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Ocean Exploration and Research

Cruise Report: EX-12-02 Legs 2 & 3, Gulf of Mexico 2012 Expedition (ROV and Mapping)

Leg 2: Tampa, Florida, to Pascagoula, Mississippi
19 March 2012 - 7 April 2012

Leg 3: Pascagoula, Mississippi, to Galveston, Texas
11 April 2012 - 29 April 2012

Contributors:
Matt Dornback, Cherokee Nation Strategic Programs under contract to NOAA Office of Ocean Exploration and Research
Jeremy Potter, Expedition Coordinator Leg 2, NOAA Office of Ocean Exploration and Research
Kelley Elliott, Expedition Coordinator Leg 3, CollabraLink Technologies, Inc., contractor to NOAA Office of Ocean Exploration and Research
Dr. Tim Shank, Science Lead Leg 2, Woods Hole Oceanographic Institution
Pen-Yuan Hsing, Science Lead Leg 2, Pennsylvania State University
Dr. James Austin, Jr., Geology Science Lead Leg 3, The University of Texas at Austin
Dr. Erin Becker, Biology Science Lead Leg 3, Pennsylvania State University/University Corporation for Atmospheric Research

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

Abstract

During March and April of 2012, NOAA's Office of Ocean Exploration and Research (OER) and a team of more than 50 scientists, managers, and students from academia, industry, and federal agencies explored the Northern Gulf of Mexico using the NOAA Ship *Okeanos Explorer*. The two expeditions, EX-12-02 Legs 2 & 3, combined remotely operated vehicle (ROV) and seafloor mapping operations in exploring the biology, geology, chemistry, and archaeology of the seafloor in this region. EX-12-02 Leg 2 conducted 16 ROV dives and collected 14,600 square kilometers of multibeam bathymetry between Tampa, FL, and Pascagoula, MS. The expedition explored areas on the West Florida Escarpment and areas in the Mississippi Canyon. More than 130 coral colonies and 400 associated animals were imaged by the ROV. EX-12-02 Leg 3 conducted 13 ROV dives and collected 14,136 square kilometers of multibeam bathymetry between Pascagoula, MS, and Galveston, TX. The expedition explored undersea canyons, deep-sea coral communities, salt domes, methane seeps and associated communities, and the water column along the continental shelf. Both acoustic and visual methods using the ROV were tested to detect and ground truth gas seeps and measure flux. Five potential or poorly known shipwreck sites identified during previous industry surveys were also investigated; these were the first archaeological sites investigated using an ROV from NOAA Ship *Okeanos Explorer*.

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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

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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 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 solely 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 February 27 to April 29, 2012, OER and partners conducted the *Gulf of Mexico 2012* (EX-12-02) cruise, a three-part telepresence-enabled ocean exploration expedition on NOAA Ship *Okeanos Explorer* to collect critical baseline data and information, and to improve knowledge about unexplored and poorly understood deepwater areas and canyons of the Northern Gulf of Mexico. This expedition consisted of three cruise “legs” addressing several scientific topics. EX-

12-02 Leg 1 (**Figure 1**) was exclusively a mapping cruise that focused on the DeSoto Canyon and Florida Escarpment, information can be found in Malik et al. (2012). EX-12-02 Leg 2 (**Figure 2**) and Leg 3 (**Figure 3**) were combined mapping and remotely operated vehicle (ROV) cruises designed to provide timely, actionable information to support decision-making based on reliable and authoritative science. This report covers the second and third legs of EX-12-02.

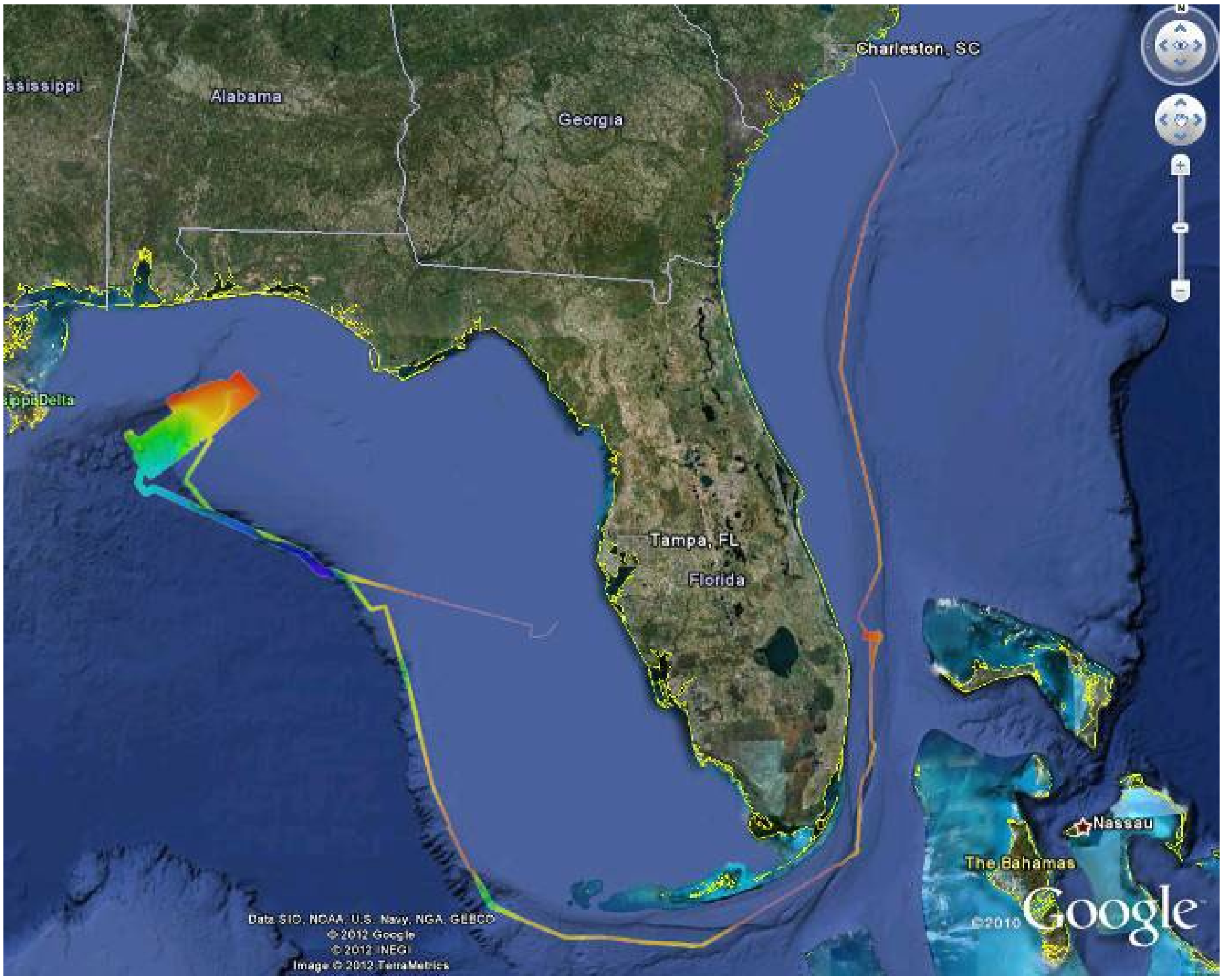

Figure 1. Overview of the operation area during EX-12-02 Leg 1 and color relief multibeam bathymetry data collected (blue = deep, red = shallow). The cruise mapped 11,501 sq km.

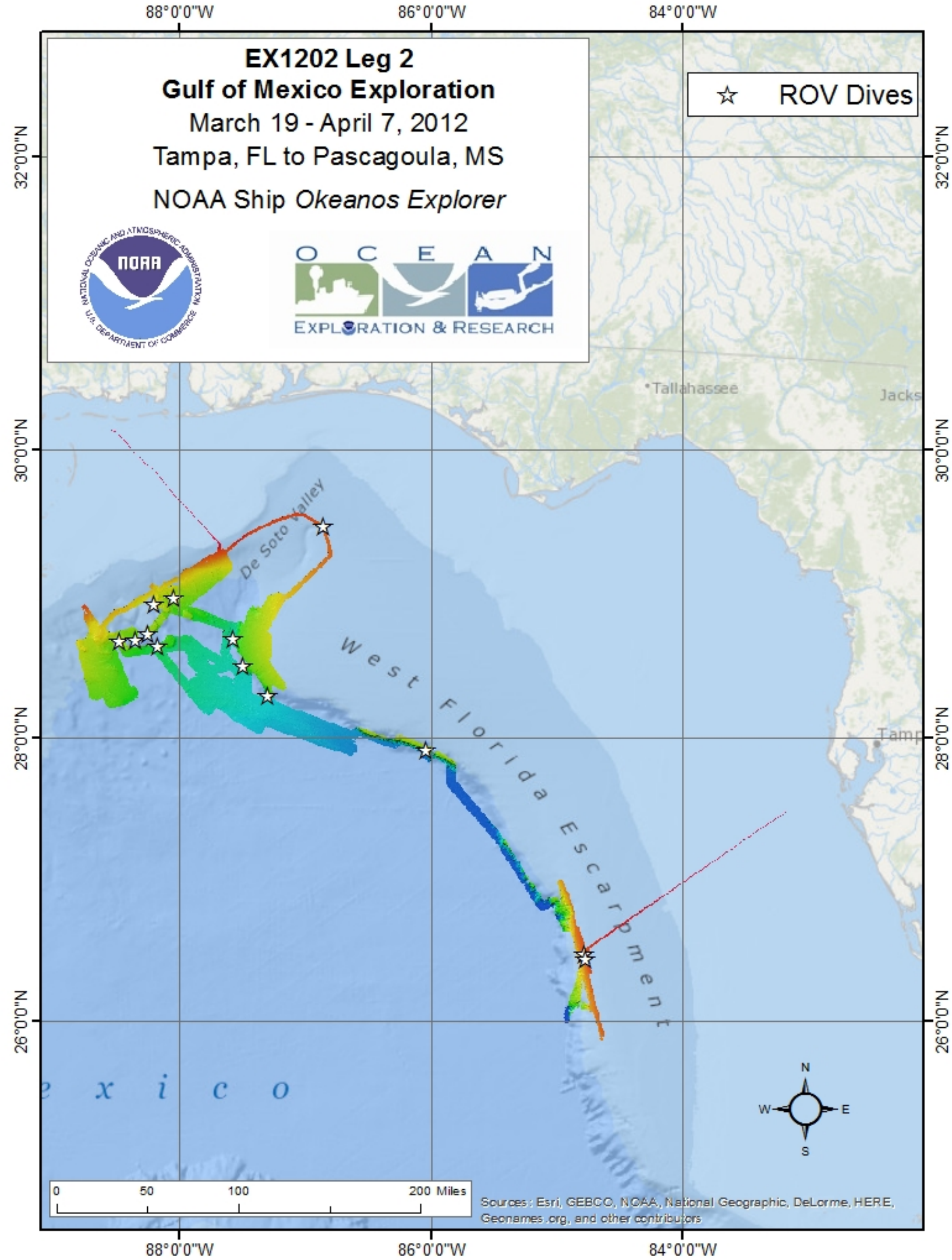

Figure 2. Map showing the EX-12-02 Leg 2 cruise's track, 16 ROV dive sites (noted with stars), and color relief bathymetry data collected (blue = deep, red = shallow).

Operations were conducted in three primary areas across these cruises: DeSoto, Mississippi, and Green Canyon areas; and the West Florida Escarpment and other relavent exploration sites within the Gulf of Mexico (see Figures 2 & 3 for vessel tracks and dive locations). A broad request went out to the science and management community asking them to identify priority sites for investigation with the ROV in the primary expedition operating areas; a diversity of sites were received and incorporated into the cruise plans. These areas were identified as "priority" for exploration through several routes:

- A May 2011 Atlantic Basin community Workshop identified priority areas identified in the Mississippi Canyon, DeSoto Canyon, and West Florida Shelf Break and Slope areas (OER, 2011).
- The Green Canyon area was a priority area for testing the multibeam system's ability to detect gaseous seeps. 2011 mapping operations provided the basis for preliminary target selection (Malik et al., 2011).
- Input was given from the management community, in particular the Bureau of Ocean Energy Management (BOEM) and NOAA's Flower Garden Banks National Marine Sanctuary to address national priorities.

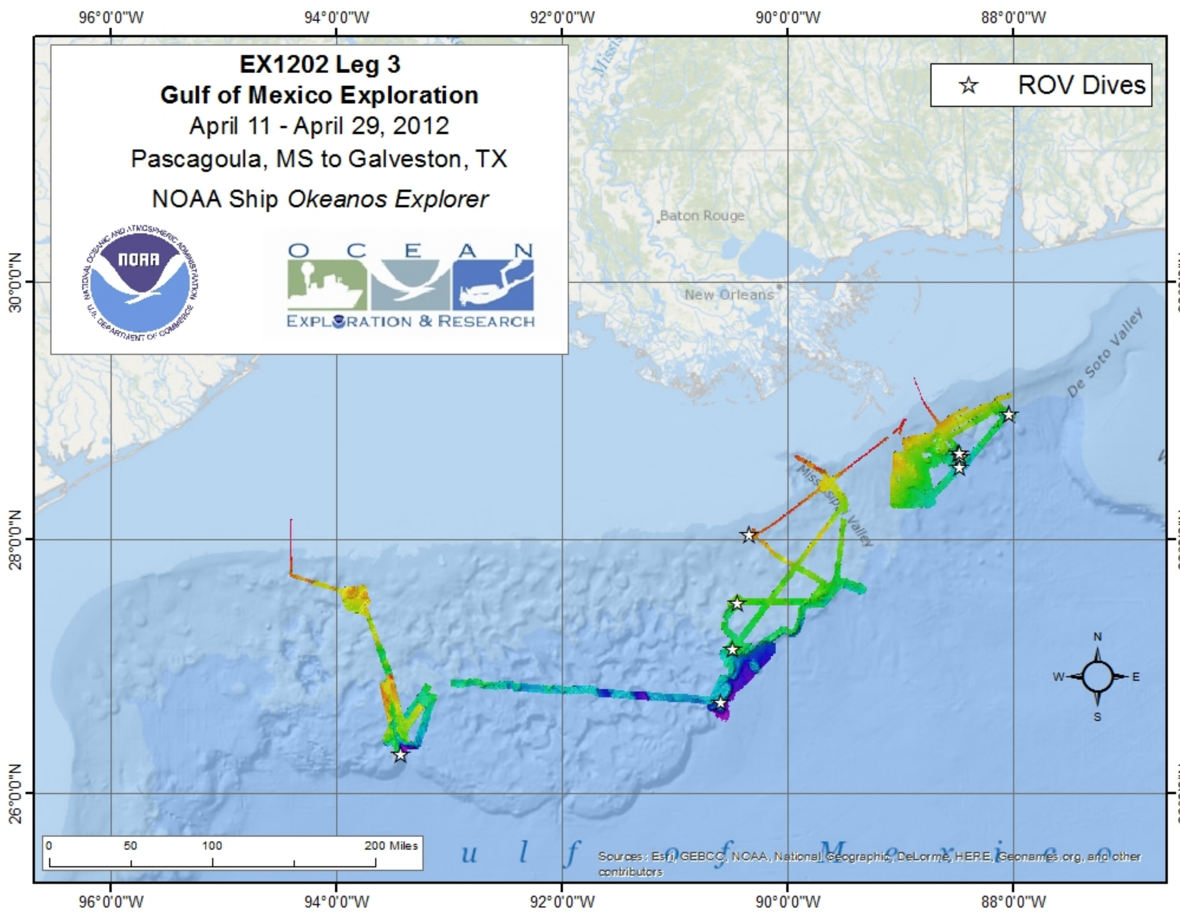

Figure 3. Map showing the EX-12-02 Leg 3 cruise's track, 13 ROV dive sites (noted with stars), and color relief multibeam bathymetry data collected (blue = deep, red = shallow).

Over 75 volunteer scientists and managers participated in target refinement web meetings, and 50 of these actively and voluntarily participated throughout the expedition. Dr. Tim Shank, Marine Biologist, Associate Scientist, and NOAA Ocean Exploration Advisory Working Group

(OEAWG) member co-led the EX-12-02 Leg 2 Expedition Science Team, along with Penn Yuan-Hsing, a Pennsylvania State University (Penn State) graduate student. Dr. Jamie Austin, NOAA OEAWG member, Nautilus Science Advisory Board member, and Senior Research Scientist at the University of Texas at Austin, co-led the EX-12-02 Leg 3 expedition science team with Dr. Erin Becker, a postdoctoral researcher with Penn State. Several scientists also served as shore-based science leads for ROV dives focused on their respective areas of expertise. Jack Irion, the Regional Preservation Officer for BOEM served as the shoreside science lead during all Underwater Cultural Heritage (UCH) dives. Drs. Tom Weber and Larry Mayer co-led the gas seep exploration mapping and ROV dives during the expedition, working closely with Bill Shedd of BOEM.

Expedition partners included NOAA National Marine Fisheries Service (NMFS), NOAA Office of National Marine Sanctuaries (ONMS), NOAA Deep Sea Coral Research and Technology Program (DSCRTP), as well as the Center for Coastal and Ocean Mapping/Joint Hydrographic Center at the University of New Hampshire (UNH), the Department of Interior's BOEM and Bureau of Safety and Environmental Enforcement (BSEE), the Cooperative Institute for Ocean Exploration Research and Technology (led by Florida Atlantic University (FAU)/Harbor Branch Oceanographic Institute (HBOI) and the University of North Carolina Wilmington), Woods Hole Oceanographic Institution (WHOI), the Smithsonian Institution (SI), Mississippi State University, University of Texas at Austin, Louisiana State University (LSU), Temple University, Florida State University (FSU), Penn State, University of Rhode Island (URI), the Institute for Exploration (IFE), the College of Charleston, and the NOAA Northern Gulf Institute.

