater video in several resolutions from the 6,000 meter ROV and the Seirios camera sled
  - Multibeam Bathymetry – continuous collection during the duration of the expedition.
  - Bottom Backscatter – continuous collection during the entire duration of the expedition
  - Water Column Backscatter – continuous collection during the entire duration of the expedition
  - Scientific Computing System (SCS) output – continuous collection of navigational, meteorological, integrated oceanographic sensor data
  - CTD / Rosette – casts will be conducted as needed to guide science operations

- XBT – casts will be conducted at an interval defined by prevailing oceanographic conditions, but not to exceed 6 hours. Casts will collect water temperature at depth for sound velocity calculations to maintain multibeam data quality
- Knudsen CHIRP 3260 –sub-bottom profiler data collected between 1000 and 1800 each day
- EK60 – single beam sonar for water column features during the entire duration of the expedition

- Data Product/Product Collections for Preservation/Stewardship:
  - Gridded bathymetry (.txt)
  - Gridded bathymetric image (.tif)
  - Fledermaus gridded bathymetry imagery (.sd)
  - Fledermaus gridded backscatter imagery (.sd)
  - Fledermaus multi-layer image file (.scene)
  - Google Earth gridded bathymetry (.kml)
  - ArcView gridded bathymetry (.asc)
  - SCS data output in NetCDF
  - Highlight Videos
  - Final Mapping Summary document
  - Final Cruise Summary document
- Volume of Data Expected
  - The volume of data expected from this cruise is approximately 6 TB per leg including full-resolution video. Without the full-resolution video, the total volume of data expected is 650 GB.
- Personally Identifiable Information (PII) concerns
  - No PII will be included in these data.

Points of Contact

- Overall Point of Contact (POC) for the data:
  - Expedition Coordinator: Kelley Elliott, Kelley.Elliott@noaa.gov
  - Data Acquisition: EX Mapping Team: oar.oer.exmappingteam@noaa.gov
  - Data Management: OER Data Management Team (oer.info.mgmt@noaa.gov)
- Responsible for Data Quality:
  - Seafloor mapping and water column data: EX Mapping Team: oar.oer.exmappingteam@noaa.gov
  - SCS data: Office of Marine and Aviation Operations (OMAO): Lt. Laura Gallant, Okeanos Explorer Operations Officer (Ops.Explorer@noaa.gov)
- Responsible for data documentation and metadata activities:
  - National Coastal Data Development Center (NCDDC); OER Data Management Team (oer.info.mgmt@noaa.gov)
- Responsible for the data storage and data disaster recovery activities:
  - NOAA National Data Centers; National Oceanographic Data Center (NODC), National Geophysical Data Center (NGDC), NOAA Central Library (NCL)
- Responsible for ensuring adherence to this data management plan, including resources are made available to implement the DMP:
  - Data Acquisition: Kelley Elliott, Expedition Coordinator
  - Data Acquisition: EX Mapping Team, oar.oer.exmappingteam@noaa.gov
  - Data Acquisition: Lt. Laura Gallant, OMAO, Okeanos Explorer Operations Officer
  - Data Management: OER Data Management Team

Data Stewardship

- What quality control procedures will be employed?
    - Quality control procedures for the data from the Kongsberg EM302 is handled at UNH CCOM/JHC. Raw (level-0) bathymetry files are cleaned/edited into new data files (level-1) and converted to a variety of products (level-2).
    - Data from sensors monitored through the SCS are archived in their native format and are not quality controlled.
    - Data from XBT firings are archived in their native format and are not quality controlled.
- What is the overall lifecycle of the data from collection or acquisition to making it available to customer?
    - All ship data from this mission is expected to be archived and accessible within 60-90 days post-mission.
    - METOC data from the SCS are converted in a post-mission model into archive-ready compressed NetCDF3 format and stored within the NCDDC THREDDS open-access server.
    - CTD data from casts are processed in a post-mission model and converted into archive-ready compressed NetCDF3 format and stored within the NCDDC THREDDS open-access server.

Data Documentation

- An ISO format metadata record to document the mission will be generated during pre-cruise planning and published in an OER catalog for public discovery and access. Documentation templates will be provided for post-mission products with references back to the overall mission metadata documents. Data collections and products will be documented with ISO or FGDC CSDGM metadata and published at the appropriate NOAA Data Center.
- ISO 19115-2 Geographic Information with Extensions for Imagery and Gridded Data will be the metadata standard employed.

