



Deepwater Atlantic Habitats II: Continued Atlantic Research and Exploration in Deepwater Ecosystems with Focus on Coral, Canyon, and Seep Communities (Deep-SEARCH)

Publicly referred to as:

Deep-SEARCH (Deep-Sea Exploration to Advance Research on Coral/Canyon/Cold-seep Habitats)

Reporting Timeframe: October 1, 2016 to September 30, 2017

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PROJECT INFORMATION

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Project Website: <https://www.tdi-bi.com/seabed-exploration-surveys/> (Jan2018)



LONG-TERM GOALS

The overarching goal for this project is to augment the ability to predict the location of seafloor communities within the study area that are potentially sensitive to natural and anthropogenic disturbances. This area encompasses a variety of different habitat types, including canyons, hard-bottoms, cold-water coral mounds, methane seeps, and soft sediments.

OBJECTIVES

An improved understanding of the distribution, structure, and function of the communities associated with each habitat type

- 1. Explore and characterize the biological communities of the study area.** This will include community descriptions from microbial to megafaunal scales, and their association with the three different focal habitat types. In addition, soundscapes will be generated for each targeted community to explore the relationship between selected habitat types and acoustic bioindicators. Species identifications will be determined by a combination of molecular and morphological methods in collaboration with our network of taxonomic colleagues. These investigations will complement those of the USGS collaborators to provide a comprehensive picture of community structure, function and habitat association. Ecosystem data will be interpreted in a trans-Atlantic context by integrating the data generated in this study with our existing data, and through our collaborations with ADEON, the NOAA Deep Sea Coral Research and Technology Program and other NOAA projects, the large EU consortia ATLAS and SponGES, and our other Canadian and European colleagues.
- 2. Examine the sensitivity of habitat-structuring fauna and associated communities to natural and anthropogenic disturbance.** We will address this objective using a combination of laboratory and field experiments, information on age structure and population dynamics of key species, the rarity of species and assemblages, and the genetic connectivity of dominant species. The application of acoustic bioindicators and acoustic similarity/dissimilarity indices will provide novel metrics for quantitative comparisons of the impact of different levels of disturbance between locations. All of these will be examined in collaboration with USGS colleagues and interpreted in a trans-Atlantic context with collaborators outside the US.
- 3. Describe the oceanographic, geological, and geochemical conditions associated with each habitat type.** These characterizations will include time-series measurements of water column temperature, salinity, dissolved oxygen, turbidity, and fluorometry, along with sediment biogeochemistry, water-column and pore-fluid methane concentrations (through direct measurements, *in situ* samplers, and bubble-plume data from multibeam surveys), pH and carbonate chemistry, nutrients and organics, physical oceanography (with ADEON and European collaborators), and geomorphology (with USGS). In particular, detailed biogeochemical studies of coral, canyon, and seep habitats in the study area are lacking.
- 4. Model the distribution of habitats and fauna with respect to environmental conditions.** In the synthesis phase, we will interpret the geological (geomorphology and habitat type) and biological data (species and community distributions) in the context of the environmental data described above. This information will be incorporated into a quantitative, ensemble modeling framework at the ecosystem scale, to achieve a robust predictive capacity for the distribution of target communities (coral-sponge, methane seep) within the study area. We will expand this interpretation to an ocean-scale context with the NOAA DSCRTP and our European collaborators.

In order to achieve these objectives, we will test a series of specific hypotheses, which will focus the questions that guide our field operations and laboratory studies. During the later years of the project, the results generated by testing these specific hypotheses will be synthesized to arrive at the ultimate goal: a robust predictive capacity for identifying the distribution of sensitive habitats using remotely sensed data in the study area, and beyond.

APPROACH

Task 1: Selection of a Scientific Review Panel

A Science Review Panel (SRP) of three experts has been selected to provide advice on all aspects of the program.