2.1 Rationale for Exploration

The Gulf of Mexico has been a major geographic focus for U.S. exploration and research for decades. While the large majority of past efforts have examined relatively shallow waters, a number of agencies and organizations have worked in deepwater areas. The National Science Foundation (NSF), NOAA, and BOEM have sponsored dozens of cruises. A long-term partnership between OER and BOEM alone resulted in more than nine expeditions since 2004 (e.g., *Expedition to the Deep Slope* and *Lophelia II*). Despite these important efforts, fundamental understanding of the deep-sea environment is often overestimated.

The expedition's main objective was to explore poorly known regions of the Northern Gulf of Mexico, and to map and image unknown features, habitats, and species. The critical need for even basic information about deepwater habitats in the Gulf of Mexico was frequently highlighted in the wake of the 2010 Deep Water Horizon (DWH) accident. The purpose of this expedition was to help reduce that large unknown. Focus was on the water column and deep unexplored diversity of benthic environments in the Northern Gulf of Mexico region. The team expected to explore cold seeps, deep coral communities, undersea canyons, and shipwrecks—perhaps even mud volcanoes and brine pools.

EX-12-02 Leg 2 included five ROV dives to deep-sea coral communities ranging from 4.2 to 17 miles around the DWH site, known to have been impacted by the spill. NOAA Ship *Okeanos Explorer* mission provided baseline information to assist in evaluating deep ocean data post-DWH on deep-sea communities in the Gulf of Mexico. More details on this work is available in Fisher (2012) and Shank (2012).

The water column was also a key area of scientific focus. During a cruise in 2011, NOAA and partners demonstrated that the *Okeanos Explorer's* multibeam sonar was capable of mapping gas seeps in the water column over broad areas and at high resolution (Malik et al., 2011). Testing new methods and technologies is an OER priority; during this expedition, acoustic methods were tested to detect gas seeps, measure flux, and improve the capabilities to explore the water column. ROV dives were planned to ground truth acoustic seep data, and to test methods using equipment mounted on the ROV to measure the rate that gas rises from seeps on the seafloor.

Locating and characterizing UCH was also an objective, with the goal of gathering data for use in assessing their eligibility for the National Register of Historic Places. Five sites identified during previous industry surveys and reported to BOEM were investigated during the two cruise legs. BOEM requires the industry to conduct surveys and archaeological assessments "to aid in its decision-making prior to issuing permits for bottom-disturbing activities related to oil and gas exploration and development" (NOAA, 2012). This expedition was the first time ROV investigations were conducted from the *Okeanos Explorer* to investigate UCH.

NOAA Ship *Okeanos Explorer* arrived in the Atlantic and Gulf of Mexico the previous year, and this expedition was the first time OER conducted community-driven telepresence-enabled ROV operations with the ship in U.S. waters, with teams of scientists participating remotely from shore.

2.2 Objectives

The expedition addressed scientific themes and priority areas put forward by scientists and resource managers from NMFS, ONMS, BOEM, and the broad ocean science community. The primary objective of the expedition was to survey deepwater areas offshore Florida, Alabama, Mississippi, Louisiana, and Texas to provide baseline data and information to support science and management needs. Specifically, this expedition sought to:

- Identify and explore the diversity of benthic habitats (e.g. seeps, deep corals, and canyons), and characterize UCH sites;

- Expand tests of acoustic methods to detect gas seeps and measure flux;
- Experiment with the ROV's ability to ground truth acoustic seep data;
- Improve capabilities to explore the water column;
- Test and refine operating procedures and products;
- Provide a foundation of publicly-accessible data and information products to spur further exploration, research, and management activities; and
- Engage a broad spectrum of the scientific community and public in telepresence-based exploration.

Gas Seep Exploration

The work was conducted at several discrete sites on Biloxi Dome in order to develop techniques for assessing/measuring fluxes quantitatively (i.e., bubble streams, liquids) from active vents. The objective of this work was to characterize the bubble size distribution at two seep locations in order to better understand obtained acoustic measurements of these same seeps and, ultimately, to understand the flux of free gas entering the water column at this location.

Underwater Cultural Heritage

Deepwater shipwrecks represent both the physical remnants of the cultural past and unique micro-ecosystems. To more fully understand them, research must be multi-disciplinary—incorporating both archaeological and environmental studies. Recent research from the *2004 Deepwrecks Project: Analysis of World War II Era Shipwrecks in the Gulf of Mexico* (Church and Warren, 2004) and *Lophelia II 2008: Deepwater Coral Expedition: Rigs, Reefs, and Wrecks* (Demopoulas et al., 2017) have provided the initial detailed impressions of the complex dynamics of deepwater shipwrecks in the Gulf of Mexico. As research moves forward, a broader data sample is needed to better understand the processes at work on these sites. The five proposed exploration sites were important to expanding wreck site data and information. They provided the first steps towards more detailed studies of these wrecks. Using visual data from these investigations, scientists made initial archaeological assessments and began preliminary documentation of biological communities on the sites. The resulting information can be used to plan and prioritize future detailed investigations. It may also be integrated, with ongoing studies to provide a more diverse sampling from a broader range of water depths. Finally, scientists can use these exploration data to develop detailed designs to guide future research in the quest to get a clearer perspective on the cultural aspects of deepwater shipwreck sites as well as a better understanding of the processes related to their formation, evolution, and function as marine ecosystems.

The overarching archaeological goal of the five dives was to ground truth, image, and conduct interdisciplinary site characterization of the anomalies identified as likely shipwrecks in the oil and gas industry surveys. These data could assist in the identification of the sites and possibly aid in determining historical significance for eligibility to the National Register of Historic Places. Operations conducted from *Okeanos Explorer* include only non-disturbance activities at UCH sites, and do not include site excavation or any artifact recovery. These dives were conducted in partnership with BOEM and the maritime archaeology community, and the combined objectives and rationale of the archaeology team were:

1. Positive identification of the site as a shipwreck.
2. Archaeological characterization to assess the site's state of preservation.
3. Collect information to aid in the identification and possible eligibility for the National Register of Historic Places.
4. Gather sub-bottom profiler data over the location to provide a better understanding of the site's substrate, buried characteristics, and the impacts of deepwater currents as indicated by scour as well as around the wreck and embedded features.
5. Gather data for future detailed assessments of the site.
6. Initial assessment of the biological processes and fauna on the site.
7. Determine the impact of the wreck on the biological systems in deep water.
8. Determine whether there have been any anthropogenic impacts to the site.
9. Use the sector-scanning sonar to delineate the site's extents and possible debris field.

3. Participants

EX-12-02 Legs 2 & 3 included onboard mission personnel as well as shore-based science personnel who participated remotely via telepresence technology. For the onboard personnel, see **Table 1** for EX-12-02 Leg 2 and **Table 2** for EX-12-02 Leg 3. See **Table 3** for a list of the shore-based personnel who supported EX-12-02 Legs 2 & 3.

Table 1. NOAA Ship *Okeanos Explorer* onboard mission team personnel during EX-12-02 Leg 2.

Name (First, Last)	Title	Affiliation
Jeremy Potter	Expedition Coordinator	OER
Tim Shank	Science Lead	WHOI/University Corporation for Atmospheric Research (UCAR)
Pen-Yuan Hsing	Science Lead	Penn State/UCAR
Elizabeth "Meme" Lobecker	Mapping Lead	OER/ERT, Inc.
Christopher Pinero	Mapping Watch Lead	University Corporation for Atmospheric Research
John Doroba	Hydrographic Survey Technician	NOAA Office of Marine and Aviation Operations (OMAO)
Dave Lovalvo	ROV Lead	OER/UCAR
Webb Pinner	Data Management team	OER/UCAR

LTJG Brian Kennedy	Mapping and Operations	OER
Tara Smithee	Mapping Intern	UCAR
Dave Wright	Engineering Team	UCAR
Roland Brian	Engineering Team	UCAR
Art Howard	Engineering Team	UCAR
Ed McNichol	Engineering Team	UCAR
Thomas Kok	Engineering Team	UCAR
Gregg Diffendale	Engineering Team	UCAR
Bobby Mohr	Engineering Team	UCAR
Karl McLetchie	Engineering Team	UCAR
Jeff Williams	Engineering Team	UCAR

Table 2. NOAA Ship *Okeanos Explorer* onboard mission team personnel during EX-12-02 Leg 3.

Name (First, Last)	Title	Affiliation
Kelley Elliott	Expedition Coordinator	OER/CollabraLink Technologies, Inc.
Jamie Austin	Science Lead	University of Texas at Austin/UCAR
Erin Becker	Science Lead	Penn State/UCAR
Adam Skarke	Mapping Lead	OER/ERT, Inc.
Dave Lovalvo	ROV Lead	OER/UCAR
Webb Pinner	Data Lead	OER/UCAR
Court Squires	Web Coordinator	OER/CollabraLink Technologies, Inc.
Stephanie Rogers	Science/Data Team	HBOI/UCAR
Dave Wright	Engineering Team	UCAR
Roland Brian	Engineering Team	UCAR
Chris Ritter	Engineering Team	UCAR
Ed McNichol	Engineering Team	UCAR
Thomas Kok	Engineering Team	UCAR
Gregg Diffendale	Engineering Team	UCAR
Bobby Mohr	Engineering Team	UCAR
Karl McLetchie	Engineering Team	UCAR
Jeff Williams	Engineering Team	UCAR
Jon Mefford	Engineering Team	UCAR
Brian Brinckman	Engineering Team	UCAR

Table 3. Shore-based science team members for EX-12-02 Legs 2 & 3.

Name (First, Last)	Email	Affiliation
Allison Mead	mallison@utig.ig.utexas.edu	University of Texas at Austin
Jamie Austin	jamie@utig.ig.utexas.edu	University of Texas at Austin
Robert Carney	rcarne1@lsu.edu	LSU
Alexis Catsambis	alexis.catsambis.ctr@navy.mil	Naval History and Heritage Command (NHHC)/Texas A&M University
Felicia Coleman	coleman@bio.fsu.edu	FSU
Erik Cordes	ecordes@temple.edu	Temple University
Melanie Damour	melanie.damour@boem.gov	BSEE
James Delgado	james.delgado@noaa.gov	NOAA
Peter Etnoyer	peter.etnoyer@noaa.gov	NOAA
Amanda Evans	EvansA@teslaoffshore.com	Tesla Offshore, LLC
Sarah Fangman	sarah.fangman@noaa.gov	ONMS
Kim Faulk	Kim.Faulk@f-e-t.com	Geoscience Earth and Marine Services (GEMS)
Chuck Fisher	cfisher@psu.edu	Penn State
Sam Georgian	georgian@temple.edu	Temple University
Grant Gilmore III	r.g.gilmore@umail.leidenuniv.nl	Leiden University
John Goff	goff@utig.ig.utexas.edu	University of Texas at Austin
Sean Gulick	sean@utig.ig.utexas.edu	University of Texas at Austin
Robert Haddad	robert.haddad@noaa.gov	NOAA
Chuck Henry	charlie.henry@noaa.gov	NOAA Office of Response and Restoration (ORR)
Santiago Herrera	sherrera@whoi.edu	WHOI
Taylor Heyl	theyl@whoi.edu	WHOI
Emma Hickerson	emma.hickerson@noaa.gov	ONMS
Pen-Yuan Hsing	penyuan.hsing@psu.edu	Penn State
Jack Irion	Jack.Irion@boem.gov	BOEM
Bill Kiene	william.kiene@noaa.gov	ONMS
Topher Lewis	clewis@indecon.com	Industrial Economics, Inc.
Jay Lunden	jlunden@temple.edu	Temple University
Rod Mather	roderick@uri.edu	URI
Larry Mayer	lmayer@ccom.unh.edu	UNH
Cat Munro	cmunro@whoi.edu	WHOI
Ian MacDonald	imacdonald@fsu.edu	FSU
Martha Nizinski	martha.nizinski@noaa.gov	NOAA
Marissa Nuttall	marissa.nuttall@noaa.gov	ONMS
Mike Prendergast	Michael.Prendergast@bsee.gov	BSEE
Shirley Pomponi	SPomponi@hboi.fau.edu	HBOI
Andrea Quattrini	tub79176@temple.edu	Temple University
John Reed	jreed12@hboi.fau.edu	HBOI

Rob Ricker	rob.ricker@noaa.gov	NOAA
Matt Rittinghouse	matthew.rittinghouse@noaa.gov	NOAA - Charleston
Harry Roberts	hrober3@lsu.edu	LSU
Steve Ross	rosss@uncw.edu	University of North Carolina Wilmington
Stephen Roth	stephen.roth@noaa.gov	NOAA - Charleston
Miles Saunders	mgs190@psu.edu	Penn State
Tim Shank	tshank@whoi.edu	WHOI
Bill Shedd	William.Shedd@boem.gov	BOEM
Andy Shepard	sheparda@usf.edu	Florida Institute of Oceanography
Enrique Salgado	enrique.salgado@noaa.gov	NOAA - Charleston
Michael Vecchione	VecchioneM@si.edu	NMFS/SI
Joshua Voss	jvoss2@hboi.fau.edu	HBOI
Dan Warren	djw@cctechnol.com	C&C Technologies, Inc.
Tom Weber	weber@ccom.unh.edu	UNH
Leslie Wickes	lnw124@gmail.com	College of Charleston

4. Methodology

EX-12-02 Legs 2 & 3 used the following equipment to accomplish the objectives:

- Dual-bodied ROV system (the IFE's *Little Hercules* ROV and the NOAA *Seirios* camera platform) to conduct daytime seafloor surveys. Select ROV dives during EX-12-02 Leg 3 included either a calibrated grid or gas capture device that was added to the front of the *Little Hercules* ROV to support seep flux analysis.
- Sonar systems (Kongsberg EM 302 multibeam sonar, Knudsen 3260 sub-bottom profiler, and Simrad EK60 single beam sonars) to conduct mapping operations at night and when the ROVs were on deck.
- A high-bandwidth satellite connection to provide real-time ship-to-shore communications (telepresence).

All environmental data collected by NOAA is archived and publicly accessible. The Data Management Plan for EX-12-02 Legs 2 & 3 is in Appendix A.

4.1 ROV Seafloor Surveys

4.1.1 ROV Technology

Targeted site characterizations are accomplished using a dual-body ROV that is dedicated to the ship and equipped with powerful lighting systems and high-definition (HD) video cameras. The dual-body system can be operated down to 4,000 m and is equipped with CTD and dissolved oxygen (DO) sensors. Like the sonar systems, the ROV system is optimized for working in deeper water; operations are conducted in 500 m[1] or deeper.

The primary vehicle in the dual-bodied system is the ROV *Little Hercules*. Owned by the IFE, *Little Hercules* was retrofitted by OER for use on the *Okeanos Explorer* through a partnership between the two programs. "Communication with *Little Hercules* is over fiber optic cable, and control of the vehicle and all onboard sensors is via surface computers located in the *Okeanos Explorer* control room*. Little Hercules* is very maneuverable, with four electric thrusters mounted in a configuration that allows it to move through the water much like a helicopter moves in air. *Little Hercules* carries a single high-definition video camera, two additional task video cameras, two high-intensity lights, a depth and altitude sensor, a CTD, and a full-color sector-scan imaging sonar system. An ultra-short baseline navigation system tracks the vehicle while it is underwater" (Bell et al., 2012).

ROV *Seirios* is the second vehicle of this dual-bodied system and is operated in tandem with *Little Hercules*, as a camera and light platform that "flies" several meters above the ROV. *Seirios* includes two HD cameras and 2,400 watts of broadcast-quality lighting. *Seirios* also carries two five-horsepower electric thrusters that allow it to move both rotationally and laterally. Additional standard equipment includes depth sensors, an altimeter, a full-color sector scan imaging sonar, a CTD, and several other "task" cameras.

Together with *Little Hercules* and the ship, the vehicles compose a three-vehicle system (**Figure 4**). The cable from the ship is connected directly to *Seirios*, which is designed to be negatively buoyant in water so the vehicle sinks. While at depth, the movement of the ocean waves on the ship is translated down the cable to *Seirios. Little Hercules* is attached to *Seirios* via a 50-meter tether and is always operated below *Seirios*. This way, *Seirios* provides additional lighting and a view of *Little Hercules* during operations. By being connected to *Seirios*, via a separate tether and not the cable connected to the ship, the *Little Hercules* is disconnected from the motion of the ship and ocean surface and is, therefore, able to move very slowly and precisely to enable close-up imagery. HD imaging is the primary capability of the ROV. The powerful lighting and dual-bodied system—coupled with a very talented group of ROV engineers, pilots, and videographers—allows the team to obtain incredible high-quality HD imagery. This imaging capability is critically important for telepresence operations to be successful.

[1] As of 2016, dives are typically conducted in 250 m of water and deeper.

