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Ocean Exploration and Research

EX1502 Leg 3
Océano Profundo 2015:
Exploring Puerto Rico's Seamounts, Trenches, and Troughs

Expedition Report

Remotely Operated Vehicle (ROV)
and Mapping Exploration of
Deepwater US Caribbean Habitats

April 09 to April 30, 2015

San Juan, PR to San Juan, PR

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Abstract:
In April 2015, NOAA Ship *Okeanos Explorer*, the only US federal ship dedicated to ocean exploration, systematically explored previously unknown deep sea ecosystems in the US waters of the Caribbean. Operations focused on deep-water habitats in and around the Puerto Rico Trench and the US Virgin Islands. Over 10,854 km² of previously unmapped seafloor were mapped with a high-resolution multibeam, revealing rugged canyons along shelf breaks, intricate incised channels, and complex tectonic features. Twelve ROV dives, in the 300-6,000 m depth range, surveyed seamounts, escarpments, submarine canyons, and the water column revealing diverse ecosystems and habitats. Discoveries include large assemblages of deep-sea corals, range extensions, and observations of several rare and new species. For example, the seastar *Laetmaster spectabilis* had not been documented since its original description in 1881. This document summarizes the operations conducted on *Okeanos Explorer* during *Océano Profundo 2015* (EX1502 Leg 3) and highlights potential features and observations of interest to the ocean science and management communities.

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1. *Okeanos Explorer* Introduction

Commissioned in August 2008, the NOAA Ship *Okeanos Explorer* is the nation's only federal vessel dedicated to ocean exploration. With 95% of the world's oceans left unexplored, the ship's combination of scientific and technological tools uniquely positions it to systematically explore new areas of our largely unknown oceans. These exploration cruises are explicitly designed in collaboration with the broad science community to provide a foundation of publicly accessible baseline data and information to support science and management needs. This baseline information often leads to further, more detailed, investigations by other parties.

The unique combination of mission capabilities including a high-resolution multibeam sonar, remotely operated vehicles, telepresence technology, and integrated data management system quicken the scientific discovery and dissemination process. These systems enable us to identify new targets in real time, dive on those targets shortly after initial detection, and then send this information back to shore for immediate near-real-time collaboration with scientists and experts at Exploration Command Centers around the world. The integrated data management systems provide for the quick dissemination of information-rich products to the scientific community. This ensures that discoveries are immediately available to experts in relevant disciplines for research and analysis.

NOAA's Office of Ocean Exploration and Research (OER) provides the nation with an unparalleled capacity for ocean exploration. The missions of the program include: 1) to discover and investigate new oceanic regions and phenomena, 2) conduct baseline research required to document discoveries, and 3) seamlessly disseminate data and information-rich products to a multitude of users. OER strives to develop technological solutions and innovative applications to critical problems in undersea exploration and to provide resources for developing, testing, and transitioning solutions to meet these needs.

2. Expedition Overview

From April 9 to April 30, 2015, *Okeanos Explorer* explored the largely uncharted deep-sea ecosystems and seafloor in the vicinity of Puerto Rico and the U.S. Virgin Islands. During *Océano Profundo 2015: Exploring Puerto Rico's Seamounts, Trenches, and Troughs*, our at-sea and shore-based science teams worked together to investigate unknown and poorly known areas, including the Puerto Rico Trench, Muertos Trough, Mona Passage, and the Virgin Islands Trough. Priority operating areas for this expedition were identified by resource managers, and federal and state partners through broad participation of the marine science community. This expedition featured some of the deepest remotely operated vehicle (ROV) dives ever conducted in the region and collected critical deep-water environmental data that will improve ecosystem understanding and inform federal and local resource managers.

A. Rationale for Exploration

A diversity of seafloor features lie just offshore Puerto Rico and the US Virgin Islands that include numerous trenches, seamounts, submarine canyons, valleys, and troughs. These

features contain valuable and vulnerable ocean resources, but very little is known about them. Thus, this was an important area to survey to increase knowledge about the biodiversity of this region. Also, because this region lies at the boundary between two tectonic plates, it is very geologically active with the potential for significant geohazards, such as earthquakes and tsunamis. Collecting high-resolution multibeam bathymetry and conducting ROV surveys for evidence of slope failure provides a better understanding of the future potential of these geohazards.

B. Objectives

EX1502 Leg 3 operations covered a wide area of the US EEZ around Puerto Rico and the US Virgin Islands. The primary goals for this cruise included: 1) collecting baseline characterization data of poorly known areas in the Caribbean portion of the US EEZ, 2) testing extended ROV dive operations, 3) bringing the ROV *Deep Discoverer* to the their maximum rated operating depth of 6,000 meters, and 4) using telepresence technology to engage the shore-based science team and the general public.

Mission objectives for EX-15-02 Leg 3 included a combination of operational, science, education, outreach, and data management objectives:

i. Science
    a. Identify and explore the diversity and distribution of benthic habitats and features in priority areas (e.g., deep corals and related benthic ecosystems, canyons, and seamounts)
    b. Ground-truth acoustic data using video imagery and characterize associated habitat
ii. Remote Science/Exploration Command Centers
    a. Test and refine ship-to-shore communications and operations procedures that engage multiple ECCs and other remote participants
    b. Engage a broad spectrum of the scientific community and public in telepresence-based exploration
iii. ROV
    a. Integrate ROV into ship systems after winter repair period and transit to the Caribbean
    b. Test and assess the feasibility of conducting daily 12 hour ROV dives
    c. Conduct ROV dives on exploration targets
    d. Train team members on use of new ROV manipulator
    e. Ongoing system familiarization, documentation, and training
    f. Test new ROV sub systems
    g. Test the ROVs maximum operating depth (6000m)
iv. Telepresence
    a. Support telepresence-enabled ROV operations
    b. Collect/create all standard video products
    c. Evaluate new video encoders
    d. Facilitate live outreach events between ship and shore
    e. Assess the feasibility handling video and staffing of daily 12 hour ROV dives

v. Mapping
    a. Collect high resolution mapping data from all three sonars during transit, with possible further development of exploration targets
    b. Support ROV operations with mapping products and expertise
    c. Collect XBT casts at regular intervals no longer than 3-4 hours, as data quality requires, during mapping operations
    d. Create daily standard mapping products
vi. Data Management
    a. Provide a foundation of publicly accessible data and information products to spur further exploration, research, and management activities, as detailed in the 2015 post-cruise product list
    b. Provide daily products to shore for operational decision making purposes, as detailed in the 2015 field products list
    c. Test the ability to record high definition video footage of a full dive onboard the ship
    d. Train data management intern
vii. Outreach
    a. Engage the general public in ocean exploration through live video and timely content (daily updates, topical essays and web logs, highlight videos, video clips, still imagery and mapping products) posted on the Ocean Explorer website
    b. Conduct ship tours for media and live interactions with VIPs and education outlets
    c. Conduct Reddit AMA from the ship

C. List of participants

At-sea mission personnel:

Name	Role	Affiliation
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Kasey Cantwell	Web Coordinator	NOAA OER (Acentia)
Brendan Reser	Data Lead	NOAA NCDDC (DGIT)
Jared Drewniak	Video Lead	NOAA OER (ERT Inc)
Andrea Quattrini	Science Co-Lead	USGS
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Jim Newman	ROV Engineer	UCAR

Bobby Mohr	ROV Engineer	UCAR
Jeff Lanning	ROV Engineer	UCAR
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3. Methods

Operations on *Okeanos Explorer* are conducted 24 hours-a-day. During EX1502 Leg 3, ROV operations were conducted during the day light hours, with mapping operations conducted during non-ROV hours. Twelve, ten, and eight hour dives were each conducted during this expedition as staffing and transits allowed. EX1502 Leg 3 operations included EM 302 multibeam, EK 60 singlebeam, and Knudsen subbottom profile data collection. Mapping operations were conducted when transiting between dive sites, opportunistically filling data holidays, and during transits to and from port for repairs. No samples were collected during this expedition and no shipboard CTD deployments were conducted. CTD data were collected via the CTD sensors onboard both ROVs.

During EX1502 Leg 3, the vehicles conducted 12 dives at depths ranging from 300-6,000 meters. The ROVs spent a collective 113:11:14 hours in the water and 73:36:31 hours on the seafloor. A total of 4778.35 GB (2381 files) of ProRes video data were collected.

During ROV dives 04, 05, and 11, midwater transects were conducted. During these transects, the vehicles conducted 10 minute transects at 100 meter intervals between depths of 800-1,200 meters. After these transects were completed, the vehicles continued their descent to survey the seafloor.

This expedition tested the feasibility of twelve hour dive operations. This operating model allowed for extended bottom times and additional baseline data collection, but was taxing on ship and mission personnel. After the in port repair period, extended ROV operations resumed, but on a rotational basis, with extended operations on deep dives and 8-10 hour operations on shallow targets.

Compared to most of the oceans, the seafloor around Puerto Rico has been relatively well mapped using ship-based sonars. However, in many places the resolution of the bathymetric grids that can be made based on existing data is limited to approximately 100-150 meter grid cells. Fifty meter resolution bathymetric grids or finer are typically required to pick desirable ROV exploration targets and plan safe ROV dive operations. The majority of dive sites of highest interest to scientists participating in the expedition were located in areas that lacked high-resolution multibeam sonar data. Therefore, most dive locations were mapped overnight just prior to conducting ROV dives during daylight hours.

For dive planning purposes, existing gridded bathymetry data were viewed in collaboration with the onshore science team each day and dive tracks were planned for the next day. Planned dive tracks were plotted in 3D and shared with the team. Mapping operations were initiated as soon as the ROV was recovered each day and continued throughout the night until ROV deployment the

following day. Kongsberg EM302 multibeam, Simrad EK60 split-beam, and Knudsen 3260 sub-bottom profiler sonar data were collected simultaneously during mapping operations. To ensure high quality multibeam data, sound speed profiles of the water column were obtained using expendable bathythermographs (XBTs) every few hours during mapping operations. Forty XBT casts were completed during the expedition. Raw multibeam bathymetry data files were acquired by SIS, and were imported into CARIS software. In CARIS, attitude and navigation data stored in each file were checked, and erroneous soundings were removed using CARIS Swath Editor and Subset Editor. EM 302 multibeam Built In System Tests (BISTs) were run throughout the cruise to monitor multibeam sonar system status and are available as ancillary files in the sonar data archives. Mapping work was completed for fifteen days of the cruise, with seven non-mapping days due to required shore-based repairs.

A. Equipment

i. ROV

Okeanos Explorer conducts high-resolution visual surveys to obtain baseline characterization data using NOAA's custom-built, dual-body, 6,000-meter- rated ROVs *Deep Discoverer* (D2) and *Seirios*. D2 has 5 high definition cameras, 5 standard definition cameras, and 24 LED lights that bring 144,000 lumens to the seafloor resulting in some of the highest quality deep sea footage in the industry. D2 also has four custom built lighting swing arms that that allow for the position and angle of the light to be adjusted for optimal imaging. *Seirios* has 1 high definition cameras, 5 standard definition cameras, and 18 LED lights that add 108,000 lumens to D2's lighting. The vehicles work in tandem, with D2 surveying the seafloor, and *Seirios* providing additional lighting and situational awareness, as well as dampening the movement of the ship.

D2 has two manipulator arms, a Schillings Orion arm and a Kraft Predator arm. EX1502L3 was the first ROV expedition since the installation of the Predator arm. ROV engineers spent several days perfecting the feedback system on the arm and then practicing with it during the extended alongside repair period. Dive 08 was an engineering dive focused on giving the pilots enough time to practice with this arm on the seafloor.

Both vehicles have a Sea Bird 9/11+ CTD with dissolved oxygen (DO) sensors. During EX1502L3, the DO sensor on *Seirios* was not operational. D2 also has a temperature probe and a sediment thickness probe referred to as the "SeaPoke". The SeaPoke was used to test sediment thickness during Dives 08 and 10. The temperature probe was not deployed during EX1502L3.

ii. Sonars

Okeanos Explorer has three scientific sonars that are operated simultaneously during mapping operations: a Kongsberg 30 kHz multibeam system, a Kongsberg 18 kHz split-beam fisheries sonar, and a Knudsen 3.5 kHz chirp sub-bottom profiler sonar.

Mapping operations onboard *Okeanos Explorer* occur continuously throughout the day and night except when the ROV is deployed.

Okeanos Explorer's EM302 30 kHz multibeam sonar is used to collect seafloor bathymetry, seafloor backscatter, and water column backscatter. Backscatter represents the strength of the acoustic signal reflected from some target, whether that's the seafloor or bubbles in the water column. The EM302 is a deep water multibeam system designed to map in depths ranging from approximately 200-7,000 meters.

The Kongsberg EK 60 (18 kHz) single beam is used to collect information about the water column, such as gas plume or seep sites, and to obtain information about biomass. The EK60 split-beam sonar is used as a quantitative scientific echosounder to identify water column acoustic reflectors - typically biological scattering layers, fish, or gas bubbles – providing additional information about water column characteristics and anomalies.

The primary purpose of the Knudsen Chirp 3260 (3.5 kHz) sonar is to provide echogram images of surficial geological sediment layers underneath the seafloor to a maximum depth of about 80 meters below the seafloor. The Sub Bottom Profiler is normally operated to provide information about the sedimentary features and the bottom topography that is simultaneously being mapped by the multibeam sonar. The data generated by this sonar is fundamental in helping geologists interpret the shallow geology of the seafloor.

Expendable bathythermographs (XBTs) were deployed to obtain sound velocity profiles to help calibrate the multi-beam system and ensure accurate bathymetric mapping. The XBT type is the Deep Blue probe produced by Lockheed Martin Sippican. Expendable bathythermographs were collected every three to six hours at an interval defined by prevailing oceanographic conditions to correct multibeam data for changes in sound speed in the water column, and were applied in real time using Seafloor Information Software (SIS). Sound speed at the sonar head was determined using a Reson SVP-70 probe, and salinity measurements near the transducers were taken using the ship's flow-through thermosalinograph (TSG).

Throughout the cruise, multibeam data quality was monitored in realtime by acquisition watch standers. Line spacing was planned to ensure 25-30% overlap between adjacent lines of multibeam sonar swaths. Cutoff angles in SIS were generally set between 60° and 70° on both the port and starboard sides. Ship speed was adjusted to maintain data quality as necessary and as transit time to the next dive site allowed.

All multibeam sonar data collected during the expedition was fully processed according to established onboard procedures and was archived with the National Center for Environmental Intelligence (NCEI, formerly NGDC). Additional details about data archival can be found in Section 6 of this report. Raw multibeam bathymetry data files were acquired by SIS, and were imported into CARIS. In CARIS, attitude and navigation data stored in each file were checked, and erroneous soundings were

removed using CARIS Swath Editor and Subset Editor. Once per day, cleaned, gridded bathymetric data were exported to ASCII text files (y,x,z) at 50 meter cell size in WGS84 datum. The ASCII files were then used to create Fledermaus SD objects. These SD objects were then exported to geotiff and Google Earth KMZ files, which were copied to the shoreside FTP on a daily basis to support shoreside scientist participation.

For more detailed information about the sonar systems, see 2015 *Okeanos Explorer* Readiness Report.

B. Operating Area

Okeanos Explorer conducts operations in some of the most remote areas of the world, exploring unknown and poorly-known deepwater habitats. During the 2011 workshop on *Systematic Telepresence-Enabled Exploration in the Atlantic Basin,* researchers from all over the world were invited to submit ideas on which parts of the Atlantic were most in need of exploration. The Puerto Rico Trench was noted as an area that needed further exploration. The area around Puerto Rico was highlighted again in a follow up community workshop in 2013 to discuss potential exploration targets in the in Caribbean and Gulf of Mexico. This second workshop ranked the Puerto Rico Trench, as well as the surrounding areas that became the working grounds for *Océano Profundo,* as high-priority targets for explorations. In early 2015, the input of multiple parts of NOAA, the Bureau of Ocean Energy Management (BOEM), and the U.S. Geological Survey (USGS) was solicited to assess the needs of the management community. In addition to partner federal agencies, additional input was gathered from numerous local management agencies such as the Puerto Rican Departamento de Recursos Naturales y Ambientales, U.S. Virgin Islands Department of Planning and Natural Resources, and the Caribbean Fisheries Management Council. All of this input helped define and refine the operating area for this expedition. In the weeks leading up to the expedition, a series of cruise planning meetings were held to facilitate discussion among the more than 40 researchers who would make up the shore-based science team to identify priority dive targets and mapping boxes.

In some areas around Puerto Rico and the US Virgin Islands, extensive multibeam bathymetry existed from past US Geological Survey and Ocean Exploration Trust expeditions. In these areas *Okeanos Explorer* completed complementary surveys to expand coverage or collected higher resolution data. Additionally, ROV Dive 04 directly below an existing transect conducted by ROV Hercules (H1300) along the western wall of Mona canyon, expanding the depth of biological and geological observations in this area.

4. Summary of Operations

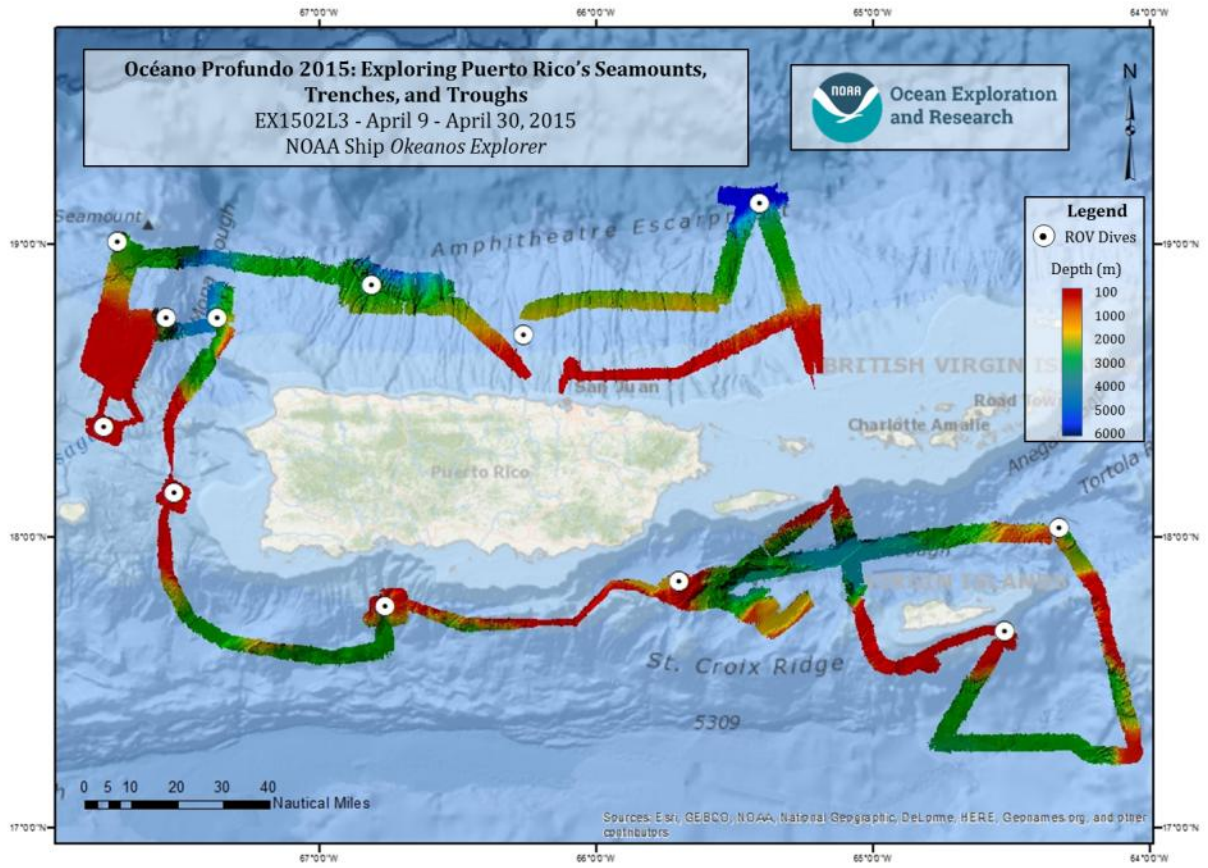

Figure 1: Summary map of EX1502 Leg 3 activities. Multibeam bathymetry collected during the expedition is shown in the rainbow color-coded bathymetry scale. White icons denote the location of ROV dives. Map made in ArcGIS 10.3.

Okeanos Explorer surveyed a diversity of seafloor features and biological communities in deep waters around Puerto Rico and the U.S. Virgin Islands from 9-30 April 2015. ROV *Deep Discoverer* (D2) completed 12 dives to depths ranging from 300 to 6,000 m. The first dive conducted was to the north of Puerto Rico, on the Arecibo Amphitheater adjacent to Guajataca Canyon (3450-4000 m). Five dives were then completed to the west of Puerto Rico in the Mona Passage/Canyon area: two dives surveyed the west and east walls of Mona Canyon (3700-4000 m), one dive was conducted south of Mona Seamount, crossing the Septentrional Fault (3200-3700 m), and two dives were conducted in deeper areas (300-600 m) of active, queen snapper fishing grounds in the Mona Passage. *Okeanos Explorer* then moved to the south of Puerto Rico, where the ROV *D2* completed its seventh dive in Guayanilla Canyon (1700-2100 m). Due to mechanical issues with the ship's AC units, *Okeanos Explorer* headed to port in San Juan, Puerto Rico on 17 April, and remained there until 23 April. On 23 April 2015, the ship departed the pier, only to quickly realize an issue with oil leaking from the bow thruster. After another night in port, *Okeanos Explorer* got underway and the ROV *D2* successfully completed an engineering dive at a depth of 1676 m, 20 miles north of San Juan. Following the engineering dive, the *Okeanos Explorer* headed to the south wall of the Puerto Rico Trench, where the ROV *D2*

successfully reached its rated depth of 6,000 m. However, it was soon noticed that two of the high voltage compensators were leaking, and thus the ROV came back to the surface without exploring the seafloor at this dive location. The last three dives of the expedition were conducted on Whiting seamount (500-1300 m), Exocet seamount (2400-2900 m)] and on a“pinnacle” features (830-930 m) south of the U.S Virgin Islands and south-east of Puerto Rico. The pinnacle features were discovered during a recent (2015) mapping expedition led by the NOAA National Ocean Service. In addition to the ROV dives, multibeam mapping operations were conducted at night. These efforts enabled mapping of new areas, filling in holidays and re-mapping areas at higher resolution than what was previously available.

A. Calendar of Events

April 2015						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				4/9 Depart for EX1502L3, start exploration mapping	**4/10** Dive 01, mapping operations at night	**4/11** Dive 02, mapping operations at night
4/12 Dive 03, mapping operations at night	**4/13** Dive 04, mapping operations at night	**4/14** Dive 05, mapping operations at night	**4/15** Dive 06, mapping operations at night	**4/16** Dive 07, mapping operations at night	**4/17** A/C failure, begin transit to San Juan for repairs	**4/18** Return to San Juan, begin repairs to A/C
4/19 Alongside for repairs	**4/20** Alongside for repairs	**4/21** Alongside for repairs	**4/22** Alongside for repairs	**4/23** Depart pier, bow thruster oil leak detected, return to San Juan	**4/24** Alongside for repairs	**4/25** Depart San Juan, Dive 08, mapping operations at night
4/26 Dive 09, mapping operations at night	**4/27** Dive 10, mapping operations at night	**4/28** Dive 11, mapping operations at night	**4/29** Dive 12, mapping operations at night	**4/30** Overnight mapping operations, AUV retrieval, return to port		

B. Expedition Daily Log

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

April 9, 2015
The ship departed San Juan, PR at 1400. Mapping operations with all three sonars were conducted en route to the first dive site and included re-surveying a large area of the carbonate escarpment to look for evidence of slope failure since the last multibeam survey in 2002/3.

April 10, 2015 – Dive 01: Arecibo Amphitheater
The first ROV dive of EX1502 Leg 3 investigated the geomorphology and potential slope failure in Guajataca Canyon along the Arecibo Amphitheater, a section of the marginal escarpment of the carbonate platform. ROV *Deep Discoverer* (D2) landed at a depth of 4,055 meters on a sedimented seafloor with little benthic fauna. During the dive, D2 traversed a sequence of variably sedimented carbonate and interspersed sandstone rocks. Most of the outcrops had iron manganese coatings of variable thickness, but at the beginning of the dive, there was some recent disruption of the iron manganese crust to reveal the white carbonate. Importantly, there was little evidence of recent slope failure. Biota in this area included previously undescribed ctenophores, brisingid sea stars, cusk eels, anemones, and a diversity of sponges, as well a few colonies of bamboo coral. As D2 climbed the escarpment, we encountered a variety of steep rock faces, with varying degrees of colonization by sponges. Fauna encountered during the second half of the dive included seastars, crinoids, sea cucumbers, swimming polychaetes, bamboo coral, sponges, ctenophores, shrimp, anemones, squat lobsters, jellyfish, and several species of rattail fishes. Mapping operations were conducted from the time the ROV was secure until arrival at the next dive site.

April 11, 2015 – Dive 02: Septentrional Fault
Dive 2 investigated the apparent termination of the Septentrional Fault. Beginning at a depth of 3,673 meters, D2 landed on rippled, coarse grain sediment with shells and detritus in the troughs of the ripples. After traversing 500 meters, we reached the valley wall and began to ascend a relatively continuous 40-degree dipping slope consisting of coarse grained sediment with a few areas of rock debris. The slope was produced by debris currents flowing down the valley side depositing sediment to cover the jagged rock faces below. Towards the end of the dive (3,225 meters), we encountered a 20-meter high outcrop of conglomerate, a rock that consists of large, rounded clasts that have been cemented together. This outcrop was likely the source of the rock debris that we observed lower on the slope. Throughout the dive there was little visible benthic life and very few fish. The most consistent observations during the dive were of anthropogenic trash and decomposing algal detritus (*Sargassum*). Fauna observed during the dive included shrimp, anemones (some colonizing trash on the seafloor), a grenadier, a slime star, sea cucumbers, brisingid seastars, hydroids, sponges, squat lobsters, crinoids, a lizardfish, and a hermit crab with an anemone on its back. D2 was recovered from a depth of 3,148 after a final observation of the dive's only bamboo coral. Mapping operations were conducted from the time the ROV was secure until arrival at the next dive site.

April 12, 2015 – Dive 03: Pichincho
Dive 03 explored Pichincho, an area identified as high priority for exploration by the Caribbean Fisheries Management Council. During this dive, we traversed a fault scarp through the upper part of the Oligocene-Miocene platform carbonate sequence. D2 landed on a sedimented bottom with bivalve shells, small rubble, scattered detritus, and anthropogenic trash. As D2 transited upslope, we encountered a number of carbonate rock faces that were encrusted with benthic

fauna, predominantly sponges, which were under overhangs and on non-sedimented surfaces. Towards the end of the dive, D2 encountered complicated carbonate topography with rounded outcrops, sinkholes, and large cracks. This is typical karst topography, which provides evidence that this location was once above sea level. Biological observations during this dive included a low abundance of at least 13 species of fish, few octocorals, lace corals, black corals, cup corals, a variety of sea stars, crinoids, squat lobsters, brittle stars, urchins, zooanthids, and shrimp. We also encountered several instances of trash littering the seafloor. Highlights of the dive included species that have yet to be formally described, a "walking" *Chaunax pictus*, and rare observations ofseastars preying upon sponges. Mapping operations were conducted from the time the ROV was secure until arrival at the next dive site.

April 13, 2015 – Dive 04: Mona Canyon- West Wall

D2 began Dive 4 with a series of mid-water transects to investigate life in the water column. During these transects, D2 imaged jellyfish, larvaceans, midwater fish, and siphonophores. D2 landed on a sedimented seafloor with scattered rubble at a depth of 3,927 meters. Our dive traversed two large steep exposures of well-bedded Late Miocene to Oligocene platform carbonates, both of which were underlain by less steeply dipping sediment-covered slopes with boulders of carbonate derived from the outcrops above. Downslope, sediment-filled channels were present, and their presence, together with the small amounts of iron manganese coating on much, but not all, of the carbonate attests to the recent instability of this slope. Fauna during this dive included a diversity of sponges, arrow worms, sea pens, black corals, a bamboo coral, a ctenophore, anemones, a variety and large number of sea cucumbers, a halosaur, crinoids, several large grenadiers, a lizardfish, urchins, sea stars, and shrimp. Some of the highlights of the dive were a dumbo octopus, imaging several delicate gelatinous organisms including several beautiful jellyfish, and documenting several instances of a potential symbiotic relationship between a predatory tunicate and a polychaete. Mapping operations were conducted from the time the ROV was secure until arrival at the next dive site.

April 14, 2015 – Dive 05: Mona Canyon- East Wall

Dive 05 began with a series of mid-water transects at 100-meter intervals between 800 and 1,200 meters. Fauna documented included squid, arrow worms, jellyfish, siphonophores, and small fish. D2 landed on the seafloor at a depth of 4,000 meters and transited upslope over Late Cretaceous to Middle Eocene volcanic arc basement rocks which makes up the core of Puerto Rico and sits below the approximately one-kilometer thick carbonate layer we'd previously dived on. After traversing approximately 100 vertical meters of sedimented seafloor with little fauna, D2 climbed 200 vertical meters of steeply dipping and sometimes near vertical cliffs of outcrop of basement volcanic rocks. Biological observations during the dive included a diversity of sponges, black corals, octocorals, sea stars, fish, shrimp, and squat lobsters. Two exciting highlights from today's dive were the close encounter with a 1.5-2 meter squid and the documentation of a rare six-arm sea star that had not been recorded, collected, or observed since the specimen was described 130 years ago. Mapping operations were conducted from the time the ROV was secure until arrival at the next dive site.

April 15, 2015 – Dive 06: Platform

Dive 06 investigated the top of the Late Oligocene to Pilocene platform carbonate sequence and traversed a relatively minor fault scarp. This fault is the easterly extension of an approximately

100-kilometer-long fault system that forms the northern wall of the rift between the Dominican Republic and Puerto Rico. The dive began at a depth of 593 meters on a relatively gently dipping, current-swept limestone pavement. After traversing 600 meters, more irregular topography was reached, which continued for about 1.2 kilometers until we reached and then traversed the eroded fault scarp. In terms of biodiversity, we had a great dive, documenting a higher diversity of coral, sponges, and fish than on the other dives so far. However, many of the scleractinian corals were small (less than 10 centimeter-tall colonies). Approximately 30 species of fishes were seen, including one observation of a queen snapper. Other fauna included anemones, sea stars, squat lobsters, and colonial tunicates. Highlights of the dive included a swimming terebellid worm, an armored sea robin responding to the ROV, and a rare sea urchin with paddle-like spines. Mapping operations were conducted from the time the ROV was secure until arrival at the next dive site.

