OCS Study
MMS 2009-051

# Proceedings: Twenty-Fifth Gulf of Mexico Information Transfer Meeting

January 2009

MMS U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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MMS 2009-051

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# INTRODUCTION

In meeting its mission to manage energy and minerals resources on the Outer Continental Shelf (OCS), the Minerals Management Service (MMS) administers an Environmental Studies Program (ESP) to gather and synthesize environmental and social and economic science information to support decision-making concerning the offshore energy program. The Outer Continental Shelf Lands Act established policy for the management of the OCS natural gas and oil leasing program and for the protection of marine and coastal environments. Section 20 of the Act authorizes the ESP and establishes three general goals for the program:

- to establish the information needed for assessment and management of environmental impacts on the human, marine, and coastal environments of the OCS and the potentially affected coastal areas;

- to predict marine biota impacts that may result from chronic, low-level pollution or large spills associated with OCS production, from drilling fluids and cuttings discharges, pipeline emplacement, or onshore facilities; and

- to monitor human, marine, and coastal environments to provide time series and data trend information for the identification of significant changes in the quality and productivity of these environments, and to identify the causes of these changes.

Toward this effort, MMS sponsors the biannual Information Transfer Meeting (ITM), bringing together researchers from throughout the United States and internationally to discuss research topics funded by the ESP and related areas of interest to MMS. The ITM provides a forum for research and information exchange relative to the offshore energy industry.

The accomplishments of the ESP for the Gulf of Mexico and of other research programs or study projects were presented. The ITM is a place to foster an exchange of information of regional interest among scientists, staff members, and decision-makers from MMS, other federal or state governmental agencies, regional industries, and academia.

Sessions for the 25th ITM included Sand and Gravel, Deepwater Benthic Habitats, Hurricanes, Seafloor Disturbance, Climate Change, Air Quality States Issues, Socioeconomics, Hydrates, Coastal Impact Assistance Program, Air Quality, Platform and Hardbottom Ecology, Alternative Energy, and Marine Archeology.

Abstracts and PowerPoint presentations follow.

# SESSION 1A

# SAND AND GRAVEL

**Chair:** **Colleen Finnegan, Minerals Management Service**

**Co-Chair:** **Roger Amato, Minerals Management Service**

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# WAVE-BOTTOM INTERACTION AND BOTTOM BOUNDARY LAYER DYNAMICS IN EVALUATING SAND MINING AT SABINE BANK FOR COASTAL RESTORATION IN LOUISIANA

**Gregory W. Stone**
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**Felix Jose**
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**Daijiro Kobashi and Seyed M. SiadatMousavi**
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**Baozhu Liu**
**Coastal Studies Institute, Louisiana State University**

Click here to view the slide show that accompanied this presentation.

Sabine Bank, a transgressive shoal located 30 km off the Louisiana-Texas border, has been considered a plausible resource for re-nourishment of the adjacent barrier islands and beaches due to the available sand volume and proximity to target restoration areas. The shallow shoal encompasses an area of 600 $km^2$ and is divided into two sections, viz., western and eastern flanks off the entrance channel to Sabine Pass. Fisheries surveys of the area estimated that fish abundance was over two times greater on the east side of Sabine Pass than on the west side. The study also demonstrated that the sandy areas of the shoal were not hypoxic at the time of the cruise, with a mean oxygen level of 4.4 mg $O_2$/L recorded at the bottom. Little has been reported on the bottom boundary layer dynamics and sediment transport from the shoal environment. A comprehensive field investigation, coupled with numerical modeling, has been completed for the Sabine Bank and is presented in this study.

Three bottom boundary layer arrays were deployed on the crest as well as on the nearshore and offshore flanks of the shoal (refer to Figure 1A.1 for the deployment locations) during spring 2004, winter 2006, and summer 2008. Time series observations of waves, currents, water level, suspended sediment concentration, temperature, and salinity at two locations close to the bottom were measured for 30-40 days each. Surficial sediments were collected during the deployment and retrieval cruises. Bottom boundary layer parameters, viz., wave and current induced shear stress and shear velocity, were computed. Sediment transport rate was quantified using the Grant and Madsen Model.

The *in situ* observations showed that waves were low amplitude and did not re-suspend sediment during fair weather conditions. Currents were sufficiently strong to re-suspend sediment during

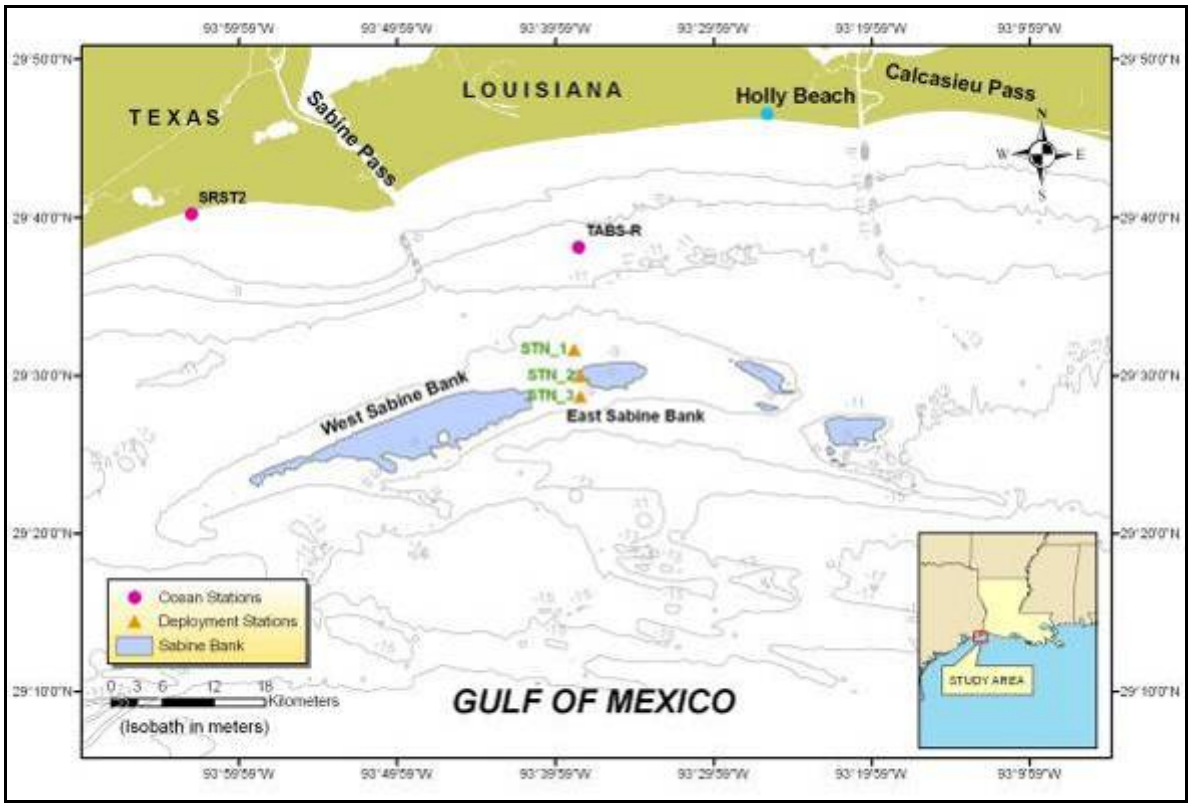


**Figure 1A.1. Location map. The yellow triangles show instrument deployment locations during 2004, 2006 and 2008. Additional met-ocean data were collected from a T ABS stati on and a met observation station (purple dots).**

the entire period except during fair weather conditions. Wave and bottom boundary layer interactions were strongly associated with the passage of cold fronts across the region. Strong southerly/southeasterly wind regimes also affected the wave and the bottom boundary layer interactions. During summer 2008, bottom boundary layer dynamics were significantly influenced by the high wind regime associated with a high pressure system that prevailed over the eastern Gulf and U.S. East Coast. The high wind regime during fair weather forced high wave height and relatively strong currents over the bank. This high wind regime occurred every two to three weeks. During the summer, except for the periods of the high wind regime, waves and currents were weak, and therefore bottom sediment re-suspension was insignificant. The turbidity data during the 2008 summer deployment imply that bottom boundary layer dynamics may be controlled by sediment supply from outside Sabine Bank, perhaps by fluvial sediment from the Atchafalaya River or Sabine Pass.

The MIKE 21 Spectral wave model (SW) and MIKE 3 Hydrodynamic model were implemented for the coast. The spectral wave model performed well for the study area, while the hydrodynamic model needs further calibration. Modification in bulk wave parameters due to two

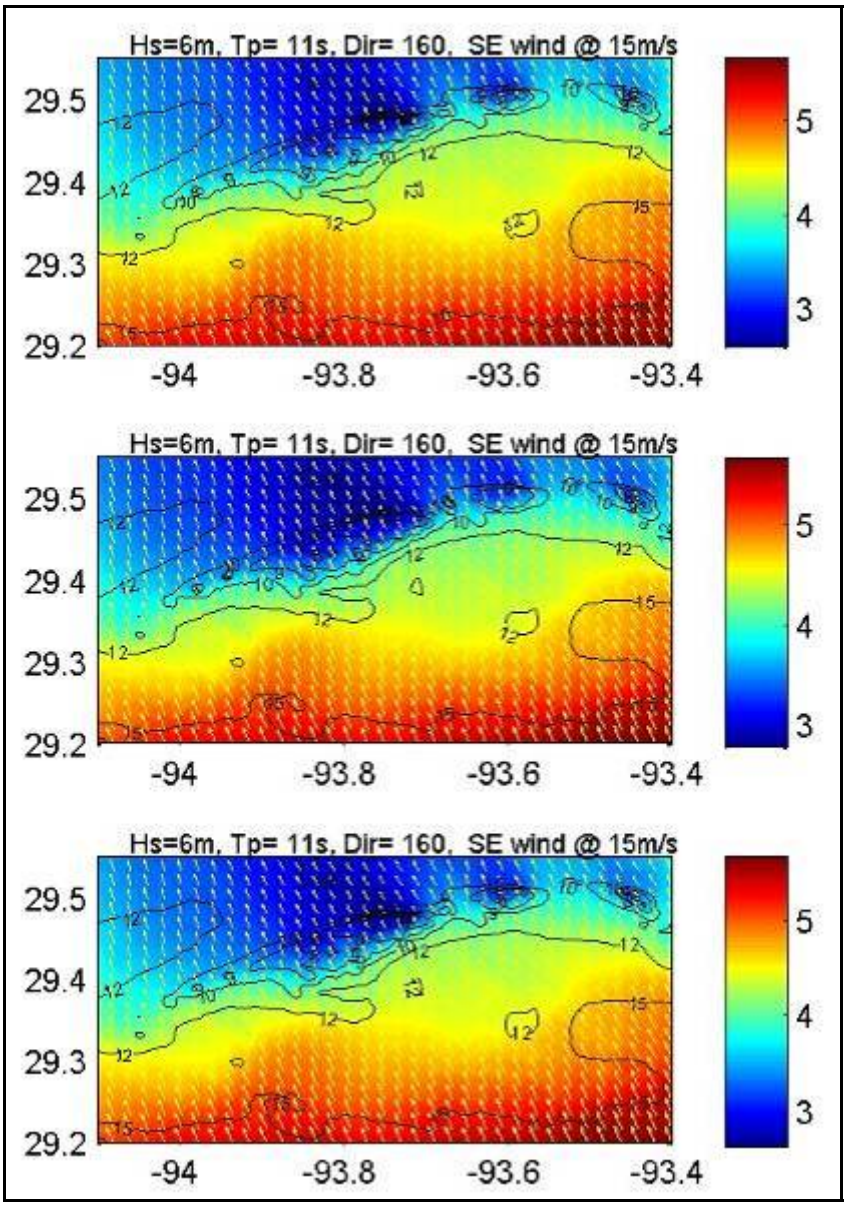


**Figure 1A.2. Significant wave height distribution over the Sabine Bank for three different bathymetries (top): pre-mining condition, (middle): cumulative mining scenario, (bottom): Holly Beach restoration project. The area and volume for targeted mining were provided by MMS.**

mining scenarios were computed using modified bathymetries. It has been observed that alteration in the significant wave height, peak period, and dominant direction were insignificant with the modified bathymetries (Figure 1A.2). Sediment re-suspension intensity (RI) was high over the inner shelf and shoal during severe and strong storms. During moderate storm conditions, the RI decreases from the shallowest western shoal to the deeper eastern shoal; the

RI off the shoal was significantly lower than on the shoal. The RI with partial mining was insignificantly lower than with the shoal present.

The computation of wave fields generated by hurricanes Gustav and Ike showed that the shoal acts as a submerged breakwater against hurricane generated waves and effectively protects the coast from substantial erosion. The level of energy dissipation over the shoal depends on the height and wavelength of the incoming waves. No significant modification in wave pattern was observed when it comes to the partial removal of the shoal crests. Wave fields with the complete removal of the shoal have not yet been computed. However, Kobashi et al. (in prep) conducted a similar study for Ship Shoal, with a scenario of complete removal of the shoal for which the alteration in the wave pattern was profoundly evident. Variation in wave heights along the coast, due to partial removal of the shoal crests, was remarkably insignificant, of the order of less than 2%. Among the five stations selected for coastal monitoring, the highest variability was observed for the eastern-most station, which in fact was not sheltered by the offshore bank.

## Reference

Kobashi, D., G.W. Stone, S.M. Khalil, and S.M. SiadatMousavi. In preparation. Impacts of sand removal from a shore-parallel Holocene transgressive shoal on hydrodynamics and sediment transport, south-central Louisiana, U.S.A.

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Dr. Gregory W. Stone is the James P. Morgan Distinguished Professor at Louisiana State University. He is Director of the Coastal Studies Institute at LSU and is a Professor in the Department of Oceanography and Coastal Science. His research interests focus on bottom boundary layer physics and sediment transport on the continental shelf, hurricane impacts along coasts and real-time monitoring of oceanographic and meteorological phenomenon. He is Director of the WAVCIS (www.wavcis.lsu.edu) ocean observing system. He has published over 200 scientific papers/reports, many of which have been through funding supplied by MMS. He has served on numerous editorial boards and as Deputy-Editor-in-Chief for the Journal of Coastal Research. Currently his research team focuses on investigations pertaining to identifying the potential hydrodynamic and sediment transport on the inner shelf, shoreface and beach environments along the Louisiana coast. He has presented MMS-funded work internationally.

Dr. Felix Jose is a post doctoral fellow at the Coastal Studies Institute, Louisiana State University. He has worked on the physical and geological aspects of the shallow shoals off the Louisiana coast. Dr. Jose specializes in coastal hydrodynamics and sediment transport modeling and has implemented a wave forecasting system for the Louisiana coast. He has been involved in various MMS-sponsored projects for the Northern Gulf of Mexico.

# ENVIRONMENTAL INVESTIGATION OF THE LONG-TERM USE OF TRINITY AND TIGER SHOALS AS SAND RESOURCES FOR LARGE-SCALE BEACH AND COASTAL RESTORATION IN LOUISIANA

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Click here to view the slide show that accompanied this presentation.

Research has been initiated to quantify the bottom boundary layer characteristics of Tiger and Trinity Shoals (Figure 1A.3) along with the physical, biological, and fishery aspects pertinent to this work. Since the shoals are located directly off the mouth of Atchafalaya and Wax Lake outlets, they are frequently blanketed with fine grained river-borne sediments, as shown in satellite imagery from the coast during the spring flood season. For Tiger shoal, the first deployment of a PCADP tripod, along with an upward looking ADCP, OBS sensors and pressure sensor, was conducted during the period 3–17 December 2008. During this two-week timeframe, three cold fronts crossed the study area and significantly influenced the hydrodynamics of the

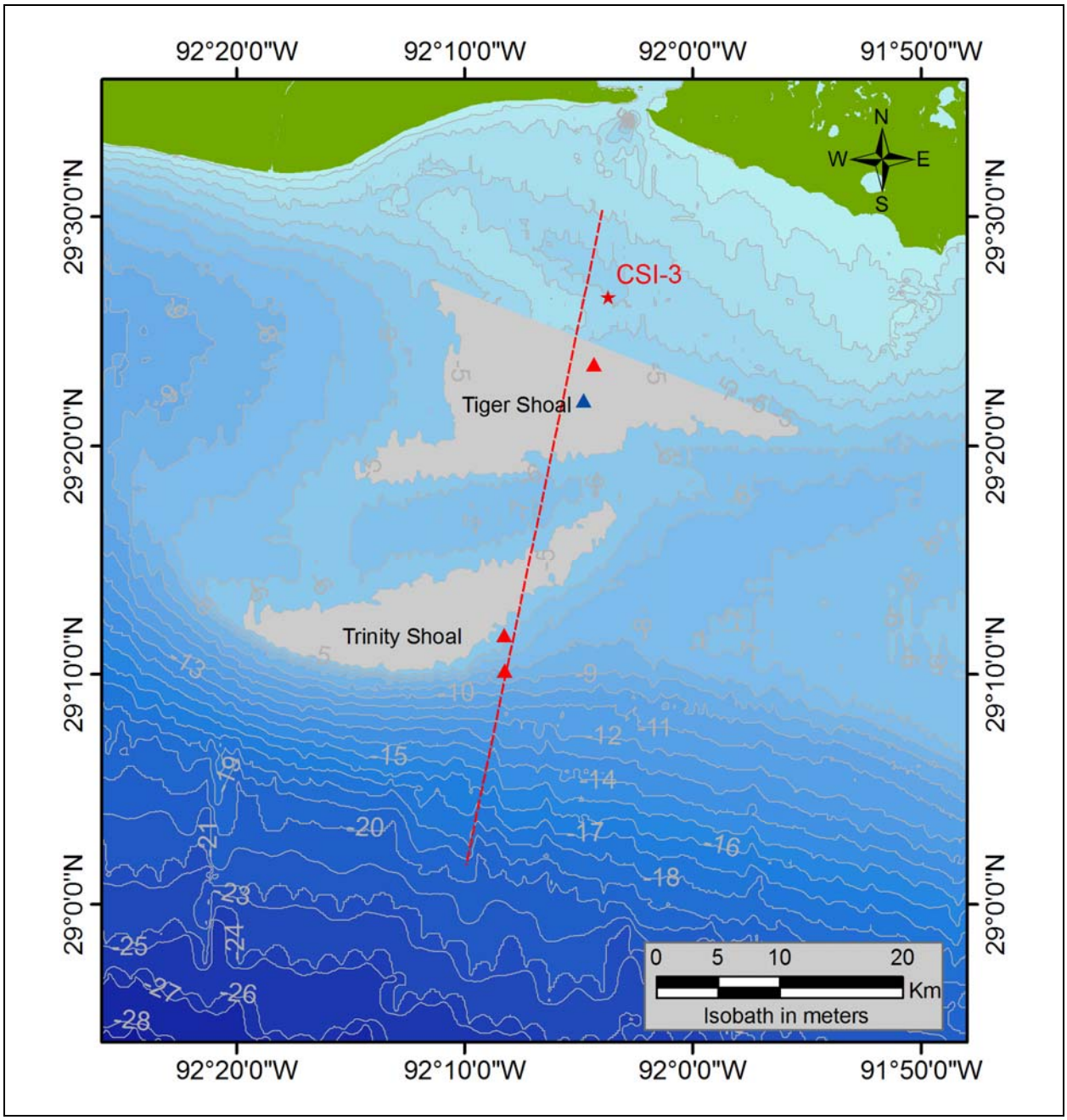


**Figure 1A.3. Study area for Trinity and Tiger Shoals. Note the blue triangle on top of Tiger Shoal, where the first physical deployment was conducted during December 2008.**

region. During one such event, on 12 December 2008, the wind speed attained 14.2 m/s while the maximum wave height observed was less than 1 m. This substantial wave attenuation observed over Tiger Shoal can be attributed to the nature of the bottom sediments. The highly viscous bottom sediment dissipates incoming waves, a phenomenon confirmed earlier by Sheremet and Stone (2003). Also, associated with the 11 December winter storm event, a reduction in water level was observed. This can be attributed to the enhanced wind stress component directed

offshore. Also, a spike in along shore current (easterly) was noticed during this event. The OBS sensor, located at 25 cm above the bed showed maximum values in accordance with the peak in the offshore wind stress; the OBS located at 60 cm above the bed, showed high values during the waxing and waning phases of the storm, indicating the delay in the settling of fine grained sediments. Except for a couple of short breaks, the wave induced shear stress at the bottom was strong enough to re-suspend the sediments during the entire deployment period. During the peak of the storms the bottom currents were also capable of reworking the bottom. This has been corroborated by the nature of the substrate collected during the deployment and retrieval of the equipment.

An array of hydrodynamic models was also implemented, as a preliminary study, to estimate the effect of waves and currents on shoal dynamics. MIKE 21 wave and hydrodynamic models, developed by DHI Water and Environment, were implemented for Tiger and Trinity shoals. A substantial reduction in wave height was observed seaward of Trinity Shoal. This can be attributed to the high bathymetric gradient off Trinity Shoal. Also, our preliminary hydro-dynamic model illustrated that strong currents existed over the shoal region, which could help in flushing out the fine grained materials during the winter storm period.

Biologically, we were primarily concerned with understanding the fishery-related ecology of these two shoals, especially in relationship to 1) our MMS-sponsored discovery that the nearby Ship Shoal was a nationally important spawning and hatching ground for the commercially and ecologically important blue crab *Callinectes sapidus* and 2) our working hypotheses that these shoals formed a complex in which a) benthic microalgae were important sources of primary production and b) infauna communities were important in i) blue crab nutrition, ii) replenishment of the surrounding system following hypoxic events, and iii) 'biological stepping' stones providing genetic continuity between the eastern and western GOM sand-based communities.

Results of three system-wide surveys involving pigment analyses of BMA and phytoplankton, box cores, trawls, gut content analyses, stable isotope analyses, and measurements of relevant physical and chemical properties were presented to test these initial findings and hypotheses. Comparisons of blue crabs collected on the shoals to those from other U.S. fisheries revealed no difference in condition factor (length-weight), fecundity (eggs/female), or abundance (cpe). Blue crabs were found to continuously spawn on TTSC during April–October. Stable isotope data suggested blue crabs were dependent on local shoal resources. The hypothesis-driven results of our statistical analyses further strengthen our findings that Trinity, Tiger, and Ship Shoals biologically function as a complex that is nationally important in the biological viability of a large segment of the GOM blue crab fishery and spatially dependent upon BMA (depending on depth and sediment characteristics). A high biomass of nutritious BMA was found on the TTSC. BMA dominated communities appear to be unique to shoals and are likely typical of shallow, sandy shoals in north central GOM. Sand mining could have adverse impacts on BPP by increasing depth (lower light) and by changing sediment characteristics from sand to silts. Biological work to be completed in 2009 involves our radio isotope analyses; our infauna biodiversity hotspot, hypoxia refuge, and colonization stepping stone hypotheses; and further coupling of the project's overall physical and biological findings.

## Reference

Sheremet, A. and G.W Stone. 2003. Observations of wave dissipation over muddy sea beds, Journal of Geophysical Research 108(C11):3357, doi: 10.1029/ 2003JC001885.

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Dr. Gregory W. Stone is the James P. Morgan Distinguished Professor at Louisiana State University. He is Director of the Coastal Studies Institute at LSU and is a Professor in the Department of Oceanography and Coastal Science. His research interests focus on bottom boundary layer physics and sediment transport on the continental shelf, hurricane impacts along coasts and real-time monitoring of oceanographic and meteorological phenomenon. He is Director of the WAVCIS (www.wavcis.lsu.edu) ocean observing system. He has published over 200 scientific papers/reports, many of which have been through funding supplied by MMS. He has served on numerous editorial boards and as Deputy-Editor-in-Chief for the Journal of Coastal Research. Currently his research team focuses on investigations pertaining to identifying the potential hydrodynamic and sediment transport on the inner shelf, shoreface and beach environments along the Louisiana coast. He has presented MMS-funded work internationally.

Dr. Richard Condrey is an associate professor in the Department of Oceanography and Coastal Sciences (DOCS) in LSU's School of Coast and Environment. He has worked extensively in population dynamics, fishery ecology, and management of shrimp, spotted seatrout, red drum, menhaden, sharks, blue crabs, and paddlefish.

Dr. Felix Jose is a post doctoral fellow at the Coastal Studies Institute, Louisiana State University. He has worked on the physical and geological aspects of the shallow shoals off the Louisiana coast. Dr. Jose specializes in coastal hydrodynamics and sediment transport modeling and has implemented a wave forecasting system for the Louisiana coast. He has been involved in various MMS-sponsored projects for the Northern Gulf of Mexico.

# DEVELOPMENT AND IMPLEMENTATION OF AN INTERACTIVE SAND RESOURCE MAPPER, OFFSHORE ALABAMA

**Stephen C. Jones**
**Geological Survey of Alabama**

Click here to view the slide show that accompanied this presentation.

Offshore sand deposits that reflect native beach characteristics are an important and finite resource in offshore Alabama. Although current sand borrow sites used for large-scale beach restoration are located in state waters, identified reserves are limited, and it is necessary to delineate potential quality sand sources within federal waters. As a result of previous Minerals Management Service project investigations beginning in 1989, five offshore Alabama sand research study areas (MMS study areas) have been delineated by the Geological Survey of Alabama (GSA), and an environmental assessment has been performed on each study area. The consideration given to bottom geomorphology, existing sediment data, and potential problem areas in early MMS study area investigations is unknown. Early investigations did not rely on recent bathymetrical interpretations and most coring activities have not considered the practicality of dredging within an explored area. Existing and newly developed geospatial data are helping to qualify viable sand sources as target areas. A detailed and accurate knowledge of bottom features, habitat designations, various obstacles, and boundaries is fundamental for delineating potential target sand sources and determining permitting feasibility. Physical obstructions include wrecks, pipelines, fishing reefs, platforms, and other bottom features. Other considerations include essential fish habitat, buffers, fairways, and other factors as constrained by practical engineering and regulatory authorization. Although nonproprietary seismic data have been collected in offshore Alabama, these data are unevenly distributed within and around the study areas and are of limited value in the characterization of high-quality sand deposits. Likewise, bottom sediment samples have been collected and characterized by various research groups, but these data are not limited to the MMS study areas and are variable in the level of analyses conducted. The GSA is compiling geospatial data to develop a robust web-based interactive mapping service and to isolate potentially viable sand deposits within the MMS study areas to guide further sediment investigations.

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Stephen C. Jones is Coastal Resources Section Director at the Geological Survey of Alabama. He received his B.S. and M.S. degrees in geology from the University of Alabama at Tuscaloosa, the latter with a special focus in hydrology. Before working at the Geological Survey, Jones served as staff geologist at ENSR Corporation, at TTL, Inc., and at LAW Engineering and Environmental Services.

# EVALUATION OF TIGER AND TRINITY SHOAL COMPLEX— A POTENTIAL OFFSHORE SAND RESOURCE FOR RESTORATION OF CENTRAL LOUISIANA

**Syed M. Khalil**
**Louisiana Office of Coastal Protection & Restoration**

**Harry H. Roberts and Clint H. Edrington**
**Coastal Studies Institute, Louisiana State University**

Click here to view the slide show that accompanied this presentation.

In 2007 MMS provided a grant to Louisiana Department of Natural Resources under Post 2005 Hurricane Gulf Coast Sand Studies fund for exploration of offshore sand in OCS waters around Tiger and Trinity Shoal Complex.

During July–August 2007 about 800 line miles of geophysical data in Tiger and Trinity Shoal Complex were collected using state owned research vessel RV Coastal Profiler. These data included bathymetric, seismic, side scan sonar and magnetic data. These geophysical data were analyzed using Petrel software developed by Schlumberger owned by the Department of Geology & Geophysics, LSU. On the basis of the analysis of the data several vibracore locations were selected. During September–October 2008, vibracores (4 meters/12 feet long) were collected from 46 locations. Due to hurricanes Gustav and Ike, it took three attempts to collect these vibracores. These vibracores have been logged at the sedimentological laboratory. Subsamples will be collected once all the cores have been logged. These samples will be analyzed for various parameters including grain size. The geophysical data will be populated into the LASARD database. The final report and deliverables will be submitted by 31 August 2009.

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Syed M. Khalil is a Geologist DCL with Louisiana Office of Coastal Protection and Restoration, Baton Rouge, Louisiana. He has more than twenty years of experience in coastal and marine geology/geophysics and has been associated with coastal engineering and restoration efforts in Florida and Louisiana since 1995. He has authored numerous papers and professional reports and is an associate editor of the *Journal of Coastal Research*. He was a United Nations Fellow at the University of Hawaii. Syed Khalil is a former Director of the Indian Geological Survey.

Harry H. Roberts is the former director of Coastal Studies Institute (for 10 years) at LSU, an emeritus member of the Department of Oceanography and Coastal Sciences (School of the Coast and Environment), and a Boyd Professor. He has had a career in marine geology that spans 40 years and has worked in many foreign countries as well as in the United States. Recently, his research has focused on three themes: (a) modern deltaic sedimentation and processes, (b) shelf-

edge deltas, and (c) surficial geology of the northern Gulf's continental slope. The latter research thrust has concentrated on building an understanding of the impacts of fluid and gas expulsion on the surficial geology and biology of the slope. Gas hydrate constitutes one of the unusual consequences of fluid and gas migration and expulsion in deep water.

# EVALUATION OF THE SAND AND GRAVEL RESOURCES SUITABLE FOR POST-RITA COASTAL RESTORATION OFFSHORE EASTERN TEXAS

**Juan Moya**
**Coastal Resources Division, Texas General Land Office**

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The Texas General Land Office (GLO) developed an agreement with the Mineral Management Service to conduct offshore sediment investigations of potential sand sources located on the Sabine River submerged paleo-channel, Sabine Bank, Heald Bank, Shepard Bank and Trinity River submerged paleo-channel, called Paleo-Sabine-Trinity Marine Features (PSTMF). The studies are to be conducted in the Outer Continental Shelf (OCS) jurisdiction.

The project was developed in two phases. In phase one, all the existing reports, nautical charts, topographic maps, geophysical data, research documents, and other relevant publications were searched to define the location and scale of potential Pleistocene and Holocene sand bodies that appear to be located along the PSTMF.

Task two consists of geophysical and geological data collection. The GLO will conduct offshore geophysical investigations and data collection using sidescan sonar mosaics, single beam high-resolution bathymetry, and CHIRP seismic profiles for the offshore areas off the PSTMF. All data collected will be corrected for tides and referenced to the state plane (Texas South Central) NAD 83 horizontal datum and the NAVD 88 vertical datum. With these data, the performing agency will present information on the potential sand bodies that could be used as sand sources for future shoreline protection projects along the PSTMF area. Collection will consist of up to 500 miles of CHIRP seismic lines, with swath bathymetry collected along each line. Lines should be close to the areas defined in the map and consistent with the proposed areas. GLO will also process the CHIRP lines to identify potential coring sites and will process the bathymetry data. The data collected and survey results will be geo-referenced to be represented in GIS format.

The GLO will conduct offshore geological investigations and geotechnical data collection of up to 20 or more submersible vibracores, each up to 20 feet long. The core locations will be based on the interpretation of the data collected on task two. The cores will provide an idea of the quality and quantity of sand in the deposits observed. The cores collected by the performing agency will be split, photographed, described, and sub-sampled. The performing agency will analyze and interpret the grain size of cores. The data collected and survey results will be geo-referenced to be represented in GIS format.

A final report with the geologic interpretation of the CHIRP and other geophysical data collected will be developed to define areas that will be tested by geotechnical coring and drilling. This interpretation should identify any significant sand deposits including estimated volumes and general quality of the sand available. The information will be used to delineate sand sources for future shoreline protection projects in the area.

The final report will be submitted to MMS by the end of 2009. The report will show the deposits containing potential sand resources that can be used for future beach shoreline protection in the Texas upper coast.

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Dr. Juan Moya received his Ph.D. in geology and geomorphology from the University of Colorado at Boulder in 1998. He has worked in Mexico, Puerto Rico, Colombia, Venezuela, United States and the Dominican Republic in coastal geologic studies. He has nine years of experience working along the Texas coast in projects and technical committees. Since 1999, Dr. Moya has worked at the Texas General Land Office for the Coastal Resources Division. He works as a project manager on beach nourishment and habitat restoration projects as well as geologic studies including storm impacts. Dr. Moya has worked as technical reviewer for the grants of Coastal Management Program and has been in charge of technical reviews for studies necessary to achieve the goals of the Coastal Resources Division at the GLO. Since early 2006, Dr. Moya has been technical coordinator/project manager with the Coastal Impact Assistance Program. Dr. Moya is also the project manager for the Texas Coastal Ocean Observation Network coordinating efforts in Texas to measure the coastal tides and vertical elevation changes in the coastal areas in Texas. He works with the Corps of Engineers and other resource agencies in different working groups. He is an Adjunct Professor with the Department of Geography with Texas State University.

## EVALUATION OF THE SAND RESOURCES SUITABLE FOR POST-KATRINA COASTAL RESTORATION, MISSISSIPPI-ALABAMA COAST

**James Flocks**
**U.S. Geological Survey and the University of Mississippi**

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The wetlands, bays, and barrier islands of the northern Gulf of Mexico were formed through the interaction of modern coastal processes with a geologic framework that began with the erosion and redistribution of Pleistocene fluvial-deltaic deposits during Holocene sea-level rise. As a result, the Louisiana-Mississippi-Alabama Shelf contains a complex arrangement of progradational facies (prodelta, delta front, distributary channel, and marsh deposits) and transgressive facies (inlet channel fills, shoal deposits, and nearshore marine deposits).

Continued sea-level rise, increased storm impact, human alteration of the landscape, and a finite sediment-supply have resulted in a measurable net loss of land area in the Northern Gulf of Mexico over the past few centuries. To accommodate the loss, a key component of coastal management is shoreline renourishment through recovery and redistribution of suitable sediments from submerged and buried sand deposits. Understanding the stratigraphic architecture is necessary to identify subsurface features that can be classified into distinct units of predominant grain-size and texture for use in stabilization and management efforts. Over the past two decades the U.S. Geological Survey has been actively developing technologies to characterize this near-surface geology and understand the process-response of the coastal zone. Remote sensing through acoustic profiling, direct sampling through coring, and the management, synthesis and distribution of existing information are key to characterizing the shallow stratigraphy and indentifying spatially distinct deposits that are potential resources for shoreline and wetland restoration. This presentation is an overview of efforts by the Coastal and Marine Geology Program and its collaborators to provide information that can be utilized by coastal managers to protect the fragile ecosystem of the Northern Gulf of Mexico coastal zone.

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Jim Flocks graduated from the Florida State University, Department of Geological Sciences with a B.S. degree in geology in 1989 and from the University of Southern California, Department of Earth Sciences with an M.S. degree in geology in 1993. His graduate work involved mapping trace-metal distributions in marine sediments. He joined the U.S. Geological Survey (USGS) Coastal and Marine Geology Program in 1993, as part of the geologic framework group in St. Petersburg, Florida, (http://coastal.er.usgs.gov). His main responsibilities with the USGS include interpreting the Quaternary depositional history of marine, coastal and lacustrine environments to provide information specific to barrier island evolution, inner shelf processes, land subsidence, and groundwater/surface water interaction. His current collaborative projects with academia,

state and federal agencies include geologic-framework assessments in Florida, Mississippi, Louisiana, and Texas.

