Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico

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LONG-TERM GOALS

The long-term goals of this study are to add to the understanding of the oceanography and ecology of the deep-sea with emphasis on cold seep communities and hard bottom communities on the Gulf of Mexico (GoM) continental slope. Preliminary studies have shown that seep communities at the slope base are different from those on the upper slope, in much the same way that the normal background fauna differ. Compared to the upper-slope, there is limited understanding of seep and other hard bottom communities below 1,000 meters in the Gulf of Mexico. TDI-Brooks' project team will meet MMS' information needs concerning the location and functioning of seep communities deeper than 1,000 meters.

OBJECTIVES

The objectives of this study are:

A. To characterize known, or newly discovered chemosynthetic communities at depths below 1,000 meters in the central and western Gulf of Mexico.
B. To characterize all other hard bottom biological communities encountered regardless of association with active hydrocarbon seep activity or living chemosynthetic community species in the central and western Gulf of Mexico.
C. To determine the comparative degree of sensitivity of anthropogenic impacts for both A and B above through a variety of approaches such as rarity, unique taxonomy/biodiversity, or other environmental risk assessment methodologies. This objective includes understanding how these deep communities are similar or different from their shallower water counterparts.
D. To further develop successful assessment methodologies for correlation of remote sensing information such as bathymetry, seabed acoustic reflectivity, subbottom structure, and other geophysical signatures obtained by non-visual techniques with the "potential" presence of non-soft bottom biological communities at depths below 1,000 meters. The objective is specifically targeted to result in some level of predictive capability that can be used by MMS to avoid impacts to lower slope sensitive biological communities such as presented by Roberts (2002) for upper slope communities.
E. To contribute to assessing and explaining diversity distribution and abundance of marine species at depths below 1,000 m in the central and western Gulf, as well as improving the understanding of the functional role of marine species in areas of active hydrocarbon seep activity or living chemosynthetic communities.

These objectives will be accomplished through a combination of both exploratory work and more focused studies including process-based work on known communities.

APPROACH AND WORK PLAN

In order to meet the objectives outlined above, the following work plan will be implemented.

- Compile and analyze all of the appropriate available data to predict the location of significant chemoautotrophic or other hard-bottom communities at depths >1,000 m in the GoM. This effort will result in selection of 10 – 20 sites for visitation during the Site Confirmation Cruise. In addition to providing specific locations for most of the dives for the first submersible cruise, ground-truth data collected during the site confirmation cruise will allow evaluation of the predictive value of the various criteria used for site selection, and will also provide data on the types of communities present at the sites. Multivariate analysis of this data (geophysical and

geochemical predictors, and presence/absence of various community types) will allow initial testing and refinement of the hypotheses relating to community occurrence, which can be further tested on the subsequent submersible/ROV cruises. These analyses will be further enriched when selected sites are more intensively imaged and sampled for macro and microbiology and chemistry. A third level of information will come from mapping community occurrence type and density onto the high resolution maps of surficial geology and seafloor topography that will be made at of each of our three to four primary study sites. Our "sub-goal" here will be to enrich the predictive value of these high-resolution data sets to include the occurrence of different types of communities/ habitats on a spatial scale of meters.

- Characterize types of significant hard bottom communities we encounter. First order community characterization will be identification of component taxa and descriptions of communities present at different sites. Second order characterizations will include distributions and abundances of taxa with respect to chemistry and surficial geology, and measures of community structure and function. Third order characterizations/analyses will include interactions with background fauna, taxonomic relations of species from key taxa to related species at other depths and in other areas, and community-level comparisons between sites and between related communities at other depths and in other areas. We will choose a variety of representative community types discovered during the site confirmation cruise (or already known communities) to characterize during the submersible and ROV cruises. All sites visited by submersible or ROV (including 6-7 in the first year) will be at least preliminarily characterized with respect to surficial geology, geochemistry of sediments and epibenthic bottom water, types of communities present, microbial activities, and mega- and macrofaunal species present. At four sites we will conduct more extensive survey and experimentation to better characterize and understand the communities, and test hypotheses relating to community composition, tubeworms, trophic interactions, and microbiology. During the submersible and ROV cruises we will collect imagery that will provide data on endemic species occurrence, distribution and densities, and visitation by vagrant mobile megafauna. We will make quantitative collections of communities that will provide the material needed for taxonomic, biogeographic, and trophic studies, and analyze the collections in ways that provide a variety of data on community structure and function as well as composition. We will make in situ chemical measurements to describe the microhabitat chemistry of the major community types. We will map the faunal distributions with respect to surficial geology and chemistry. We will characterize the microbial communities in the sediments, and initiate temporal studies of the communities (with time lapse camera, base line imaging, and growth).
- Our descriptions of the communities encountered and from analyses of background fauna trapped, trawled and imaged over the course of the study will contribute to the assessment of diversity, distributions, and abundance of marine species below 1,000 m in the GoM. Correlation analyses of faunal occurrence with geologic features and seep chemistry will further contribute to the explanation of these patterns. Our trophic analyses, time-lapse camera data, community analyses, and growth studies will greatly improve our understanding of the functional role of many of the marine species we encounter. By working under the auspices of the Census of Marine Life ChEss program and providing all data collected for their database we will assure widespread international access to all biodiversity and biogeography data collected.
- Direct determination of sensitivity of individual species to particular potential anthropogenic impacts will be addressed through assessment of rarity and unique taxonomy/biogeography of key species and communities, biodiversity of communities, and by interpretation made in the context of the degree of similarity to related communities on the upper Louisiana slope and what is known about those communities. The comparisons of community-level associations to similar communities elsewhere, and the proposed vestimentiferan growth studies will strengthen the power