Data Sharing

- All data recorded, observed, generated or otherwise produced on the *Okeanos Explorer* are considered non-proprietary and will be made available to the public as soon as possible after a period of due diligence in performing quality assurance and data documentation procedures.

Initial Data Storage and Protection

- Data are recorded and stored on NOAA shipboard systems compliant with NOAA IT procedures. Data are moved from ship to shore using a variety of standard, documented data custody transfer procedures. Data are transferred to NOAA data centers using digital and physical data transfer models depending upon data volume.

Long-Term Archiving and Preservation

- Data from this mission will be preserved and stewarded through the NOAA National Data Centers. Refer to the *Okeanos Explorer* FY13 Data Management Plan (EX_FY13_DMP.pdf) for detailed descriptions of the processes, procedures, and partners involved in this collaborative process. Appendix A has an excerpt from EX_FY13_DMP.pdf) that illustrates the data and product pipelines that will be employed for this mission.

Data Management Objectives

The DMT's common objectives for this mission are:

- Ensure the near real-time update of the *Okeanos Atlas* with
  - Ship track and hourly observations received via email.
  - Daily logs pulled from URI through RSS feeds and links to related images on oceanexplorer.noaa.gov website.
  - Daily cumulative bathymetric image overlays received via URI SRS.
- Execute multibeam and oceanographic data pipelines according to the FY13 DMP (EX_FY13_DMP.pdf).
- Develop ISO metadata for collection-level and dataset-level records collected from the ship (multibeam, singlebeam sonar, sub-bottom profiler, XBT, CTD, EX METOC,)

Specific mission objectives include:

- Ensure that SOP and standard naming conventions are understood and being followed by ship personnel.
- Review and correct the list of camera names/codes/locations in the standard naming conventions documentation
- Ensure that the full-resolution video capture procedures are fully functioning and are capturing the video at the best possible resolution
- Develop a consistent, automated method for ensuring that video products are being generated
- Determine the status of the SCS data capture of the CTD sensor data on the submersibles and resolve any issues
- If additional sensors are added to the CTD, develop SOP to properly capture data in SCS

Expedition Principals for Data Management

Webb Pinner, OER Telepresence, EX Data and Information Lead, Webb.Pinner@noaa.gov
Brendan Reser, NCDDC, Okeanos Explorer Program Data Manager, Brendan.Reser@noaa.gov
Sharon Mesick, NCDDC, Federal Program Manager, Data Management IPT Chair, Sharon.Mesick@noaa.gov
Susan Gottfried, NCDDC, OER Data Management Coordinator, Susan.Gottfried@noaa.gov
Andy Navard, NCDDC, Okeanos Atlas Developer, Andrew.Navard@noaa.gov
Evan Robertson, NGDC, Geophysical Data Officer, Evan.Robertson@noaa.gov
Tom Ryan, NODC, Oceanographic Data Officer, Thomas.Ryan@noaa.gov
Anna Fiolek, NCL, Multimedia Librarian, Anna.Fiolek@noaa.gov

Appendix A: Data and Product Pipelines (excerpt from EX_FY13_DMP.pdf)

A. *Oceanographic/Meteorological/Navigational Data Archive Pipeline*

Data from hull-mounted and off-board oceanographic and meteorological (METOC) sensors; integrated oceanographic sensors from the submersibles; and navigational instrumentation on both the vessel and its submersibles are monitored through the ship's Scientific Computer System (SCS). Some of these data will be used in a near real-time mode to update the *Okeanos Atlas*. All of these data will be archived at the National Oceanographic Data Center (NODC) Marine Data Stewardship Division (MDSD) in Silver Spring, MD. A cruise-level and several collection level metadata records describing the data inventory to be archived at the NODC/MDSD will be included with the data submission.