## SESSION 1B

## DEEPWATER BENTHIC HABITATS
## MMS/NOAA OER/USGS
## Collaborative Studies of Coral Habitats

**Chair:** **Gregory Boland, Minerals Management Service**

**Co-Chair:** **James Sinclair, Minerals Management Service**

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# AN OVERVIEW OF INTERNATIONAL MULTIDISCIPLINARY STUDIES ON DEEP-SEA REEFS IN THE GULF OF MEXICO WITH PRELIMINARY OBSERVATIONS FROM THE VIOSKA KNOLL AREA

**Steve W. Ross**
**University of North Carolina-Wilmington**
**Center for Marine Science**

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## Diversity, Systematics, and Connectivity of Vulnerable Reef Ecosystems (DISCOVRE). See: http://fl.biology.usgs.gov/DISCOVRE/index.html

Previous (Lophelia I) investigations helped resolve some basic questions about habitat distributions, species occurrence and the general biology of deep water coral and hardground communities on the continental slope of the central and western Gulf of Mexico (GOM). For example, the species and relative abundances of fishes and larger invertebrates that co-occur with *Lophelia* habitat are reasonably documented. We know that GOM *Lophelia* are genetically structured on relatively small scales and that *Lophelia*-associated bacterial communities differ dramatically between collection sites. Water depth, water temperature, substrate type, currents, and food availability may play important roles in the ecology of these systems. But, there is still much to learn about the fundamental processes that structure, link, and constrain these uncommon habitats. The best approach to help resolve important resource management questions is a combination of 1) focused studies and *in situ* experiments at a few sites, and 2) limited exploration and description of additional sites that include the eastern GOM. Topical areas of the DISCOVRE studies include 1) physical oceanography, 2) trophodynamics, 3) genetics, 4) microbiology, 5) benthic ecology (vertebrate and invertebrate), and 6) geochemistry (paleoecology).

This four-year multidisciplinary research program is focused on understanding the physical oceanography, biology, ecology, genetic connectivity, and trophodynamics of deep-sea coral and reef environments in the GOM (300–1,000 m depths), on both natural and artificial (shipwreck) sites. An additional goal is to develop and synthesize information on *Lophelia*, and other deep corals/ hardgrounds, and compare community composition, fauna/habitat linkages, genetic structures and energetics across latitudes, habitat types, depth zones, and regions. The data from proposed studies, supplemented with previous deep coral data, will allow for a regional synthesis at the end of these studies. This program, funded by U.S. Geological Survey (USGS), collaborates closely with a companion program (Lophelia II) funded by the Minerals Management Service, with ship support from National Oceanic and Atmospheric Administration (NOAA) OER, and conducted by a team organized through TDI Brooks, Inc. The USGS program has integrated a diverse group of collaborators, including scientists from the USGS (A. Demopoulos, C. Kellogg, C. Morrison), University of North Carolina Wilmington (UNC-W, S.W. Ross), UNC Chapel Hill (J. Bane, H. Seim), NOAA Fisheries (M. Nizinski), the Royal Netherlands Institute for Sea Research (NIOZ, T. van Weering, G. Duineveld, F. Mienis), and

the Scottish Association for Marine Science (SAMS, J.M. Roberts, A. Davies). Sampling involves a combination of traditional techniques (e.g., photography, quantitative sample collections) and advanced tools (including remotely operated vehicles, multibeam sonar, benthic landers, and genetic analysis) in order to better understand these critical, poorly studied deep-sea habitats.

To date, the first cruises have been conducted using the NOAA vessel Nancy Foster in October 2008. The cruises included two adjacent legs with the following objectives.

First DISCOVRE cruise major objectives:

LEG I (5–13 October 2008)
- Benthic Lander Operations – short & long-term
- ROV Operations – 10 hour daily ops when possible
- Midwater & Benthic net sampling – mostly at night
- CTD profiles – periodic transects and profiles

LEG II (19–23 October 2008)
- Multibeam sonar mapping: West Florida slope

While these first cruises were successful, deteriorating weather and problems with ROV performance hindered data collection. Nevertheless, large amounts of data were collected.

Cruise Summary:

LEG I, VK 826 & VK 906/862
Benthic landers – 4 deployments, 2 short (5 days) & 2 long-term (one year)
ROV – 6 dives
Bottom trawls – 17 stations
Opening/closing midwater nets – 18 stations
Plankton nets – 11 stations
Benthic traps – 4 sets
CTD – 32 stations
Miscellaneous gear – light traps, settling plates

From the above methods hundreds of specimens of fishes and invertebrates were collected. We took subsamples for microbiology, genetics (278 samples), and stable isotopes (773 samples to help in studies of feeding). We tried to photograph all unique specimens, resulting in photos of 352 specimens. The remaining animals were preserved for later identification and other data collection.

Preliminary data from the short term (5 day) lander deployments indicated relatively slow currents from the west northwest with little or no tidal signals. One major event occurred which decreased current speeds, changed current direction, and decreased temperature, but only at the

off mound site. CTD data indicated a persistent turbidity layer over the coral mounds and low dissolved oxygen near the coral sites, compared with the rest of the water column.

LEG II, West Florida slope, 222 sq km mapped with multibeam sonar

On Leg II we mapped an area of the continental slope off the Florida West coast covering about 47 x 4.5 km or about 222 sq km. These are the first maps of such detail for this area. The most prominent feature observed is a long scarp about 30–50 m tall running north-south nearly the whole length of the survey area. Seaward (westward) of this scarp are numerous (perhaps thousands) of scattered mounds and ridges about 5–20 m tall. Many of these may be dead or living deep-sea coral features, but proving that will be a task for future cruises. This area is quite different from the GOM deep reef habitats examined in Leg I and those off the southeastern US. Comparing these ecosystems will provide insight about how these systems form, are maintained, and their status (growing, declining, young, old).

The DISCOVRE project will continue through the next three years. An outline of future activities includes:

Pick up two landers at VK826 first week of Sep 2009
Cruises planned for late 2009 and 2010
- – Survey of W. Florida slope high priority
- – Continue long term data collection on Vioska Knoll sites
- – Sample *Gulf Penn* and *Gulf Oil* deep water shipwrecks
- – Use ROVs in all areas, supplemented with other methods

Data analysis & publications in fourth year.

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Dr. Steve W. Ross is a Research Professor at the University North Carolina at Wilmington, Center for Marine Science. Dr. Ross has spent most of his career involved in the marine sciences of the southeastern U.S. region. He earned a B.S. degree in zoology from Duke University, an M.A. degree in zoology from UNC-Chapel Hill, and a Ph.D. in zoology from NC State University. He was the Research Coordinator for the North Carolina Coastal Reserve Program for 13 years. In addition to serving on the research faculty at UNC-W, Dr. Ross is also a project leader for the U.S. Geological Survey. He holds graduate adjunct faculty status at NC State University and UNC-Wilmington. His area of specialization is ichthyology (fishes), particularly ecology and life history (age, growth, feeding, reproduction). He has conducted numerous diverse projects in estuaries and offshore waters and has served as chief scientist on many cruises, including those using submersibles. The current work of Dr. Ross and his team involves assessment of the communities of unique deep water habitats off the southeastern U.S. They are examining energy flow (trophodynamics) and relationships of animals to various habitats, including deep coral banks, canyon systems, and rocky areas. The ultimate goal of these studies is to provide information that will facilitate management and protection of these poorly known, productive habitats.

# COMMUNITY STRUCTURE AND TROPHIC FUNCTION OF DEEP-REEF FISH AND INVERTEBRATE COMMUNITIES IN THE GULF OF MEXICO

**Amanda W. J. Demopoulos and Kenneth Sulak**
**U.S. Geological Survey Florida Integrated Science Center**

**Steve Ross**
**University of North Carolina, Wilmington**

Click here to view the slide show that accompanied this presentation.

Deep-sea coral ecosystems are highly complex and little is known of their community and trophic structure and function. The information presented here represents an ongoing study of the benthic ecology of deep-coral ecosystems in the Gulf of Mexico. It will summarize work published on deep-reef demersal fish communities and include new results from recent food web studies on reef fish and invertebrate assemblages. Our specific objective was to evaluate the extent to which reef-associated fish utilize local resources for nutrition. Study areas were located in the northern Gulf of Mexico on the continental slope off Louisiana. Specific coral locations represented two geological mound features identified as MMS Lease Blocks Viosca Knoll 826 and Viosca Knoll 862. Collections were made on 11 research dives during two submersible cruises in 2004 and 2005. Otter trawls and baited traps also were deployed to collect mobile fish and invertebrates.

After analyzing video from the submersible dives, the following fish appeared to be highly associated with the live reef: *Conger oceanicus, Helicolenus dactylopterus, Grammicolepis brachiusculus,* and *Hoplostethus* spp. Stable carbon and nitrogen isotope analyses revealed a simple food web, encompassing four trophic levels, and results indicated that phytodetritus may be a primary food source for these communities. Sedentary fauna, including suspension-feeding coral, exhibited stable carbon isotope values indicative of nutrition derived from plankton. However, certain sponges and urchins had distinct values, indicating that they were feeding on a unique, but unidentified food source.

Deciphering food resources for the reef fish associates, *H. dactylopterus, G. brachiusculus,* and *Hoplostethus* spp., proved to be very challenging. None of the food resources analyzed had stable isotope values consistent with serving as a food source for these fish. Although the fish appeared to be highly associated with the reef environment, stable isotope results indicated that they were not feeding directly on the local resources sampled in this study. However, isotope values for the crustaceans, *Eumunida picta* and *Bathynectes longispina*, indicated that they may serve as food for *Conger oceanicus*. In addition, stomach contents of the *C. oceanicus* contained several different crustacean taxa. Given that these fish are often observed in close proximity to the live reef environment, they are likely candidates for feeding on local resources (e.g., *E. picta* and *B. longispina*). While conclusive interpretations of food habits for mobile fish and

invertebrates are unavailable for these deep-reef environments, additional collections for stable isotope and stomach analyses will assist our understanding of trophic linkages among these fauna.

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Amanda W. J. Demopoulos received her B.S. degree in oceanography from the University of Washington and her Ph.D. from the University of Hawaii. Presently, she is a benthic ecologist at the USGS Florida Integrated Science Center. Her general research interests include the biodiversity, community ecology, and food-web structure of benthic communities.

Ken Sulak is a USGS research biologist and lead scientist for the Coastal Ecology and Conservation Research Group (FISC-Gainesville, Florida). Dr. Sulak has published extensively on the life history and ecology of marine fishes. From 1997–2006, he was lead scientist for a series of OCS deep-reef community ecology studies in the northern Gulf of Mexico, in MMS stewardship areas, culminating in the Lophelia I project. The focus of his deep-reef research has now moved to the Bahamas and Caribbean.

Dr. Steve W. Ross is a Research Professor at the University North Carolina at Wilmington, Center for Marine Science. Dr. Ross has spent most of his career involved in the marine sciences of the southeastern U.S. region. He earned a B.S. degree in zoology from Duke University, an M.A. degree in zoology from UNC-Chapel Hill, and a Ph.D. in zoology from NC State University. He was the Research Coordinator for the North Carolina Coastal Reserve Program for 13 years. In addition to serving on the research faculty at UNC-W, Dr. Ross is also a project leader for the U.S. Geological Survey. He holds graduate adjunct faculty status at NC State University and UNC-Wilmington. His area of specialization is ichthyology (fishes), particularly ecology and life history (age, growth, feeding, reproduction). He has conducted numerous diverse projects in estuaries and offshore waters and has served as chief scientist on many cruises, including those using submersibles. The current work of Dr. Ross and his team involves assessment of the communities of unique deep water habitats off the southeastern U.S. They are examining energy flow (trophodynamics) and relationships of animals to various habitats, including deep coral banks, canyon systems, and rocky areas. The ultimate goal of these studies is to provide information that will facilitate management and protection of these poorly known, productive habitats.

## GENETIC DISCONTINUITY AMONG REGIONAL POPULATIONS OF *LOPHELIA PERTUSA* IN THE NORTH ATLANTIC OCEAN

**Cheryl L. Morrison**
**U.S. Geological Survey - Biological Resources Division,**
**Leetown Science Center – Aquatic Ecology Branch and**
**University of Hawai'i at Manoa, Department of Oceanography**

**Steve W. Ross**
**University of North Carolina-Wilmington, Center for Marine Science**

**Martha S. Nizinski**
**NMFS National Systematics Laboratory, Smithsonian Institution**

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**Johanna Järnegren**
**Norwegian Institute of Nature Research, NO-7485, Trondheim, Norway**

**Rhian G. Waller**
**University of Hawai'i at Manoa, Department of Oceanography**

**Robin L. Johnson and Tim L. King**
**U.S. Geological Survey - Biological Resources Division,**
**Leetown Science Center - Aquatic Ecology Branch**

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The degree to which populations are demographically connected through larval dispersal is imperative to our understanding of resilience to disturbance, yet little is known about larval dispersal ability and population connectivity in *L. pertusa*, the dominant framework-forming coral on the continental slope in the North Atlantic Ocean. Using a suite of nine DNA microsatellite markers, we assessed the spatial scale and pattern of genetic connectivity among widely separated *L. pertusa* localities. Approximately 400 *L. pertusa* samples were collected from 16 localities including (a) seven deep reefs off the southeastern U.S. coast (SEUS, from North Carolina to Florida, depth range 287–740m), (b) Manning and Rehoboth Seamounts off New England (NES, 1418-1679m), (c) three natural *L. pertusa* reef localities plus the *Gulfpenn* shipwreck in the Gulf of Mexico (GOM, 315–533m), and (d) Rockall Banks and Mingulay Reef off Scottland (153–562m), plus Trondheim Fjord, Norway (140m), in the eastern North Atlantic Ocean (ENAO).

Patterns of microsatellite differentiation reject the hypothesis that *L. pertusa* represents a single, interbreeding population in the North Atlantic Ocean. On the broadest scale, a Bayesian modeling approach without prior geographical information found three distinct groupings or clusters of individuals: GOM, SEUS, NES plus ENAO. Quantitative estimates of hierarchical gene diversity (AMOVA) were significant, and 4% (based on the number of different alleles, $F$st) or 11% (based on the sum of squared size differences, $R$st) of the total variance was explained by between-cluster differences ($P < 0.0001$). Estimates of pairwise population differentiation were highest with NES populations (average $F$st = 0.162), intermediate with the ENAO populations ($F$st = 0.088), and smallest between SEUS and GOM populations ($F$st = 0.027). Within each of the regional clusters, we found increased connectivity across broader geographic distances suggesting that some larvae are broadly dispersed, as well as evidence for incomplete mixing at smaller spatial scales suggesting retention of larvae. Thus, dispersal of *L. pertusa* larvae appears generally localized, but long distance dispersal occurs with enough frequency for regional genetic cohesion. Further investigation of genetic connectivity patterns in *L. pertusa* and other deep coral organisms throughout the Atlantic Basin, along with improved oceanographic data, may elucidate mechanisms of population maintenance and isolation.

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Dr. Cheryl Morrison is a geneticist at the USGS Leetown Science Center, Aquatic Ecology Branch, in Kearneysville, WV. Her work at USGS involves the application of genetics tools to assist in the management of biodiversity, and she has worked with a variety of organisms including freshwater fishes, unionid bivalves, jumping mice and corals. Dr. Morrison is a part of the USGS DISCOVRE team (Diversity, Systematics and Connectivity of Vulnerable Reef Ecosystems) working in the Gulf of Mexico and applies genetics techniques to help understand evolutionary relationships among corals, crabs, and reef-associated fauna, and to assess connectivity among deep reef areas. Cheryl received her B.S. degree in marine biology from UNC-Wilmington (1991) and a Ph.D. in biology from Florida State University (1997).

Dr. Steve W. Ross is a Research Professor at the University North Carolina at Wilmington, Center for Marine Science. He has spent most of his career involved in the marine sciences of the southeastern U.S. region. He earned a B.S. degree in zoology from Duke University, an M.A. degree in zoology from UNC-Chapel Hill, and a Ph.D. in zoology from NC State University. He was the Research Coordinator for the North Carolina Coastal Reserve Program for 13 years. Dr. Ross is also a project leader for the U.S. Geological Survey. He holds graduate adjunct faculty status at NC State University and UNC-Wilmington. His area of specialization is ichthyology (fishes), particularly ecology and life history (age, growth, feeding, reproduction). He has conducted numerous diverse projects in estuaries and offshore waters and has served as chief scientist on many cruises, including those using submersibles. The current work of Dr. Ross and his team involves assessment of the communities of unique deep water habitats off the southeastern U.S. They are examining energy flow (trophodynamics) and relationships of animals to various habitats, including deep coral banks, canyon systems, and rocky areas. The ultimate goal of these studies is to provide information that will facilitate management and protection of these poorly known, productive habitats.

# INTRODUCTION AND PROJECT OVERVIEW: NEW MMS/NOAA OER STUDY "LOPHELIA II" EXPLORATION AND RESEARCH OF NORTHERN GULF OF MEXICO DEEPWATER NATURAL AND ARTIFICIAL HARD BOTTOM HABITATS WITH EMPHASIS ON CORAL COMMUNITIES: REEFS, RIGS AND WRECKS

**James M. Brooks**
**TDI-Brooks International, Inc., College Station, Texas**

Click here to view the slide show that accompanied this presentation.

In August 2008, TDI-Brooks International Inc. was awarded a $3.7M four-year project from the U.S. Minerals Management Service (MMS). This is an interagency study involving MMS and the National Oceanic and Atmospheric Administration (NOAA) Office of Ocean Exploration and Research (OER) and will also include additional collaboration with the U.S. Geological Survey.

Up to 24 days of ship time the first year and a similar number of days for years two and three aboard NOAA OER-funded research vessels including operating personnel, made available by the NOAA OER, will be used to conduct this program. Other research vessels, remotely operated vehicles (ROV), human occupied vehicles (HOV) and autonomous underwater vehicles (AUV) from NOAA OER may also be employed in FY 2009 and 2010.

This study will focus on the exploration and investigation of deepwater non-chemosynthetic biological communities in the deep (>300 m) Gulf of Mexico (GOM) that have developed on both natural and artificial hard substrates with emphasis on deepwater coral habitats. An additional aspect includes exploration of shipwreck sites in the deep Gulf with historical and biological objectives.

The objectives of the program are to discover and describe new locations at greater than 300m depth in the Gulf of Mexico with extensive coral community development, particularly including *Lophelia pertusa;* to 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 Gulf of Mexico through both laboratory experiments and field data collection; and to 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. These objectives will be achieved with principal investigators from TAMU, Penn State, LSU, TAMUCC and WHOI.

The initial cruise for this program was conducted on NOAA research vessel *Nancy Foster* from 5 September through 2 October 2008. Presenting preliminary results from this cruise are the following:

Lophelia II: Preliminary Biological Findings from 2008 ROV Dives — Peter Etnoyer, TAMUCC

Lophelia II: Preliminary Archeological Findings from 2008 ROV Dives — Rob Church, C & C Technologies, Inc.

The cruise was completed in two legs. Leg 1 mobilized and embarked from Galveston, Texas on 5 September and ended 13 September 2008 in Gulfport, Mississippi. The second leg staged from Gulfport. It disembarked on 20 September and demobilized in Pascagoula, Mississippi on 2 October 2008.

The primary objective of the first cruise was to conduct a reconnaissance of eight shipwreck sites and assess the archaeological and biological potential of these wrecks for inclusion in the project. The findings and results from the first and second legs of Cruise 1 are as follows.

**Leg1**

- The Ewing Banks Wreck site was confirmed as an historic nineteenth-century shipwreck site
- Ewing Banks Wreck contained more *Lophelia* 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 and substantial coral colonies were documented
- 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
- Microbial experiment placed on the site in 2004 was reexamined
- A temperature logger was placed on *Gulfpenn*'s bow

**Leg 2**

- Multibeam data was collected at 13 sites
- 10 lowerings of the ROV were completed over eight different sites,

- 50 hours total bottom time, CTD data were collected during each lowering, 61 biological and geological samples were obtained

- Five sites were completed with adequate visual surveys

- MC 751 (eight hrs) has a high abundance of live *Lophelia pertusa*, and is a good candidate for future work

- GC 140 (17 hrs) has a high diversity of gorgonians and antipatharians

- A new area of *Lophelia pertusa* colonization was discovered north of the previous site at GC 234 (five hrs)

- VK 906 (10 hrs) has coral mounds south of previously explored area

- The hard grounds at GB 201 (nine hrs) is covered in sediment, has a very low coral abundance and was eliminated as a potential site

- New factors for site selection were determined

- The presence of pockmarks in multibeam data and on the seafloor likely contribute to sedimentation, and consequently, reduce coral survivorship (GB201).

- Low relief sites are potentially suitable if other conduits for sediment removal are present (MC751).

The second cruise of the program (Second Reconnaissance Cruise) is scheduled in the April-May 2009 timeframe using the TDI-Brooks vessel *RV Brooks-McCall* and the Sentry AUV. The objective will be to study the remaining sites from Cruise 1 and additional sites in > 1,000 m water depth.

A third cruise is planned in August-September 2009, using the NOAA Ship *Ron Brown* and Jason II. The primary objective will be to study sites selected from first and second reconnaissance cruises, plus other known sites (*e.g.*VK826 & GC852).

A preliminary schedule of remaining tasks for the program fiscal year is presented as follows:

Cruise 2 Plans to MMS..... March 2009
Cruise 2..... April 2009
Cruise 2 Report..... June 2009
Quarterly Status Letter..... June 2009

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Dr. James Brooks is President & CEO of TDI-Brooks International Inc, the primary contractor for the MMS program *"Lophelia II" Exploration and Research of Northern Gulf of Mexico Deepwater Natural and Artificial Hard Bottom Habitats with Emphasis on Coral Communities: Reefs, Rigs and Wrecks***.** Dr. Brooks has been conducting research and oil industry-sponsored service projects in the Gulf of Mexico for the last 30 years. As part of his surface geochemical exploration (SGE) studies, which he developed for industry in the early 1980s, he has collected approximately 9,000 cores in the Gulf, mostly in deep water. These SGE coring studies resulted and contributed to the discoveries of macro oil seepage, chemosynthetic communities, and gas hydrates in the Gulf of Mexico. He was a co-discoverer of oil seep and chemosynthetic communities in the deep water Gulf of Mexico in 1985. He made the first discoveries of thermogenic gas hydrates in the deep water Gulf of Mexico that were published in *Science.* He participated in the initial discoveries of other oil-seep related phenomena including oil-stained cores on the continental slope, widespread occurrence of shallow and outcropping gas hydrates, brine seepage, and visible oil seepage to the sea surface. His current SGE coring and satellite seep studies in the southern Gulf for PEMEX resulted in a recent publication in *Science* on the discovery of tar flows and chemosynthetic communities in the Campeche Knoll region offshore Mexico. He has also made the first discovery of chemosynthetic ecosystems in West Africa (Nigeria), north of the equator. Dr. Brooks has over 210 peer-reviewed publications.

# PRELIMINARY BIOLOGICAL FINDINGS FROM 2008 ROV DIVES ON REEFS AND WRECKS

**Peter J. Etnoyer**
**Harte Research Institute, Texas A&M University – Corpus Christi**

**Michael Kullman**
**TDI-Brooks International**

**Douglas Weaver**
**Harte Research Institute, Texas A&M University – Corpus Christi**

**Erik E. Cordes**
**Biology Department, Temple University**

Click here to view the slide show that accompanied this presentation.

Two legs of the 2008 MMS Lophelia II project aboard the RV *Nancy Foster* surveyed and sampled benthic megafauna at nine sites in the northwestern Gulf of Mexico using the Saab Seaeye Falcon ROV in water 200–500 m deep between 5 September and 2 October 2008. Suspension feeding anthozoans were the predominant habitat forming species, including *Lophelia pertusa* scleractinian corals, large *Leiopathes* sp. black corals, *Callogorgia* and *Acanella* sp octocoral sea fans, *Actinia* sp. and the Venus Fly-trap anemone, *Actinoscyphia* sp.

The first leg of the cruise 5–17 September surveyed three shipwrecks with potential *L. pertusa* colonization: the Ewing Banks wreck (EB), the *Gulfoil*, and *Gulfpenn*. Six benthic surveys were accomplished on the second leg: Green Canyon (GC) 140, 9.5 hours; Garden Banks (GB) 201, 9.5 hours; GC234, 5.25 hours; GC 140, 7.33 hours; Mississippi Canyon (MC) 751, 8 hours; Vioska Knoll (VK) 906, 9 hours. The total cumulative survey time on the second leg was ~50 hours.

*Lophelia sp.* was identified on the *Gulfoil* wreck, EB wreck, and sites GC234, MC751, and VK906. The abundance of coral on the *Gulfoil* rivals the high coral cover of the *Gulfpenn*. Notable coral associated invertebrates encountered in the benthic surveys included *Euminida picta* galatheoid crabs, golden crab *Chaceon fenneri,* three species of basketstar, two species of urchin, and gooseneck barnacles. Galatheiod crabs, crinoids, and two species of urchins occurred on the surrounding soft bottom substrate.

Coral associated fishes included large groups of the Atlantic roughy *Hoplostethus occidentalis* and big roughy, *Gephyroberyx darwinii,* yellowfin bass *Anthias nicholsi,* and deepbody boarfish *Antigonia capros* among carbonate blocks, large black corals, and sea fans. Blackbelly rosefish *Helicolenus dactyloperus*, snowy grouper *Epinephelus niveatus,* thorny tinselfish *Grammicolepis*

*brachiusculus,* chain dogfish *Scyliorhinus retifer*, and the conger eel *Conger oceanicus* were associated with carbonate rocks and outcrops.

The hakes (*Urophycis* sp.and *Laemonema* spp.) were the most frequently sighted fishes on the soft bottom benthos, and large schools of barrelfish *Hyperoglyphe perciformis,* and lanternfishes family Myctophidae were locally common in the water column. Commercially fished species included barrelfish, snowy grouper, golden tilefish, the alfonsino *Beryx sp.* and the golden crab. Discarded longlines were present at two sites: GC 140 and VK 906.

At MC751, *L. pertusa*. co-occurred with vestimentifieran tubeworms, *Callogorgia* sp. sea fans, *Acesta* clams, urchins, and filamanetous bacteria at a presumed cold seep outcropping. This was most extensive *L. pertusa* aggregation observed on the cruise, second only to the previously explored VK826 site in terms of live coral cover. MC751 was ranked as a low priority during the site selection process due to low bathymetric relief, but mounds of *Lophelia* were present.

Gorgonian octocorals and antipatharian black corals were conspicuous at sites with carbonate slabs. Several collections were made, including two *L. pertusa*, 12 gorgonians from five genera and two black coral species. Directly associated with these habitat-forming species were four ophiuroids, two galatheoid crabs, and several stalked barnacles. One of the galatheoids was ovigerous. A single unhatched catshark egg case was recovered from a large antipatharian.

Large black corals were commonly observed at shallower (< 400 m) sites with large carbonate slabs. The largest black coral colonies measured ~1.5 m height and 2 m breadth. Large colonies appeared to provide habitat for associated species of fish (yellowtail bass, Atlantic roughy, and chain catshark) and invertebrates (stalked barnacles, galatheoid crabs, and basketstars). Black corals are not well documented as habitat formers, so this is important and noteworthy.

Other notable cruise highlights include the first occurrence of bubblegum coral *Paragorgia* sp. in the Gulf of Mexico, and remarkable feeding behavior for the crab *Euminida picta*. Bubblegum corals are common high latitude waters such as the coasts of Nova Scotia and Alaska, but have never been found in the Gulf. Galatheoid crabs are commonly associated with deep coral habitat and are presumed to be suspension feeders, but we witnessed *E. picta* predation on squid. There may also be evidence for echinoid predation on *L. pertusa* and *Acanella* sp. bamboo corals.

High quality standard definition video from the second leg of the cruise was edited to excerpts 4–13 minutes in duration using a consistent method in a new technique. The summary videos are intended to be comprehensive, consecutive, and fully representative. The diversity of geological features and biological occurrences is captured, but redundancy is minimized to reduce running time. The excerpts are a mnemonic device to aid in recollection and presentation of benthic survey results but could be suitable for analysis. An example will be provided.

To summarize, Lophelia II 2008 ROV surveys effectively enhanced our understanding of the benthos in the following ways: demonstrating that gorgonians and black corals are important habitat for fish and invertebrates 200–500 m, showing that galatheoid crabs are demersal predators, finding catsharks lay eggs on black corals, identifying at least one species never

**Table 1B.1.**

**A Summary of Biota and Their Relative Abundance at Dive Sites for Leg Two of Lophelia II, Fall 2008. The codes for the chart are: 0 = absent, + = present, ++ = abundant, +++ = very abundant.**

| Site | Fish | Crab | Lophelia | Gorgonacea | Antipatharia | Anemones | Class | Depth (m) |
|---|---|---|---|---|---|---|---|---|
| GC140b | ++ | 0 | 0 | ++ | + | 0 | Shallow | 230–280 |
| GC140a | ++ | + | 0 | + | + | ++ | Shallow | 270–300 |
| GB201 | + | + | 0 | + | + | + | Mid | 300–520 |
| VK906 | ++ | + | - | + | ++ | ++ | Mid | 380–410 |
| GC234 | +++ | +++ | + | ++ | 0 | 0 | Deep | 450–500 |
| MC751 | + | ++ | ++ | ++ | 0 | + | Deep | 450–500 |

known to occur in the Gulf, discovering a large healthy aggregation of *L. pertusa* co-occurring with tubeworms at a cold seep site, and introducing the first documentation of *L. pertusa* coral mounds in the Gulf of Mexico.

In general, all surveys were characterized by intermittent "patch reefs" of suspension feeding anthozoans on carbonate boulders with various degrees of surrounding soft sediment or rubble substrate between them, and a water column characterized by copious amounts of marine snow. *L. pertusa* was present at the deepest sites, while large black corals were present at the shallowest sites. Highest relative abundance of fish and crabs were at the deepest sites. Gorgonacea were common at all sites (Table 1B.1).

The benthic collections made during the expedition will prove useful, but future explorations would benefit greatly from a multi-chambered rotary suction sampler and a work class ROV with twin three-function manipulators to explore deeper water, enhance collection capabilities, increase productivity, and isolate biological specimens from a hostile environment. Custom designed collection tools would also be useful.

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Peter Etnoyer is a doctoral fellow at Harte Research Institute for Gulf of Mexico Studies (HRI) at Texas A&M University - Corpus Christi with a background in octocoral systematics, marine ecology, and geographic information systems. He holds a master's and bachelor's degree from Duke University and a NOAA David Johnson Award (2008) for outstanding and innovative use of satellite data. His role on the Lophelia II project is to collect and identify deep-sea octocorals and to produce a high-definition documentary video chronicling the four-year research project.

Douglas Weaver is a marine biologist and geographic information specialist who has been diving and conducting research in the Gulf of Mexico for 20 years. He received his undergraduate degrees in marine biology and art from Millersville University (PA), and his master's degree in zoology from the University of Florida. He is currently pursuing his Ph.D. in reef fish ecology and deep reef habitat characterization at Texas A&M, Corpus Christi. His research interests

include coral reef fish biology and ecology, landscape ecology, and seafloor characterization of shelf-edge hardbottom and coral reef communities.

# LOPHELIA II: PRELIMINARY ARCHEOLOGICAL FINDINGS FROM 2008 ROV DIVES

**Robert A. Church, Daniel Warren, and Robert Westrick**
**C & C Technologies, Inc.**

Click here to view the slide show that accompanied this presentation.

An interdisciplinary research team of archaeologists and biologists setout on the first leg of the first cruise of the four-year Reefs, Rigs, and Wrecks Study sponsored by the MMS and NOAA OER. The cruise took place onboard NOAA's Research Ship *Nancy Foster* utilizing a Falcon SeaEye ROV from Sea Vision. The main objective of the first shipwreck cruise was to conduct a reconnaissance of eight shipwreck sites and assess the archaeological and biological potential of the wrecks for inclusion in project. Five of the sites have not previously been explored. The eight sites for the reconnaissance included the "Ewing Banks Wreck" site, the *Gulfpenn* site (previously investigated), the tentatively identified *Gulfoil* site, the "Green Lantern" site (previously investigated), the tentatively identified *Holly Ann Vieser* site, the "Oval Shape" site, the "Steel Hull" site, and the "Viosca Knoll Wreck" site (previously investigated). Secondary objectives included photo mosaics of each site, visual area survey around the sites to determine the extent of artifact scatter, detailed imaging of coral colonies at each site, collecting coral samples, collecting four sediment cores at each site, setting temperature loggers at select coral sites on the wrecks, reexamining a microbiology experiment placed at *Gulfpenn* in 2004, setting microbiology experiments at two additional wreck sites, and locating the missing stern section of *Gulfpenn*.

Hampered by inclement weather and equipment problems, the team was only able to dive on four of the wreck sites: the Ewing Banks Wreck, *Gulfpenn*, the potential *Gulfoil*, and the Green Lantern Wreck. The greatest hindrance to the expedition was Hurricane Ike, which arrived in the middle of the cruise. The team was only able to investigate two of the sites before the storm and two sites after the storm passed. The dive at the Green Lantern Wreck Site, however, had to be aborted, because of poor visibility and stronger than normal current on the heels of the Hurricane.

Despite limited dive time and adverse conditions, several project goals were achieved. The team confirmed that the two previously unexplored sites (the Ewing Banks Wreck and the potential *Gulfoil*) were historically and biologically significant sites. The *Gulfoil* site was identified and substantial *Lophelia* was discovered colonizing the surface of the shipwreck. The Ewing Banks Wreck was found to be a historic copper-clad sailing vessel with more *Lophelia* growing on it than has been found on other wooden shipwreck sites in the Gulf of Mexico. The lack of machinery, chain, or evidence of mast or rigging, however, left more questions than answers. In addition, a few of the secondary objectives were also met, including placing a temperature logger at *Gulfpenn*, locating her missing stern section, and reexamining the previously placed

experiment at the site. A good recognizance was conducted of the Ewing Banks Wreck and a small wood sample was collected, which is yielding promising results regarding microbial activity in the wood.

Future field work regarding the shipwreck component of the project should concentrate on sites that are both historically and biological significant, such as *Gulfoil*, *Gulfpenn* , the Ewing Banks Wreck, the Viosca Knoll Wreck, & the Green Lantern Wreck (most archaeological objectives have been meet at Gulfpenn as a result of Study MMS 2007-15). Two unidentified sites, referred to as "Steel Hull" and the "7,000-foot Wreck," remain a high priority for future investigation. During the next field season, the team plans to recover select diagnostic martial remains from the older wreck site to aid in identification. Other goals include mapping the site boundaries and artifact field of *Gulfoil* and placing additional microbial test platforms at select sites to analyze the deterioration rate.

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Robert Church is the senior marine archaeologist with C & C Technologies, Inc. of Lafayette, Louisiana. He has led numerous deepwater shipwreck investigations in the Gulf of Mexico, including the recently completed Deep Wrecks I Study (MMS 2007-015), the "Viosca Knoll Wreck" Project (MMS 2008-018), and the 2001 initial investigation of the *U-166* wreck site. Mr. Church has an M.A. degree in maritime history and nautical archaeology from East Carolina University and a B.A. degree in history with a minor in biology from the University of Arkansas at Little Rock. Mr. Church was the Chief Scientist for the first cruise leg of the MMS and NOAA's new deepwater Reefs, Rigs, and Wrecks Study.

Daniel Warren is the senior marine archaeologist with C & C Technologies, Inc. and Assistant Geosciences Manager in C &C's Houston office. He was the Co-P.I. for the MMS/NOPP's Deep Wrecks I Study (MMS 2007-015), and the Chief Scientists for the NOAA OE, U-166 mapping Project in 2003, and P.I. for the project to identify the Steam Yacht, Anona in 2002. Mr. Warren has a B.A. degree in anthropology with a minor in history from the University of Illinois at Champaign-Urbana and an M.A. degree in maritime history and nautical archaeology from East Carolina University. He is the archaeology P.I. for the MMS and NOAA's new deepwater Reefs, Rigs, and Wrecks Study.

Robert Westrick is a marine archaeologist with C & C Technologies, Inc. of Lafayette, Louisiana. He has worked on a number of underwater archaeology projects, including the excavation of Blackbeard's *Queen Anne's Revenge*, and the excavation of El Capitana El Rubi: A Spanish galleon shipwreck from the 1733 plate fleet. He has a B.A. degree in business administration with a minor in history from the University of Toledo and an M.A. degree in maritime history and nautical archaeology from East Carolina University. Mr. Westrick was a field archaeologist on the first cruise leg of the MMS and NOAA's new deepwater Reefs, Rigs, and Wrecks Study.