of these analyses. Our team's collective familiarity with both GoM and other chemosynthetic and coral communities, including the associated fauna, will allow us to quickly recognize sites of rare or unique community composition. The Fisher lab at PSU maintains a voucher collection of 46 species collected with mussel beds or tubeworm aggregations at water depths of over 1,000 m in the Gulf of Mexico, and 111 species collected with tubeworm aggregations and 40 species collected with *Lophelia pertusa* thickets on the upper slope. These collections will allow us to identify species with distributions extending to the upper slope, as well as previously unknown species. Existing collaborations with molecular and classical taxonomic experts familiar with the Gulf of Mexico seep and coral associated fauna, as well as other seep fauna world wide, will facilitate the identification of unknown species. Although we are not proposing a population genetic component *per se*, the proposed molecular analyses of foundation and other key species will provide information necessary to detect significant levels of genetic isolation at any site, analyze relations to taxa at other sites, and determine bathymetric ranges of the metapopulations.

The following is a description of key individuals participating in this work and their roles. Dr. James Brooks will be the Project Manager and will take the lead in administration of this project and assist in the geochemical studies. Dr. Charles Fisher will coordinate the biological studies, Dr. Harry Roberts will coordinate the geological/geophysical studies, and Ms. Liz Goehring will coordinate the education and outreach activities. Dr. Erik Cordes will work with Fisher's team on studies of seep communities and take a leadership role on synthesis and publication of results for other hard bottom communities discovered. Dr. Stephane Schaeffer will oversee work in his laboratory, including molecular phylogenetic screening of foundation species and their symbionts (tubeworms, mussels and clams) and other potential new species (and symbioses), as needed. Dr. Robert Carney will lead the studies of interactions with background fauna and trophic exchange between seep/hard bottom communities and larger mobile fauna. Drs. Fisher, Carney, and Cordes will share responsibility for coordination with taxonomists and molecular phylogenists and proper curation of samples. Dr. Ian MacDonald will direct the use of digital imagery in all phases of the study, from the initial site survey and selection process to site descriptions and contributions to faunal inventory. Dr. Samantha Joye will be responsible for the microbial ecology and sulfide geochemistry studies. Dr. Tim Shank (WHOI) has indicated his willingness to phylogentically characterize any potential new species of megafaunal crustaceans and to include at least the shrimp in his ongoing biogeographic analyses. Dr. Bob Vreijenhoek (MBARI) will do the same with clams and their symbionts and other gastropods as needed. Limpets and snails will also be sent to Anders Waren (Swedish Museum of Natural History) and chitons to Julia Sigwart (University College Dublin) for morphological characterization. Dr. Stéphane Hourdez (Stacione Biologique de Roscoff, France) will take the lead on polychaete phylogenetic characterizations and descriptions of new species of polynoids and siboglinids (using both molecular and classical approaches). He will also assist with molecular characterization of foundation species. Dr. Stephane Cairns (Smithsonian) will oversee curation and identification of cnidarians, with assistance of Daphne Fautine (University of Kansas) and Dennis Opreska (Oak Ridge). Dr. Cheryl Morrison (USGS Leetown Science Center) will include any samples of *Lophelia pertusa* collected in her ongoing studies of the phylogeography and population genetics of this foundation coral species, and also to collaborate with Dr. Cairns by contributing to the molecular systematics of other hard corals, as needed. Dr. Sabine Stohr (Swedish Museum of Natural History) has agreed to examine all ophuiroids collected. Dr. Monika Bright and her research team (Univ. Vienna) will sort and identify meiofauna collected with mussel and tubeworm communities and in sediment cores. Other faunal groups will be sent to appropriate experts as needed. Additionally, two internationally recognized research groups from the Max Planck Institute of Marine Microbiology in Bremen will bring unique expertise and equipment to bear on the study. Nicole Dublier's group will