April 16, 2015 – Dive 07: Guayanilla Canyon, East Wall
Dive 07 transited up the east wall of Guayanilla Canyon starting from a depth of 2,100 meters. At the start of the dive, D2 encountered nice outcrops of well bedded, but cleaved, shales and sandstones that form part of the Late Oligocence Juana Diaz Clastic Formation. As we traversed up slope, we transitioned into extensive outcrops of bedded carbonates of the Middle Miocene to Early Pliocence Ponce carbonate formation. Most outcrops appeared to have gentle dips; however, in the middle of the carbonate section, we observed several examples of slope failure. During the dive, we observed several species of corals, but relatively few sponges and sessile fauna overall. We reached a vertical cliff face at ~1,800 meters that had little to no colonization of benthic fauna, but evidence of extensive bioerosion in some of the layers. Other notable observations on this dive included a dandelion siphonophore, benthic jellyfish, and a benthic ctenophore on a sea pen. Mapping operations were conducted after the ROV was secure.

April 17, 2015
Overnight the ship's A/C system failed and the day's dive was canceled. An underway repair was tried, but it was determined that an in-port repair was needed. Without a functioning A/C system, the ship was deemed uninhabitable, and the ship immediately began a transit to San Juan, PR where further repairs could take place. Mapping operations were conducted until it was no longer safe to use the sonar equipment without risking damage from overheating.

April 18, 2015
Okeanos Explorer returned to San Juan, PR at 0830. Alongside A/C repairs began immediately.

April 19-20, 2015
Alongside repairs continued.

April 21-22, 2015
Alongside A/C repairs completed, but the ship lost an engineer to a family emergency. Without a full Engineering Department, the ship did not meet safe manning requirements, so the ship remained alongside until an augmenting engineer could be secured.

April 23, 2015
As the ship departed the pier, an oil leak from the bow thruster was detected. *Okeanos Explorer* returned to port and began alongside repairs for this new issue.

April 24, 2015
Alongside repairs on the bow thruster were completed by late afternoon, but it was too late in the day to get underway given staffing constraints.

April 25, 2015- Dive 08: Engineering Dive
The ship left the pier at 0900 and conducted an engineering dive just north of San Juan. D2 landed on a sedimented seafloor with a gentle slope and stayed stationary for most of the dive while the ROV team practiced using the manipulator arms. Few biological observations were made including a few sea cucumbers, fish, and shrimp. Mapping operations were conducted during transit to the dive site and overnight.

April 26, 2015 – Dive 09: Puerto Rico Trench - South Wall
Dive 09 was the first time D2 reached it rated depth of 6,000 meters. As the ROV descended and reached 6,000 m, the ROV pilots noticed a problem with the mineral oil levels in the high voltage compensator system on D2. The vehicles were recovered early and troubleshooting continued once the vehicles were on deck. However brief, this was the deepest ROV dive conducted to date in the Puerto Rico Trench. Mapping operations were conducted from the time the ROV was secure until arrival at the next dive site.

April 27, 2015 – Dive 10: Pinnacles
Dive 10 was conducted on two geologic anomalies just south of St. Croix. These anomalies were identified a few weeks earlier during a seafloor mapping survey by the National Ocean Service on NOAA Ship *Nancy Foster*. After processing the bathymetry data, the scientists were intrigued by two distinct pinnacle features. Given the rarity of these features and the uncertainty of their origin, the *Okeanos Explorer* was asked to investigate the sites further. D2 landed on a sedimented seafloor at a depth of 870 meters and began to transit upslope to investigate the unknown features. Both features had a high diversity of fauna and were on a mud covered surface that is likely the top of the Pliocene-Miocene carbonate platform. The first pinnacle was angular in plan-view with a diameter of 200 meters and a height of 50 meters. The lower part of the mound consisted of iron manganese-coated carbonate debris with some mud covering. Larger, rounded carbonate boulders formed the mid part of the slope and the upper surface was largely mud covered. The second feature (~930-915 meters water depth) was smaller and also consisted of iron manganese-coated carbonate rubble. Coral and associate diversity was high on both features. Interestingly, there were different coral species present on the mounds surveyed in different depths. At least 26 species of black corals, octocorals, cup corals, and other stony corals were observed. Several sponges, brittle stars, squat lobsters, barnacles, fish, shrimp, urchins, and hermit crabs were also observed. Most of the species observed today were new observations for this expedition. The origin of the pinnacles remains an enigma, with perhaps the most likely explanation being that they are blocks that slid down from the slope-shelf break up slope that are breaking down *in situ*. Mapping operations were conducted from the time the ROV was secure until arrival at the next dive site.*April 28, 2015 – Dive 11: Exocet Seamount*

Dive 11 was conducted on Exocet Seamount, located northwest of St. Croix. The dive began with five midwater transects conducted for 10 minutes every 100 meters in depth, from 800-1,200 meters. During these transects, D2 observed several empty larvacean houses, a few ctenophores, arrow worms, jellyfish, midwater fishes, and a fantastic organism that we believe to be a foraminiferan that looked like a sunburst. D2 landed on a sedimented seafloor with little fauna at a depth of 2,898 meters. As we transited up slope, we encountered manganese-encrusted carbonate rocks exhibiting evidence of possible cleavage and folding. Corals observed during this dive included a cup coral, one black coral, two bamboo corals, and two other octocorals. Also observed were at least eight species of fish, four sea star species, shrimp, squat lobsters, and several species of glass sponges. Of note, several items of trash (e.g., plastic, rusty steel cans) were seen, particularly in the beginning of the dive. Mapping operations were conducted from the time the ROV was secure until arrival at the next dive site.

April 29, 2015 – Dive 12: Whiting Seamount

Dive 12 was the first ever exploration of Whiting Seamount. D2 landed on a rubble strewn slope at a depth of 1,301 meters. This dive traversed from the Cretaceous-Eocene volcanic arc basement across the unconformity with the overlying Late Oligocene to Early Pliocene Platform sequence. Several species of corals and sponge were observed during this dive, many new for this expedition, including a few black coral, bamboo coral, an unknown purple Plexaurid, and cup corals. At least 15 fish species were observed, including tinselfish, a few species of rattails, several cusk eels, Darwin's Slimehead, and catsharks. Numerous species of crustaceans were seen during our transit upslope, including squat lobsters and "decorator" crabs. Seastars, brisignids, crinoids, and ophiuroid brittle stars were also common. We also documented at least two range extensions, as a Shaefer's anglerfish (*Sladenia shaefersi)* and a jellynose (Ateleopodidae) were not previously known to occur off Puerto Rico. Mapping operations commenced as soon as vehicles were secured on deck.

April 30, 2015

Mapping operations continued throughout the return transit to port. At 0200, *Okeanos Explorer* recovered the Slocum glider that had been deployed during EX1502L2 and which had been declared lost at sea until April 29th. The ship arrived in San Juan at 0900 and demobilization began.

iii. Dive Table

Dive #	Site Name	Date	Region	Latitude	Longitude	Max Depth (m)	Length (HH:MM:SS)	Focus
1	Arecibo Amphitheater	4/10/15	Puerto Rico Trench	18°, 51.604' N	066°, 48.625' W	4062.8	11:07:36	Geomorphology and potential slope failures in Guajataca Canyon
2	Septentrional Fault	4/11/15	Mona	19°, 00.433' N	067°, 43.661' W	3675.8	8:25:12	Investigated the apparent termination of the Septentrional Fault
3	Pichincho	4/12/15	Mona	18°, 22.681' N	067°, 46.780' W	609.4	11:30:3	Benthic habitat under known fishing grounds for snapper
4	Mona Canyon - West Wall	4/13/15	Mona	18°, 45.039' N	067°, 33.135' W	3928.1	11:54:16	Water column transects; geology and biology investigation to extend previous E/V *Nautilus/Hercules* dive H1300
5	Mona Canyon-East Wall	4/14/15	Mona	18°, 44.956' N	067°, 21.966' W	4025.7	9:14:12	Water column transects; geology and biology of canyon wall
6	Platform	4/15/15	Mona	18°, 08.960' N	067°, 31.322' W	606.2	9:40:39	Benthic habitat under known fishing grounds for snapper
7	Guayanilla Canyon - East Wall	4/16/15	South of Puerto Rico	17°, 45.654' N	066°, 45.622' W	2139.9	11:28:35	Investigate biology and geology around Investigator Fault in the canyon wall
8	Engineering Dive	4/25/15	North of San Juan	18°, 41.535' N	066°, 15.804' W	1678.1	5:31:30	Give ROV pilots time to train on the manipulators
9	Puerto Rico Trench - South Wall	4/26/15	Puerto Rico Trench	19°, 09.053' N	065°, 24.430' W	5999.7	7:22:25	6,000 m test for vehicles, investigate PR trench south wall

10	Pinnacles	4/27/15	South of St. Croix	17°, 40.580' N	064°, 31.519' W	933.7	7:37:52	Investigate two unknown batymetric anomalies recently discovered by National Ocean Service
11	Exocet Seamount	4/28/15	USVI Seamounts/ East of St. Croix	18°, 01.809' N	064°, 19.650' W	2900.7	9:26:55	Water column transects; investigate bio/geo of Exocet seamount
12	Whiting Seamount	4/29/15	USVI Seamounts/ West of St. Croix	17°, 50.773' N	065°, 42.056' W	1303.3	9:51:59	Investigate biology and geology of Whiting seamount

5. Summary of Findings

A. Biology

Benthic Communities
Benthic communities observed across the various geological features included a diversity of demersal fishes, crustaceans (hermit crabs, squat lobsters), echinoderms (sea cucumbers, sea stars, sea urchins), sponges (demosponges and glass sponges), worms (serpulids and terebellids) and corals (octocorals, black corals, and stony corals).

Figure 2: This chrysogorgiid octocoral, tentatively identified as *Chrysogorgia desbonni*, serves as a host to squat lobsters observed at Pichincho.

Sessile species colonization was extremely patchy both within and across dives. Often, there were large portions of hardbottom habitat that had no obvious sessile fauna colonization, particularly at depths > 3000 m. Demosponges (including cladorhizids) and hexactinellid glass sponges were the most common sessile species, and observed colonizing hardbottoms to various degrees. Demosponges appeared to be most abundant at the shallowest depths of Whiting Seamount (Dive 12), Pichincho (Dive 03), and the Platform (Dive 06) areas. Corals were diverse (approx. 50 species) across the region, and observed during all dives. Corals observed included octocorals (e.g., plexaurids, sea pens, soft corals, bamboo corals), black corals (e.g., *Bathypathes, Stichopathes*, and others), lace corals (stylasterids), and scleractinians (e.g., *Lophelia pertusa, Madrepora* sp., *Enallopsammia rostrata).* In particular, they were most abundant and diverse (approx. 26 species) at the "pinnacles" site (Dive 10) south of St. Croix at depths of 930-830 m.

A diversity of mobile megafauna were also observed throughout the expedition. Approximately 75-100 species of demersal fishes were seen across the broad depth range sampled, including (but not limited to) catsharks (Scyliorhinidae), cusk eels (Ophidiidae), rattails and grenadiers (Macrouridae), queen snappers (Lutjanidae), deep-sea lizardfish (Bathysauridae), greeneyes (Chlorophthalmidae), and tripod fish (Ipnopidae). Fishes appeared to be most diverse and abundant at the "Platform site" (Dive 06) at depths of 600-300 m. Several fauna (e.g., squat lobsters, brittle stars, polychaetes) were found inhabiting corals, with many species not observed on surrounding substrates. For example, at the "pinnacles" site (Dive 10), *Gastroptychus* sp. squat lobsters were commonly observed inhabiting an unknown black coral. Echinoderms were also quite common and diverse across the region.

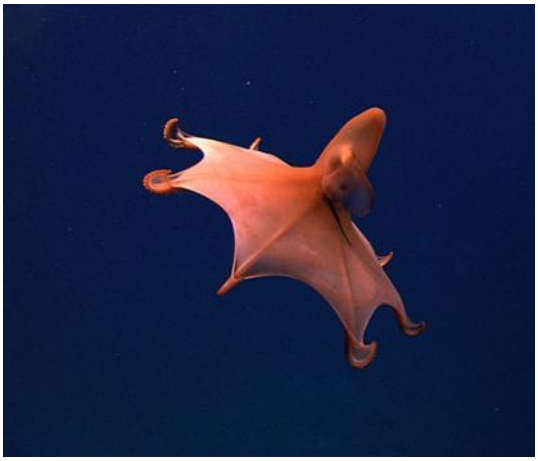

Figure 3: During this expedition two rare Blind Octopods (Cirrothauma murrayi) were observed on Dives 04 and 07.

Several species of seastars (e.g., *Calyptraster* sp., *Hymenaster* sp., *Pteraster* sp.), feather stars (comatulid crinoids), basket stars (Gorgonocephalidae), ophiuroids (e.g., *Asteroschema* sp.), brisingids (e.g., *Novodinia* sp., *Freyella* sp., *Freyastera* sp.), urchins (e.g., *Cidaris ?rugosa, Cidaris blakei, Phormosoma* sp.), and sea cucumbers (e.g., *Benthodytes sp., Enypiniastes* sp., Elasiopods*)* were noted. Although a few squid and octopods were observed, it was noted that they were not common along any of the dive tracks.

Midwater Communities

Midwater transects were conducted during the descents of three ROV dives (Dives 04, 05, and 11). Each transect was conducted for 10 min at 100 m depth intervals from 800-1200 m. The midwater transects documented many notable observations while capturing detailed images of numerous midwater organisms, including larvaceans, chaetognaths (arrow worms), fishes (barracudinas, hatchetfish, bristlemouths), ctenophores, siphonophores, and hydromedusae jellyfish. It was noted that most of the species observations occurred at depths ranging from 800-1000 m. Two notable midwater observations included an exceptionally large (~10 cm diameter), unknown, pelagic foraminifera at 900 m depth and a 1.5-2 m long squid, *Asperoteuthis acanthoderma,* imaged at 800 m. Interestingly, in the past 10 years, this species of squid is being reported more frequently from the Caribbean and the Gulf of Mexico (known previously to occur in the Pacific). These midwater findings illustrate the utility of continuing to explore the pelagic zone, and thus, furthering our knowledge of this poorly studied environment.

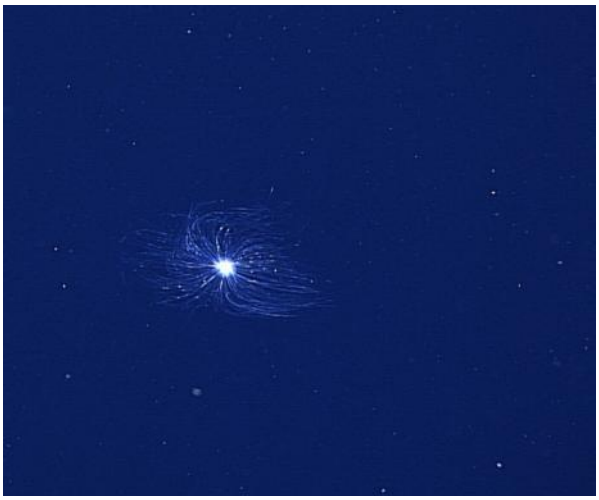

Figure 4: Unidentified pelagic foraminifera observed during 11 at Exocet Seamount.

Other Notable Observations

The starfish species, *Laetmaster spectabilis,* was seen at 3915 m in Mona Canyon. This is one of the rarest known sea stars, known previously from only one or two specimens collected in 1881. In addition, at least two new species were observed. One included a new species of wrasse (*Polylepion* sp. A) found in the Mona Passage at both Pichincho (Dive 03) and Platform sites (Dive 06) at depths of approximately 350 m. This species has been collected previously off Curacao, and is in the process of being formally described (C. Baldwin, pers. comm.). Secondly, a possible new species of benthic ctenophore was observed 38 km north of Puerto Rico in the Guajataca Canyon within the Aricebo Amphitheater at 3800-3900 m. Three individual animals were observed. This species may have only ever been observed once before on the Middle Atlantic

Figure 5: During Dive 04, this predatory tunicate with a polychaete living with it was observed several times.

Ridge. Additionally, at this site a bathypelagic ctenophore that was jet-black in color and had one long tentacle was observed. Range and depth extensions for several species of fishes were also documented. For example, Shaefer's anglerfish and the ateleopodid jellynose were not previously recorded from deep waters off Puerto Rico. Other notable observations included predatory tunicates, many of which had polychaete associates, benthic ctenophores (Dive 07), benthic jellyfish (Dive 07), and a dandelion siphonophore (Dive 07). Several woodfalls were also observed (particularly Dives 02, 04), many of which consisted of *Bambu* sp. (bamboo plants) and had associated woodfall fauna (e.g., limpets). Trash was observed during every dive, and included plastic debris, glass bottles, aluminum cans, and (potentially) items used for military target practice. Notably, there appeared to be a high amount of trash along the dive track at the Septentrional Fault (Dive 02).

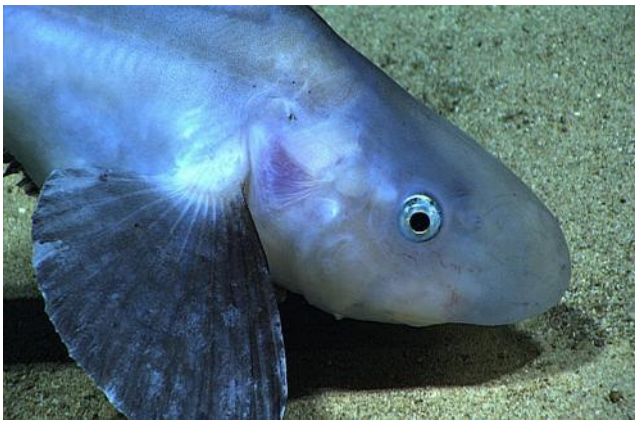

Figure 6: A new observation for Puerto Rico waters, this ateleopodid jellynose fish was observed at the end of Dive 12 on Whiting Seamount at a depth of 545 meters.

B. Geology

Tectonic Setting

The island of Puerto Rico is an emergent part of the Puerto Rico-Virgin Islands microplate, which lies between the much larger North American and Caribbean plates in a broad zone of strike-slip and oblique subduction (e.g. Van Gestel et al., 1999). The northern margin of the microplate is defined by a major oblique and strike slip fault system in the Puerto Rico Trench, the deepest part of the Atlantic Ocean (8395 m). Its southern margin is defined by a convergent boundary marked by the Muertos Tough (5500 m) and an associated accretionary prism. The western margin is marked by extension beneath the Mona Passage. The south eastern boundary is defined by the trans-tensional Anegada Passage Fault zone.

The geology of Island of Puerto Rico, which continues into the offshore areas explored during EX1502L3, consists of a basement or core of Jurassic-Eocene island arc rocks, unconformably overlain by a post island arc platform sequence of Oligocene to Pliocene clastic and younger shallow-water carbonate deposits. North-south shortening due to subduction of both the North American and Caribbean plates has led to Post Eocene to Late Neogene east-west arching of Puerto Rico that extends from Mona Passage across the Cordillera Central through the Virgin Islands (Figure 7). This arch accounts for the exposure of the island arc rocks through the center of Puerto Rico, and the northward and southward dipping platform sequences to the north and south of Puerto Rico. It is the offshore margins of the platform sequence and the underlying basement island arc rocks that were explored during EX1502L3.

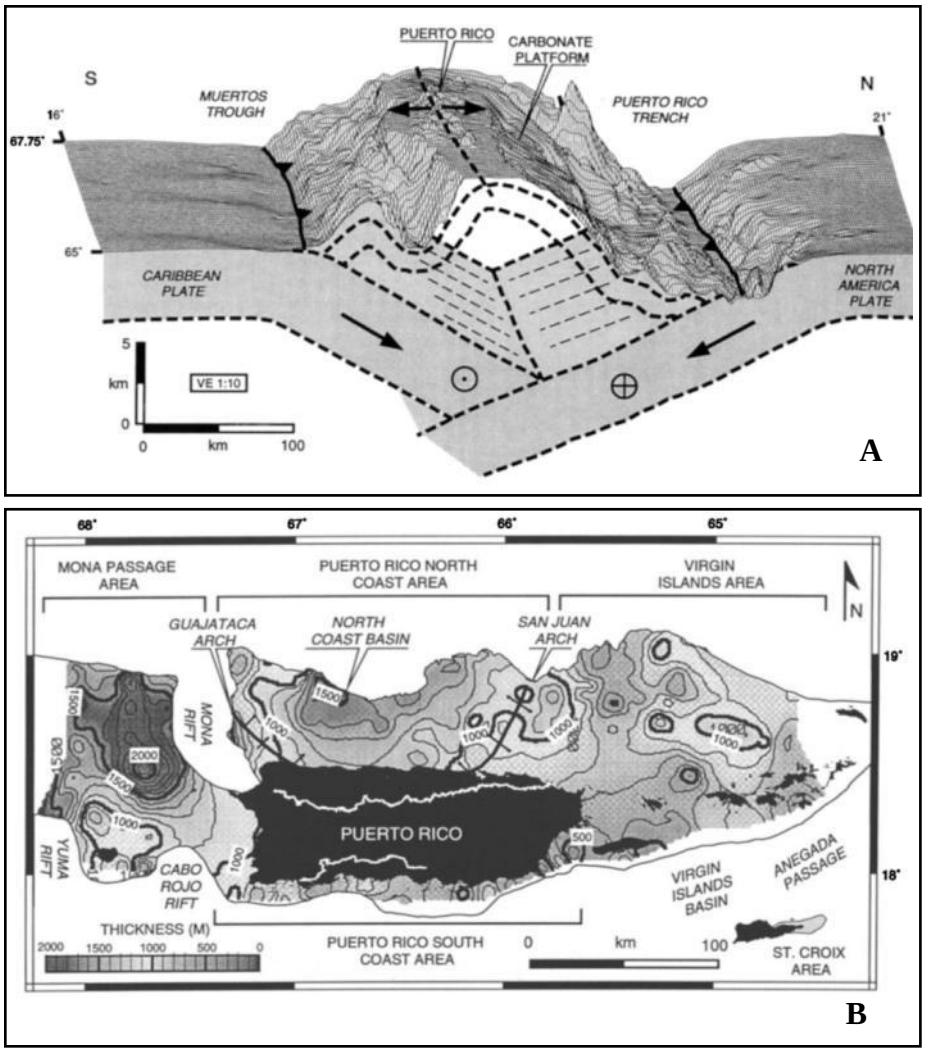

Figure 7: Top (A) - 3-D cartoon illustrating the tectonic setting of Puerto Rico and the folding of the carbonate platform sequence using available bathymetry (10:1 vertical exaggeration). Bottom (B)- Carbonate platform sequence isopach map (100 m contour) derived from multi-channel seismic (MCS) data. Figure curtesy of Van Gestel *et al*., 1998.

Observing continental geology by ROV

The island arc rocks forming the basement are a complicated sequence of folded and faulted volcanoclastic rocks and lavas intruded by plutonic rocks of various ages. The overlying platform sequence has limited deformation, but each of the stratigraphic formations comprising it are of variable thickness (Figures 7 and 9). Submarine outcrops of both the basement and platform carbonates are extensively covered by thin, dark colored, Fe-Mn coatings. Together, these factors make rock identification during the ROV dives difficult without sampling. Although time-consuming, the process of picking up a sample and examining its non Fe-Mn coated underside allowed successful identification of carbonate rocks during Dive 11, and a felsic plutonic rock body during Dive 12.

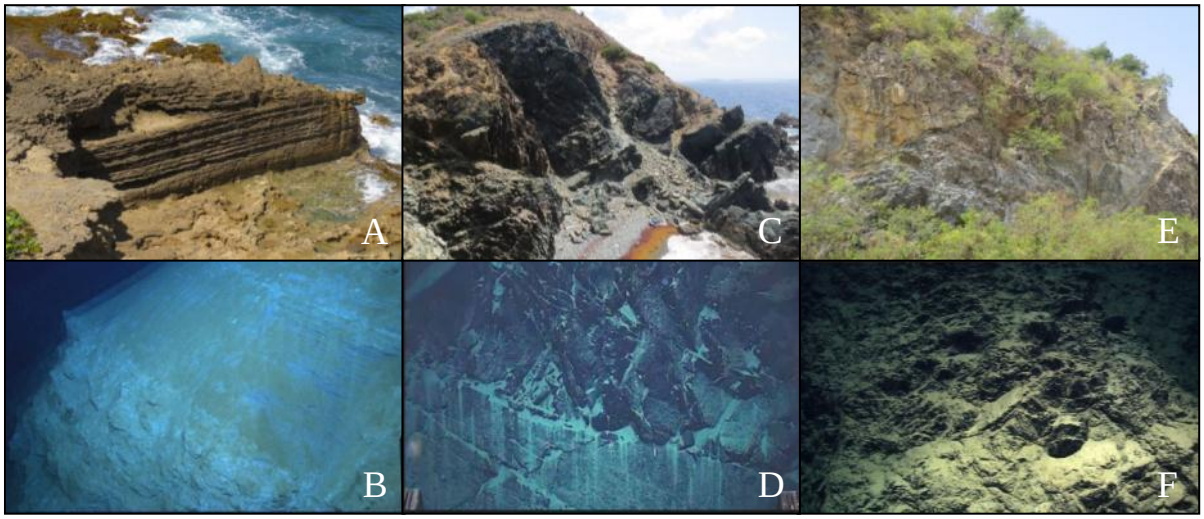

Figure 8: Comparison of onshore exposures and submarine exposures. A) Eolianite: Holocene calcareous sandstone in San Juan, PR; B) Cibao/Los Puertos Formation bedded carbonate observed during Dive 04 at Mona Canyon; C) Louisenhoj Formation: Cretaceous arc volcanics and sediments in St. Thomas, USVI; D) Intrusive or tectonic contact in arc volcanic/plutonic rocks observed during Dive 07; E) Water Island Formation: Cretaceous volcanoclastic rocks and lavas in St John, USVI; F) Jurassic-Eocene arc volcanic/plutonic rocks observed during Dive 05.

Figure 8 shows comparative photographs of both onshore and submarine outcrops explored during EX1502 Leg 3 to highlight the difficulties of trying to identify complicated, deformed, island arc series rocks during ROV dives. Most of the rock/stratigraphic identifications given in this report and in the dive summaries were based on i) occasional outcrops or parts of outcrops without Fe-Mn coatings, ii) morphology and structural orientation of the outcrops, and/or iii) information from published, interpreted, multi-channel seismic (MCS) data (e.g. Van Gestel et al., 1998 and Mann et al., 2005) (Figure 8) to help constrain what rocks were expected during each dive.

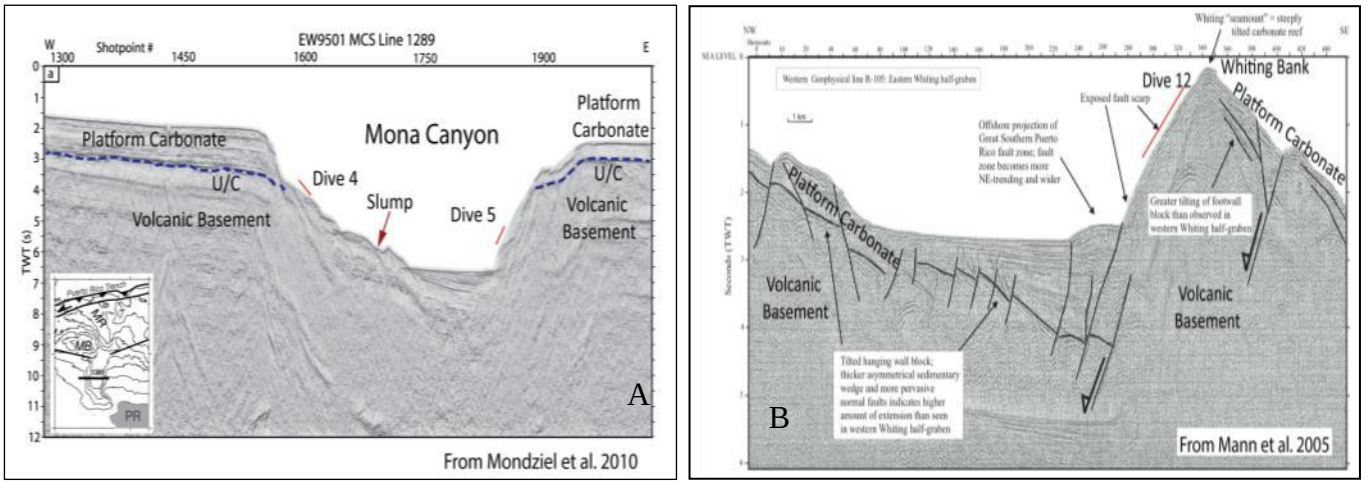

Figure 9: Multi-Channel Seismic (MCS) dData forover Mona Canyon and Whiting Seamount. A) EW9501 MCS Line 1289 crossing the central Mona Canyon (see insert map for location), blue dashotted line shows basement/platform sequence unconformity (Mondziel *et al*., 2010); B) MCS Line R-105 across the eastern Whiting Graben and Whiting Bank (Mann *et al*., 2005). Red lines show locations of Dives 04, 05, and 12

Stratigraphy

The Oligocene to Pliocene Platform sedimentary sequence is subtly different in the north and south of Puerto Rico (Figure 10) (Frost et al., 1983; Mann et al., 2005), with the constituent formations showing significant variations in thickness over the entire area (Figure 7) (Van Gestel et al. (1998). The majority of the dives were within this sequence; Figure 10 highlights example photographs of different parts of the stratigraphic section recorded during the dives. There are a wide variety of carbonate rocks ranging from soft chalks of the Los Puertos or Cibao Formation, encountered during Dive 04 to more resistant, massive carbonates of the Lares Formation encountered during Dive 01. Perhaps the most significant finding was the presence of spectacular conglomerates at 3170 m (Figure 10) towards the top of Dive 02 on the southern side of the Septentrional Fault. These are likely the basal conglomerates of the Oligocene San Sebastian Formation, and, if so, require that basement arc rocks lie below the debris flows immediately to the south of the surface trace of the Septentrional Fault, and that the existing geological maps need updating.