# SESSION 1C

# HURRICANES

**Chair:** **Bob Cameron, Minerals Management Service**

**Co-Chair:** **Pat Fitzpatrick, Minerals Management Service**

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# THE NATIONAL HURRICANE CENTER: FORECAST PROCESS AND RESEARCH FOR IMPROVING FORECASTS

**Jack Beven**
**Senior Hurricane Specialist**
**National Hurricane Center**

Click here to view the slide show that accompanied this presentation.

This talk covers the operations at the National Hurricane Center (NHC), starting with the products of the Tropical Cyclone Advisory suite, the associated graphical products, and the non-tropical cyclone products issued by the center. It discusses how the NHC forecasts hurricanes, including the data used in tracking the storm and the process used in creating the forecasts. It includes a discussion of the current track and intensity forecast errors, coordination of watches and warnings, and information on research to improve the forecasts.

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Jack Beven is a Senior Hurricane Forecaster at the National Hurricane Center (NHC) in Miami. Previously, he worked as a Forecaster development meteorologist in the Tropical Satellite and Forecast Unit of the Tropical Prediction Center, a Lead Marine and Aviation Forecaster in the Tropical Analysis Branch of the TPC and a Hurricane Forecaster at NHC. He holds a B.S. in physics with a combined astronomy/geology minor from LSU and M.S. and Ph.D. degrees in meteorology from Florida State University.

# HURRICANE METOCEAN HINDCASTING

**Vincent J. Cardone**
**Oceanweather Inc., Cos Cob, CT**

Click here to view the slide show that accompanied this presentation.

Since the end of World War II, increasingly intense and sophisticated monitoring of the location, intensity, and internal meteorological structure of hurricanes that threaten the Atlantic and Gulf coasts of the United States (US) has been afforded by *in situ* weather stations (coastal and island stations and later offshore moored data buoys and instrumented offshore platforms), satellite remote sensing from geostationary and polar orbiters, and airborne flight level and remote sensing. Direct measurements of boundary layer winds with the Stepped Frequency Microwave Radiometer (SFMR) and the GPS Dropwindsonde allow the diagnosis of the time and space evolution of complex boundary layer wind distributions with unprecedented degree of accuracy. This, in turn, has allowed more accurate hindcasting of ocean response (waves, mixed layer currents, storm surge) using modern numerical models.

The extreme ocean response exhibited by recent devastating US Gulf storms Ivan (2004, Cox et al. 2005), Katrina (2005, Cardone et al. 2007) and Ike highlight the severe limitations of simple intensity scales such as Saffir-Simpson and simple wind models such as the Holland model for hindcasting (and warning) purposes. Fortunately, modern computer power allows the application of the most sophisticated analysis techniques and models to large populations of real historical storms or synthetic storms (within the joint probability approach) to improve reliability of offshore meteocean design criteria. Extensive validation of the most robust third-generation (3G) wave hindcast technology (e.g. Khanekar et al. 1994) against wave measurements in recent US Gulf storms show that peak significant wave height (spectral peak wave period) along the track of a major storm may be specified with bias of order 10 cm (1.0 sec), and scatter index (ratio of standard deviation between the hindcast and the measurement/mean of measurement sample) of 0.15 or less (Reece and Cardone 1982; Cardone et al. 1996; Jensen et al. 2006; Forristall 2007).

Despite this progress, several critical issues require additional research. Differences in tuning of wave model source term physics and differing assumptions about the air-sea momentum transfer (drag) coefficient result in larger, mainly positive, hindcast biases in some variants of currently applied 3G models. This implies uncertainty in the wave response of the most extreme hurricanes such as storm of Maximum Potential Intensity (MPI). In addition, while high resolution coupled mesoscale dynamical models (e.g. MM5, HWRF) have greatly improved in recent years and yield important process knowledge, their surface wind fields are still not as accurate as wind fields produced by intensive assimilation of measurements using either kinematic analysis approaches (such as NOAA's HWnd (Powell et al. 2008), Oceanweather's IOKA (Cox and Cardone 2000), or application of planetary boundary models applied in a

diagnostic sense and driven by detailed forcing derived from measured data. (Thompson and Cardone 1996).

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Dr. Vincent Cardone received his Ph.D. from the Department of Meteorology and Oceanography of New York University (NYU) in 1970. He served on the faculties of NYU and City College of New York before founding Oceanweather, Inc. He has authored or co-authored over 75 papers on wind and wave modeling, wave hindcasting and forecasting, evaluation of remote marine wind sensing systems, air-sea interaction, tropical cyclone wind modeling, and assessment of wind and ocean response climate. He is a Fellow of the American Meteorological Society and has served on national and international committees including the NASA Spacecraft Applications Advisory Committee, the Scientific Committee on Research (SCOR) Working Group on Waves, the International Ship and Offshore Structures (ISSC) Environmental Committee and as a Board Member of the US Commercial Weather Services Association. Recently he served on the Interagency Performance Evaluation Task Force (IPET) set up in the wake of the Hurricane Katrina to develop a New Orleans Hurricane Protection System.

## GULF OF MEXICO HURRICANE DAMAGE POTENTIAL SCALE

**Jill Hasling**
**Weather Research Center**

Click here to view the slide show that accompanied this presentation.

2004, 2005 and 2008 remind us that major hurricanes have returned to the Gulf of Mexico. Anyone old enough can remember the busy decade of the 1960s. When you review the Category 4 hurricanes on the Saffir/Simpson Scale that moved over the oil and gas leases of the Gulf of Mexico, the 1960s were a very busy decade with Hurricane Carla – 1961, Hurricane Hilda – 1964, Hurricane Betsy – 1965, Hurricane Beulah – 1967 and Hurricane Camille – 1969. This is compared with Hurricane Ivan – 2004, Hurricanes Katrina and Rita – 2005 and Hurricanes Gustav and Ike – 2008. Hurricane Ike demonstrated that a hurricane does not have to be a Category 4 hurricane to cause devastating waves, but that size matters.

Meteorologists at Weather Research Center are using GIS mapping to study past, present and future Gulf of Mexico hurricanes. This tool has led to the development of the Freeman Damage Potential Scale that could be used to forecast potential damage to offshore facilities in the Gulf of Mexico. Hurricanes come in all sizes, intensities and speeds. Using Weather Research Center's Hurricane Wind and Wave Model, past hurricanes are mapped with the platforms that could be at risk from high waves.

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Jill F. Hasling is President of Weather Research Center and Director of The John C. Freeman Weather Museum. She became a Board Certified Consulting Meteorologist (CCM) of the American Meteorological Society (AMS) in 1992 and Fellow of the Society in 2000 and is still one of the few women Fellows of the Society. Jill was the sixth woman to become a CCM; in 1992 she became the first woman member of the National Council of Industrial Meteorologists (NCIM), an association of private sector meteorologists, and served as the first woman President of NCIM in 2001. She also serves on the Council of the AMS and the National Weather Association.

Jill has worked in the field of meteorology since 1974 as a programmer, forecaster, researcher, and forensic meteorologist. She founded Weather Research Center with her father, Dr. John C. Freeman, in 1987. Through WRC, Jill has devoted her career to teaching other meteorologists the skills necessary to become marine and tropical meteorologists. WRC's outreach programs have served nearly 1,000,000 people in the community.

Jill was Chairman of the AMS Board of Certified Consulting Meteorologists in 2008 and is Co-Chair of the AMS WeatherFest Committee. She is also a member of the Marine Technology Society and National Council of Industrial Meteorologists.

## UNMANNED AIRCRAFT HURRICANE RECONNAISSANCE

**Pat Fitzpatrick**
**GeoSystems Research Institute**
**Mississippi State University at Stennis Space Center**

Click here to view the slide show that accompanied this presentation.

Unmanned platforms released into the tropical cyclone environment offer excellent potential for improved understanding of hurricane science and advancing forecasting skill. NOAA is pursuing this potential through two methodologies: Unmanned Aircraft Systems (UAS) and constant altitude balloons. These platforms can take measurements in data-sparse regions and/or otherwise dangerous regions that reconnaissance flights need to avoid.

While a variety of UAS platforms exist for a variety of military and marine science applications, the primary plane used for hurricanes is the *Aerosonde.* The Aerosonde has been in development since the 1990s, and even flew across the Atlantic in a test flight in 1998, taking observations continuously. From 2000–2004, prototype flights into typhoons from Taiwan were unsuccessful, crashing into spiral bands or the eyewall. However, in 2005, one successfully circled Hurricane Ophelia and returned to its base, and another Taiwan flight successfully penetrated Typhoon Longwang's eyewall.

In 2007, the first successful flight into an Atlantic hurricane (Hurricane Noel) occurred. A NASA chase aircraft escorted the Aerosonde for the first three hours of the mission at a nominal altitude of 4,000 ft. until well offshore and returned to Wallops when weather conditions deteriorated in closer proximity to the hurricane. The UAS mission continued overnight with the Aerosonde being drawn into the core of the hurricane and measuring winds as high as 80 mph. The Aerosonde followed the storm core taking measurements and loitering in the eyewall with several ascending/descending passes. As the Aerosonde approached the center of Noel from the north around 400 m altitude, a reconnaissance P-3 penetrated from east to west at around 3,500 m altitude and also released GPS dropsondes. This shows some of the UAS advantages: it can collect data right above the sea (in the boundary layer) where P-3s cannot, can take measurements at many different levels as well as with multiple vertical ascents and descents, and can supplement reconnaissance flights with simultaneous observations. Other advantages of the Aerosonde include its potential recoverability (such as in Ophelia) and its lower cost compared to manned flights.

A current disadvantage involves flight restrictions from the FAA including around offshore oil rigs.

The Aerosonde has the following specs:

- Wing span: 2.9 m
- Flight speed: 15–60 m/s
- Maximum range: 2,500 km (less for high speed, low altitude missions)
- Altitude range: 100–5,000 m
- Launch system: car/roof-rack system (55 mph launch speed needed)
- Measurements: pressure, temperature, relative humidity, winds (Errors: 1 mb, 0.1 C, 2 –5%RH, 1 m/s)

More information is available at http://uas.noaa.gov and http://www.aerosonde.com.

Another NOAA initiative is called the Weather In Situ Deployment Optimization Method (WISDOM). The WISDOM project seeks to improve three to seven day hurricane track and intensity predictions by deploying "super pressure" near-constant altitude balloons into the hurricane environment. In this application, WISDOM GPS/SATCOM Radio attached to the balloon is used to measure wind via measurement of latitude, longitude, and altitude over a period of five to ten days. Future generations of the payload will also include measurements of temperature, pressure, and relative humidity. A proof of concept occurred in 2008, in which balloons were successfully launched from Colorado by NOAA employees, and from Mississippi, Florida, Puerto Rico, and Barbados by students from Mississippi State University, the University of Miami, and the Caribbean Institute for Meteorology and Hydrology. Post-launch teleconference briefings included meteorological, ensemble models, and trajectory discussions.

It is anticipated that the WISDOM Project will expand in the 2009 hurricane season, including possibly a mission in which hundreds of balloons launches will "saturate" a major hurricane environment (based on trajectory models) which could be used for a field study and modeling tests.

More information is available at http://wisdom.noaa.gov, which also contains data archives.

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Pat Fitzpatrick received his B.S. and M.S. degrees in meteorology from Texas A&M University and his Ph.D. in meteorology from Colorado State University. He is an associate research professor at Mississippi State University. Dr. Fitzpatrick has also served on the faculties of Jackson State University, Colorado State University, and Texas A&M and has worked as a hurricane forecaster for Shell Oil. His research interests include hurricanes, storm surge, numerical modeling, data assimilation, and severe weather. He has authored several peer reviewed publication and two books.

## HURRICANE SIZE VERSUS INTENSITY AND IMPLICATIONS REGARDING IMPACT

**Lieutenant Colonel Richard G. Henning, USAF Reserve (Retired)**
**Consulting Meteorologist**

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In early September 2008, Hurricane Ike crossed the Gulf of Mexico diagonally (moving from the western tip of Cuba on Tuesday 9 September to landfall just after midnight on Saturday morning 13 September). During this four-day interval, Ike was listed as either a Category 1 or 2 storm on the Saffir Simpson Scale. In spite of never being classified as an "intense" hurricane (Category 3 or higher) during this period, it generated a substantial envelope of very large waves that resulted in a surprising amount of damage to gas and oil production facilities in the northwestern Gulf. With a 520 nautical mile radius of sustained tropical storm force winds (in excess of 34 knots), in spite of the storm lacking more intense winds in its core, the abnormally large fetch around the periphery of Ike allowed an enormous amount of wave energy to accumulate across vast reaches of the Gulf.

The ability of a hurricane to generate waves in deep water settings (and its ability to generate surge upon reaching shallow water at landfall) depend upon factors that are not well captured by the Saffir Simpson Scale. These include the following:

- The size of the RMW (Radius of Maximum Winds) along with the corresponding size of the envelopes containing hurricane force winds (greater than 64 knots), winds greater than 50 knots, and gale force (or tropical storm force) winds

- The fetch of the winds blowing across the ocean surface (the length, orientation, and the duration of these wind vectors)

- Bathymetry (depth and shape) of the sea floor

Small but intense, tightly structured, hurricanes (with very small eyes surrounded by a single, very intense eyewall containing a single powerful wind field maximum) are inherently unstable. They tend to be short-lived phenomena, evolving through internal mechanisms into core regions characterized by multiple eyewalls, much larger eyes, and greatly expanded wind fields.

Passage over land tends to hasten the breakdown of the single, tightly structured core into a broader center (ie: Gustav over western Cuba, Ike over eastern Cuba, Andrew over the Florida Everglades in 1992)

Passage over land, however, is not necessary for such a change to occur (ie: Wilma changed greatly over the Northwest Caribbean prior to landfall over the Yucatan Peninsula, Katrina's

wind field weakened in intensity but expanded greatly in size over the open waters of the northern Gulf well before landfall, Rita developed multiple eyewalls over the center of the Gulf) While such transformation is nearly inevitable, it is not certain to occur (i.e., Camille in 1969 maintained a very small core structure across the entire Gulf).

Such was the case during the summer of 2008 with both Ike and Gustav, two intense, tightly structured Category 4 hurricanes that were both greatly changed in terms of their inner core structure by passage over Cuba. In both cases, they became much larger hurricanes with the potential to generate substantial wave action over a much larger portion of the northern Gulf, thereby impacting more production facilities. However, even though very high waves (with maximum significant wave heights in excess of 30 feet) were dispersed over a wider area (making more platforms vulnerable to damage), this dispersion of wave energy made the class of waves seen in Ivan, Katrina and Rita (where maximum significant wave heights exceeded 50 feet in all three storms) less likely to occur, reducing the number of facilities that faced the kind of complete destruction seen in these storms of 2004 and 2005.

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On 1 January 2009, Lieutenant Colonel Richard Henning retired from the U.S. Air Force Reserves after a total of 24 years in uniform. His career included 14 years flying as a member of the 53rd Weather Reconnaissance Squadron, the Hurricane Hunters, based out of Biloxi, MS., logging 167 hurricane eyewall penetrations. He served as the airborne Mission Director leading reconnaissance missions into over 40 named storms, of which 28 were hurricanes including flights in recent years into notable Gulf Hurricanes Ivan, Katrina, Gustav and Ike. For the past four years, he has been a Consulting Meteorologist to over 25 law firms along the Gulf Coast involved in hurricane litigation, writing reports on over 300 property locations impacted by recent storms and providing expert witness testimony on over 40 cases.

# PALEOTEMPESTOLOGY: GEOLOGICAL RECORDS OF PREHISTORIC HURRICANE ACTIVITY

**Terry McCloskey and Kam-biu Liu**
**Department of Oceanography & Coastal Sciences**
**Louisiana State University**

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Paleotempestology is a young field of science that studies past hurricane activities by means of geological and archival techniques. The overall purpose of paleotempestology is to extend the short historical hurricane record thousands of years into the past, primarily by examining sedimentary records. To date, the most successfully utilized geologic proxy has been the identification of overwash sand layers deposited by hurricane-generated storm surges in coastal wetlands. The basic conceptual and methodological framework supporting paleotempestology are described. Important findings from the Gulf coast of the United States indicate that the regionally averaged return period for "catastrophic" storms (category 4 or higher) is ~ 300 years. However, this long-term average ignores observed millennial scale variability in activity, with catastrophic events occurring three to five times more frequently during the active periods. To understand the forcing mechanisms behind these activity regime changes studies are now being conducted throughout the circum-Caribbean area. Preliminary evidence suggests that low frequency latitudinal movement of the North Atlantic circulation system may be driving a slow north/south migration of the zone of maximum hurricane activity.

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Terry McCloskey graduated magna cum laude from Princeton University with a B.A. in geosciences. He is currently a doctoral candidate in the department of Oceanography and Coastal Sciences at Louisiana State University, where he was awarded a NSF Graduate Research Fellowship. His research focuses on establishing multi-millennial hurricane strike records for several sites within the greater North Atlantic basin.

# SESSION 1D

# SEAFLOOR DISTURBANCE

**Chair:** **Dave Moran, Minerals Management Service**

**Co-Chair:** **Maureen Mulino, Minerals Management Service**

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# CONVENTIONAL BARGE ANCHORING TECHNIQUES AND AVOIDANCE METHODS

**Don Eckert**
**Global Industries**

Click here to view the slide show that accompanied this presentation.

This report reviews the anchoring system components for conventional pipelay barges. It also details how barges use their anchoring systems to avoid biologically sensitive seafloor areas while laying flowlines.

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Don Eckert has 30 years of experience in the oil and gas industry, the last 20 of which have been with Global Industries, where he works as Lead Equipment Engineer.

## ESTABLISHING MOORING FOUNDATIONS AND SEAFLOOR INTERFACE

**Matt Smith**
**Delmar**

Click here to view the slide show that accompanied this presentation.

Typical mooring foundations utilized in mooring MODUs in the USGOM have varying effects on the seafloor surface. Drag embedment anchors, drag-installed vertically loaded anchors, suction piles, and gravity installed anchors — each of these will cause a different amount of the seafloor soil to be disturbed. Additional considerations of this discussion include conventional anchor deployment from MODU self-contained mooring systems and the grounded length section of the mooring system when connected to the vessel. Because each of these anchor foundation types has specific installation procedures, discussion will highlight the different effects of these procedure and mooring components on what will be considered "virgin" sea floor conditions.

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Matt Smith serves as Vice President of Operations for Delmar Systems Inc. in Broussard, Louisiana. His career in offshore anchor handling began in 1981. As a crew member for several mooring contractors prior to his employment at Delmar in 1996, he worked from entry level to Offshore Crew Superintendent. When Delmar initiated a technical support effort in the mid-nineties, he transferred to Houston and functioned as a Special Project Coordinator and Consultant in support of both domestic and foreign mooring operations. In his current capacity, he serves to bridge the interface between operations and engineering for Delmar. He collaborates closely with Delmar's Engineering Manager Evan Zimmerman to unify engineering and operations in support of the mooring operations carried out by Delmar.

## ANCHORS FOR DEEPWATER MOORING — PLANNING AND INSTALLATION

**Jamie Armstrong and Bob Wilde**
**Intermoor, Inc.**

Click here to view the slide show that accompanied this presentation.

This presentation overviews MODU and FPU mooring system planning and installation techniques used to prevent disturbance of chemosynthetic communities and to avoid seafloor geohazards. A review of anchor types and their associated seafloor footprints is also presented.

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Jamie Armstrong is Senior Operations Engineer with InterMoor Inc. He has worked for InterMoor for over six years and specializes in mooring system design and installation of both temporary and permanent installations. For the last year and a half, he has been the lead engineer planning the mooring installation and platform tow out of the ATP MinDOC Mirage platform under construction in Corpus Christi. Jamie received his B.S. in ocean engineering from Texas A&M University.

Bob Wilde received his B.S. in civil engineering from California State University, Fresno, and his M.S. in structural engineering from University of California, Berkeley. He is a licensed professional engineer in the states of Texas and California. He has 31 years of experience in the energy industry, 27 years of that in the offshore oil industry. Since 1986, he has been involved in the design and fabrication of foundations and tethering systems for floating structures including Conoco Jolliet, Conoco Heidrun, Exxon Diana, Vastar Horn Mountain, Kerr-McGee Red Hawk and BP Holstein, Thunder Horse, Mad Dog, Shell Perdido and Chevron Tahiti. He is Chief Engineer for InterMoor where he directs the research and development activities, including a new enhanced passive compensator design. He is a co-inventor of the suction embedded plate anchor known as the SEPLA.

## ENVIRONMENTAL PROTECTION THROUGH IMPROVED COMMUNICATION

**Jack Garrett**
**GulfSafe**

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### Why GulfSafe

For years offshore excavators, dredging contractors and researchers have been confronted with the challenge of finding the exact location of offshore pipelines and utilities throughout the Gulf of Mexico. Mapping systems provide general information; however, strong currents often move the locations of subsea systems. Finding a current list of facility owners and their contacts has also been difficult. Therefore, an offshore damage prevention and notification system is needed.

– Over 35,000 miles of pipelines crisscross the floor of the Gulf.
– Thousands of miles of telecommunications cables exist there today.
– Soon, wind generation of electricity will begin in the Gulf.

Our nation's critical infrastructure is expanding offshore and GulfSafe was formed to meet the challenges of working in this complex and dangerous environment. In 2007, 811 was launched to elevate awareness of land-based notification systems. Onshore 811, Offshore GulfSafe.com.

### Who We Are

Texas Excavation Safety System, Inc. (TESS) has over 20 years of notification system experience, and operates the only notification system functioning in the offshore environment.

### GulfSafe Operation

GulfSafe begins operation first quarter 2009. Unlike traditional one-call operations, GulfSafe's notification process is primarily web-based. Use of the service to request notifications of activity is free. All costs are paid by member companies.

GulfSafe will begin by serving four of the Minerals Management Service Planning areas for the Outer Continental Shelf (OCS): the Western Gulf of Mexico; Central Gulf of Mexico; Eastern Gulf of Mexico and the Straits of Florida. Expansion into other planning areas will take place as needed.

### Advantages

– No cost to the excavator or public
– Significantly improves current prevention programs

– Improves worker & public safety
– Creates jobs and tax revenue for the state
– Can be written into rule or a requirement for lease holders
– Improves protection for the environment
– Reduces the possibility of a negative economic impact
– Provides one unified system for all coastal states' submerged lands and federal waters

## Contact GulfSafe


| Director of Regulatory Services | Director of Damage Prevention |
|---|---|
| Jack Garrett | David Wofford |
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| jackgarrett@gulfsafe.com | davidwofford@gulfsafe.com |


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Jack Garrett is the Director of Regulatory Services with GulfSafe. He has 18 years of experience working in damage prevention and utility management. His background includes work in telecommunications, natural gas distribution, liquid pipelines as well as electric distribution. He has held the positions of Quality Assurance Manager, Corporate Training Manager with several subsidiaries of large utilities and pipeline companies. Jack has spent the last eight years working for Texas Excavation Safety System Inc. the parent company of GulfSafe, the first One-Call Notification System designed to work exclusively in a maritime environment covering the Gulf of Mexico and the Straits of Florida.

Website: www.GulfSafe.com

# SESSION 1E

## GOM DEEPWATER BENTHIC HABITATS II
## MMS/NOAA OER/USGS
## Collaborative Studies: Continuation of Deepwater Coral Session and Investigations of Chemosynthetic Communities on the Lower Slope of the GOM; Final Project Year

**Chair:** **Gregory Boland, Minerals Management Service**

**Co-Chair:** **James Sinclair, Minerals Management Service**

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## TRENDS IN *LOPHELIA* MICROBIOLOGY: FROM THE GULF TO GLOBAL

**Christina Kellogg**
**U.S. Geological Survey**

Click here to view the slide show that accompanied this presentation.

Corals are now recognized to be holobionts (compound organisms), composed of the coral animal plus associated microbes, both eukaryotic and prokaryotic. Studies of shallow-water corals suggest that associated bacteria may benefit the corals by cycling carbon, fixing nitrogen, chelating iron, and producing antibiotics that protect the coral from other microbes. Cold-water or deep-sea corals have a fundamentally different ecology due to their adaptation to cold, dark, high-pressure environments, and as such have novel microbiota. The goal of this study was to characterize the microbial associates of the cold-water scleractinian coral, *Lophelia pertusa*, from two sites in the northeastern Gulf of Mexico. Multiple individual colonies from two geographic locations were compared to clarify whether *Lophelia* has a species-specific bacterial community, as has been described for shallow-water corals (e.g., Ritchie and Smith 1997; Rohwer et al. 2002), and to refine the microbial diversity associated with this cold-water coral. This is the first study to collect the coral samples in individual insulated containers and preserve them at depth in an effort to minimize thermal shock and maintain *in-situ* microbial diversity. It is also the first study to employ both culture-based and molecular techniques to characterize the microbial ecology of *Lophelia*. Comparing sequence data from the Gulf of Mexico to sequence data from Norwegian fjords revealed that there are conserved *Lophelia*-specific bacterial symbionts.

To date, only two microbiological studies have been published on *Lophelia pertusa*. Yakimov et al. (2006) investigated *Lophelia pertusa* in the Mediterranean basin. The coral-associated bacterial communities were distinct from those of the water column and benthos. However, only 12 unique bacterial sequences were obtained from live *Lophelia*, and these classified within the *Proteobacteria*, *Holophaga-Acidobacteria*, and *Nitrospira* groups (Yakimov et al. 2006). Recently, a more comprehensive study analyzed 340 bacterial sequences from *Lophelia* sampled in a Norwegian fjord (Neulinger et al. 2008). This Gulf of Mexico study is the largest yet, with 508 *Lophelia*-associated bacterial sequences analyzed. Larger sample sets reveal more biodiversity and uncover rare microorganisms.

An issue of concern is the care with which samples need to be collected for microbial-ecology studies. Deep-sea coral samples are typically collected by a trawl, net, dredge, or by a submersible/ROV. With these methods, many corals may be combined in a single container, which is not acceptable for microbiological studies because the microbial community of one coral could contaminate that of the other. Similarly, contact with sediment, other invertebrates, mobile fauna, or water masses between the collection point and the surface could contaminate the coral samples. Additionally, there is concern that changes in temperature and pressure such

as those that exist between the seafloor and the surface could affect the microbial community associated with these corals (i.e., the bacterial community may shift in response to these factors). A special sampling device was designed and built to minimize these concerns while collecting samples for this study.

Glycerol artificial seawater agar was used to culture bacteria from *Lophelia* mucus/tissue slurries. Bacterial genera included both those typically cultured from shallow-water tropical corals and deep-water psychrophiles (bacteria adapted to cold environments). Unusual isolates are being further characterized by antibiotic-resistance profiles, carbon-utilization patterns, and fatty-acid composition.

Molecular analysis of bacterial diversity showed a marked difference between the two study sites, Visoca Knoll 906/862 and Visoca Knoll 826, that are about 20 nautical miles apart. The bacterial communities from VK826 were dominated by a variety of unknown mycoplasmal *Tenericutes* and *Bacteroidetes*, whereas the libraries from VK906/862 were dominated by *Proteobacteria*. In addition to many novel sequences, the 16S rRNA clone libraries revealed bacterial sequences in common between Gulf of Mexico *Lophelia* and Norwegian fjord *Lophelia*, shallow-water corals and deep-sea octocorals. A cluster of ribotypes, present in all *Lophelia* colonies analyzed (n=6), is related to sulfide-oxidizing gill symbionts of seep clams and was 95-97% similar to sequences found in Norwegian *Lophelia*. The presence of a mycoplasmal sequence nearly identical (99% similarity) to that found associated with Norwegian *Lophelia* also indicates that in spite of the geographic heterogeneity observed in *Lophelia*-associated bacterial communities, there are *Lophelia*-specific microbes.

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Christina A. Kellogg received her Ph.D. in marine microbiology from the University of South Florida for her work on the genetic diversity of environmental viruses. She did postdoctoral research on an NIH-funded fellowship at the Georgetown University Medical Center, using molecular methods to identify novel drug targets in pathogenic fungi. She also interned for several months at Human Genome Sciences, processing microarrays and using bioinformatics software to mine the data. She joined the U.S. Geological Survey as one of the first Mendenhall Fellows, characterizing the microbial communities in African dust, beach sediments, sea grass beds and coral reefs. In her current position as an environmental microbiologist, Christina applies molecular techniques and classical microbiological methods to study microbes in aerosols, the marine environment, tropical corals and deep-sea corals.

# INTRODUCTION AND PROJECT OVERVIEW, YEAR 3: INVESTIGATIONS OF CHEMOSYNTHETIC COMMUNITIES ON THE LOWER CONTINENTAL SLOPE OF THE GULF OF MEXICO: "CHEMO III"

**James M. Brooks**
**TDI-Brooks International, Inc.**

Click here to view the slide show that accompanied this presentation.

In 2005, TDI-Brooks International Inc. was awarded contract number: 1435-01-05-39187, "Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico" (CHEMO III), issued by the U.S. Department of the Interior, Minerals Management Service. This presentation summarizes information regarding operational procedures, stations occupied, sampling activity, future activities, and schedules for this program. Preliminary results for different aspects of the program are presented by the following:

- Site selection and geology of key Chemo III sites, Dr. Harry H. Roberts;
- Reconnaissance methods for a regional inventory of seep chemosynthetic communities, Dr. Ian R. MacDonald;
- Patterns of microbial activity and distribution in sediments of the deep slope, northern Gulf of Mexico, Dr. Samantha B. Joye;
- Preliminary investigations of the hard-ground communities below 1,000 meters in the northern Gulf of Mexico, Dr. Erik C. Cordes;
- Trophic relations and interactions with background fauna, Dr. Robert S. Carney.

Three cruises and an AUV survey were completed for this contract. The Reconnaissance Cruise was conducted on the TDI-Brooks research vessel R/V *Gyre* from 11 to 25 March 2006, and was the initial cruise conducted for this contract. The cruise was completed in two week-long legs with an interim port call in Venice, Louisiana. Leg I (11–18 March) was dedicated to drift camera work to survey the sea-bed at selected sites. Leg II (19–25 March) involved both drift camera and trawling/box core work efforts. The cruise mobilized and embarked from Freeport, Texas. The objective was to provide timely input for the site selection process for the subsequent A*lvin* expedition (May 2006). The Deep Chemosynthetic Community Characterization Cruise was conducted on the Wood's Hole Oceanographic Institute (WHOI) research vessel R/V *ATLANTIS* and the *Alvin* Deep Submergence Vehicle (DSV) from 7 May–2 June 2006, and was the second cruise conducted for this contract. The cruise mobilized and embarked from Key West, Florida, and de-mobilized at Galveston, Texas. In February 2007, sampling sites were mapped in great detail using the C & C Technologies Autonomous Underwater Vehicle (AUV) in preparation for intensive sampling planned for the 2007 field season. The AUV is equipped with instrumentation for collecting high-resolution multibeam bathymetry, chirp sonar subbottom profiles, and side-scan sonar swaths. AUV data sets for AT340, GC852, WR 269, and AC 601 were acquired. The Deep Chemosynthetic Reconnaissance II Cruise (DCR2) was

conducted on the NOAA Ship research vessel *Ronald H. Brown* and the ROV *Jason* from 4 June–6 July 2007 and was the last cruise conducted for this contract. The cruise mobilized and embarked from Panama City, Florida, and de-mobilized at Galveston, Texas. Post-cruise reports were completed for all cruises and were submitted to MMS.

The primary purpose of this research is to discover and characterize the sea floor communities that live in association with hydrocarbon seepage and on hard ground in the deep Gulf of Mexico. The sites studied are in areas energy companies will explore for oil and gas. The objectives of the program were as follow:

- characterize known or newly discovered chemosynthetic communities below 1,000-meters;
- characterize as well other hard bottom biological communities encountered regardless of association with active seepage and living chemosynthetic communities;
- determine the comparative degree of sensitivity of anthropogenic impacts as well as similarity/differences with their shallower water counterparts;
- develop successful assessment methodologies to develop predictive capability that can be used by MMS to avoid impacts to lower slope sensitive biological communities; and
- to contribute to assessing and explaining diversity distribution and abundance at depths below 1,000-meters and understanding functional role of marine species in areas of active seepage

A highly qualified and experienced team was assembled to provide the required expertise and to provide a fully integrated organizational structure. The project team includes scientists that have worked together as a team since the 1980s for both MMS environmental studies programs and other national programs. The principal investigators include the following:

Dr. James Brooks, TDI-Brooks, Program Manager;
Dr. Charles Fisher, Penn State, Biology Group Leader;
Dr. Harry Roberts, LSU, Geology/Geophysics Group. Leader;
Dr. Robert Carney, LSU, Deep-Sea Ecology;
Dr. Ian MacDonald, TAMU-CC, Imaging & Remote Sensing;
Dr. Samantha Joye, Univ. of GA, Microbiology & Geochem;
Dr. Erik Cordes, Harvard, Hard-bottom & Ecology;
Ms. Liz Goehring, Penn State, Education Outreach;
Dr. Gary Wolff, TDI-Brooks, Data Management;
Dr. Bernie Bernard, TDI-Brooks, Bus. Mgt. & HC Geochem; and
Dr. Stephane Hourdez, France, Polychaete Group. Leader.

The Scientific Review Group (Task I) include the following:

Dr. James P. Barry-Monterey Bay Aquarium Res. Inst.;
Dr. William R. Schroeder-University of Alabama; and
Dr. Daniel L. Orange- AOA Geophysics and UC-Santa Cruz.

Many of the key personnel for the current program were involved in the MMS Chemo I and II programs. Chemo I and II MMS projects were directed toward earlier reconnaissance and process studies using the *Johnson Sea-Link* and *NR-1* submersibles and were thus restricted to study of communities in water depths <1,000-meters.

The schedule of major goals during the program was organized to provide information for the primary tasks. Heavy field concentration in the first year with the first six months (September to February) focused on a review of historical data (cores, SAR, AUV and 3-D seismic) and industrial data to select 20–40 sites.

The goal of the Reconnaissance Cruise was to determine dive sites for the upcoming *Alvin* cruise. This was accomplished by characterizing a larger number of sites for predicative capability and collecting box cores and trawls for seep-background studies. More than 20 sites were surveyed from the review of historical data and the Reconnaissance (Site Confirmation) Cruise. The primary accomplishments of this cruise were the photoreconnaissance of 24 sites; the USBL tracking and positioning of a photo sled over target sites; and the collection of 10,922 photos with many showing brine, bacteria, mussels (131), tube worms (135), and coral. Trawls were also done at three sites and box cores were obtained for isotopic analysis of faunal contents.

The primary goal of the 2006 *DSRV Alvin/Atlantis* Cruise was to discover and characterize the seafloor communities that live associated with HC seepage and on hard ground in the deep GOM. There were 23 dives performed over the course of the cruise which included photography and videos, push cores, faunal collections using various tools and growth studies.

The primary goal of the 2007 ROV Cruise on the *R/V Ron Brown* using *Jason II* was to conduct near-bottom multibeam (SM 2000) and photographic surveys of the prime sampling sites identified during a previous cruise (2006 *R/V Atlantis* and *DSV Alvin*). Within the framework of these data sets, detailed sampling and mapping of benthic communities, sediments, lithified substrates, and brines were continued. Tubeworms stained in 2006 were collected for growth studies. Remote camera systems were deployed and recovered. New sites, within the study area, chosen from analyses of 3-D seismic data were explored.

Two recent chemosynthetic discoveries in other oceans have provided additional information on the areal and depth distribution of chemosynthetic communities. Nigerian chemosynthetic discoveries at two sites were sampled with box cores in 1,600 and 2,200 m water depths. The sites were 200 miles apart. Also, Indian Ocean chemosynthetic community discoveries in the Bay of Bengal were made by Dr. Charles Fisher and colleagues. They recorded new species of tube worms related to ones off Papau, New Guinea, new species of mussels related to *B. childressi* and two species of vesicomyid clams.