Task 2: Refinement of Hypotheses, Field Methodologies, and Logistics

2.1. Exploration of Slope-Scale Patterns

The proposed study includes components that are exploratory in nature, in addition to components that directly test specific hypotheses. There is some published information on the canyons, seeps, and corals in the study area, and members of our team are among the key personnel that carried out these investigations and co-authored publications on these habitats.

2.2. Testing Our Current Ability to Predict Habitat Type

Central to this study is the continued development of our ability to predict the distribution of coral and seep communities from remotely collected data sets.

2.3. Understanding Deep Coral and Seep Fauna Distribution Patterns

The general habitat requirements of deep-water corals, including appropriate settlement substrate, habitat geometry, physical and environmental regimes, are moderately well understood. However, even when conditions appear to be appropriate, coral communities are not always present.

2.4. Biogeography, Biodiversity, and Interspecific Interactions

The mid-Atlantic slope between Virginia and Georgia encompasses a variety of habitats that exhibit similarities to canyon, coral, and seep communities in the surrounding area and the broader region including the Atlantic and adjacent marginal seas.

2.5. Connectivity Among Deepwater Atlantic Habitats

The range of habitats within the study area, including coral, canyon, seep, soft sediment and pelagic communities, are distinct in terms of the biological, geological, geochemical, and oceanographic factors that define them, but are also interconnected to form a broad ecosystem.

2.6. Population and Organismal Biology in the Context of Sensitivity to Disturbance

Species vary greatly in their sensitivity to disturbance; populations of fast growing, short-lived species with early onset of maturity can generally recover more quickly from a disturbance event than populations of slow-growing, long-lived species, the latter of which are typical of deep-sea habitats.

2.7 Microbiology and Geochemistry of Deepwater Atlantic Habitats

Continental slope environments support a diverse array of habitats that are dictated by variation in sedimentation patterns, local geology, physical oceanography, and fluid discharge. Different deepwater Atlantic habitats likely have unique biogeochemical capabilities and drivers that contribute to the success and proliferation of biological communities.

Task 3: Integration of USGS Teams

The USGS investigators are fully integrated into this large, collaborative consortium. Cordes and Demopoulos (the USGS lead) will continue to be in frequent contact to plan the field work as well as the joint group meetings as the project unfolds. This will continue through the synthesis and final reporting process.

Task 4: Site Selection

The proposed study region straddles the BOEM South Atlantic and Mid Atlantic Planning Areas (BOEM 2015). The area of interest lies between just north of Norfolk Canyon (~37.5°N) and the Georgia-Florida border (~30°N), from 50 miles offshore to the edge of the US exclusive economic zone (EEZ). The proposed project will target hard-bottom and soft sediment fauna from canyons, deep-sea coral ecosystems and methane seeps in the area of interest, particularly focusing on the areas of 'geological plays,' where energy industry activities are most likely to interact with marine ecosystems. Site selection commenced prior to the first cruise, although due to weather conditions, only a few of these sites could be surveyed during that field season.

Task 5: Field Sampling

5.1 Research Cruises

There are four cruises directly included in this project: A cruise on the NOAA Ship *Pisces* with the AUV *Sentry* took place in September 2017. There will be a mapping and water-column sampling cruise on the NOAA Ship *Nancy Foster* in April 2018, an Atlantis/Alvin cruise in August 2018 (collaborating with the NOAA DSCRTP), and a 24-day ROV cruise (currently planned with the *Jason II* ROV on the NOAA Ship *Ron Brown*) in 2019. The PIs are currently working on a proposal for an externally funded cruise on the *R/V Falkor* in 2020.

5.2 Moorings and Landers

There will be five ADEON moorings in the study area, one just north of Norfolk Canyon, one near Hatteras Canyon, one at the Cape Fear *Lophelia* site, and two at different depths among the Stetson Banks and Savanna Banks coral sites. There are two additional ADEON moorings near the southern border of the study area at 350 m and 1,000 m depth. There will also be two landers available from our collaborators Furu Mienis and Gerard Duineveld, members of the SponGES consortium from the Royal Netherlands Institute for Sea Research (NIOZ). These consist of two different designs and one of each will be available for this project. The landers will first be deployed during one of the cruises in 2018.