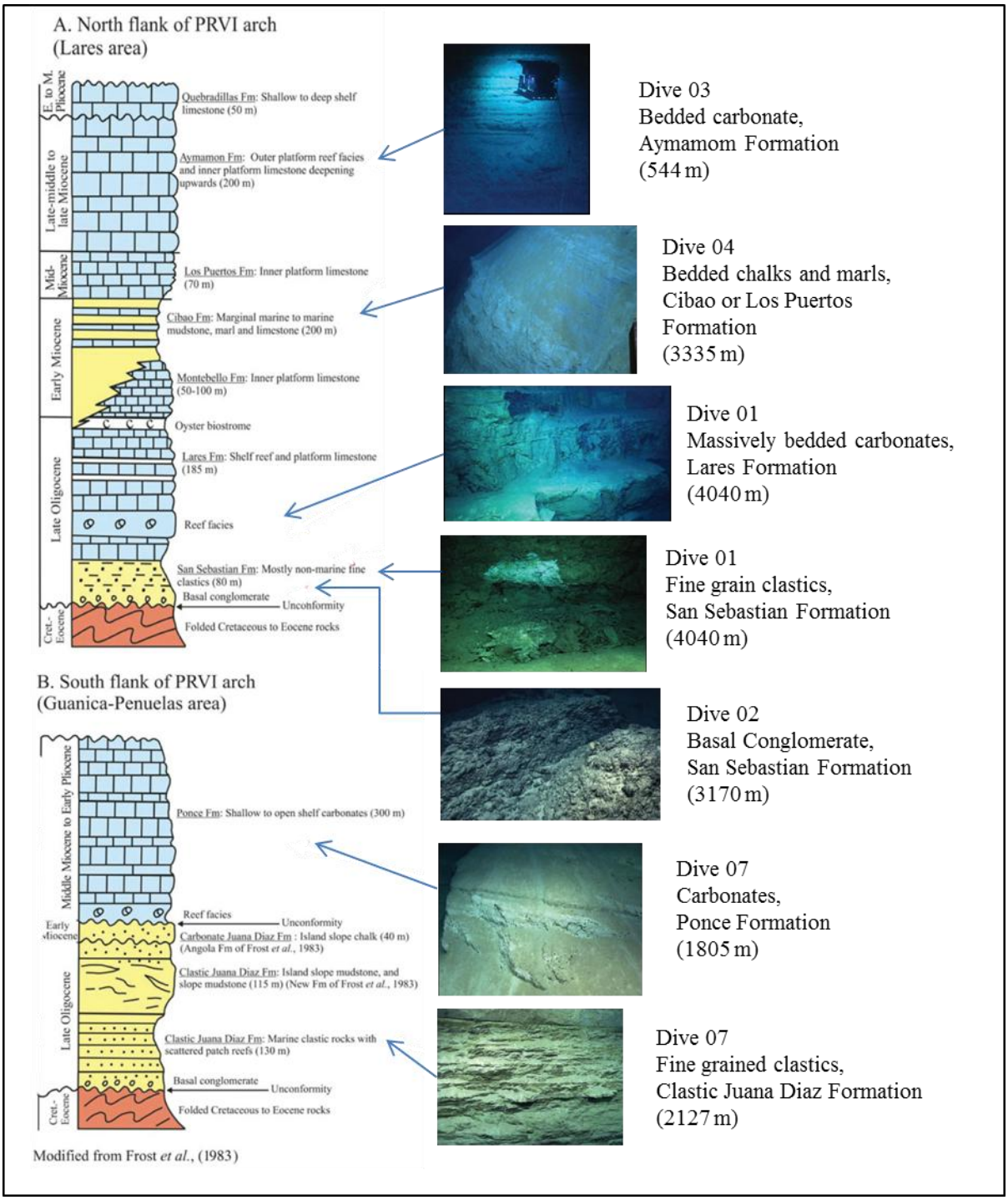

Figure 10: Oligocene to Pliocene clastic and carbonate stratigraphic sequence in relation to observed geologic formations. Stratigraphic columns adapted from Mann et al., 2005.

Key Dives

i) Dives 3 and 6 were shallow dives (600-300 m) in Mona Passage that traversed fault scarps in the Lower to Middle Miocene Ayamon and Los Puertos Formations. Evidence of erosion, and the sedimentation indicates that the faults have not been active recently. Chaytor & ten Brink (2010) interpreted these faults as part of a system of faults created by oblique extension in the Mona Passage area due to the rotation of the Puerto-Rico-Virgin Islands microplate within the North American/Caribbean Plate Boundary. They use the age of the faulted rocks to suggest the faulting must be post Miocene in age.

The carbonates show heavy biologic encrustation and are weathered. Of particular interest, is the spectacular karst weathering of the carbonates at approximately 400 m (Figure 11). The origin of the apparent karstic topography is enigmatic. One possible explanation is sub-aerial weathering after the sequence had been exposed above sea-level during the Last Glacial Maximum sea-level lowstand. Subsequently, the sequence has subsided below sea-level due to both sea level rise and due to crustal extension below the Mona Passage (Chaytor & ten Brink, 2010).

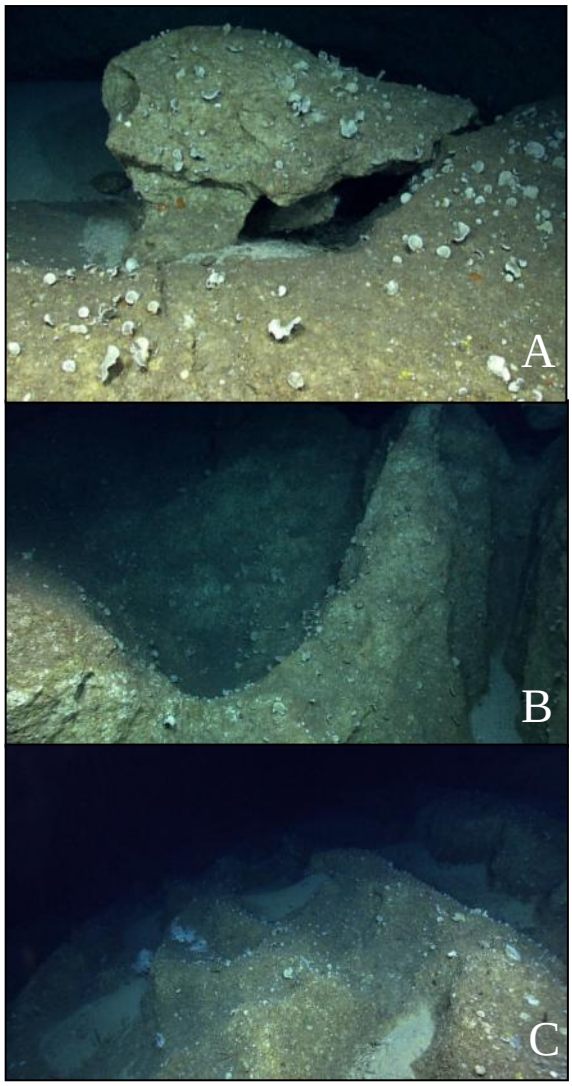

Figure 11: Karstic weathering of carbonates in Mona Passage- evidence for sub-aerial weathering and subsidence. A) Dive 03 at Pichincho at a depth of 315 m; B) Dive 03 at Pichincho at a depth of 307 m; Dive 06 at Platform at a depth of 310 m.

ii) Mona Canyon is a 20–30 km wide, 140 km long, north south trending, submarine canyon with 2-3.5 km of vertical relief (Figure 12). It is an extensional rift that initiated during the Middle Oligocene and forms part of the western edge of the Puerto Rico Virgin Islands microplate (Mondziel et al., 2010). Dives 04 and 05 were carried out respectively on the western and eastern walls of the Canyon. Dive 04 traversed chalk and marl carbonates of the Cibao or Los Puertos Formations. The dip of the carbonates which was consistently towards the SW and towards the canyon wall (Figure 12), and the depth of the dive, which seems to below the bottom of the carbonate sequence as recognized on the MCS data (Figure 9), strongly suggests that the entire sequence traversed during the dive had slumped down the Canyon wall forming the top part of the spectacular slump seen in the bathymetry (Figures 9 and

12). Dive 05 on the eastern wall of the canyon was entirely within the Jurassic-Eocene island arc basement, below the younger platform sequence. Porphyritic volcanic rocks and possible bedded volcanoclastic deposits were recognized. Felsic plutonic rocks were tentatively identified towards the top of the dive. Although, Mondziel et al, (2010) used MCS to suggest the eastern canyon wall is a fault scarp, the actual scarp is degraded and eroded. One, meter scale, fallen, block was observed with clear slickensides (Figure 12); perhaps this is a remnant of the eroded fault scarp.

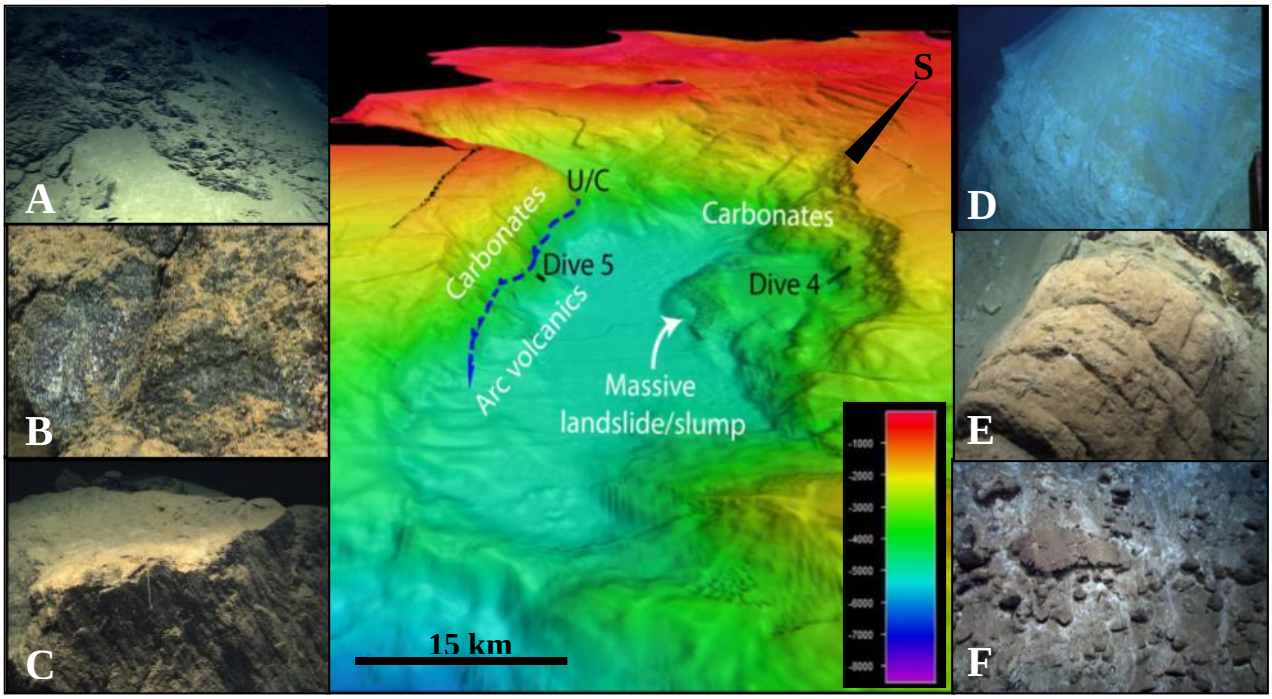

Figure 12: Mona Canyon dives. Images A-C are from Dive 05 along the east wall of Mona Canyon which traversed the Jurassic-Eocene volcanic arc basement. Images D-F are from Dive 04 along the west wall of Mona Canyon which traversansected the Oligocene-Pliocene platform carbonate sequence. A) Potential Bbedded volcanoclastic rocks (3751 m); B) Porphyritic volcanics (3963); C) Fault slickensides on boulder, potentially the remnant of the canyona bounding fault (3993 m); D) Ciabo/Los Puertos Formation bedded chalks (3335 m); E) Rotated slump block of bedded carbonates (3380 m); F) Debris flow sitting on top of Cibao Formation carbonates (3720 m). Vertical exaggeration is 1:1. Bathymetry data shown compiled from data collected by USGS. (http://dx.doi.org/10.3133/ofr20131125) and by NOAA OER

iii) Whiting Seamount is a rotated, uplifted, fault block off the south-eastern coast of Puerto Rico that forms the southeastern margin of the Whiting Graben (Figures 9 and 13). It was formed by extension along the southeastward continuation of the Great Southern Puerto Rico fault zone (Mann et al., 2005). Dive 12 was located on the eroded fault scarp exposing the uplifted footwall block. The dive traversed dominantly Jurassic-Eocene island arc basement rocks. During the lower part of the dive (1275 m), a rock was picked up and the reverse, non Fe-Mn coated, side examined to reveal that it was a plutonic (granitoid) rock (Figure 13A), perhaps part of the large felsic pluton found onshore at the south-eastern end of Puerto Rico. At 1040 m, the D2 ROV encountered a small box canyon cutting into the slope, which presented a spectacular exposure of a geological contact (Figure 13B). This contact could be an inverted unconformity, an intrusive contact or a tectonic contact. Thinly

layered rocks, which are likely bedded volcaniclastic deposits, with apparent cross bedding (806 m), were observed from 819-580 m (Figure 13C). Given the thickness of the younger platform sequence shown by the MCS data (Figure 9), these rocks are likely part of the island arc basement sequence. Clear carbonate crusts were observed above 571 m (Figure 13D). These might mark the beginning of the platform sequence, although they could be draped carbonate crusts over the scarp.

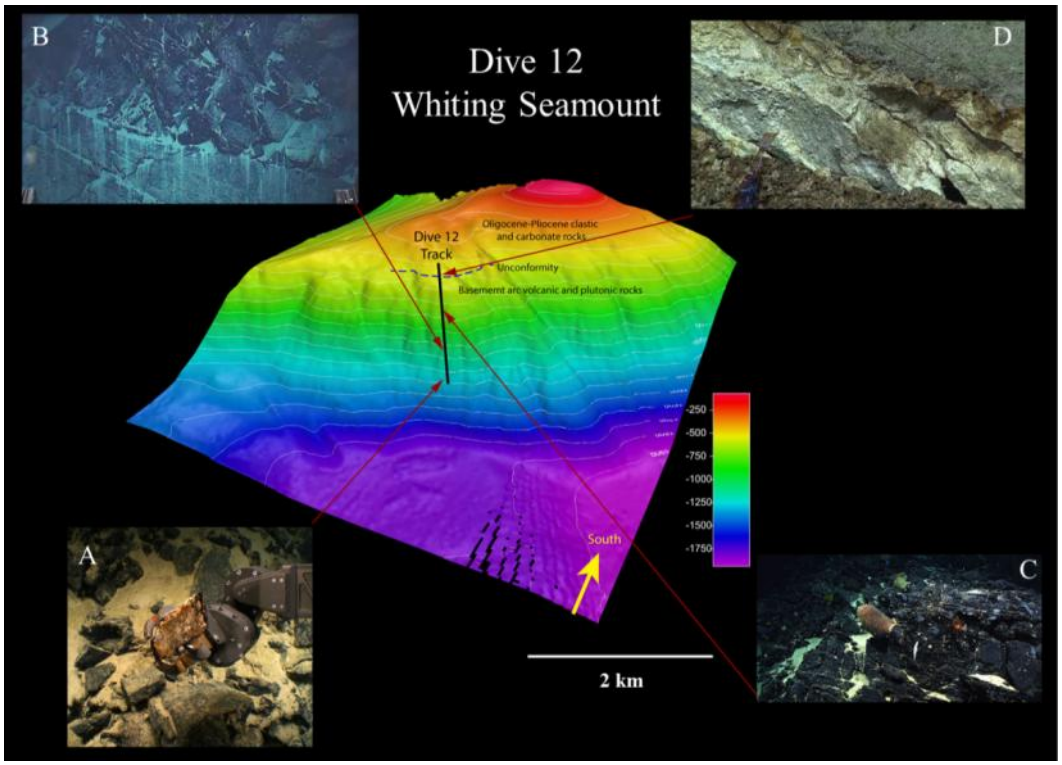

Figure 13: Geologic overview of Dive 12 which climbed the north face of Whiting Seamount. A) The base of the wall was composed of basement granitoid or plutonic rock (1275 m); B) Contact point within basement (1039 m); C) Potential thinly bedded volcanics (753 m). Vertical exaggeration is 1:1.

iv) Dive 10 was conducted at a site dubbed "Pinnacles" located south of St Croix. The two mounds or pinnacles investigated during the dive sit at 870-900 m on top of a probable Middle Miocene to Lower Pliocene platform carbonate sequence to the south east of St Croix (Figure 14). The pinnacles were two of several mounds recently discovered to the south of St Croix in March 2015 during surveying by the RV Nancy Foster (NOAA NOS, Tim Battista *et al.*). The dive clearly confirmed that these pinnacles were made of carbonate, but their origin remains unclear. At least two possibilities can be put forth for their origin. First, the mounds could be *in-situ* and represent a relict surface protruding above the present day planar surface that dips to the south from St Croix. Alternatively, the mounds are large 200 m wide, 50 m high blocks or slides (Figure 14) that detached from the relatively steep shelf-slope break 5km to the north. This interpretation is supported by the angular 5 sided margin to the first mound which could be explained if the shape of the detached block was controlled by jointing in the outcrop and by the observation that bedding may be dipping and therefore not *in-situ*. This explanation requires in-situ weathering and breakdown to produce the rock debris sitting on the mound today. The prevalence of

the Fe-Mn coating and the amount of biological colonization suggest that if this is indeed a slide block, the transport of the block was not recent. Whilst this second interpretation requires a rather dramatic event (a 200 m relatively coherent block sliding 5 km), it might be the best way to account for the observations.

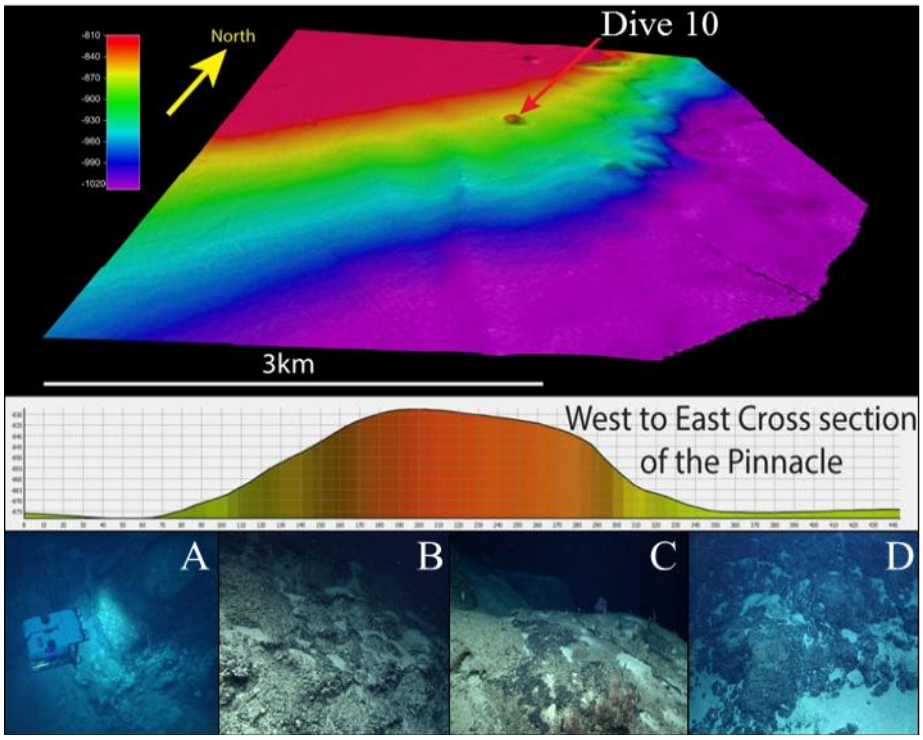

Figure 14: Dive 10 investigated a raised feature that was 50 m high and 200 m in diameter. A) West side of the pinnacle at 837 m; B) East side of the pinnacle at 840 m; C) East side of the pinnacle at 847 m; East side of the pinnacle at 867 m. Vertical exaggeration of the map is 1:1. Bathymetry data shown courtesy of NOAA National Ocean Service.

Slope Stability

A key objective of the dive and mapping program was to look for evidence of recent slope instabilities/failure. Extremely large slump deposits have previously been recognized in the bathymetric data, including the large slump deposit in Mona Canyon (Figure 12) that may have been related to the 1918 San Fermin Magnitude 7.3 Earthquake. Other large slumps have been documented in the Puerto Rico Trench. These landslides or slumps are important for hazard assessment, because they could potentially trigger significant tsunamis. To this end, one of the first multibeam mapping objectives during EX1502L3 was to re-map the northern wall of the Arecibo Escarpment to look for changes in slope character/bathymetry between the original multibeam survey of 2002/3 and the current survey of April 2015. Slope failure on the escarpment may have occurred due to ground-shaking associated with the January 2014, Magnitude 6.4 earthquake that had its epicenter just 57 km north of Hatillo. Close inspection of the two multibeam data sets revealed no significant differences and therefore no evidence for a change in the slope at the 100-150 m scale resolution.

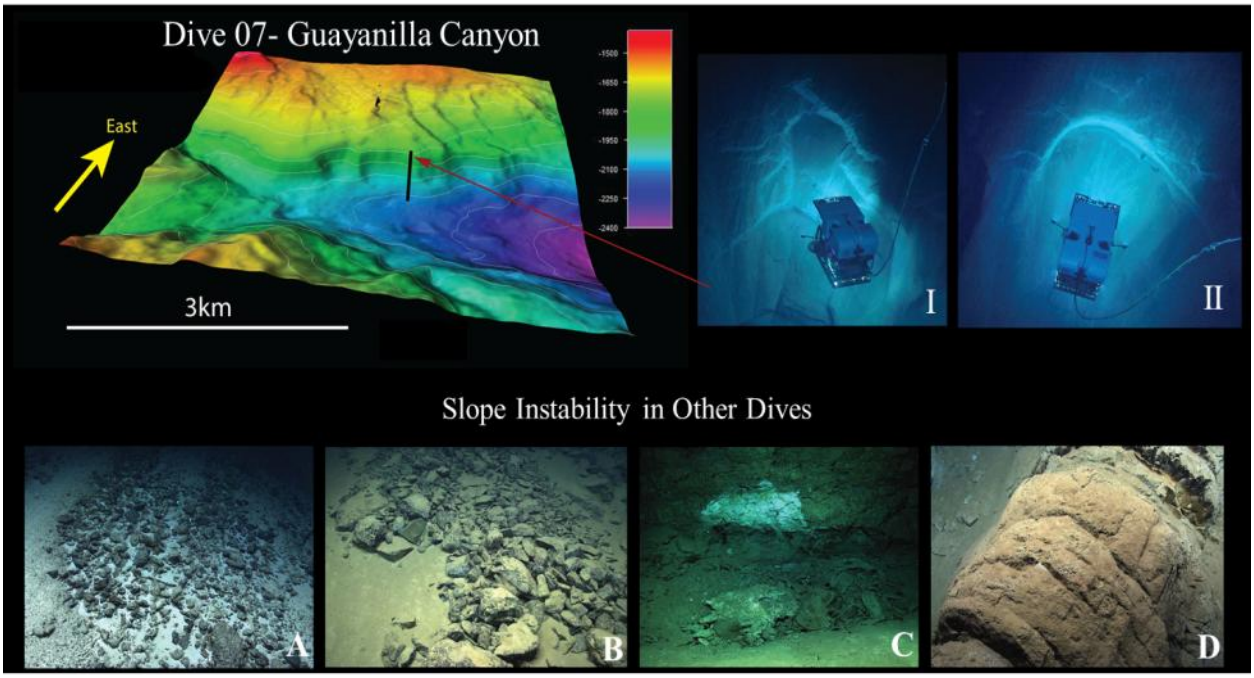

Figure 15: Slope Stability was documented during every dive. During Dive 07 in Guayanilla Canyon, headwall failure was documented at 1800 m (images I and II). Slope failures were also observed during other dives: A) recent debris flow observed during Dive 02 near the Septentrional Fault at 3598 m; B) recent debris flow observed during Dive 05 at 3949 m in Mona Canyon; C) recent rock face failure noted during Dive 01 in Guajataca Canyon along the Arecibo Amphitheater; D) rotated slump block documented during Dive 04 in Mona Canyon at 3380 m. Bathymetry data shown compiled by USGS. (http://dx.doi.org/10.3133/ofr20131125).

Very few examples of recent slope failure were seen during any of the dives. Figure 15 summarizes those that were seen. Spectacular 20m wide, arcuate, head wall scarps in the steeply dipping carbonate Juana Diaz Formation; Guayanilla Canyon, were seen to the south of Puerto Rico (Dive 07) (Figure 15 I & II). Small, relatively recent debris flows with rounded cobbles were seen during Dives 01, 02 and 05 (Figure 15A and B), and local spalling of the rock face was seen during Dive 01 (Figure 15C). As discussed previously, Dive 04 on the west wall of Mona Canyon was entirely within a series of rotated slump blocks (Figure 15D), but this was not a recent slumping event.

C. Mapping

Mapping data were collected along 2,415 linear kilometers of ship transit lines, with more than 10,850 square kilometers of seafloor area mapped with the multibeam sonar. Figure 1 shows a summary of the multibeam data coverage completed during the expedition. While much of the data was collected during single transit lines, a 180 square nautical mile area off the northwestern shore of Puerto Rico was mapped for the first time with multibeam sonar, contributing significantly to coverage within the exclusive economic zone (Figure 1). Whiting Seamount was also entirely mapped, including its summit, which will likely make a contribution to more accurate nautical charts for the region.

Single beam EK60 18 kHz and Knudsen 3260 chirp sub-bottom sonar data were collected nearly continuously during all multibeam sonar mapping operations. Figure 16 shows the ship tracklines where EK60 and sub-bottom sonar data files were collected.

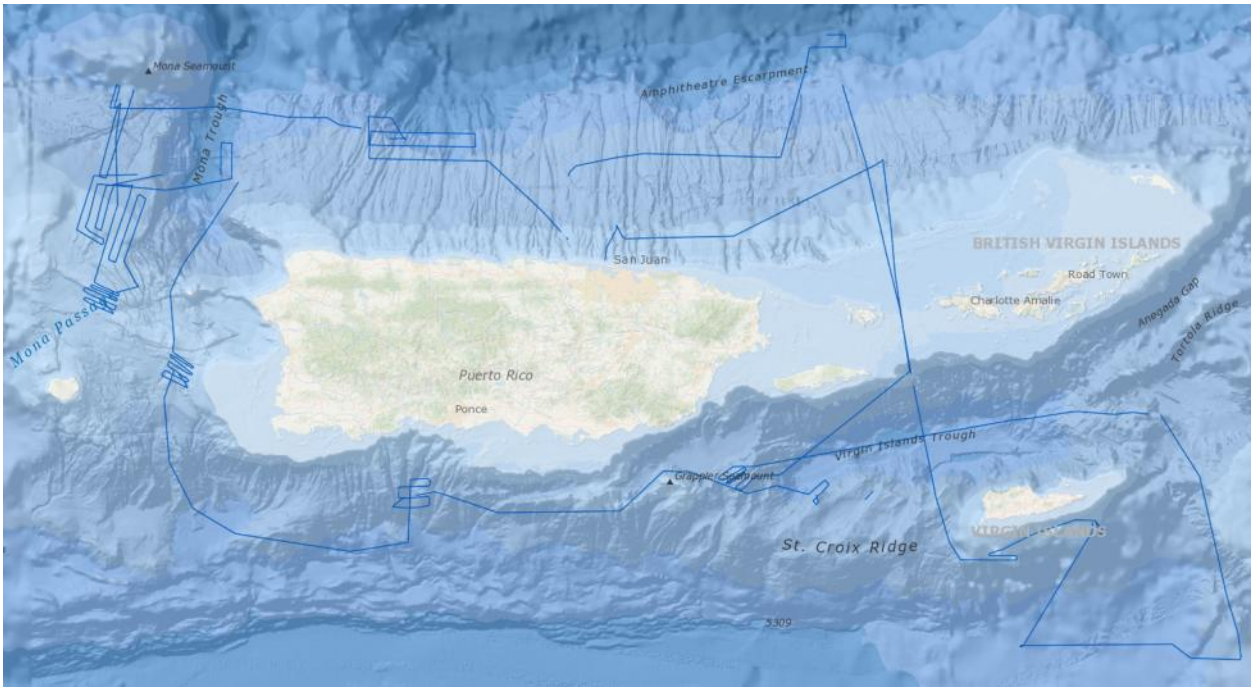

Figure 16: Tracklines of EK 60 singlebeam and Knudsen 3260 sub-bottom sonar data collected during EX1502 L3. Map Credit: National Geophysical Data Center (2014): Water Column Sonar Data Collection. National Geophysical Data Center, NOAA. doi: 10.7289/V5HT2M7C [accessed 11/10/2015].

The majority of mapping work was directed at mapping the locations of ROV dives planned for the following day, and mapping during transits between dive locations. However, as time allowed, efforts were made to fill in known gaps in existing high resolution multibeam bathymetry coverage in the region. Figure 17 shows 50 m resolution multibeam data coverage before and after *Okeanos Explorer* mapping of Whiting Seamount during this cruise.