Dr. James Brooks is President & CEO of TDI-Brooks International Inc, the primary contractor for the MMS program *"Lophelia II" Exploration and Research of Northern Gulf of Mexico Deepwater Natural and Artificial Hard Bottom Habitats with Emphasis on Coral Communities: Reefs, Rigs and Wrecks***.** Dr. Brooks has been conducting research and oil industry-sponsored service projects in the Gulf of Mexico for the last 30 years. As part of his surface geochemical exploration (SGE) studies, which he developed for industry in the early 1980s, he has collected approximately 9,000 cores in the Gulf, mostly in deep water. These SGE coring studies resulted and contributed to the discoveries of macro oil seepage, chemosynthetic communities, and gas hydrates in the Gulf of Mexico. He was a co-discoverer of oil seep and chemosynthetic communities in the deep water Gulf of Mexico in 1985. He made the first discoveries of thermogenic gas hydrates in the deep water Gulf of Mexico that were published in *Science***.** He participated in the initial discoveries of other oil-seep related phenomena including oil-stained cores on the continental slope, widespread occurrence of shallow and outcropping gas hydrates, brine seepage, and visible oil seepage to the sea surface. His current SGE coring and satellite seep studies in the southern Gulf for PEMEX resulted in a recent publication in *Science* on the discovery of tar flows and chemosynthetic communities in the Campeche Knoll region offshore Mexico. He has also made the first discovery of chemosynthetic ecosystems in West Africa (Nigeria), north of the equator. Dr. Brooks has over 210 peer-reviewed publications.

## CHEMO III: SITE SELECTION AND PROCEDURES

**Harry H. Roberts**
**Coastal Studies Institute, Department of Oceanography and Coastal Sciences**
**School of the Coast and Environment, Louisiana State University**

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The Gulf of Mexico is well known for its hydrocarbon seeps, associated chemosynthetic communities, and gas hydrates (Brooks et al., 1986; Childress et al., 1986). However, most direct observations and samplings of seep sites have been concentrated above water depths of 1,000 m because of the scarcity of deeper-diving manned submersibles and research ROV. In the summer of 2006 NOAA and MMS supported 25 days of DSV *Alvin* dives on the deep slope. In June-July of 2007 the ROV *Jason* was used from the NOAA research vessel *Ronald H. Brown* to sample and photograph key sites first visited by *Alvin* and additional sites identified by analysis of geophysical data held by MMS. Site selection for the 2006 *Alvin* dives was accomplished through surface reflectivity analysis of the MMS slope-wide 3D-seismic data database followed by a photo reconnaissance cruise using drift camera technology (Roberts et al., 2007). The seafloor reflectivity analysis consists of identifying the presence and character of high amplitude "bright spots" associated with the first return from the ocean bottom-water interface. These highly reflective areas are illustrated from a swath of seafloor in the Mississippi Canyon lease block area, Figure 1E.1. From 80 potential sites, 20 were studied by photo reconnaissance from which 10 sites were selected for *Alvin* dives. The 80 sites initially selected from 3D-seismic surface amplitude analysis are shown in Figure 1E.2. Sites actually visited by *Alvin* and *Jason* are illustrated in Figure 1E.3. Four of the sites selected for sampling were surveyed using the C & C Technologies AUV. Multibeam bathymetry, chirp subbottom profiles, and side-scan sonar data were collected from an altitude of 40 m above the bottom. The four sites surveyed were Alaminos Canyon Block 601 (AC 601), Walker Ridge Blocks 269-270 (WR 269-270), Green Canyon Block 852 (GC 852), and Atwater Valley Block 340 (AT 340).

Chemosynthetic communities were found at all sites. However, the robustness and diversity of the communities varied considerably both in across-slope and along-slope directions. Five sites (AT 340, GC 852, WR 269-270, AC 645, and AC 818) had impressive chemosynthetic communities and well-defined fluid-gas expulsion geology.

The AT 340 site was a regional mound-like feature supported by salt in the subsurface. Small mounds up to (10 m relief) and depressions covered the surface of the regional feature and accounted for the highest surface amplitude on 3D-seismic data. Carbonate blocks, boulders, and slabs defined the mounds, some of which had over 10 m relief. Most of the carbonates contained abundant mussel shells. Living mussels were found in sizable "beds" between carbonate blocks where gas seepage was occurring in association with these mounds. Tube worm colonies were scattered throughout the mounds at the edges of carbonate blocks-slabs and between them. At

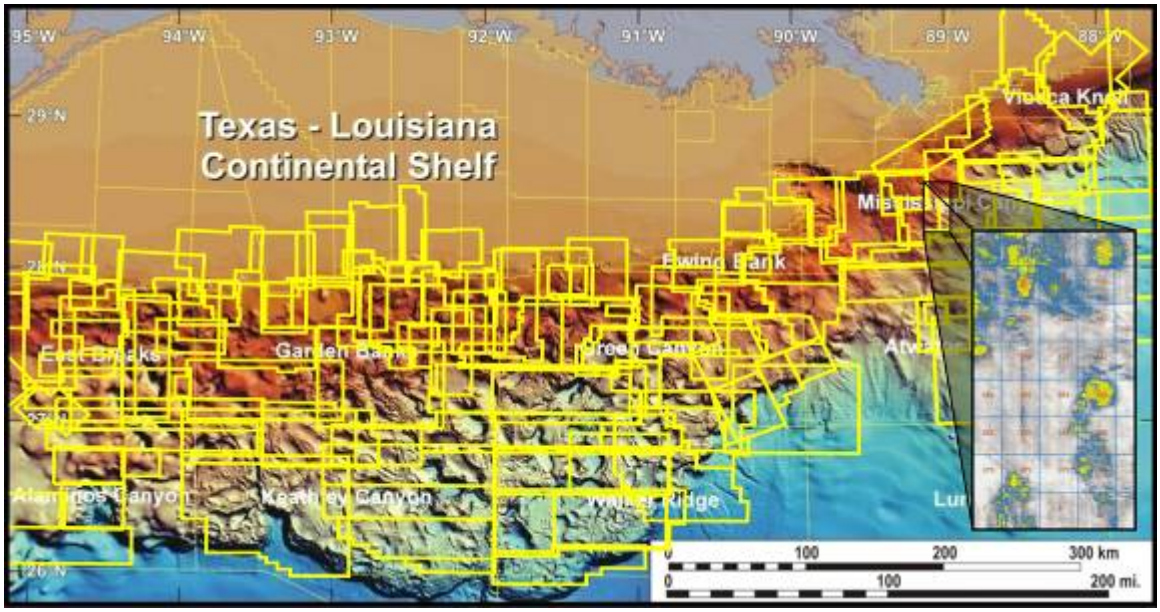


**Figure 1E.1. The MMS proprietary 3D-seismic database covers nearly all of the Gulf's northwestern and northern continental slope. The yellow rectangles represent individual survey data sets. Scattered over the slope are numerous surface reflectivity "bright spots" (inset) that represent locations of fluid-gas expulsion. The reflective hard-bottom is primarily authigenic carbonate formed as a by-product of microbial oxidation of hydrocarbons.**

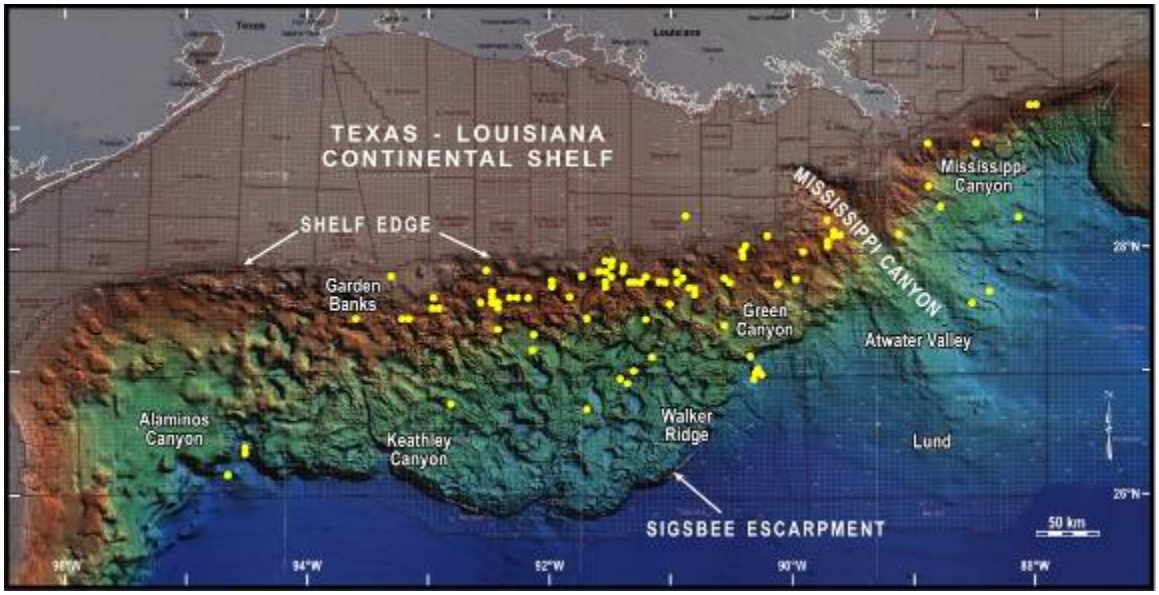


**Figure 1E.2. Eighty 3D-seismic surface reflectivity anomalies as potential dive sites prior to the 2006 *Alvin* cruise.**

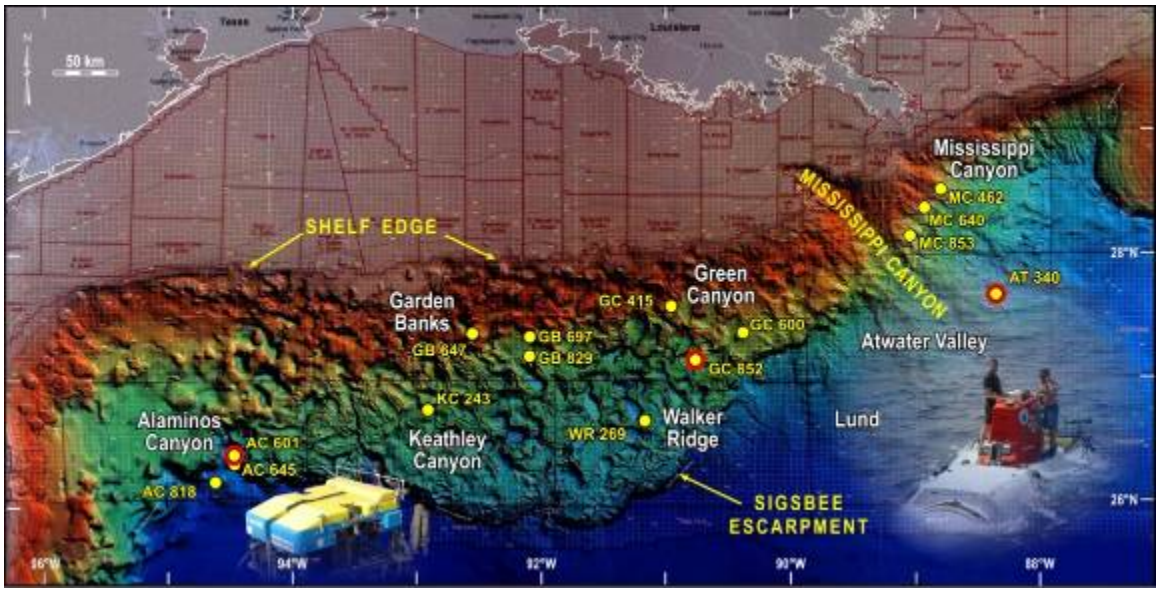


**Figure 1E.3. A total of 15 sites were actually visited, photographed, and sampled during the 2006 and 2007 *Alvin* and *Jason* cruises. The sites circled in red were surveyed with the C & C Technologies' AUV.**

off-mound locations brine seepage was common. Scattered mussels and numerous heart urchins were found in these areas of reducing sediment.

The GC 852 site consisted of a N-S trending ridge that rose over 200 m above the surrounding seafloor and exhibited high amplitudes on surface 3D-seismic data, especially on top of the ridge and on the western flank. Scattered mussel beds and tube worm communities were found near the ridge top of the southern half of the feature. Outcrops of carbonate ledges were common to the western flank of the ridge, and large carbonate blocks were typical of the ridge top. At the highest point along the ridge (slightly south of the middle of the ridge) an extensive community of both hard and soft corals was found (water depth 1,392–1,500 m). At the time of the *Alvin* dives a strong current (estimated to be > 1.5 kts) was found at this site, making sampling difficult. This current was not encountered in subsequent 2007 *Jason* dives. Review of the Loop Current images after the *Alvin* cruise revealed that an eddy was over the site during the dives.

Surface and subsurface analysis of 3D-seismic data from the WR 269-270 site by McConnell et al. (2003) suggested the presence of gas hydrate in the subsurface, a fragmented bottom simulating reflector (BSR). A mounded seafloor, described as a complex of large "gas mounds," occurred over the zone of interpreted gas hydrate accumulation. Dives at the WR 269-280 were focused on one of these mounds which had a crater-like central vent that was highly reflective on 3D-seismic surface amplitude data suggesting a hard bottom. The structure of the mound was that of a rather large fluid-gas expulsion feature with interpreted flow deposits radiating from the central vent. On the flanks of the mound large pogonophoran tube worm communities with holothurians were found. These communities had developed within areas of seafloor

characterized by reducing sediment. At the apex of the mound, blocks and slabs of authigenic carbonate containing mussel shells and tube worm molds were present and floored the central vent. Large living mussels and colonies of tube worms were scattered among the carbonates. Small outcrops of gas hydrate were also observed in the largely lithified walls of the crater at the mound crest.

In the deep water of Alaminos Canyon, two sites with abundant chemosynthetic communities were visited and sampled using both *Alvin* and *Jason*. The AC 645 site was discovered by a 1991 *Alvin* dive. This site consisted of a small, but well-defined mound of carbonate blocks and slabs with abundant tube worm communities and mussel beds surrounding the base of the mound and scattered throughout it. The mound stands out on surface amplitude data as a circular "bright spot." In contrast, the AC 818 site had very little surface amplitude signature on 3D-seismic data. The chemosynthetic communities and reflective hardgrounds at this location were distributed in a narrow band (a few 10s of meters) along a linear fault that was obviously the conduit for migration of hydrocarbons to the modern seafloor. However, the trophic resources to support a thriving chemosynthetic community were limited. Although living vestimentiferan tube worms, bathymodiolid mussels, and lucinid-vesyconyid-like clams were found along with localized slabs and nodular masses of authigenic carbonate at AC 818, they were distributed in a narrow fairway along the fault and sometimes below 3D-seismic resolution. The net result was that the high surface amplitudes along the fault appeared as a "string of beads" and probably would not have been detected in the communities had they not been discovered by video and bottom photography taken in support of a nearby drilling site.

At AC 601 (WD ~ 2,340 m) a brine lake (4 m deep and 180 m wide, salinity ~ 90‰) was investigated and sampled. White "flocs" floating in the brine and concentrated at the "shoreline" were found to be barite. No visible animal life was observed in the brine, but moribund fauna were found both in the lake and on the shoreline. Isolated living communities of mussels and urchins were found on the lake margins. Geochemically, the water column methane concentration above the lake exceeded all other *Alvin* dive sites by an order of magnitude. Methane was supersaturated all the way to the surface, suggesting the site could be a source of methane to the atmosphere.

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Harry H. Roberts is the former director of Coastal Studies Institute (for 10 years) at LSU, an emeritus member of the Department of Oceanography and Coastal Sciences (School of the Coast and Environment), and a Boyd Professor. He has had a career in marine geology that spans 40 years and has worked in many foreign countries as well as in the United States. Recently, his research has focused on three themes: (a) modern deltaic sedimentation and processes, (b) shelf-edge deltas, and (c) surficial geology of the northern Gulf's continental slope. The latter research thrust has concentrated on building an understanding of the impacts of fluid and gas expulsion on the surficial geology and biology of the slope. Gas hydrate constitutes one of the unusual consequences of fluid and gas migration and expulsion in deep water.

# CHEMO III: CHANGES IN COLD SEEP AND HARD GROUND COMMUNITY STRUCTURE ALONG A DEPTH GRADIENT ON THE LOUISIANA SLOPE

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One of the primary goals of the Chemo III project was to characterize the chemoautotrophic megafaunal communities associated with hydrocarbon seepage at depths greater than 1,000 m. Although a handful of sites with such communities were known before this project, only a few had been characterized in any detail. Therefore, one of the first steps in the Chemo III project was to discover a sufficient number of new sites with chemoautotrophic megafaunal communities at depths greater than 1,000 m to allow robust geographic community and population analyses and comparisons to the abundant data available from sites found at depths shallower than 800 m. Over the course of this project we conducted ROV or manned submersible studies of 15 sites, only one of which had been previously studied in any detail and only four of which had been previously imaged. Bacterial mats and/or seep fauna were present at all 15 sites, symbiont-containing bathymodioline mussels were present at 13 of the sites and vestimentiferan tubeworms were present in 12 of the 15 sites. Over the course of this study a total of 117 collections were made that included megafauna. Forty-seven of these collections were quantitative community collections which included twelve bushmaster collections of intact tubeworm aggregations and 35 mussel pot or mussel scoop samples. The data from these collections is analyzed with similar data on upper slope communities from the Chemo II project, and from the Florida Escarpment (3,290 m) collected as part of a previous Ocean Exploration project.

The three species of bathymodioline mussels were found with overlapping depth distributions. *Bathymodiolus childressi* is the dominant mussel found on the upper slope, and was present at sites down to 2,220 m. *B. brooksi* was found from 1,080 to 3,290 m and *B. heckerae* from 2,180 to 3,290 m. There were several individuals collected with shell morphologies that appeared

intermediate between these described species, however subsequent analyses of CO1 gene sequence identified these as either *B. brooksi* or *B. childressi*.

Reconciling morphological and taxonomic identifications with molecular genetic analysis of the vestimentiferans on the lower slope has proved to be more difficult. Based on morphological criteria we had identified one new species of *Lamellibrachia* (sp nov 1) and one potential new species of Escarpid in our collections, along with numerous *Escarpia laminata* at all depths below 1,250 m. A preliminary molecular genetic survey of the 2006 collections along with sequencing of the presumed new Escarpid determined that *Lamellibrachia* sp nov 1 was not distinguishable from *L. luymesi* using standard mitochondrial genes and that the potential new species of Escarpid was not distinguishable from *E. laminata*. However, a second species of *Lamellibrachia* (sp nov 2) was detected. We have now isolated DNA from over 100 additional individuals of *Lamellibrachia* spp. and *Escarpia laminata*, including additional individuals of *L. luymesi* from the upper slope. We have confirmed that there is a single CO1 genotype of escarpid, *Escarpia laminata,* on the lower slope found from 1,250 to 3,290 m depth, and it is distinct from both *Seepiophila jonesi* and a rare unidentified escarpid from the upper slope. *Seepiophila jonesi* was present in one of our collections from the lower slope in lease block GB 647 at a depth of 1,000m. We have also confirmed that there are at least two species of *Lamellibrachia* on the lower slope, although one is not distinguishable from the upper slope *L. luymesi* using either mitochondrial 16S or CO1 genes. *L. luymesi* = *L.* sp nov 1 is found from 500 to 2,320 m and *L.* sp nov 2 was collected from 1,275 to 2,320 m. The difficulty in distinguishing the different tubeworm species may reflect the biology of these species. Low levels of genetic diversity within population may result from continuous reproduction of a small number of related individuals over their long life spans or from recent formation of new species. We are currently processing samples for analyses of two nuclear genes and several microsatellites to further resolve the clades of *Escarpia* and *Lamellibrachia* in the Gulf of Mexico.

Overall, the macrofauna communities associated with tubeworms and mussels that were sampled from similar depths were the most similar. There were clear divisions in community types between the upper (< 800 m) and lower (> 900 m) slope seeps and also between the tubeworm and mussel-associated communities within depth ranges. Only 15 morphotaxa collected with tubeworms or mussels bridged this depth range, while over 105 are found only among the upper slope communities and at least 55 are found only among the lower slope communities. The species of seep-associated decapod shrimp (*Alvinocaris* spp.) and galatheid crabs (*Munidopsis* spp.) found on the lower slope were different from those on the upper slope. The shrimp *Alvinocaris muricola* was in fact the dominant member of the lower slope mussel- and tubeworm-associated communities. A much higher phylogenetic-level change in fauna with depth is seen among the dominant seep-associated heterotrophs that feed on detritus or organic films. Gastropod molluscs (snails and limpets) are dominant in this category above 900 m, while below 1,400 m echinoderms predominate, notably the ophiuroid (brittle star) *Ophioctenella acies*, the synallactid holothuroid (worm-like sea cucumber) *Chirodota heheva*, and the heart urchin *Sarsiaster greigi*. This phylum-level shift from Mollusca to Echinodermata mirrors a similar shift in the non-seep fauna with depth and suggests that similar depth related effects may

influence the composition of both the normal slope communities and the seep environments embedded in it.

On the other hand, the previously reported bathymetric trends of decreasing biomass and faunal density with depth in more typical Gulf of Mexico communities were not apparent in collections of the seep-associated communities. Density and biomass of fauna in the lower slope collections were within the range of those reported from the upper slope seeps, and biomass estimates for the tubeworm communities were generally higher in deep water than at the upper slope seeps. In general, density and biomass values were greater in mussel beds than tubeworm aggregations. A mid-slope diversity maximum, as reported in the background Gulf of Mexico communities and the deep-sea soft benthos world-wide, was not apparent in these samples. This is likely due to the more consistent influence of seep productivity in regulating these characteristics of hydrocarbon seep communities.

As on the upper slope, tubeworm aggregations and mussel beds on the lower slope hosted different associated communities. Mussel beds contained higher abundances of *Ophioctenella acies*, and tubeworms contained high abundances of two species of capitellid polychaetes, *Heteromystides* sp. and *Protomystides* sp. Both community types hosted high abundances of *Alvinocaris muricola*. Comparisons among mussel bed samples indicated that community similarity was most closely correlated to the depth of the collection ($r = 0.244$, $p < 0.001$) and the proportion of *B. brooksi* in the samples ($r = 0.350$, $p = 0.019$). Distance between collections was not significantly correlated to community similarity, suggesting that depth is a stronger determinant of community type than distance. Among tubeworm aggregations at depths greater than 1,000 m, depth ($r = 0.174$, $p = 0.099$) was a slightly better predictor of community similarity than distance between collections ($r = 0.136$, $p = 0.199$).

Neither our tubeworm growth data nor extensive tissue stable isotope data sets have been fully analyzed yet, but several points stand out in our preliminary analyses and provide significant insights into the biology of the major symbiont-containing fauna of the deep seeps in the Gulf of Mexico. We obtained single-year growth data on 330 stained individuals of *Escarpia laminata*, from three different sites, and 60 stained individuals of *Lamellibrachia* sp. These data suggest that *E. laminata* grows at a similar rate to *Seepiophila jonesi* on the upper slope and that *Lamellibrachia* spp. on the lower slope appears to grow even more slowly than *Lamellibrachia luymesi* on the upper slope. We were also able to re-image four *E. laminata* banded in 1992, whose total growth over the intervening 15 years ranged from 1 to 4 cm. Taken together these data suggest that the lower slope species live at least as long as the 250+ years calculated for *L. luymesi* and *S. jonesi* on the upper slope.

The nature of the niche differentiation that allows two species of seep vestimentiferans, with the same types of symbionts, to co-occur over centuries in single aggregations has never been determined and has puzzled researchers in the field for many years. The extensive data set from paired tissue stable C and N analyses provides exciting insights into this question. *E. laminata* and *Lamellibrachia* sp. were present together in 10 discrete collections of individual vestimentiferan aggregations, and three individuals of each species were analyzed. Although the tissue

$\delta^{13}C$ values of both species were often significantly different among collections (ranging from averages of -30 to -60‰ in different collections), in 9 of 10 collections the values were not different between species. This suggests that the two species are accessing similar DIC pools, even though the $\delta^{13}C$ values of DIC in these pools vary considerably among collection sites, and in some cases between different sizes of tubeworms. On the other hand, although the total range in tissue $\delta^{15}N$ within a species, among sites is only 5–7‰, average *Lamellibrachia* $\delta^{15}N$ values are always between 2 and 4‰ lower than those of *E. laminata* from the same collection. This provides very strong evidence that these two species are either accessing two different pools of inorganic nitrogen or using very different mechanisms to take up and incorporate inorganic nitrogen into their tissues.

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Charles (Chuck) Fisher is a Professor and Chair of the Graduate Program in Biology at the Pennsylvania State University. He has participated in 57 oceanographic research expeditions, serving as chief scientist on 26 of them. Dr. Fisher became involved in research on deep-sea hydrothermal vent ecosystems shortly after their discovery in the late 1970s and in research on the hydrocarbon seeps of the Gulf of Mexico in 1986. He has published over 120 peer-reviewed papers on the biology of hydrothermal vents and cold seeps. Dr. Fisher served as the chair of the US NSF Ridge 2000 program until 2005 and is currently the co-chair of the InterRidge Biology working group and a member of the Steering Committee for the Census of Marine Life 'ChEss' (Chemosynthetic Ecosystems) program.

Erin Becker is a Ph.D. student in biology at Penn State University after having completed a B.S. in ecology and evolution at the University of Pittsburgh in 2005. She has worked with using stable isotopes to determine food web interactions in communities associated with the reef-building coral Lophelia pertusa on the Upper Louisiana Slope. She is currently employing the same techniques to determine food web structure in tubeworm-, mussel-, and pogonophoran-associated communities in the deep slope environment.

Bob Carney began graduate studies of the deep-sea benthos at Texas A&M under Willis Pequegnat and went on to complete his Ph.D. studying the deep Pacific benthos at Oregon State. A professor of Oceanography and Coastal Sciences at LSU since 1986, he has held positions at the Smithsonian Institution, the National Science Foundation, and Moss Landing Marine Lab. Since returning to the Gulf of Mexico, he has carried out research on chemosynthetic communities as well as shelf-depth environmental aspects of oil and gas development. In addition to his Gulf of Mexico work, he is active in the global-scale synthesis of continental slope ecology being fostered by the Census of Marine Life. He is PI and co-director of the Continental Margins Ecosystems project (COMARGE).

Dr. James Brooks is President & CEO of TDI-Brooks International Inc, the primary contractor for the MMS program *"Lophelia II" Exploration and Research of Northern Gulf of Mexico Deepwater Natural and Artificial Hard Bottom Habitats with Emphasis on Coral Communities: Reefs, Rigs and Wrecks***.** Dr. Brooks has been conducting research and oil industry-sponsored

service projects in the Gulf of Mexico for the last 30 years. As part of his surface geochemical exploration (SGE) studies, which he developed for industry in the early 1980s, he has collected approximately 9,000 cores in the Gulf, mostly in deep water. These SGE coring studies resulted and contributed to the discoveries of macro oil seepage, chemosynthetic communities, and gas hydrates in the Gulf of Mexico. He was a co-discoverer of oil seep and chemosynthetic communities in the deep water Gulf of Mexico in 1985. He made the first discoveries of thermogenic gas hydrates in the deep water Gulf of Mexico that were published in *Science.* He participated in the initial discoveries of other oil-seep related phenomena including oil-stained cores on the continental slope, widespread occurrence of shallow and outcropping gas hydrates, brine seepage, and visible oil seepage to the sea surface. His current SGE coring and satellite seep studies in the southern Gulf for PEMEX resulted in a recent publication in *Science* on the discovery of tar flows and chemosynthetic communities in the Campeche Knoll region offshore Mexico. He has also made the first discovery of chemosynthetic ecosystems in West Africa (Nigeria), north of the equator. Dr. Brooks has over 210 peer-reviewed publications.

# FOOD-WEB STRUCTURE OF SEEP MACROBENTHOS FROM THE GULF OF MEXICO

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Chemosynthetic environments provide a haven for chemoautotrophic bacterial mats and megafaunal invertebrates that house endosymbiotic bacteria (Fisher 1990, Conway et al. 1994). Studies to date have focused primarily on understanding the nutritional modes of the larger megafaunal or epifaunal taxa in seeps; however, sediments provide a substrate for smaller infaunal invertebrates whose food resources have not been well studied. Potential carbon sources (food) available to infauna include photosynthetically fixed material raining from surface waters (e.g., phytoplankton-derived organic matter), terrestrially-derived material transported to deep waters, or chemosynthetically-fixed carbon provided by free-living or symbiotic bacteria (Conway et al. 1994, Levin and Michener 2002). Stable isotope analysis has proven useful in discerning nutritional modes and can provide basic information about what fuels seep communities. This study investigated the trophic structure of infaunal benthos residing in close proximity to known seep environments in the Gulf of Mexico. Using stable isotope analysis, we identified potential primary food sources utilized by these fauna and the relative role of chemosynthetic-derived nutrition versus dependence on phytodetritus in infaunal diets.

To better understand the food webs of deep slope hydrocarbon seep habitats, we selected three sampling sites: Atwater Valley (AT 340), Green Canyon (GC 852), and Alaminos Canyon (AC 601). At each of these sites, we established transects running across known seep locations based on information from E. Cordes (Temple University) and C. Fisher (Pennsylvania State University). Sediment samples for infaunal analysis were collected using a box core. In addition, vertical redox potential (Eh in mV) profiles (0-1, 1-2, 2-3, 3-5, 5-7, 7-10 cm) were obtained from undisturbed cores by inserting a combination redox electrode through the sediment surface; redox potential was read on a portable pH-millivolt meter. Seventeen sediment cores were sectioned vertically (0-1, 1-2, 2-3, 3-5, 5-7, 7-10 cm) after recovery. The sediment was then sieved through a 300 μm screen and specimens were sorted live at sea to collect macrofauna for stable isotopic analysis. Living organisms were identified, placed into filtered seawater for 24 hours to evacuate their guts, washed in milli-Q water, then placed in pre-weighed tin boats or combusted vials, and frozen at -70$^{o}$C. In the laboratory, the specimens were dried at 60$^{o}$C, weighed, and acidified with 1% $PtCl_2$ to remove inorganic C. A total of 240 infauna were

analyzed for $\delta^{13}C$ and $\delta^{15}N$ stable isotopes. Potential food resources, including particulate organic matter (POM), sediments, and filamentous bacteria from surface sediments, also were processed for stable carbon and nitrogen isotopes.

While the sampling locations targeted areas of known seep assemblages, none of the box core collections recovered large bacterial mats or megafauna (clams, mussels, tubeworms) typically present in seep environments. Results from stable isotope analysis indicated that the infauna fell into three groups: (1) those that derived carbon from photosynthetic sources (most enriched in $^{13}C$ and $^{15}N$), (2) consumers of chemosynthetically-fixed carbon (possibly sulfide oxidizing bacteria), and (3) consumers depleted in$^{13}C$ and $^{15}N$ relative to the measured bacterial sources (possibly feeding on an unmeasured source).

Box cores collected at Atwater Valley were approximately 75–260 m away from known seep environments. Of the seven cores collected, four had low redox values, indicative of a reducing sediment environment. Three cores had visible bacterial filaments on the sediment surface and several cores had bacteria present in the sorted sediments. Stable $\delta^{13}C$ ranged from -45 to -17 ‰ and $\delta^{15}N$ ranged from –7 to 12 ‰. Few species had isotope values consistent with a photosynthetic-derived diet. Most of the infauna fell between two isotopic endmembers: phytoplankton and methane-derived carbon. The intermediate values may indicate that the fauna are relying on either a mixed diet of these two sources or on sulfur oxidizing bacteria. Low $^{15}N$ values may indicate presence of symbionts within the infauna, utilizing local nitrogen sources that are depleted in $^{15}N$.

At Green Canyon, box core collections were 27 to 1,000 m from known seeps. There were nine successful box cores; four cores had very low redox values and some cores had a noticeable sulfidic odor. As with the Atwater Valley cores, bacteria were observed both on the surface of the sediment cores as well as within the sorted samples. Stable isotope values were more variable than those obtained from Atwater Valley; $\delta^{13}C$ ranged from -55 to -11 ‰ and $\delta^{15}N$ ranged from -8 to 11 ‰. Gastropods from Green Canyon may have methane-derived carbon as indicated by their very light $\delta^{13}C$ values. Group 3 (see above) were depleted in $^{13}C$ and $^{15}N$ relative to measured primary sources, indicating that they may be assimilating methane oxidizing bacteria; these particular microorganisms typically have very negative carbon isotope values.

Only one box core was collected at Alaminos Canyon, and it was approximately 78 m from a known seep site. Redox values were high (positive) in the upper 3 cm of sediments, but decreased with depth. Stable $\delta^{13}C$ values ranged from -36 to -20 ‰ and $\delta^{15}N$ ranged from -6 to 8‰. Few taxa had isotope values consistent with a phytoplankton-derived diet. Most of the infauna fell into groups 2 and 3 (see above), indicating that their primary carbon source is derived through chemoautotrophic processes.

Overall, a majority of the heterotrophic infauna found at these three geographically distinct seep sites exhibited stable isotope values consistent with chemosynthetic-based nutrition. The lightest $^{13}C$ values likely reflect assimilation of methane-derived carbon. However, most of the infauna analyzed had intermediate isotope values falling between phytoplankton and methane-derived

carbon sources. Chemosynthetic bacterial mats can be extensive in the Gulf of Mexico (Sassen et al. 1994); free-living bacteria are also present, all of which could fuel these communities. Our results from the lower slope soft sediments were consistent with other work conducted in seep environments (Levin 2005, Levin and Mendoza 2007). Overall, infaunal isotope values from the three lower slope sites overlapped, suggesting that the chemosynthesis-based nutrition may be more common throughout the deep Gulf of Mexico than previously appreciated.

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Daniel Gualtieri received a B.S. degree in wildlife ecology and conservation from the University of Florida in 2007. He is currently working in Dr. Amanda Demopoulos' lab at the U.S. Geological Survey contracted by Jacobs Technology. He is assisting with several projects examining habitat linkages, biodiversity and community ecology of marine ecosystems, and trophic dynamics in terrestrial and aquatic environments.

# MESOPELAGIC FISHES OF THE NORTH-CENTRAL GULF OF MEXICO AND PRELIMINARY TROPHODYNAMICS DESCRIPTION

**Steve W. Ross, A.M. Quattrini, A. Roa-Varón, and J.P. McClain**
**University of North Carolina-Wilmington, Center for Marine Science**

Click here to view the slide show that accompanied this presentation.

Considering the size and importance of the Gulf of Mexico (GOM), research on the overall mid-water fauna has been relatively restricted. Past studies indicated that though relatively few fish taxa dominate GOM midwater fauna, GOM mesopelagic fish fauna contain more species than neighboring regions and define a unique ecotone. However, most GOM midwater fish studies have been concentrated in the eastern GOM off west-central Florida, particularly around one station. Data on vertical distributions are limited and are mostly from the eastern GOM studies.

In collaboration with ongoing benthic studies, we sampled the midwater fauna over three cold seep habitats > 1,000 m and a comparative area over a cold-water coral bank (< 1,000 m) in the north-central GOM. Our goal was to intensively sample a few widely separated sites, and to sample most of the water column at each site over the 24-hour period. Specifically, our objectives were to 1) characterize the vertical distributions of the mesopelagic fishes using depth discrete sampling, 2) describe diel migration patterns (if any) of the fishes, 3) describe size composition of the midwater fish fauna, and 4) compare ichthyofaunal composition and behavior among the three offshore deeper sites and the inshore study site. Additionally, we report preliminary feeding data for the midwater community.