5.3 Midwater sampling

The biogeochemistry and carbonate chemistry of the water column will be sampled using a CTD-rosette equipped with 20L Niskin bottles. Pelagic nekton/micronekton will be sampled with a dual-warp Superior midwater trawl. Net fishing depths will be informed by real-time active acoustical detection of deep-scattering layers (DSLs), with trawls targeted within, above, and below DSLs. In addition to physical sampling, midwater transects will be conducted during the up and/or down transits of ROVs during seafloor imaging/mapping.

5.4 AUV Surveys

The **Sentry** AUV was used on the first cruise in September 2017 to conduct surveys of some unexplored sites and to provide higher resolution bathymetry for others. The results of this cruise will be presented in the forthcoming cruise report (currently in internal review at USGS).

5.5 Submersible sampling

Each submersible (**Alvin** or ROV) dive will be planned in accordance with the priorities for the site and the sampling that remains to be completed at each site in consultation with the PIs and the USGS personnel. At each of the key sites, the vehicle will be used to obtain the following sets of data and samples: large-scale transects, local-scale imagery focused on (but not exclusive to) octocoral-associated fauna, targeted collections of fauna, quantitative community collections, push-core samples, and water samples.

Task 6: Sample and Data Analysis

6.1 Oceanographic Measurements

Oceanographic variables will be measured using a combination of single time-point (or very short time series) measurements by the ship, CTD rosette, and CTDs on the submersibles (AUV, ROV, or manned), and continuous measurements by the two landers and the moorings of our ADEON collaborators.

6.2 Midwater Sampling

Midwater trawl samples will be taxonomically processed by the PIs or other experts as needed. Specimens will be measured and weighed for size-frequency analyses and food-web modeling efforts.

6.3 Large-Scale Video Transects

Wide-angle video collected when the submersible is moving along the bottom will be divided into standardized time segments. Fishes and other benthic fauna (in collaboration with USGS) will be enumerated and identified during these segments to enable standardized abundance measures.

6.4 Local-Scale Photographic Data

The high-resolution still images will be georeferenced and mosaicked together to form single composite images. These will be used for quantitative assessments of the spatial extent of chemosynthetic seep fauna and percent cover of coral and sponge communities. These images will also be examined for the presence of other megafauna, and their densities and substrate associations will be quantified (in collaboration with USGS). Close-up stereo imagery (with physical markers) will be used to monitor changes in the health of coral assemblages and growth of individual coral colonies over a range of depths and habitat type.

6.5 Targeted Collections of Benthic Fauna

Protocols for collecting and processing corals, sponges and other selected benthic fauna will follow those in the NOAA Deep-Sea Corals Collection Protocols (Etnoyer et al 2006). On the ship, all samples will be put in labeled containers with chilled sea water and stored in a cold room until processing. Each colony or individual will be photographed and then subsampled, with tissue being removed for genetic, stable isotope, microbiological (USGS), and reproductive analyses as appropriate for the species.

6.6 Quantitative Community Collections

On board the ship, the community collections will be thoroughly processed to maximize the potential yield of information and minimize the need for further collections.

6.7 Push Core Sampling

On board the ship, ROV-collected push cores (~25 cm) will be extruded and sliced into 3 to 5 cm intervals (8 samples per core, depending on core depth and including a sample of the overlying water) and samples from each depth will be used for geochemical, microbiological, and microbial activity measurements

6.8 Laboratory experiments

Coral colonies and mussels collected during the cruises will be maintained in cold-water recirculating aquaria at FSUCML until needed for experiments.