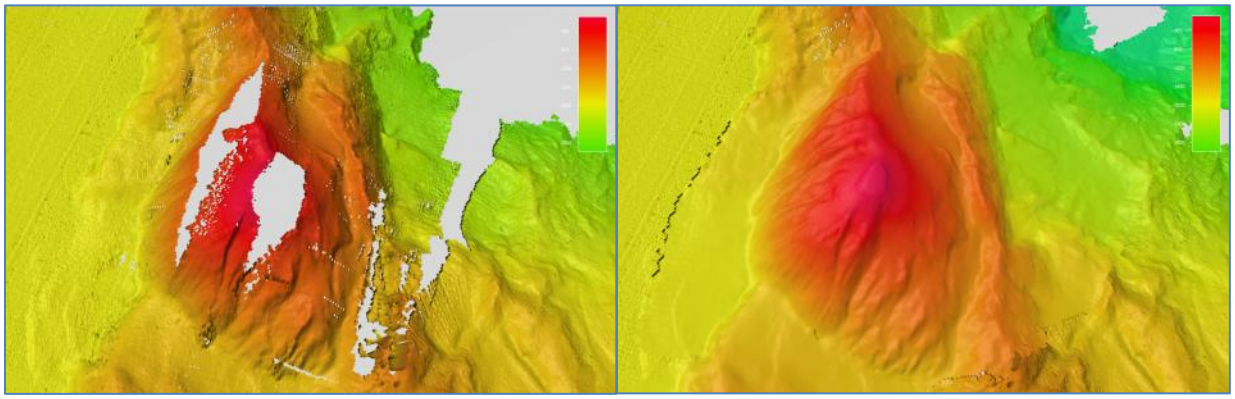

Figure 17: Left image shows 50 m resolution multibeam bathymetry coverage of Whiting Seamount mapped previously by NOAA Ship *Ron Brown*. Right image shows coverage after complementary multibeam mapping accomplished by *Okeanos Explorer* during EX1502 Leg 3. Note complete coverage of the summit of the seamount, providing new shoal soundings (as shallow as 71 m) useful for updating nautical charts.

Figure 18 shows pre-existing 100 m resolution multibeam data coverage on the continental shelf on the west side of Mona Passage before this cruise (left), and after the cruise with 50 m resolution new data coverage (right).

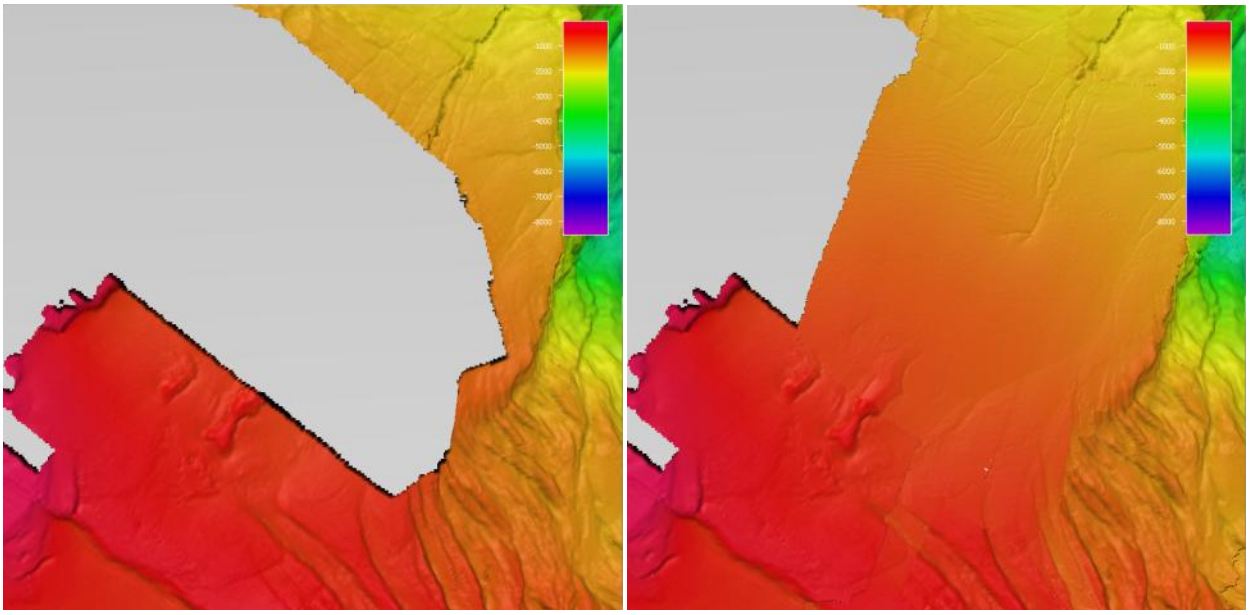

Figure 18: Left image shows 100 m resolution multibeam bathymetry coverage for a continental shelf area on the northwest side of Mona Passage (Andrews et al. 2014) *http://dx.doi.org/10.3133/ofr20131125*). Right image shows 50 meter resolution new coverage after complementary multibeam mapping accomplished by *Okeanos Explorer* during EX1502 Leg 3.

Mapping Statistics

Line kilometers of survey	2,415
Square kilometers mapped	10,854
Number / Data Volume of EM 302 raw bathymetric / bottom backscattermultibeam files	283 files/ 13.1GB
Number / Data Volume of EM 302 water column multibeam files	283 files / 41.2 GB
Number / Data Volume of EK 60 water column singlebeam files	822 files / 1.98 GB
Number / Data Volume of subbottom sonar files	474files / 2.42 GB
Number of XBT casts	40

EM 302 Multibeam Sonar Crossline Analysis

Within CARIS software, fifty meter resolution grid surfaces were generated separately for a mainscheme area and for an orthogonally oriented crossline for comparison. Mainscheme and crossline surfaces were then compared using the "surface differencing" tool in CARIS. The results show a normally distributed result, with the mean difference between the two surfaces being 1.4 m. This result indicates that in survey water depths ranging from 4200-5000 meters, multibeam tracks surveyed in orthogonal directions at different times obtained seafloor depths that agreed with each other (on average) to within less than one and a half meters. Figure 17 displays summary statistics and a histogram plot of the differences between the mainscheme and crossline. The minimum/maximum value points were located in the outer beams of the sonar

swath were uncertainties in sounding are highest. These results provide strong validation of the quality of the multibeam bathymetry data.

File Names of Crosslines Compared:
0203_20150427_022228_EX1502L3_MB (heading 167°)
0243_20150429_015441_EX1502L3_MB (heading 259°)

Statistical information:
Minimum: -54.64 m
Maximum: 35.79 m
Mean: -1.4 m
Std_dev: 6.17 m
Total count: 15,425

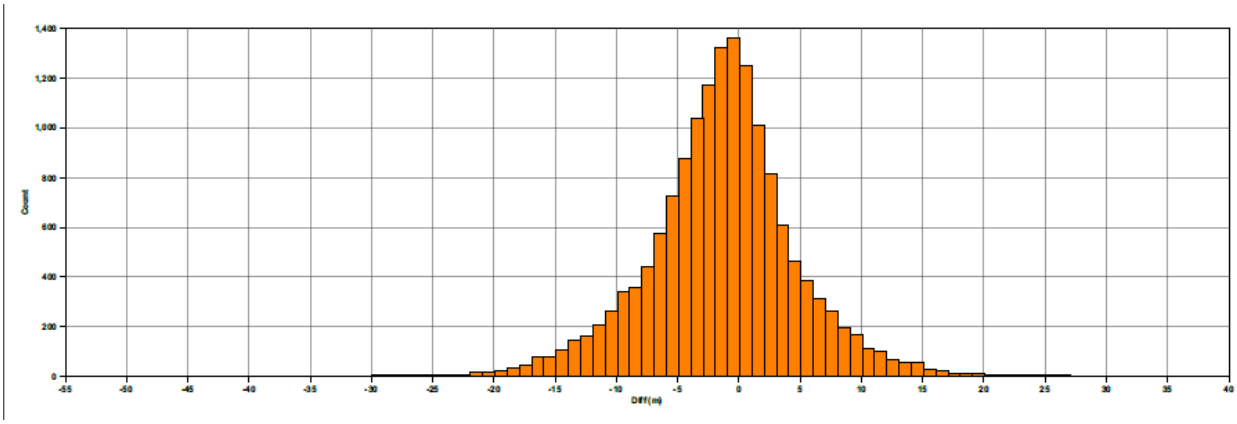

Figure 19: Summary statistics and a histogram plot of the differences between 50 m resolution bathymetric surfaces generated from two separate multibeam data files collected on different days and from orthogonal orientations over the same patch of seafloor.

6. Data Deposition and Archival

All data collected by *Okeanos Explorer* are archived and publically available within 90 days of the end of each cruise via the National Center for Environmental Intelligence (NCEI, formerly NGDC) online archives. Data can be accessed via the following websites:

- OER Digital Atlas at http://www.ncddc.noaa.gov/website/google_maps/OE/mapsOE.htm
- OER ROV Data Archives at http://service.ncddc.noaa.gov/rdn/oer-rov-cruises
- NGDC Interactive Bathymetry Data Viewer at http://maps.ngdc.noaa.gov/viewers/bathymetry/
- NGDC Interactive Multibeam Data Viewer at http://maps.ngdc.noaa.gov/viewers/multibeam/

Additional data requests are handled through the NOAA Ocean Exploration and Research Program Data Access Request Form which can be found here:
https://docs.google.com/a/noaa.gov/forms/d/1pU3jbcV5ffunMKUbYgnA2OK-ZT9qj2Dh6JgZ79TTORM/viewform?formkey=dHAycC1MYndJb0hTdGRaYXAzVTVBdWc6MA&fromEmail=true

The complete 2015 Field Season *Okeanos Explorer* Data Management Plan can be found in the Data Management Report, accessible through http://service.ncddc.noaa.gov/rdn/oer-waf/media/docs/EX_FY15_DMP.pdf

7. Additional Information

EX1502L3 was the third in a three-leg, 52-day expedition. Legs 1 and 2 focused on mapping the seafloor where primarily only low-resolution satellite-derived bathymetry existed previously. Data from these cruises were used to identify ROV dive targets and to identify mapping holidays that were filled during Leg 3. Additional information about these cruises, specific operations, and summaries of their findings can be found in the Mapping Data Acquisition and Processing Reports for the respective cruises at the citations below:

McKenna, L. (2015). *EX-15-02L1 Caribbean Exploration: Mapping Data Acquisition and Processing Report*. Office of Ocean Exploration and Research, Office of Oceanic &Atmospheric Research, NOAA, Silver Spring, MD 20910. OER Expedition Rep. 2015-02-01, 94 p..

Lobecker, E., Rose, E., Schmidt, W., Ovard, M., Allen, S., Meyer, J., Wegner, C., Mello, K., Millan, J.. (2015). *EX-15-02L3 Caribbean Exploration: Mapping Data Acquisition and Processing Report*. Office of Ocean Exploration and Research, Office of Oceanic &Atmospheric Research, NOAA, Silver Spring, MD 20910. OER Expedition Rep. 2015-02-02, 94 p..

Daily Situation Reports, internal operational records, are also on file with OER. For questions, please contact OER.

8. References

Andrews, B.D., ten Brink, U.S., Danforth, W.W., Chaytor, J.D., Granja Bruña, José-Luis, Llanes Estrada, Pilar, and Carbó-Gorosabel, Andrés, 2014, Bathymetric terrain model of the Puerto Rico trench and the northeastern Caribbean region for marine geological investigations: U.S. Geological Survey Open-File Report 2013–1125, 10 p., 1 pl., *http://dx.doi.org/10.3133/ofr20131125*.

Chaytor,J.D.,and U.S.ten Brink 2010, Extension in Mona Passage, northeast Caribbean, Tectonophysics, 493,74–92, doi:10.1016/j.tecto.2010.07.002.

Frost, S.H., Harbour, J.L., Realini, M.J., and Harris, P.M., 1983, Oligocene Reef Tract development southwestern Puerto Rico Part 1, report: Miami, Florida, University of Miami, 144 p.

Mann, P., J. Hippolyte, N. R. Grindlay, and L. J. Abrams, 2005b, Neotectonics of southern Puerto Rico and its offshore margin, in, Mann, P., ed., "Active tectonics and seismic hazard of Puerto Rico, the Virgin Islands, and offshore areas," Geological Society of America Special Paper 385, 173-214.

Mondziel, S., N. Grindlay, P. Mann, A. Escalona, and L. Abrams, 2010. Morphology, structure, and tectonic evolution of the Mona canyon (northern Mona passage) from multibeam bathymetry, side-scan sonar, and seismic reflection profiles, Tectonics, 29, TC200310.1029/2008TC002441.

van Gestel, J.-P., Mann, P., Dolan, J.F., Grindlay, N.R., 1998. Structure and tectonics of the upper Cenozoic Puerto Rico-Virgin Islands carbonate platform as determined from seismic reflection studies. J. Geophys. Res., 103, 30505-30530.

van Gestel, J.-P., Mann, P., Grindlay, N.R., Dolan, J.F., 1999. Three-phase tectonic evolution of the northern margin of Puerto Rico as inferred from an integration of seismic reflection, well, and outcrop data. Mar. Geol., 161, 257-286.

9. Appendices

APPENDIX A: Data Management Plan

Data Management Plan
Okeanos Explorer (EX1502L3): Caribbean Exploration (ROV)

OER Data Management Objectives
QA/QC of submersible data sets following calibration by seabird; participate in engineering dive as first dive; evaluation of rsync procedure from ship to shore in heavy seas; update configuration files as necessary; integrate new rsync routine with new user accounts and shipboard data sets hosted by synology; evaluate new hardware (primary storage device for EVS); train new data management intern; cross-train two ROV team members on data management procedures;

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1. General Description of Data to be Managed

1.1 Name and Purpose of the Data Collection Project

Okeanos Explorer (EX1502L3): Caribbean Exploration (ROV)

1.2 Summary description of the data to be collected.

This will be the first cruise to have 12-hour ROV operations. The daily schedule for the cruise cruises will usually be split between daytime ROV operations and nighttime CTD and mapping operations. ROV operations will focus in depths >500m and will include high-resolution visual surveys. Mapping operations will include overnight sub-bottom data collection over key features, multibeam data collection, and water column backscatter data.

1.3 Keywords or phrases that could be used to enable users to find the data.

expedition, exploration, explorer, marine education, noaa, ocean, ocean discovery, ocean education, ocean exploration, ocean exploration and research, ocean literacy, ocean research, OER, science, scientific mission, scientific research, sea, stewardship, systematic exploration, technology, transformational research, undersea, underwater, Davisville, mapping survey, multibeam, multibeam backscatter, multibeam sonar, multi-beam sonar, noaa fleet, okeanos, okeanos explorer, R337, Rhode Island, scientific computing system, SCS, single beam sonar, singlebeam sonar, single-beam sonar, sub-bottom profile, water column backscatter, oceans, Puerto Rico, US Virgin Islands, Puerto Rico Trench, benthic habitats, benthic ecosystems, habitat characterization

1.4 If this mission is part of a series of missions, what is the series name?

Okeanos ROV Cruises

1.5 Planned or actual temporal coverage of the data.

Dates: 4/9/2015 to 4/30/2015

1.6 Planned or actual geographic coverage of the data.

Latitude Boundaries: 21 to 16.92

Longitude Boundaries: -67.32 to -63.77

1.7 What data types will you be creating or capturing and submitting for archive?

Cruise Plan, Cruise Summary, Data Management Plan, Highlight Images, Quick Look Report, Bottom Backscatter,
Okeanos Explorer (EX1502L3): Caribbean Exploration (ROV)

CTD (raw), Dive Summaries, EK60 Singlebeam Data, Expedition Cruise Report, GSF, HDCS, Multibeam (image), Multibeam (processed), Multibeam (product), Multibeam (raw), SCS Output (compressed), SCS Output (native), Sub-Bottom Profile data, Water Column Backscatter, XBT (raw), Selected Raw Video, Raw Video (digital), Raw video inventory logs, Mapping Summary, HL Image captions/credits, HL Video captions/credits

1.8 What platforms will be employed during this mission?

NOAA Ship Okeanos Explorer, Deep Discoverer ROV, SEIRIOS Camera Sled

2. Point of Contact for this Data Producing Project

Overall POC:	Brian Kennedy, Commissioned Officer, NOAA Office of Ocean Exploration and Research, brian.kennedy@noaa.gov
Title:	Expedition Coordinator
Affiliation/Dept:	NOAA Office of Ocean Exploration and Research
E-Mail:	brian.kennedy@noaa.gov
Phone:	401-874-6150

3. Point of Contact for Managing the Data

Data POC Name:	Susan Gottfried
Title:	Data Management Coordinator
E-Mail:	susan.gottfried@noaa.gov

4. Resources

4.1 Have resources for management of these data been identified? True

4.2 Approximate percentage of the budget devoted to data management. (specify % or "unknown")

unknown

5. Data Lineage and Quality

5.1 What is the processing workflow from collection to public release?

SCS data shall be delivered in its native format as well as an archive-ready, documented, and compressed NetCDF-4 format to NODC; multibeam data and metadata will be compressed and delivered in a bagit format to NGDC.

5.2 What quality control procedures will be employed?

Quality control procedures for the data from the Kongsberg EM302 is handled at UNH CCOM/JHC. Raw (level-0) bathymetry files are cleaned/edited into new data files (level-1) and converted to a variety of products (level-2). Data from sensors monitored through the SCS are archived in their native format and are not quality controlled. Data from CTD casts and XBT firings are archived in their native format and are not quality controlled. CTDs are processed into profiles for display only on the Okeanos Atlas.

6. Data Documentation

6.1 Does the metadata comply with the Data Documentation Directive? True

6.1.1 If metadata are non-existent or non-compliant, please explain:

Okeanos Explorer (EX1502L3): Caribbean Exploration (ROV)

not applicable

6.2 Where will the metadata be hosted?

Organization: An ISO format collection-level metadata record will be generated during pre-cruise planning
URL: http://www.ncddc.noaa.gov/oer-waf/ISO/Resolved/
discovery and access. The record will be harvested by data.gov.

Meta Std: ISO 19115-2 Geographic Information with Extensions for Imagery and Gridded Data will be the metadata standard employed; a NetCDF-4 standard for oceanographic data will be employed for the SCS data; the Library of Congress standard, MAchine Readable Catalog (MARC), will be employed for NOAA Central Library records.

6.3 Process for producing and maintaining metadata:

Metadata will be generated via xml editors or metadata generation tools.

7. Data Access

7.1 Do the data comply with the Data Access Directive? True

7.1.1 If the data are not to be made available to the public at all, or with limitations, provide a valid reason.

Not Applicable

7.1.2 If there are limitations to public data access, describe how data are protected from unauthorized access or disclosure.

Account access to mission systems are maintained and controlled by the Program. Data access prior to public accessibility is documented through the use of Data Request forms and standard operating procedures.

7.2 Name and URL of organization or facility providing data access.

Org: NOAA National Centers for Environmental Information (NCEI)
URL: explore.noaa.gov/digitalatlas

7.3 Approximate delay between data collection and dissemination. By what authority?

Hold Time: no
Authority: not applicable

7.4 Prepare a Data Access Statement

No data access constraints, unless data are protected under the National Historic Preservation Act of 1966.

8. Data Preservation and Protection

8.1 Actual or planned long-term data archive location:

Data from this mission will be preserved and stewarded through the NOAA National Data Centers. Refer to the Okeanos Explorer FY15 Data Management Plan at NOAA's EDMC DMP Repository (EX_FY14_DMP_Final.pdf) for detailed descriptions of the processes, procedures, and partners involved in this collaborative effort.

8.2 If no archive planned, why?

8.3 If any delay between data collection and submission to an archive facility, please explain.

30-90 days

8.4 How will data be protected from accidental or malicious modification or deletion?

Data management standard operating procedures minimizing accidental or malicious modification or deletion are in place aboard the Okeanos Explorer and will be enforced.

8.5 Prepare a Data Use Statement

Data use shall be credited to NOAA Office of Ocean Exploration and Research.

APPENDIX B: ROV Dive Summary Forms

<table>
<tr><td>Site Name</td><td colspan="3">Arecibo Amphitheater (Guajataca Canyon)</td><td rowspan="4"> 
</td></tr>
<tr><td>ROV Lead/ Expedition Coordinator</td><td colspan="3">Brian Bingham/
Brian Kennedy</td></tr>
<tr><td>Science Team Leads</td><td colspan="3">Andrea Quattrini and Mike Cheadle</td></tr>
<tr><td>General Area Descriptor</td><td colspan="3">Puerto Rico and US Virgin Islands</td></tr>
<tr><td rowspan="2">ROV Dive Name</td><td>Cruise Season</td><td>Leg</td><td>Dive Number</td></tr>
<tr><td>EX1502</td><td>3</td><td>DIVE01</td></tr>
<tr><td rowspan="2">Equipment Deployed</td><td>ROV:</td><td colspan="2">Deep Discoverer</td></tr>
<tr><td>Camera Platform:</td><td colspan="2">Seirios</td></tr>
<tr><td rowspan="6">ROV Measurements</td><td>☒ D2 CTD</td><td>☒ Depth</td><td>☒ Altitude</td></tr>
<tr><td>☒ Scanning Sonar</td><td>☒ USBL Position</td><td>☒ Heading</td></tr>
<tr><td>☒ Pitch</td><td>☒ Roll</td><td>☒ HD Camera 1</td></tr>
<tr><td>☒ HD Camera 2</td><td>☒ ROV HD 2</td><td>Seirios CTD</td></tr>
<tr><td>☒ Temperature Probe</td><td>☒ D2 DO Sensor</td><td>☐ Seirios DO Sensor</td></tr>
<tr><td></td><td colspan="3"></td></tr>
<tr><td>Equipment Malfunctions</td><td colspan="3">The Seirios CTD is not configured for this dive. The main HD camera on D2 could not be color balanced properly. Operating with a secondary DO sensor that was last calibrated in 2013.</td></tr>
<tr><td>ROV Dive Summary (From processed ROV data)</td><td colspan="3">Dive Summary: EX1502L3_DIVE01

In Water at: 2015-04-10T12:21:48.062000
18°, 51.716' N ; 066°, 48.878' W

Out Water at: 2015-04-10T23:29:25.062000
18°, 51.666' N ; 066°, 48.185' W

Off Bottom at: 2015-04-10T21:22:02.656000
18°, 51.530' N ; 066°, 49.174' W

On Bottom at: 2015-04-10T14:31:05.312000
18°, 51.604' N ; 066°, 48.625' W

Dive duration: 11:7:36

Bottom Time: 6:50:57

Max. depth: 4062.8 m</td></tr>
<tr><td>Special Notes</td><td colspan="3"></td></tr>
</table>

Scientists Involved *(please provide name / location / affiliation / email)*	Bernard Ball	Duke University Marine Lab	bernie.ball@duke.edu
	Jason Chaytor	USGS	jchaytor@usgs.gov
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Purpose of the Dive

i) To investigate the lithology of the exposed rocks along the escarpment,

ii) To identify features that could be related to failure of the escarpment/platform. And in particular to look for recent features that might be related to the January 2014 recent Magnitude 6 Earthquake.

iii) To look for evidence of sediment flows emanating from the canyons.

iv) To explore for fresh water seeps along the marginal escarpment.

v) To document the biology living on and around the escarpment from 3000-4000m.

Description of the Dive:

This dive was situated at the mouth of Guajataca Canyon, on the marginal escarpment of the carbonate platform, in the Arecibo Amphitheatre, very close to the epicenter of the January 2014, Magnitude 6.5 earthquake. The dive began at 12:18 UTC and D2 descended to 4060m and landed on a gently sloping surface of fine biogenic carbonate mud at the base of a canyon wall with a mean slope of 32^{o}. The dive ended at 3452 m after traversing a sequence of massive to rubbly weathering carbonates with intercalated clastic sediments, with D2 leaving the slope at 20:23 UTC.

Geology:

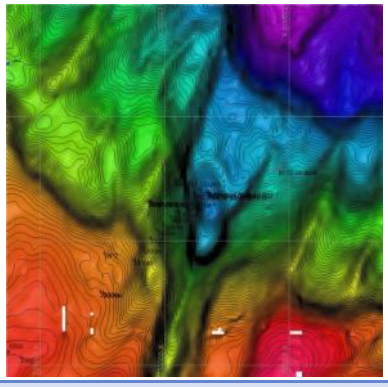
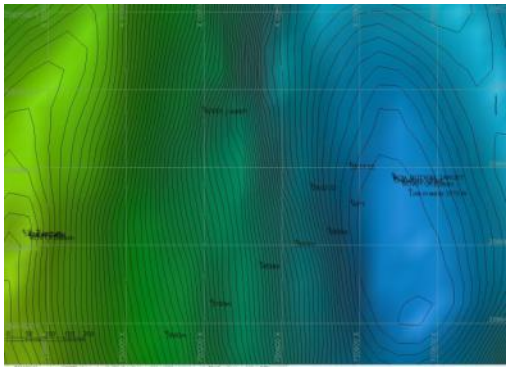
The dive traversed a thick sequence of Late Oligocene to Early Pliocene carbonate rocks with intercalated clastic rocks. Exposures consisted of up to 10's of meters high cliff sections separated by gently dipping slopes or ledges covered by biogenic mud/sediment. Most outcrops were vertically jointed and a thin Fe-Mn crust of variable thickness covered most rock surfaces. Overall 30-40% of the traverse was over rock outcrop.

The first outcrop, reached at 4060m (14:48 UTC), was small (50cm high by 12 m across) and sediment draped and of ambiguous lithology due to extensive Fe-Mn coating. It was heavily fractured but exhibited a weak, sub-horizontal, bedding/foliation, and a light coloration beneath the Fe-Mn coating suggests that it might be carbonate. Gestel et al (1988) report that the Late Oligocene to Early Pliocene platform sequence is 1.5km thick in this location (from seismic data). Given that this outcrop was only ~1000m below the top of the platform (~ 3050m), it's likely that this outcrop is within the platform sequence. The next outcrop encountered at 4058m (1505 UTC) was more substantial, consisting of highly fractured carbonate rocks lying above a shale/marl layer at the base (see photo below). The presence of shales/marls could indicate that this is an outcrop of the Early Miocene Cibao Formation, which contains marls and mudstones. In one part of the outcrop (4058m; 15:11 UTC), an approximately 2m section of the Fe-Mn encrusted face of the layer had spalled off revealing the white fractured carbonate rocks. This was the best example of very recent "slope failure" seen during the dive. The close-up photo (15:09 UTC) of the fresh rock face hints that these rocks might be in the damage zone of a fault. Immediately, above this locality, the outcrops were relatively massive carbonates, commonly with obvious sub-horizontal bedding (see photo below; 15:14 UTC). The presence of Fe-Mn coating on only some faces of this outcrop, suggests episodic uncovering of the outcrop or the possibility of recent slope failure. D2 then traversed a relatively steep slope consisting of commonly Fe-Mn encrusted, and/or mud dusted, carbonate outcrops separated by areas of sediment. The top of this relatively continuous sequence of exposures was reached at 3750m (~18:10 UTC) and this sequence could correspond to the Middle Miocene Los Puertos Formation. Occasional, small talus piles were crossed e.g. at 4025m, (15:48 UTC), and at ~4011m (15:55 UTC D2 passed over a sediment dusted talus slope of rounded boulders, perched on a ledge above a large, steep faced outcrop. Vertical joints were noted at 3785m (17:45 UTC).

The rest of the traverse crossed, commonly sediment draped, rubbly weathering, carbonate rock exposures of varying height and slope separated by gently dipping sediment covered slopes. A small downslope chute of coarse grained gravel was observed at 3625m (18:46 UTC), and sediment trails were seen on several of the rock faces (e.g. 3625m, 18:46 UTC). Other sediment chutes, at for example 3967m (16:27 UTC) and 3515m (19:35 UTC), indicate some downslope movement of sediment into the trench. A large, steep rock face with vertical joints was encountered at 3586m (18:49 UTC) and Fe-Mn encrusted outcrops at 3546m (19:23 UTC) had a rubbly appearance suggestive of conglomerate. Clear sub-horizontal bedding was seen at 3489m (19:52 UTC). An overall picture emerged of relative stability of the escarpment; there were no significant recent slope failures and downslope movement of sediment was not extensive. Both of these observations are consistent with the escarpment eroding in piecemeal fashion, rather than by catastrophic failure. No freshwater seeps were found during the dive.

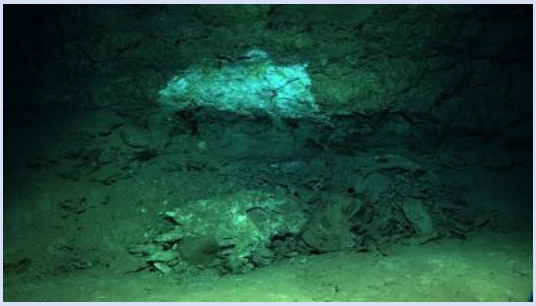
Biology:
Two fish, one siphonophore, and eight jellyfish were observed during descent with the majority observed in the upper 2000 m of the descent. Fishes were rarely observed in the lower part of the dive, but rattail fishes (*Coryphaenoides ?armatus, Nezumia* sp.) were observed from 3700 m upwards, with spectacular examples at 3694 m (18:24 UTC), 3000 m (~ 18:45 UTC) and 3567 m (19:11 UTC). Several of the fish hosted ectoparasites. Two individuals of ophidiid cusk eels (?*Bassozetus* sp.) were also observed during the dive. At least five species of isolated stalked and non-stalked glass sponges were observed. Sponges were the most common sessile species observed throughout the dive. However, they were patchily distributed on vertical rock faces, with some areas being more heavily colonized than others. Occasionally, amphipods were associated with the sponges. Spectacular examples of swimming ctenophores were observed at 3913 m (16:59 UTC) and 3787 m (17:39 UTC) and a jellyfish (Nacromedusae) was observed at 3765 m (17:58 UTC). Five observations of midwater shrimp were also observed. Purple Holothurians (*Benthodytes* sp.) became increasing common as the dive progressed upwards including a spectacular, defecating example at 3464m (20:05 UTC). Their tracks in the sediment were observed at three localities. Eight, up to 10cm diameter, squat lobsters were seen, together with one crab at 2910 m and a spectacular gastropod at 3576m (19:04 UTC). Bamboo octocorals were observed regularly from 4002m (16:09 UTC) until the end of the dive. Actinaria anemones, stalked crinoids and spectacular brisingid sea stars were relatively common. Other identifications included pteropod shell tests on the seafloor.

As the vehicles left the bottom, Seirios became entangled in a submarine cable running adjacent to the dive site. Vehicles we successfully untangled and returned to the surface with little damage.

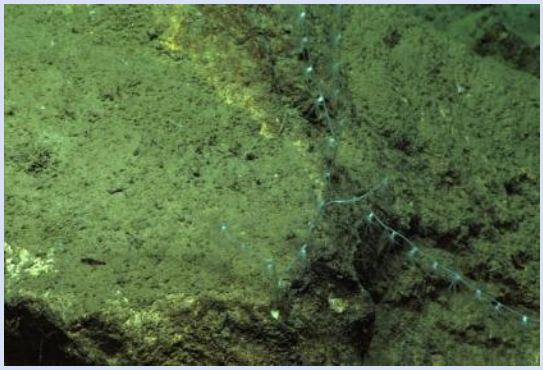
Overall Map of ROV Dive Area	**Close-up Map of Main Dive Site**
	

Representative Photos of the Dive

A potential new species of ctenophore. Three of these organisms were spotted during this dive.