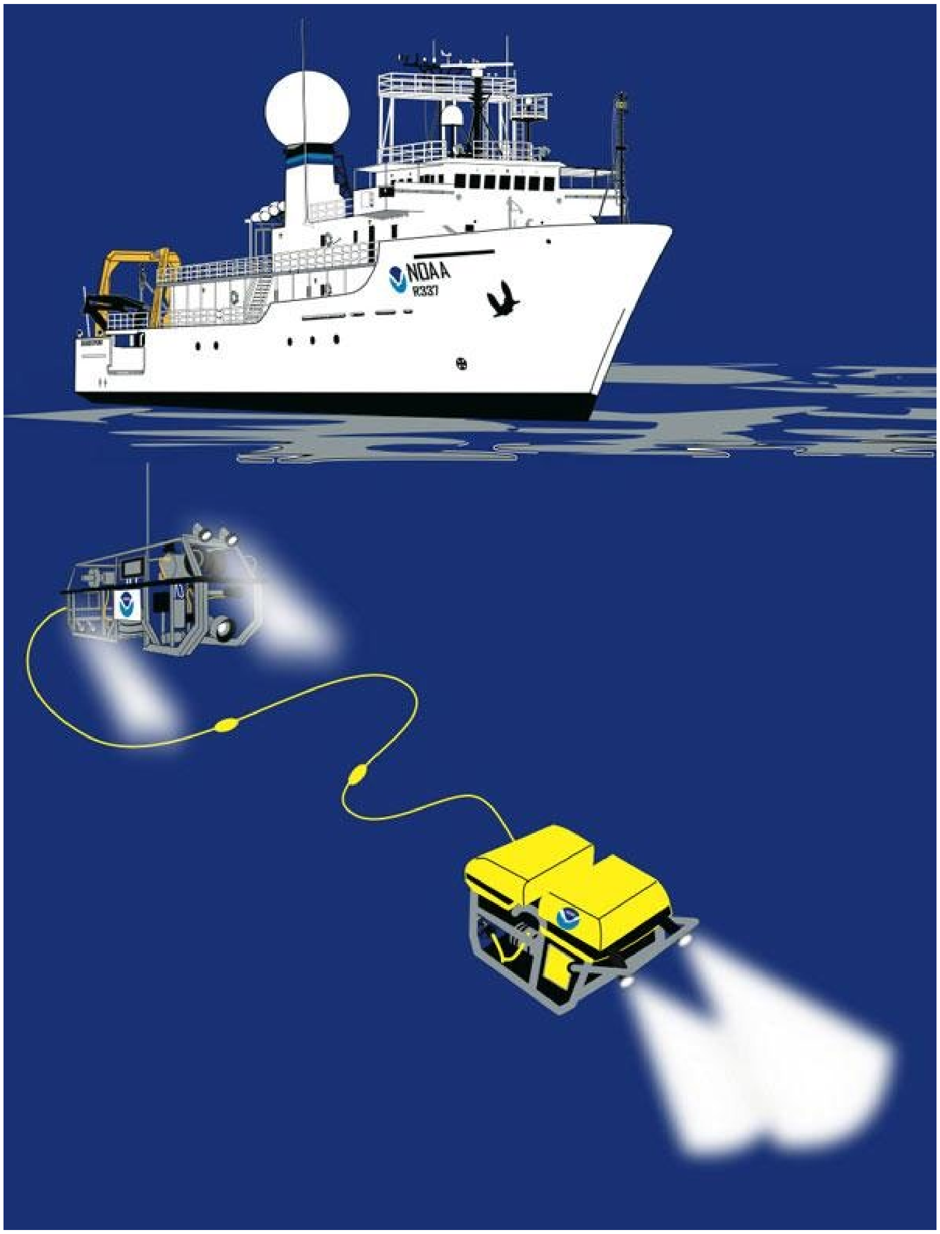

Figure 4. NOAA Ship *Okeanos Explorer* with camera sled, *Seirios*, deployed and below that, IFE's *Little Hercules* ROV. Credit: *Randy Canfield and NOAA.*

4.1.2 Survey Operations

ROV dive operations supported the expedition objectives listed in Section 2.2 and included high-resolution visual surveys of the seafloor. During each dive, the ROVs descended to the seafloor and then moved from waypoint to waypoint, documenting the geology and biology of the area. Most of the ROV dives were approximately seven to nine hours, conditions and logistics permitting. Dives were primarily conducted during the day—operations are described in detail by Quattrini et al. (2015). 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 Kennedy et al. (2019) and Cantwell et al. (2020). The operating model for OER's *Okeanos Explorer* cruises is based on telepresence-enabled participation whereby the small onboard science team is augmented by a significantly larger shore-based science team located around the world.

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.

Gas Seep Exploration

Methodology included mapping with the EM 302 system to acoustically identify plumes from active vents, and subsequently visiting one or more of those vents with the *Little Hercules* ROV. During these ROV dives, either a calibrated grid or gas capture device was mounted to the front of the *Little Hercules* ROV, directly across from the HD camera, to support seep flux analysis.

The seep sites with a relatively fast flow of bubbles, appearing to have a small (less than 5 cm) origin on the seafloor, are amenable to capture and flux rate estimates using the methane bucket configuration. Comparisons between flux estimates via direct capture with the methane bucket and bubble counting with the grid was very helpful. Seep sites with a more dispersed origin at the seafloor, but which in aggregate was also observed to have a relatively fast flow rate, represent a region in which the methane bucket configuration may not be a useful means of estimating the flux rate for a seep, but where the efficacy of bubble sizing/counting using the calibrated grid may provide a reasonable estimate of the rate at which gas is exiting the seafloor. In order to make the calibrated grid methodology work at this type of seep, a good statistical sample of the bubble size distribution at different locations within the seep was needed.

The calibrated grid was placed directly opposite the primary HD camera on *Little Hercules*, and enabled the collection of imagery data to allow scientists to assess sizes and rates of bubble escape from a seep. The ROV was maneuvered so that the seep was rising in front of, and as close to, the calibrated grid as possible. Maneuvering so that the bubbles were very close to the grid aided interpretation of the HD imagery by constraining the camera-to-bubble distance so that the bubbles could be properly sized. Once *Little Hercules* was moved into position at each location, five minutes of HD video was collected for each location.

The gas capture device, known as the methane bucket, was also added to the front of the *Little Hercules* ROV directly in front of the main HD camera for several dives. The objective of this work was to make a direct estimate of flux from a seep site by collecting a known volume of gas over a known duration of time. Bubbles were captured using an inverted clear cylinder on the

ROV, and the resultant clathrate (frozen gas hydrate, a mixture of water and methane ice) was allowed to turn back into gas as the ROV rose slowly to the surface. This allowed investigators to measure volume precisely. Here was the methane bucket survey procedure:

1. The ROV finds a seep at a preselected location (identified during a previous dive).
2. With the bucket top open, the ROV maneuvers so that the bucket is located directly over the seep (if possible, 100% capture is very helpful for this operation).
3. The bucket top should be closed and the bucket should be allowed to be ~3/4 filled. One of the potential issues is the adhesion of hydrates on the methane bucket prior to the bucket top being closed. To mitigate this possible effect, the ROV team should seek to minimize the time between maneuvering the ROV over the seep and closing the bucket top.
4. The ROV should then maneuver away from the seep so as to cease filling the bucket, and then rise to ~250 m water depth in order to let the hydrate return to gas, at which point a volume measurement can be made.

This is a link to a video showing some of the methane bubbles (link validated December 2020): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/photolog/photolog.html#cbpi=/okeanos/explorations/ex1202/logs/apr18/media/video/highlights-0418.html

4.1.3 Underwater Cultural Heritage (UCH) Surveys

For information on the standard operating procedures when surveying underwater cultural heritage sites with the ROV, see **Appendix C**.

4.2 ROV Water Column Survey

Between the deep-sea bottom and the sunlit surface waters are the open waters of the deep pelagic environment. ROVs can contribute important pelagic observations. During EX-12-02 Legs 2 & 3, OER tested ROV water column exploration methods described in Netburn et al. (2018). The lower DeSoto Canyon was chosen because the area provided an opportunity for potentially important observations while developing the methods. Such canyon areas are preferred feeding grounds for sperm whales, and recent fishing with large midwater trawl nets has shown that this area supports robust numbers of a variety of large squids and other species that are potential prey for the whales. However, trawling cannot provide the detailed information on vertical distribution and behavior that could be observed with an ROV.

During the expedition, the team tested a methodology for ROV midwater exploration transects while the ROV descended through potential sperm whale feeding habitat on its descent to other objectives on the bottom. During the time devoted to determining midwater capabilities and developing methods, the team searched depths between 600 and 1,200 m. The ROV was driven for 10 minutes along horizontal transects at 100-meter depth intervals between these depths. Additional guidance for conducting these transects included:

- Exact location and heading should be determined by the ship, relative to wind/current.
- Search 600 m to 1,200 m at 100 m increments, for 10 minutes each.
- Search each increment by powering the ROV horizontally in a straight line.
- Wait to begin each "mini-transect" until both the ROV and tow body have stabilized in the water.

4.3 Acoustic Operations

Mapping Technologies

Acoustic operations included Kongsberg EM 302 multibeam echo sounder, Simrad EK60 18 kHz split beam echo sounder, and Knudsen 3260 sub-bottom profiler data collection (Lobecker, 2012). The three[2] sonars are operated simultaneously to collect exploration data, providing new information about seabed depth and acoustic reflectivity, water column biomass and other anomalies, and sub-seafloor layers and features. These systems are described in detail below. These mapping systems are maximized for operating in deeper waters. The sonars can be operated as shallow as 250 m, but OER typically focuses operations 500 m and deeper.

Survey Methodology

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, or to conduct water column time series investigations of known gas seeps (Skarke, 2012). In regions with no existing data, exploration transit lines were planned to optimize potential discoveries. Specific goals for EX-12-02 Legs 2 & 3 included:

- Identify and explore the diversity of benthic habitats in the region, including seeps, deep corals, and canyons;
- Locate and characterize UCH, including shipwrecks, in order to assess their eligibility for the National Register of Historic Places;
- Conduct water column flux experiments over seeps in an effort to develop a methodology to ground truth acoustic backscatter data with the ROV.

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[2] Additional sonars have since been added to the NOAA Ship *Okeanos Explorer*. In 2015, five additional frequencies of Kongsberg EK60 split-beam sonars were added (38, 70, 120, 200, 333 kHz), as well as two Teledyne Acoustic Doppler Current Profilers (38 and 333 kHz).

4.3.1 Multibeam Sonar (Kongsberg EM 302)

Multibeam seafloor mapping data were acquired using the Kongsberg EM 302 sonar, which operates at a frequency of 30 kilohertz (kHz). This multibeam sonar is capable of detecting the seafloor in up to 10,000 m of water and can conduct productive mapping operations in 8,000 m of water. The system generates a 150° beam fan containing up to 432 soundings per ping in waters deeper than 3,300 m. In waters shallower than 3,300 m, the system is operated in dual swath mode and obtains up to 864 soundings per ping by generating two swaths per ping cycle. The multibeam sonar is used to collect seafloor bathymetry, seafloor backscatter, and water column backscatter data. Backscatter represents the strength of the acoustic signal reflected from a target, such as the seafloor or bubbles in the water column. The system is calibrated with a multibeam sonar patch test annually. 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, transit line spacing was designed to maximize coverage over seafloor areas with no previous high-resolution mapping data. In the focus survey 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, or to collect time series data at active gas seep sites to improve understanding of flux over time.

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 mapping data collected during *Okeanos Explorer* cruises, notably EX-11-05, EX-11-06, and EX-12-02-Leg 1. Some dive planning and mapping operations were conducted using bathymetric grids created using all available bathymetry archived at the NOAA National Centers for Environmental Information (NCEI) and with their Autogrid tool. Smith and Sandwell (1997) satellite altimetry data were also used to plan operations.

4.3.2 Sub-Bottom Profiler (Knudsen Chirp 3260)

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

4.3.3 Single Beam Sonar (Simrad EK60)

Okeanos Explorer is equipped with an 18 kHz Simrad EK60 general purpose transceiver; which collects information about the water column, such as at gas plume and seep sites, and provides information about biomass, such as plankton diurnal migration or the presence of fish and fish schools. EK sonars are quantitative scientific echo sounders that are calibrated to identify the target strength of water column acoustic reflectors—typically biological scattering layers, fish, or gas bubbles—providing additional information about water column characteristics and anomalies.

Water column surveys with the EK60 and EM 302 were conducted continuously throughout EX-12-02 Legs 2 & 3, during both overnight mapping operations and daytime ROV operations. This sonar was calibrated during the EX-11-05 cruise, and calibration values from that cruise were applied to the EK sonars for EX-12-02 Legs 2 & 3.

4.3.5 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 a flow-through thermosalinograph (TSG).

4.4 Conductivity, Temperature, and Depth (CTD)

CTD measurements were collected by two different methods. The most frequent method was with the integrated ROV CTD system. This system records CTD and associated sensors on every dive. The second method was with a dedicated CTD—lowered with a winch—to provide better information on the critical properties of the water column. Additional sensors installed on both of the CTDs include measured light scattering (LSS), DO, and oxygen reduction potential (ORP).

4.5 Telepresence Operations

The *Okeanos Explorer* is a dedicated ocean exploration ship, with a mission and goal to travel to places where little to nothing is known in order to make discoveries. Oftentimes, the team does not know what they will find, and thus cannot plan to have subject matter experts from multiple disciplines onboard the ship. Therefore, as a dedicated ship of exploration, the

Okeanos Explorer is equipped with "telepresence" technology—allowing the team onboard to remotely engage a theoretically unlimited shoreside intellectual capital.

4.5.1 Telepresence Overview

Via telepresence (**Figure 5**), live images from the seafloor and other science data flow over satellite and high-speed Internet pathways to scientists standing watches in Exploration Command Centers (ECCs) or other Internet-enabled locations. Telepresence enables a shore-based team of scientists, students, and the public to join the expedition in real time.

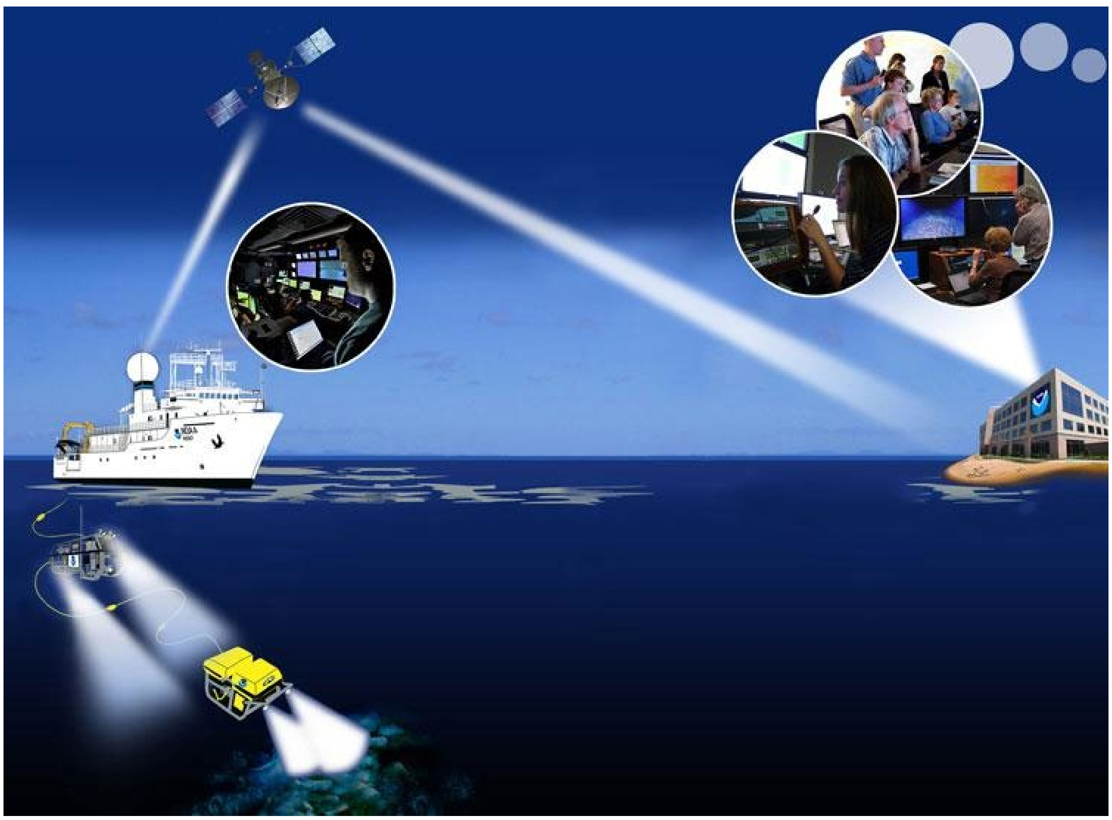

Figure 5. A telepresence-enabled platform: satellite technology enables data and video to be transmitted in real time, from NOAA Ship *Okeanos Explorer* and ROVs working at depth, to a shore-based hub where the video is transmitted in HD out on Internet2 to a variety of receiving stations on shore, including a number of Exploration Command Centers (ECCs) located around the country. A lower-resolution and higher-latency version is also available via standard Internet. Access to the video and a suite of Internet-based collaboration and communication tools allows scientists located on shore to join the operation in real time. *Image courtesy of OER.*

Typically only two scientists sail onboard the ship, and the majority of the science team participates from shore (**Figure 6**).