Task 7: Data Interpretation, Synthesis, and Reporting

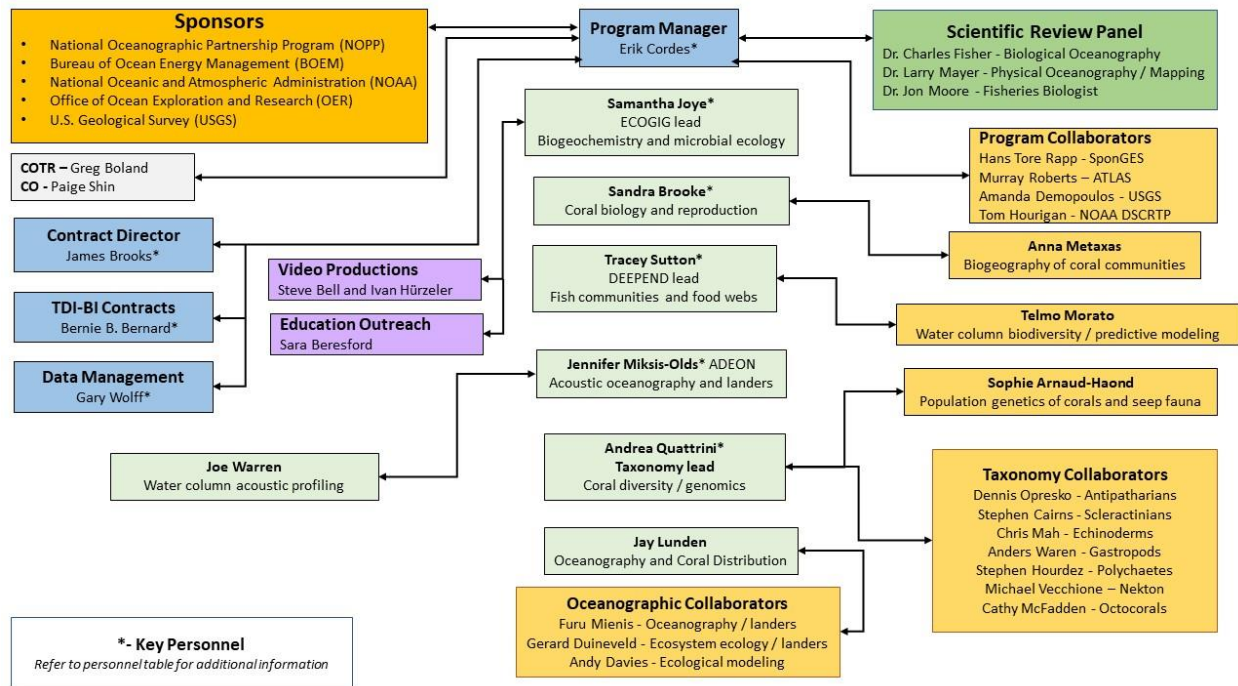
Task 8: Development of Educational Outreach Materials

Through this program, we will advance the goal of creating a public that is knowledgeable of general biological and ecological processes in the deep sea and supportive of stewardship activities that promote healthy ecosystems, responsible use of ocean resources, and increased environmental literacy.

Task 9: Submission of Project Data for Long-Term Preservation and Access

Submission of Project Data will be completed with the minimum time delay, within a maximum of 1 year after capture, and will be coordinated with the BOEM COR and NOAA data manager.

Key individuals participating in this project and their roles:



WORK COMPLETED

Cruise 1 (PC1705)