The outcrop encountered at 4058m (1505 UTC) was more substantial, consisting of highly fractured carbonate rocks lying above a shale/marl layer at the base.

 An unknown species of octocoral observed during Dive 01	 At 15:14 UTC the outcrops were relatively massive carbonates, commonly with obvious sub-horizontal bedding (see photo below;)
Please direct inquiries to:	NOAA Office of Ocean Exploration & Research 1315 East-West Highway (SSMC3 10th Floor) Silver Spring, MD 20910 (301) 734-1014

Site Name	**Septentrional Fault**		
ROV Lead/ Expedition Coordinator	Brian Bingham/ Brian Kennedy		
Science Team Leads	Andrea Quattrini and Mike Cheadle		
General Area Descriptor	Puerto Rico and US Virgin Islands		
ROV Dive Name	Cruise Season	Leg	Dive Number
	EX1502	3	DIVE02
Equipment Deployed	ROV:	Deep Discoverer	
	Camera Platform:	Seirios	
ROV Measurements	☒ D2 CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ ROV HD 2	☒ Seirios CTD
	☒ Temperature Probe	☒ D2 DO Sensor	☐ Seirios DO sensor
Equipment Malfunctions	Operating with a secondary DO sensor that was last calibrated in 2013		
ROV Dive Summary (From processed ROV data)	Dive Summary: EX1502L3_DIVE02 In Water at: 2015-04-11T13:44:29.078000 19°, 00.373' N ; 067°, 43.862' W Out Water at: 2015-04-11T22:09:41.546000 18°, 59.841' N ; 067°, 42.722' W Off Bottom at: 2015-04-11T20:15:30.593000 18°, 59.644' N ; 067°, 43.562' W On Bottom at: 2015-04-11T16:12:02.421000 19°, 00.433' N ; 067°, 43.661' W Dive duration: 8:25:12 Bottom Time: 4:3:28 Max. depth: 3675.8 m		
Special Notes			

Scientists Involved ***(please provide name / location / affiliation / email)***	Amy Baco-Taylor	Florida State University	abacotaylor@fsu.edu
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	Susan Schnur	Oregon State University	sschnur@coas.oregonstate.edu
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	Uri ten brink	USGS	utenbrink@usgs.gov
	Michael Vecchione	NMFS National Systematics Lab	vecchiom@si.edu

Purpose of the Dive

i) To investigate the lithology of the exposed rocks along the southern slope of the valley formed above the eastern termination of the Septentrional Fault.

ii) To identify any deformation related to the Septentrional Fault, with a view to understanding why the fault apparently terminates at the eastern end of this valley.

iii) To identify features that could be related to slope failure.

iv) To look for evidence of sediment flows both within the valley and down the valley wall.

v) To document the biology living on and around the slope from 2600-3650m.

Description of the Dive:

This dive was sited within a narrow east-west trending valley formed above the Septentrional Fault. This fault is a major left lateral strike slip fault which separates the Mona Block/Seamount in the south from the carbonate platform to the north. The dive began at 13:35 UTC and D2 descended to 3675m and landed on a horizontal valley floor, 500m to the north of the southern valley wall. The dive traversed up the southern side of the valley and ended on significant outcrop at 3177m (20:16 UTC). It might be worth noting that Gastel et al., 1998 use seismic reflection data to argue the carbonate platform sequence is here 1200-1800m thick. Therefore, given our dive started at only 3675m and the top of the slope is only ~ 1km above, at ~4700m, it seems likely that the entire dive was spent within the Carbonate platform sequence.

Geology:

The dive started with D2 landing on a horizontal, coarse sediment covered valley floor at 3675m; 500m away from the southern wall of the valley. The sandy/pebbly sediment exhibited from irregular to moderately regular (see photo below), to spectacularly parallel, ripples (wavelength = 12-20 cm) which had a strike of 140, rotating to 130 as the valley wall was approached (17:14 UTC). White shell debris was observed on the lee slope of the ripples tentatively suggesting that the sea bottom current flow direction was 050. This observation can be verified by careful checking of the videos. Interestingly, D2 recorded a bottom current of 0.13 m/s due east, consistent with the flow direction interpreted using the

ripples. Approximately ten ~20 cm high, straight, E-W trending, sand ridges were observed during the traverse to the valley wall (see Seirios photo below). The spacing of the ridges was initially at 10-15m (16:46 UTC), but decreased to 5m (16:59 UTC) and then increased again to ~ 10m, before no more were seen (17:14 UTC). The origin of the ridges was unclear, but the preferred interpretation was that they were current related, perhaps related to currents flowing from south to north down the carbonate platform.

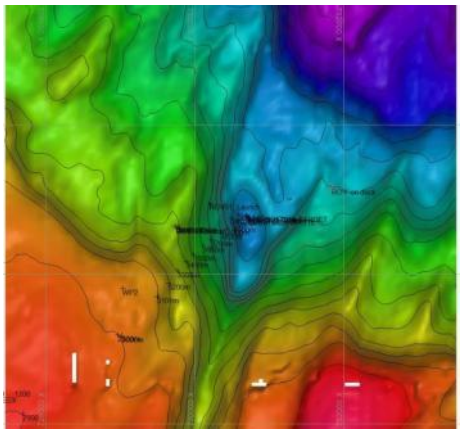
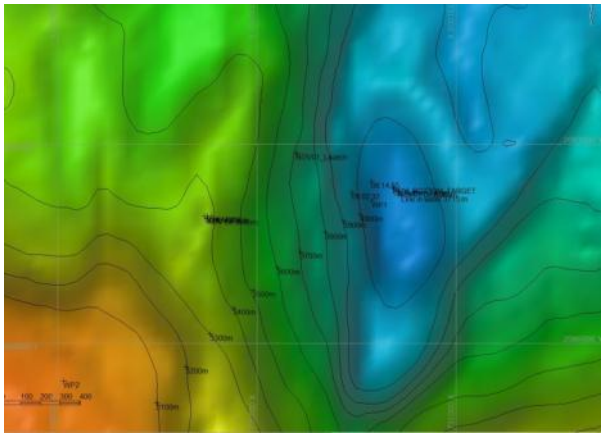
As the valley wall was approached, the slope began to increase (17:17 UTC) and Fe-Mn encrusted rock debris began to appear and increase (17:29 UTC). The rock debris was commonly rounded, often poorly sorted, and varied in diameter from cm to m scale and was likely of variable composition. Some rocks showed bedding or foliation and some were definitely made of carbonate (e.g. 3620m; 17:57 UTC). Nice current "shadows" in the mud were visible (17:31 UTC). The slope began to steepen to 40^{o} at 17:49 UTC (3631 m) and remained very consistent for ~ 400 vertical meters until outcrop was reached at 3224 m (19:56 UTC). It was a dominantly sandy slope, with irregularly spaced patches of rounded cm-m scale Fe-Mn coated rock debris. The slope is likely a sediment covered talus slope created by multiple depositional events (18:13 UTC, 3582m) Downslope gravel chutes, streaks and rills were present at various locations on the slope (3577 m, 18:17 UTC; 3940m, 18:42 UTC, 3366m, 1918 UTC; 3250m, 19:49 UTC). Some of these slope deposits were only lightly sediment covered and therefore relatively recent (e.g. 3598m, 18:12 UTC). The lithology of the rock debris was likely very variable, and difficult to discern just using video. However, possible carbonate fault breccia or volcanoclastic breccia was recognized at 3582 m (18:14 UTC), and at 3409m (19:00 UTC). Definite carbonate boulders with burrows, and with Fe-Mn coating removed were observed at 3721 m (19:40 UTC); the amount of carbonate boulders seemed to increase towards the top of the slope.

At 3224m (19:56 UTC), outcrop was reached and approximately 40 m of bedded conglomerate was traversed, which contained well rounded, very coarse clasts (up to 1m in diameter). Another 20 meters of more sediment covered, finer clast size (20-40cm), conglomerate (see photo below) with light colored recent sediment chutes was traversed before D2 left for the surface at 3170m (20:15UTC). Debate ensued about the origin of the conglomerate. Tentative consensus was reached that it might be fluvial in origin, produced by erosion of the pre-Eocene island arc and thus older than the carbonate platform deposits. At 3175m (20:11 UTC), a broken open, possibly carbonate clast was visible in the outcrop. If so, the conglomerate might be part/base (?) of the platform carbonate sequence. In any case, weathering/breaking down this set of outcrops likely supplied the rock debris that was traversed during the early part of the dive.

Biology:
As the D2 traversed over sand ripples in the beginning of the dive, *Sargassum* detritus and pteropod shells were noted to accumulate in pockets between the ripples. This area was fairly barren in terms of fauna, with only a few shrimps (*Aristaeopsis edwardsiana*) observed over a distance of 500 m. One squid, likely *Vampiroteuthis* sp., was observed at 16:42 UTC (3765 m) in the Seirios camera. In the rock debris field, a few sponges and at least one anemone (or corallimorph) were observed attached to the rocky substrate. One galatheoid squat lobster associated with a sponge was noted. Of note, a *Hymenaster* deep-sea slime star was reported at a depth of 3640 m (17:44 UTC). At 18:38 (3511 m), a hermit crab (*Parapagrus* sp.) with an anemone on its back was observed on soft substrate. The D2 then approached the steep, vertical rock outcrop at 19:56 UTC (3224 m), yet it was noted that the rock faces appeared mostly barren. Relatively few sponges and sessile fauna, in general, colonized the rocks. In this area a few swimming holothurians were noted as well as the sea cucumber *Benthodytes* sp. At the end of the dive, an unidentified organism (bryozoan or branching sponge) was found under an overhang as well as one whip-like, bamboo coral (*Isididae*).

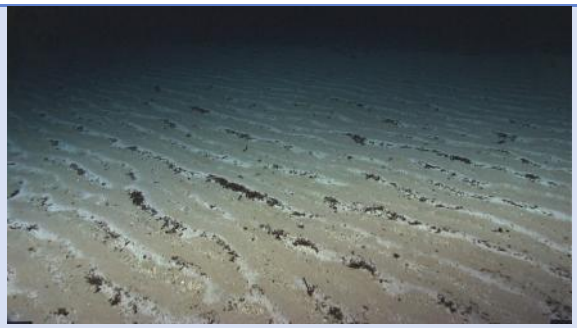
A few pieces of bamboo (plant) debris were found throughout the dive. Most of these were colonized by limpets and serpulid tubeworms; however, at 18:06 UTC (3608 m depth) a brisingid sea star (*Freyastera*

sp.) was noted on the bamboo. In addition, only two fishes were observed throughout the dive: the deep-sea lizardfish *Bathysaurus mollis* and the grenadier *Coryphaenoides armatus*. There was also a noticeable lack of midwater fauna during the descent and throughout the course of the dive.

Overall Map of ROV Dive Area	**Close-up Map of Main Dive Site**
	

Representative Photos of the Dive

Approximately ten ~20 cm high, straight, E-W trending, sand ridges were observed during the traverse to the valley wall.



The sandy/pebbly sediment exhibited from irregular to moderately regular, to spectacularly parallel, ripples (wavelength = 12-20 cm) which had a strike of 140 (17:14 UTC).

<table>
<tr>
<td> 
Antropogenic debris, potentially a balloon.</td>
<td> 
Conglomerate with light colored recent sediment chutes was traversed before D2 left for the surface at 3170m (20:15UTC)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Please direct inquiries to:</td>
<td colspan="2">NOAA Office of Ocean Exploration & Research
1315 East-West Highway (SSMC3 10th Floor)
Silver Spring, MD 20910
(301) 734-1014</td>
</tr>
</table>

Site Name	**Pichincho**		
ROV Lead/ Expedition Coordinator	Brian Bingham/ Brian Kennedy		
Science Team Leads	Andrea Quattrini and Mike Cheadle		
General Area Descriptor	Puerto Rico and US Virgin Islands		
ROV Dive Name	Cruise Season	Leg	Dive Number
	EX1502	3	DIVE03
Equipment Deployed	ROV:	Deep Discoverer	
	Camera Platform:	Seirios	
ROV Measurements	☒ D2 CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ ROV HD 2	☒ Seirios CTD
	☒ Temperature Probe	☒ D2 DO Sensor	☐ Seirios DO sensor
Equipment Malfunctions	Operating with a secondary DO sensor that was last calibrated in 2013. Port top swing arm was damaged during Dive 03, it was recovered safely and repaired overnight.		
ROV Dive Summary (From processed ROV data)			
Special Notes	After few observations of fish, approximately halfway through the dive, science team asked that Seirios lighting be turned down to see if decreased light would increase fish observations.		
Scientists Involved *(please provide name / location / affiliation / email)*	Amy Baco-Taylor	Florida State University	abacotaylor@fsu.edu
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	Graciela Garcia-Moliner	Caribbean Fishery Management Council	graciela.garcia-moliner@noaa.gov
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	Christopher (Chris) Mah	National Museum of Natural History (Smithsonian)	brisinga@gmail.com
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	Michelle Schärer	Woods Hole Oceanographic Institution	michelle.scharer@upr.edu
	Timothy Shank	NMFS National Systematics Lab	tshank@whoi.edu
	Michael Vecchione		vecchiom@si.edu

Purpose of the Dive

i) To explore possible habitats for deep water snappers and groupers
ii) To document the biology living on and around the un-named fault scarp from 600m to 300m depth.
iii) To determine the lithology and stratigraphy of the rocks exposed by the fault.
iv) To identify structural features that could be related to the fault.

Description of the Dive:

This was a shallow dive located on a 30^{o} dipping slope below Mona Passage. The slope was formed by a weathered and sedimented fault scarp within the Late Oligocene to Early Pliocene platform carbonate sequence. The dive began at 10:48 UTC and D2 descended to 608m and landed on a sub-horizontal valley floor to the south of the fault scarp. The dive consisted of a four short upward transects and three east-southeasterly transects parallel to the scarp. The dive ended at 21:56 UTC at 303m on the scarp. Little to no bottom current was apparent during 10 hours of the dive. However, after an hour spent at 300 m depth, a strong current (~1 knot) swept through the area, disabling pilot control of the ROV. The dive ended 30 min after this occurrence as the ROV could not get back to the scarp.

Geology:

The dive started with D2 landing on a sub horizontal, rippled, sand rich surface at 608 m. D2 then proceeded in a north, north easterly direction towards a slope formed by an un-named 30 km long normal fault in Mona Passage. Progressively more gravel and rock debris were encountered as D2 traversed towards the slope. The first boulders (608 m, 11:50 UTC) were large (meter scale) slabs of bedded, burrowed and honey-combed textured carbonate, surrounded by sediment. The base of the slope was reached at 606m at 12:54 UTC. Near the foot of the slope (594m, 14:08 UTC) large, meter scale, fauna encrusted and sandy coated slabs of carbonate were encountered. These slabs had clearly broken off from higher up the scarp and fallen to the base of the slope. Carbonate rock outcrop was reached at 541m (14:59 UTC) and extended with a staircase geometry of up to 10 meter scale vertical faces separated by gently dipping sediment and boulder covered slopes until 396m (18:40 UTC). The sequence was variably bedded on a 30 cm to 1 meter scale (e.g. 533m, 15:40 UTC; see photo below) and showed clear differential erosion, with stronger layers forming resistant layers and ledges and less resistant layers being eroded. In several places the carbonate was clearly exposed and recognizable due to local rock face failures. Burrows were visible in some fresh outcrops, but on the whole most of the section was covered by sediment and encrusting sponges, corals and other biology. There is the possibility that cementation was occurring within the covering sediment forming hard crusts on some of the exposures. At 410m (18:16 UTC), large boulders were encountered sitting on a ledge above a slope scarp.

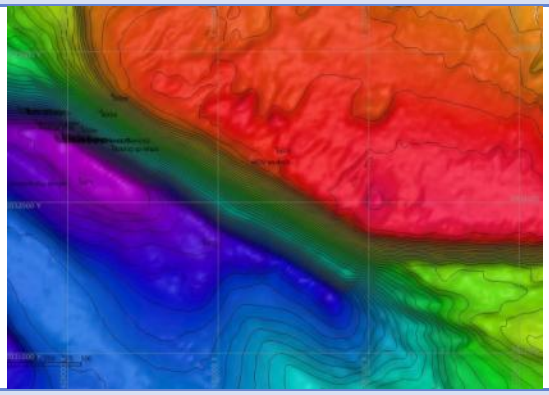
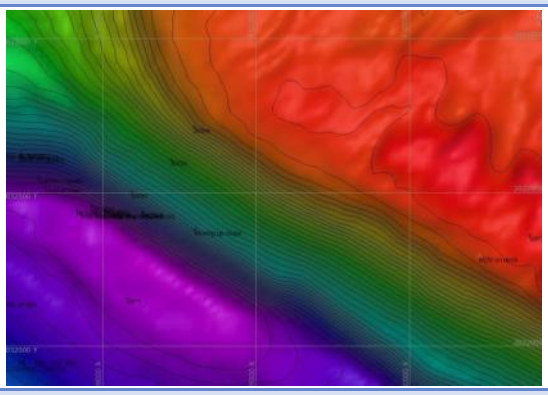
At about 374m (18:57 UTC), the slope slightly shallowed and the character of the carbonate exposures

changed. Above 374 m, until at least 303 m, the carbonate is very irregularly weathered, displaying a karstic topography, with rounded outcrop with sinkhole-like depressions with the beginnings of limestone pavement development (see photo below). Cave-like features formed by differential erosion of weaker layers were clearly observed (e.g. 309 m, 20:04 UTC). At one locality a crack in the carbonate outcrop, provided an example of how the rock face can fail and produce the boulders that were seen lower down the slope (304 m 20:00 UTC). The origin of the apparent karstic topography is enigmatic. One possibility is weathering occurred after the sequence had been exposed above sea-level during the Last Glacial Maximum sea-level lowstand, and subsequently, the sequence has subsided below sea-level due to sea level rise and due to crustal extension below the Mona Passage (Chaytor & ten Brink, 2010). Depressions in the surface of the limestone karst contained accumulations of winnowed coral fragments together with less common echinoid spines. At the margins of these accumulations, larger objects, such as gastropod shells, sponge fragments, bivalve shells and limestone pebbles were observed. We speculate that the periodically strong currents in this area may have transported and winnowed these fragments from elsewhere.

Biology:
In the beginning of the dive, the ROV traversed over mostly a mud bottom with scattered gravel. This area was also covered with dead demosponges, few live demosponges, and scattered dead, bivalve shells. As the ROV continued, larger boulders and carbonate blocks were present and then large, carbonate outcrops were present at 541 m (14:59 UTC). Numerous species of demosponges, encrusting sponges, and hexactinellid glass sponges (cf**.** *Lefroyella decora***)** colonized these hard substrates, with demosponges (Corallistidae) and encrusting sponges dominating, particularly the shallower depths (~450-300 m). In some places along the scarp, no sessile fauna were present whereas in other areas, sessile fauna were highly dense. Branching sponges (*Dictoplax sp.?,)* were common throughout the dive as well, and at least visually, appeared morphologically similar to stylasterid corals. Stylasterids and other deepwater corals were present, however, relatively few were observed. A few individual cup corals, likely *Javania* sp., were seen throughout the course of the dive. An unknown octocoral (?Chrysogorgiidae), plexaurids, and whip-like and feather-like antipatharians were observed attached to rock boulders and outcrops. Notably, at 16:33 UTC (493 m depth), several colonies of gold coral (Zoanthidae) were observed and at 20:05 UTC (307 m depth) several scleractinian corals (?*Madrepora* sp.) were observed colonizing an undercut in a large carbonate outcrop.

Fishes
Thirteen fish species were seen during the dive. At 11:44 UTC, depth 606 m, an unidentified fish with mottling coloration (Ophidiidae?) was hiding under a live sponge. At the base of the large carbonate outcrops, other fishes observed included the beardfish *Polymixia nobilis,* ocean bass *?Synagrops* sp., scorpionfish cf. *Phenacoscorpius nebris,* greeneye *Chlorophthalmus agassizi,* and deepwater cardinalfish *Epigonus* spp. Along the portion of the dive that traversed high-relief, carbonate outcrops, the D2 observed numerous *Epigonus* spp., as well as a dogfish shark *Squalus cubensis* and the gaper *Chaunax pictus.* Notably, it appeared that the gaper changed color (from orange to more yellow) as it was disturbed by the ROV. At a depth of approximately 400 m, the fish assemblage appeared to shift. From 400-300 m depth, the D2 observed a soldierfish *Ostichthys trachypoma,* temperate slopebasses *Symphysanodon ?berryi,* a yet to be described species of wrasse *Polylepion* sp. A moray eel *Gymnothorax maderensis,* and the longfin bulleye *Cookeolus japonicus.*

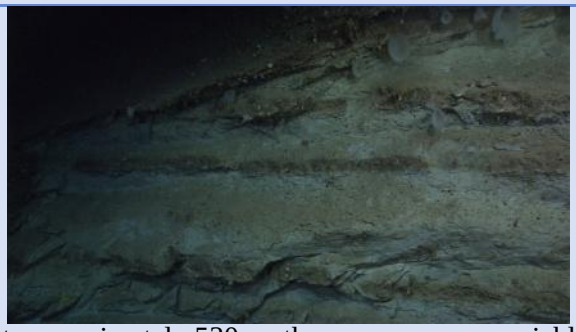
Other notable observations:
Barnacle crinoids (*Holopus* sp.) were common throughout the dive. On the unknown ?Chrysogorgiidae octocoral, an unknown chirostylid squat lobster was observed. A ~10 cm nemertine (ribbon worm) was seen moving along the seafloor at 13:23 UTC. Numerous species of asteroid sea stars were observed, with two notable feeding observations: *Henricia* sp. (14:26:57 UTC, 587 m) and *Plinthaster dentatus* (15>54 UTC, 524 m) feeding on a sponge.

Overall Map of ROV Dive Area	Close-up Map of Main Dive Site
	

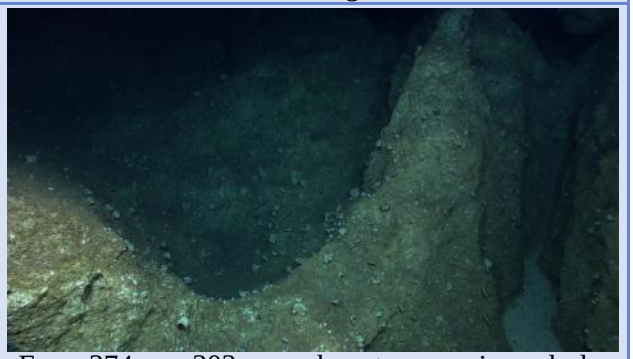
Representative Photos of the Dive

An unknown chirostylid squat lobster was observed on an unknown ?Chrysogorgiidae octocoral.

Numerous species of demosponges, encrusting sponges, and hexactinellid glass sponges colonized hard substrates throughout the dive.



At approximately 530 m, the sequence was variably bedded on a 30 cm to 1 meter scale and showed clear differential erosion.



From 374 m – 303 m, carbonates were irregularly weathered, displaying a karstic topography.

Please direct inquiries to:	NOAA Office of Ocean Exploration & Research 1315 East-West Highway (SSMC3 10th Floor) Silver Spring, MD 20910 (301) 734-1014

<table>
<tr><th>Site Name</th><td colspan="2">Mona Canyon- West Wall</td><td rowspan="4"> 
</td></tr>
<tr><th>ROV Lead/Expedition Coordinator</th><td colspan="2">Brian Bingham/
Brian Kennedy</td></tr>
<tr><th>Science Team Leads</th><td colspan="2">Andrea Quattrini and Mike Cheadle</td></tr>
<tr><th>General Area Descriptor</th><td colspan="2">Puerto Rico and US Virgin Islands</td></tr>
<tr><th rowspan="2">ROV Dive Name</th><td>Cruise Season</td><td>Leg</td><td>Dive Number</td></tr>
<tr><td>EX1502</td><td>3</td><td>DIVE04</td></tr>
<tr><th rowspan="2">Equipment Deployed</th><td>ROV:</td><td colspan="2">Deep Discoverer</td></tr>
<tr><td>Camera Platform:</td><td colspan="2">Seirios</td></tr>
<tr><th rowspan="5">ROV Measurements</th><td>☒ D2 CTD</td><td>☒ Depth</td><td>☒ Altitude</td></tr>
<tr><td>☒ Scanning Sonar</td><td>☒ USBL Position</td><td>☒ Heading</td></tr>
<tr><td>☒ Pitch</td><td>☒ Roll</td><td>☒ HD Camera 1</td></tr>
<tr><td>☒ HD Camera 2</td><td>☒ ROV HD 2</td><td>☒ Seirios CTD</td></tr>
<tr><td>☒ Temperature Probe</td><td>☒ D2 DO Sensor</td><td>☐ Seirios DO sensor</td></tr>
<tr><th>Equipment Malfunctions</th><td colspan="3">Operating with a secondary DO sensor that was last calibrated in 2013</td></tr>
<tr><th>ROV Dive Summary (From processed ROV data)</th><td colspan="3">Dive Summary: EX1502L3_DIVE04
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In Water at: 2015-04-13T10:35:18.593000
18°, 45.056' N ; 067°, 33.990' W

Out Water at: 2015-04-13T22:29:35.375000
18°, 44.630' N ; 067°, 33.769' W

Off Bottom at: 2015-04-13T20:48:18.062000
18°, 44.577' N ; 067°, 34.080' W

On Bottom at: 2015-04-13T14:24:59.187000
18°, 45.039' N ; 067°, 33.135' W

Dive duration: 11:54:16

Bottom Time: 6:23:18

Max. depth: 3928.1 m</td></tr>
<tr><th>Special Notes</th><td colspan="3"></td></tr>
</table>

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	Christopher Moore		

Purpose of the Dive

i) To make geological and biological observations along a transect from 3900m to 3200m directly beneath the dive track of E/V Nautilus/Hercules dive H1300 which began at 2900m below sea level.

ii) To look for and examine the late Cretaceous to Middle Eocene arc rocks which lie immediately below the Middle Oligocene to Late Miocene platform carbonate sequence.

iii) To identify features that could be related to failure of the canyon wall.

iv) To carry out five 10-minute horizontal mid water transects every 100m from 800-1200m to observe mid water biology.

v) To document benthic communities along the canyon wall.

Description of the Dive:

This deep dive was located on a 22^{o} dipping slope on the west wall of Mona Canyon directly beneath the dive track of E/V *Nautilus*/ROV *Hercules* dive H1300 which began at 2900m below sea level. The bottom of the track dive track was located on the top of a very large slump deposit which is clearly visible in the bathymetry and may have formed by slope failure caused by the magnitude 7.5 1918 San Fermin Earthquake.

The dive began at 10:28 UTC and D2 descended to 800m at11:20 UTC and began to carry out the mid water transects. The transects were complete at 12:47 UTC and D2 headed down, landing on a muddy slope at 14:26 UTC (3927m). The dive track headed WSW up a slope of mud and outcrops of carbonate, which was likely the head wall of the large slump and ended at 20:48 UTC (3173m). Little to no bottom current was apparent during the 6 hours of the dive on the seafloor.

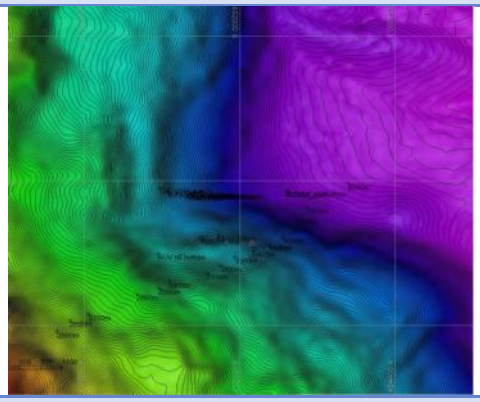
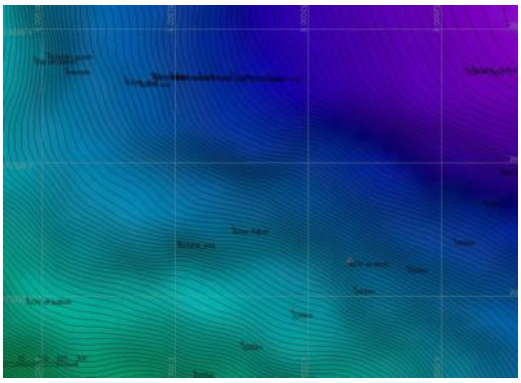
Geology:
The dive began on a muddy/sandy slope at 3927 m (14:26 UTC) which showed some lighter patches of sediment disturbance due to bioturbation and possibly rockfall. Scattered angular and rounded 20-30 cm clasts of carbonate were present on the muddy surface. Some of the more angular clasts were Fe-Mn coated, but the majority were rounded and without appreciable Fe-Mn crusts. Occasional large meter scale boulders were observed (e.g. 3816 m, 16:11 UTC). No ripples were observed in the sediment, throughout the dive. The frequency of the clasts was irregular, but in general they increased in number until 3788 m (16:02) when carbonate outcrop was reached. The outcrop formed a steep face which extended for 80 vertical meters from 3788 m to 3708 m (16:43 UTC) and was likely the source of the clasts seen below. It consisted of sediment dusted, massive, pale colored carbonate mostly without Fe-Mn coatings. Some of the carbonate was soft and therefore likely chalk (3710 m; 16:43 UTC) (See photo below); downslope channels were recorded in the lower part of the outcrop (3770 m, 16:23 UTC). Possible weak bedding was observed, highlighted by a thin layer of Fe-Mn coated carbonate. Similar Fe-Mn coated layers are visible in the *in-situ* carbonates higher up the canyon wall as observed by the E/V Nautilus/Hercules dive H1300. Presumably, some layers within the carbonate are chemically more receptive to growing Fe-Mn coatings. The carbonates appeared to dip relatively steeply, into the slope to the SW and if so, would suggest the outcrop is a large rotated slump block. This interpretation is also supported by the depth of the outcrop, which if in-situ, would mean the platform carbonate is ~2100 m thick in this cliff face, which seems larger than estimates of thickness (1650 m) in this area from seismic data. Sediment debris shoots were observed over the outcrop (e.g. 3754 m, 16:32 UTC).