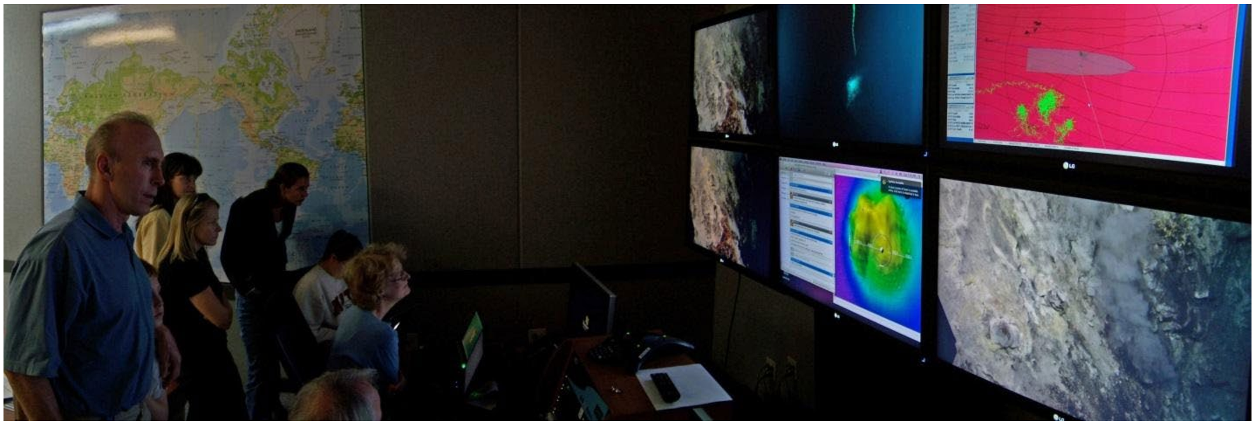

Figure 6. Scientists participate in an ROV dive remotely from the Seattle ECC.

4.5.2 Telepresence Technology

Remote participation in the seagoing operations is made possible through several technologies. The primary is a 3.7-meter C-band very small aperture terminal (VSAT) antenna capable of streaming up 20 megabits per second (Mbps) of data to shore. A VSAT is used to transmit and receive data such as video, voice, and computer information from the ship to a satellite in space that then transmits the data to a shoreside hub. The 20 Mbps bandwidth allows up to three HD video feeds and data to be streamed from the ship to shore in near-real time. The video feeds can include the cameras on the ROVs while underwater, or one of more than a dozen cameras in mission spaces onboard the ship—showing equipment deployments and recoveries, personnel at work—or even computer data acquisition screens of ongoing operations. Once onshore at the ISC, the video feeds are then run through an encoder, and a lower-resolution version is streamed online to be made available to anyone with standard Internet connection. Making the feeds publicly available on standard Internet enables scientists to participate from anywhere with an Internet connection, and allows scientists as well as the general public to follow along and take a front row seat as discoveries are made in real time.

The bandwidth also allows data to be sent to shore in near-real time. The ship has an integrated, end-to-end data management protocol, which includes both a ship and a shoreside data repository server. These servers are continuously compared via a synchronization process to mirror each other. This process ensures the latest data and data products collected onboard the ship are automatically transferred to shore. The rsync process is run hourly, 24 hours per day/seven days per week, during the cruise and makes the data onboard the ship available to shoreside science participants within an hour to a few days after being collected.

A number of ECCs around the country tap into these Internet2 feeds and include additional tools and equipment, allowing scientists to participate in the cruise from shore. ECCs typically have three large monitors displaying each of the video feeds coming off the ship (**Figure 6**), and are equipped with an RTS intercom unit or conference phone and computers. The RTS intercom units use Voice over Internet Protocol (VoIP) technology to allow the shoreside scientists to communicate directly with both the scientists onboard the ship and scientists located at other ECCs that are equipped with this same technology. During the *Gulf of Mexico 2012* expedition, the RTS intercom unit onboard the ship was also dialed into a teleconference line. Combined with access to the live video feed on standard Internet, scientists could—for the first time—fully participate in an *Okeanos Explorer* cruise from anywhere with a phone and Internet connection.

4.5.3 Shoreside Participation

Scientists are able to participate from shore by viewing these live feeds online and talking directly with the onboard and fellow remote scientists in real time through RTS Intercom units (**Figure 7**). At the same time, instant messaging is used to facilitate communication and logging of science observations. A group chat room called the "Eventlog" is set up to enable science participants both to communicate with each other, but also to log observations during science operations. Each entry includes the participant's name and is given a Universal Time Coordinated (UTC) date and time code. All of the systems onboard the ship are synchronized to UTC date and time, and allow correlation of any entries in the Eventlog with datasets collected onboard the ship.

Figure 7. Dr. Dave Butterfield (left) and Dr. Ed Baker communicate from the ECC in Seattle to the *Okeanos* Explorer via an IP-enabled RTS intercom system. The intercom system leverages the *Okeanos Explorer's* Internet connectivity to connect all of the ship-based and shore-based intercom units into a single system.

Participation is also facilitated by daily ship-to-shore science meetings, which focused on discussing the latest data, sharing operational updates, and collaboratively planning the next ROV dive. Computer data screens were transmitted off the ship as a live feed during these meetings so everyone on the call was looking at the same view and could collaboratively discuss and refine operations and dive plans for the next day.

Finally, the latest datasets and products transferred from the ship to the shoreside repository server could be accessed by the shoreside science team using a file transfer protocol (FTP) site. This way, the shoreside science team could download and review the latest data, and be prepared to provide input on the next steps of the exploration during the next cruise planning meeting.

4.5.4 Open Data

Catalyzing follow-on work is best accomplished through an open data model. The data acquired and products developed are shared in real time both during and after each cruise. Within 60-90 days following cruise completion, the data and products are sent to the national archives. This way, the data collected meets the needs of many different stakeholders and helps achieve the goal of enabling follow-on research and management activities.

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) (link validated December 2020) describes the agency's specific procedures for NEPA compliance.

An environmental review memorandum was completed for NOAA Ship *Okeanos Explorer* expeditions EX-12-02 Legs 2 & 3 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 B**. OER is preparing a programmatic environmental assessment to cover future expeditions.

6. Schedule

EX-12-02 Leg 2 was a total of 20 days at sea, from March 19, 2012, 7 April 7, 2012. It departed from Tampa, Florida, and returned to port in Pascagoula, Mississippi. See **Table 4** for a day-by-day breakdown of EX-12-02 Leg 2. There were 18 scheduled dives, with 16 dives achieved (see **Table 6** for details).

Table 4. EX-12-02 Leg 2 schedule.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
3/18 Mobilization at Tampa, FL	**3/19** EX Departure Transit Mapping	**3/20** Dive 01: Rocky Scarp #1 Overnight mapping	**3/21** Dive cancelled due to weather Mapping operations for day and night	**3/22** Dive 02: Shallow Ridge, W. FL Escarpment Overnight mapping	**3/23** Dive 03: West Florida Escarpment Canyon Overnight mapping	**3/24** Dive 04: DeSoto Canyon 493 Overnight mapping
3/25 Dive 05: DeSoto Canyon (DC) #673 Overnight mapping	**3/26** Dive 06: DeSoto Canyon 493 (West Facing Scarp) including 600-1,200 m water column transects during descent Overnight mapping	**3/27** Dive 07: West Florida Escarpment Restricted Archaeology Overnight mapping	**3/28** Dive 08: DeSoto Canyon Dragon Head Overnight mapping	**3/29** Dive 09: DeSoto Canyon Restricted Archaeology Overnight mapping	**3/30** Dive 10: DeSoto Canyon Restricted Archaeology Overnight mapping	**3/31** Dive 11: Mississippi Canyon MC294/338 Overnight mapping
4/1 Dive 12: Mississippi Canyon 297 Overnight mapping	**4/2** Dive 13: Mississippi Canyon 388 Overnight mapping	**4/3** Dive 14: Mississippi Canyon 255 Overnight mapping	**4/4** Dive cancelled due to weather Mapping operations for day and night	**4/5** Dive 15: Mississippi Canyon 036 Overnight mapping	**4/6** Dive 16: Salt Dome Seep Target Overnight mapping	**4/7** EX arrival in Pascagoula, MS
4/8 Mission team departure and preparation for EX-12-02 Leg 3	**4/9**	**4/10**	**4/11**	**4/12**	**4/13**	**4/14**

EX-12-02 Leg 3 was a total of 19 days at sea, from April 11, 2012, to April 29, 2012. It departed from Pascagoula, Mississippi, and returned to port in Galveston, Texas. See **Table 5** for a day-by-day breakdown of EX-12-02 Leg 3. There were 17 scheduled dives, with 13 dives achieved (see **Table 7** for details).

Table 5. EX-12-02 Leg 3 schedule.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
4/8	**4/9**	**4/10** Mission personnel arrive	**4/11** Mobilization at Pascagoula, MS EX departs in the afternoon Transit mapping	**4/12** Dive 01: Biloxi Salt Dome B Overnight mapping	**4/13** Dive 02: Biloxi Salt Dome A Overnight mapping	**4/14** Dive 03: Biloxi Salt Dome B (Methane Bucket Experiment) Overnight mapping
4/15 Dive cancelled due to methane bucket malfunction Mapping operations for day and night	**4/16** Dive 04: Pascagoula Dome (Methane Bucket Experiment) Overnight mapping	**4/17** Dive 05: Pascagoula Salt Dome (Grid Experiment) Overnight mapping	**4/18** Dive 06: South of Biloxi B Overnight mapping	**4/19** Dive 07: Site 359 Restricted Archaeology Overnight mapping	**4/20** Dive 08: EW915/959 Overnight mapping	**4/21** Dive 09: GC 470 Dive shortened due to weather Overnight mapping
4/22 Dive cancelled due to weather Mapping operations for day and night	**4/23** Dive cancelled due to weather Mapping operations for day and night	**4/24** Dive 10: Sigsbee Overnight mapping	**4/25** Dive 11: SW of Sigsbee Overnight mapping Live telepresence event with the Roddenberry Foundation, Jerry Schubel, and the Aquarium of the Pacific	**4/26** Dive 12: NE of Keathley Canyon Restricted Archaeology Dive delayed until night due to weather Overnight mapping	**4/27** Dive 13: Keathley Canyon Overnight mapping	**4/28** Dive cancelled due to weather Mapping operations for day and night
4/29 Transit mapping EX arrival in Galveston, TX Demobilization	**4/30** Demobilization Mission team departure	**5/1**	**5/2**	**5/3**	**5/4**	**5/5**

7. Results

Metrics for the EX-12-02 Legs 2 & 3 expedition's major exploration and scientific accomplishments are summarized in **Table 6** and **Table 7**. More detailed results are presented in the subsections that follow.

Table 6. Summary of exploration metrics for EX-12-02 Leg 2.

Exploration Metrics	Totals
Days at sea	20
Days at sea in U.S. EEZ	20
Linear km mapped by EM 302	4,153
Square km covered by EM 302	14,418
Square km covered by EM 302 in U.S. EEZ	14,252
Vessel CTD casts	1
XBT casts	61
ROV dives	16
ROV dives in U.S. EEZ	16
Maximum ROV seafloor depth (m)	2550
Minimum ROV seafloor depth (m)	280
Total time on bottom (hh:mm:ss)	95:58:00
Water column survey time (hh:mm:ss)	3:30:00
Total ROV time (hh:mm:ss)	132:25:00

Table 7. Summary of exploration metrics for EX-12-02 Leg 3.

Exploration Metrics	Totals
Days at sea	19
Days at sea in U.S. EEZ	19
Linear km mapped by EM 302	4,458
Square km covered by EM 302	14,416
Square km covered by EM 302 in U.S. EEZ	14,302

Vessel CTD casts	0
XBT casts	70
ROV dives	13
ROV dives in U.S. EEZ	13
Maximum ROV seafloor depth (m)	2095
Minimum ROV seafloor depth (m)	349
Total time on bottom (hh:mm:ss)	68:31:00
Water column survey time (hh:mm:ss)	NA
Total ROV time (hh:mm:ss)	94:00:00

7.1 ROV Survey Results

During EX-12-02 Leg 2, depth ranges explored during the 16 ROV surveys were between 280 and 2,550 m. The ROVs spent a total of 96 hours on the bottom. See **Table 8** for dive-specific information about each of the dives.

Table 8. Summary information for the 16 ROV dives conducted during EX-12-02 Leg 2.

Date (yyyy mmdd)	Dive #	Site Name	Max Depth (m)	Dive Duration (hh:mm:ss)	Bottom Time (hh:mm:ss)	Max Latitude	Min Latitude	Max Longitude	Min Longitude
20120320	01	Rocky Scarp #1	452.4	07:00:00	07:00:00	26.468557	26.466593	-84.771343	-84.779453
20120322	02	Shallow Ridge, W. FL Escarpment	429.7	07:00:00	06:00:00	26.441276	26.431247	-84.751397	-84.765378
20120323	03	West Florida Escarpment Canyon	2140.7	09:00:00	06:00:00	27.916381	27.911324	-86.034468	-86.040219
20120324	04	DeSoto Canyon 493	2471.7	08:00:00	04:00:00	28.512169	28.501043	-87.482639	-87.486663
20120325	05	DeSoto Canyon (DC) #673	2148	08:00:00	05:00:00	28.311242	28.29568	-87.28597	-87.289626
20120326	06	DeSoto Canyon 493 (West Facing Scarp)	2255.7	08:00:00	02:00:00	28.691692	28.677577	-87.546521	-87.565299
20120327	07	Restricted UCH	*FOUO	07:00:00	04:00:00	*FOUO	*FOUO	*FOUO	*FOUO

20120328	08	DeSoto Canyon Dragon Head	476.3	08:00:00	07:00:00	29.478406	29.472198	-86.852431	-86.855688
20120329	09	Restricted UCH	*FOUO	07:00:00	07:00:00	*FOUO	*FOUO	*FOUO	*FOUO
20120330	10	Restricted UCH	*FOUO	08:00:00	07:00:00	*FOUO	*FOUO	*FOUO	*FOUO
20120331	11	Mississippi Canyon MC294/338	1374.7	09:00:00	07:00:00	28.673687	28.668811	-88.475629	-88.477239
20120401	12	Mississippi Canyon 297	1585.5	08:00:00	05:00:00	28.685211	28.678366	-88.343393	-88.349359
20120402	13	Mississippi Canyon 388	1899.2	08:00:00	05:00:00	28.636479	28.623715	-88.168876	-88.173916
20120404	14	Mississippi Canyon 255	1613.5	07:00:00	04:00:00	28.73415	28.722321	-88.243507	-88.252446
20120405	15	Mississippi Canyon 036	1104.7	08:00:00	07:00:00	28.936344	28.932686	-88.199507	-88.203653
20120406	16	Salt Dome Seep Target	1182.2	09:00:00	06:00:00	28.982895	28.97623	-88.029446	-88.040607

* Restricted UCH information is for official use only (FOUO) and available upon request to OER.

During EX-12-02-Leg 3, depth ranges explored during the 13 ROV surveys were between 349 and 2,095 m. The ROVs spent a total of 68 hours on the bottom. See **Table 9** for dive-specific information about each of the dives.

Table 9. Summary information for the 13 ROV dives conducted during EX-12-02 Leg 3.

Date (yyyy mmdd)	Dive #	Site Name	Max Depth (m)	Dive Duration (hh:mm:ss)	Bottom Time (hh:mm:ss)	Max Latitude	Min Latitude	Max Longitude	Min Longitude
20120412	1	Biloxi Salt Dome B	1402.8	09:47:09	07:42:00	28.676582	28.672938	-88.462819	-88.481728
20120413	2	Biloxi Dome A	1418.1	08:05:48	06:03:12	28.64747	28.639958	-88.454968	-88.458926
20120414	3	Biloxi B (Methane Bucket Experiment)	1363.6	05:55:42	02:41:02	28.675674	28.674874	-88.46543	-88.470035

20120416	4	Pascagoula Dome (Methane Bucket Experiment)	1123.1	04:06:20	01:28:25	28.979936	28.97721	-88.028231	-88.030434
20120417	5	Pascagoula Salt Dome (Grid Experiment)	1124.1	03:58:19	02:29:06	28.978613	28.976374	-88.024944	-88.03052
20120418	6	South of Biloxi B	1740.8	08:00:35	05:46:41	28.572334	28.566043	-88.463176	-88.472184
20120419	7	Restricted UCH	*FOUO	07:00:00	07:00:00	*FOUO	*FOUO	*FOUO	*FOUO
20120420	8	EW915/EW959	349	08:02:46	07:24:59	28.044815	28.040349	-90.31875	-90.33553
20120421	9	GC 470	1037	06:43:07	05:13:13	27.514905	27.504244	-90.443167	-90.445999
20120424	10	Sigsbee	1165.1	09:43:53	08:08:01	27.139347	27.12852	-90.481737	-90.487599
20120425	11	SW of Sigsbee	2094.9	09:11:24	06:26:41	26.728174	26.718949	-90.591145	-90.595738
20120426	12	Restricted UCH	*FOUO	04:00:00	02:00:00	*FOUO	*FOUO	*FOUO	*FOUO
20120427	13	Keathley Canyon	2040.9	08:01:05	05:16:15	26.307944	26.296281	-93.428097	-93.439439

* Restricted UCH information is FOUO and available upon request to OER.

7.1.1 Accessing ROV Data

All links to the ROV data were validated December 2020.

OER Digital Atlas

ROV data from EX-12-02 Legs 2 & 3 are archived at NCEI and available through OER's Digital Atlas (https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm). To access these data, click on the Search tab, enter "1202L2" or "1202L3" in the Enter Search Text field, and click Search. Click on the point on the map that represents 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 and associated ROV dive data are archived at NCEI and available on their *Okeanos Explorer* website.

