Deepwater Program: Exploration and Research of Northern Gulf of Mexico
Deepwater Natural and Artificial Hard Bottom Habitats with Emphasis on Coral
Communities: Reefs, Rigs and Wrecks

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LONG-TERM GOALS

A primary goal of this study is to obtain a robust predictive capability for the occurrence of rich cnidarian (primarily scleractinian coral) hard ground communities in the deep Gulf of Mexico. To achieve this long-term goal, this study will accomplish three interrelated and interdependent objectives.

OBJECTIVES

The objectives of this study are:

1) Discover and describe new locations at greater than 300m depth in the GoM with extensive coral community development, particularly including *Lophelia pertusa*.

2) Gain a more comprehensive understanding of the fundamental processes that control the occurrence and distribution of *Lophelia* and other extensive coral communities at depths greater than 300 m in the GoM through both laboratory experiments and field data collection.

3) Document and understand the relations between coral communities on artificial and natural substrates with respect to community composition and function, phylogeographic and population genetics, and growth rates of the key cnidarian foundation fauna.

*Our specific biological objectives:*

1) To discover and characterize new sites:
   a. Characterize key sites at the largest scale with high resolution bathymetry, side scan sonar imaging, 3D seismic data, and current models
   b. Characterize the coral density at all study sites at the 10 to 100 m scale with randomized photo transects and general site descriptions.
   c. Characterize the community composition at the 1 to 10 m scale at significant coral sites (man-made and natural) with analysis of close up imagery, replicate 5x5m photomosaics, and quantitative community collections.

2) Analyze connectivity among all sites in the GoM (man-made and natural), and to other sampled populations, with comparative community, phylogeographic and population genetic analyses.

3) Compare the structure, species richness and diversity of communities tightly associated with Lophelia on man-made structures and from natural sites in the GoM

4) Experimentally determine the tolerance and growth response of Lophelia to temperature, pH/alkalinity, dissolved oxygen and electrical current.

5) Characterize and constrain growth rates of key species of colonial cnidarians (pioneer colonies) using analyses of images of the largest colonies on man-made structures of known age.

6) Characterize key variables at sites with the most significant communities of coral colony development over one year by monitoring temperature, currents, larval seasonal distribution and sediment quality and quantity at 2-4 sites between 2009 and 2010.

By integrating this information, we will develop a predictive model to examine the potential occurrence of significant assemblages of *L. pertusa* or other cnidarians at unexplored sites and artificial reefs in the deep GoM.

Historic Shipwreck Component

The proposed study will be multidisciplinary in scope. It will focus on the archaeological and biological aspects of up to six shipwrecks in the north-central portion of the GoM. Water depths at the designated investigation sites range from 554m to 2,286m. Each shipwreck will be investigated to determine identity, site boundaries, National Register eligibility, preservation state and stability,
associated biological communities, and an artificial reef effect on meiofauna and/or mobile fish communities.

Our specific archaeological objectives:

1) To record each vessel through detailed imagery to establish its type, date of construction, and positive identification if possible.

2) To establish nationality, ownership (past and present), use history, cause of loss, mission and cargo at time of loss through fieldwork and historical research.

3) To determine the extent and condition of the artifact assemblage on each vessel and the presence of diagnostic artifacts.

4) To determine potential eligibility to the National Register of Historic Places through archival research and the analysis of imagery and to prepare a National Register nomination form for potentially eligible vessels.

5) To assess impacts of biofouling communities to these shipwrecks to determine the stability of these sites and rate of deterioration.

Our specific bacteriological objectives:

1) Determine the rates of deterioration of test coupons placed on platforms and sited on specific shipwrecks that have already been visited and were installed on previous expeditions to those sites of interest. Determination may take the form of passive observations of the coupon condition within the platform of interest. If significant deterioration rates have already occurred then the platform may be recovered for on-ship and in-laboratory investigations.

2) Fresh test platforms may be deployed to either replace recovered platforms or to determination the deterioration rate at a fresh site of archeological significance.

3) Examine recovered natural samples from deteriorating sites and localized waters that may contain active bacterial communities traditionally associated with corrosive or bio-concretious growths.