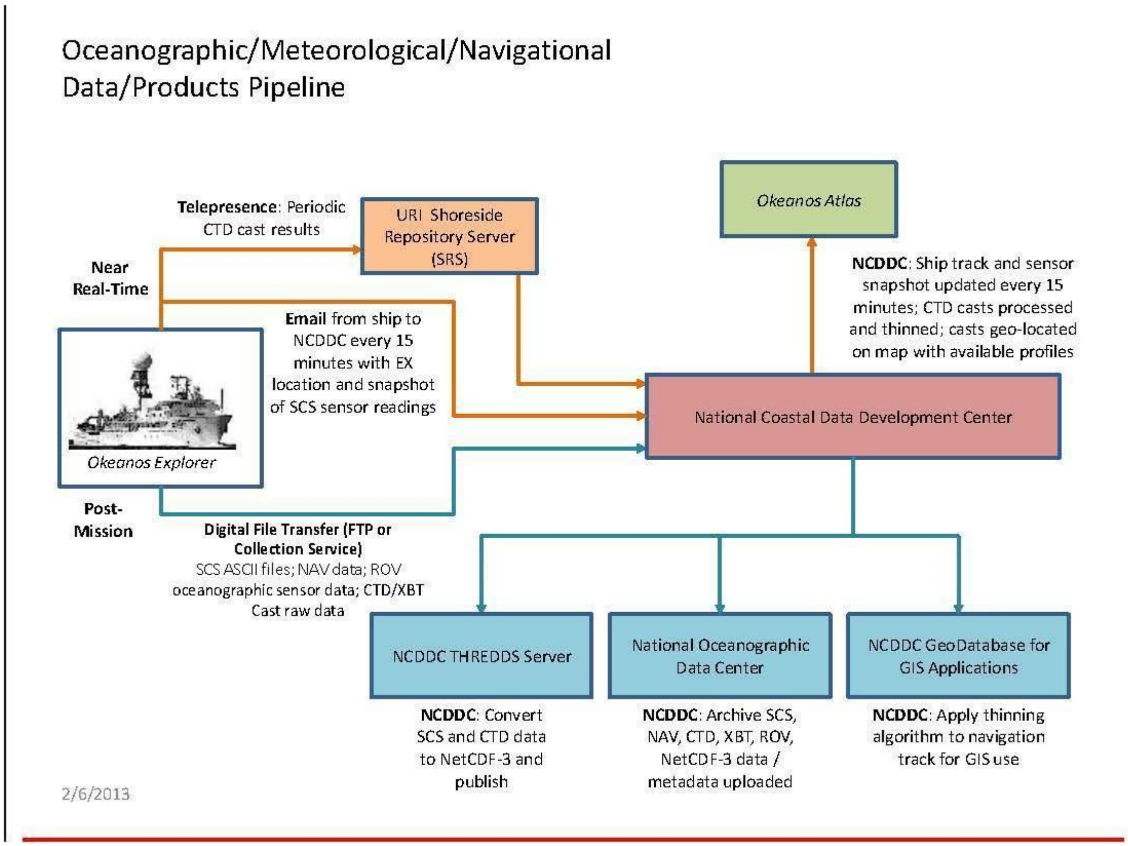

Fig 4: Okeanos Explorer Oceanographic Data Pipeline

Near Real-Time:

At periodic (currently fifteen minutes) intervals, an email from the ship to NCDDC is delivered with the ship's position and a snapshot of the SCS sensor suite.

As CTD casts are deployed, the results of the cast are included in the periodic synchronizations to the SRS.

The GIS team at NCDDC processes:

- CTD cast data into thinned profiles for comparison to World Ocean Atlas historical profiles in the same region and month. The thinned profiles are geo-located on the *Okeanos Atlas*. The corresponding temperature profile plot from the World Ocean Atlas is added for comparison.
- Ship track and sensor snapshot readings are geo-located on the *Okeanos Atlas*.

Post-Mission

All SCS data, including navigation and CTD/XBT cast data are delivered to NCDDC either via ftp or through a Collection Service.

SCS navigation data are used to apply a thinning algorithm and return an optimized thinned navigation track, which is added to the GeoDatabase for GIS applications.

Using the SCS configuration file, a header line is appended to each SCS ASCII data file.

All of the SCS data files are used to generate an archive-ready compressed NetCDF-3 formatted file.

The CTD Cast raw data are used to generate a second NetCDF-3 formatted file.

ncISO metadata records are generated for the NetCDF-3 files, and FGDC CSDGM metadata records are generated for the SCS ASCII files, the NAV data set, and the CTD and XBT data sets.

All data sets and the corresponding metadata are uploaded to the National Oceanographic Data Center (NODC), where they will be accessioned and archived.

The NetCDF3 file will be ingested into an NCDDC hosted Thematic Real-time Environmental Distributed Data Services (THREDDS) server for user discoverability and access.