Sampling was conducted from 9–29 August 2007 over three middle to lower slope cold seep sites (AC601, GC852, AT340) and one upper slope deep-sea coral site (VK826) in the north-central to western GOM. Discrete depth midwater trawling was emphasized in the depth range of near surface to 1,377 m, in approximately 100 m bins. While tows varied in depth, most tows at each site were constrained to a relatively small geospatial area over known seep or coral habitats. A plankton net (0.5 m diameter, 335 μm mesh) was suspended in the center mouth of the Tucker trawl (2 x 2 m, 1.59 mm mesh), providing two separate samples from each deployment. However, the catch of juvenile and adult fishes from both nets was combined to give one sample per tow. The net was deployed in an open position. Because of the rapid lowering, steep wire angle, and minimal forward movement, we assumed there was little fishing as the net was deployed. When it reached the target depth, it was towed for 30 min at ~2 kn ground speed, usually against the current. After 30 minutes, a weighted messenger was sent down the ship's wire to close the net, after which it was retrieved. A temperature-depth recorder (SeaBird SBE39) was attached to the upper net bar to record time, depth, and temperature during each tow.

All fishes were fixed in 10% formalin seawater solution and after the cruise were transferred to 50% isopropanol. All non-larval specimens were identified to the lowest possible taxa and were

measured to the nearest mm standard length. Species captured (e.g., carangids, monacanthids, exocoetids) that were exclusive to surface waters (< 100 m) were eliminated from analyses. Samples from nets which failed to close properly were not used for depth related analyses. Diets of dominant fishes were examined via stomach analysis and analysis of stable isotopes of C and N. A variety of other taxa and items were also analyzed for stable isotopes to better describe the overall midwater food web.

The 159 Tucker trawl stations yielded a total of 9,728 individuals, representing at least 126 species (30 families) of juvenile and adult midwater fishes. In terms of species richness, the collections were dominated by Myctophidae (38 species), Stomiidae (17 species), Gonostomatidae (12 species), and Sternoptychidae (10 species). Overall, the most abundant species comprising 60% of the total catch included: *Notolychnus valdivae, Cyclothone pallida, C. braueri, C. pseudopallida, C. alba, Valencienellus tripunctulatus, V. poweriae, Lepidophanes guentheri, Benthosema suborbitale,* and *Cyclothone acclinidens.* Three species, *Ceratias holboelli* (one from AT340), *C. uranoscopus* (one from GC852), and *Sphyraenops bairdianus* (3 from VK826), appear to be new records for the Gulf of Mexico. Two forms of *Cyclothone*, sp. 1 and sp. 2, did not match known species descriptions. Additional investigation may prove these to be undescribed species. Additional taxonomic problems were presented by the family Howellidae. Current data on this family did not allow us to determine generic or species level classification, and it is possible that we collected more than one species. One species considered to be endemic to the GOM, *Stemonosudis bullisi*, was collected at VK826.

Despite the wide separation of study sites, mesopelagic fish assemblages were comparable among sites (Global R=0.22, PRIMER-E). Since AC601 was only sampled on one night (5 stations), it was represented by the least number of individuals (n=197) and fish species (n=31), none of which were unique to this site. We omitted this site from further analyses. The 69 tows at GC852 and the 49 tows at AT340 produced 105 species (6,193 individuals) and 82 species (2,238 individuals), respectively. Thirty-six Tucker trawl tows at the inshore station, VK826, yielded 57 species and 1,100 individuals. Thirty fish species were collected only at GC852, while only 10 species each were unique to AT340 and VK826. Within the top four families (see above), comparable numbers of species were collected at the two offshore sites, GC852 and AT340, while many fewer species (except in the family Gonostomatidae) were collected at VK826.

Fish assemblages were similar between day and night within each site (Global R values < 0.26, PRIMER-E); however, there were differences in assemblages by depth. Mean depths per tow were overlain onto multidimensional scaling ordination plots, clearly displaying depth-related patterns. At both AT340 and GC852, stations that were sampled in the greatest depths (~ > 700 m) were most similar to each other and stations sampled in the shallowest depths (~ < 200 m) were most similar to each other. In addition, both day and night stations from ~ > 700 m were similar. These results indicated that there is an assemblage of mesopelagic fishes that occur in deeper depths throughout the day/night, including *C. pallida, C. pseudopallida, C. acclinidens,* and *Sternoptyx pseudobscura.* Others occur in shallower depths throughout the day/night, including *V. tripunctulatus, Vinciguerria nimbaria,* and *Centrobranchus nigroocellatus.*

The dominant species collected per site were examined in further detail to discern vertical migration patterns by size. Our results indicated that both juveniles and adults behaved similarly, migrating to shallower waters during the day. However, the range of depths occupied differed among species and among sites. Nearly all species shifted distributions upward over the shallower, inshore site (VK826).

Preliminary trophic data using stable isotopes of C and N indicated that the mesopelagic community has a phytoplankton based food web with cephalopods dominating the top of the food web. There was no evidence for a chemosynthetic influence on the food web. Stomach analyses of the mesopelagic fishes collected indicated that the majority were general zooplanktivores, feeding mostly on copepods, ostracods, and euphausids. *Chauliodus sloani* was the only piscivore of the species examined. Diet analyses are continuing and will include additional fish species as well as a broad category of items throughout the water column analyzed for stable isotopes.

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Dr. Steve W. Ross is a Research Professor at the University North Carolina at Wilmington, Center for Marine Science. Dr. Ross has spent most of his career involved in the marine sciences of the southeastern U.S. region. He earned a B.S. degree in zoology from Duke University, an M.A. degree in zoology from UNC-Chapel Hill, and a Ph.D. in zoology from NC State University. He was the Research Coordinator for the North Carolina Coastal Reserve Program for 13 years. In addition to serving on the research faculty at UNC-W, Dr. Ross is also a project leader for the U.S. Geological Survey. He holds graduate adjunct faculty status at NC State University and UNC-Wilmington. His area of specialization is ichthyology (fishes), particularly ecology and life history (age, growth, feeding, reproduction). He has conducted numerous diverse projects in estuaries and offshore waters and has served as chief scientist on many cruises, including those using submersibles. The current work of Dr. Ross and his team involves assessment of the communities of unique deep water habitats off the southeastern U.S. They are examining energy flow (trophodynamics) and relationships of animals to various habitats, including deep coral banks, canyon systems, and rocky areas. The ultimate goal of these studies is to provide information that will facilitate management and protection of these poorly known, productive habitats.

Andrea Quattrini is a fisheries research technician with the University of North Carolina Wilmington, Center for Marine Science. She holds a B.S. degree in biology from Millersville University in Pennsylvania. In 2002, Andrea completed her M.S. degree in marine biology at the University of North Carolina Wilmington, where she investigated the distribution of larval fishes among water masses off North Carolina. Her current research interests include the ecology and life histories of shelf-edge and deep coral bank fishes. Andrea is also assisting efforts, with Dr. S.W. Ross, to study deep coral habitats off the southeastern United States. Andrea has participated in several offshore cruises and has been a watch chief. In 2009 she will move to Temple University to pursue a Ph.D. degree.

# SESSION 1F

# CLIMATE CHANGE

**Chair:** **Bob Cameron, Minerals Management Service**

**Co-Chair:** **Richard McNider, Minerals Management Service**

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# HURRICANES AND CLIMATE: THE DEBATE OVER TROPICAL CYCLONES AND ANTHROPOGENIC CLIMATE CHANGE

**Pat Fitzpatrick**
**GeoSystems Research Institute**
**Mississippi State University at Stennis Space Center**

Click here to view the slide show that accompanied this presentation.

The possible association between tropical cyclones[1] and global climate change has energized much controversy in the last few years. The Atlantic hurricane season in 2005 inflamed this issue. The 2005 Atlantic season set records for most number of tropical cyclones (27); most hurricanes (14); most Category 5 hurricanes (3); most intense hurricane on record (Hurricane Wilma, 882 mb); most intense storm in the Gulf of Mexico (Hurricane Rita, 897 mb); and the most costly storm on record (Hurricane Katrina, $150–200 billion). Katrina was also the fifth deadliest United States storm on record (1,500–1,600 fatalities). Indeed, since 1995 most years have witnessed above-normal Atlantic hurricane activity. The period of 1970 to 1994 consisted of relatively quiet Atlantic seasons, suggesting that some kind of climate shift has occurred. Other recent high-impact tropical cyclone events around the globe also support this assertion.

It is well-established that water temperatures in most ocean basins have increased by 0.5 to 1.0˚F in the past several decades. Most scientists attribute this to anthropogenic global warming. The genesis and intensification of tropical cyclones is critically influenced by warm oceans. Therefore, some scientists have postulated that global warming has augmented hurricane activity. Several recent studies have provided evidence for this allegation. One analysis shows that the number of Category 4 and 5 hurricanes has increased since 1975. Another study shows that the number of Atlantic tropical cyclones closely parallels the increase of water temperature from the late 1800s.

However, critics point out three main flaws in this proposed global warming relationship. First, tropical cyclones exhibit natural variability in terms of intensity and numbers. Second, the historical record has reliability issues. Both factors insert considerable uncertainty in drawing any relationships between tropical cyclones and anthropogenic climate change. Finally, other factors besides water temperature affect tropical cyclones, and it is unknown how these other influences will change on a warmer planet.

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[1]A tropical cyclone is the generic term for a non-frontal low-pressure system over tropical or sub-tropical waters with organized thunderstorm activity and cyclonic surface wind circulation. Tropical cyclones with maximum sustained surface winds less than 39 mph are called *tropical depressions*. Once this wind reaches 39 mph, it is a *tropical storm*. If wind reach 74 mph, they are called a *hurricane* in the Atlantic Ocean, but have different names in other ocean basins (such as a *typhoon* in the West Pacific). Intense tropical cyclones are defined as Category 3 (winds 111–130 mph), Category 4 (131–155 mph), or Category 5 (>155 mph).

For example, intense tropical cyclones (Category 3 or better) in the Atlantic Ocean exhibit multidecadal variability. It is generally accepted that this oscillatory behavior is due to slow water temperatures cycles in the Atlantic which last 20–30 years. Atlantic hurricane activity tends to be active when this phase has above normal water temperatures (such as 1945–1970 and starting in 1995), while Atlantic activity is relatively quiet during the cooler ocean mode (such as 1970–1994). Intertwined in these long cycles are El Niño phases associated with warmer-than-average oceans in the central and eastern equatorial Pacific that last two to seven years; Atlantic activity is dramatically reduced during an El Niño because it creates Atlantic wind patterns that are hostile to tropical cyclones. Likewise, El Niño years also shift tropical cyclone activity in the Pacific and Indian oceans.

Serious questions about the historical record also exist. Prior to the era of satellites, many tropical cyclones were missed entirely. Therefore, all datasets after 1960 will, on average, contain more storms. The intensity of many tropical cyclones is also unknown. Currently, only the United States performs aircraft reconnaissance flights. Only one other basin ever had aircraft measurements (the west Pacific, from 1946 through 1987). When aircraft measurements are missing, all estimates are done primarily using satellite techniques, and are known to contain errors. The combination of intensity, uncertainty, and missing storms makes extrapolating any trends from this dataset a dubious exercise.

Finally, while water temperature is the most important factor in tropical cyclone dynamics, many other environmental factors affect these storms. These include the deep warm water; moisture availability; weak wind shear; a source of rotation; and no land interaction/landfall. Only when all these factors exist can a hurricane reach its maximum potential intensity for a given water temperature. In fact, few hurricanes reach their potential because some inhibiting factor exists. Furthermore, global warming could enhance some negative influences regionally; an ensemble of 18 global climate models show that wind shear and dry air will increase in the Atlantic, while in contrast the opposite occurs in the west Pacific where environmental factors favor more hurricanes. Therefore, anthropogenic warmer oceans do not necessarily correlate to increased tropical cyclone activity or stronger hurricanes globally. Climate models give mixed results on whether the average storm intensities will change, but most show evidence for some increase in intensity.

For more information on this topic, the reader is referred to documentation written by the 6$^{th}$ International Workshop on Tropical Cyclones of the World Meteorological Organization (WMO), titled *Statement on Tropical Cyclones and Climate Change*. This publication, released in November 2006, can easily be found by typing the report name and organization in a web search engine. Overall, this report discourages making any firm conclusions on hurricane intensity trends.

It should be pointed out that some researchers disagree with the WMO report. Holland and Webster (2007) state the following "with confidence": "*The recent upsurge in … frequency … is due in part to global warming and this is most likely the dominant effect. Earlier variations, such as the sharp increase in the 1930s, were also probably impacted by greenhouse warming. … We*

*have noted with some concern the contradictory conclusions … which describe the data as being of high quality sufficient to determine "natural variability" … but … insufficient …. to determine trends."*

## Reference

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Pat Fitzpatrick received his B.S. and M.S. degrees in meteorology from Texas A&M University and his Ph.D. in meteorology from Colorado State University. His is associate research professor at Mississippi State University. Dr. Fitzpatrick has served on the faculties of Jackson State University, Colorado State University, and Texas A&M and has worked as a hurricane forecaster for Shell Oil. His research interests include hurricanes, storm surge, numerical modeling, data assimilation, and severe weather. He has authored several peer reviewed publications and two books.

# DETECTING A GREENHOUSE WARMING SIGNAL USING ONLY MAXIMUM DAILY TEMPERATURES

**Richard T. McNider, Arastoo Pour-Biazar, William B. Norris, Justin Walters, Xingzhong Shi, and John R. Christy**
**Department of Atmospheric Sciences**
**University of Alabama in Huntsville**

Click here to view the slide show that accompanied this presentation.

The essence of concern in greenhouse gas climate change is that heat will be trapped and *accumulate* in the earth system, thus altering the climate and altering ecosystems. One of the most significant signals in the thermometer-observed temperature record since 1900 is the decrease in the diurnal temperature range over land, largely due to warming of the minimum temperatures. The cause for this nighttime warming in the observed temperatures has been attributed to a variety of causes including increases in atmospheric water vapor, cloud cover, jet contrails, and changes in surface characteristics, such as land cover and land use. Climate models have in general not replicated the change in diurnal temperature range well.

Here we would like to try to distinguish between warming in the nocturnal boundary layer due to a redistribution of heat and warming due to the accumulation of heat. The temperature at night at shelter height is a result of competition between thermal stability and mechanical shear. If stability wins then turbulence is suppressed and the cooling surface becomes cutoff from the warmer air aloft, which leads to sharp decay in surface air temperature. If shear wins, then turbulence is maintained and warmer air from aloft is continually mixed to the surface, which leads to significantly lower cooling rates and warmer temperatures. This warming occurs due to a redistribution of heat. As will be shown by techniques of nonlinear analysis the winner of the stability and shear contest is very sensitive to changes in greenhouse gas forcing surface roughness, cloudiness, and surface heat capacity (including soil moisture). Further, the minimum temperatures measured in the nocturnal boundary layer represent only a very shallow layer of the atmosphere which is usually only a few hundred meters thick. It is likely that the observed warming in minimum temperature, whether caused by additional greenhouse forcing or land use changes or other land surface dynamics, is reflecting a redistribution of heat by turbulence—not an accumulation of heat.

Because of the redistribution phenomena and the shallow layer affected, observed minimum temperatures are a very poor measure of the accumulation of heat in the atmosphere. As will be shown using an analysis of grid size dependence, because climate models with their course resolution cannot accurately simulate the physics important to heat redistribution, their minimum temperatures are suspect. Surface maximum temperatures would seem to represent a more robust measure of the heat content of the atmosphere since daytime boundary layers connect the surface to a depth of one to two kilometers or more and are well mixed. Climate models more accurately

simulate daytime mixing which, by its non-local nature, is not as dependent on grid resolution. Thus, daytime maximum temperatures should be much better for detecting and simulating this heat accumulation in the atmosphere.

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Richard McNider is a Distinguished Professor Emeritus at the University of Alabama, Huntsville (UAH). Previously, he worked for the Alabama Pollution Control Commission and was Professor of Atmospheric Science and Mathematics at UAH. He holds a Ph.D. from the University of Virginia.

Dr. Pour Biazar received his Ph.D. in atmospheric sciences from the University of Alabama in Huntsville (UAH) in 1995 and works as a research scientist at UAH. He has been involved in many air quality campaigns and in recent years has been investigating the utility of satellite observations in air quality studies.

## GLOBAL/REGIONAL/LOCAL SCALE CLIMATE VARIABILITY AND CHANGE

**Roger Pielke Sr.**
**Cooperative Institute for Research in Environmental Sciences**

Click here to view the slide show that accompanied this presentation.

The current focus of the IPCC on climate change with their emphasis on global warming is really a framework to promote energy policy. Climate variability and change, including the human role, are much more than global warming and cooling, and scientific evidence for this will be presented.

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Dr. Roger A. Pielke Sr. is a Senior Research Scientist in CIRES and a Senior Research Associate at the University of Colorado-Boulder in the Department of Atmospheric and Oceanic Sciences (ATOC). He received a B.A. in mathematics from Towson State College and an M.S. and Ph.D. in meteorology from Pennsylvania State University. Dr. Pielke has worked for NOAA's Experimental Meteorology Lab, the University of Virginia, and Colorado State University. He served as Colorado State Climatologist from 1999–2006. Dr. Pielke has studied terrain-induced mesoscale systems, including the development of a three-dimensional mesoscale model of the sea breeze. He has published several books and over 330 papers in peer-reviewed journals.

# SESSION 2A

# AIR QUALITY STATES ISSUES

**Chair:** **Bob Cameron, Minerals Management Service**

**Co-Chair:** **Jim Smith, Texas Commission on Environmental Quality**

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## AIR QUALITY IN TEXAS: SCIENTIFIC AND REGULATORY PERSPECTIVES

**Jim Smith**
**Texas Commission on Environmental Quality**

Click here to view the slide show that accompanied this presentation.

This presentation summarizes the Second Texas Air Quality Study (TexAQS-II). This study has greatly advanced the science of air quality in eastern Texas, while air quality has improved dramatically. It first discusses trends in air quality relative to the current and future 8-hour ozone standards and offers an overview of Texas' standing on the 85 ppb standard and the new 75 ppb standard.

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Jim Smith has served as a photochemical modeler air quality researcher and manager for the TCEQ for sixteen years. He has worked on State Implementation Plans for Houston-Galveston-Brazoria, Dallas-Fort Worth, and Beaumont-Port Arthur. He has been closely involved with incorporation of results of three major field studies into the state's air quality planning efforts: the 1993 Coastal Oxidant Assessment for Southeast Texas (COAST), the 2000 Texas Air Quality Study (TexAQS 2000) and the 2005–2006 Texas Air Quality Study (TexAQS II). He has been a consultant with the U.S. Environmental Protection Agency during the development of the guidance for the use of models and was a member of the Review Panel for the Uncertainty Analyses of Models in Integrated Assessments program at the EPA National Center for Environmental Research. After receiving a Ph.D. in mathematics from Texas Tech in 1980, Jim worked in aerospace remote sensing at the Johnson Space Center and as a software developer. He has written several papers dealing with the technical aspects of regulatory modeling and has represented the TCEQ at dozens of national air quality forums.

## LOUISIANA AIR QUALITY ISSUES

**Jennifer Mouton**
**Louisiana Department of Environmental Quality**

Click here to view the slide show that accompanied this presentation.

The new ozone standard and Louisiana's projected attainment status.

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Jennifer Mouton is a Senior Environmental Scientist in the Air Quality Assessment Division of the Louisiana Department of Environmental Quality. She serves as the state expert and primary assistant to the Administrator in the development of air quality planning and assessment functions, guidance, and regulations. Jennifer began her career as an air quality specialist with LDEQ eighteen years ago and has held various positions since then. Most recently, she served as Division Administrator prior to stepping down to assume a senior scientist position. During her career, she has conducted numerous compliance inspections and complaint investigations, managed the air engineering support services, and managed the development of a new emissions inventory reporting application. She has been a presenter at numerous state, EPA and industry workshops and conferences. Jennifer holds a B.S. degree in agronomy and an M.S. degree in environmental science from McNeese State University.

## MISSISSIPPI AIR QUALITY ISSUES

**Jerry Beasley**
**Mississippi Department of Environmental Quality**

Click here to view the slide show that accompanied this presentation.

Information regarding the status of air quality in Mississippi will be presented. This includes updated air quality data, attainment/nonattainment issues, monitoring, and other issues.

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Jerry Beasley is the chief of the Air Quality Planning Section at the Mississippi Department of Environmental Quality (MDEQ). He has been employed at the MDEQ for 18 years. Mr. Beasley has a B.S. degree and an M.S. degree in chemical engineering — both from Mississippi State University. He is a registered Professional Engineer in Mississippi and a Board Certified Environmental Engineer with the American Academy of Environmental Engineers.

## ALABAMA AIR QUALITY ISSUES

**Leigh Bacon**
**Alabama Department of Environmental Management**

Click here to view the slide show that accompanied this presentation.

The Sipsey Class I $SO_2$ Increment Assessment project focuses on evaluating the current state of the Class I Increments at the Sipsey Wilderness Area, located within the Bankhead National Forest in Northwest Alabama and the impact of massive reductions in $SO_2$ over the last three decades from the utilities.

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Leigh Bacon is Chief of the Meteorological Section at ADEM and has been with the department for over 16 years. For many of those years, her work focused on PSD/NSR activities and Air Quality forecasting. Over the last five to seven years, in particular, she has worked with regional initiatives such as the Gulf Coast Ozone Study (GCOS) and the VISTAS Regional Haze Initiative. She is currently working with the Department on the Birmingham Area Particle Study (BAPS) which focuses on PM2.5 issues in downtown Birmingham.

## SESSION 2B

## GOM DEEPWATER BENTHIC HABITATS III
## MMS/NOAA OER/USGS
## Collaborative Studies: Investigations of Chemosynthetic Communities on the Lower Slope of the GOM; Final Project Year

**Chair:** **Gregory Boland, Minerals Management Service**

**Co-Chair:** **James Sinclair, Minerals Management Service**

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# QUANTITATIVE IMAGE ANALYSES OF COLD SEEP AND HARD GROUND COMMUNITIES ON THE LOWER LOUISIANA SLOPE

**Ian MacDonald**
**Texas A&M University - Corpus Christi**

**Stephanie Lessard-Pilon**
**Pennsylvania State University**

Click here to view the slide show that accompanied this presentation.

## Introduction

Quantitative photography has been an important tool for detecting chemosynthetic communities on the Gulf of Mexico slope (MacDonald et al. 1989). It provides a means for characterizing the general animal composition for chemosynthetic and non-chemosynthetic species and for testing the relationship between species and abiotic habitat styles. With careful spatial control, it is possible to develop estimates of percent cover and frequency of occurrence for diagnostic species. Repeated measures can also be used to show changes over long and short time periods. High resolution images and mosaics of multiple images are useful for taxonomic identification, species interactions, and range extensions. Various photographic methods have been employed during the course of the CHEMO III program (*Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico*). In this presentation we outline the application of quantitative photography for large-area surveys of study sites occupied during CHEMO-III. We describe the results to date from analysis of over some 2,600 images collected along random sampling transects at study sites. Figure 2B.1 shows the locations where photographic surveys were completed during a June 2007 expedition with ROV JASON. We will also describe analysis of high-resolution mosaics of multiple digital images taken over aggregations of chemosynthetic animals.

## Methods

Images were collected with a vertically oriented digital still camera mounted on the underside of JASON. Illumination was provided by a pair of 300 watt-sec strobes. Two green lasers were mounted in parallel, 28 cm apart, and aimed so that their dots appeared near the center of each image. A video display in the ROV control room allowed the investigators to preview a low-resolution version of the 3.2 megapixel images. Pictures were taken using a 10 to 15 s intervalometer (for transecting) or manual operator control (for collecting images to form mosaics). Full-resolution images were stored on the cameras internal memory and were not available until after an ROV lowering had been completed.

For photo-surveying, images were collected along a series of ten transects ~50 to100 m in length distributed within a designated area of interest e.g. 350 m E-W by 200 m N-S. An excel macro

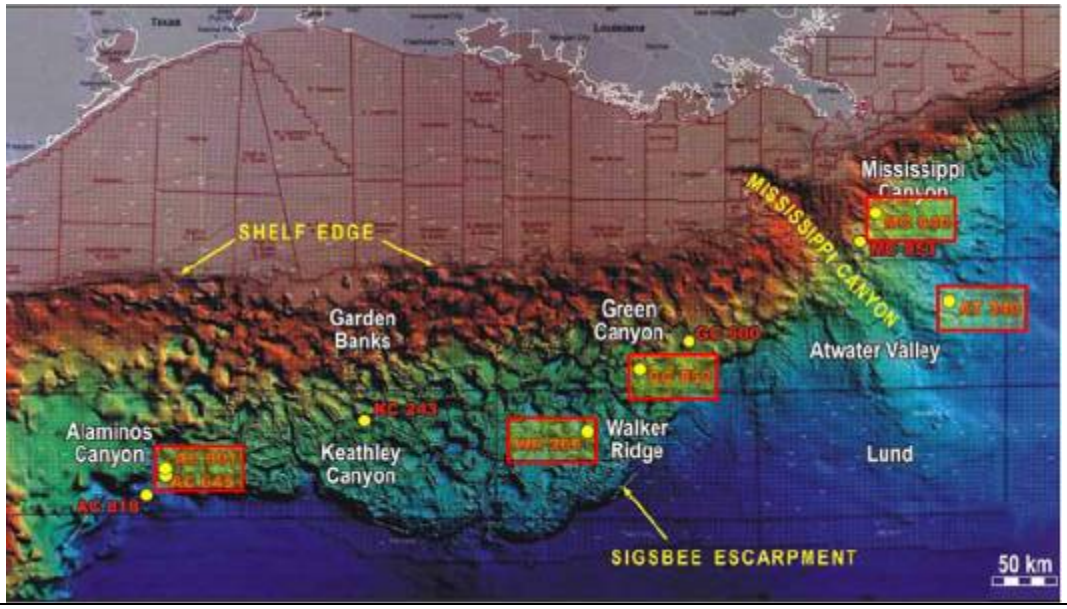


**Figure 2B.1. Gulf of Mexico map showing CHEMO III sampling sites. Boxes are survey locations.**

was developed to randomly position transects within the designated area. Transect orientation was parallel, and positions were randomized but controlled so that the ends of transects fell within the area boundaries. Height above bottom was also randomized due to concerns for biasing for or against features of different scales. The average area covered by a survey image was about 9 $m^2$. Eight surveys were completed at six sites. Typically a survey comprised 350 to 400 images and covered a total of about 3000 $m^2$. Figure 2B.2 shows a competed survey pattern from the AC340 study site.

For analysis of photo-survey images, operators calculated the scale of each image by measuring the distance between the laser dots. Habitat areas were measured and individual animals were counting using procedures in the Image-J ® software package. Care was taken to avoid double counting when images overlapped.

To collect images for construction of mosaics, the ROV was piloted along a series of short (typically <15m) transects using closed loop navigation. Images were collected with an overlap of ~30–50%. Scaled markers were placed in the mosaic area to aid positioning and size determination. Individual images were joined into high-resolution mosaics using MatLab procedures compiled by investigators at Woods Hole Oceanographic Institution.

## Results

Distinct differences in habitat coverage were detected among the six study sites. Distribution of habitat categories related to hydrocarbon seepage and chemosynthetic life was typically patchy and generally occupied less than 15% of any of the surveyed areas. The most widespread habitat type was authigenic carbonate, which occurred as rubble, low-relief pavements and massive

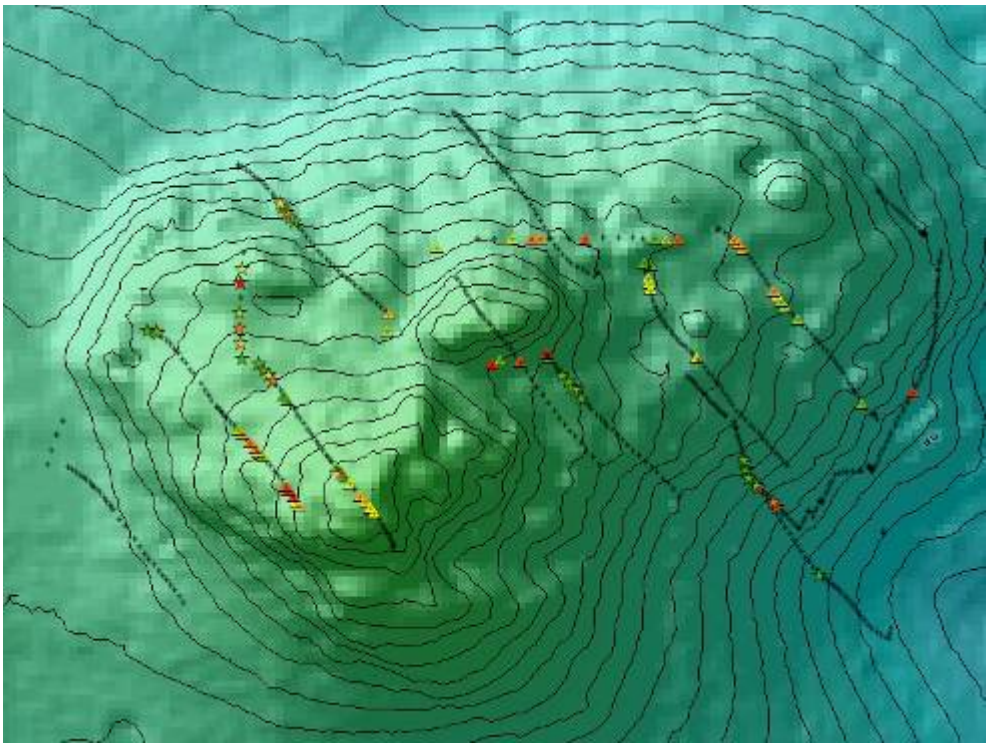

**Figure 2B.2. Photo-survey transects across a 300 x 250 m region in AC 340. Triangles indicate relative abundances of tube worms, stars and heart urchins.**

boulders. Non-chemosynthetic animals were most commonly associated with tube worms or mussels, however a echninoid (heart sea urchin) also achieve high abundances and wide-spread distributions. Figure 2B.3 shows a summary of percent habitat coverage among the eight surveys.

Analysis of the high-resolution mosaics showed evidence for behavior patterns over short time scales and possible successional changes over longer time scales. By repeating mosaics over 10 and 12-day intervals, movement patterns and trail-making activity of heart sea urchins could be measured with precision. These processes are thought to be important for determining rates of bioturbation in sediments and enhancement of oxidative consumption of hydrocarbons. Figure 2B.4 shows repeated mosaics of sea urchin aggregations. A much longer (15-year) time course was achieved when we collected a mosaic over a site that had previously been mosaicked in 1992. Although the 1992 mosaic was compiled from lower-resolution video images, comparisons indicated a change in the relative abundance of tube worms (increasing) and mussels (decreasing).

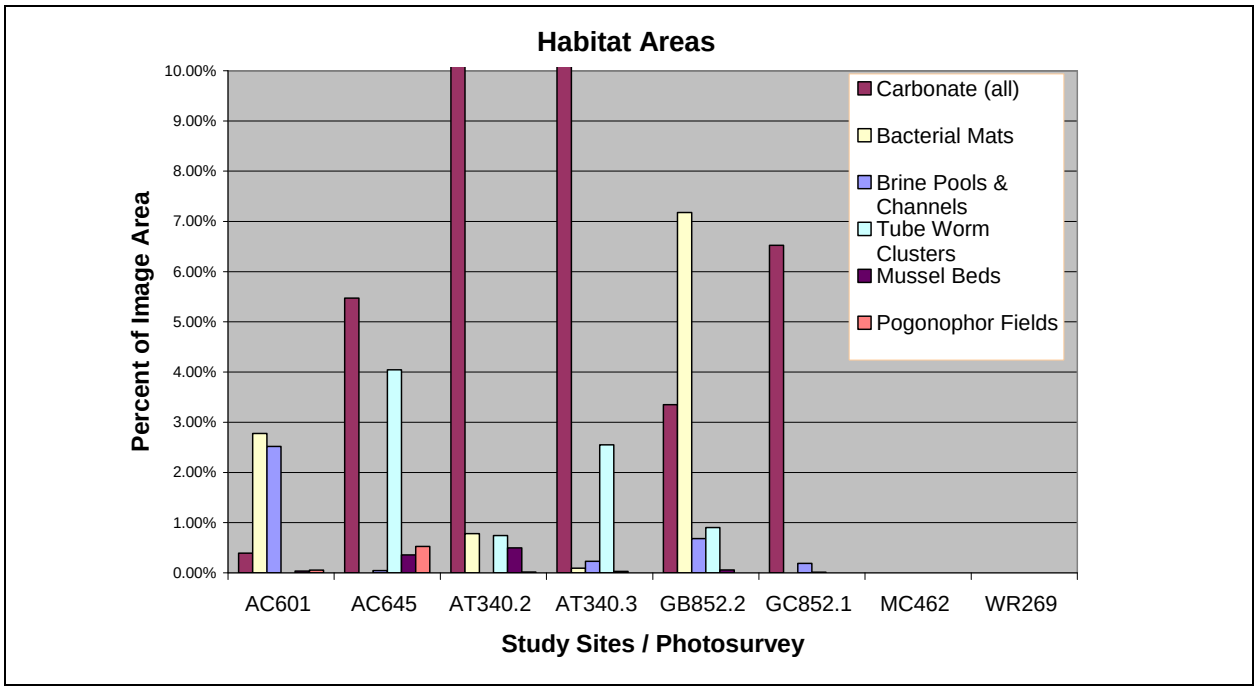


**Figure 2B.3. Summary results of habitat coverage in eight surveys completed at six of the CHEMO III study sites (see Figure 2B.1 for locations).**

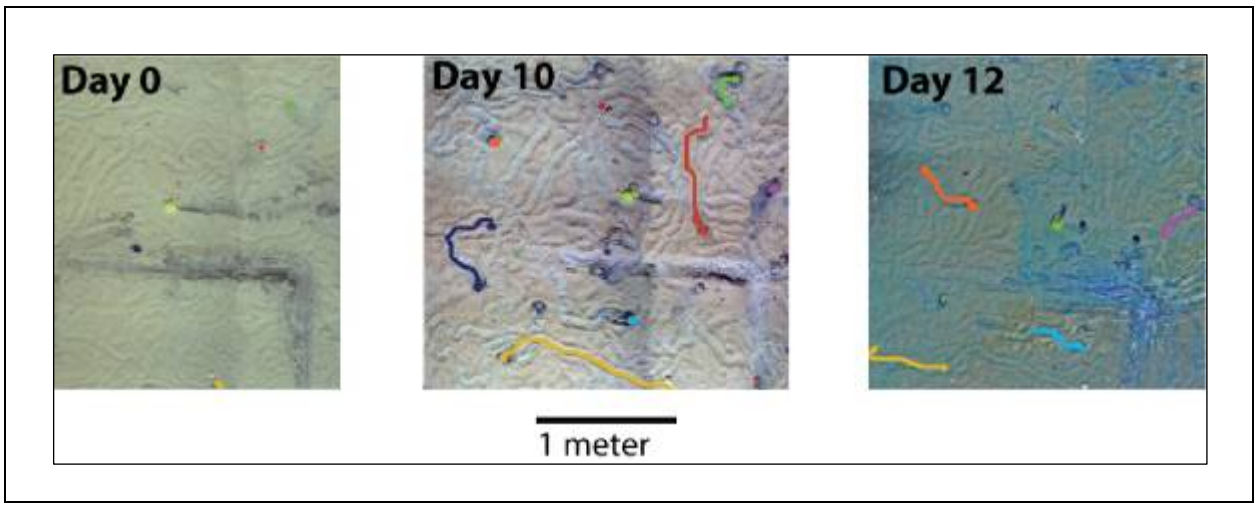


**Figure 2B.4. Trails formed by heart sea urchins over ~10-day time-scales. Movements appear intermittent.**

## Discussion

Quantitative photography has provided cost-effective and repeatable results useful for characterizing chemosynthetic communities. As investigations have moved into deeper waters with the CHEMO III project, improved methods and equipment have increased the scope of

possible investigations. Photographs also play an important role in documenting the deep-sea world for the general public.