4) On selected recovered test coupons conduct such experiments as would allow a more precise projection of the rates of deterioration of test material through the rates of pitting (in the event of mild steel) to losses in physical composition (in the event of cloths and wood.

5) Recovered bacteriological communities from the sites of interest will be subjected to laboratory analysis to determine major bacterial communities, degrees of activity (using the ATP methodology), and identification of community structures by fatty acid methyl ester analysis (MIDI/BART technologies).

**APPROACH AND WORK PLAN**

In order to meet the objectives outlined above, the following scientific and technical plan is being implemented.

Key individuals participating in this work and their roles are: Dr. James Brooks will be the Project Manager and will take the lead in administration of this project. Dr. Charles Fisher (Pennsylvania
State University) will coordinate the biological studies, Dr. Harry Roberts (Louisiana State University) will coordinate the geological/geophysical and oceanographic studies, Mr. Dan Warren and Mr. Rob Church from C&C Technology will coordinate the wrecks studies along with, Dr. Chris German (WHOI) will coordinate the time series sediment trap studies, and Ms. Liz Goehring (Penn State and NSF Ridge 2000 office) will coordinate the education and outreach activities.

Dr. Charles Fisher will oversee the biological aspects of the study and the interface with the USGS teams and the geological and oceanographic measurements and studies. He will work closely with Dr. Roberts, Dr. Cordes, Dr. German, and other PIs to plan and conduct the submersible/ROV portions of the field work. His research group will take responsibility for quantitative physical and photographic collections, community composition and structure analyses, and trophic studies of the endemic and other closely associated seep and coral fauna. Dr. Harry Roberts, will take the lead in site selection for exploration of potential new natural deep coral communities and also coordinate the geological and oceanographic deployments and studies. His colleague, Dr. Susan Welsh will develop and run a very high resolution numerical circulation model of the Gulf of Mexico that will be used to help identify the likely geographic areas and depth ranges for recruitment of *L. pertusa* larvae on the northern slope and compute dispersal kernal trajectories and dispersion of coral larvae by oceanographic current. Dr. Erik Cordes will take responsibility for the live *Lophelia pertusa* experiments, gorgonian genetics, and coordinate the phylogeography and taxonomy team. He will also work with Fisher’s team on studies of coral communities and be responsible for coordination with other outside taxonomic experts. Dr. Ian MacDonald will direct the use of digital imagery in the initial site survey and recon cruise, contribute to the site selection process, oversee the use of transect imagery for site descriptions and contributions to faunal inventory, and oversee deployment and analyses of the time lapse cameras and imagery. Dr. MacDonald will also oversee the Fisheries review in Year 1 of the project. Dr. Chris German will take the lead on deployments of the time series sediment traps and oversee the integrated analyses of the samples. Dr. William Schroeder will also assist in the analysis of coral communities on rigs and wrecks and also participate in the over-all study synthesis phase. Dr. Tim Shank will conduct studies on the population genetics of several coral associated taxa. Dr. Iliana Baums will oversee development of molecular markers for studies of population connectivity in antipatharians and also serve as consultant for the construction of live *Lophelia* maintenance aquaria. Dr. Stephen Cairns will be responsible for the identification of the hard coral samples collected. He is the generally acknowledged world’s expert on scleractinian corals and deep-water corals in general and has extensive experience and a long publication record with the corals of the Gulf of Mexico. Peter Etnoyer will oversee the classical taxonomy of octocorals and Dr. Dennis Opresko the classical taxonomy and phylogeography of antipatharians.