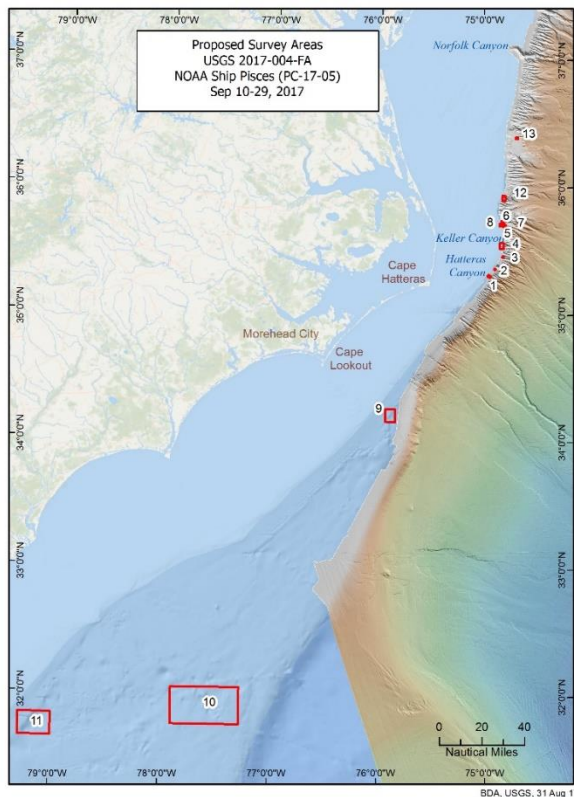
Between 12 and 26 September 2017, the NOAA Ship **Pisces** conducted a research expedition (PC1705) in the mid- and south Atlantic Ocean, focused on exploring the seafloor for seeps, corals, and canyons. During this expedition, the Pisces mapped 44.7km of seafloor. Using the AUV **Sentry**, an additional 145 km of seafloor was mapped. These efforts helped to fill in the gaps in available mapping information, some of which dates back to the 1800s.

During the PC1705 expedition, despite three hurricanes, we were able to complete 3 Sentry dives; two surveyed unverified seeps located offshore of North Carolina, and one dive at a potential coral habitat located off South Carolina. PC-17-05 (OMAO), 2017-004-FA (USGS)

This expedition is the first of four cruises for the Deep SEARCH project focused on exploring and characterizing seeps, corals, and canyon environments along the Atlantic margin. This project is a collaboration among three federal agencies: Bureau of Ocean Energy Management (BOEM), NOAA Office of Ocean Exploration and Research (OER), and the U.S. Geological Survey (USGS). TDI Brooks with academic partners has been selected to serve as BOEM contractor for this study. Data gathered during this mission and future cruises for this project will help inform multiple management issues concerning this region. The cruise focused on several putative seep sites, canyons, and hard bottom

features located <100 nm offshore, 36.8455°N, -74.5844°W to 31.7421°N, -79.0941°W.

The goal of this expedition was to validate several seep targets (**Figure 1**), image and map seeps, canyons (e.g., Keller, Pamlico, Hatteras, and unnamed canyons), and hard bottom features located between Virginia and Georgia. Specific objectives included:



1. Survey canyon, seep, and hard bottom features using AUV **Sentry** multibeam, subbottom profiling, digital still camera, and other sensors to characterize the seafloor in and around these benthic habitats.
2. Conduct CTD casts to collect sediment and water samples to 2,000 m.
3. Collect multibeam bathymetry with the ship's Simrad ME70 in areas lacking high resolution bathymetric data.
4. Conduct trawling operations using a mid-water tucker trawl net.
5. Create a georeferenced database that incorporates MB bathymetry, the seafloor imagery, CTD data, and other environmental sensor data from **Sentry** with locations of benthic communities, including seep organisms and deep-sea corals and sponges.

Figure 1. Study area for Cruise PC1705

Data Agreement

The submission format and content with NOAA (Megan Cromwell and Susan Gottfried) is being finalized.

RESULTS

1. Bathymetric Mapping - Multibeam (ME-70): 44.7 km of survey lines collected during transits to Sentry dive locations; Sentry (Reson 7125) 145 km (depth, backscatter)
2. Analysis of imagery and sediment collections are underway.
3. AUV:Sentry - 3 Dives: 454-"Kitty Hawk-Alternate-1", 455-"Pea Island B", 456-33 kms north of "Stetson Bank".
4. Water chemistry and CTD analyses are pending
5. Bathymetry, sidescan and sub-bottom data collected by Sentry during Dives 454 and 455 show seafloor characterized by hemipelagic sedimentation and numerous instances of sub-surface gas accumulation and seafloor gas release. The mapping and geophysical imaging captured parts of canyon head morphologies. Monocores from Kitty Hawk and Pea Island areas confirm hemipelagic



and somewhat higher energy processes at depth. Sentry dive 456 captured mapping and sidescan imagery of hard bottom (carbonate?) and adjacent areas of sediment accumulation (some showing mega-ripples perhaps reflective of strong bottom currents).