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Ian R. MacDonald, Ph.D. is Professor of Environmental Science with the Physical and Environmental Sciences Department of Texas A&M University - Corpus Christi. Dr. MacDonald is an internationally recognized authority on the biology and geology of marine oil seeps with some 60 peer-reviewed articles and over 60 reports and popular articles on related topics. His work on gas hydrates in 1994 was the first to demonstrate a link between water column processes and the stability of shallow gas hydrates. He has contributed to work on the biogeochemistry of gas hydrates, including the discovery of so-called ice worms. He has published pioneering work on asphalt volcanoes and chemsynthetic life in the southern Gulf of Mexico. His research has entailed extensive use of such deep-diving submarines as *Johnson Sea-Link, Alvin*, and the Navy nuclear submarine *NR-1.* Altogether he has spent a total of 60 continuous days at depths of 1,800 feet or more in the Gulf of Mexico, his particular interest is the application of imaging technology and *in-situ* instrumentation to marine research. Although primarily focused on the Gulf of Mexico region, MacDonald maintains an active international perspective. In the recent years, his research has also taken him to the Canadian Pacific, the Caspian, and the Chukchi Sea.

# BIOGEOCHEMISTRY, MICROBIAL ACTIVITY, AND MICROBIAL DISTRIBUTIONS IN SEDIMENTS OF THE DEEP SLOPE

**Samantha B. Joye, Marshall W. Bowles, Vladimir A. Samarkin, Kimberley S. Hunter, Kathy M. Bowles, and Katherine E. Segarra**
**University of Georgia**

**Helge Niemann**
**University of Basel, Switzerland**

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Variations in pore water geochemistry and rates of microbial processes in sediments from different cold seep habitats along the lower continental slope (Gulf of Mexico) were examined. Nutrients (nitrate ($NO_3^-$), nitrite ($NO_2^-$), ammonium ($NH_4^+$), dissolved organic carbon (DOC)), dissolved gases (methane ($CH_4$), sulfide ($H_2S$)), dissolved inorganic carbon (DIC), and major ions (chloride ($Cl^-$), sulfate ($SO_4^{2-}$)), were determined in four replicate cores per habitat. A comparison of different seep habitats with contrasting micro- and macro-fauna revealed differences in geochemistry and microbial activity. Control or non-seep sediments were used as background level indicators and were categorically different from all habitats assessed (i.e, brines, oily brines, tube worm, pogonophoran, bacterial mat, and urchin-hosting sediments). All sediments maintained methane levels higher than control sediments, with oily brine sediments (MC853) having the highest methane concentrations (~7 mM). Sulfate was depleted in all habitat types, but bacterial mat sediments contained ample sulfate, indicating rapid sulfide oxidation. Animal hosting sediments (i.e. tubeworm, pogonophoran, and urchin habitats) were characterized by elevated levels of DOC and relatively low levels of ammonium, thereby suggesting possible exudation of DOC into the sediments by the resident animals. Brine sediments maintained the highest levels of DOC and ammonium concentrations, and ammonium concentrations were linearly related to salinity. Brine flows represent a distinct additional source of organic matter to cold seeps. Sulfate reduction (SR) and methane oxidation (MO) rate assays were performed in addition to basic geochemistry. Sulfate reduction rates were much lower along the deep slope than previously observed at shallow slope sites. Similarly, MO rates were much lower than those measured on the upper slope. Highest SR rates were measured in brines while highest MO rates were measured in animal-inhabited sediments (pogonophoran).

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Samantha B. Joye is a Professor of Marine Sciences at the University of Georgia, Athens, GA. Dr. Joye received her B.Sc. in biology from the University of North Carolina at Chapel Hill in 1987. She received her Ph.D. in marine sciences from the University of North Carolina at Chapel Hill in 1993. After a two-year post doctoral fellowship in California, she became an Assistant Professor of Oceanography at Texas A&M University in College Station, TX. She moved to the

University of Georgia in January 1998 and has served as Assistant, Associate and now Full Professor of Marine Sciences. Her research involves the biogeochemistry and microbial ecology of extreme environments, including gas, oil, and brine seeps in the Gulf of Mexico and saline lakes in Northern California and the Antarctic.

Marshall Bowles is a Ph.D. candidate at the University of Georgia (UGA), where his dissertation work focuses on the biogeochemical processes occurring within cold seep sediments. Specifically, his interests are in the relationship between sulfur, carbon, and nitrogen cycling in seep environs using classic radioactive and novel molecular techniques. He received a B.S. degree in 2003 from James Madison University and a Master of Environmental Management degree from Duke University in 2005. In his tenure at UGA, he has participated in numerous research expeditions, including the Eel River Basin, Hydrate Ridge, and the Gulf of Mexico.

# VIRUSES IN COLD-SEEP SEDIMENTS

**Christina A. Kellogg**
**U.S. Geological Survey**

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Numerous cold seeps and their associated chemosynthetic communities have been documented and studied in the Gulf of Mexico over the past 25 years. There are estimated to be $10^{30}$ marine viruses in the world oceans (Suttle 2007), and typically the number in the underlying sediments exceeds the water-column abundance by 10–100 times (Middelboe et al. 2006). Bacteriophages, viruses that specifically infect bacteria, make up the majority (reviewed by Fuhrman 2000). As the most numerous organisms in the marine environment, these viruses control bacterial diversity and succession, productivity, and the flow of carbon (viral lysis of bacteria converts cellular components into dissolved organic matter, transferring nutrients away from grazers and stimulating other heterotrophic prokaryotic growth) (Fuhrman 1999; Suttle 2005; Wommack and Colwell 2000). Additionally, high viral abundance in sediments has been shown to be an indicator of increased microbial activity (Glud and Middelboe 2004; Middelboe et al. 2003). In spite of the fundamental role that microorganisms play in chemosynthetic communities, no investigation of the viral dynamics in the cold-seep environments of the Gulf of Mexico has been undertaken.

Few studies have been conducted on sediments below 1,000 m and only one in a cold-seep environment (Middelboe et al. 2006). Further limiting our knowledge of viral dynamics in deep-sea sediments and cold seeps is the fact that all four of the existing studies conducted in these environments (Danovaro et al. 2005; Danovaro et al. 2002; Danovaro and Serresi 2000; Middelboe et al. 2006) involved samples preserved with formaldehyde or glutaraldehyde prior to enumeration. Rapid and variable viral decay has been shown to occur in aldehyde-fixed samples, resulting in underestimates of viral abundance (Wen et al. 2004). Because viral decay is not constant in aldehyde-fixed samples, corrections and comparisons between studies cannot be made (Wen et al. 2004). To provide accurate viral counts, unfixed samples must be used.

The objective of this study was to produce accurate baseline data on the abundance of prokaryotes and viruses in surface sediments below a depth of 1,000 m. The sites chosen included a variety of cold-seep environments in the northern Gulf of Mexico to test the hypothesis that chemosynthetic communities are areas of increased viral production.

Push cores were taken at four Gulf of Mexico sites at water depths below 1,000 m using an ROV. The sites included non-seep reference sediment, brine seeps, a microbial mat, an urchin field, and a pogonophoran worm community. Samples were processed immediately for enumeration of viruses and prokaryotes without the addition of a preservative. Prokaryote counts were an order of magnitude lower in sediments directly in contact with macrofauna (urchins,

pogonophorans) compared to all other samples ($10^7$ vs. $10^8$ cells/gram dry weight) and were highest in areas of elevated salinity (brine seeps). Viral-like particle (VLP) counts were lowest in the reference sediments and pogonophoran cores ($10^8$ VLP/g dry weight), high in brine seeps ($10^9$ VLP/g dry wt), and highest in the microbial mats ($10^{10}$ VLP/g dry wt). Virus-prokaryote ratios (VPR) ranged from <5 in the reference sediment to >30 in the microbial mats and >60 in the urchin field. VLP and VPR ratios were all significantly greater than those reported from sediments in the deep Mediterranean Sea and in most cases were higher than recent data from a cold-seep site near Japan. The high VPR ratios suggest that greater microbial activity in or near cold-seep environments results in greater viral production and therefore higher numbers of viruses.

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Christina A. Kellogg received her Ph.D. in marine microbiology from the University of South Florida for her work on the genetic diversity of environmental viruses. She did postdoctoral research on an NIH-funded fellowship at the Georgetown University Medical Center, using molecular methods to identify novel drug targets in pathogenic fungi. She also interned for several months at Human Genome Sciences, processing microarrays and using bioinformatics software to mine the data. She joined the U.S. Geological Survey as one of the first Mendenhall Fellows, characterizing the microbial communities in African dust, beach sediments, sea grass beds and coral reefs. In her current position as an environmental microbiologist, Christina applies molecular techniques and classical microbiological methods to study microbes in aerosols, the marine environment, tropical corals and deep-sea corals.

# TROPHIC LANDSCAPE OF SEEPS AND THEIR ENVIRONS

**Robert S. Carney**
**Department Oceanography & Coastal Sciences**
**Louisiana State University**

**Erin Becker**
**Department of Biological Sciences**
**Pennsylvania State University**

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When the full depth of continental slopes is considered, seep communities are seen as systems in which productivity is independent of depth embedded in a larger gradient of heterotrophic (secondary) production that decreases exponentially with depth. The influx of labile detritus to bottom is thought to barely meet the demands of the benthos, giving rise to the widely accepted idea that deep-sea ecosystems are food limited. If this limitation really exists, then the chemosynthetic production of seeps should play an increasingly important role with depth. This is a central question in the trophic analysis components of the Chemo-III project.

Our methods involve collection of fauna within seeps via submersibles and ROVs. These methods also involve collection by similar means of non-seep fauna close to seeps and more removed animals by means of trawling. Trapping was an important sampling method on the upper slope, but was much less productive at greater depths due in part to a decline in species easily attracted to traps. In all 3 otter trawl samples, 10 beam trawl samples, 16 Alvin dives, and 8 Jason dives collected animals from outside the immediate seep environment.

The modes by which seep-produced carbon can enter heterotrophic food webs include predation, consumption of exuvia from foundation species, ingestion of free-living chemosynthetic microbes during detritivory. Over a larger area methane plumes emanating from seeps may contribute to an isotopically distinct detrital rain ingested by benthic deposit feeders.

Upper-slope investigations established that the isotopic signature of source organisms varied greatly from site to site both in terms of $\delta^{15}N$ and $\delta^{13}C$. Scatter within communities was sometimes best explained as being due to trophic enrichment and sometimes due to mixing with the prevailing phyto-detritus carbon of the background. In comparison, lower seep mussels showed a narrower range of $\delta^{15}N$ depletion and greater $\delta^{13}C$ depletion. Lower slope tubeworms showed $\delta^{15}N$ values similar to upper-slope values but with a more depleted and scatted $\delta^{13}C$ profile. Thus, deeper chemosynthetic biomass appears to be isotopically distinctive.

At Alaminos Canyon 818 initial results suggest a greater dependence on seep production by “normal “ megafauna. At Atwater Valley 340, the picture is not as clear, but little consumption

of phytodetritus by seep associates is evident. When the holothuroids, the consummate detritus feeders, are examined, there is little evidence of seep input even for animals taken close to scattered seeps except by *Chirodota heheva*. This vermiform holothuroid has only been found in deep sulfidic systems and must be consuming a microbe-rich detritus within the seeps. Predatory seastars do consume seep carbon id sampled within 50m of a seep, especially *Ampheraster* sp.

A final resolution as to whether deeper seeps contribute more to the food-poor background remains to be resolved. One major problem that the isotopic profile of the deeper source species is highly variable. A second problem is that there appear to be fewer seep-exploiting species at the greater depths.

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Bob Carney began graduate studies of the deep-sea benthos at Texas A&M under Willis Pequegnat and went on to complete his Ph.D. studying the deep Pacific benthos at Oregon State. A professor of Oceanography and Coastal Sciences at LSU since 1986, he has held positions at the Smithsonian Institution, the National Science Foundation, and Moss Landing Marine Lab. Since returning to the Gulf of Mexico, he has carried out research on chemosynthetic communities as well as shelf-depth environmental aspects of oil and gas development. In addition to his Gulf of Mexico work, he is active in the global-scale synthesis of continental slope ecology being fostered by the Census of Marine Life. He is PI and co-director of the Continental Margins Ecosystems project (COMARGE).

Erin Becker is a Ph.D. student in biology at Penn State University after having completed a B.S. in ecology and evolution at the University of Pittsburgh in 2005. She has worked with using stable isotopes to determine food web interactions in communities associated with the reef-building coral Lophelia pertusa on the Upper Louisiana Slope. She is currently employing the same techniques to determine food web structure in tubeworm-, mussel-, and pogonophoran-associated communities in the deep slope environment.

# A MOLECULAR PERSPECTIVE ON GALATHEOID BIODIVERSITY AT DEEP-SEA CORAL AND COLD SEEP HABITATS IN THE NORTHWEST ATLANTIC OCEAN

**Martha S. Nizinski**
**National Oceanic and Atmospheric Administration**
**National Marine Fisheries Service National Systematics Laboratory**
**Smithsonian Institution**

**Cheryl L. Morrison**
**United States Geological Survey**
**Leetown Science Center, Aquatic Ecology Branch**

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Recent surveys using submersibles and ROVs have collected a diverse assemblage of galatheids and chirostylids associated with deep coral banks (off southeastern United States and north-central Gulf of Mexico), and cold seeps (Gulf of Mexico) in the western Atlantic.

As a complement to ongoing taxonomic and ecological studies of these species, DNA sequence data (COI, 16S, 18S) were generated for barcoding and to elucidate phylogenetic relationships. Furthermore, the evolutionary history of western North Atlantic species were put into context with better characterized Pacific species, allowing for comparisons of relationships between species collected at different habitat types, depths, and ocean basins. Based upon phylogenetic analysis of mitochondrial COI data, a new species of *Munidopsis* from deep *Lophelia* coral sites had a basal placement and was distantly related to *Munidopsis* species from hydrothermal vents. Additionally, a Gulf of Mexico cold seep *Munidopsis* species was most similar to a recently described eastern Pacific non-vent species. Analyses of COI and 16S mitochondrial data identified two monophyletic clades containing chirostylid taxa; one clade included three species of *Eumunida* (one western Atlantic and two Indo-Pacific), and the other clade contained several western Atlantic *Gastroptychus* and *Uroptychus* species. Our results indicate that the galatheoid fauna of deep coral and cold seep sites in the northwestern Atlantic are comprised of both species with close relationships to widespread species groups, suggestive of faunal connections, as well as genetically unique lineages.

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Martha Nizinski is a zoologist for NOAA/NMFS National Systematics Laboratory, National Museum of Natural History, Washington, DC. Dr. Nizinski earned a B.S. in biology at West Virginia Wesleyan College, a M.S. in zoology at University of Maryland, and her Ph.D. in marine science at the Virginia Institute of Marine Science, School of Marine Science, College of William and Mary. She has been employed by the Systematics Laboratory since 1987, first as a technician, then as a zoologist. After completion of her doctoral degree in 1998, Dr. Nizinski

began her research program studying the biodiversity, biogeography, taxonomy, and systematics of marine invertebrates, particularly decapod crustaceans. Her current research interests include taxonomy and systematics of galatheoid crabs; biodiversity, biogeography, population genetics and community structure of decapod crustaceans, and biodiversity and community structure of invertebrate fauna associated with deep-water coral reefs and cold seeps.

Dr. Cheryl Morrison is a geneticist at the USGS Leetown Science Center, Aquatic Ecology Branch, in Kearneysville, WV. Her work at USGS involves the application of genetics tools to assist in the management of biodiversity, and she has worked with a variety of organisms including freshwater fishes, unionid bivalves, jumping mice and corals. Dr. Morrison is a part of the USGS DISCOVRE team (Diversity, Systematics and Connectivity of Vulnerable Reef Ecosystems) working in the Gulf of Mexico and applies genetics techniques to help understand evolutionary relationships among corals, crabs, and reef-associated fauna, and to assess connectivity among deep reef areas. Cheryl received her B.S. degree in marine biology from UNC-Wilmington (1991) and a Ph.D. in biology from Florida State University (1997).

# SESSION 2C

# SOCIOECONOMICS I

**Chair:** **Tim Holder, Minerals Management Service**

**Co-Chair:** **Harry Huton, Minerals Management Service**

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# MARGINAL PRODUCTION IN THE GULF OF MEXICO AND LOST PRODUCTION FROM EARLY DECOMMISSIONING

**Mark J. Kaiser**
**Center for Energy Studies**
**Louisiana State University**

Click here to view the slide show that accompanied this presentation.

Hurricanes Ivan, Katrina, and Rita passed through the Gulf of Mexico during 2004 and 2005 and resulted in the largest number of destroyed and damaged offshore oil and gas structures in the history of Gulf operations. In the final official government assessment produced by the Minerals Management Service, a total of 126 platforms were destroyed and over 183 structures were identified as having extensive damage. The number of structures destroyed or damaged during hurricane events depends upon the path and strength of the storm, the location of infrastructure relative to the storm path, and site-specific characteristics such as structure vintage and strength. Property owners of damaged infrastructure are faced with a decision: Should the asset be abandoned along with its future cash flow or should the property be redeveloped? The decision to redevelop is made relative to other opportunities in a company's portfolio based on an economic comparison of the cost and risk of redevelopment against the benefits of future production. Fields early in their lifecycle are likely to support the production rates and reserves necessary for redevelopment, while mature fields are likely to be abandoned. Production associated with wells and structures not redeveloped are classified as lost. The first part of the presentation describes the likely contribution the collection of destroyed assets would have made to future production in the Gulf of Mexico, assuming that none of the destroyed assets will be redeveloped. The value of the remaining reserves from the set of destroyed structures is estimated to range between $1.3 billion to $4.5 billion, depending upon the scenario assumptions employed. For a future average oil and gas price of $100/bbl and $10/Mcf, for example, the total lost production is estimated to be $3.7 billion. We summarize the impact of the storms on the Gulf of Mexico oil and gas infrastructure and discuss the main issues involved in redevelopment decision making.

The second section describes a model to forecast the number of marginal structures in the shallow-water Gulf of Mexico and their relative contribution to production. All producing properties are unique and have costs and benefits specific to each stage of its life cycle. The capital intensive expenditures associated with drilling offshore wells and installing infrastructure during the early stages of development are usually quickly recovered the first few years of production, and operations are highly profitable during this time. As fields mature and operations transition into the later stages of their life cycle, decreasing revenue streams, higher operating costs, and fewer upside opportunities lead to declining profitability, and the field may become a candidate for divestiture. Eventually, all properties are abandoned when the marginal cost of production exceeds marginal revenue. Assets transition to marginal status at some point during

their life cycle before production is no longer economic. The number of shallow-water committed assets that are economic and marginal throughout a 60-year time horizon are estimated, along with the expected quantity and value of their production and revenue streams. The amount of hydrocarbon production from the committed asset class circa 2006 is estimated at 1,056 MMbbl oil and 13.3 Tcf gas, or 3,279 MMBOE. Marginal production is expected to contribute 4.1% of the total oil production and 5.4% of the total gas production from the inventory of producing structures circa 2006. The value of marginal production is estimated to contribute 1.2% of the $149 billion in total expected revenue.

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Mark J. Kaiser is Research Professor and Director, Research and Development, at the Center for Energy Studies at Louisiana State University in Baton Rouge, Louisiana. His primary research interests are related to policy and regulatory issues, modeling, and econometric studies in the energy industry, especially the oil and gas sector. He holds a Ph.D. from Purdue University.

# ACCESSING IMPACTS OF OCS ACTIVITIES ON PUBLIC INFRASTRUCTURE, SERVICES, AND POPULATION IN COASTAL COMMUNITIES FOLLOWING HURRICANES KATRINA AND RITA

**J. Matthew Fannin, Mark Schafer, Walter Keithly,**
**Arun Adhikari, and Ashley Barras**
**Louisiana State University**

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This research explores the diversity of fiscal and demographic effects following Hurricanes Katrina and Rita on coastal Louisiana parishes influenced by outer-continental shelf (OCS) energy activities. In this dimension of the research, a coastal community impact model (CCIM) is estimated to measure the fiscal effects of changes in initial OCS economic activity.

The CCIM model is an evolution of the original Louisiana Community Impact Model (LCIM) developed as one of a larger group of Community Policy Analysis System (COMPAS) models. In the first iteration, LCIM estimated individual, category-specific public expenditure demand equations using ordinary least squares and generalized least squares techniques in a cross-sectional modeling framework. Due to the heterogeneity of coastal parish local governments and their economies compared to parishes further removed from the coast, it is expected that a modeling approach which recognizes this heterogeneity will improve forecasting performance.

We applied a quantile regression framework to selected labor market equations in the labor market module and selected public service expenditure demand equations in the fiscal module. Quantile regression generates unique parameter estimates for separate quantiles of the dependent variable distribution. For example, this allows parishes with lower spending profiles in certain fiscal equations to have different parameter estimates than those parishes with higher spending profiles.

We tested the forecasting performance of OLS equations against quantile regression forecasts using Theil coefficient estimates. Results indicated there were no performance improvements for incommuting and outcommuting earnings equations in the labor force module. However, forecasting performance with per capita public works and per capita public safety expenditure demand equations were measurably improved with lower Theil coefficient estimates in almost all quantiles in these equations.

These results suggest that alternative estimators may provide increased forecasting performance over first-generation cross-sectional models used in Community Policy Analysis System models. Modelers should consider quantile regression in addition to historical estimators in their estimation activities.

J. Matthew Fannin is an Assistant Professor with the Louisiana Center for Rural Initiatives and the Center for Natural Resource, Economics and Policy within the Department of Agricultural Economics and Agribusiness at Louisiana State University. Dr. Fannin received his B.S. and M.S. degrees in agricultural economics from LSU and his Ph.D. in agricultural economics from the University of Missouri. He has an extensive background in regional economic modeling and impact analysis. He helped to develop the initial Louisiana Community Impact Model measuring labor force and fiscal sector changes from OCS activities. During his tenure at Missouri, he served as an Officer of Statistics with the Central Statistics Office, Republic of Ireland, where he developed a Social Accounting Matrix (SAM) system for a region in the Republic of Ireland. He has performed numerous economic impact analysis in many sectors of the economy including agriculture, manufacturing, tourism, transportation, healthcare, and higher education. He has authored numerous academic presentations and publications focusing on impact assessment and modeling, transaction cost theory, and innovation economics.

# SPATIAL RESTRUCTURING AND FISCAL IMPACTS IN THE WAKE OF DISASTER: THE CASE OF HURRICANES KATRINA AND RITA

**Tim Slack, Joachim Singelmann, and Candice A. Myers**
**Department of Sociology**
**Louisiana State University**

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The oil and gas industry has long played a prominent role in the social and economic life of coastal communities in the Gulf of Mexico Region (GOMR). This ongoing study draws on both primary and secondary data to assess the impact of Hurricanes Katrina and Rita on the oil and gas industry in the context of the broader recovery challenges faced by GOMR communities. The presentation provides a sampling of findings from guided conversations with key informants in storm affected communities as well as secondary data analysis examining post-storm population shifts and labor market restructuring.

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Tim Slack is an Assistant Professor in the Department of Sociology at Louisiana State University. He conducts research on topics related to poverty and inequality, rural sociology, social demography, and work and labor markets. Dr. Slack's work has appeared in peer-reviewed journals and edited volumes, and has been supported by funding from the National Science Foundation, U.S. Department of Agriculture, U.S. Department of the Interior, and other sources.

## ANALYSIS OF OFFSHORE RISK AND POST-HURRICANE REACTION

**David E. Dismukes**
**Center for Energy Studies**
**Louisiana State University**

Click here to view the slide show that accompanied this presentation.

This research focuses on industry reactions to changes in perceived operating risks resulting from hurricanes Katrina and Rita in 2005. The risks examined in this research are primarily associated with weather, and to a lesser extent, with the environment. The main areas of risk mitigation explored in this research include insurance and asset diversification. This research surveys current general forms of insurance in the offshore industry including traditional insurance, self-insurance, club or pooling insurance, and catastrophe bonds. Trends in the structure, participation, and costs of these various insurance instruments are considered.

This research also considers asset diversification trends associated with offshore production in the aftermath of the 2005 hurricanes. Empirical analyses were employed to determine if there were any significant post-hurricane shifts in asset ownership or operations.

The preliminary results suggest that most operators in the GOM turned to traditional and newly-emerging forms of insurance to mitigate risk in the aftermath of the 2005 hurricanes. While the cost of insuring increased significantly, these insurance cost increases do not appear to have resulted in any meaningful deterioration of interest in GOM operations. Further, no significantly measurable shifts in ownership shares or asset concentrations are apparent post-storm.

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David E. Dismukes is a Professor, Associate Executive Director, and Director of Policy Analysis at the Center for Energy Studies, Louisiana State University. His research interests are related to the analysis of economic, statistical, and public policy issues in energy and regulated industries. Over the past 20 years, he has worked in consulting, academia, and government service. David has been on the LSU faculty for over 14 years and since that time has led a number of the Center's research efforts on topics associated with most all aspects of the energy industry. He speaks regularly to professional, trade, and civic associations on important energy issues, trends, and topics. Dr. Dismukes received his M.S. and Ph.D. in economics from the Florida State University.

# SESSION 2D

# HYDRATES

**Chair:** **Bill Shedd, Minerals Management Service**

**Co-Chair:** **Paul Godfriaux, Minerals Management Service**

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# ABUNDANCE, GEOPHYSICAL CHARACTER, AND DISTRIBUTION OF "BSRs" (BOTTOM SIMULATING REFLECTORS) IN THE GULF OF MEXICO AND THE ATLANTIC BASINS

**Bill Shedd**
**Minerals Management Service**

Click here to view the slide show that accompanied this presentation.

Natural gas hydrate is a solid, ice-like lattice of a natural gas molecule surrounded by water molecules that form under low temperature and high pressure in the deep ocean margins worldwide and in polar regions onshore. "BSRs," or bottom simulating reflectors, are generated at the base of hydrate saturated sediments (acoustically fast) when underlain by free gas saturated sediments (acoustically slow). The MMS has an ongoing effort to identify and map BSRs in the GOM and the Atlantic in support of its assessment of hydrates as a resource and the site selection process for the Department of Energy's Joint Industry Project (JIP) to drill and sample hydrates in the GOM. To date, over 100 BSRs have been mapped.

In areas of laterally and vertically consistent geothermal heat flow, as in the Atlantic, the base of hydrate stability simulates the structure of the seafloor. In areas where heat flow is uneven, as in the Gulf of Mexico due to diapiric salt, BSRs often do not simulate the structure of the seafloor and can "plume" upwards to or near the seafloor.

There are three types of BSRs: 1) Continuous, 2) Segmented (or discontinuous), and High Relief (or, pluming).

Continuous BSRs occur in vertically and laterally homogeneous sedimentary sections, most typically in fine-grained settings. The type section for the continuous BSR is the Blake Ridge in the Atlantic.

Segmented BSRs occur in heterogeneous stratified sedimentary sections with alternating beds of sand and shale. The BSR is expressed strongly where sands are gas charged below the base of hydrate stability and hydrate charged above. In the intervening shale beds, the BSR is weak or absent due to low concentrations of gas and hydrate. This is the most common type in the GOM and in the Mid and North Atlantic.

The high relief BSRs occur in areas of laterally variable heat flow, especially near the flanks of salt, where vertically migrating gas, oil, and warm brine cause the hydrate stability zone to thin dramatically. These are common in the GOM where there is active salt diapirism and hydrocarbon migration; few high-relief BSRs have been identified in the Atlantic due to the paucity of salt diapirs. There is a strong correlation in the GOM between the presence of BSRs

and seafloor amplitude anomalies interpreted to be hydrocarbon seeps – 81% of all BSRs in the GOM are associated with seafloor amplitude anomalies, 19% are not.

Combinations of these three types are common in the GOM, accounting for around 27% of all BSRs recognized to date. Of the three types, 58% are segmented BSRs, 12% are continuous BSRs, 5% are high relief, and 30% are combinations.

The average size of BSRs in the Atlantic is much larger than in the GOM—2.34 million acres in the Atlantic versus 6,848 acres in the GOM. The size estimates in the Atlantic were generated from a relatively coarse 2-D seismic grid, whereas the GOM is covered by overlapping 3-D seismic surveys.

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William (Bill) Shedd graduated from the University of Rochester in 1973 with a B.A. in geology. As part of his coursework there, he attended the 1972 fall semester at the West Indies Lab, St. Croix, U.S. Virgin Islands, and he worked for the Smithsonian Institute under Dr. Walter Adey on a Holocene carbonate reef research project. He also worked for Western Geophysical on a marine crew in the Gulf of Mexico in 1974 until he began his M.S. coursework at Louisiana State University in geology. After completing his coursework at LSU, he worked for Shell Oil Company from 1977 to 1981 and several independent oil companies as a geoscientist until becoming a co-founder of Independent Energy Corp. in 1989. From 1994 to 1997 he consulted for several large and small independent oil companies in exploration, development, log analysis, geophysical interpretation, and well site analysis. In 1997 he joined the Minerals Management Service as a geophysicist in the Resource Evaluation Division, Geological & Geophysical Section evaluating lease blocks after lease sales. While doing this work, he recognized that seafloor amplitude response on industry 3-D seismic data is an effective tool in locating oil and gas seeps, subsurface migration conduits, natural gas hydrates, and chemosynthetic communities. He then joined the Resource Studies Section at the MMS and became active in the submersible dive program contracted through LSU to Dr. Harry Roberts to groundtruth the seismic mapping of the seafloor amplitude anomalies. He is currently also active in the methane hydrate assessment study.

# METHANE HYDRATE RESOURCE ASSESSMENT OF THE OUTER CONTINENTAL SHELF: IN-PLACE GULF OF MEXICO RESULTS

**Matt Frye**
**Minerals Management Service**

Click here to view the slide show that accompanied this presentation.

The Minerals Management Service (MMS) is a U.S. Department of the Interior agency responsible for managing the mineral resources of the U.S. Outer Continental Shelf (OCS). The MMS is in the process of performing the first comprehensive assessment of potential gas hydrate resources on the OCS since a USGS-led 1995 effort. Preliminary stochastic modeling results for the U.S. Gulf of Mexico (GOM) indicate a mean in-place gas hydrate resource base of 21,444 trillion cubic feet (TCF). Complete documentation of the input parameters and modeling methodology is available in OCS Report MMS 2008-004.

Regional MMS personnel assessed approximately 425,000 $km^2$ in the GOM where pressure and temperature conditions provide a stable physical environment for the formation of hydrate, and where seismic data are available for subsurface interpretation. GOM-wide interpretations of shallow sand distribution, seafloor amplitude anomalies, bathymetry, and depth to salt were generated using the MMS proprietary seismic database. Supporting subsurface data (wellbore, geological, etc.) were integrated with the geophysical data.

The GOM assessment model structure consists of nearly 200,000 cells that measure 2.32 $km^2$ each. The stochastic FORTRAN-based model incorporates the uncertainty of many input variables through multiple trial runs, producing a distribution of results where the mean is the expected value. The model methodology is based on mass balance, where inputs include an initial endowment of TOC, a volume of candidate reservoir rock, and a fraction of the rock volume that allows for hydrate concentration.

Input and output data for the GOM are spatially referenced and allow for hydrate resources to be distributed with reference to underlying geologic features. Relatively large volumes of these resources are estimated to accumulate near the margins of intra-slope minibasins and near the front of the Sigsbee Escarpment.

The GOM model is being modified for application to the Atlantic OCS. Additional work is underway to prepare input data files for the Pacific and Alaskan OCS margins, as well as to develop a technically recoverable module that will model ultimate producibility of the in-place resources.

Matt Frye serves as a geoscientist with the U.S. Department of Interior's Minerals Management Service (MMS) in Herndon, Virginia. He is actively involved with oil and gas resource assessments on the U.S. Outer Continental Shelf, including the ongoing development of the MMS gas hydrate assessment model. Previously, Matt spent nearly eight years in the MMS New Orleans office as a geoscientist with a focus on deepwater exploration and prospect evaluation. He earned a B.S. from Ohio University and an M.S. from New Mexico State University, both in geological sciences.

# SEAFLOOR REFLECTIVITY ANOMALIES AND THEIR RELATIONSHIPS TO SURFICIAL AND SHALLOW GAS HYDRATE OCCURRENCE

**Harry H. Roberts**
**Coastal Studies Institute**
**Department of Oceanography and Coastal Sciences**
**School of the Coast and Environment**
**Louisiana State University**

Click here to view the slide show that accompanied this presentation.

The northern Gulf of Mexico continental slope is one of the most complex passive margins in today's oceans. Over time, enormous volumes of sediment delivered by a world-class river and its ancestors (the Mississippi River and older systems that drained the North American continent) to the northern Gulf were deposited over a thick salt unit which formed in the early stages of Gulf evolution. Deformation of the salt by sedimentary loading and thickening of the siliciclastic sediment wedge created many traps and pathways for the upward migration of hydrocarbons, brines, formation fluids, and sometimes fluidized sediment to the modern seafloor. Because of this geologic framework, the Gulf of Mexico became the first major deep water province for oil and gas production. With the evolution of the deep water oil and gas business came data collection on an enormous scale to support both exploration and production. The development and collection of 3D-seismic starting in the late 1980s was responsible for outstanding success in finding oil and gas resources and was the fundamental database for developing our modern understanding of the northern Gulf's subsurface and surface geology. Among other discoveries were the large number of sites where fluid and gas expulsion processes had impacted the modern slope surface. Coring and direct observation of sites of hydrocarbon seepage and venting using manned submersibles and ROVs, starting in the mid-1980s, correlated seeping hydrocarbons with unusual chemosynthetic benthic communities that lived on seep-related chemistry (Kennicutt et al. 1985; Childress et al. 1986; Roberts and Aharon 1994). In addition, the presence of gas hydrate was observed in cores from seep locations (Brooks et al. 1986).