Data Class	Instrument	Data Type	Format	Metadata Granularity	Archive Center
OCN/ MET	All SCS monitored sensors	Meteorological and Oceanographic data sensors	ASCII	1 meta rec	NODC/MDSD
NAV	DGPS, CNAV	EX, ROV, and sled navigation	ASCII	1 meta rec	NODC/MDSD
ALL	All	Archive Ready	NetCDF-3	1 meta rec	NODC/MDSD

Table 3: Oceanographic/Meteorological/Navigational Metadata Granularity and Target Archive

B. Multibeam Survey Data Archive Pipeline

The multibeam survey data collected by bottom-looking and complementary sensors, data from the calibration instruments, and the products generated after the data is returned to and post-processed at UNH will be archived at the NGDC. These data will be accompanied with a collection level metadata record for the NGDC as well as individual metadata records for each raw (level-0) file, each edited (level-1) file and each data product (level-2) and report (level-3) generated as a result. In addition, the submission to NGDC will include the following:

- raw (level-0) mapping survey and water column data files,
- CTD and/or XBT profile data used for calibration in multibeam survey,
- post-processed, quality assured, and edited (level-1) data files,
- specific data products (level-2) from the Fledermaus software, including cumulative GeoTIF images, gridded bathymetric files, KML files, KMZ images, .sd output files, and an ArcGrid format, and
- comprehensive mapping survey data summary (level-3) report.

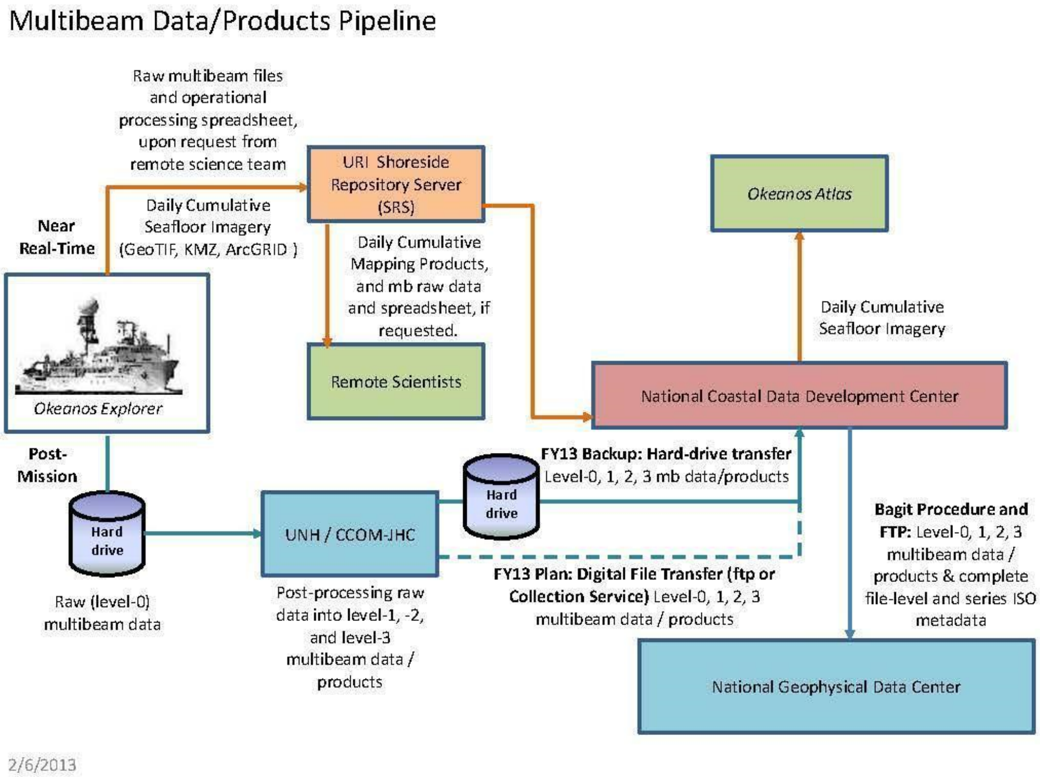

Fig. 5: Okeanos Explorer Multibeam Data Pipeline

Near Real-Time

If the remote science team has requested that some raw multibeam data be transferred in near real-time to the SRS, the raw data and a current copy of the processing spreadsheet will be transmitted during the Rsync process.