In addition to this core team we have assembled an international team of collaborators that significantly expands our taxonomic expertise. Limpets and snails will be sent to Anders Waren (Swedish Museum of Natural History) for morphological characterization. Dr. Stéphane Hourdez (Station Biologique de Roscoff, France) will take the lead on polychaete phylogenetic characterizations and descriptions of new species (using both molecular and classical approaches). Dr. Daphne Fautin (University of Kansas) has agreed to assist in the taxonomic identification of sea anemones Dr. Sabine Stohr (Swedish Museum of Natural History) has agreed to examine all new ophiuroids collected. Maria Pia Miglietta (Penn State University) will lead the morphological and genetic identification of the hydroids. Other faunal groups will be sent to appropriate experts as needed.
C & C Technologies, Inc. (C & C) of Lafayette, LA has partnered with Droycon Bioconcepts Inc. (DBI) of Regina Canada to fulfill the archaeological component of the study. Marine archaeologist Daniel Warren (C & C) will be the principle investigator and Robert Church will be the C & C project manager and co-principle investigator. Dr. Sheli Smith is the director of operations for the PAST Foundation, a subcontractor to C & C. She has substantial knowledge in eighteenth and nineteenth century marine architecture. Her expertise in these areas will be key to assessing three to four of the wreck sites in this study thought to date from those periods.

Dr. Roy Cullimore, the CEO of DBI, and Lori Johnston primary role on this project will be to evaluate the deterioration rate, preservation, and stability of the wreck sites. Re-examining test platforms placed during the earlier studies will be instrumental to this analysis. They will also coordinate with Dr. Christina A. Kellogg with USGS for other microbiology aspects during the project.

Dr. Bernie Bernard, TDI-Brooks Director and Chief Technology Officer, will coordinate the navigation and logistics portion of the project. Dr. Gary Wolff will act as the projects Data Manager as he has for other MMS projects including Chemo-III. Ms. Suzanne Cardwell will provide financial and project administrative support.

WORK COMPLETED

The Lophelia II Cruise was conducted on the NOAA Ship research vessel Nancy Foster from September 2, 2008 to October 2, 2008, and was the first cruise conducted for this contract. The cruise mobilized and embarked from Galveston, Texas and returned to Gulfport, Mississippi for the second leg. The second leg concluded on 2 October 2008 and demobilized in Pascagoula, Mississippi.

RESULTS

Cruise1 Leg1 - The Ewing Banks Wreck site was confirmed to be a historic shipwreck site, which likely dates to the nineteenth century. More Lophelia was discovered growing on that site than any other nineteenth century wooden wreck known in the Gulf of Mexico. Many of the wreck’s attributes, such as the lack of cargo, rigging, or machinery, make it an intriguing mystery. The identity of Gulfoil was confirmed on a brief dive at the site and substantial coral colonies were documented. The preliminary examination suggests the Lophelia coverage at Gulfoil may be more substantial than that documented at Gulfpenn in 2004. The dive on Gulfpenn allowed the identification of the stern section of the tanker, the microbial experiment placed on the site in 2004 was reexamined, and a temperature logger was placed on Gulfpenn’s bow.

Cruise1 Leg2 - During the 12 working days at sea, multibeam data was collected at 13 sites and 10 lowerings of the ROV were completed over 8 different sites. There were two ROV operations days lost to weather conditions, one dive never reached the bottom, and three other dives were ended with under two hours of bottom time due to technical problems with the ROV. During almost every dive the manipulator failed, and this severely limited the capacity to collect physical samples for future genetics work. On most of the latter dives, only one attempt was made to collect samples in areas of high coral diversity and density due to the anticipation of manipulator failure and the extremely long amount of time required to sample (1-5 samples obtained in 1-3 hours).
IMPACT AND APPLICATIONS

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

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

Quality of Life
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.

Science Education and Communication
Education outreach efforts outside of the cruise website build on and leverage from the success of both the NOAA OE educational materials and the existing FLEXE (From Local to Extreme Environments) educational project. Our objective is to develop a full instructional unit on deep-sea coral ecology integrated with the NOAA/OE lessons, multimedia modules and OceanExplorer website to be featured as the GLOBE FLEXE campaign for the 2010-2011 academic year.

TRANSITIONS
Data is provided to the ChEss database, which is a component of the Census of Marine Life (CoML) Ocean Biogeographic Information System (OBIS) data base. This work will contribute significantly to the goals of the Atlantic Equatorial Belt studies of the ChEss program, particularly the components that will allow interpretation of our findings in the context of hardground habitats around the world.

RELATED PROJECTS

- The Deepwater Program: Northern Gulf of Mexico Continental Slope Habitat and Benthic Ecology (MMS contract 1435-01-99-CT-30991).
Figure 1. The northern Gulf of Mexico sites and study area
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