Studies of chemosynthetic communities, gas hydrate, and surficial geology of the slope continue (Roberts et al. 2007) and because of the slope's enormous volume of 3D-seismic data, we now can appreciate the slope-wide scope of fluid-gas expulsion. At the present time, high quality 3D-seismic surveys cover the entire slope from east Texas on the west to DeSoto Canyon on the east, Figure 2D.1. Finding sites of hydrocarbon seepage and venting (fluid and gas expulsion sites) can now be accomplished with a high degree of accuracy using 3D-seismic surface amplitude analysis. This methodology involves analyzing the seafloor reflector for strength of the return (Roberts et al. 2006). Both areas of highly positive or very reflective seafloor as compared to background values and areas of negative or lower than background values can be found. Figure 2D.2 illustrates a number of highly reflective areas in the Mississippi Canyon lease area and a

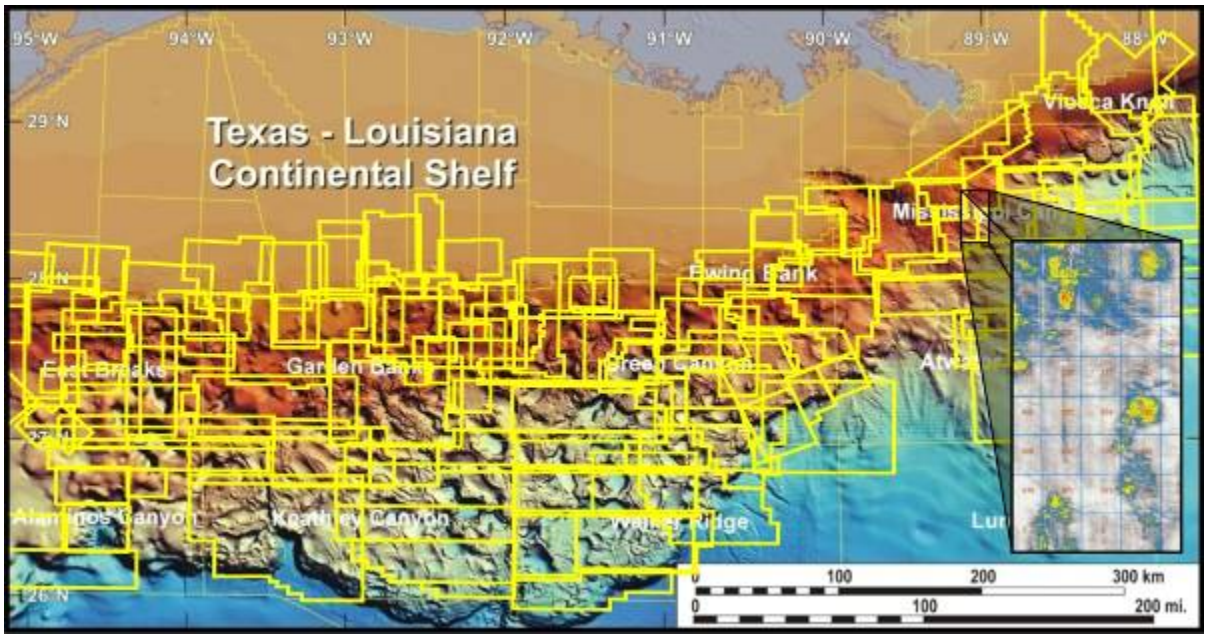


**Figure 2D.1. The MMS proprietary 3D-seismic database covers nearly all of the Gulf's northwestern and northern continental slope. The yellow rectangles represent individual survey data sets. Scattered over the slope are numerous surface reflectivity "bright spots" (inset) that represent locations of fluid-gas expulsion. The reflective hard bottom at these sites is primarily authigenic carbonate formed as a by-product of microbial oxidation of hydrocarbons.**

mound that developed on the seafloor corresponding to one highly reflective site with a distinct fluid-gas migration pathway from the deep subsurface. Positive reflectivity correlates to hard bottom areas and low positive or negative reflectivity corresponds to soft bottom (usually gascharged). Because the northern Gulf's continental margin is an active seaward building system, outcrops of "old" rocks are not found. In contrast, they are found on margins that experience low sedimentation rates. So, areas of hard bottom in the northern Gulf are either outcrops of salt, sand, or some sort of mineralization. Both direct observations and sampling of highly reflective areas of the slope indicate that almost all of these reflectivity anomalies are carbonates that have formed in place as by-products of microbial utilization of hydrocarbons. Barite and gas hydrate outcropping at the seafloor or in the shallow subsurface also create these anomalies, but compared to carbonates their contributions are small. Low positive or negative anomalies are usually the venting sites where gas and gas-charged fluidized sediment is being forced into the water column and flowed onto the surrounding seafloor. The MMS database of proprietary 3D-seismic data has been used to identify seafloor reflectivity anomalies over the entire continental slope of the northern Gulf (> 76,000 sq. miles). The bathymetric geometry and amplitude response of fluid-gas expulsion features is largely controlled by the rate at which hydrocarbons, brines, formation fluids, and fluidized sediment arrive at the seafloor.

**Figure 2D.2. This picture of gas hydrate exposed at the seafloor was taken in GC 234. The s urrounding chemosynthetic fauna, modest amounts of authigenic carbonate, and outcrops of gas hydrate are typical of expulsion sites that are between rapid venting and very slow seepage.**

Positive bathymetric features, such as mud volcanoes, occur where high flux rate seeps with significant sediment expulsion are present on relatively low slopes, whereas sediment flows occur on steep slopes. Mud volcanoes generally have low amplitude response on the seismic data due to lack of authigenic carbonate and possible presence of gas. Flows can have either high or low amplitude depending on the composition of the flow. The presence of carbonate lithification, shells, and sand-sized sediment can create high amplitudes. Most flows are fine-grained. Low-to-moderate expulsion rate sites result in mounds often covered with authigenic carbonates (formed by chemosynthetic bacteria) which, if swept by bottom currents, will be exposed and become suitable substrates for benthic magafauna such as hard corals, and anoemones. Chemosynthetic communities inhabit these sites. Low to moderate expulsion rates in pre-existing bathymetric depressions result in authigenic hardgrounds that do not get exposed and current swept. These are not suitable substrates for non-chemosynthetic magafauna due to soft sediment cover over the carbonate. So, rapid flux settings are not suitable for either chemosynthetic or normal benthic

magafauna because of high sedimentation rates, even though hydrocarbons may be present. Only lucinid-vesycomyid clams and bacterial mats are found in these settings. Because of frequent elevated heat flow and high salinities at these venting sites, conditions for gas hydrate stability are not met. Very slow seep sites may have authigenic carbonates and occasional bacterial mats, but gas hydrates are not found at the surface or are not interpreted to occur in the shallow subsurface. Intermediate flux settings, however, have all of the requirements for densely populated chemosynthetic communities, authigenic carbonate formation, and gas hydrate deposits outcropping at the seafloor or in the shallow subsurface (MacDonald et al. 1994), Figure 2D.2. It has been proposed that shallow gas hydrate deposits form a trophic resource for chemosynthetic communities can be linked to long-term maintenance of such communities (Carney 1994). Therefore, identifying these intermediate flux settings using 3D-seismic surface reflectivity patterns and strengths coupled with profile views of sites can be a valuable process for identifying gas hydrate deposits outcropping at the seafloor or in the shallow subsurface.

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Harry H. Roberts is the former director of Coastal Studies Institute (for 10 years) at LSU, an emeritus member of the Department of Oceanography and Coastal Sciences (School of the Coast and Environment), and a Boyd Professor. He has had a career in marine geology that spans 40 years and has worked in many foreign countries as well as in the United States. Recently, his research has focused on three themes: (a) modern deltaic sedimentation and processes, (b) shelf-edge deltas, and (c) surficial geology of the northern Gulf's continental slope. The latter research thrust has concentrated on building an understanding of the impacts of fluid and gas expulsion on the surficial geology and biology of the slope. Gas hydrate constitutes one of the unusual consequences of fluid and gas migration and expulsion in deep water.

# STATUS OF THE PROJECT TO MONITOR A CARBONATE/HYDRATE MOUND IN MISSISSIPPI CANYON BLOCK 118 AND THE MOVEMENT OF HYDROCARBON FLUIDS WITHIN IT

**Thomas M. McGee**
**University of Mississippi**

Click here to view the slide show that accompanied this presentation.

In 1998, the Minerals Management Service supported organization of the Gulf of Mexico Hydrates Research Consortium to carry out research into hydrate occurrences in near-sea-floor sediments in the northern Gulf. A carbonate/hydrate mound approximately one kilometer in diameter occurs in Mississippi Canyon Lease Block 118. The Consortium chose it to be the site of a multi-sensor, multi-discipline sea-floor observatory, and MMS declared a three-by-three kilometer region of sea floor that contains the mound to be reserved exclusively for research.

When completed, the observatory will include seismo-acoustic, geochemical and micro-biologic sensors. The intention is to monitor ambient seismo-acoustic noise, fluid venting and environmental conditions for a period of five to ten years. The goal of the monitoring is to improve understanding of the plumbing system through which hydrocarbon fluids and water migrate within near-sea-floor sediments. If gas hydrates are stable within these sediments, they can form within the migration pathways and possibly obstruct the plumbing to the point that the migration paths are altered. It is these alterations that monitoring is expected to detect.

This presentation describes progress in characterizing the mound and the status of the project as of the end of 2008.

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Thomas M. McGee received a B.Sc. in geophysical engineering, (St. Louis University, 1961), worked on seismic oil exploration crews in the Rocky Mountains and on the Gulf Coast, became a party chief for Geophysical Service Incorporated, and served on the first digital marine crew in the Gulf of Mexico. He returned to St. Louis University in 1966, completed doctoral exams (without dissertation) in 1968 and was appointed NATO visiting lecturer at the University of Utrecht, The Netherlands, in 1969. In the 1970s and 1980s he was marine geophysicist to the Geology Department at the University of British Columbia, founded a geophysical consulting company (Thalassic Data Limited of Vancouver, B.C.) and consulted in the planning and execution of engineering surveys at sea. In 1987 he returned to the University of Utrecht as Hooftdocent (Head Teacher) of marine geophysics and wrote a dissertation to receive a Ph.D. degree in 1991. He continued teaching and consulting in Europe until coming to the Mississippi Mineral Resources Institute of the University of Mississippi in 1997 where he is now a Research Associate Professor.

# SESSION 2E

## CIAP (COASTAL IMPACT ASSISTANCE PROGRAM)

**Chair:** **Bruce Baird, Minerals Management Service**

**Co-Chair:** **Bob Martinson, Minerals Management Service**

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# THE COASTAL IMPACT ASSISTANCE PROGRAM UPDATE—CHANGES IN PROCESSES

**Bruce Baird**
**Minerals Management Service**

Click here to view the slide show that accompanied this presentation.

The Coastal Impact Assistance Program (CIAP) is a federal grant program under the Energy Policy Act of 2005 to distribute $1 billion to six coastal oil-and gas-producing states. Under the CIAP, the Secretary of the Interior may distribute $250 million for each of the fiscal years 2007 through 2010, with the Minerals Management Service tasked to manage the CIAP. Money is allocated to Alabama, Alaska, California, Louisiana, Mississippi, Texas, and their eligible coastal political subdivisions (CPS) for the following purposes:

- projects and activities for the conservation, protection, or restoration of coastal areas, including wetland;
- mitigation of damage to fish, wildlife, or natural resources;
- planning assistance and the administrative costs of complying with the CIAP;
- implementation of a federally-approved marine, coastal or comprehensive conservation management plan; and
- mitigation of the impact of OCS activities through funding of onshore infrastructure projects and public service needs.

As the program has been implemented, several changes have been made in three key areas: 1) Plan (and Amendment) Review Process; 2) Interpretation of the Authorized Uses; and 3) Grant Process.

Under the Plan Review Process, key changes included elimination of separate Completion and Adequacy reviews, and the creation of an Executive Review Panel (ERP) to rule on allowability of projects.

A key change in the Interpretation of the Authorized Uses (AU) was made, so that projects submitted under AU 1 must demonstrate how the project *directly* or, as appropriate, *indirectly* benefits the natural coastal environment through the conservation, protection, or restoration of the natural coastal environment.

Changes in the Grant Process included elimination of separate Completion and Adequacy reviews, semi-annual (instead of quarterly) withdrawal limits in the ASAP grant payment system, and allowing of a recipient that co-funds a project to reference in its application the partner's approved documents as opposed to having to provide an additional copy.

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Bruce H. Baird attended the University of New Orleans where he earned a B.S. degree in biological sciences in 1980. He then attended Florida State University and earned an M.S. degree in biological oceanography in 1984. He worked as a water quality assessment specialist with the Louisiana Department of Environmental Quality from 1985 until 1988, a marine biologist with the Louisiana Department of Wildlife and Fisheries from 1988 until 1991, and a biologist with the Environmental Branch of the New Orleans District, U.S. Army Corps of Engineers from 1992 to 2006. His work experience involves estuarine fisheries issues, particularly effects of freshwater diversion projects on oysters, shrimp, and finfish, and includes biological sampling, development of biological monitoring programs, data analysis, and preparation of monitoring reports. He has prepared numerous environmental assessments and has served as a voting member of both the Caernarvon and Davis Pond Interagency Advisory Groups. On 1 October 2006, Mr. Baird joined the U.S. Minerals Management Service, Gulf of Mexico Region as a project officer to implement the newly initiated Coastal Impact Assistance Program.

# THE COASTAL IMPACT ASSISTANCE PROGRAM: SUMMARY OF LOUISIANA GRANTS PROJECTS

**Robert J. Martinson**
**Minerals Management Service**

Click here to view the slide show that accompanied this presentation.

The Coastal Impact Assistance Program (CIAP) is a federal grant program under the Energy Policy Act of 2005 to distribute $1 billion to six coastal oil-and gas-producing states. Under the CIAP, the Secretary of the Interior may distribute $250 million for each of the fiscal years 2007 through 2010, with the Minerals Management Service tasked to manage the CIAP. Money is allocated to Alabama, Alaska, California, Louisiana, Mississippi, Texas, and their eligible coastal political subdivisions (CPS) for the following purposes:

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- planning assistance and the administrative costs of complying with the CIAP;
- implementation of a federally-approved marine, coastal or comprehensive conservation management plan; and
- mitigation of the impact of OCS activities through funding of onshore infrastructure projects and public service needs.

States with an approved CIAP plan are eligible to receive CIAP funds. Louisiana's CIAP Plan was approved in November 2007. Plans for the remaining Gulf of Mexico states should be approved shortly. Louisiana will receive $255,095,796 for fiscal years 2007 and 2008. The allocations for 2009 and 2010 will be released in late April 2009, but for Louisiana will likely be somewhat less than the previous two years. The entire four-year Louisiana CIAP Plan includes the restoration of over 8,500 wetland and barrier island acres, conservation of 124,262 wetland and coastal acres, 21,600 cubic feet per second of Mississippi River diversions, and nearly 75 miles of shoreline protection and restoration. Work on the Louisiana projects has begun. As of 23 December 2008, Louisiana has submitted 57 grant applications. Seventeen of these grant applications have been approved with a value of $64,000,000.

Robert J. Martinson attended Colorado State University where he earned a B.S. degree in biological sciences in 1977 and an M.S. degree in zoology in 1980. He worked as a research associated for one year and with an environmental consulting firm for four years before joining the U.S. Army Corps of Engineers, New Orleans District in 1985. He worked initially in the Regulatory Program for three years and then moved to Planning in 1988. In 1990, he went to the U.S. Bureau of Reclamation, Denver Office, where he provided technical input on western water projects and conducted policy review. In 1994, Mr. Martinson rejoined the New Orleans District Planning Division. In 2000 Mr. Martinson was promoted to Chief of the Ecological Planning and Restoration Section with 12 employees. Work consisted of a wide variety of studies on flood control, hurricane protection, ecological restoration, navigation and hurricane Katrina and Rita reconstruction efforts. Over the years, Mr. Martinson has written dozens of environmental assessments and several environmental impact statements and supervised preparation of an equal number. On 1 October 2006, Mr. Martinson joined the Minerals Management Service, Gulf of Mexico Region as a project officer to implement the newly initiated Coastal Impact Assistance Program.

## LOUISIANA GRANT PROJECT 1
## (LAKE SALVADOR SHORELINE PROTECTION)

**Gregory M. Grandy**
**Louisiana Office of Coastal Protection and Restoration**

Click here to view the slide show that accompanied this presentation.

The Lake Salvador Shoreline Protection (Phase III) Project is the first CIAP project to complete construction. Through the project, the State of Louisiana and St. Charles installed 7,300 linear feet of rock dike along the northwestern portion of the Lake Salvador shoreline. The Lake Salvador shoreline is susceptible to erosion because of the long fetch across the lake, the vulnerable shoreline configuration, and the highly unconsolidated sediment base. These factors are responsible for the high shoreline erosion rate of approximately 13 feet per year, primarily at the expense of the adjacent fresh marsh.

Please see below a timeline of the milestone events on the CIAP Lake Salvador Shoreline Protection (Phase III) Project timeline:

- Louisiana submits CIAP plan to MMS (1 June 2007)
- MMS approved Louisiana CIAP Plan (29 November 2007)
- Louisiana submits CIAP grant (December 2007)
- Louisiana and St. Charles Parish execute interagency agreement (17 December 2007)
- Louisiana CIAP grant executed (9 April 2008)
- St. Charles Parish submits CIAP grant (31 March 2008)
- Louisiana agrees to advance $2.3 million prior to parish grant being executed (April 2008)
- Lake Salvador project pre-bid meeting (24 June 2008)
- Lake Salvador project bid opening (17 July 2008)
- Construction Kick-Off Meeting (22 October 2008)
- Construction Contractor on-site (3 November 2008)
- Construction Completion (22 January 2009)

The Lake Salvador Shoreline Protection (Phase III) Project was an extension of two previous shoreline protection projects on Lake Salvador. The first phase was completed in 1998 through the Coastal Wetlands Planning, Protection and Restoration Act Program, and the second phase was completed in early 2005 with funding through the NOAA CIAP program. The Lake Salvador Shoreline Protection (Phase III) Project was able to be accelerated for construction through the MMS CIAP program because the engineering, surveying, geotechnical investigations, landrights, cultural resources, and permitting for the work had been previously completed through the Phase II project.

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Greg Grandy is a Senior Project Manager with the Louisiana Office of Coastal Protection and Restoration. He manages the Coastal Impact Assistance Program (CIAP) for the state of Louisiana as well as several protection and restoration projects for the state of Louisiana, including the Grand Isle and Vicinity project in coordination with the U.S. Army Corps of Engineers and the Louisiana Coastal Area Barataria Basin Barrier Shoreline Restoration at Caminada Headland and Shell Island. Prior to coming to work for the state and working on CIAP, Mr. Grandy managed coastal restoration projects cooperatively implemented by the Louisiana Department of Natural Resources and the National Oceanic and Atmospheric Administration, including the Little Lake Marsh Creation and Shoreline Protection Project, the Four-Mile Cut Terracing Project, the Pass Chaland to Pass La Mer Barrier Island Project and the Brown Marsh Research Program for the state of Louisiana. Mr. Grandy was awarded the Coastal Steward Award in 2008 by the Coalition to Restore Coastal Louisiana for his work on the CIAP program.

# MARITIME FOREST RIDGE/MARSH RESTORATION NORTH OF PORT FOURCHON, LOUISIANA

**Kerry St. Pé and Richard DeMay**
**Barataria-Terrebonne National Estuary Program**

Click here to view the slide show that accompanied this presentation.

In late 1999, the Barataria-Terrebonne National Estuary Program (BTNEP) was invited to participate in a discussion with the Greater Lafourche Port Commission employees regarding the restoration of a maritime forest ridge or what is known locally as a chenier ridge just north of the port facilities. This project was being considered as a result of the planned expansion of the port. The entire chenier ridge would be constructed in three phases over a period of time. The ridge itself would be over 12,000 feet in length, eight feet in height, and 200 feet in width upon completion of the three phases. Flanking both sides would be 100 feet of marsh along the entire reach of the ridge. This restoration project would be constructed in shallow open water immediately north of the mitigated marsh that the port was responsible for constructing. Beginning in 2002, the initial material to build the ridge/marsh project was pumped to the desired location/desired height using a suction dredge. Periodically since then, the port has continued its plans for expansion and each time a different lift or section has been added to the project. In 2005, the BTNEP program paid for the initial shaping of 2,300 feet of the ridge/marsh platform by utilizing excavators and bull dozers. Soon after, numerous attempts were made to plant different species of grasses and woody plants across the shaped section. These attempts were not of a statistical design and represented more a demonstration than an actual scientific effort. In 2008, another 3,000 feet of ridge/marsh platform was shaped using heavy equipment. It is on this section that we will conduct statistically designed experiments involving the planting of both herbaceous and woody plants. Survival, growth, and soil chemistry will be evaluated through time. In addition, soil amendments will be used within this controlled study to determine their impacts on survival, growth, and changes in soil chemistry. This study will begin in 2009 and will continue for four years.

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Kerry St. Pé, for the past 11 years, has been the Executive Director of the Barataria-Terrebonne National Estuary Program, a nationally recognized effort dedicated to preserving and restoring the 4.2 million-acre area between the Mississippi and Atchafalaya Rivers in Southeast, Louisiana. He worked for 23 years as a field biologist and regional coordinator for the Louisiana Departments of Wildlife and Fisheries and Environmental Quality and served as Interim Administrator of the Louisiana Universities Marine Consortium (LUMCON) for three years. Kerry has conducted several major studies on the impacts of oilfield brine on Louisiana wetlands as well as studies of clam shell dredging in several Louisiana lakes. He serves on the Ocean Resource and Research Advisory Panel, a national advisory panel to the Secretary of the Navy

and state and local advisory boards and is a frequent public speaker. His wetland restoration work has been featured in the best selling book *Bayou Farewell, The Rich Life and Tragic Death of Louisiana's Cajun Coast* by Mike Tidwell and most recently in the PBS documentary, *Washing Away: Losing Louisiana.* Kerry grew up in Port Sulphur, Louisiana during the 1950s and 1960s where the vast coastal marshes surrounding his home inspired him to become a marine biologist. He graduated from Nicholls State University in 1973.

Richard DeMay attended Louisiana Tech University in the mid 1980s and obtained a B.S. degree in wildlife conservation in 1987. He later attended LSU and obtained an M.S. degree in 1991. Richard began working for the Barataria-Terrebonne National Estuary Program in 1991 serving as the Scientific/Technical Coordinator during the program's planning years when numerous technical projects were initiated. He now serves as Senior Scientist overseeing several aspects for the BTNEP program. His primary duties include implementation of the Migratory and Resident Bird Action Plan, management of the various BTNEP Web Sites, and coordination of the activities associated with the Maritime Forest Ridge and Marsh Restoration Project at Fourchon. He participated in two IPA's in the late 1990s; the first two-year IPA was with the U.S. Fish and Wildlife Service and focused on coastal restoration projects in Louisiana. The second two-year IPA was with the National Wetlands Research Center and focused on seagrass work across the northern Gulf of Mexico.

## LOUISIANA GRANT PROJECT 3
## (BARATARIA LAND BRIDGE DEDICATED DREDGING)

**Gregory M. Grandy**
**Louisiana Office of Coastal Protection and Restoration**

Click here to view the slide show that accompanied this presentation.

The Barataria Land Bridge Dedicated Dredging project is a marsh creation and nourishment project in Jefferson Parish, Louisiana. The project is located along the southeastern side of Bayou Rigolettes between the Harvey Cut and Bayou Perot in Jefferson Parish. The project will restore marsh by hydraulically dredging sediment from Bayou Rigolettes and depositing that material in shallow open water. The existing broken marsh will be nourished by the addition of a thin layer of sediment and will vegetate the hydraulically placed sediment by natural colonization of existing native wetland vegetation.

Please see below a timeline of the milestone events on the CIAP Barataria Land Bridge Dedicated Dredging Project timeline:

- Louisiana submits CIAP plan to MMS (1 June 2007)
- MMS approved Louisiana CIAP Plan (29 November 2007)
- Louisiana submits CIAP grant (December 2007)
- Louisiana CIAP grant executed (5 June 2008)
- Barataria project bid opening (10 July 2008)
- Construction Notice to Proceed (11 September 2008)
- Construction kick-off meeting (25 September 2008)
- Construction contractor on-site (30 September 2008)
- Construction completion anticipated (January 2010)

Construction of the Barataria Land Bridge Dedicated Dredging Project is being jointly funded through the Coastal Wetlands Planning, Protection and Restoration Act Program. The Barataria project first phase was first nominated by Jefferson Parish as a CWPPRA project in March 2001 and approved as a CWPPRA project in January 2002 to begin the engineering and design phase of work. The Louisiana Department of Natural Resources and the U.S. Fish and Wildlife Service

were the partners on the engineering and design phase of the project. The Barataria Project was able to be accelerated for construction through the MMS CIAP program because the engineering, surveying, geotechnical investigations, landrights, cultural resources, and permitting for the work had been previously completed through the CWPPRA program. The Barataria project is being funded for construction with 60% funds from the CIAP program and 40% funds from the CWPPRA program. The portion of the Barataria Land Bridge Dedicated Dredging Project being funded through CIAP is a 752 acre marsh creation and nourishment project in Jefferson Parish.

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Greg Grandy is a Senior Project Manager with the Louisiana Office of Coastal Protection and Restoration. He manages the Coastal Impact Assistance Program (CIAP) for the state of Louisiana as well as several protection and restoration projects for the state of Louisiana, including the Grand Isle and Vicinity project in coordination with the U.S. Army Corps of Engineers and the Louisiana Coastal Area Barataria Basin Barrier Shoreline Restoration at Caminada Headland and Shell Island. Prior to coming to work for the state and working on CIAP, Mr. Grandy managed coastal restoration projects cooperatively implemented by the Louisiana Department of Natural Resources and the National Oceanic and Atmospheric Administration, including the Little Lake Marsh Creation and Shoreline Protection Project, the Four-Mile Cut Terracing Project, the Pass Chaland to Pass La Mer Barrier Island Project and the Brown Marsh Research Program for the state of Louisiana. Mr. Grandy was awarded the Coastal Steward Award in 2008 by the Coalition to Restore Coastal Louisiana for his work on the CIAP program.

## SESSION 2F

## SOCIOECONOMICS II

**Chair:** **Harry Luton, Minerals Management Service**

**Co-Chair:** **Sindey Chaky, Minerals Management Service**

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# GULF COAST COMMUNITIES AND THE FABRICATION AND SHIPBUILDING INDUSTRY: A COMPARATIVE COMMUNITY STUDY

**Diane Austin**
**Bureau of Applied Research in Anthropology**
**University of Arizona**

Click here to view the slide show that accompanied this presentation.

This study is being conducted to describe and analyze the shipbuilding and fabrication industry in the Gulf of Mexico and its dynamic interactions with its host communities. The study will describe the industry, the services it provides, and its labor demands and how those needs are met. It also will provide information about the industry's geographic distribution, environmental impacts, trends, dynamics, and demographic and socioeconomic significance. Finally, the study will explore variation within the industry (e.g., large firms vs. small ones) and the effects of that variation. While, for comparative purposes, this description will include the industry as a whole, it will focus on the Gulf's petroleum-related sectors, on their similarities and differences to the industry as a whole, and on their socioeconomic consequences to the Gulf of Mexico Region.

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Diane Austin is an Associate Research Anthropologist with the Bureau of Applied Research and Anthropology and Associate Professor in the Department of Anthropology at the University of Arizona. Her interests include environmental anthropology; environmental and natural resource policy; environmental education; community development; social impact assessment; and social and environmental justice. Her current research is focused on notions of sustainability in community development on the U.S.-Mexico border, social impacts of the offshore oil and gas industry in the Gulf of Mexico; and the development of community-based participatory research approaches. Contact Information: Bureau of Applied Research in Anthropology; P.O. Box 210030; 316 Anthropology Building; University of Arizona; Tucson, Arizona 85721-0030; 520-626-3879; daustin@email.arizona.edu

# THE HISTORY OF THE GULF COAST SHIPYARDS AND FABRICATION INDUSTRY

**Jason Theriot**
**University of Houston**

Click here to view the slide show that accompanied this presentation.

In October 2006, the U.S. Minerals Management Service (MMS) funded a three-year study entitled Gulf Coast Communities and the Fabrication & Shipbuilding Industry: A Comparative Community Study. These specialized industries are responsible for the lion's share of the employment generated by the offshore oil and gas industry and, over time, have anchored and stimulated the growth of many Gulf coast communities. They have shaped their physical attributes, populations, and fiscal, social, and economic systems as well.

Despite their significance, however, these shipbuilding and fabrication industries, their histories, and their dynamic interactions with their host communities have not been well described or analyzed. This study is being conducted to address this significant gap in MMS data and analysis.

This paper provides a general overview of the shipbuilding and fabrication study from the industry perspective and will focus on two specific shipbuilding communities to describe the industries in these regions and to illustrate how these industries have changed over time.

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Jason P. Theriot is a Ph.D. candidate in the Department of History at the University of Houston. His major field is energy/environmental history. He is the author of a three-volume book series entitled *To Honor Our Veterans: An Oral History of World War II Veterans from the Bayou Country*. He is working on dissertation research about pipelines, oil field canals, and wetlands, tentatively titled, "The Tennessee Gas 'Muskrat Line': Building America's Energy Corridor through South Louisiana's Wetlands." Jason is also working as a researcher on two MMS studies: Gulf Coast Communities and the Fabrication & Shipbuilding Industry: A Comparative Community Study and History of the Gulf of Mexico Offshore Oil and Gas Industry during the Deepwater Era (History III).

# AUGMENTING LOCAL INFRASTRUCTURE TO MEET INDUSTRY NEEDS: COMMUNITY RESPONSES TO THE FABRICATION AND SHIPBUILDING INDUSTRIES

**Diane Austin**
**Bureau of Applied Research in Anthropology**
**University of Arizona**

Click here to view the slide show that accompanied this presentation.

The fabrication and shipbuilding industries make particular demands on local infrastructure and can be a major influence on the nature and scope of infrastructure projects. Their impacts are exacerbated or mitigated by federal, state, and local policies. Direct infrastructure needs include ports, channels, highways, and railroads that provide access to and from company facilities, both for materials and supplies and for employees. They also include data and telecommunications and energy services. Indirect needs include employee housing, emergency response capabilities, and local zoning and building codes. These infrastructure services are generally interrelated, and resources directed to one are not available for another. Community responses to infrastructure needs vary according to the level of need, resources available or attainable, and the political influence of industry advocates. The industries and communities within which they are located face particular concerns due to the hurricanes of 2005 and 2008. Two types of infrastructure needs are considered here, one direct and one indirect, to illustrate when and how communities respond to industry needs.

## Direct Needs – Channels

The U.S. Gulf of Mexico fabrication and shipbuilding industries produce large vessels and structures that must enter the waters of the Gulf. One of the most critical factors in the siting, operation, and expansion of fabrication and shipyards is the depth of the channel providing access to the Gulf. Resources for channel construction and maintenance come from federal, state, and local governments as well as private developers and users. Especially in areas where coastal erosion has dramatically altered the coastline, proposals to deepen channels may not be universally accepted. For example, in Terrebonne Parish, LA, deeper channels offer potential economic benefits in the competition among communities to attract companies and among companies to win bids on large projects, but deeper channels also have potential environmental impacts. Already in the region, deep channels have significantly altered natural hydrology and altered water flow pathways, which have at times resulted in saltwater intrusion (Ko et al. 2004). At the same time, spoil banks created from the dredge materials have reduced overland flow exchange and sediment input to the wetland surface.

## Indirect Needs – Employee Housing

The Gulf coast communities in which major fabrication and shipyards are located share many of the housing issues confronted by their neighbors in other parts of the United States. However, they also face special concerns. Many communities were affected by the hurricanes of 2005 and/or those of 2008. The 2005 hurricanes destroyed hundreds of thousands of homes, leading to federal assistance specifically for rebuilding. A lack of housing has been cited as a major contributor to worker shortages in the fabrication and shipbuilding industries.

The fabrication and shipbuilding industries create specific impacts on housing in Gulf of Mexico communities, though industry-related housing needs vary considerably based on numerous factors such as whether employees are full or part-time and their relationship (e.g., via contract or direct hire by a company) and tenure with the company. For the purposes of illustration, three types of employees are considered: those who have permanent residences near their place of work and earn wages that put them well above the area median income, those who have permanent residences near their place of work and earn wages that put them at or below 120 percent of the area median income, and those who do not have permanent residences near their place of work. Rebuilding efforts have sparked new and reignited old debates on the allocation of federal dollars to low income residents and appropriate uses of the coastal shoreline.

High wage employees have considerable flexibility in choosing their residences. Across the United States, since the 1970s, an increase in income inequality has been accompanied by an increase in economic segregation. Mississippi, however, is one of the states with the lowest level of such segregation. Within all four states of the western and central Gulf of Mexico, some communities attract "white collar" workers while others are identified as "blue collar" towns.

As housing prices have outpaced household incomes, addressing the needs of public sector and lower paid private sector workers has become a concern of governments in the United States and other parts of the world. This reflects an expansion from low to moderate income home buyers, which are defined by the Department of Housing and Urban Development as those making up to 100 percent of the area median income (AMI) where the home is located, to low to moderate income working families, which are defined as those households earning at least the annual minimum wage in which members work a full time job or equivalent and earn up to 120 percent of the local area median income (National Housing Conference 2005, CHP 2007).[1]

Various options have been utilized for employees who do not have residences near their place of work. These employees can be categorized in three groups: (1) U.S. citizens; (2) immigrants on work visas; and (3) undocumented immigrants. The latter are not readily distinguished from other members of the population, so their housing needs are not discussed separately here. Often, specialists are brought in from various places within the United States for short periods of time to fulfill specific industry needs. These individuals are often housed by the companies for which

[1] Low to moderate income working families have also been defined as those living at less than 300 percent of the federal guidelines (Brown 1999).

they work via long-term arrangements at area hotels and consequently impact local taxes and the availability of hotels for other uses such as tourism. Some companies are exploring the possibility of moving to shift work, such as 7 days on and 7 days off or 14 and 14, as is common for employees working on offshore rigs and platforms, to address both worker shortages and lack of housing; they would provide temporary housing for their employees like that which is currently being used by some for immigrants on work visas.

Companies that can demonstrate a need for employees that cannot be filled by U.S. citizens can apply for and receive permission to hire foreign workers on specialized visas. One of these, the H2B visa, has become more common within the fabrication and shipbuilding industries, especially since the 2005 hurricanes. Unlike with the H2A visa for agricultural laborers, companies employing H2B visa workers are not required to supply housing for their employees. Nevertheless, given the lack of options in many Gulf coast communities, many employers have become actively involved in helping their immigrant workers find housing, utilizing dormitories, trailers, rented houses, and barracks.

## Summary

The infrastructure needs of the fabrication and shipbuilding industries are linked to one another and to others such as workforce needs. As a dominant local industry and major employer, fabrication and shipbuilding can be a major influence on the nature and scope of infrastructure projects. The impacts of these industries are exacerbated or mitigated by federal, state, and local policies.

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# FROM BOATS TO BICYCLES: DIVERSIFICATION, SOCIAL NETWORKS, AND CULTURE ON SMALL SHIPYARDS IN ALABAMA AND SOUTH LOUISIANA

**Victoria M. Phaneuf and Sarah E. Raskin**
**Bureau of Applied Research in Anthropology**
**University of Arizona**

Click here to view the slide show that accompanied this presentation.

In this paper, we show that small shipyards along the coasts of Alabama and Louisiana serve a critical and unique function: they are among key sites where bayou culture is perpetuated. Diversification and social networks are both facets of local culture that are preserved by the industry. In addition to being valued because they are associated with characteristics traditionally considered positive, such as dynamism, flexibility, ingenuity, and close social relations, at the same time they can be good for business and help shelter the yards from variability in the industry. We argue that even as small yards modernize and adapt in response to industry trends, such as by hiring foreign workers, they continue to exhibit qualities and cultural patterns that have characterized bayou culture for generations. This discussion is informed by theories of cultural reproduction, diversification, and social networks, and based on four case studies of small shipyards in southern Louisiana and Alabama.

The case studies illustrate how shipyard owners use social networks to enter into the business, find clients, diversify their products, and acquire the necessary resources to make these changes. For purposes of organization, the case studies are divided into "pull" and "push" categories, the first where individuals are primarily adapting to outside forces, the second where they are creating or taking advantage of opportunities. The focus remains on how the negotiation between good business practices, diversification, and social networks serves to maintain and perpetuate bayou culture, and how use of that culture in turn serves to maintain these businesses.

Specifically, owners of small shipyards in south Louisiana and Alabama use social networks and diversification as strategies to maintain their business through times of change and constancy in oil and gas, and in maritime industries more generally. We argue that not only are these practices critical to the solvency of businesses and the stability of the industry, but that they also perpetuate traditional bayou culture in their very workplace practices, as is demonstrated here through their use of social networks and diversification in product, client base, and management practices. Some of these practices seem at first glance contrary to cultural reproduction. For example, it is hard to see how importing laborers from other countries, closing a long-standing family business, or ceasing to use traditional technology to benefit from new market trends and construction processes can lead to the continuation of local cultural patterns. However, as many of our informants pointed out, such practices help them continue rich maritime traditions in the face of a depleted local work force and stay competitive in business, allowing other local practices and customs to flourish.

Although for the purposes of this paper we have divided these small yards into a push- or pull-trend over the long term, as you can see in these examples, in any given moment each of them seems to do a little bit of both to keep afloat. That one informant told us, "We build tanks, baskets. We can fix a bicycle to…whatever," speaks to the persistence of small vessel builders. This sentiment does not tell us, however, whether diversity of work was sought out or attained through taking advantage of opportunities presented. In fact, statements such as this tell us that even as small yards' diversification speaks to the important role of social networks and their perpetuation of bayou maritime culture, it may also speak to a failure to compete successfully with bigger boat building operations and, thus, the limits of these business' potential. Future considerations will include discussions of failed attempts to diversify and other less successful case studies.