As operational GeoTIFF images are created, these will also be transmitted to the SRS by the Rsync process.

The data management team at NCDDC will pull the GeoTIFF images and the operational bathymetry processing spreadsheet for near real-time metadata generation. Participating scientists wanting access to the raw multibeam in near real-time can pull the individual files with the metadata that provides operational and provisional processing steps and a disclaimer for non-QC status of the data.

Daily cumulative GeoTIFF images of the seafloor imagery will be geo-located on the Okeanos Atlas by the GIS team at NCDDC.

Post-Mission

All bottom-looking sensor data and complementary data (water column and sound velocity) are saved to a hard-drive. This hard-drive will be either brought back or shipped to the University of New Hampshire Center for Coastal and Ocean Mapping (UNH CCOM) for post-processing.

A full complement of multibeam data from a 30-day EX cruise on which the Kongsberg EM302 multibeam system runs continuously will produce 200-300 Gigabytes of raw multibeam (37.5% of total volume) and water column data (62.5% of total volume). At UNH, the mapping team will post-process the multibeam data through the following steps:

- The raw (level-0) data will be saved to the CCOM file servers, where they will be quality checked and post-processed.
- The edited level-0 data is saved as level-1 data files in a non-proprietary format – ASCII xyz files (cleaned not gridded).
- The post-processing steps used to produce the level-1 data will be documented.
- Level-2 products will be generated from the level-1 data files.
- The post-processing steps used to produce the level-2 data products will be documented.
- The level-1 data, level-2 products, post-processing steps, and working data processing spreadsheets will be copied to the hard drive in a new folder. A processing spreadsheet for FY13 will contain the temporal and spatial limits of each file and any supplemental information documenting problems or issues that affected the quality of the data in that file.

In FY13, an attempt to use an ftp protocol or collection service to transfer the multibeam data and products from UNH is planned. A normal hard-drive delivery will remain in effect as a backup until the digital file transfer process is sufficiently tested and becomes normal operations.

At NCDDC, all multibeam related files will be post-processed through metadata generation procedures. Metadata will be generated for each individual survey track file (level-0 and -1), for accompanying CTD/XBT profile data sets, for composite xyz files, KMZs, GeoTIFFs, png images, and Fledermaus output (level-2), and a set of data products and reports (level-3). Finalized data/metadata will be compressed and bundled using the Bagit software and delivered to NGDC via ftp protocol.

Data Class	Instrument	Data Type	Format	Metadata Granularity	Archive Center
GEO	Kongsberg EM302 (30 kHz)	Multibeam Bathymetry, Bottom Backscatter, Water Column Backscatter (proprietary format read into MBSystem)	.all, .wcd (proprietary)	1 meta rec per .all file in Multibeam Data folder and subfolders	NGDC
GEO	Simrad EK60	Singlebeam (time,depth)	.txt, (ASCII), .raw (proprietary)	Included in the SCS feed	TBD
GEO	Knudsen CHIRP 3260 (3.5 kHz)	Sub-bottom profile	.sgy, .kea, .keb (proprietary)	1 meta rec = Subbottom Profile Data folder	NGDC
OCN	SeaBird SBE-911plus	CTD Cast	.hex, .con (Proprietary); .cnv, .hdr, .bl, .jpg (processed)	1 meta rec = CTD folder	NGDC
OCN	Sippican MK-21 eXpendable BathyThermograph (XBT)	XBT	.edf (ASCII), .rdf (proprietary)	1 meta rec = XBT folder	NGDC
OCN	RESON	Sound Velocity (m/s)	TBD	1 meta rec = RESON folder	NGDC
OCN	Calculated	Sound Velocity (m/s)	.asvp (ASCII)	1 meta rec = Profile_Data/SVP or Profile_Data/ASVP	NGDC

Table 4: Multibeam Survey Metadata Granularity and Target Archive

C. *Video Data Archive Pipeline*

Low-resolution video segments will be archived at the NOAA Central Library (NCL) in Silver Spring, MD, a division of NODC. All available resolutions of the underwater video and their metadata will be temporarily stored in private and dedicated storage space on the NODC server and periodically backed up in a scheduled tape rotation.