- EX-12-02 Leg 2 https://www.ncei.noaa.gov/waf/okeanos-rov-cruises/ex1202l2/
- EX-12-02 Leg 3 https://www.ncei.noaa.gov/waf/okeanos-rov-cruises/ex1202l3/

Mission Logs

Mission logs for EX-12-02 Legs 2 & 3 are posted on the OER website. These are short summaries written for a general audience, including all aspects of the mission and images of the operation.

- https://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/welcome.html

ROV Dive Video

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

7.2 Acoustic Operations Results

During EX-12-02 Leg 2, multibeam mapping operations results included 4,153 linear kilometers (km) mapped and 14,418 square km covered (**Figure 8**), all of which were within the U.S. EEZ. By combining multibeam surveys from EX-11-05, EX-11-06, EX-12-02 Leg 1, and EX-12-02 Leg 2, a comprehensive view of the West Florida Escarpment can be stitched together (**Figure 9). ** The full results of acoustic mapping operations are discussed in Lobecker et al. (2017).

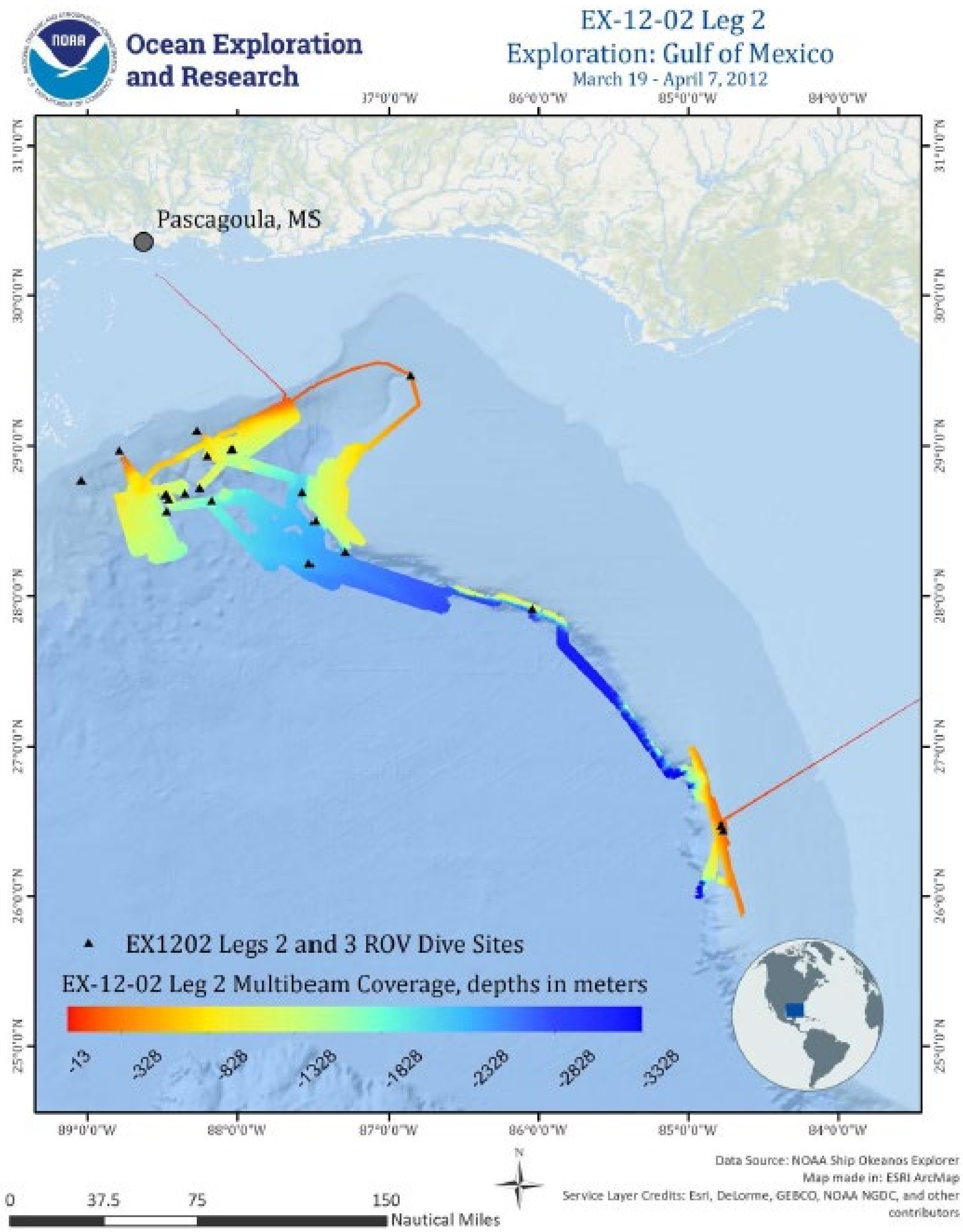

Figure 8. Cruise map showing new multibeam collected during EX-12-02 Leg 2.

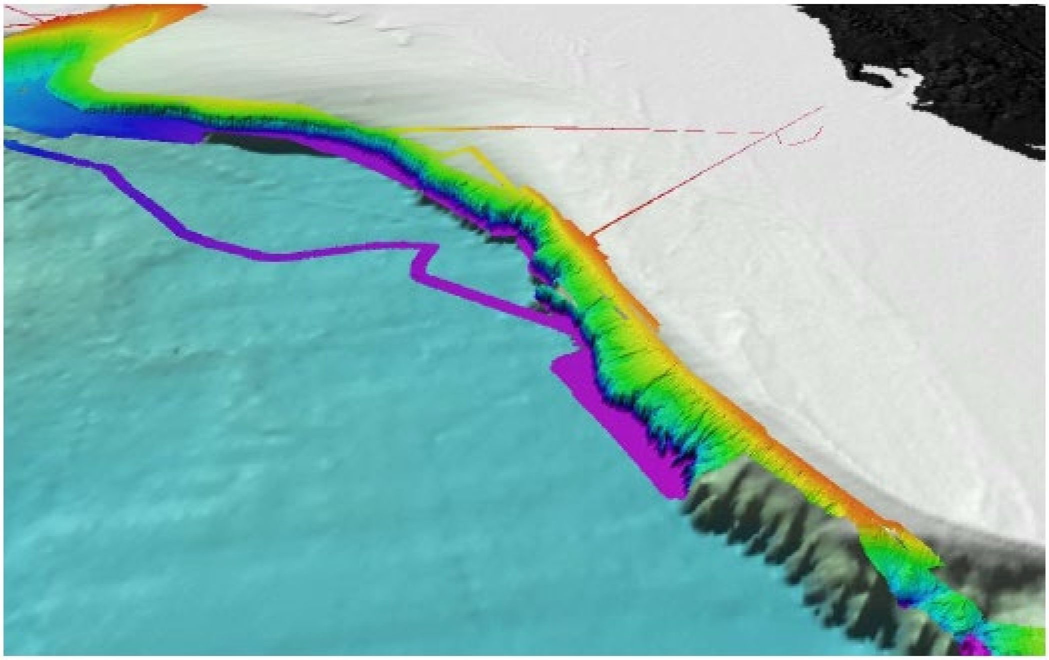

Figure 9. Cumulative EM 302 multibeam data over the West Florida Escarpment collected during EX-12-02 Legs 1 & 2, EX-11-06, and EX-11-05. Data collected is in color relief (blue = deep, red = shallow).

During EX-12-02 Leg 3, multibeam mapping operations results included 4,458 linear km mapped and 14,416 square km covered (**Figure 10**). The full acoustic mapping results are discussed in Candio S. (2020).

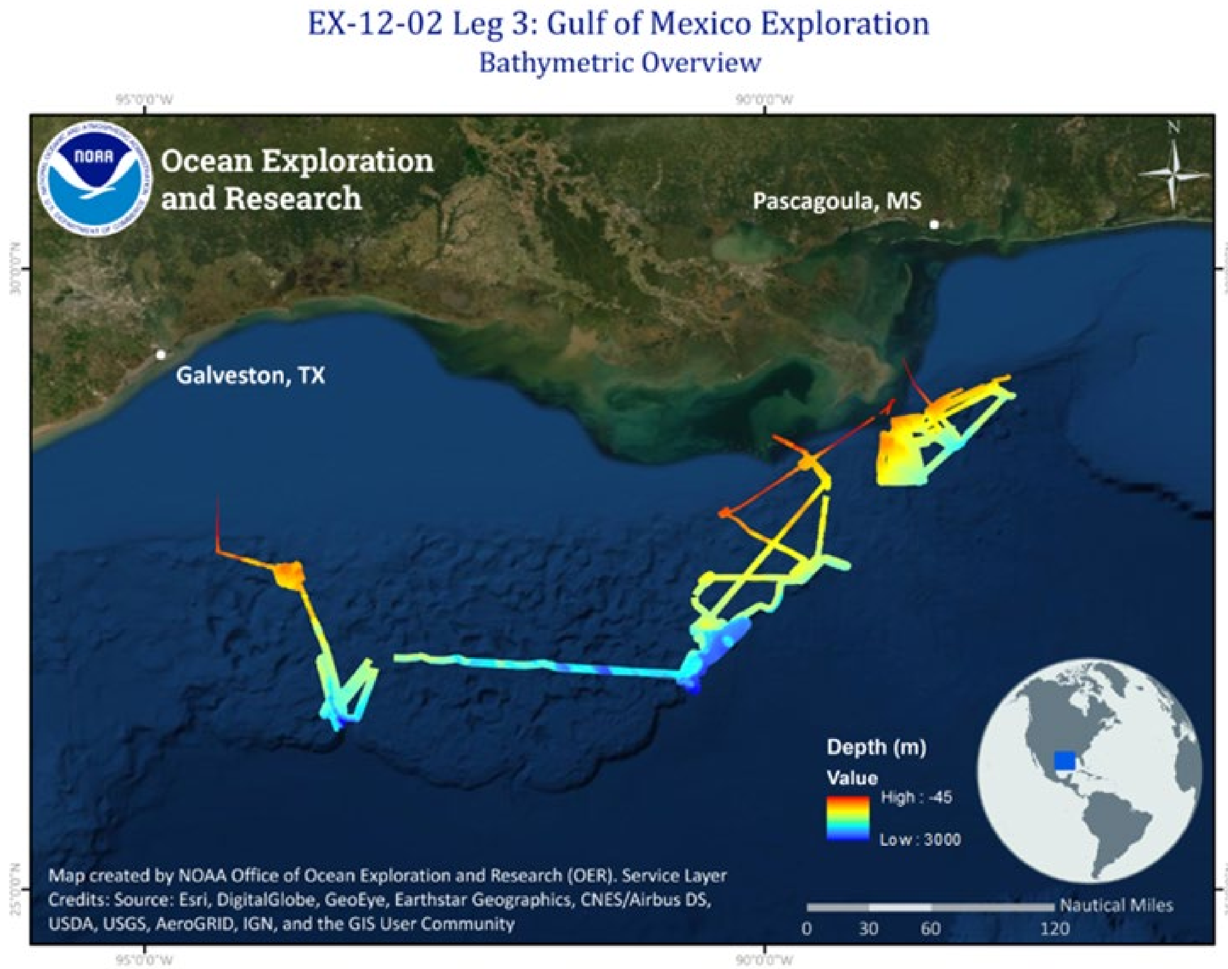

Figure 10. Overview of the operation area during EX-12-02 Leg 3 and color relief multibeam bathymetry data collected (blue = deep, red = shallow). The cruise mapped 14,416 sq km.

Additional information about the mapping conducted during EX-12-02 Legs 2 & 3, including data quality assessments, are in the EX-12-02 Leg 2 (Lobecker et al., 2017) and EX-12-02 Leg 3 mapping data reports (Candio, 2020).

7.2.1 Acoustic Operations Data Access

All links to the acoustic operations data were validated December 2020.

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/). To access these data, click on the Search Bathymetric Surveys button, select "NOAA Ship *Okeanos Explorer*" from the Platform Name dropdown menu, and select "EX1202L2" or "EX1202L3" from the

Survey ID 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.

Sub-Bottom Profiler (Knudsen Chirp 3260)

The sub-bottom profiler was not run during any of the EX-12-02 Leg 2 & 3 expedition's 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/). To access these data, select "Subbottom Profile" under Marine Surveys and click on Search Marine Surveys. In the pop-up window, select "EX1202_2" or "EX1202_3" 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-12-02 Legs 2 & 3 are archived at NCEI and available through their Water Column Sonar Data Viewer (https://www.ngdc.noaa.gov/maps/water_column_sonar/index.html). To access these data, click on the Additional Filters button, deselect "All" next to Survey ID, and select "EX1202L2" or "EX1202L3" 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.

7.3 Conductivity, Temperature, and Depth (CTD) Measurements

CTD profile data from EX-12-02 Leg 2 are archived at NCEI and available through OER's Digital Atlas (https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm), but no vessel CTD casts were conducted during EX-12-02 Leg 3. To access these data, click on the Search tab, enter "EX1202L2" in the Enter Search Text field, and click Search. Click on the point that represents EX-12-02 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.

8. Summary

Three cruises between March and April of 2012 explored the diversity and distribution of deep-sea habitats and marine life in the Northern Gulf of Mexico. The *Gulf of Mexico 2012* expedition Leg 1 expanded previous multibeam coverage during transits along the Florida Straits, Florida Escarpment, and West Florida Shelf. Primary survey operations focused on the DeSoto Canyon area and added to data acquired in 2011. EX-12-02 Legs 2 & 3 focused mapping, ROV, and telepresence operations on the West Florida shelf, Florida Escarpment, Green Canyon, Mississippi Canyon, DeSoto Canyon, the Sigsbee Escarpment, and Keathley Canyon. A variety of habitats were characterized, including cold seeps, deep coral communities, historic shipwrecks, undersea canyons, mud volcanoes, brine pools, and midwater environments. Highlights included:

- Five dives on known deep-sea coral communities support the national priority of improving our understanding of how deepwater coral communities change over time.
- In collaboration with the UNH Center for Coastal and Ocean Mapping (CCOM) and BOEM, scientists and technicians used a subset of Leg 3 ROV dives to test new tools developed to measure gas flux and ground truth EM 302 multibeam mapping capabilities.
- The team located seeps and conducted short-term monitoring for seep bubble signatures in the acoustic water column data. The ship repeatedly passed over the seep locations using an EM 302 multibeam echo sounder that is traditionally used for bottom mapping.
- During the first cruise leg, a water column survey methodology was developed and tested, using the ROV to explore life in the largely unknown water column biome.
- During EX-12-02 Legs 2 & 3, five potential or poorly known shipwreck sites that previously identified in industry surveys were investigated. These were the first archaeological sites investigated using an ROV from the *Okeanos Explorer*; by the end of the cruise, sufficient information had been collected to suggest that three of the sites were likely eligible for the National Register of Historic Places, and two likely represented significant or unique archaeological sites.

All areas explored were within the U.S. EEZ or the Extended Continental Shelf. At least 50 scientists, students and managers participated in the expedition remotely using telepresence technologies. Live video of the ongoing expedition was shared publicly online and received more than 80,000 visits.

8.1 EX-12-02 Leg 2

Mississippi Canyon Area Temporal Baselining

The critical need for even basic information about deepwater habitats in the Gulf of Mexico was frequently highlighted in the wake of the 2010 Deep Water Horizon accident. During EX-12-02 Leg 2, five dives provided an opportunity to assist with the national priority of assessing the deep-sea environment post spill. These dives were conducted on five deep-sea coral communities documented during previous expeditions in 2010 and 2011.

Between March 31 and April 5, the team visited five sites in the Mississippi Canyon (MC) area (lease blocks MC294, MC297, MC388, MC255, and MC036). These sites were seven miles southwest, 4.2 miles southwest, 4.7 miles southwest, 16 miles east, and 17 miles to the northeast of the well, respectively.

Figure 11. Close up image of a brittle star with arms wrapped around a paramuricid coral. The feeding side of the central disc is clearly visible in this still frame from *Little Hercules's* high-definition camera. The coral polyps, yellow buds distributed along the branches, are retracted. The scale across the bottom of the field of view is approximately 10 centimeters.

Using *Little Hercules*'s HD camera, more than 130 coral colonies and more than 400 associated individual animals living on them (**Figures 11 & 12**) were documented in great detail. Working around these corals, documenting individual branches and identifying small animals required extreme precision as disruptions could impact observations.

Figure 12. An amphipod (white upper center), a shrimp-like crustacean, here less than one centimeter in length, attached to a dead paramuricid coral branch from which hydrozoans (grey) are extending. Two flea-sized amphipods (red, below the white) on a hydroid branch are also visible.

Biology of the Northern Gulf of Mexico

High-diversity coral, sponge, and fish communities were documented on mounds and ridges during Dives 01 and 02 on the West Florida Escarpment, and during Dive 08 on a hill near DeSoto Canyon. All of these sites were in the 382-475 m depth range and strong water currents were noted. Fascinating observations included a *Plumarella* sp. coral colony with gonads visible inside its tissue on Dive 02 (**Figure 13**), and two instances of an anemone predating on a hatchetfish on Dive 08.

Figure 13. A “pregnant” coral. This is an octocoral, as evidenced by the eight tentacles on its polyps. The white dots visible in its almost translucent body may be developing embryos.