Immediately above the outcrop, the slope once again became a more gentle sediment covered slope with only rare carbonate clasts. The number of carbonate clasts began to increase at 3577 m (17:24 UTC) and continued to increase until outcrop was reached at 3382 m (18:30 UTC). The clasts were similar to those seen at the start of the dive, being mostly 20-30 cm in size, rounded, with little Fe-Mn coating. However, some more angular blocks were Fe-Mn coated and occasional larger blocks were observed. Some clasts showed bedding. Rills & trails of small clasts heading downslope were observed at 3477 m (17:57 UTC), 3454 m (18:07 UTC) and 3420 m (18:18 UTC) and increased in frequency as the outcrop was approached.
The second limestone outcrop extended for 112 vertical meters from 3382 m until 3270 m (19:43 UTC). The outcrop consisted of sediment dusted, massive, pale colored carbonate mostly without Fe-Mn coatings (see photo below). Very clear, meter deep and a few meters wide, channel-like depressions within the outcrop extended up the slope. Often they contained sediment and pebbles. They may be caused by downslope movement of debris flows. Some *in-situ* small debris flows were observed at the top of the outcrop (3270 m, 1943 UTC). Bedding was clearly observed in much of the outcrop and appeared to be dipping SW at approximately 15-20^{o}. If this dip is correct, then this outcrop would also likely be part of a large, coherent, greater than 120m tall, rotated slump block. The base of this outcrop occurs approximately 1700m below the top of the west wall of the canyon and so the depth of the outcrop does not exceed the overall thickness of the platform carbonate sequence. Sediment cover increased

towards the top of the outcrop and debris chutes and debris flows were common (3624m, 19:46 UTC). Above the outcrop, the slope shallowed and became a muddy slope with occasional carbonate clasts of all sizes. The transect ended in sediment with sparse 10-20cm diameter clast at 3173m (20:45 UTC).
We did not manage to see the late Cretaceous to Middle Eocene arc rocks that lie beneath the platform carbonates.

Biology
The D2 reached (14:26 UTC, 3927 m) a muddy bottom with various amounts of scattered rock rubble and rock debris. Amongst the rock, anchored in the sand, several sea pens (*Umbellula* sp.) and black corals (?*Bathypathes* sp.) were evident. The black whip coral (?*Stichopathes* sp.) was also observed attached to hard substrates in the beginning of the dive. A few sponges (Cladorhizidae, Hexactinellidae) and anemones colonized the rocks, but densities were fairly low. Further up slope (3588 m), one species of bamboo coral (Isididae) was observed. Interestingly, on the massive (80 m tall) carbonate blocks further up slope (~ 3700 and 3300 m), which appeared to be chalky, no visible colonizing species were found. Approximately five species of fish were seen: *Aldrovandia* sp., *Coryphaenoides* spp., *Bathypterois grallator*, *Bassozetus* sp., and *Bathysaurus mollis*. Numerous holothurians (4-5 species) were evident, with an abundance of swimming forms (?*Peniagone* or *Amperima* sp.). Other echinoderms included brisingids (*Freyastera* sp.), sea stars (*Pteraster* sp.) and brittle stars (Ophiuroidea), and spiny urchins (unidentified). As for the crustaceans observed, numerous shrimp were present (*Aristaeopsis edwardsiana),* yet only one squat lobster (*Munidopsis* sp.) was observed.

A notable observation included several predatory tunicates, each with, seemingly, a symbiotic polychaete. Wood falls were prevalent throughout the dive, with typical wood fall fauna present (e.g., limpets, serpullids, *Idas* sp.). Sediment traces from echiurans and holothurians were evident in the muddy areas of the survey area. Five midwater transects (10 min each) conducted every 100 m from 800-1200 m were successful, with several amazing image captures of jellyfish, larvaceans, hatchetfish, dragonfish, and siphonophores.

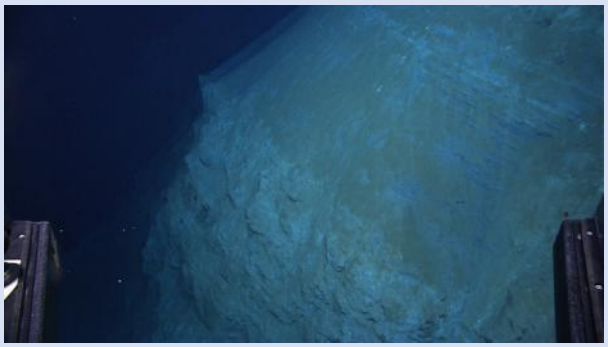
Overall Map of ROV Dive Area	**Close-up Map of Main Dive Site**
	

Representative Photos of the Dive

During the descent, D2 imaged a blind octopod (*Cirrothauma murrayi*)

A notable observation included several predatory tunicates, each with, seemingly, a symbiotic polychaete.

The second limestone outcrop extended for 112 vertical meters from 3382 m until 3270 m (19:43 UTC). The outcrop consisted of sediment dusted, massive, pale colored carbonate mostly without Fe-Mn coatings.



Outcrop viewed from D2 a couple meters off the seafloor.

<table>
<tr><td>Site Name</td><td colspan="2">Mona Canyon-East Wall</td><td></td></tr>
<tr><td>ROV Lead/ Expedition Coordinator</td><td colspan="2">Brian Bingham/
Brian Kennedy</td><td rowspan="3"> 
</td></tr>
<tr><td>Science Team Leads</td><td colspan="2">Andrea Quattrini and Mike Cheadle</td></tr>
<tr><td>General Area Descriptor</td><td colspan="2">Puerto Rico and US Virgin Islands</td></tr>
<tr><td rowspan="2">ROV Dive Name</td><td>Cruise Season</td><td>Leg</td><td>Dive Number</td></tr>
<tr><td>EX1502</td><td>3</td><td>DIVE05</td></tr>
<tr><td rowspan="2">Equipment Deployed</td><td>ROV:</td><td colspan="2">Deep Discoverer</td></tr>
<tr><td>Camera Platform:</td><td colspan="2">Seirios</td></tr>
<tr><td rowspan="5">ROV Measurements</td><td>☒ D2 CTD</td><td>☒ Depth</td><td>☒ Altitude</td></tr>
<tr><td>☒ Scanning Sonar</td><td>☒ USBL Position</td><td>☒ Heading</td></tr>
<tr><td>☒ Pitch</td><td>☒ Roll</td><td>☒ HD Camera 1</td></tr>
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<tr><td>☒ Temperature Probe</td><td>☒ D2 DO Sensor</td><td>☐ Seirios DO sensor</td></tr>
<tr><td>Equipment Malfunctions</td><td colspan="3">Operating with a secondary DO sensor that was last calibrated in 2013</td></tr>
<tr><td>ROV Dive Summary (From processed ROV data)</td><td colspan="3">Dive Summary: EX1502L3_DIVE05
^^
In Water at: 2015-04-14T13:00:54.140000
18°, 44.772' N ; 067°, 22.433' W

Out Water at: 2015-04-14T22:15:06.796000
18°, 45.068' N ; 067°, 20.983' W

Off Bottom at: 2015-04-14T20:10:58.109000
18°, 44.936' N ; 067°, 21.795' W

On Bottom at: 2015-04-14T16:54:38.062000
18°, 44.956' N ; 067°, 21.966' W

Dive duration: 9:14:12

Bottom Time: 3:16:20

Max. depth: 4025.7 m</td></tr>
<tr><td>Special Notes</td><td colspan="3"></td></tr>
</table>

Scientists Involved *(please provide name / location / affiliation / email)*	Amy Baco-Taylor	Florida State University	abacotaylor@fsu.edu
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	Christopher Moore		

Purpose of the Dive

i) To carry out five 10 minute horizontal traverse mid water transects every 1000m from 800-1200m to observe mid-water biology.

ii) To document hard substrate megabenthos and other benthic communities along the canyon wall and to compare the communities to those found at similar depths on the west wall of Mona Canyon.

iii) To observe lithology and structure along a transect from 4000m to 3300m to compare with observations of the west wall of Mona Canyon, including looking for evidence of faults on the east wall of the canyon.

iv) To look for, and examine, the late Cretaceous to Middle Eocene arc rocks which lie immediately below the Middle Oligocene to Pliocene platform carbonate sequence.

v) To identify features that could be related to failure of the canyon wall.

Description of the Dive:

This deep dive was located on a >40^{o} dipping slope on the east wall of Mona Canyon. The dive began at 12:47 UTC. D2 descended to 800 m at1 3:47 UTC and began to carry out the mid water transects. The transects were complete at 15:11 UTC and D2 headed down towards 4000 m. Because the start of the dive was on a relatively step slope, D2 stopped descending at 4005 m (16:46) and then proceeded to move towards the slope reaching the slope at 4019 m (16:56 UTC). D2 then headed up a sediment covered talus

slope with occasional exposed talus blocks, until, at 3909 m (18:56 UTC), lightly sediment covered outcrop was reached. D2 then continued up the outcrop, which in places consisted of near vertical rock faces until the end of the dive at 3730m (20:27 UTC). Weak currents were encountered throughout the dive.

Geology:
The dive began on a steep muddy/clayey slope at 4019m (16:54 UTC). Immediately the D2 encountered, a large (5 meter dia.), sediment covered block of Fe-Mn coated rock. This occurrence set the tone for the first part of the dive which traversed 110 vertical meters of dominantly sediment covered talus. The sediment appeared to be thick in places, completely covering the talus, but in other places, collections of often very large (a few meters dia.), Fe-Mn coated, angular blocks were present. Sediment draping was variable, which together with the blocks sitting on the surface of the mud suggests that some of the blocks were relatively recent rock fall. The blocks were noticeably bigger, had more extensive Fe-Mn coatings and were more angular than those encountered on the west wall, although there were a few accumulations of smaller blocks (30 cm dia), often trapped on the slope behind larger blocks (e.g. 3989 m, 17:56 UTC). The relative absence of smaller clasts suggests that there was significant transport of material downslope. In places the mud was rippled (e.g. at 4002 m, 17:38 UTC and 3948 m, 18:29 UTC), indicating current activity. Sediment chutes and debris aprons were observed at 3949 m (18:36 UTC) and 3925m (18:47 UTC). Although the Fe-Mn coating was extensive, a few clasts/blocks were found to have non coated faces providing a glimpse into the true lithology of the rocks. At 3981 m(18:08) a possible volcanic breccia with 2-5 mm dia clasts was observed and elsewhere green colored rocks with white veins were seen (3976, 18:11 UTC and 3949-2930, 18:31-18:45 UTC). These rocks may be greenschist facies metavolcanics with quartz or carbonate veins.

Outcrop, encountered at 3909m (18:56 UTC), continued upwards until and (beyond) the end of the dive at 3730m (20:27 UTC). This outcrop was clearly the source of the blocks seen below. The lower part of the outcrop consisted of steep, fractured, sometimes rubbly, Fe-Mn encrusted exposures. Planar, sub-vertical exposures were seen in several places, but at 3885 m (19:06 UTC) possible vertical striations were observed on a slope parallel vertical face. This could be a fault surface or possibly a joint surface with some vertical slip. The rocks at this height also were similar in color to the greenschist blocks recognized downslope and consequently this part of the exposure may consist of greenschist facies volcanic rocks. Downslope sediment trails were observed at 3856 m (19:28 UTC). At 3855 m (19:29 UTC), the outcrop became more massive and joints with variable orientations were clearly visible. At 3771 m (219:59 UTC) red coloration was observed on a broken face. Very tentatively, because of their massive character, we suggest that these rocks may be plutonic rocks, perhaps of granodioritic composition. At 3751 m (20:07 UTC), the slope became more gentle with areas of debris accumulation and the character of the outcrop changed and became less massive. Another broken rock face was seen to be red in color at 3739 m (20:13 UTC). These exposures might be volcanic rocks. At the top of the dive (3731 m, 2018 UTC) massive exposures with steeply dipping joints, created re-entrants in the cliff face. Speculating wildly, these rocks could have been dikes.

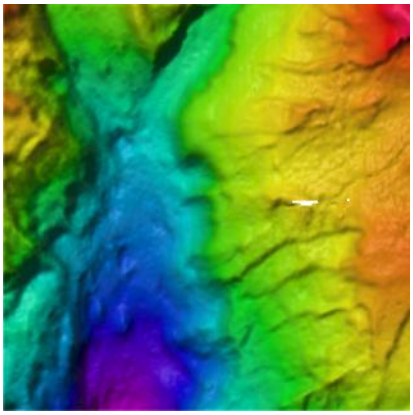
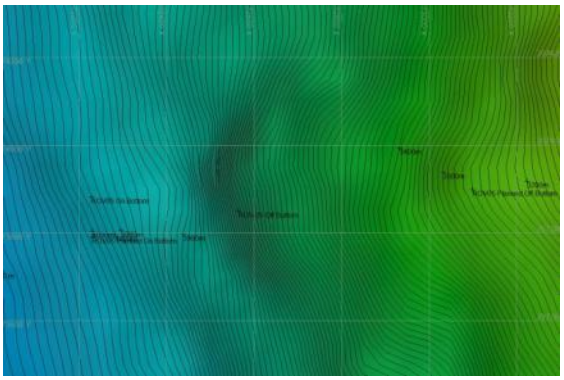
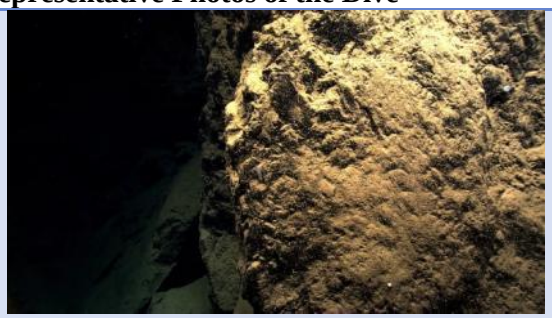
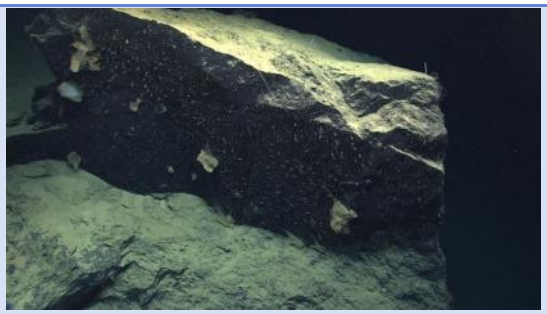
The dive clearly traversed the Late Cretaceous to Middle Eocene meta-volcanic/plutonic basement that forms the core of Puerto Rico and sits below the Late Oligocene to Pliocene platform carbonate sequence and consequently traversed a very different sequence of rocks than seen at similar depths on the west wall. Here on the east wall, the top of the platform carbonates is interpreted to be in a down-dropped fault block at ~2600 m and using seismic evidence that suggests the platform carbonate sequence is 750 m thick at this locality (Mondziel et al, 2010), leads to the prediction that the base of the carbonate unconformity occurs at ~3350 m. Hence the end of today's dive at 3730 m was approximately 400 m below that unconformity.

Biology:

The dive began with five mid-water transects conducted from 800-1200 m depth. Prior to starting the first transect at 800 m (13:41 UTC), amazing imagery was captured of a squid, *Asperoteuthis acanthoderma*, swimming away from D2. Mid-water organisms appeared to be more abundant during the first two transects conducted from 800-1000 m. During all transects, jellyfish, lobate ctenophores, siphonophores, larvacean houses, barracudinas (Paralepididae), and arroworms (Chaetognatha) were common. A fair amount of particulate matter was noticed near the bottom at 16:49 UTC, 4000 m depth.

Sponges (Pheronematidae, Euretidae, Cladorhizidae), branching ? bryozoans, and crinoids were observed attached to the clean rock faces. Numerous arborescent foraminiferans were also seen colonizing the rock faces. Several anemones with very wide bases and short tentacles were observed as well as a cerianthid tube anemone. The same species of black coral with two morphotypes was observed throughout the dive: the whip-like morphotype at 17:28 UTC (4007 m) and the whip-branched-at-tip morphotype at 17:44 UTC (3995 m), 17:54 UTC (3984 m), and 19:08 UTC (3883 m). White color morphs of an alcyoniidae octocoral, (the mushroom coral) were prevalent throughout the course of the dive. Further up slope (3726 m) near the end of the dive, 4-5 colonies of a bamboo coral (Isididae) were observed. Overall, it was noted that sessile colonization was not very dense throughout the entire dive track. However, more sessile species appeared to colonize the Mn-Fe coated rock faces of the large, angular rock slabs at the deepest depths and shallowest depths surveyed. In contrast, no to little colonization was evident on the massive outcrops that occurred between these two layers.

Decapod crustaceans were fairly common; several *Munidopsis* sp. squat lobsters were observed as well as *Aristaeopsis edwardsiana.* As for fishes, only two individuals of *Bassozetus* sp. were observed. Several brisingids, comatulid crinoids and sea lilies were common throughout the dive. Two species of swimming holothurians were observed, including *Enypniastes* sp. and ?*Peniagone/Amperima* sp. A sea cucumber (Elasiopod) unfamiliar to ship and shoreside participating scientists was observed at 19:48 UTC (3796 m) and 20:05 UTC (3763 m). Additionally, an unidentified animal (urchin? or Porifera?) was seen at 18:20 UTC (3962 m). Notably, a 6-armed seastar, *Laetmaster spectabilis,* was observed on hard substrate at 18:53 UTC (3916 m). This is the first record of this species since the description of the holotype, which was collected off Cuba, in 1881.

Overall Map of ROV Dive Area	Close-up Map of Main Dive Site
	
Representative Photos of the Dive	
 Exposures along this outcrop are potentially volcanic rock.	 D2 encountered, a large (5 meter dia.), sediment covered block of Fe-Mn coated rock.
 An unidentified species of bamboo coral observed towards the end of the dive.	 A 6-armed seastar, *Laetmaster spectabilis,* was observed on hard substrate at 18:53 UTC (3916 m).

Site Name	Platform		
ROV Lead/ Expedition Coordinator	Brian Bingham/ Brian Kennedy		
Science Team Leads	Andrea Quattrini and Mike Cheadle		
General Area Descriptor	Puerto Rico and US Virgin Islands		
ROV Dive Name	Cruise Season	Leg	Dive Number
	EX1502	3	DIVE06
Equipment Deployed	ROV:	Deep Discoverer	
	Camera Platform:	Seirios	
ROV Measurements	☒ D2 CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ ROV HD 2	☒ Seirios CTD
	☒ Temperature Probe	☒ D2 DO Sensor	☐ Seirios DO sensor
Equipment Malfunctions	Operating with a secondary DO sensor that was last calibrated in 2013. CTD had to be restarted during descent.		
ROV Dive Summary (From processed ROV data)	In Water at:	2015-04-15T10:47:37.203000 18°, 09.060' N ; 067°, 31.356' W	
	Out Water at:	2015-04-15T20:28:16.781000 18°, 10.037' N ; 067°, 30.894' W	
	Off Bottom at:	2015-04-15T20:14:55.140000 18°, 09.977' N ; 067°, 30.937' W	
	On Bottom at:	2015-04-15T11:28:06.984000 18°, 08.960' N ; 067°, 31.322' W	
	Dive duration:	9:40:39	
	Bottom Time:	8:46:48	
	Max. depth:	606.2 m	
Special Notes			

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	Steve Haddock	MBRI	

Purpose of the Dive

i) To explore benthic habitats for deep water snappers and groupers
ii) To document the biology living on and around the un-named fault scarp from 600m to 300m depth.
iii) To determine the lithology and stratigraphy of the rocks exposed by and in front of the fault.
iv) To identify structural features that could be related to the fault.

Description of the Dive:

This was a shallow dive which started on a gentle, smooth 10^{o} slope, but then traversed an area of irregular bathymetry before ascending a 17^{o} dipping, highly weathered, fault scarp. This fault is the easterly extension of an ~100km long anastomosing fault system that forms the northern wall of a WNW-ESE trending rift between the Dominican Republic and Puerto Rico. The traverse was entirely within the Middle Oligocene to Pliocene platform carbonate sequence. The dive began at 10:37 UTC. D2 descended to 605m and landed on a gently dipping sandy slope to the south of the fault scarp. The dive ended at 20:16 UTC at 301m at the top of the scarp. Near the top of the scarp there were several pits/depressions that contained mostly dead coral rubble. Moderate bottom currents of 0.06 to 0.09 m/s were noticed throughout the 9 hour dive. Steep temperature and dissolved oxygen gradients were noted during the dive, including a large decrease in DO near the approach to the top of the ridge.

Geology:

The dive started with D2 landing on a gently dipping, irregularly rippled, sandy seafloor near a rubbly,

low standing, outcrop of carbonate at 605m (11:28 UTC). D2 then traversed to the NNE up a gentle slope covered by rippled sandy sediments, often with shell fragments until 585 m (13:02 UTC). The ripples had variable character and orientation, but a common N-S to NW-SE trend was observed. Ripple asymmetry suggests they were formed by a north-easterly flowing current. At 581m (13:04 UTC) a resistant crust on sub-horizontally bedded carbonate emerged through the sandy sediment. In one location a 20cm high section of undercut limestone was seen below the more resistant crust. At 576m (13:37 UTC), limestone pavement with frequent 30cm diameter, partially sediment filled depressions (sinkholes?) was observed and this limestone pavement was continuously exposed until 448 m (16:45 UTC). The limestone pavement is likely swept clean by the strong currents in the area. Occasional elongate, depressions, with more coarse sediment, were seen (e.g. 566m, 13:50 UTC & 527m, 14:58 UTC). These are likely eroded vertical cracks in the limestone pavement. The depressions began to increase in frequency at 485 m (14:40 UTC) as the top of the gentle slope was approached and the amount of sandy sediment increased. From 448m (15:40 UTC), D2 descended 15m from a local topographic high to a depth of 433m (17:34 UTC). In this part of the dive, sediment cover was more extensive and rippled (NW-SE trending), and the topography of the limestone was more complicated. A small, 2m high, NE-SW trending, burrowed and undercut carbonate ridge was observed at 442m (16:58 UTC), together with another small, 1m high, scarp at 439m (17:20 UTC).

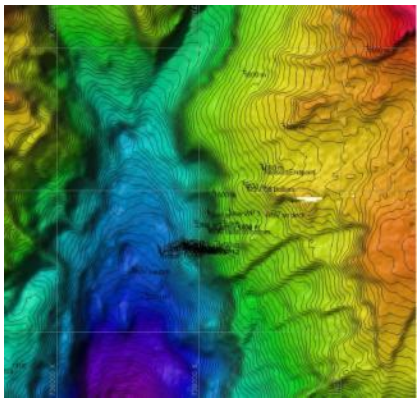
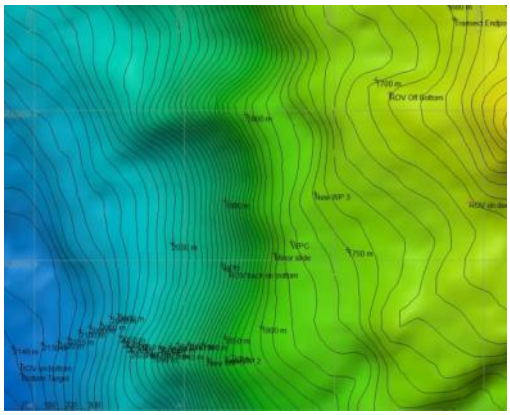
At 433m (17:34 UTC) D2 began the ascent up the WNW-ESE trending fault scarp. Initially large talus blocks were observed on sediment, but very quickly, more extreme topography was observed with both north (435m, 17:44 UTC) and south facing scarps. At 434m (17:52 UTC) a relatively deep (5-10m) ~E-W trending, chasm was encountered. Large meter scale, angular, blocks, lacking sediment cover or karstic topography, were present in the south side of the chasm having detached from the northward facing wall. The absence of karstic weathering and the relative lack of sediment cover suggests these blocks might have recently fallen from the scarp. This scarp is therefore the best candidate for the most recent fault activity. The gradient of the slope began to increase at 444m (18:18 UTC) and the topography became even more complicated (e.g. 430m 18:25 UTC), with extensive karst weathering superimposed on what was likely once a structurally complicated fault scarp consisting of several WNW-ESE trending fault blocks. Outcrops are very rounded and large 1m diameter coral debris filled sinkholes are present. At 320m (19:43 UTC) the bedding appeared to be back-tilted and dipped at 60^{o} towards the fault scarp, suggesting that this was a back tilted fault block. At 306m (19:54 UTC), the top of the scarp was reached and the topography flattened out into a limestone pavement with coral debris filled depressions. D2 left the seafloor from 301m at 20:16 UTC.

The carbonate sequence, likely consists of interbedded limestones and sandstones from the Pliocene to Late and Middle Miocene Ayamon and Los Puertos Limestones. They were exposed by the un-named 100km long normal fault system with ~300m of total throw. This fault system may also have a strike slip component of motion, but no evidence of the actual fault surfaces were found, likely having been eroded away by the differential erosion exhibited by the scarps. This erosion, and the sedimentation indicates that most of the fault system has not been recently active. Chaytor & ten Brink (2010) suggested that this fault system was created by oblique extension in the Mona Passage area due to the rotation of the Puerto-Rico-USVI microplate within the North American/Caribbean Plate Boundary. They use the age of the faulted rocks to suggest the faulting must be post Miocene in age.

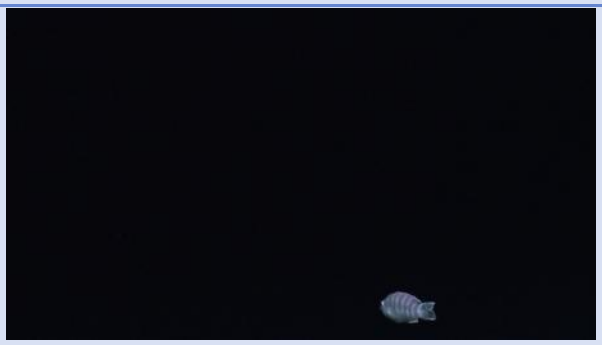
Biology:
The dive on the east side of the Mona Passage was conducted at a similar depth range as Pichincho (Dive 3), and contrasted in several important ways, in terms of the ecology and biodiversity of fishes and invertebrates. Overall, there was a higher diversity of corals, sponges, and fishes observed during this dive compared with other dives. The dive began on a sedimented slope and continued upslope where we encountered at least 30 putative species of fishes, including a draconet (*?Centrodraco acanthopoma)*, spike fish (Triacanthodidae, new for the expedition), green eyes (*Chlorophthalmus agassizi*), deepwater

cardinalfish (*Synagrops bellus)*, scorpionfish (Scorpaenidae), beardfish (*Polymixia* spp.), 2-3 shark species (e.g., ?*Scyliorhinus torrei, S. cubensis*), Darwin's slimehead (*Gephyroberyx darwinii*), Alfonsino (*Beryx decadactylus*), cusk eels *(?Benthocometes robustus*, unidentified ophidiid), flatfish, and sea robins (*Peristedion antillarum*). Toward the end of the dive, we observed one of our target fish species, the queen snapper (*Etelis oculatus).* Notably, a slender dory (*Parazen* sp.) was imaged puffing up the sediment, possibly trying to feed. Also, a species currently in the process of being described (by C. Baldwin et al., Smithsonian Institution) was observed (*Polylepion* sp. A). Finally, we observed a sea robin (*Peristedion antillarum)* picking up an ophiuroid with rostrum.

Throughout the dive, several coral species were observed, including black corals (?*Parantipathes*-branched and unbranched forms, ?*Leiopathes* sp.), soft corals (?Aquaumbridae), colonial and solitary scleractinians *(?Oculina* sp. *Lophelia pertusa*, the latter confirmed by S. Cairns, unidentified cup corals), primnoid and chrysogorgiid octocorals, and hydrocorals (stylasterids). However, along the top of the platform, many of the scleractinians and black coral colonies were small (< 10 cm tall colonies). Associates observed on the corals included crustaceans (?*Rochinia*, chyrostylid squat lobsters-e.g., *Gastrotychus* sp.), brittle stars (Ophiuroidea) and large basket stars (Gorgonocephalidae). On the sediment surface, we observed a new species of squat lobster for the expedition, Agononida, type of Munidae. Decorator crabs were found climbing the rock substrate and several species of shrimp were observed, including some gravid with green eggs and white and red striped forms. Other cnidarians documented on the dive included colonial zoanthiids on coiled stalks and fans, and a few anemones not observed on previous dives. Notably, we observed a predation event of an urchin eating black coral tissue. We encountered several yellow terribellid polychaetes on the sediment surface, with their tentacles undulating in the water column. Other notable observations included a few large slit shell gastropods on the soft sediment substrate, a large nemertean crawling along the rock surface and interesting tunicates, including predatory forms and flower shaped forms found attached to the rocks. Additionally, several sponge species were found encrusting the rock substrate, including cup sponges Corallistidae and Astrophorids. Several types of echinoderms were encountered, including sea stars (e.g., brisingids, *Tamaria passiflora*), crinoids (e.g., *Holopus* sp.), urchins (?*Cidaris rugosa, C. blakei*, aspidodiadema with curved spines, *Phorosom*a sp.), and holothurians (at least 2 species) some of which had some amphipods associated.

Overall Map of ROV Dive Area	Close-up Map of Main Dive Site
	

Representative Photos of the Dive

 Toward the end of the dive, we observed one of our target fish species, the queen snapper (Etelis oculatus).	 Unidentified coral with a brittle star associate.
 Enigmatic karstic weathering found at shallower depths during the dive.	 *Polylepion* sp. A was observed at the end of the dive.