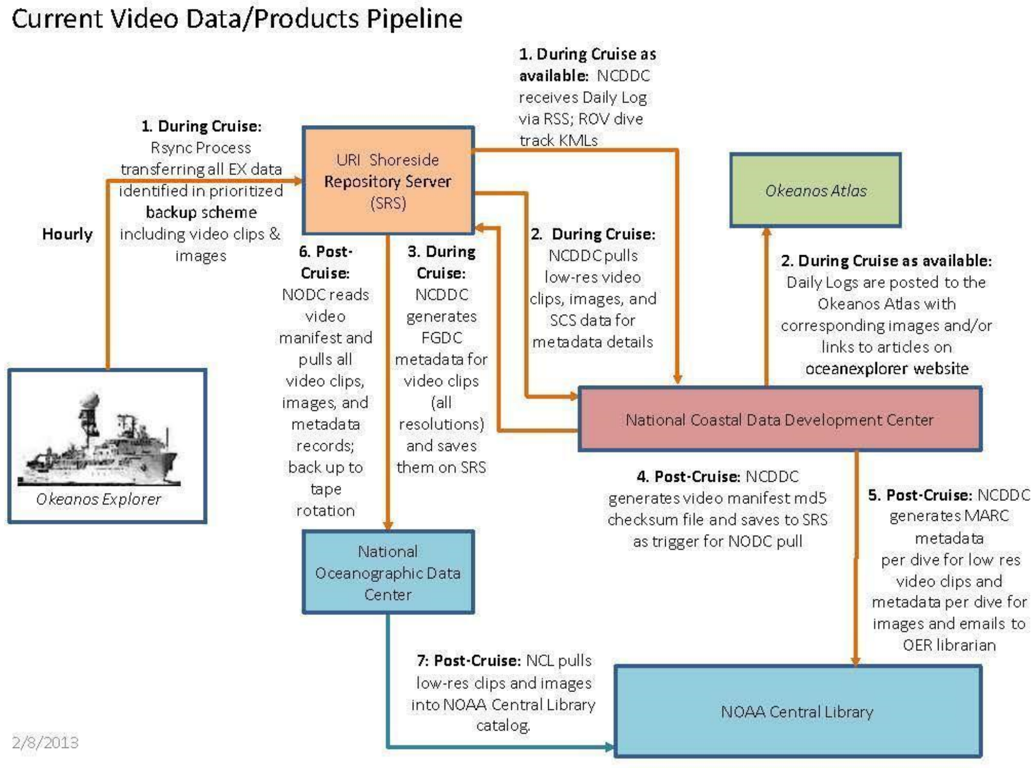

Fig 6: Okeanos Explorer Video Data Pipeline

Ocean Exploration and Research

Near Real-Time

Video segments to be preserved will be marked and saved onboard the EX by onboard videographers through collaboration with the onboard and remote science team. These clips will be saved with embedded metadata – cruise ID, camera ID, date/time, lat/lon, and file name and saved in the Ship Board Repository Server (SBRS). These enhanced multimedia files will be transmitted via an automated process (outlined in Section VI-B) to the Shoreside Repository Server (SRS) and saved in web-streaming low-resolution quality and, if possible, a medium-to-high resolution. The files will be named using a strict naming convention outlined in the "Okeanos Shore-Side FTP Server Standard Operating Procedures" document and in Section VI-C of this document.

Low-resolution video clips and images will be downloaded by NCDDC from the SRS for metadata generation routines. Image and video files will have embedded metadata and the file name will also include fields for the metadata.

Daily logs generated by the Expedition Coordinator will also be pulled from the SRS as they become available. Dive tracks in kml format are pulled from the SRS as they become available.

Daily Logs and representative images and dive tracks and links to representative video clips are displayed on the Okeanos Atlas,

The embedded information and the file names of the downloaded low-res video clips will be used in the routines to produce the FGDC metadata for each. An FGDC metadata record will also be generated for the medium-to-high resolution counterpart to the clip, although that clip will not be downloaded from the SRS. The generated metadata records will be named similarly to the video clips they represent and all metadata will be uploaded to the SRS in the same folder with the video clips. A manifest file with md5 checksum values will be generated daily for all of the video clips and metadata records available on the SRS. The manifest file will be uploaded to the SRS.

Post-Mission

At the end of the mission, MARC metadata for each dive will be generated for video clips and framegrab images. All MARC metadata records are emailed to the NOAA Central Library for the mission catalog.