Dive 03 explored Green Canyon off of the West Florida Escarpment and Dives 04, 05, and 06 explored sections of the DeSoto Canyon. A common theme between the dives was the lack of sessile organisms around the heavily-sedimented lower portions of the canyons, around 2,200-2,400 m. Mobile fauna, such as Synaphobranchid eels and holosaur fish, were commonly seen in the lower canyons, along with holothurians (**Figure 14**). During the ascents up the canyons, rocky outcroppings started appearing with increasingly diverse assemblages of corals, sponges, anemones, shrimps, and fishes. During Dive 06 an unknown pennatulid octocoral was observed, as well as a tripod fish.

Figure 14. *Benthothuria* sp., an escape swimmer: When disturbed by the ROV, the *Benthothuria* sp. flexes its body and empties its gut of heavy sediment. Having come off bottom, it remains suspended due to the neutral buoyancy of its thick purple body wall.

Water Column Transects

During EX-12-02 Leg 2, Dive 06, a test of ROV midwater exploration transects was conducted while the ROV descended through potential sperm-whale feeding habitat on its way to other objectives on the bottom. During the time devoted to determining midwater capabilities and developing methods, depths of 600-1,200 m were searched because these are known feeding depths for sperm whales. The ROV was driven for 10 minutes along horizontal transects at 100-meter depth intervals. A precise distance is impossible to determine but the transect total was roughly 900 m (**Figure 15**). The crew managed to improve methods substantially between the beginning and the end of these observations. Having cameras on both *Little Hercules* and *Seirios* doubled the volume of water that could be observed during the transects. Although no clear observation of animals known to be whale food was made, fishes, shrimps, large drifting gelatinous animals, and mucus feeding structures were observed. Now that a better method for conducting ROV water column transects is known, OER intends to devote more time to exploring the midwater environment on future cruises.

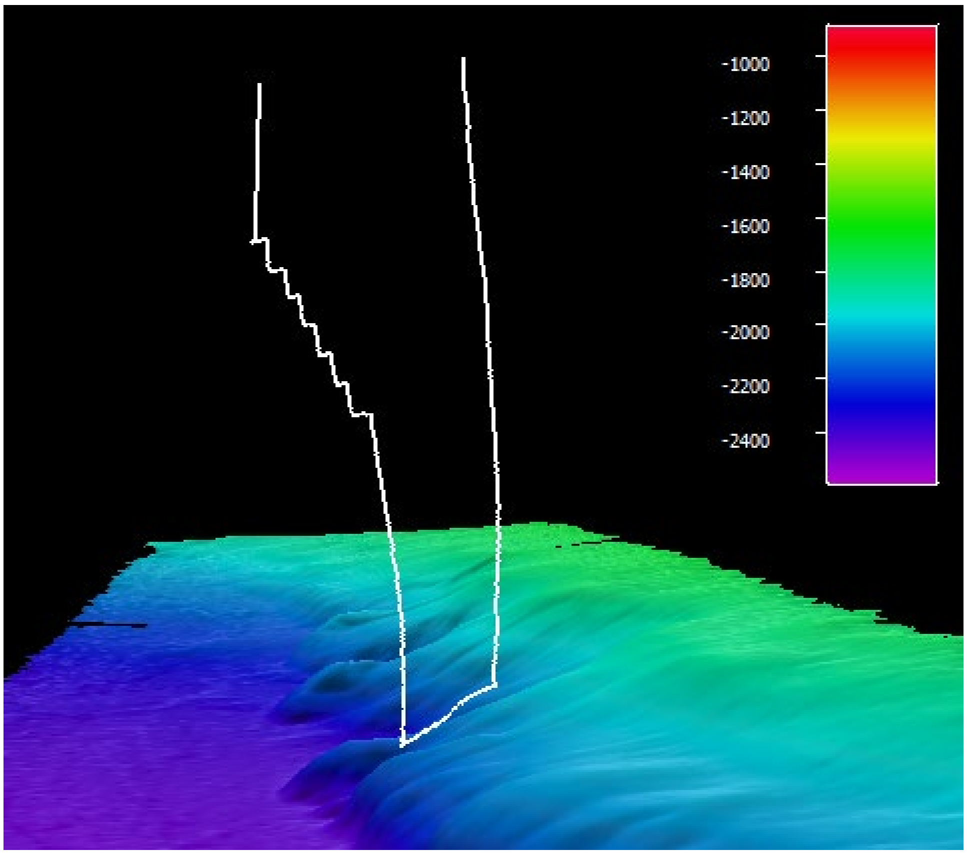

Figure 15. Multibeam bathymetry along the Florida Escarpment, with the EX-12-02 Leg 2 ROV Dive 06 track shown in white, depths shown in color scale in meters. Sawtooth portion of ROV dive track indicates water column exploration transects. Image created in Fledermaus with vertical exaggeration 3 applied.

Dive 16 of EX-12-02 Leg 2 included water column exploration transects (**Figure 16**) prior to exploring the seafloor. Horizontal video transects, 10 minutes each, were conducted every 100 m between 600-1,100 m during descent, totaling roughly 600 m of transect distance.

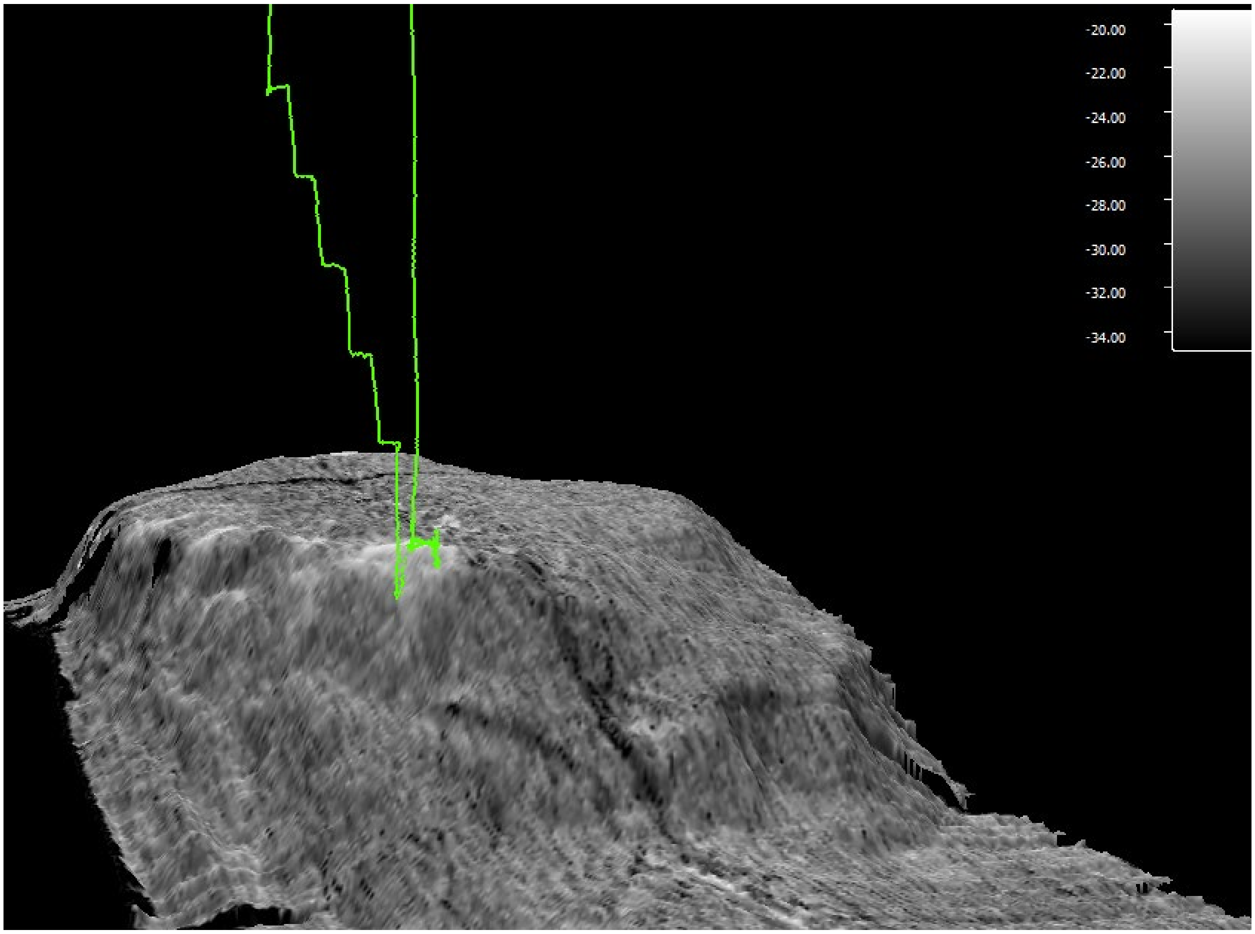

Figure 16. Image of multibeam bathymetry and draped bottom backscatter collected at Salt Dome, with the EX-12-02 Leg 2 ROV Dive 16 track shown in green, acoustic reflection strength down in color scale in decibel (dB). Sawtooth portion of ROV dive track indicates water column exploration transects. Image created in Fledermaus with vertical exaggeration 6 applied.

Underwater Cultural Heritage (UCH) Sites

During EX-12-02 Leg 2, three underwater cultural heritage sites were investigated. The first, Site 15584 in the DeSoto Canyon area, indicated what at first appeared to be a mass of cables, however a closer look revealed rigging elements and degrading wood. The site is thought to be the remnants of a mast either from a de-masting event (never before noted in the archaeological record and the first known in the Gulf of Mexico), or the mast of a shipwreck that has not yet been located. Investigation of Site 15429 in the Viosca Knoll area during Dive 09 revealed an iron hulled sailing vessel from the late 19th or early 20th centuries with steam-assisted machinery. Site 407, also in the Viosca Knoll area, revealed the wooden ribs or frames of a ship, with the frames on one side and at the bow covered so extensively by anemones and sponges it was difficult to obtain additional information.

8.2 EX-12-02 Leg 3

Seep Exploration

Of the 13 ROV dives conducted during EX-12-02 Leg 3, the first six addressed the gas seep exploration objective. Multiple seeps on the seafloor were identified in several areas, predominantly along the flanks of surfacing salt domes, and escaping bubble streams were imaged in detail.

In addition, bubbles were captured using an inverted clear cylinder on the ROV, and the resultant clathrate (frozen gas hydrate, a mixture of water and methane ice) was allowed to turn back into gas as the ROV rose slowly to the surface (**Figure 17**). This allowed investigators to measure volume precisely. Bubble streams were also calibrated using a visual grid affixed to the ROV.

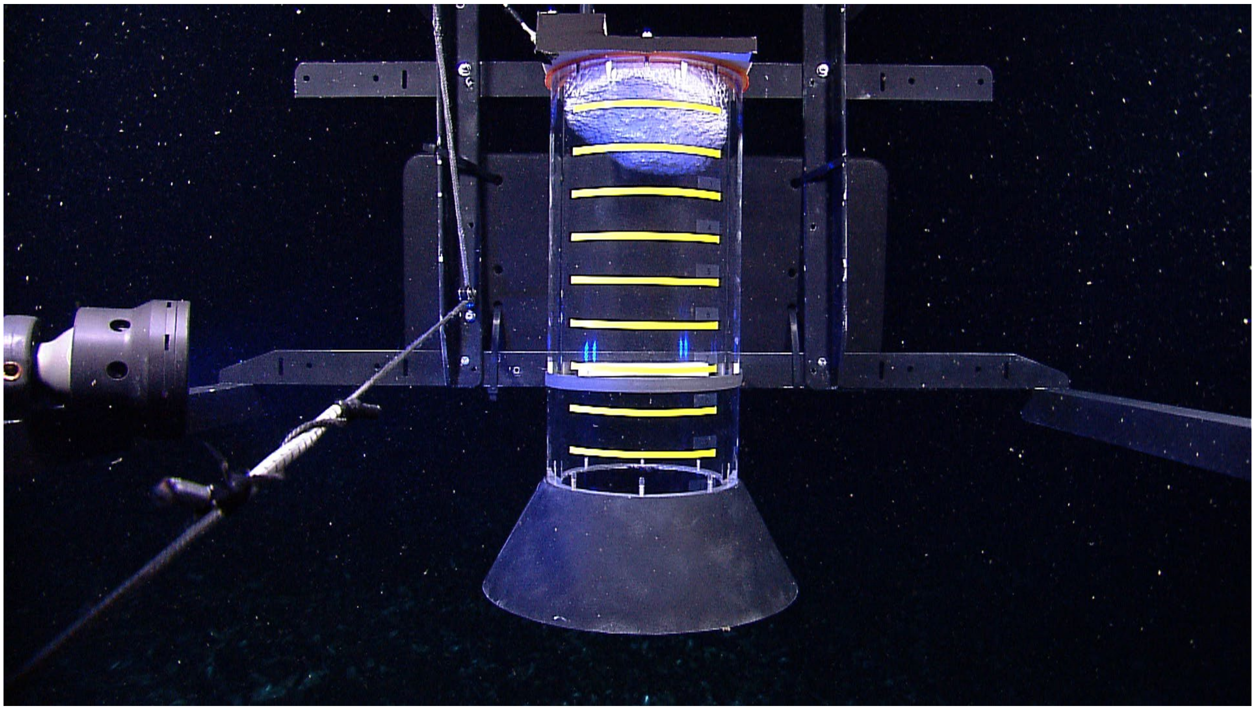

Figure 17. Methane bubbles rise into a clear cylinder, designed for measuring gas flux, where they form a mixture of hydrate and gas.

The ship revisited a series of naturally-occurring gaseous seeps that it first documented while conducting spatial exploration in 2011. On this cruise, there was an opportunity to temporally explore how the seeps change through time, and some important preliminary discoveries were made. From the evening of April 12 through the morning of April 13, six passes were made over the seeps along the same ship trackline (**Figure 18**). When considered together, the images from each consecutive pass form a “time lapse” series, which yields insight into seep behavior (Skarke, 2012).

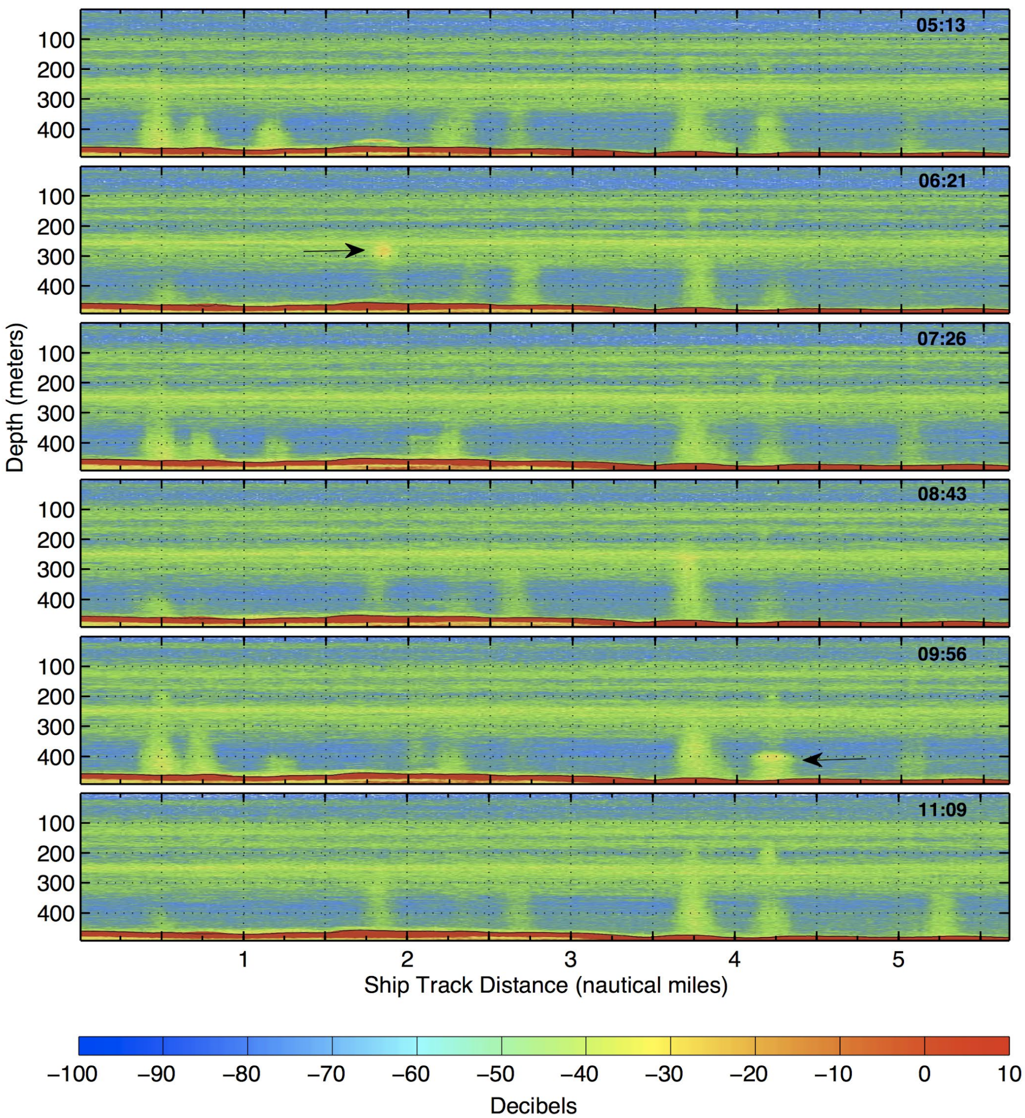

Figure 18. A time series of six sonar images collected over gaseous seeps at Biloxi Dome. The yellow-green vertical columns are seeps of gas bubbles emitted from the seafloor (red). Note changes in seep intensity through time and the appearance of "bursting" behavior denoted by the arrows.