Please direct inquiries to:	NOAA Office of Ocean Exploration & Research 1315 East-West Highway (SSMC3 10th Floor) Silver Spring, MD 20910 (301) 734-1014

Site Name	Guayanilla Canyon		
ROV Lead/ Expedition Coordinator	Brian Bingham/ Brian Kennedy		
Science Team Leads	Andrea Quattrini and Mike Cheadle		
General Area Descriptor	Puerto Rico and US Virgin Islands		
ROV Dive Name	Cruise Season	Leg	Dive Number
	EX1502	3	DIVE07
Equipment Deployed	ROV:	Deep Discoverer	
	Camera Platform:	Seirios	
ROV Measurements	☒ D2 CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ ROV HD 2	☒ Seirios CTD
	☒ Temperature Probe	☒ D2 DO Sensor	☐ Seirios DO sensor
Equipment Malfunctions	Operating with a secondary DO sensor that was last calibrated in 2013		
ROV Dive Summary (From processed ROV data)	Dive Summary: EX1502L3_DIVE07 ^^ In Water at: 2015-04-16T10:46:35.187000 17°, 45.562' N ; 066°, 45.836' W Out Water at: 2015-04-16T22:15:10.750000 17°, 46.125' N ; 066°, 44.805' W Off Bottom at: 2015-04-16T21:31:52.703000 17°, 46.142' N ; 066°, 44.920' W On Bottom at: 2015-04-16T11:56:08.484000 17°, 45.654' N ; 066°, 45.622' W Dive duration: 11:28:35 Bottom Time: 9:35:44 Max. depth: 2139.9 m		
Special Notes			

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Purpose of the Dive

i) To determine the lithology and stratigraphy of the rocks exposed in the east wall of the Guayanilla Canyon.

ii) To traverse across the trace of the Investigator Fault in the canyon wall and to look for deformation related to the movement of that fault.

iii) To document benthic communities living on and around the east wall of the canyon from 2150m to 1690m depth.

Description of the Dive:

This dive was located on the east wall of Guayanilla Canyon at the approximate location of the intersection of the canyon with the Investigator Fault. The proposed dive track trended to the north-east, obliquely traversing along the valley wall in order to attempt to cross the sub-vertical trace of the Guayanilla Fault. The ROV landed on the seafloor at 2139m (11:57 UTC). During the dive, the heading of the ROV was modified in order to spend as much time as possible on steeper slopes, resulting in a dive track that initially headed just north of east to the top of the first and major, 35^{o} dipping, scarp at 1860 m. The ROV then "flew" NNW off the seafloor for 250m and returned to the seafloor at 1910m and continued in a north-easterly direction up the scarp until the top of the scarp was reached at 1806m. The ROV continued to traverse in a north-easterly direction across a sediment covered 7^{o} slope until 1755m, when the ROV headed north to meet a second smaller scarp. The ROV traversed up this second scarp in an easterly direction until 1736m, at which point, the ROV continued in a northeasterly direction across sediment until 1709m, when it headed due east until the end of the dive at 1689m, leaving bottom at 21:30 UTC. The traverse was entirely within the Oligocene to Early Pliocene stratigraphic succession that occurs on the southern flank of Puerto Rico. Moderate bottom currents were noticed throughout the 9

hour dive.

Geology:
The dive started with D2 landing on a gently dipping, bioturbated sediment covered surface at 2139m (11:57 UTC). The sediment was very fine grained (muddy), contained lots of shell debris, notably pteropod shells, and holothurian trails were common. After heading east, a ~ 2m high outcrop was with a small debris apron at its base was reached at 2127m (12:14 UTC). This outcrop consisted of sub-horizontal, well bedded, 10 cm thick shale units with one 70cm thick sandstone unit near the top of the section. A north dipping cleavage was observed in the more fine-grained units. After passing over muddy sediments a more substantial 6m high outcrop was reached at 2081m (12:34 UTC). This outcrop was more sediment covered, and less shale rich than the first outcrop, but was well bedded with 10cm to 40cm layers of dominantly sandstone. There seemed to be a pile of angular blocks forming a layer on top of the outcrop. A distinct south-dipping joint cuts this outcrop. After transiting another stretch of sediment with one talus block, more outcrop was reached 2052m (12:42 UTC). This outcrop was less well bedded and might be more fractured and was partially sediment covered; however, a north dipping cleavage was still visible. The first two outcrops are very likely of the Late Oligocene Clastic Juanna Diaz Formation, possibly from the lower marine clastic sequence. The rock type of the third outcrop could not be determined well enough to confidently relate to the stratigraphic succession, however they could be carbonates from either the carbonate Juanna Diaz Formation or from the base of the Middle Miocene Ponce Formation.

The transect continued over gently dipping muddy, pteropod shell bearing, sediments until 1989m (13:04 UTC) where loose blocks of bedded and burrowed carbonate overlie outcrops of carbonate rock. From here until ~1793m, the carbonate forms a moderately steep slope (mean dip of 35^{o}), sometimes (80%) sediment covered with limestone blocks, and sometimes (20%) with steep outcrops of near horizontally bedded, sometimes chalky, limestone, especially at the top of the scarp. Essentially, the slope consist of differentially eroded carbonate layers draped by debris and sediment. A significant part of the dive was spent examining this slope and outcrops in two separate W-E transects (see Description of the Dive above). Notable features included, Fe-Mn coated horizons (1885m, 14:00 UTC; 1887m, 15:52 UTC; 1904m, 14:42 UTC; 1882m, 16:10 UTC) similar to those seen in the west wall of Mona Canyon, ubiquitous apparent bioerosion/burrows in most exposures and both fine 10cm scale bedding (1885 m, 14:00 UTC; 1805, 16:44 UTC) and massive bedding (1865m, 14:07 UTC, 1853, 16:27 UTC; 1803, 16:47 UTC). The other conspicuous feature of the slope was the evidence for sediment/talus transport and slope failure. One meter wide downslope channels were seen in the slope face at 1889m (15:54 UTC), 1878m (16:14 UTC), 1867m (16:22 UTC), 1823m (16:42 UTC), 1806, (18:30 UTC) as were downslope sediment trails at 1793 m (17:55 UTC) and 1798m (17:1 UTC). At the top of the outcrop, spectacular 20m wide, arcuate, head wall scarps were present. Interestingly, at the very top of the slope, the carbonates seemed to not be horizontal, but instead dip steeply (60^{o}) to the west, perhaps because the carbonates had rotated over the top of the slope during the process of slope failure. Inspection of the multi-beam bathymetry, shows that the top of this slope forms a continuous southward dipping surface for 6 km down the eastern wall of the Guayanilla Canyon, perhaps suggesting a relatively un-faulted and continuous stratigraphy in this area. Seismic data (Chaytor et al., in prep.) show that the shelf sequence near to this dive is relatively gently dipping, continuous and up to 900m thick.

From 1806m (18:30 UTC), the ROV returned to traversing gently sloping carbonate sediment, with the frequency of clasts/boulders of carbonate increasing as the final steeper slope was approached at 1747m (20:24 UTC). This slope provided a 20m high section of outcropping, sub-horizontal, parallel bedded carbonate rocks. Down-slope erosion channels were also present (1747, 20:28 UTC). The ROV dive returned to traversing muddy, pteropod sediments from 1725m (20:37 UTC) until the end of the dive at 1689m (21:30 UTC).

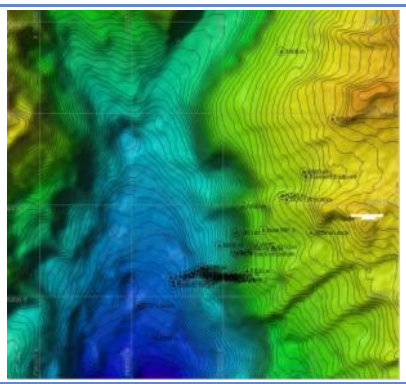
The carbonate outcrops traversed during this dive were from the Middle Miocene to Early Pliocene Ponce Formation of shallow to open shelf carbonates. If there was no faulting between the outcrops, a minimum of 250 vertical meters of carbonate were traversed (a typical on shore thickness for the Ponce Formation is 300m (Mann et al, 2005)) and a minimum of 140m of the underlying Juanna Diaz Formation (typical on shore thickness is 285m). Therefore, in summary, this dive was spent in the Late Oligocene to Early Pliocene shelf sequence that's found on and offshore of the south coast of Puerto Rico.
We did not recognize the Investigator Fault in the east valley wall during this dive. Post dive, examination of the 50m resolution bathymetry suggests the Investigator Fault may run through the northern end of our dive.

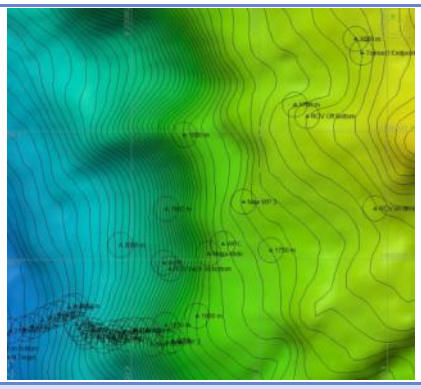
Biology:
Overall, it was noted that sessile, faunal colonization was not very dense throughout the entire dive. Most of the sponges (Hexactinelldae, Cladorhyzidae) and corals (*Metallogorgia melanotrichos, Lepidisis* sp.*)* were attached to the rock boulders and blocks at depths <1800 m. The *Metallogorgia* had its obligate associate brittle star with it. A few sea pens were also present (Protoptiidae, ?*Anthoptilum* sp., *Umbellula* sp.) There was little to no colonization evident on the face of the massive scarp at ~1800 m; however, some of the layers were heavily bio eroded. Additionally, tube anemones (Ceriantheria) were present in this layer.

Upon reaching the bottom, it was noticed that holothurians were quite abundant at this site compared to the other sites surveyed to date. At least six species of holothurians were observed throughout the dive, including *Benthodytes* sp., *Enypniastes* sp.,?*Peniagone/Amperima* sp. an elasiopod, and two additional, unidentified species. Additionally, numerous sea urchins (*Phromosoma* sp.) were observed during the beginning of the dive, some moving fairly quickly over the seafloor. These observations suggest that this area has considerable organic input, consistent with notions on delivery of increased organic matter to submarine canyons.

Several different species of squat lobsters were observed on this dive, including *Munidopsis* sp. and *Munida* sp., which had not yet been observed during this expedition. Other crustaceans included pagurid hermit crabs, one with an anemone on its back, and different species of mysid, nematocarcinid and crangonid shrimps. Several species of seastars, crinoids, and brittle stars were also observed. As for fishes, at least eight demersal species were observed, including 1-2 species of *Bathysaurus* lizardfish, snailfish (Liparidae), halosaurs (*Aldrovandia* sp.), ophidiid (?*Xyelacyba* sp.), a cutthroat eel (Synaphobranchidae), and tripod fish (*Bathypterois phenax, Ipnops murrayi, Bathytyphlops* sp.). Additionally, several midwater fishes were observed during the descent.
Comatulid crinoids and sea lilies were common throughout the dive. Notable observations included a benthic, platyctenid ctenephore on an *?Anthoptilum* sea pen (19:05, 1763 m), a solitary hydroid (Corymorphidae, (17:22 UTC, 1796 m), a dandelion siphonophore "tethered" into a vertical rock face (17:51 UTC, 1792 m), and several observations of benthic jellyfish (*Ptychogastria* sp.*)* (16:23 -1741 UTC, 1790-1865 m) attached to a vertical rock face. In addition, at least one wood fall was observed, with little colonization of fauna (?bivalves and serpulid tubeworms).

Overall Map of ROV Dive Area	**Close-up Map of Main Dive Site**





Representative Photos of the Dive

Dandelion siphonophore tethered" into a vertical rock face (17:51 UTC, 1792 m).

A distinct south-dipping joint cuts this outcrop.

Ipnops murrayi was observed during the dive.

D2 imaged several well defined small scale slope failure along 20 m wide, arced headwall scarps.

Please direct inquiries to:	NOAA Office of Ocean Exploration & Research 1315 East-West Highway (SSMC3 10th Floor) Silver Spring, MD 20910 (301) 734-1014

Site Name	Engineering Dive		
ROV Lead/ Expedition Coordinator	Brian Bingham/ Brian Kennedy		
Science Team Leads	Andrea Quattrini and Mike Cheadle		
General Area Descriptor	Puerto Rico and US Virgin Islands		
ROV Dive Name	Cruise Season	Leg	Dive Number
	EX1502	3	DIVE08
Equipment Deployed	ROV:	Deep Discoverer	
	Camera Platform:	Seirios	
ROV Measurements	☒ D2 CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ ROV HD 2	☒ Seirios CTD
	☒ Temperature Probe	☒ D2 DO Sensor	☐ Seirios DO sensor
Equipment Malfunctions	Operating with a secondary DO sensor that was last calibrated in 2013. Error in Depth sensor in SCS for both vehicles during descent. ROV team rebooted system which fixed the problem.		
ROV Dive Summary (From processed ROV data)	Dive Summary: EX1502L3_DIVE08 ^^ In Water at: 2015-04-25T17:06:35.984000 18°, 41.436' N ; 066°, 15.950' W Out Water at: 2015-04-25T22:38:06.546000 18°, 41.603' N ; 066°, 15.405' W Off Bottom at: 2015-04-25T21:41:53.921000 18°, 41.530' N ; 066°, 15.826' W On Bottom at: 2015-04-25T18:01:04.656000 18°, 41.535' N ; 066°, 15.804' W Dive duration: 5:31:30 Bottom Time: 3:40:49 Max. depth: 1678.1 m		
Special Notes			

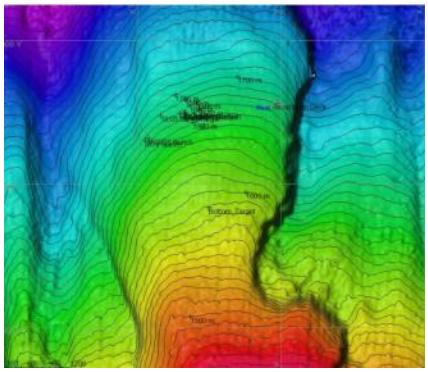
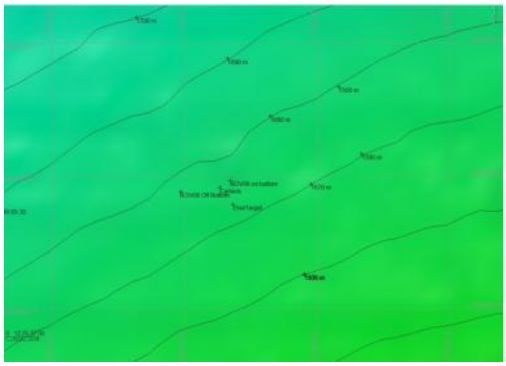
Scientists Involved *(please provide name / location / affiliation / email)*	Mike Cheadle	University of Wyoming	cheadle@uwyo.edu
	Mike Ford	NOAA Fisheries	michael.ford@noaa.gov
	Andrea Quattrini	USGS	aquattrini@usgs.gov
	Christopher Kelley	University of Hawaii	ckelley@hawaii.edu

Purpose of the Dive

The purpose of this engineering dive was to give ROV pilots time to train on the manipulators and to check white balance control had been restored to one of the Zeus Plus cameras that had failed during Dive 01.

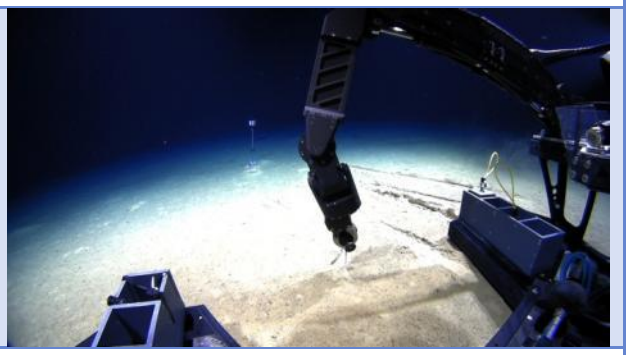
Description of the Dive:

ROV *Deep Discoverer* landed on a soft sedimented bottom at a depth of 1678 m. ROV pilots spent time training with the manipulator arms, practicing with the SeaPoke, weights with different handles, the temperature probe, and setting up a remote GoPro camera stand. During the dive fauna observed included a few holothurians, shrimp, and a few fish. About half way through the dive, the manipulator was able to bring a "handful" of sediment to the camera for close inspection.

Overall Map of ROV Dive Area	**Close-up Map of Main Dive Site**
	

Representative Photos of the Dive

A "deep sea selfie" of D2 taken by a GoPro.



Engineering trials of D2's new manipulator arm

Please direct inquiries to:	NOAA Office of Ocean Exploration & Research 1315 East-West Highway (SSMC3 10th Floor) Silver Spring, MD 20910 (301) 734-1014

Site Name	Puerto Rico Trench- South Wall		
ROV Lead/ Expedition Coordinator	Brian Bingham/ Brian Kennedy		
Science Team Leads	Andrea Quattrini and Mike Cheadle		
General Area Descriptor	Puerto Rico and US Virgin Islands		
ROV Dive Name	Cruise Season	Leg	Dive Number
	EX1502	3	DIVE09
Equipment Deployed	ROV:	Deep Discoverer	
	Camera Platform:	Seirios	
ROV Measurements	☒ D2 CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ ROV HD 2	☒ Seirios CTD
	☒ Temperature Probe	☒ D2 DO Sensor	☐ Seirios DO sensor
Equipment Malfunctions	Operating with a secondary DO sensor that was last calibrated in 2013. Today's dive was aborted from 6,000 m after pilots noticed D2's high voltage oil compensator was very low.		
ROV Dive Summary (From processed ROV data)	Dive Summary: EX1502L3_DIVE09 ^^ In Water at: 2015-04-26T10:46:07.296000 19°, 09.053' N ; 065°, 24.430' W Out Water at: 2015-04-26T18:08:32.765000 19°, 08.418' N ; 065°, 24.493' W Dive duration: 7:22:25 Bottom Time: N/A Max. depth: 5999.7 m		
Special Notes			
Scientists Involved *(please provide name / location / affiliation / email)*	Peter Auster	Mystic Aquarium & UConn	peter.auster@uconn.edu
	Mike Cheadle	University of Wyoming	cheadle@uwyo.edu
	Amanda Demopoulos	USGS	ademopoulos@usgs.gov
	Mike Ford	NOAA Fisheries	michael.ford@noaa.gov
	Scott France	University of Louisiana at Lafayette	france@louisiana.edu
	Graciela Garcia-Moliner	Caribbean Fishery Management Council	graciela.garcia-moliner@noaa.gov

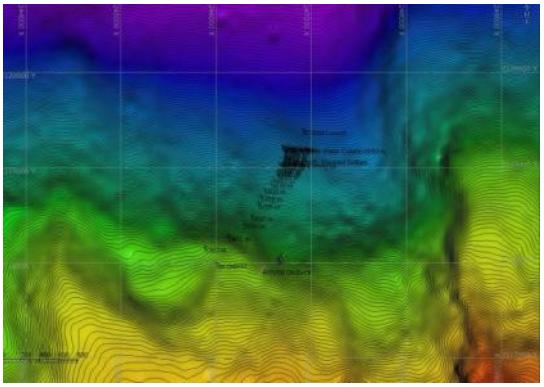
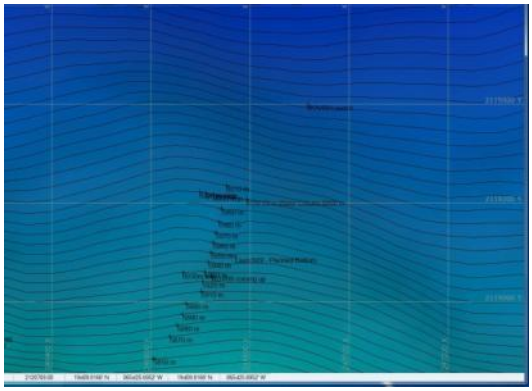
	Christopher Kelley	University of Hawaii	ckelley@hawaii.edu
	Andrea Quattrini	USGS	aquattrini@usgs.gov
	Taylor Heyl	WHOI	theyl@whoi.edu
	Thomas Ritter	Montana State University	thomas.ritter@msu.montana.edu
	Timothy Shank	Woods Hole Oceanographic Institution	tshank@whoi.edu

Purpose of the Dive

1) Pressure test ROVs to 6,000 m
2) Investigate the lithology and stratigraphy of the rocks exposed in the south wall of the Puerto Rico Trench.
3) To document benthic communities living on and around the southern wall of the trench at a depth of 6,000 m.

Description of the Dive:

Today we conducted a 6,000 m ROV dive along the southern wall of the Puerto Rico Trench. The vehicles successfully reached 6,000m, but shortly thereafter the dive was aborted due to an issue with D2's high voltage oil compensator. Observations in the water column during descent and ascent included fish, ctenophores, salps, and siphonophores.

Overall Map of ROV Dive Area	**Close-up Map of Main Dive Site**
	

Representative Photos of the Dive

	
ROV control interface as D2 hit 6000 m.	Using the camera platform to inspect the oil compressor prior to aborting the dive.

Please direct inquiries to:	NOAA Office of Ocean Exploration & Research 1315 East-West Highway (SSMC3 10th Floor) Silver Spring, MD 20910 (301) 734-1014

Site Name	Pinnacles		
ROV Lead/ Expedition Coordinator	Brian Bingham/ Brian Kennedy		
Science Team Leads	Andrea Quattrini and Mike Cheadle		
General Area Descriptor	Puerto Rico and US Virgin Islands		
ROV Dive Name	Cruise Season	Leg	Dive Number
	EX1502	3	DIVE10
Equipment Deployed	ROV:	Deep Discoverer	
	Camera Platform:	Seirios	
ROV Measurements	☒ D2 CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ ROV HD 2	☒ Seirios CTD
	☒ Temperature Probe	☒ D2 DO Sensor	☐ Seirios DO sensor
Equipment Malfunctions	Operating with a secondary DO sensor that was last calibrated in 2013. ROV CTD had a ground fault and was turned off UTC 1315 to trouble shoot. Certain still images were not properly exported due to an issue in post processing.		
ROV Dive Summary (From processed ROV data)	Dive Summary: EX1502L3_DIVE10 ^^^ In Water at: 2015-04-27T12:37:14.515000 17°, 40.721' N ; 064°, 31.566' W Out Water at: 2015-04-27T20:15:06.640000 N/A ; N/A Off Bottom at: 2015-04-27T20:00:04.140000 17°, 39.980' N ; 064°, 31.181' W On Bottom at: 2015-04-27T13:20:41.093000 17°, 40.580' N ; 064°, 31.519' W Dive duration: 7:37:52 Bottom Time: 6:39:23 Max. depth: 933.7 m		
Special Notes			

Scientists Involved *(please provide name / location / affiliation / email)*	Amy Baco-Taylor	Florida State University	abacotaylor@fsu.edu
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	Jason Chaytor	USGS	jchaytor@usgs.gov
	Mike Cheadle	University of Wyoming	cheadle@uwyo.edu
	Erik Cordes	Temple University	ecordes@temple.edu
	Amanda Demopoulos	USGS	ademopoulos@usgs.gov
	Mike Ford	NOAA Fisheries	michael.ford@noaa.gov
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	Les Watling	University of Hawaii at Manoa	watling@hawaii.edu
	Taylor Heyl	WHOI	theyl@whoi.edu

Purpose of the Dive

i) To determine the lithology, structure and origin of two recently discovered ~100-200m diameter mounds/pinnacles sitting on the top of the gently sloping carbonate platform to the SE of St. Croix.

ii) To document benthic communities living on and around these two mounds/pinnacles from 870m to 818m depth for the first mound/pinnacle and from 933m to 920m for the second smaller mound/pinnacle.

Description of the Dive:

This dive was located on a probable Middle Miocene to Lower Pliocene platform carbonate sequence to the south east of St Croix and designed to explore two mounds/pinnacles that were recently discovered in March during surveying by the RV Nancy Foster (NOAA NOS, Tim Battista et al.). The ROV landed on a muddy seafloor at 866m (13:23 UTC) and traversed SW, reaching the base of the mound at 868m (13:58 UTC). It then climbed the mound reaching, and traversing across, the top until 817m (16:11 UTC). At this point the ROV "flew" to the west to the seafloor on the western side of the mound, landing at 865m (17:32 UTC). The ROV then traversed due east along a gully up the western side of the mound. At 827m (18:02), the ROV reached a gentle muddy slope and the decision was taken to "fly" the ROV to the second mound to the SE. Bottom was reached at 928m (19:10 UTC). The ROV then proceeded up this second mound and reached the top at 920m (19:59 UTC), at which point the dive was completed and the ROV returned to the surface. The current came from the NE throughout the dive and was measured at 13 cm/s at the start of the dive.

Geology:
The dive on the first mound started with D2 landing on a gently dipping, bioturbated sediment covered surface at 866m (13:23 UTC). The sediment was very fine grained (muddy), and contained lots of shell debris, notably pteropod shells. Traversing to the SW, the sea floor deepened to 871m (13:55 UTC) as D2 crossed a moat around the base of the mound. A single rounded, 20cm diameter, rock was observed at 870m (13:57 UTC) and loose rubble fringing the mound was reached at 868m (13:58 UTC). All rocks throughout the dive were Fe-Mn encrusted and no interior surfaces were observed. However, the recognition of i) pitted, honey-combed, surfaces (e.g. 851m, 15:05 UTC), ii) rare burrowed surfaces, together with iii) occasional indications of bedding surfaces (e.g. 849m, 16:04 UTC), iv) the presence of thin crusts on some exposures similar to those seen in dives 3 & 6 in the Mona Passage area (e.g. 855m, 14:45 UTC; 823m, 16:31 UTC) and v) proto-karstic weathering on the top of the mound (818m, 16:42 UTC) suggests this mound is made of platform carbonate.

Overall, the mound appeared to be a relatively solid mass, with outcrop at the surface (e.g. 867m, 14:05 UTC) or lightly dusted with sediment (e.g. 857m, 14:23 UTC; 835m, 16:15 UTC). However, rounded rock debris of variable size was present in some locations and thicker mud deposits were present in depressions and areas of more shallow slope (e.g. 855m, 14:53 UTC). The top of the mound was sub-planar and approximately sub-horizontal. It was mud covered, but a sea-poke test showed the unconsolidated mud was only 2cm thick (817m, 16:57 UTC).

At 16:50 UTC, D2 flew to the west side of the mound and landed on soft sediment at 865m (17:32 UTC). The western base of the mound was marked by a few pieces of 30cm-1m diameter talus sitting on an *in-situ* carbonate crust (864m, 17:34m). The traverse upslope, to the east, followed a 30m wide gully. Initially D2 traversed over sediment dusted outcrop (e.g. 846m, 17:56 UTC), until a steep, vertically jointed, rounded, outcrop with boulder debris was reached at 837m (1801 UTC) at which point D2 had to rise more steeply. Possible gently dipping bedding was visible at 827m (18:14 UTC). The slope quickly became more gentle as the mud covered top of the western side of the mound was reached at 826m (18:15 UTC). At this point the dive on this mound was halted and D2 flew to the mound to the SSE landing on a muddy sea floor at 928m (19:10 UTC).

The second mound was reached at 929m (19:29 UTC) and was very quickly examined as we were short of time. It mostly consisted of Fe-Mn encrusted one meter diameter boulders and smaller debris (e.g. 929m, 19:29 UTC), but clear bedding was recognized at 928m (19:30 UTC) in a loose boulder and, dipping, in a possible outcrop at 924m (19:47 UTC). Probable outcrop, with partially sediment filled proto-karstic weathering was found at the top of the mound (923m, 19:55 UTC). This mound is also thought to be composed of carbonate.

The dive clearly confirmed the mounds were made of carbonate, but their origin is still unclear. There are

two possibilities. Firstly, the mounds could be *in-situ* and represent a relict surface protruding above the present day planar surface that dips to the south from St Croix. Alternatively, the mounds are large 200m wide, 50m high blocks that detached from the relatively steep shelf-slope break 5km to the north. This interpretation is supported by the angular 5 sided margin to the first mound (see bathymetry) which could be explained if the shape of the detached block was controlled by jointing in the outcrop and by the observation that bedding may be dipping and therefore not *in-situ*. This explanation requires in-situ weathering and breakdown to produce the rock debris sitting on the mound today. The prevalence of the Fe-Mn coating and the amount of biological colonization suggest that if this is indeed a slide block, the transport of the block was not recent. Whilst this second interpretation requires a rather dramatic event (a 200m relatively coherent block sliding 5km), it seems to be the best way to satisfy the observations.

Biology:
The dive began off the feature on a muddy bottom at a depth of 866 m. Several fishes were observed here, including at least two species of rattail fishes (*Nezumia ?aequalis* and *?Hymenocephalus* sp.) and a halosaur (*?Aldrovandia* sp.). Several nematocarcinid shrimps were evident in the area as well. Also of note, several dead sponge stalks colonized by zoanthids were anchored in the soft sediment. One ?*Acanella* bamboo coral was observed at 13:46 UTC.

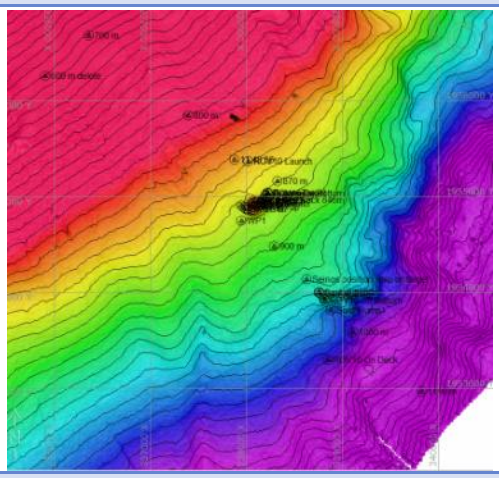
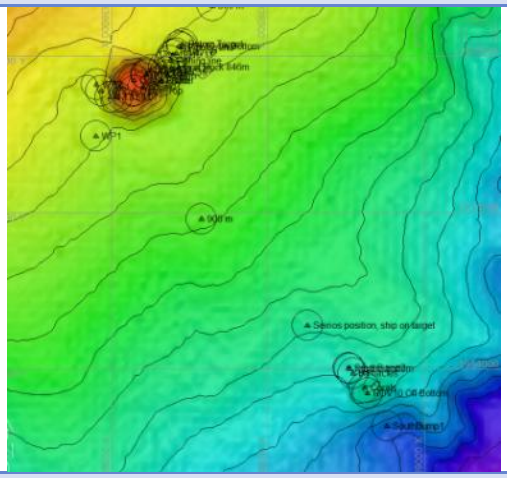
D2 reached the base of the feature at 14:00 UTC and worked its way up the eastern flank of the mound to the top (depth of 820 m). Then, the D2 came off the feature to the western side and then transited up the western flank of the mound. Numerous species of corals were observed on both sides of this mound. Diversity appeared to be similar, however, it appeared that corals were less abundant on this western slope transit compared to the transit on the eastern slope. The most abundant coral included an unknown morphotype of an antipatharian black coral (each with at least one *Gastroptychus* sp. squat lobster), and this was most abundant just below the top of the mound. At least four additional black coral species were observed (*e.g., Stichopathes* sp., ?*Bathypathes* sp., and 2 unknown species) as well as five species of scleractinian corals (*Madrepora* sp., *Javania* sp., *Enallopsammia* sp.,*?Lophelia pertusa,* and another unidentified cup coral). Octocorals were also common, and included at least eight species of plexaurids, primnoids, anthothelids, corallids, and chrysogorgiids. Of note, two *Iridogorgia ?magnispiralis* colonies were observed and one *?Dendrobranchia* sp. was observed.