A final manifest file and md5checksum file are generated and uploaded to the SRS.

NODC automated routines will be in place to recognize when the md5 checksum file is available for processing. Video clips and corresponding metadata will be saved to NODC dedicated storage space and backed up to tape until such time that a permanent solution to high-definition video archive is available.

The NOAA Central Library will pull all of the low-res video clips from the NODC server and do a bulk ingest into their system, cataloging these clips by corresponding dive in their online video data management system (VDMS).

Data Class	Instrument	Data Type	Format	Metadata Granularity	Archive Center
MUL	ROV/Sled Cameras	Low-res video clips	h.264 low	1 MARC meta rec per each dive	NCL
MUL	ROV/Sled Cameras	Medium-res video clips	h.264 med	1 FGDC meta rec per each	NODC/MDSD (temporary hold)
MUL	ROV/Sled Cameras	Highlight Images	.jpg	1 MARC meta rec for the folder	NCL
MUL	ROV/Sled Cameras	Still images	.jpg	1 MARC meta rec for the folder	NCL
MUL	Topside Cameras	Still images	.jpg	1 MARC meta rec for the folder	NCL

Table 5: Video Metadata and Target Archive

Appendix B. Dive codes

(From eventlog EX1301L1, *last accessed February 26, 2021*)

Biology
MUC - Unidentified mucus structure
USO - Unidentified Sessile Object
STR - mucus string
FEC - Fecal (matter)
EGG - Egg (case)

Taxa
MAT - Bacterial (Mat)
FOR - Foraminifera
GRO - Gromiid
XEN - Xenophyophoran
SPO - Sponge
BRA - Brachiopod
BRY - Bryozoan
TUN - Tunicate
SAL - Salp
LAR - Larvacean house
ECN - Echiuran (or radial feeding trace)
CTE - Ctenophore
CNI - Cnidarian
HYD - Hydroid
JFH - Jellyfish
ACN - Actinaria (anemone)
ZOA - Zoanthid
COR - Coral
CORA - Antipatharian
CORL - Lophelia
CORM - Madrepora
CORG - Gorgonian
CORP - Paramuricea
CORS - Stylasterid
CPEN - Pennatulacean
CORW - Whip coral
ECO - Echinoderm
ASR - Asteroid
HOL - Holothurian
CRI - Crinoid
CRIHYO - Hyocrinida
CRIBAT - Bathycrinidae

CRIBOU - Bourgeuticrinidae
CRIANT - Antedonidae
CRIZEN - Zenometridae
CRIPNT - Pentametrocinidae
CRIATE - Atelecrinidae
CRITHA - Thalassometridae
OPH - Ophiuroid
URC - Urchin
ART - Arthropod
PYC - Pycnogonid
COP - Copepods
CRA - Crab
CRAKC - King crab (family Lithodidae)
CRARED - Red Deep Sea Crab (Chaceon quinquedens)
CRASPI - Spider crabs (family Majoidea)
LOB - Lobster
SQA - Squat Lobster
PAG - Pagurid (hermit)
SHI - Shrimp
BAR - Barnacle
APH - Amphipod
ISO - Isopod
MOL - Mollusk
MUS - Mussels
NUD - Nudibranch
OCT - Octopus
SQD - Squid
GAS - Gastropods (not limpets)
LIM - Limpets
CHI - Chiton
CLA - Clams
PTE - Pteropod
FSH - Fish
FCHN - Chondrichthyes
FCOD - Codlets
FREF - Reeffish (grouper, tilefish, AJs, snapper)
FANT - Anthiins (fancy bass)
FELO - Elongate (eels, brotulids)
FOVO - Ovoid (roughys, boarfish, dories)
FLAT - Flatfish
WOR - Worm
POL - Polychaete
SCA - Scale (worm)

TUB - Tubeworms (not Riftia)
SER - Serpulid worm
RIF - Riftia
SPA - Spaghetti Worms

Geology
BUR - Burrow
COB - Cobble
MUD - Mud
ROC - Rock
RUB - Rubble
SAD - Sand
SED - Sediment
WAL - Wall
WOD - Wood

Lava Morphology
TAL - Talus
PIL - Pillow
ENT - Entrail
LOB - Lobate
07/12/2013,
SHE - Sheet
FOL - Folded
JUM - Jumbled
HAC - Hackly