Seep endemic fauna observed included mussels (*Bathymodiolus brooksi*) (**Figure 19**), vestimentiferan tubeworms (*Lamellibrachia* sp. and *Escarpia laminata*) (**Figure 20**), visible brine staining and bacterial mats (*Beggiatoa* sp.), shrimp (*Alvinocaris muricola*), galatheid crabs, *Chaceon* sp. crabs, numerous swimming copepods, stoloniferans, and methane hydrates colonized by the methane ice worm (*Hesiocaeca methanicola*).

Figure 19. Bubbles of methane gas rise through a mussel bed (*Bathymodiolus brooksi*) at the Pascagoula Dome.

Figure 20. An aggregation of vestimentiferan tubeworms (*Lamellibrachia* sp.). Such aggregations provide habitat for many smaller animals such as the small white anemones covering the tubeworm tubes and the shrimps *Alvinocaris muricola*.

Sigsbee Escarpment

Dives 08 and 09 were conducted in an area north and east of Sigsbee Escarpment, where OER collaborated with BOEM to identify dive targets based on BOEM's 3D seismic data. This area is characterized by uplifting salt deposits and hydrocarbons trapped beneath the impermeable salt, which occasionally escape through seeps. Dive 08 discovered several interesting seep features and biological communities, including large brine pools, small seep volcano features emitting gas/oil and brine (**Figure 21**), and multiple brine rivers flanked by carbonate hardgrounds (**Figure 22)** inhabited by corals (*Anthomastus* spp., bamboo corals), bacterial mats, anemones, and tubeworms.

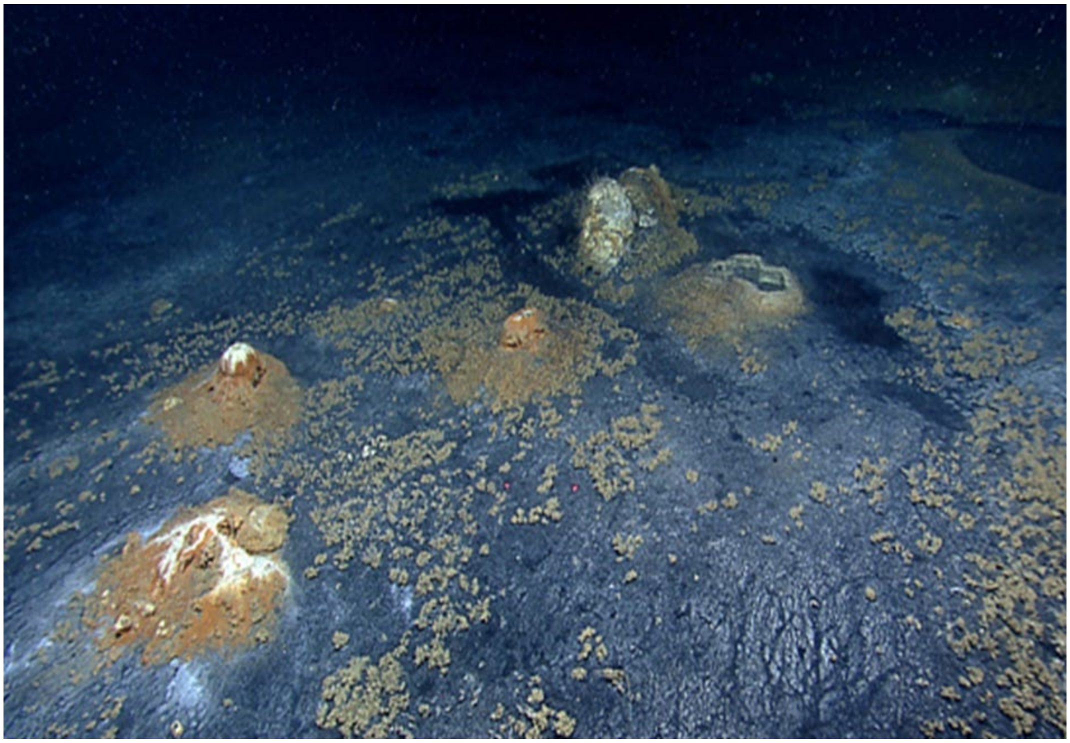

Figure 21. Salt "volcanoes" with oil, gas, and brine being expelled.

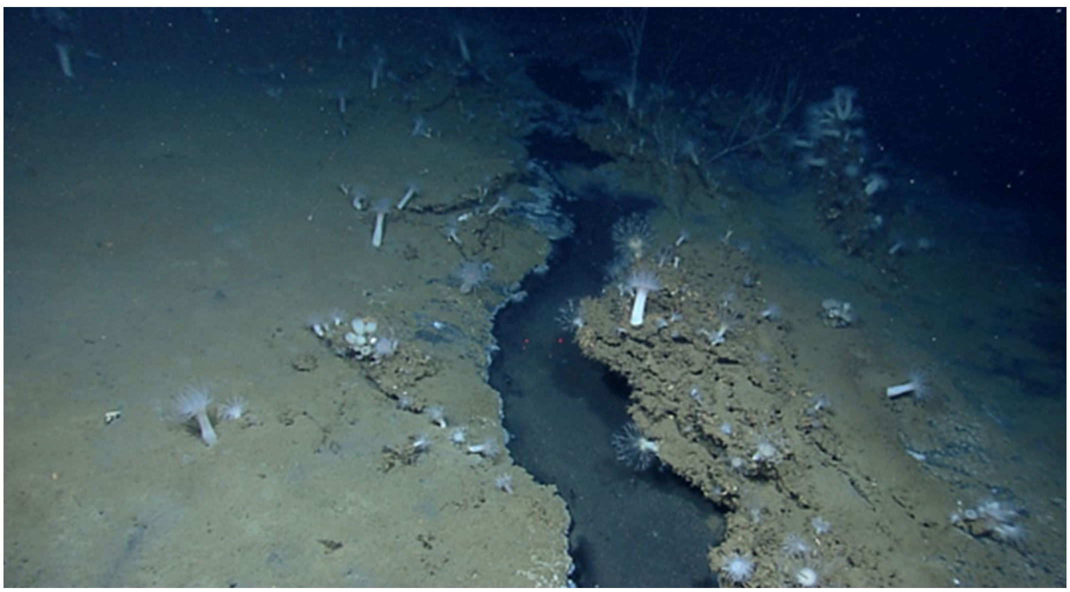

Figure 22. Underwater "rivers" and ponds of liquid brine were discovered at the EW915 site. When enough pressure is applied to buried salt by the overlying seafloor sediments, the salt flows, just like squeezing a tube of toothpaste. When salt squeezes up near the seafloor, it mixes with seawater and dissolves into brine, which is then brought to the seafloor by buoyant gas and oil. But, because brine is denser than seawater, it flows along the seafloor as rivers and streams, often collecting in massive pools to form brine lakes.

During Dive 09, no active seeps were identified. Towards the end of the dive, an extinct brine pool was observed. *Little Hercules* encountered no seep-related megafauna, nor any sessile cnidarians or sponges that typically inhabit hardgrounds (no hardgrounds were observed).

However, there was an unusually large abundance of fishes throughout the entire area. The most abundant were rattails (at least two species), followed by halosaurs, then eel pouts. There was an occasional cutthroat eel and chimera (short-nosed and long-nosed kinds).

Sigsbee Escarpment

Dive 10 ascended a salt dome on Sigsbee Escarpment with a number of asphalt outcrops. Some of the asphalt was liquid enough to form bubbles, which reflected the lights of the ROV. At one outcrop, the bubbles had long stalks and at another, the bubbles were surrounded by a casing of mucus (possibly from an unknown animal) (**Figure 23**). Other outcrops consisted of carbonate hardgrounds, inhabited by a variety of sessile animals: soft corals (gorgonians with associated ophiuroids, *Anthomastus* spp., bamboo corals, *Chrysogorgia* spp.), isolated tubeworms (*Lamellibrachia* sp.), sponges, and anemones. Three frogfish and a giant isopod were associated with one cluster of carbonate hardgrounds that was also colonized by sessile fauna (corals, sponges, and anemones).

Figure 23. Asphalt droplets emanating slowly from the seafloor. Some are suspended in a mucus casing.

Dive 11 was marked with occasional bedding plane outcrops, which appeared as near-horizontal steps in the otherwise steep slope, furnishing habitat for a variety of deepwater corals and their associates on both bedding planes and fragments (**Figure 24**). Several colonies of *Paramuricid* sp. octocorals were encountered, and their brittle star associates, presumably of the genus *Asteroschema*. Other noteworthy habitants of this community included whip, fan, and bushy bamboo corals (Keratoisidinae), and a few chrysogorgid corals cf. *Iridogorgia* and cf. *Chrysogorgia* with their respective crustacean associates (shrimp cf. *Bathypalaemonella* *serratipalma*), small paragorgiid bubblegum corals, a couple of mushroom corals cf. *Anthomastus*, *Swiftia* sp., and hexactinellid glass sponges. Large comatulid crinoids and squat lobsters were the most abundant mobile benthic fauna.

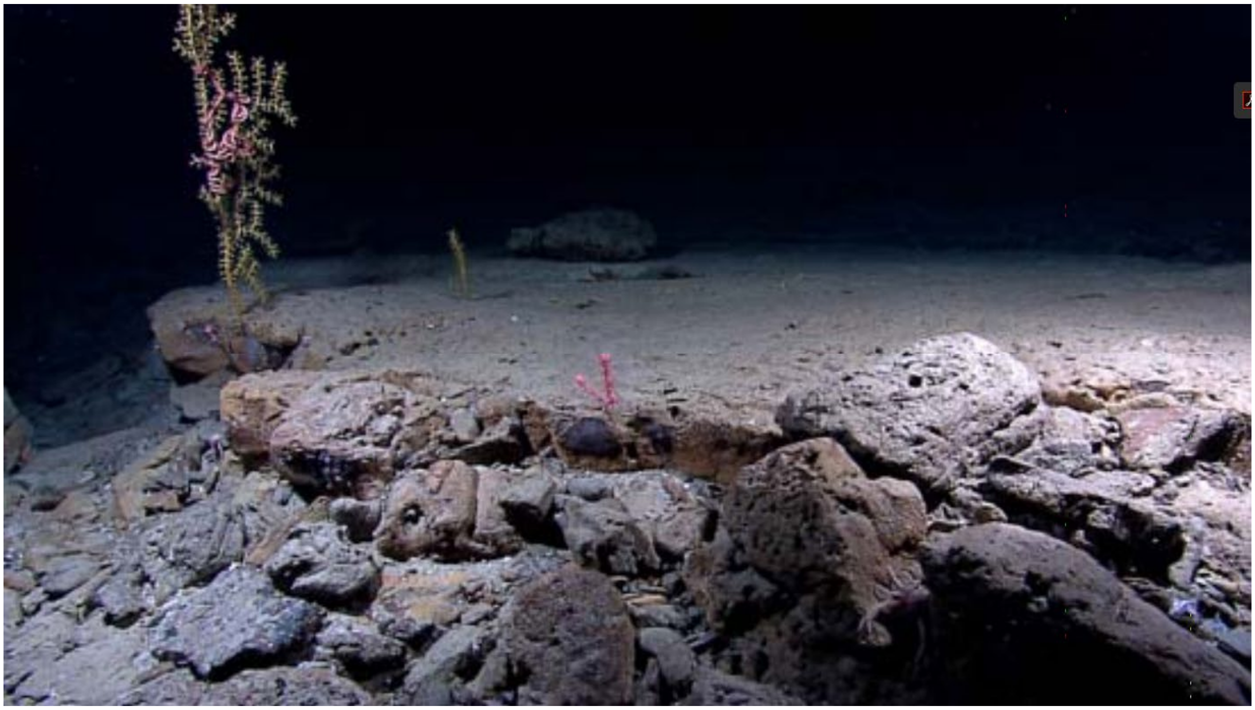

Figure 24. Soft corals colonized the flat step areas between steep cliff faces.

Keathley Canyon Area

Dive 13 traversed Keathley Canyon, observing many isidid ocotocorals and a few small basket-shaped isidid corals. The basket isidids each had one shrimp associate clinging to the branches, and two had another tiny shrimp hovering about the polyps like a hummingbird. One sea pen was being predated by a large fat sea star that was slowly climbing the coral skeleton eating all living tissue along the way (**Figure 25**). Another one of these sea stars was seen under a chrysogorgid coral, probably preying about that coral as well. There were many holothurians of at least three different types and several fish, including tripod fish, *Ipnops* sp. (which has photoreceptors on the top of its head instead of eyes), a giant snake eel, halosaurs, and rattails. There were at least three different kinds of sponges. Cylindrical hexactinellid sponges held a pair of amphipods within a cage of spicules, a long stalked sponge had zoanthids on the stalk and tiny amphipods swimming about its cone-shaped top, and another round sponge sat atop an ophiuroid, which sat atop an anemone. There were many large furrows speculated to be whale feeding traces (**Figure 26**).

Figure 25. A predatory sea star eating a sea pen (isidid octocoral).

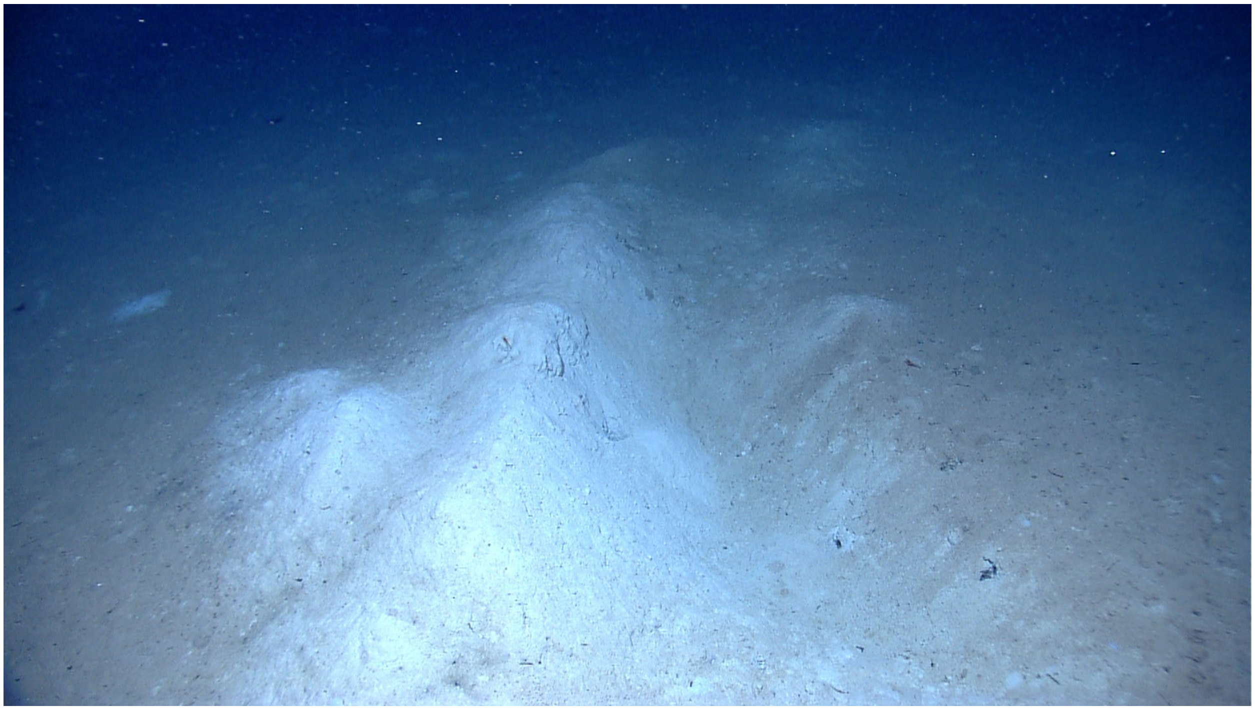

Figure 26. Impressions, called furrows, were found on the seafloor.

Underwater Cultural Heritage (UCH) Sites

During EX-12-02 Leg 3, two shipwrecks were investigated: Site 359, in 400 meters of water near the Mississippi Canyon, and Site 15577, in 1,330 meters of water east of the Keathley Canyon. The first, Site 359, was a large, stoutly built, and remarkably intact wooden-hulled sailing vessel initially dated to the late 19th or early 20th century. It measured 61 meters in length and may be the best-preserved wooden shipwreck yet discovered in the Gulf of Mexico. The second, Site 15577, was a wooden-hulled sailing vessel sheathed in copper, likely from the early 19th century (**Figure 27**). A dense collection of artifacts were inside the hull, including bottles of all shapes, sizes, and colors; plates; multiple anchors and cannon; and stacked muskets (Horrell and Borgens, 2014). This site was later named the “Monterrey wreck”.

All of these sites were investigated with an interdisciplinary team of archaeologists, historians, scientists, and managers from across industry, government, and academia. Despite their geographic distribution, they came together to accomplish initial characterization of five sites resting hundreds to thousands of meters deep on the Gulf of Mexico seafloor. By the end of the cruise, sufficient information had been collected to suggest that three of the sites were likely eligible for the National Register of Historic Places, and two likely represented significant or unique archaeological sites. Further research and analysis would be required to know for sure. The imagery and data collected during the expedition was just the first step to open the history books to these wreck sites. Continued analysis will start to fill in the pages of their stories.