After surveying the western and eastern flanks of this mound, the D2 picked up off the seafloor (at ~18:22 UTC) and transited to another mound 1.2 km to the southeast. Upon arriving on the seafloor (~19:10 UTC), more sponge stalks colonized with zoanthids were noted. However, these sponges were not all dead; there were several live sponges in the area as well. The D2 surveyed this mound feature at a depth of 928 m to 920 m. Corals were common during the survey (NW to SE transit), and noted to be diverse. There were several coral species present (e.g., *Enallopsammia* sp., *Corallium* sp., *Chrysogorgia* sp.) on this mound that were also observed on the shallower mound; however, there were several species not encountered on the shallower mound. These species included: *Paramuricea* sp., *?Narella* sp., *Anthothela* sp., *Jasonisis* sp., *Lepidisis* sp., and a stoloniferan octocoral.

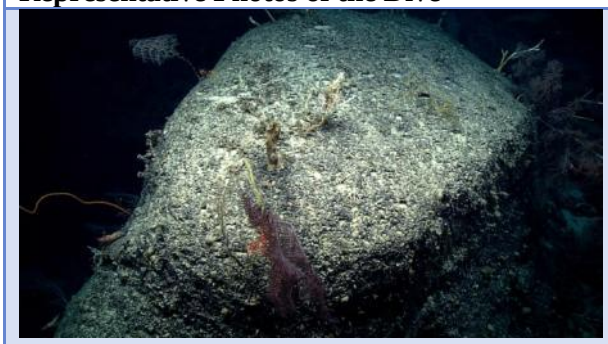
At least 10 species of fish were observed during this dive, including: *?Aldrovandia* sp., *?Benthocometes robustus, Cyclothone* sp., ?*Hymenocephalus* sp., *Nezumia ?aequalis, Synagrops bellus,* an unknown Macrouridae, an unknown Ophidiidae, *Nemichthys* ?*curvirostris*, and *Neoscopelus ?macrochir.* Crustaceans were abundant throughout the dive, including several observations of pagurid hermit crabs both inhabiting coral colonies and the surrounding substrate. Galatheoid squat lobsters were both common and diverse during this dive. *Gastroptychus* sp. was abundant, and observed colonizing almost every black coral colony (of the same morphotype) encountered. Several *Munidopsis* spp. and *Munida spp.* were observed inhabiting corals and the surrounding substrates, respectively. Two unknown squat lobsters were observed hiding within two *Chrysogorgia* colonies. Shrimps (Pandalidae) were very large (up to and greater than 10 cm in total length). Ophiuroid brittle stars were common. *Ophomusium* –like

morphotypes were observed on soft substrates whereas *Asteroschema* sp. were commonly observed wrapped tightly around octocoral colonies. Asteroid sea stars were rare during this dive, but included one *observation of Tremaster mirabilis, ?Mediaster bairdii and an additional asteroid sea* stars. Other coral associates included gooseneck barnacles, amphipods, mysids, and polychaete worms.

Notable Observations:
Trash was observed on the soft sediment surrounding the feature, including plastic trash bags, derelict fishing gear (or a hydrophone and cable), and a possible fishing line. At 14:43 UTC, a shrimp "grooming" itself with its chela was imaged at a depth of ~ 857 m. At 15:09 UTC, an *Enallopsammia* coral colony was observed that may have been parasitized, as large, bulbous portions of the skeleton were apparent. Two observations of gorgonocephalid basket stars were observed; both were perched on octocorals at 16:40 UTC (818 m) and 18:21 UTC (825 m). Several squat lobsters were observed on this dive, including some that had not yet been observed during this expedition. Of note, one galatheiod squat lobster inhabiting *Madrepora* was well camouflaged, with coloration matching the coral (16:27 UTC, 829 m). On this same *Madrepora* colony, one Eunicidae polychaete worm was observed, peaking its head between two coral branches. Coral diversity was high on this dive, including at least 26 species of corals. An unknown macrourid, with a very long chin barbel and black, filamentous fin rays was noted at 19:44 UTC (925 m). Also during this dive, we noted numerous dead coral skeletons, several of which were colonized by living scleractinians.

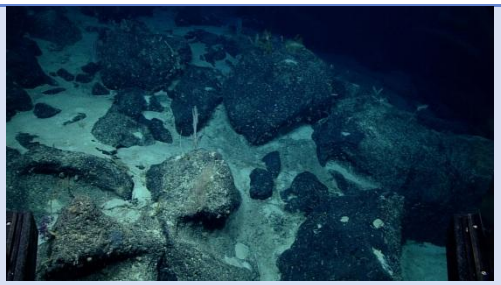
Overall Map of ROV Dive Area	**Close-up Map of Main Dive Site**
	

Representative Photos of the Dive



Coral diversity was high on this dive, including at least 26 species of corals.

Basket star with a number of arms extended.

 The second mound mostly consisted of Fe-Mn encrusted one meter diameter boulders and smaller debris.	 A one galatheiod squat lobster inhabiting a *Madrepora colony* was well camouflaged, with coloration matching the coral.
Please direct inquiries to:	NOAA Office of Ocean Exploration & Research 1315 East-West Highway (SSMC3 10th Floor) Silver Spring, MD 20910 (301) 734-1014

Site Name	Exocet Seamount		
ROV Lead/ Expedition Coordinator	Brian Bingham/ Brian Kennedy		
Science Team Leads	Andrea Quattrini and Mike Cheadle		
General Area Descriptor	Puerto Rico and US Virgin Islands		
ROV Dive Name	Cruise Season	Leg	Dive Number
	EX1502	3	DIVE11
Equipment Deployed	ROV:	Deep Discoverer	
	Camera Platform:	Seirios	
ROV Measurements	☒ D2 CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ ROV HD 2	☒ Seirios CTD
	☒ Temperature Probe	☒ D2 DO Sensor	☐ Seirios DO sensor
Equipment Malfunctions	Operating with a secondary DO sensor that was last calibrated in 2013		
ROV Dive Summary (From processed ROV data)	Dive Summary: EX1502L3_DIVE11 ^^ In Water at: 2015-04-28T10:48:19.250000 18°, 01.891' N ; 064°, 19.440' W Out Water at: 2015-04-28T20:15:14.671000 N/A ; N/A Off Bottom at: 2015-04-28T19:04:40.515000 18°, 01.738' N ; 064°, 20.196' W On Bottom at: 2015-04-28T13:28:57.046000 18°, 01.809' N ; 064°, 19.650' W Dive duration: 9:26:55 Bottom Time: 5:35:43 Max. depth: 2900.7 m		
Special Notes			

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Purpose of the Dive

i) To carry out five 10 minute horizontal traverse mid water transects every 100m from 800-1200m to observe mid-water biology.

ii) To document benthic communities living on and around the eastern margin of Exocet Seamount

iii) To determine the lithology and geological structure of the eastern margin of Exocet Seamount

iv) To compare the fauna found on Exocet with that found on seamounts to the north-east (Dog, Conrad & Noroit) and west (Grappler and Whiting)

Description of the Dive:

This dive was the first ROV dive on Exocet Seamount, which is a poorly understood seamount that is bathymetrically complicated and has not been the subject of seismic surveying. The dive began at 10:40 UTC. D2 descended to 800m at 11:25 UTC and began to carry out the mid water transects. The transects were complete at 12:58 UTC and D2 headed down towards 2900m. The ROV landed on a soft sediment, pteropod shell hash covered seafloor at 2898m (13:30 UTC). A sea-poke test showed the sediment to be >75 cm deep (2897m, 13:39 UTC). The dive then proceeded due west reaching the bottom of the slope at 2881m (14:07 UTC) and then headed in a direction of 260, up a relatively continuous slope (mean dip 32^{o}) until the dive ended at 2385m water depth (19:05 UTC). There was a negligible surface current at the start of the dive and little current on the seafloor.

Geology:

This dive was the most difficult dive to interpret in terms of the geology, because the lack of previous exploration on Exocet Seamount, and its likely structural complexity means there is no background framework to help constrain the geological observations. Additionally, all bar one exposure was Fe-Mn coated, making rock identification difficult. Consequently, the interpretation of the outcrops is very tentative in the lower part of the dive.

The dive started with D2 landing on a planar, very gently sloping, sediment covered surface at 2898m (13:30 UTC). The sediment was very fine grained (muddy), and contained copious amounts of shell debris, notably pteropod shells (2890 m, 13:57 UTC). D2 proceeded due east over the gently sloping muddy surface and the narrow talus apron to the main seamount slope was reached at 2881m (14:07 UTC). The presence of scour marks around the base of the talus boulders indicated current activity. Near the base of the hill slope, the ROV changed heading to 260 and followed this heading until the end of dive at 2385m. A steep slope of boulder covered outcrop was reached at 2879 m (14:08 UTC), and this style of exposure continued for approximately 100 vertical meters to 2778 m (14:43 UTC). The exposure consisted of meter sized rounded, sometimes knobbly weathering, massive blocks with sparse, rounded, talus, draped by mud. Possible, weak layering or bedding was observed in many of the exposures e.g. at 2854 m (14:14 UTC) and 2805 m (14:26 UTC). The lithology of this series of outcrops is unknown, however the massive nature of the exposures, the lack of simple and clear bedding and the absence of pitted, honey-comb textured surfaces suggests that these could be exposures of the Cretaceous to Eocene volcanic/plutonic basement, in which case the weak layering/bedding might have been stratification within the volcanic sequences. Alternatively, the outcrops could be exposures of Oligocene to Late Miocene sedimentary rocks. In which case, given the proximity of Exocet Seamount to St Croix these rocks would correspond to part of the Kingsmill and Jealousy Formations and their sub-surface continuation.

At 2778 m (14:44 m), the slope became more gentle and outcrop became more sparse, with more extensive sediment. At 2775 m (14:49 UTC) the outcrops began to have a conspicuous E-W orientation, and parallel outcrops with infilling mud seemed to almost define a muddy “road” up the slope (e.g. see Seirios view at 14:51 UTC (2773m) and at 14:58 UTC (2765 m)). Additionally, further up the slope, the outcrop became vertically jointed with the joints having the same E-W trend (e.g. 2688 m; 15:40 UTC and 2681 m; 15:44 UTC). At 2684 m (15:43 UTC), D2 observed an outcrop where the Fe-Mn crust had been broken off to reveal fractured, vertically jointed carbonate. This vertical E-W trend could be traced to at least 2552 m (17:04 UTC) upslope. The simplest interpretation of this feature is that it is a small offset. E-W fault zone, which perhaps formed early within the Oligocene to Miocene sedimentary sequence. Other, second order, E-W trends are seen elsewhere in the bathymetry of Exocet Seamount suggesting that these might be part of an early, within Miocene basin, E-W trending, steeply dipping fault set that was subsequently truncated by the later, NE-SW trending faulting that formed the Anegada Passage.

At 2718m (15:21 UTC), an outcrop of moderately SE dipping, 10 cm thick beds were observed emerging above the mud. These are most likely from the Miocene platform sequence (Kingsmill Formation) and are the therefore from this point upwards, the transect was most likely within the platform sequence. Additional evidence that the remaining part of the transect was within platform carbonates is provided by: i) As discussed above, a broken rock face exposed likely carbonate at 2684m (15:43 UTC), ii) A rock "break" test using the manipulator arm at 2681m (15:45 UTC) revealed that outcrop was made of carbonate, and iii) beds (starting at 2525m, 17:44 UTC) dipping 30^{o} to the east-south-east with "limestone pavement" were seen at the end of the dive (e.g. 2369m, 18:54 UTC).

A very spectacular, but enigmatic, outcrop was found at 2688m (15:40 UTC). Here vertically layered (jointed or bedded) rocks are apparently truncated by shallowly dipping rocks suggesting an unconformity. However more vertically layered rocks are found upslope of this outcrop (e.g. 2684m (14:43 UTC), and so it is unlikely that it's a simple unconformity between vertically layered rocks below and gently dipping rocks above, unless the traversed section is quite extensively tectonically disrupted. Crosscutting joints (e.g. 2651m, 16:03 UTC) in some outcrops and cleavage in others (e.g. 2709m, 15:27 UTC) perhaps hints that structural complexity is present.

In summary, it is clear that carbonate rocks, likely of the Miocene Kingsmill Formation, are present in the top of the dive transect. It also seems likely that a fault cuts the sequence near the dive transect. The presence of more complicated tectonic disruption is speculative, but, if present could explain the possible structural complexity. The nature/lithology of the lowermost section is not very well constrained.

Biology:
Dive 11 began with five midwater transects conducted for 10 min every 100 m in depth, from 800-1200 m. During these transects the D2 observed several empty larvacean houses, a few ctenophores, arrow worms, hydromedusae (jellyfish), midwater fishes (e.g., Gonostomatidae) and a potential foraminiferan (aka, "sunburst creature"). Several of these observations were new for this expedition, and new observations for the shore- and ship-board scientists. Most of the sightings in midwater were in 800-1100 m depth. These findings combined with the previous midwater findings repeatedly illustrate the utility of exploration in the pelagic zone.

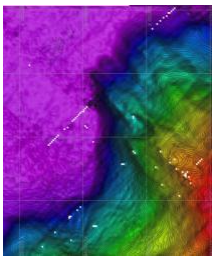
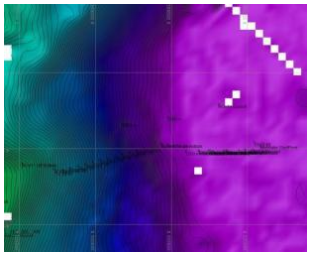
The D2 reached bottom at 13:30 UTC, at a depth of 2898 m. Several pieces of *Sargassum* detritus were observed, as well as piles of pteropod shells. A few rusted steel cans were observed in the area. One shrimp (*A. edwardsiana?),*a large, ophidiid cusk eel, and at least one dark purple, asteroid "slime-star" were observed; however, the area surrounding the seamount was generally devoid of megafauna.

The D2 approached the base of the seamount at ~14:15 UTC and continued up slope to a depth of 2384 m. Overall, colonization by sessile fauna was low. Several species of hexactinellid sponges were observed, a few of which were not easily identified. However, throughout the dive, the abundance of sponges remained low. In addition, only six corals were seen. These included: a *Desmophyllum* cup coral at 14:54 UTC (2766 m), an unknown black coral at 16:55 UTC (2565 m), a stoloniferan overgrowing a sponge, a primnoid whip coral, and a bamboo coral all at ~18:20 UTC (2448 m), and another bamboo (same species) at 18:34 (2436 m). Interestingly, considerable hard substrates were observed throughout the dive, and although there was some sediment overlying some surfaces, many of the rock surfaces were bare.

Overall, at least eight fish species were seen throughout the dive, including: *Bathysaurus mollis, Bathypterois phenax, Ipnops murrayi,* ?*Xyelacyba myersi,* three additional unknown ophidiids, and gonostomatids (?*Cylcothone sp.)*. A few white, squat lobsters (*Munidopsis* spp.) were observed. Additionally, at least one brisingid and three additional species of seastars were observed, including:

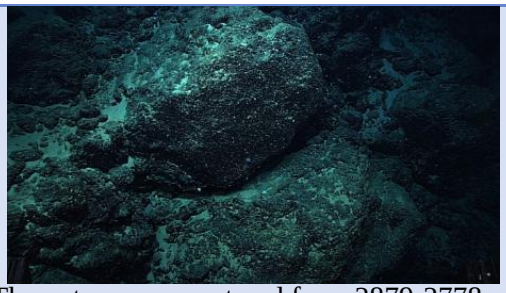
Hymenaster sp., *Circeaster americanus*, and *Ceramaster grenadensis* (identifications confirmed by C. Mah, NMNH). A few shrimps were observed, including nematocarcinids.

Notable Observations:
Of note, several pieces of trash were observed throughout the dive, including rusted steel cans and plastic bags. At least five species of holothurians were observed, including one translucent form (17:49 UTC, 2521 m) that had not been observed before on this expedition. Also, a blind lobster (Polychelidae) was observed (17:35 UTC, 2544 m) buried in the sediment, and although difficult to tell, was likely just a molted exoskeleton.

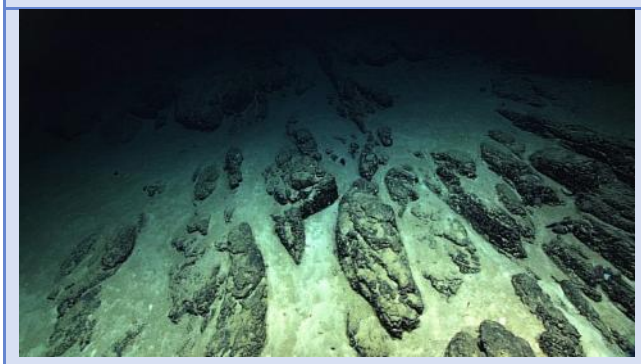
Overall Map of ROV Dive Area	**Close-up Map of Main Dive Site**
	

Representative Photos of the Dive

A potential foraminiferan, although still unidentified, was documented during the midwater transects.



The outcrop encountered from 2879-2778 m consisted of meter sized rounded, massive blocks with sparse, rounded, talus, draped by mud.



Beginning at 2718 m, an outcrop of moderately SE dipping, 10 cm thick beds were observed emerging above the mud.

One of the few corals observed during the dive, even though there was ample hard substrate available.

Please direct inquiries to:	NOAA Office of Ocean Exploration & Research 1315 East-West Highway (SSMC3 10th Floor) Silver Spring, MD 20910 (301) 734-1014

Site Name	Whiting Seamount		
ROV Lead/ Expedition Coordinator	Brian Bingham/ Brian Kennedy		
Science Team Leads	Andrea Quattrini and Mike Cheadle		
General Area Descriptor	Puerto Rico and US Virgin Islands		
ROV Dive Name	Cruise Season	Leg	Dive Number
	EX1502	3	DIVE12
Equipment Deployed	ROV:	Deep Discoverer	
	Camera Platform:	Seirios	
ROV Measurements	☒ D2 CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ ROV HD 2	☒ Seirios CTD
	☒ Temperature Probe	☒ D2 DO Sensor	☐ Seirios DO sensor
Equipment Malfunctions	Operating with a secondary DO sensor that was last calibrated in 2013		
ROV Dive Summary (From processed ROV data)	Dive Summary: EX1502L3_DIVE12 ^^^ In Water at: 2015-04-29T10:45:45.406000 17°, 50.940' N ; 065°, 42.257' W Out Water at: 2015-04-29T20:37:44.953000 17°, 49.973' N ; 065°, 41.494' W Off Bottom at: 2015-04-29T20:11:46.640000 17°, 50.064' N ; 065°, 41.487' W On Bottom at: 2015-04-29T11:31:02.984000 17°, 50.773' N ; 065°, 42.056' W Dive duration: 9:51:59 Bottom Time: 8:40:43 Max. depth: 1303.3 m		
Special Notes			

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Purpose of the Dive

i) To document benthic communities living on and around the north-western margin of Whiting Seamount/Bank.

ii) To determine the lithology and geological structure of the north-western margin of Whiting Seamount/Bank.

iii) To compare the fauna found on Whiting Seamount with that found on seamounts to the north-east (Dog, Conrad, Noroit & Exocet)

Description of the Dive:

This dive was the first ever ROV dive on Whiting Seamount/Bank The dive began at 10:43 UTC and D2 descended to 1301m (11:28 UTC) and observed the north-western slope of the seamount. This slope is a partially eroded fault scarp, the uppermost 1900m of which is exposed. The dive began on this slope, approximately 600m from the bottom of the scarp. The dive then proceeded south east, climbing the slope until 507 m (19:53 UTC), when D2 left the seafloor. This dive traversed from the Cretaceous-Eocene basement across the unconformity with the overlying Late Oligocene to Early Pliocene Platform sequence (the Juana Diaz and Ponce Formations). There was a surface current of 0.5 knot from the northeast and a negligible seafloor current at the start of the dive, but the seafloor current increased as D2 ascended. At ~ 938 m (15:45 UTC), the current came from the west.

Geology:

The dive started with D2 landing on the northwestern slope of Whiting Seamount at 1279m (11:30 UTC). Most of the rocks during the entire dive were Fe-Mn encrusted making rock identification difficult. The first outcrop at 1278 m (11:31 UTC) was extensively cracked and jointed, generating tabular, but angular clasts. This outcrop had a different character to subsequent outcrops. At 1275 m (11:39 UTC), the outcrop character became more massive, but still with planar, non-weathered faces. At 1273 m (11:42 UTC), the ROV was set down and the manipulator arm used to remove the Fe-Mn coating from a clast. This operation was very successful, and revealed that the rock was an igneous rock, likely a granodiorite (12:17 UTC) from the Cretaceous/Eocene basement. This massive, often angular outcrop continued intermittently with more talus and/or mud rich sections up to 1039 m (14:41 UTC). Dipping joints defining a weak layering were seen in several of these outcrops (e.g. 1197 m, 12:56 UTC and 1119 m, 13:40 UTC).

At 1123 m (14:38 UTC), D2 entered a small (20m across) box canyon and whist rising up the vertical, north-west trending, west wall of the canyon, it imaged a spectacular, clear, sub-horizontal contact between massive outcrop below and northerly dipping beds/joints (1039 m, 14:40 UTC). Both sets of rocks on either side of this contact are most likely Cretaceous to Eocene basement rocks. It is tempting to interpret the rocks below the contact as the continuation of the granodiorite intrusive body surveyed at 1273 m (11:42 UTC) and the rocks above as the meta-volcanic rocks of the basement. Above this outcrop, the fraction of true outcrop decreased, but intermittent (with mud) angular outcrop and/or talus continued until 842 m (16:37 UTC). The angular and massive nature of these outcrops and sub-vertical jointing (e.g. 950m, 15:28 UTC; 935m, 15:40 UTC) suggests that these rocks are still part of the Cretaceous/Eocene basement. Above 842 m (16:37 UTC), the slope shallows and mud becomes much more prevalent. At 806m (16:51 UTC), the talus appeared to contain clasts of sedimentary origin and possible cross bedding was observed in a clast from 801m (16:54 UTC).

At 792m (16:57 UTC), definite sedimentary bedding was observed in a boulder. Thus, although the unconformity between the basement & the overlying platform sequence was not seen, it is interpreted to lie between 842 and 802 meters water depth, and therefore the rocks directly above 842/802 meters are clastic rocks from the clastic Juana Diaz Formation.

At 694 m (17:33 UTC), weathered, honeycombed outcrop suggests that the rocks were carbonates, and if so, these rocks are either from the uppermost Early Miocene Carbonate Juana Diaz Formation or from the carbonate Miocene Ponce Formation. This would mean the thickness of the clastic Juana Diaz Formation is 108-148 m in this location. From 694 m to 571 m (18:44 UTC), outcrop was sporadic between poorly developed talus piles and mud, but all the rocks had honey-comb weathering suggestive of weathered carbonates. At 595 m (18:14 UTC), D2 was maneuvered to measure the dip of the carbonates as ~50^{o} to the south east; this relatively steep dip is consistent with Whiting Seamount being a rotated fault block and is consistent with the dip if the carbonates seen in seismic data (Mann et al., 2005). From 571m until 522 m, 19:33 UTC), outcrop and talus decreased, but clear, often broken, gently dipping, 5-5 cm thick carbonate crusts appeared. These were sub-parallel to the slope and therefore discordant to the bedding measures earlier. Consequently these mud covered carbonate crusts seem to be a diagenetic feature possibly caused by cementation of the carbonate mud. From 522 m until the end of the dive at 507 m (19:57 UTC), sparse talus piles with weathered/honeycombed clasts were present. If the identification of carbonate rocks is correct, it would mean that we traversed 111m of the Early Miocene carbonate facies of the Juana Diaz Formation and the carbonate Miocene, Ponce Formation. Given that the top of Whiting Seamount is 75m below the sea surface, the preserved thickness of the Miocene carbonate (Juana Diaz and Ponce Formation) sequence would be ~ 530m.
It should be noted that this was the only dive in the whole series that convincingly traversed from the Eocene/Cretaceous basement, crossing the unconformity, into the Oligocene to Pliocene Platform sequence. Dive 5 was solely within the Cretaceous/Eocene basement, Dive 11 was unclear and all the rest were within the carbonate platform sequence.

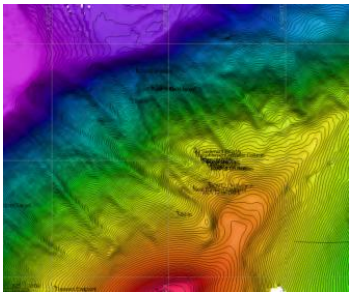
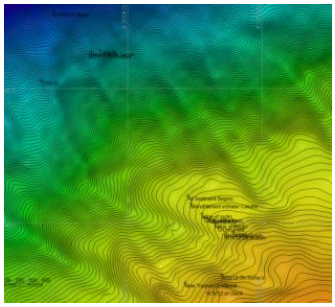
Biology:
Immediately upon D2's arrival on the seafloor (~11:30 UTC, 1275 m depth), many piles of dead scleractinian corals were observed. These dead coral patches were not composed mostly of broken coral rubble, rather they contained fairly large, intact branches. Live scleractinian, colonial corals (just a few branches) were observed twice in this area, at 12:44 UTC (1262 m) and 13:03 UTC (1183 m). Throughout this area of the slope, several dislodged, dead octocorals(?) were also observed. Additionally, many dead octocoral(?) skeletons were observed still attached to hard substrates. (The tentative id on the octocorals is due to the fact the most abundant, live sessile species observed a bit shallower appeared to be branching sponges with large "holdfasts", overgrown by zoanthids). Epifauna, including hydroids and serpulid tubeworms were noted overgrowing several of the dead skeletons. Very few live sponges

colonizing hard substrates were observed in this area, as well as a few live, whip, black corals (?*Stichopathes* sp.).

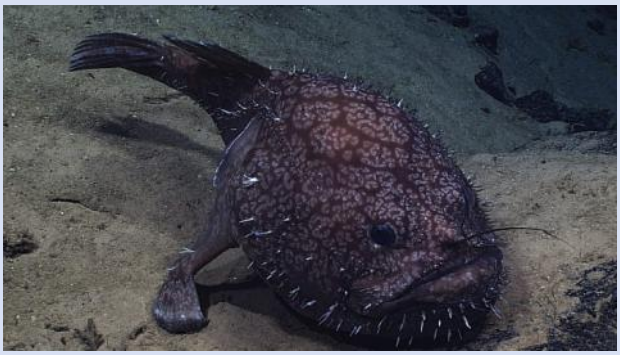
At ~1150 m, the abundance of dead corals seemed to decline. The D2 began observing more, live octocorals and large, branching sponges(?) colonized by zoanthids. Numerous species of corals and sponges (demosponges and hexactinellids), many new for this expedition, were observed throughout this dive. Octocorals observed during this dive included: bamboo corals (?*Eknomisis* sp., ?*Lepidisis* sp., *?Acanella* sp.), *Victorgorgia* sp., white stoloniferous corals, *Chrysogorgia* sp., an unknown purple Plexauridae, and *Paramuricea* sp. As for other scleractinians (observed at depths <1100 m), *Enallopsammia rostrata* colonies (some live and dead) and cup corals (e.g., *?Javania* sp. and ?*Flabellum* sp.) were common. Although not as common, a few black corals were observed (?*Stichopathes* sp, *Bathypathes* sp., three unidentified species) during the dive.

At least 15 fish species were observed during this dive, including *Neoscopelus* sp., tinselfish (Grammicolepidae), a few species of rattails (*Nezumia* sp., *Gadomus* sp.), several cusk eels (*?Benthocometes robustus*, unknown ophidiids), Darwin's Slimehead (*Gephyroberyx darwinii)*, and scyliorhinid catsharks. At least two range extensions are noted, as they were not previously known to occur off Puerto Rico: a Shaefer's anglerfish (*Sladenia shaefersi)* was observed at 14:03 UTC (1099 m) and a jellynose (Ateleopodidae) at 19:07 UTC (545 m). Numerous species of deacapod crustaceans were seen throughout the dive, including galatheiod squat lobsters and "decorator" crabs. Seastars, brisignids, crinoids, and ophiuroid brittle stars were common.

Trash was encountered throughout the dive, and included a likely "target missile" with a parachute attached. Numerous benthic fauna colonized this piece of trash, including a *Gephyroberyx darwinii*, sponges, and anemones. At least two large black coral colonies were observed (at 18:26 UTC, 587 m and 18:48 UTC, 570 m); each hosting several ophiuroid brittle stars and squat lobsters. At the end of the dive, a large (~.5 m wide) purple, plexaurid octocoral was observed with numerous brittle stars (*Asteroschema* sp) and squat lobsters, including what appeared to be the first *Eumunida* sp. of the expedition.

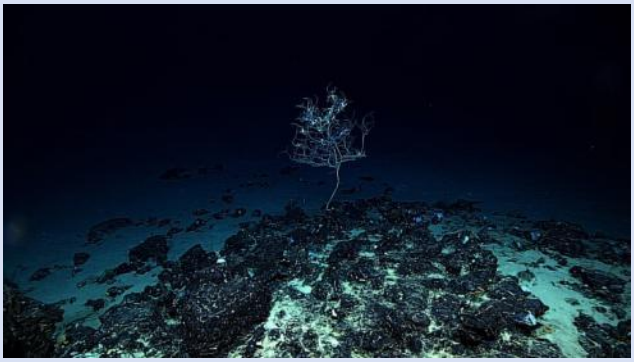
Overall Map of ROV Dive Area	Close-up Map of Main Dive Site
	

Representative Photos of the Dive



A Shaefer's anglerfish (*Sladenia shaefersi)* was observed at 14:03 UTC (1099 m).

At 1123 m, D2 entered a small (20m across) box canyon.



A large colony of black coral with may brittle star associates.

A jellynose (Ateleopodidae) was documented at 19:07 UTC (545 m).

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