Sediment Cover
LIG - Light
POC - Partial/Pockets
HEA - Heavy/Coalescent
BLA - Blanket

Feature
ASG - Axial Summit Graben
AVR - Axial Volcanic Ridge
CAR - Carbonate
CLI - Cliff
COL - Collapse
CON - Contact
FAU - Fault
FIS - Fissure
HAY - Haystack
HYX - Hydrothermal

PIL - Pillar
SCP - Scarp
SEP - Seep

Appendix C: Categorical Exclusion

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
OCEANIC AND ATMOSPHERIC RESEARCH
Office of Ocean Exploration and Research
Silver Spring, MD 20910

July 2, 2013

MEMORANDUM FOR: The Record

FROM: John McDonough
Acting Director NOAA Office of Ocean Exploration and Research (OER)

SUBJECT: Categorical Exclusion for NOAA Ship *Okeanos Explorer* cruise EX304, Legs 1 & 2

NAO 216-6, Environmental Review Procedures, requires all proposed projects to be reviewed with respect to environmental consequences on the human environment. This memorandum addresses the NOAA Ship *Okeanos Explorer's* scientific sensors possible affect on the human environment.

Description of Projects
This project is part of the Office of Ocean Exploration and Research's "Science Program." It will conduct remotely operated vehicle (ROV) operations and ocean mapping activities designed to increase knowledge of the marine environment. This project is entitled "EX1304 Northeast U.S. Canyons Expedition" and will be led by Kelley Elliott, an Expedition Manager for NOAA OER. The work will be conducted in July and August at various locations along the Northeast U.S. Submarine Canyons and at Mytilus Seamount. A tandem 6,000 meter ROV system will be deployed and CTD rosette casts may be conducted during the expedition. The Kongsberg EM 302 multibeam (30 kHz) and the Kongsberg EK 60 singlebeam (18 kHz) will be operated during the project. A Knudsen 3260 Sub-Bottom Profiler (3.5 kHz) is expected to be occasionally operated during the cruise. Additionally, expendable bathythermographs (XBTs) will be conducted in conjunction with multibeam data collection. Multibeam mapping operations will be conducted at all times during the transit.

Effect of Projects
As expected with ocean research with limited time or presence in the marine environment, this project will not have the potential for significant impacts. Knowledgeable experts who are aware of the sensitivities of the marine environment will conduct the at-sea portions of this project.

Categorical Exclusion
This project would not result in any changes to the human environment. As defined in Sections 5.05 and 6.03.c.3 (a) of NAO 216-6, this is a research project of limited size or magnitude or

Printed on Recycled Paper

negligible. As such, this project is categorically excluded from the need to prepare an environmental assessment.

Signed: [signature]   Date: 7/2/2023

John McDonough, Acting Director

Appendix D: Acronyms

3D—Three dimensional
ACUMEN—Atlantic Canyons Undersea Mapping Expeditions
AERONET—NASA Aerosol Robotic Network
CTD—Conductivity, temperature, and depth
D2—ROV *Deep Discoverer*
DO—Dissolved oxygen
EEZ—Exclusive Economic Zone
EX—NOAA Ship *Okeanos Explorer*
HAPC—Habitat area of particular concern
IFREMER—L'Institut Français de Recherche pour l'Exploitation de la Mer
ISC—Inner Space Center
kHz—Kilohertz
km—Kilometers
LSS—Light scattering spectroscopy
MAN—NASA Maritime Aerosol Network
MPA—Marine protected area
NASA—National Aeronautics and Space Administration
NCDDC—NOAA National Coastal Data Development Center
NCEI—NOAA National Centers for Environmental Information
NEFSC—NOAA Northeast Fisheries Science Center
NEPA—National Environmental Policy Act
NMFS—NOAA National Marine Fisheries Service
NOAA—National Oceanic and Atmospheric Administration
OER—NOAA Office of Ocean Exploration and Research
ORP—Oxygen reduction potential
ROV—Remotely operated vehicle
SBE—Sea-Bird Electronics
SIS—Seafloor Information System
TSG—Thermosalinograph
UCAR—University Corporation for Atmospheric Research
UMES—University of Maryland Eastern Shore
URI—University of Rhode Island
USGS—U.S. Geological Survey
WHOI—Woods Hole Oceanographic Institution
XBT—Expendable bathythermograph