DELIVERABLES/DATA TRANSMISSIONS

No data submitted

1. **National Security – na**
2. **Economic Development (e.g., new product lines, businesses, practices, increased efficiency, new manufacturing techniques) na**
3. **Quality of Life (e.g., public health, ecosystem health, coastal resource management) na**
4. **Science Education and Communication**

NOAA-OER normally maintains an expedition website for the duration of the expeditions. e.g. cruise PC1705(<http://oceanexplorer.noaa.gov/explorations/17deepsearch/welcome.html>)

IMPACTS AND APPLICATIONS

1. National Security

This program will provide critical information on the exploration, characterization and function of hardground communities to BOEM. As manager of the nation's seafloor mineral resources, BOEM will use this information to aid in the development of critical energy resources, which may affect domestic energy production.

2. Economic Development (e.g., new product lines, businesses, practices, increased efficiency, new manufacturing techniques)

Increased energy and mineral production will have a positive economic impact at numerous levels in industry.

3. Quality of Life (e.g., public health, ecosystem health, coastal resource management)

Information on the location and functioning of hardground communities gathered by this program will have a positive impact on other ocean users, the natural environment, and the human environment. It will aid in minimizing the environmental impact on sensitive habitat and mitigate any potential damage to these communities.

4. Science Education and Communication

Education outreach efforts outside of the cruise website build on and leverage from the success of the NOAA OE educational materials. Our objective is to develop a full instructional unit on the products of this program integrated with the NOAA/OE lessons, multimedia modules and OceanExplorer website.

RELATED PROJECTS

Atlantic Seafloor Partnership for Integrated Research and Exploration (ASPIRE): ASPIRE is a multi-year, multi-national ocean exploration campaign organized through NOAA's Office of Ocean Exploration and Research. ASPIRE is bringing together scientists and managers from both sides of the Atlantic (European Union, Canada, and U.S.) to identify linkages between existing projects and collaboratively plan future initiatives when possible. The ASPIRE campaign, while still in the nascent planning stage, is envisioned to be a major contribution to the 2013 Galway Statement on Atlantic Ocean Cooperation.

Southeast Deep Coral Initiative (SEDCI) - SEDCI conducts multiple research expeditions each year, which survey deep-sea coral ecosystems using ships, deep-sea submersibles and other equipment. Additionally, SEDCI conducts complementary research projects focused on seafloor mapping, species identification, habitat suitability monitoring, environmental monitoring and data mining. These efforts will provide important baseline information that is needed to support management efforts of deep-sea coral ecosystems.: <https://coastalscience.noaa.gov/project/southeast-deep-coral-initiative/>



PUBLICATIONS

Cordes, EE, Demopoulos, AWJ, Boland, G, Adams, C., 2017. Deep SEARCH: Deep Sea Exploration to Advance Research on Coral/Canyon/Cold seep Habitats. *Oceanography*. Submitted for publication

PATENTS – none

WORK PLAN

Project schedule for 2018 - A project meeting will be held sometime early in the year, either at Ocean Sciences in Portland OR from Feb 11-17, 2018 or in Philadelphia at Temple University. The details of where and the itinerary are still under discussion among the PIs.

Originally, there was one cruise scheduled for 2018, but it has become two. The **Nancy Foster** in April will be a mapping cruise, primarily, to fill in some of the gaps left by the shortened **Pisces** cruise this past Fall due to three different hurricanes.

The second cruise of 2018 will be on the **Atlantis** with **Alvin**. This is currently scheduled for Aug 19 to Sept 3, 2018.

OUTREACH MATERIALS

NOAA-OER maintained an expedition website for the duration of the expedition.
(<http://oceanexplorer.noaa.gov/explorations/17deepsearch/welcome.html>)