use quantitative mRNA analyses to determine the relative activities of chemoautotrophic and methanotrophic symbiont populations in the dual symbiont-containing mussels. Antje Botieus' group will bring their in-situ seep-chemistry analysis system and expertise on the ALVIN and ROV cruises. Dr. Bernie Bernard will coordinate the isotope, hydrocarbon and ancillary measurements. Dr. Thomas McDonald will be the principle hydrocarbon chemist for the project. Dr. Gary Wolff will act as the projects Data Manager, as he has for numerous previous large multi-disciplinary MMS projects. Ms. Kathy Allan will be the projects technical editor. She along with Ms. Suzanne Cardwell will provide financial and project administrative support.

The work plan for the upcoming year includes a historical data review and two cruises. The site confirmation cruise, scheduled 11-25 March 2006 aboard the R/V PELICAN, will use a variety of cost-effective methods to conduct a preliminary survey of ten (10) to twenty (20) sites from a surface ship, using over-the-side imaging equipment and shipboard acoustic methods. Survey sites will be selected from the 20 to 40 high probability sites based on MMS priorities, depth distribution, and transit time logistics. The primary purpose of this field effort will be to make a final determination about which sites to study using NOAA/MMS provided submersible assets in FY-2006 and 2007. An ancillary purpose of this cruise will be to conduct trawling and box coring off and near sites for isotopic characterization of the seep-background interactions in the vicinity of seep sites in the deep GoM. The first submersible cruise is scheduled to begin on 9 May 2006 aboard the R/V ATLANTIS using the submersible ALVIN. In 2006, we anticipate having between 15 and 20 dive days available for this project. Site selection and cruise planning will be designed to avoid any loss of dives due to transit between sites. During 2006 we will plan on visiting a total of six to seven sites. We will conduct a preliminary site and community characterization and sampling program at every site visited. At three of the sites we will make more extensive collections and initiate some temporal, process-oriented studies. To accomplish this we plan on spending between three and four days at each of the three sites for intensive study, and one or two days at each of three to four additional sites for preliminary site and animal community characterizations and collections.

WORK COMPLETED

The Data agreement with NODC and Post Award meeting was held November 3, 2005 at the MMS office in Houston, Texas.

RESULTS

Because this is a new project, no results are available at this time.

IMPACT AND APPLICATIONS

National Security

This program will provide critical information on the location and functioning of seep 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 seep 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

The development of educational outreach material for this program will have two phases. Phase I will involve developing new "Classroom to Sea" Gulf of Mexico labs to help students understand the remote environment of the deep sea by making direct comparisons with their own environment. Phase II will involve disseminating the labs with teacher training workshops. The 3-day teacher course will provide teachers with information about cutting-edge research, relevant OE lessons, inquiry skills related to the specific labs and the data analysis required. The short course will be offered to coincide with the 2007 cruise so that teachers can access the cruise website, observe the at-sea lab, and download the data.

TRANSITIONS

Because this is a new award, there are no products available for use in other programs. However, data collected during this study will be provided to the ChEss database (which is a component of the CoML OBIS data base) all gene sequences will be submitted to the international genetic data base, GenBank. The work proposed here 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 seeps around the world. The second component of the CoML program relevant to this project is the CoMargE component. Dr. Carney is the co-director of CoMargE and is supported by the MMS Coastal Marine Program to transfer past MMS survey data into the CoML OBIS database system. Therefore, procedures and software are already in place to carry out data transfer to this International Marine Life database.

RELATED PROJECTS

Studies closely related to this effort include other chemosynthetic and deep water ecosystem studies funded by MMS.

1) Chemosynthetic Ecosystems Study (MMS Report 95-0021). http://www.gomr.mms.gov/homepg/regulate/environ/studies/1995/95-0021%20Vol%20I.pdf.
2) Stability and Change in Gulf of Mexico Chemosynthetic Communities (MMS Report 2002-036). http://www.gomr.mms.gov/homepg/regulate/environ/studies/2002-036.pdf.
3) The Deepwater Program: Northern Gulf of Mexico Continental Slope Habitat and Benthic Ecology (MMS contract 1435-01-99-CT-30991).

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