Figure 27. Site 15577—the “Monterrey wreck”: While most of the wood has long since disintegrated from what is believed to be an early- to mid-19th century wooden-hulled shipwreck on the deep Gulf of Mexico seafloor, copper that sheathed the hull beneath the waterline as a protection against marine-boring organisms remains, leaving a copper shell retaining the form of the ship. The copper has turned green due to oxidation and chemical processes over more than a century on the seafloor. Oxidized copper sheathing and possible draft marks are visible on the bow of the ship.

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10. Appendix

Appendix A: Data Management Plan

EX-12-02 Legs 2 & 3 Data Management Plan

All data collected during this expedition is expected to be archived at the National Geophysical Data Center (NGDC) in accordance with the NOAA / OER data management protocols specific to Legs 2 and 3 of the EX-12-02 mission entitled "Gulf of Mexico Exploration." For more detailed information on the data management effort for the Okeanos Explorer in FY12, please refer to that document.

SECTION A
General Description of the Data to be Managed

- Name of Dataset
  - "EX1202 Legs II & III: Gulf of Mexico Exploration"
- Mission Specific Keywords:
  - Tampa
  - Desoto Canyon
  - Mississippi Canyon
  - Green Canyon
  - West Florida Shelf Break
  - West Florida Shelf Slope
  - West Florida Shelf
  - Deepwater Horizon
  - Flower Garden Banks
  - National Marine Sanctuary
  - Pascagoula
  - Galveston
  - Water-column flux
  - Ground-truth acoustic
  - Gas seeps
  - Deep corals
- Summary description:
  - During Legs II and III of the *Okeanos Explorer (EX)* mission EX1202, the vessel will perform ROV, CTD, and mapping operations in the northeastern region of the Gulf of Mexico around DeSoto, Mississippi, and Green Canyons.
  - Data management procedures are fully documented in the data management plan for the Okeanos Explorer for the FY12 field season (EX_FY12_DMP.pdf)
- Temporal Bounds:
  - Leg II: March 19, 2012 – April 7, 2012
  - Leg III: April 11, 2012 – April 29, 2012
- Spatial Bounds:
  - Legs II and III:
    - Northern – 30
    - Southern – 26
    - Western – -92
    - Eastern – -85

- Data Type Collections for Preservation/Stewardship:
  - Multibeam Bathymetry – continuous collection during the entire 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
  - XBT – continuous casts approx. 2-4 hours apart collecting water temperature at depth for sound velocity calculations
  - CTD – test casts with Rosette firings collecting conductivity, temperature, depth and water samples at targeted depths
  - Knudsen CHIRP 3260 –sub-bottom profiler data as deemed appropriate by the ship
  - EK60 – single beam sonar for water column features during the entire duration of the expedition
  - Low and medium-resolution video clips
  - Video framegrabs
- Data Product/Product Collections for Preservation/Stewardship:
  - Gridded bathymetry (.txt)
  - Gridded bathymetric image (.tif)
  - Fledermaus gridded bathymetry imagery (.sd)
  - Fledermaus gridded backscatter imagery (.sd)
  - Google Earth gridded bathymetry (.kml)
  - ArcView gridded bathymetry (.asc)
  - SCS data output in NetCDF
  - CTD data output in NetCDF
  - Final Mapping Summary document
  - Final Cruise Summary document
  - Dive Planning Reports
  - Dive Summary Reports
  - ROV Tracklines
  - Dive Trailers
  - Highlight Images
  - Cruise Summary Report
- Volume of Data Expected
  - Approximately 150 GB of data is expected to be collected on this mission.
- Personally Identifiable Information (PII) concerns
  - No PII will be included in these data.

Points of Contact

- Overall Point of Contact (POC) for the data:
  - Data Acquisition: Jeremy Potter (Jeremy.Potter@noaa.gov)
  - Data Management: Susan Gottfried (Susan.Gottfried@noaa.gov)

- Responsible for Data Quality:
  - Seafloor mapping and water column data: Elizabeth Lobecker
  - SCS data: Office of Marine and Aviation Operations (OMAO): LT Megan Nadeau, Okeanos Explorer Operations Officer (Ops.Explorer@noaa.gov)
  - Imagery and Video data: Webb Pinner (Webb.Pinner@noaa.gov)
  - Video products: Jeremy Potter
- Responsible for data documentation and metadata activities:
  - National Coastal Data Development Center (NCDDC); Susan Gottfried, OER Data Management Coordinator
- 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: Jeremy Potter, OER, Expedition Manager
  - Data Acquisition: Lt. Megan Nadeau, OMAO, Okeanos Explorer Operations Officer
  - Video data: Webb Pinner, OER, Okeanos Explorer Systems Architect
  - Data Management: Susan Gottfried, OER Data Management Coordinator

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 and converted to a variety of products.
  - Data from sensors monitored through the SCS are archived in their native format and are not quality controlled.
  - Data from the unmanned vehicles 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 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 NODC/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. Data collections and products will be documented with ISO, FGDC CSDGM, or MARC 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. Special consideration will be made to data availability in the case where submerged cultural resources are targeted or inadvertently discovered.

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 FY12 Data Management Plan (EX_FY12_DMP.pdf) for detailed descriptions of the processes, procedures, and partners involved in this collaborative process. Section B has an excerpt from EX_FY12_DMP.pdf) that illustrates the data and product pipelines that will be employed for this mission.

Data Management Objectives

The DMT's objectives for this mission are:

- Provide personnel to man the potential ECC at Stennis Space Center; provide escort for Foreign Nationals, if necessary.
- Develop ISO collection-level and dataset-level metadata records for multibeam, singlebeam sonar, and sub-bottom profiler data.
- Develop ISO metadata for individual survey track lines.
- Develop ISO metadata for multibeam survey products.
- Develop FGDC metadata for XBT, CTD, and METOC data.
- Develop FGDC metadata for each video clip, both medium and low-resolution.
- Develop MARC metadata for each ROV dive operation video collection.
- Develop MARC metadata for each ROV dive operation image collection.
- Develop MARC metadata for each video or image product and for each report or summary generated.
- The Expedition Coordinator will be notified to direct someone onboard to copy all SCS, EK60, CTD, XBT, and multimedia data (native, low, and medium resolutions) to hard-drive supplied by the data management team to bring back for post-processing.
- 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.

- CTD cast locations with thinned profiles to be compared to the World Ocean Atlas historical profiles for the general location and month.
  - Daily cumulative bathymetric image overlays received via URI SRS.
  - ROV tracklines with representative image, if available
- Execute multibeam, oceanographic, and video data pipelines according to the FY12 DMP (EX_FY12_DMP.pdf).

Expedition Principals for Data Management
Webb Pinner, OER Telepresence, EX Data and Information Lead, Webb.Pinner@noaa.gov
Sharon Mesick, NCDDC, Federal Program Manager, 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
Dave Fischman, NGDC, Geophysical Data Officer, David.Fischman@noaa.gov
Tom Ryan, NODC, Oceanographic Data Officer, Thomas.Ryan@noaa.gov
Anna Fiolek, NCL, Multimedia Librarian, Anna.Fiolek@noaa.gov

SECTION B: Data and Product Pipelines (excerpt from EX_FY12_DMP.pdf)

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 collection level metadata record describing the data inventory to be archived at the NODC/MDSD will be included with the data submission.

Oceanographic/Meteorological/Navigational Data/Products Pipeline

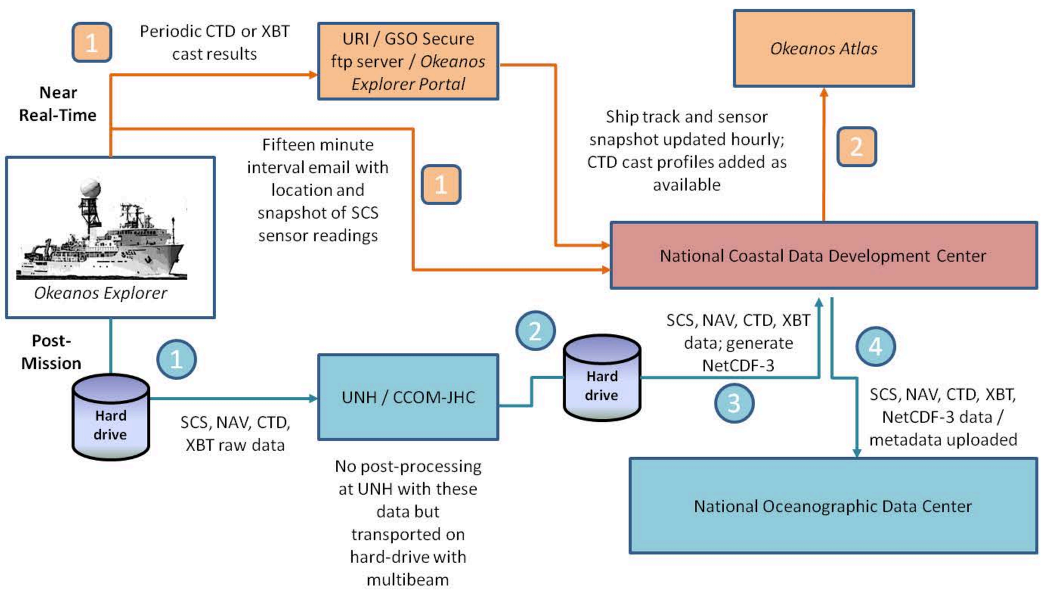

Fig 1: Oceanographic/Meteorological/Navigational Data Archive Pipeline

At periodic (currently twenty 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 or XBT casts are deployed, the results of the cast are included in the hourly 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. Ship track and sensor snapshot readings are geo-located on the Okeanos Atlas.

1 All SCS data, including navigation and CTD/XBT cast data are saved to a hard-drive. This hard-drive is the same that will hold the multibeam survey raw data and products generated on-board. 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, after which it will be shipped to NCDDC.

2 The Data Management team will post-process the SCS, NAV, CTD, and XBT raw data files, adding ASCII headers to each file and generating NetCDF-3 formatted files for the entire cruise for both SCS/NAV data and CTD/XBT data. FGDC CSDGM metadata will be generated for the navigational data and for the METOC sensor data.

3 The ASCII files, and the metadata will be uploaded to the National Oceanographic Data Center (NODC), where they will be accessioned and archived.

4 The NetCDF3 files will be stored within 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

Appendix B: Categorical Exclusion Memo

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

February 29, 2012

MEMORANDUM FOR: The Record

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

SUBJECT: Categorical Exclusion for NOAA Ship *Okeanos Explorer* cruise EX1202, Legs 2 & 3

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 "EX1202 Northern Gulf of Mexico Expedition" and will be led by Jeremy Potter, an Expedition Manager for NOAA OER. The work will be conducted in March and April at various locations in the Northern Gulf of Mexico. A tandem 4,000 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 may also be operated. 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 with only short-term effects on the environment and for which any cumulative effects are negligible. As such, this project is categorically excluded from the need to prepare an environmental assessment.

Signed: [signature] Date: 2/29/2012

John McDonough, Deputy Director

Appendix C: SOP for the Survey of Underwater Cultural Sites

ROV Investigation Procedure for Potential Archaeological Targets

This outlines the standard operating procedure (SOP) for initial investigations of potential submerged cultural resources. While this SOP addresses shipwrecks, it also applies to aircraft or any other anthropogenic features. Equipment requirements include the ROV and *Seirios* camera sled with HD video, parallel lasers for scale and Hydrargyrum medium-arc iodide (HMI) lighting.

During deployment, the ROV and *Seirios* HD video cameras should record continuously, if useful for the biologists and oceanographers on the way to the bottom. All navigation and positioning data should be recorded including ROV track, depth/altitude, ultra-short baselline (USBL) ping rates. Other oceanographic sensors deployed on the vehicles, including the CTD, should be operational and data collected.

Deployment at Potential Archaeological Sites

Operation: The ROV should be deployed using standard procedures for the ROV and *Seirios*. *Seirios* maintains a safe altitude off the bottom and is connected to the ROV by a 40-meter soft tether. Operating methods combined with syntactic floats attached to the tether provide buoyancy to keep the tether off the bottom and to avoid snag hazards. The ROV should approach the wreck from downstream of the current and at a high enough altitude to not disturb the seafloor.

Reasoning: This approach to the wreck site is taken for both the safety of the ROV and protection of the wreck itself. Since unknown entanglements not seen on geophysical data may be present, this approach lessens the chance for the ROV to inadvertently become ensnared in wreck debris. Additionally, organic remnants of the vessel that have disintegrated may still be visible as stains, linear patterns of organisms, or biological remains on the seafloor. This approach allows these remnants to be observed and documented.

Reconnaissance of Target

Operation: The initial inspection of the site should begin with an overall reconnaissance of the primary target. Once the bottom conditions are assessed and currents carefully considered, the dive supervisor and the marine archeologist will determine the safest approach for documenting the target. As much as possible and practical, and within the limits of visibility and lighting, the ROV should carefully document the entire object in a systematic approach that provides a good visual overview of not only the target but also the distribution of associated marine organisms.

During the reconnaissance portion of the investigation cameras should not be zoomed in and out, but if necessary to use the zoom, it should be done only on a minimal basis. If the target is found to not be a shipwreck, the object will be documented and the investigation concluded.

Reasoning: The completion of a reconnaissance survey provides an overall first documentation of the site and allows scientists to grasp an understanding of the site layout. With this information, scientists can utilize available exploration time more efficiently for documentation of key areas or objects.

Inspection of Key Areas

Operation: Following the reconnaissance, specific features or areas of the wreck will be investigated and close-up video acquired to assist identifying the shipwreck's origin, age, cargo type, use, or other cultural affiliations. In addition, this inspection should provide close-up video of marine organisms and other features of interest to the science team. Navigation fixes will be taken at the bow, stern, and along both starboard and port gunwales to help delineate the size and orientation of the wreck. During this segment of the operation, care must be taken to ensure the tether does not impact the wreck site and that any disturbance from thruster wash is kept at a minimum.

Reasoning: During the reconnaissance cruise, key features of the wreck site or key areas were identified and prioritized. This segment of the investigation allows scientists to use the remaining time efficiently to document these locations with detailed HD video.

Video Transects and Debris Field

Operation: The ROV available in 2012 has limited ability to do accurate survey work. This will impact the ability to conduct video transects and debris field investigations. If possible, a high altitude video survey of the site and surrounding area should be made using the ROV or *Seirios* camera sled. A series of video transect lines should be run as looking straight down, or as close to vertical as possible, without zooming. Following the initial survey, significant or diagnostic features should be investigated and close-up video acquired. The surrounding area should be investigated to record the debris field. Use scanning sonar to define the geometry and size of the debris field. Record depressions, scours, mounds, and impact scars that reveal information on the sinking process, oceanographic processes, or underlying geology.

Reasoning: Since site visits are limited in deepwater areas, as much information needs to be acquired as possible, keeping in mind the limitations of the current ROV. Transects allow site plans to be developed to assist future investigation planning.

Appendix D: Acronyms

3D—Three-dimensional
BOEM—Bureau of Ocean Energy Management
BSEE—Bureau of Safety and Environmental Enforcement
CCOM—UNH Center for Coastal and Ocean Mapping
CTD—Conductivity, temperature, and depth
dB—Decibel
DO—Dissolved oxygen
DSCRTP—NOAA Deep Sea Coral Research and Technology Program
DWH—Deepwater Horizon
ECC—Exploration Command Center
EEZ—Exclusive Economic Zone
EX—NOAA Ship *Okeanos Explorer*
FAU—Florida Atlantic University
FOUO—For official use only
FSU—Florida State University
FTP—File transfer protocol
GEMS—Geoscience Earth and Marine Services
HBOI—Harbor Branch Oceanographic Institute
HD—High-definition
HMI—Hydrargyrum medium-arc iodide
IFE—Institute for Exploration
IP—Internet Protocol
ISC—Inner Space Center
kHz—Kilohertz
km—Kilometers
LSS—Light scattering sensor
LSU—Louisiana State University
Mbps—Megabits per second
MC—Mississippi Canyon
NCEI—NOAA National Centers for Environmental Information
NEPA—National Environmental Policy Act
NHHC—Naval History and Heritage Command
NMFS—NOAA National Marine Fisheries Service
NOAA—National Oceanic and Atmospheric Administration
NSF—National Science Foundation
OEAWG—NOAA Ocean Exploration Advisory Working Group
OER—NOAA Office of Ocean Exploration and Research
OMAO—NOAA Office of Marine and Aviation Operations
ONMS—NOAA Office of National Marine Sanctuaries
ORR—NOAA Office of Response and Restoration
ORP—Oxygen reduction potential
Penn State—Pennsylvania State University

ROV—Remotely operated vehicle
RTS—A brand of intercom systems
SI—Smithsonian Institution
SIS—Seafloor Information System
SOP—Standard operating procedure
TSG—Thermosalinograph
UCAR—University Corporation for Atmospheric Research
UCH—Underwater Cultural Heritage
UNH—University of New Hampshire
URI—University of Rhode Island
USBL—Ultra-short baseline
UTC—Universal Time Coordinated
VoIP—Voice over Internet Protocol
VSAT—Very Small Aperture Terminal
WHOI—Woods Hole Oceanographic Institution
XBT—Expendable bathythermograph