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Victoria Phaneuf is a Ph.D student in the Department of Anthropology of the University of Arizona. A cultural anthropologist, she received her master's degree from that department in 2006. Her geographical research interests are the U.S. Gulf of Mexico, Vermont, France, and North Africa. She focuses on migration, borders, social networks, and performance.

Sarah Raskin, MPH, is a doctoral student in sociocultural anthropology at the University of Arizona. A former fellow at the U.S. Centers for Disease Control and Prevention, her interests include health disparities in the U.S. South, medical technology, and public translation of science. Sarah's dissertation research returns her to her home region of central Appalachia, where she will evaluate state-level initiatives to sanction mid-level providers in order to improve healthcare access and develop a 21st century workforce.

# EXPLORING THE SOCIAL FOOTPRINT OF PORTS

**Tom McGuire**
**Bureau of Applied Research in Anthropology**
**University of Arizona**

Click here to view the slide show that accompanied this presentation.

We have something of a handle on oil ports in Louisiana, locales where upstream offshore oil and gas activities are the primary drivers of the social, economic, and political landscapes. We have some understanding of how ports and communities respond to cycles in the industry, how those cycles may affect segments of the industry differentially, how ports servicing expensive deepwater exploration and production may have quite different pulses than those building for and supplying the shallow shelf. As we moved along the Gulf Coast for the study we are reporting on here—the impact of fabrication and shipbuilding on coastal communities—however, we become immersed in locales where upstream oil and gas activities are not the only, or the dominant shapers of the social landscape. This study enabled us to examine communities where oil-related shipbuilding and fabrication are significant, but not the only players. Some, such as Pascagoula, have major rig fabricators, but a naval yard as well, a yard whose pulse is set by congressional appropriations and presidential directives, not by the supply and demand for oil. Others, such as Brownsville, attend most closely to the supply and demand for steel and scrap metal in manufacturing plants across the border. Others have been, are, or hope to be major factors in international shipping and maritime trade.

This presentation addresses the literature and borrows the building blocks for an understanding of ports and their evolution, and makes observations on how oil and gas-related activities articulate – or not – with the wider range of activities associated with the diverse port complexes of the Gulf of Mexico. This inquiry is grounded with an example from the port complex heavily aligned with downstream oil and gas, as well as other diverse maritime activities: the Coastal Bend of Texas—Corpus Christi, Ingleside, Aransas Pass. This is preliminary to understanding the other complexes involved in the study: Mobile and south Mobile County, Pascagoula/Moss Point, South Lousiana, Orange/Port Arthur, and Brownsville/Port Isabel.

## Defining Ports

Most definitions of ports emphasize marine shipping, not surprisingly. For example, Amy Helling and Theodore Poister (2000) offer the following: "The term *port* usually refers to a nucleus of facilities, at least some of which are publicly owned or maintained, that provide berths at which vessels can load and unload cargo and/or passengers. Maritime ports are those that serve vessels engaged in international trade." (p. 300). Harold Mayer (1988) gives a broader definition, using port to "designate a unit of organization or operation of a set of facilities associated with the transfer or interchange of waterborne commerce, or of other maritime

activities such as naval installations, or the servicing of fishing fleets or pleasure craft. … some ports include specialized installations for handling ferry, cruise ship, or other traffic (p. 78). Finally, Peter de Langen and Evert-Jan Visser (2004) highlight "port clusters" or complexes rather than delimited ports, "clusters of economic activities, related to the arrival of cargo and ships" (2004, p. 173). They analyze, for example, the "Lower Mississippi Port Cluster" (LMPC)—the lower 230 miles of river accessible to ocean-going vessels, encompassing 12 parishes and more than 160 cargo-handling facilities. In volume of "throughput," the favored metric for assessing the performance of ports, the LMPC is the largest port complex in the world. The LMPC, like many similar clusters, is a complex mixture of public and private ownership, responsibilities, and operation.

Ports can be further defined by mode of governance and spatial and geographical characteristics. The majority of public port authorities in the United States are "landlord" governors, developing facilities and leasing them to private operators. Others are "operating" ports, where port employees oversee day-to-day activities—loading and unloading grain terminals, procuring stevedoring services and longshore labor, scheduling vessel movements. All port authorities face a similar juggling task, however. They are responsible for facilitating economic development through private enterprise at the same time that they are public agencies mandated to manage the port in the public interest.

Mayer (1988), a geographer, discusses ports in terms of the "spatial characteristics," suggesting that the usefulness of ports and their harbors are a function of "geographic *situation* with relation to the existing or potential traffic, and upon the conditions of their *site,* which refers to the characteristics and configurations of the land and water within the port area proper and its approaches" (p. 78). A port's situation involves both its *hinterland*—the inland area that is the source or destination of a port's traffic—and the *foreland*—the overseas equivalent of a port's hinterland.

## The Port Complex of Corpus Christi

With these simple tools in hand, what does the port complex of Corpus Christi look like?

Site-wise, Corpus Christi sits on a bluff, 30-40 feet high, the highest land between Norfolk, VA, and Vera Cruz, Mexico. It is protected by a barrier island, but only set on a shallow-water bay. Aransas Pass is a natural pass through the barrier island, so the U.S. Army Corps of Engineers built jetties to stabilize the pass in 1899. Harbor Island became a Corps-built port in 1912, a location of ship-building for WWI and for the importation of Mexican oil. In 1919, a hurricane destroyed docks there, and Corpus Christi business leaders took the opportunity to lobby for Corpus Christi proper as the permanent and safe deepwater port, with transportation connections via three railroads. But it needed a channel, so the powerful operators of the King Ranch empire formed the South and West Texas Deep Water Harbor Association and succeeded in getting Congress to approve in 1922 a deep channel 21 miles across Corpus Christi Bay from Aransas Pass. Simultaneously, the Nueces County Navigation District was established, forerunner to the

current Port of Corpus Christi Authority, which now owns, operates, or leases facilities and properties around the bay.

A huge gas field five miles west of Corpus Christi opened in 1923, and the first oil well began producing there in 1930. Readily available supplies of cheap and abundant natural gas attracted interest from industrial plant operations and led the port to lobby for deepening the channel. The channel was deepened to 30 feet in the early 1930s and the port constructed oil docks. In 1929, Humble set up a refinery across the bay at Ingleside and a loading facility at Harbor Island, spurred on by discovery of oil in San Patricio County in the early 1930s. The Industrial Canal was then dredged west from the Turning Basin to accommodate industrial operations attracted by gas and oil availability. In 1934, Taylor Refinery located along the canal as the first refinery on the Corpus Christi side of the bay. Soon, 45 companies engaged in manufacturing of oil field and well supplies located on or near port land. In 1937, Corpus Christi declared itself the "oil capital of the South Texas Empire."

By the 1960s, liquid cargo—primarily petroleum and its products—represented 75% of total tonnage through port, shipped mainly to the U.S. east coast. In the 1970s, domestic oil production declined, but the Middle East oil embargo provided impetus for port's Harbor Island Project—construction of an oil-receiving terminal and dredging of a 45-foot channel for Very Large Crude Carriers for sources outside the Arab world. The port had the deepest water of any port on the Gulf Coast. Docks that once had been shipping oil and refined products out of the wells and refineries around Coastal Bend and rich hinterland reversed the flow, importing huge quantities. By early 1980s petroleum companies were importing more than 75% of oil they were refining at Corpus Christi.

Thus, the port complex of Corpus Christi remains a functioning port city—a working waterfront, for better or worse. In large part, this seems to be due to the region's articulation, in different periods, at different nodes, with the downstream to upstream flow of oil and gas. But it is experiencing pressures that many other ports are facing—the conflict among those with interests in working waterfronts and proponents of the new waterfront, designed to accommodate the amenity values of shorefront residence, recreation, and consumption. A brief example suffices. In 1985, President Reagan signed a bill authorizing funding for Naval Station Ingleside with the Port Authority purchasing land and transferring it to the Navy. "Homeport" had planned to support a carrier group and the Port Authority acquired adjacent land to entice companies who wished to supply services to the Navy. With the end of the Cold War, the Navy expansion was cut back, and Naval Station Ingleside, needing a new mission, was reinvented as the "Mine Warfare Capital." Under base reduction plans, NAVSTA Ingleside is scheduled to close in 2010, and the Port Authority has "reversionary rights" to the base real estate after closure. The closure decision touched off a struggle over control of the future of the base between the Nueces County-dominated (Corpus Christi) Port Authority and officials and citizens of San Patricio County, where the naval station was located. The contest is over the clash of potential uses. The base is a virtual campus, self-contained and self-sufficient, occupied by the military for only a brief period, so the site does not require the expensive environmental cleanups required on other closed bases. But the deep channel and substantial bulkheads and docks—and the Coastal Bend's

historic involvement with oil and gas—make it a prime site for the expansion of industrial activity. The contest is ongoing, unresolved.


## Acknowledgment

This abstracts draws on the historical background report prepared for the project by Jamie Christy of the University of Houston.


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Tom McGuire is Research Anthropologist in the Bureau of Applied Research in Anthropology, and Research Professor, Department of Anthropology, University of Arizona. After completing his Ph.D., with a dissertation on politics and ethnicity among the Yaqui of Sonora, Mexico, he has studied and reported on fisheries in the Gulf of California, Native American water rights issues in the Southwest, cattle ranching on Indian reservation, and the process of citizen involvement in solar standards within the American Society for Testing and Materials. For the last decade, he has been involved in a series of MMS Studies on the historical and social impacts of OCS on coastal communities along the Gulf of Mexico.

# CONES OF UNCERTAINTY: THE NATURE OF BUSINESS IN HURRICANE COUNTRY

**Ben McMahan**
**University of Arizona**

Click here to view the slide show that accompanied this presentation.

This analysis emerged from a larger study of the labor issues facing the shipbuilding and fabrication industries in the Gulf Coast, given the relevance of the topical interests of the study (e.g. changing source of labor and increased workload after hurricanes); and the temporal overlap between ethnographic field data collection and the hurricane season of 2008. This season was forecast to be above average in terms of hurricane activity and included numerous named storms that ravaged the Gulf, in particular Hurricane Ike and to a certain extent, Gustav and Dolly, resulting in one of the costliest hurricane seasons on record. The storms of 2008 join recent powerful storm events and storm seasons that have hit the Gulf Coast (e.g. Ivan, Katrina, Rita in 2004 and 2005), the experience of which has had dramatic social and economic impacts on the region, as well as their impacts on the ways in which residents, workers, and business-owners frame their lives and their place in the region, as well as having large impacts on the scope and availability of fabrication work. This paper looks at the experience of the 2008 storm seasons, as they unfolded during six months of ethnographic data collection in Southern Louisiana and Southeastern Texas (Morgan City and Port Arthur/Orange, respectively), to document how the recent and historical experience of hurricane storms and seasons affects business strategies, labor patterns, and perceptions of risk.

The risk and reality of hurricanes are relevant to the shipbuilding and fabrication industries on the Gulf Coast in a number of ways, including the sheer number of rigs and platforms that operate in the potential path of Gulf storms, as well as the necessary proximity of communities which are linked to the offshore industry. The threat of a serious storm event is more a matter of when than if, and communities and businesses must prepare for impacts and disruptions, and workers and residents must respond and deal with these disruptions following storm events. This paper explores how two different communities' experience with hurricanes is and was shaped by both the broad and specific community contexts, using recent storm events as an analytical-marker, and paying specific attention to the shipbuilding and fabrication companies in each area. This includes a discussion of how the recent events have facilitated a reconsideration of what it means to live and do business in the region and what might be done to more adequately prepare for storm events, or the ensuing aftermath. The impacts that are considered in more detail include the short- and long-term impacts on the workforce by temporary and permanent evacuations by local workers, the draw of cleanup and recovery work for workers who might otherwise work in fabrication, the community and company strategies to prepare for and deal with hurricane impacts, and the changing ways in which company managers and community leaders frame their community in light of the increased visibility of hurricane impacts and subsequent risk

perception. While hurricanes are chance events with unique impacts that are particular to each storm and storm season, there are some patterns that emerge from this analysis. Hurricane events can only serve to exacerbate the cyclical nature of the fabrication industry, leading to strategic decisions about workforce management, including the use of H2B visa workers and contractor labor. Companies are also forced to address numerous issues regarding employees, including the possible provision of housing or shelter, adequate recovery and rebuilding time after storms, and the reality that fabrication yards may be back online and ready to work long before the workforce has returned or is ready to work. Companies are also rethinking recruitment, as recent events, and especially Katrina in 2005 have cast a spotlight on the nature of hurricane and hurricane risk in the region, making recruitment to the area ever more difficult. Finally, that fabrication and shipbuilding may act as a driving force in local preparedness capacity, especially in areas where this is the primary local industry, as lost time is lost money and local officials and company owners want to see the yards back online and the workers working as soon as possible and take numerous steps to ensure that this is the case.

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Ben McMahan is a Ph.D. candidate in sociocultural anthropology at the University of Arizona. His research interests include risk perception/communication, social memory of epidemics, modernity and relations to nature, participatory research and GIS mapping in ethnography, political ecology, public policy, urban anthropology, anthropological theory, history, ethnography and video/visual ethnography, social movements and popular epidemiology. He is a frequent presenter at professional meetings and the author of numerous referred publications.

## SESSION 3A

## AIR QUALITY I

**Chair:** **Holli Ensz, Minerals Management Service**

**Co-Chair:** **Stacie Meritt, Minerals Management Service**

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# GULF OF MEXICO OZONE DEPOSITION AND DEVELOPMENT OF IODINE CHEMISTRY MODULE IN CMAQ

**Daewon W. Byun, Beata Czader, Hun-Cheol Kim,**
**Soontae Kim, and In-Bo Oh**
**University of Houston**

Click here to view the slide show that accompanied this presentation.

Iodine from the microalgae in the sea surface in coastal area can affect atmospheric chemistry through the titration reaction of ozone and iodine as well as photochemical reactions involving chlorine, iodine and other halogens from phytoplanktons in the coastal waters. In addition, iodine and other halogens in the air involve homogeneous and heterogeneous reactions with anthropogenic and natural emissions that subsequently change concentrations of ozone and atmospheric particular matter. Present regulatory ozone modeling often fails to account for these effects in the coastal waters and such omission can lead to the overestimation of the impact of offshore oil and gas generation operations when developing the state implementation plans for the new eight-hour ozone standard. The first part of the study demonstrated that the changes in the ozone deposition flux to the ocean surface due the sea surface processes can play an important role in the ozone budget in the coastal boundary layer and influence onshore and inland distribution of ozone. The second part of study involves development of iodine-extended atmospheric chemistry module in CMAQ and quantification of ozone loss and production budget in the Gulf of Mexico coastal boundary layer. In the presentation, we provide information on the modification of the CMAQ dry deposition module to account for the sea-surface chemical reactions, estimation of dissolved iodide concentrations from the chlorophyll distribution estimated from the satellite observation, and analyses of iodine effects on dry deposition velocities, deposition amounts, and air concentrations for ozone.

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Dr. Daewon Byun has been a professor in the Department of Geosciences, with joint appointment in the Department of Chemistry, University of Houston (UH) since 2001. Dr. Byun is also the Director for the Institute for Multidimensional Air Quality Studies (IMAQS). Prior to joining UH, Dr. Byun was the science team leader of the U.S. Environmental Protection Agency (EPA) Models-3 Community Multiscale Air Quality (CMAQ) model development project.

# OPERATION OF MMS RASS WIND PROFILER AT THE UNIVERSITY OF HOUSTON COASTAL CENTER

**Daewon W. Byun and Barry Lefer**
**University of Houston**

Click here to view the slide show that accompanied this presentation.

The Houston-Galveston-Brazoria (HGB) area has been known as one of the severe ozone (O3) non-attainment regions in the USA. In combination with the high emissions environment in the Houston Ship Channel (HSC) and Houston metropolitan areas, certain meteorological conditions can lead to bad air quality in the HGB area. Highly polluted air parcels laden with emissions from the Houston Ship Channel and urban areas sent out to the Galveston Bay and Gulf of Mexico in the early morning by land breeze then return back the HGB area with enhanced photochemical reactivity by land/sea breeze. Recognizing importance of the effects of petroleum production and processing operations on the local and regional air quality, The U.S. Department of Interior Minerals Management Service (MMS) has installed a 915 MHz Radar Wind Profiler/Radio Acoustic Sounding System (RASS) at the University of Houston Coastal Center (UHCC) in January 2007. The instrument measures vertical profiles of temperature and wind up to 5–6 km altitude at every hour continuously. Located approximately 14 miles northwest from the Galveston Island, UHCC is an ideal place to study a range of coastal meteorological phenomena including sea/land breeze circulations, low-level jet, the nocturnal inversion, and the impact of these meteorological phenomena on air quality. UH Institute for Multidimensional Air Quality Studies (IMAQS) have established extensive atmospheric boundary layer measurement facilities including the 42-m micrometeorological tower, a medium range SODAR, a 10-m air quality tower, and suite of soil and radiation instruments at UHCC. Measurements by the Wind Profiler/RAS system, together with routine surface meteorological observations, allow study of the vertical structure of the land-sea breeze interacting with the diurnally evolving coastal boundary layer. In the presentation, we report a case study discussing interaction of land-sea breeze with the evolving coastal boundary layer. We present measurements of vertical profiles of wind and temperature by the Wind Profiler/RASS measurement and mean and atmospheric turbulence flux measurements from the micrometeorological tower at the UHCC to understand what atmospheric conditions of the coastal boundary layer have triggered development of thunderstorms from the arrays of sea-breeze induced roll clouds.

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# EVALUATION OF NASA AURA'S DATA PRODUCTS FOR USE IN AIR QUALITY STUDIES OVER THE GULF OF MEXICO

**Arastoo Pour Biazar, Richard T. McNider, Kevin Doty,**
**Mike Newchurch, Lihua Wang, and Yun-Hee Park**
**University of Alabama in Huntsville**

**Maudood Khan**
**The Universities Space Research Association**

**Xiong Liu**
**Harvard-Smithsonian Center for Astrophysics**

**Daewon W. Byun**
**University of Houston**

**Robert Cameron**
**Minerals Management Service, Gulf of Mexico OCS Region**

Click here to view the slide show that accompanied this presentation.

There are significant sources of uncertainty in the realization of both transport and transformation in air quality model predictions, and therefore, advancing the state of air quality model predictions depends on improvements in both. Reducing these uncertainties is of special interest to the MMS mission in the Gulf of Mexico (GoM) region as they impact the air quality assessments in this region.

One source of uncertainty is the inaccurate specification of background air over the open waters in this region. In this study we utilize OMI ozone profiles together with MODIS aerosol products to improve the representation of the chemical atmosphere in the MM5/CMAQ air quality modeling system. The simulations are performed for August 2006 over the continental United States and evaluated against surface, ozonesonde, and satellite observations. An overview of the results will be presented.

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Dr. Pour Biazar received his Ph.D. in atmospheric sciences from the University of Alabama in Huntsville (UAH) in 1995 and works as a research scientist at UAH. He has been involved in many air quality campaigns and in recent years has been investigating the utility of satellite observations in air quality studies.

Richard McNider is a Distinguished Professor Emeritus at the University of Alabama, Huntsville (UAH). Previously, he worked for the Alabama Pollution Control Commission and was Professor of Atmospheric Science and Mathematics at UAH. He holds a Ph.D. from the University of Virginia.

Dr. Daewon Byun has been a professor in the Department of Geosciences, with joint appointment in the Department of Chemistry, University of Houston (UH) since 2001. Dr. Byun is also the Director for the Institute for Multidimensional Air Quality Studies (IMAQS). Prior to joining UH, Dr. Byun was the science team leader of the U.S. Environmental Protection Agency (EPA) Models-3 Community Multiscale Air Quality (CMAQ) model development project.

# SATELLITE DATA ASSIMILATION INTO METEOROLOGICAL/ AIR QUALITY MODELS

**Arastoo Pour Biazar, Richard McNider, Kevin Doty,**
**Scott M. Mackaro, Kate La Casse, and Stephanie Haines**
**University of Alabama in Huntsville**

**William Lapenta, Gary Jedlovec, and Ron Suggs**
**NASA Marshall Space Flight Center**

**Robert Cameron**
**Minerals Management Service**

Click here to view the slide show that accompanied this presentation.

The correct representation of physical atmosphere is of utmost importance in air quality studies. Especially in regions such as Gulf of Mexico (GoM) where sea-breeze circulations play an important role in the air quality of the coastal areas, better representation of meteorology is imperative.

This presentation summarizes results from studies where GOES-derived skin temperature, insolation, surface albedo, cloud albedo, and cloud top temperature have been utilized to improve the predictions of the MM5/CMAQ air quality modeling system. GOES-derived products are assimilated in MM5 to recover moisture availability and heat capacity over the south-central U.S. Also GOES observed cloud information is used to adjust photolysis rates within CMAQ. The assimilation of GOES skin temperatures, while improving the model performance, was causing a dry warm bias in the results. Investigation into the cause of this phenomenon led to the development of a 1D boundary-layer model with a new land-surface formulation. The results from the new model were evaluated against the observations from Oklahoma Mesonet and ARM_CART Central Facility sites.

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Dr. Pour Biazar received his Ph.D. in atmospheric sciences from the University of Alabama in Huntsville (UAH) in 1995 and works as a research scientist at UAH. He has been involved in many air quality campaigns and in recent years has been investigating the utility of satellite observations in air quality studies.

Richard McNider is a Distinguished Professor Emeritus at the University of Alabama, Huntsville (UAH). Previously, he worked for the Alabama Pollution Control Commission and was Professor of Atmospheric Science and Mathematics at UAH. He holds a Ph.D. from the University of Virginia.

## SESSION 3B

## PLATFORM AND NATURAL HARD BOTTOM ECOLOGY I

**Chair:** **Maureen Mulino, Minerals Management Service**

**Co-Chair:** **James Sinclair, Minerals Management Service**

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CORAL DISTRIBUTION, ABUNDANCE, AND GENETICS IN THE NORTHERN GULF OF MEXICO: ROLE OF THE FLOWER GARDEN BANKS AND OIL/GAS PLATFORMS Paul W. Sammarco, Amy D. Atchison, D.A. Brazeau, G.S. Boland, A. Lirette ..... 175

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# CORAL DISTRIBUTION, ABUNDANCE, AND GENETICS IN THE NORTHERN GULF OF MEXICO: ROLE OF THE FLOWER GARDEN BANKS AND OIL/GAS PLATFORMS

**Paul W. Sammarco**
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**Department of Oceanography & Coastal Sciences, Louisiana State University**

**Amy D. Atchison**
**Department of Oceanography & Coastal Sciences, Louisiana State University and**
**Louisiana Universities Marine Consortium (LUMCON)**

**D.A. Brazeau**
**Department of Pharmaceutical Sciences, University at Buffalo**

**G.S. Boland**
**Environmental Section, Minerals Management Service**

**A. Lirette**
**Louisiana Universities Marine Consortium (LUMCON)**

Click here to view the slide show that accompanied this presentation.

The Flower Garden Banks (FGB) are the only two major coral reefs in the northern Gulf of Mexico. The thousands of oil/gas platforms introduced since the 1940s have provided the only new hard substratum in the upper euphotic zone since the late Pleistocene. The extent to which corals have colonized these structures across the northern Gulf of Mexico (GOM) was not known. Here, we have determined the range of occurrence of corals on oil/gas platforms in the northern GOM, their distribution and abundance over this broad geographic range, their species diversity patterns, and the genetic affinities among populations of the dominant coral species. We first examined 13 platforms around the FGB and then another 35 platforms along four transects spanning from 20 km offshore to the edge of the continental shelf or beyond. The first transect extended S-SE from Corpus Christi, Texas; the second, S from Lake Sabine, Texas to 10 km beyond the shelf edge; the third, S from Terrebonne Bay, Louisiana; and the fourth, S-SW from Mobile, Alabama. Visual surveys of corals were conducted by teams of SCUBA divers. Small tissue samples were collected for molecular genetic analysis by Amplified Fragment Length Polymorphism (AFLP), controlling for DNA contamination. Genetic data were analyzed by AMOVA, AFLPOP, and STRUCTURE.

Ten hermatypic and three ahermatypic coral species were found. The dominant hermatypes were *Madracis decactis, Diploria strigosa*, and *Montastraea cavernosa*. The dominant ahermaytypes were *Tubastraea coccinea* (an Indo-Pacific invasive species), *Oculina diffusa,* and *Phyllangia*

*americana*. Hermatypic coral species diversity (no. spp.) was generally higher at the shelf edge than inshore, peaking on platforms around the FGB. Total hermatypic coral density followed a similar pattern, falling to zero in inshore waters. Densities of *Madracis decactis* (a brooder) were low off Corpus Christi, more abundant off Port Arthur, peaked off Terrebonne Bay—"down-current" of the FGB, and were low again off Mobile. *Diploria strigosa*, a broadcaster, was only found off Port Arthur, and in low abundances, with a density peak around the FGB. *Montastraea cavernosa* followed a pattern similar to *D. strigosa,* but was also found in low numbers off Mobile.

By contrast, total coral density peaked in the east, off Terrebonne Bay and Mobile. *T. coccinea* (a brooder) was the dominant ahermatype driving this pattern. Ahermatypic species diversity was generally equitably distributed across the northern GOM. In general, the brooders were well-represented across the entire region; the broadcasters were not, indicating that brooders are more effective than broadcasters at dispersal and recruitment in a patchy environment.

AMOVA and STRUCTURE analyses indicated that genetic distance in *Madracis decactis* increased with geographic distance from the FGB, implying that the FGB was the source of larvae for these platform populations. Both AMOVA and AFLPOP analyses revealed low genetic diversity within platform populations with increasing genetic distance among sites as geographic distance increased. These results suggest strong founder effects and imply that coral populations regenerating from a severe perturbation or mass mortality may require very long periods of time before they begin to resemble the genetic structure of their parent populations, if at all.

Genetic affinity in *Tubastraea coccinea* was high across the shelf. Both *Tubastraea coccinea* and *Madracis decactis* exhibited genetic affinities between platform populations within a transect on each side of the river mouth, but showed no affinity across the mouth. This indicates that the Mississippi River is a strong geographic barrier to larval dispersal and recruitment. *T. coccinea* showed higher affinities than *M. decactis* within a transect, indicating that this invasive species is more effective at larval dispersal and recruitment than the indigenous and most abundant hermatypic species in this region.

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Dr. Paul W. Sammarco is a Professor at the Louisiana Universities Marine Consortium (LUMCON) in Chauvin, Louisiana, USA. He has been conducting research on coral reef ecology for over 35 years, in the western Atlantic (Caribbean, Florida Keys, Gulf of Mexico, and the Bahamas) and on the Great Barrier Reef, Australia, and he has over 200 publications. He has served as an Assistant Professor at Clarkson University (NY), a senior research scientist at the Australian Institute of Marine Science, and Executive Director and a Research Professor at LUMCON. He also served for several years as the Director of Environmental Research for the Department of Prime Minister and Cabinet in Australia. Dr. Sammarco is currently conducting an interdisciplinary study to examine coral communities associated with gas and drilling platforms throughout the northern Gulf of Mexico, a study that involves deep-water

reconnaissance on the platforms and on those structures used in the joint federal/state offshore "Rigs-to-Reefs" program. He is also determining the genetic affinities of major coral species in this region. This work is being conducted with support from the U.S. Department of the Interior – Minerals Management Service through the LSU Coastal Marine Institute (CMI).

Ms. Amy Atchison worked as a graduate student at the Louisiana Universities Marine Consortium (LUMCON) and Department of Oceanography and Coastal Sciences, Louisiana State University under the direction of Dr. Paul Sammarco. Amy led a major component of the Coastal Marine Institute study reported here. She is a scientific diver and performed the underwater data collection for her graduate thesis on the use of platforms as artificial reefs for coral recruitment.

Daniel Brazeau is the Director of the Pharmaceutical Genetics Laboratory (PGL) in the School of Pharmacy and Pharmaceutical Sciences and a Research Associate Professor in the Department of Pharmaceutical Sciences at the University at Buffalo. He received his B.S. and M.S. in biology from the University of Toledo and his Ph.D. in biological sciences from the University at Buffalo. After completing postdoctoral training in population genetics at the University of Houston, he was a research assistant professor in the Department of Zoology at the University of Florida and Director of the University of Florida's Genetic Analysis Laboratory in the Interdisciplinary Research Center for Biotechnology. His work at the PGL includes providing training and research support for an array of molecular genetic techniques to help researchers address questions about population genetics, gene expression, bioinformatics, genotyping and molecular genetics. The PGL also provides education and training to outside researchers and professionals through workshops and short courses in molecular techniques including DNA microarrays, siRNA, quantitative real-time PCR, statistical packages/programs for genetic analysis, microsatellite development and analysis, and molecular genetic methodologies. Dr. Brazeau's research interests involve population molecular genetics and pharmcogenomic studies.

Gregory S. Boland is a biological oceanographer with the Department of Interior's Minerals Management Service (MMS) in New Orleans, Louisiana. His areas of interest include deep-sea biology, coral reef ecology, artificial reef ecology, and fishery biology. His research career began at Texas A&M University in 1974 and led to his M.S. degree. Prior to his current position with MMS, he served as a principal investigator on numerous large Gulf of Mexico studies at LGL Ecological Research Associates in Bryan, Texas including offshore platform studies, deep-sea biology and coral reef monitoring projects. He also worked with Gil Rowe for ten years at Texas A&M University's Department of Oceanography where he was involved in a variety of benthic ecology studies worldwide, including the development and operation of a deep-sea benthic lander.

Ms. Angela Lirette served in the United States Army from 1989 to 1991, specializing in digital electronics. She received her B.Sc. in biology from Nicholls State University in 2005. Employed as a research assistant and technician at the Louisiana Universities Marine Consortium (LUMCON) from 2006 to 2008, Angela worked on a large-scale project with Dr. Paul W. Sammarco, researching the effects of the 3,600 offshore oil and gas platforms on the distribution

and abundance of scleractinian corals in the northern Gulf of Mexico. She specialized in DNA purification of the corals, statistical analyses of data collected, computer graphics, field-trip preparation for research cruises, at-sea research assistance, and SCUBA diving. She has also worked as a safety diver and assistant instructor for offshore water survival and as an American Heart Association CPR instructor. She is currently a technician for an alarm company where she installs, programs, and troubleshoots alarm systems.

# RIGS-TO-REEFS STRUCTURES AND CORAL COMMUNITY DEVELOPMENT IN THE NORTHERN GULF OF MEXICO: A FIRST VIEW

**Paul W. Sammarco**
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**Department of Oceanography & Coastal Sciences, Louisiana State University**

**G.S. Boland and James Sinclair**
**Environmental Sciences Section, Minerals Management Service,**
**U.S. Department of the Interior**

**A. Lirette**
**Louisiana Universities Marine Consortium (LUMCON)**

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**Louisiana Universities Marine Consortium (LUMCON)**
**Department of Oceanography & Coastal Sciences, Louisiana State University**

Click here to view the slide show that accompanied this presentation.

There are currently ~3,600 oil/gas platforms in the Northern Gulf of Mexico (GOM). Coral communities are now known to have developed on these structures. Federal regulations require that platforms be removed within one year of cessation of production. The MMS policy, revised in 1998, combined with the National Fishing Enhancement Act of 1984 (Public Law 98-623, Title II), and the subsequent National Artificial Reef Plan, permit obsolete oil and gas structures to be converted to state-owned artificial reefs in the Rigs-to-Reefs (R2R) program. Among the options provided for implementation of this program were cutting and placing the top adjacent to the standing structure, toppling the whole structure in place, or towing to a designated R2R site. The R2R structures were required to clear the surface by a minimum of 26 m depth. Here we attempted to determine whether coral community development is occurring on R2R structures in the N. GOM, and whether those communities differ from those on standing oil/gas platforms.

The jackets of both standing and toppled R2R structures were surveyed by ROV (Video-Ray, SeaBotix LBV-300, and Phantom-2) from 26 m to the maximum depth of the site in question (120 m) recording digital video images on DVD. SCUBA divers also performed visual and video surveys between 30 and 39 m depth for standardization purposes. The R2R sites examined were EC-273P (East Cameron site, LA) and HI-A-271, HI-A-281, HI-A-355, and HI-A-492 (TX High Island Rigs-to-Reefs Planning Area). The standing platforms surveyed were WC-643 (W. Cameron site, LA) and HI-A-376.

Five species of corals were found: *Madracis decactis* (a hermatype); and *Tubastraea coccinea, Oculina diffusa, Phyllangia americana*, and an as-yet unidentified species (ahermatypes). There

was no significant difference in total coral density (no. per 10 $m^2$) between standing and toppled (R2R) platforms. This was because of opposing interspecific patterns in density between species. *T. coccinea* and *M. decactis* had significantly higher densities on the R2R structures, possibly implying that they prefer either horizontal surfaces or more disturbed habitats. *P. americana* was present in higher densities on standing platforms, indicating that this species may prefer either vertical surfaces or more stable substratum. There was no significant difference between densities of *O. diffusa* between the two types of structures.

On average, corals exhibited a significantly deeper distribution on R2R structures than on standing platforms, and this pattern was most prominent in *O. diffusa*. Depth distribution in *M. decactis* was similar between the two types of structures. These early results indicate that, despite differences in details between coral distribution and abundances on these two types of structures, standing platforms and R2R platforms both act similarly as artificial reef substrata in the N. GOM for coral community development.

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Dr. Paul W. Sammarco is a Professor at the Louisiana Universities Marine Consortium (LUMCON) in Chauvin, Louisiana, USA. He has been conducting research on coral reef ecology for over 35 years, in the western Atlantic (Caribbean, Florida Keys, Gulf of Mexico, and the Bahamas) and on the Great Barrier Reef, Australia, and he has over 200 publications. He has served as an Assistant Professor at Clarkson University (NY), a senior research scientist at the Australian Institute of Marine Science, and Executive Director and a Research Professor at LUMCON. He also served for several years as the Director of Environmental Research for the Department of Prime Minister and Cabinet in Australia. Dr. Sammarco is currently conducting an interdisciplinary study to examine coral communities associated with gas and drilling platforms throughout the northern Gulf of Mexico, a study that involves deep-water reconnaissance on the platforms and on those structures used in the joint federal/state offshore "Rigs-to-Reefs" program. He is also determining the genetic affinities of major coral species in this region. This work is being conducted with support from the U.S. Department of the Interior – Minerals Management Service through the LSU Coastal Marine Institute (CMI).

Gregory S. Boland is a biological oceanographer with the Department of Interior's Minerals Management Service (MMS) in New Orleans, Louisiana. His areas of interest include deep-sea biology, coral reef ecology, artificial reef ecology, and fishery biology. His research career began at Texas A&M University in 1974 and led to his M.S. degree. Prior to his current position with MMS, he served as a principal investigator on numerous large Gulf of Mexico studies at LGL Ecological Research Associates in Bryan, Texas including offshore platform studies, deep-sea biology and coral reef monitoring projects. He also worked with Gil Rowe for ten years at Texas A&M University's Department of Oceanography where he was involved in a variety of benthic ecology studies worldwide, including the development and operation of a deep-sea benthic lander.

James Sinclair has a B.S. in marine biology from Texas A&M University at Galveston and an M.S. in biological sciences from the University of New Orleans. His past work includes the culture of cephalopods, aerobic and anaerobic filtration, analysis of benthic community structure, propagation and restoration of submersed aquatic vegetation, and artificial reef development. He currently serves as a marine biologist for the U.S. Minerals Management Service where he works to protect sensitive benthic communities on the continental shelf of the Gulf of Mexico and Atlantic.

Ms. Angela Lirette served in the United States Army from 1989 to 1991, specializing in digital electronics. She received her B.Sc. in biology from Nicholls State University in 2005. Employed as a research assistant and technician at the Louisiana Universities Marine Consortium (LUMCON) from 2006 to 2008, Angela worked on a large-scale project with Dr. Paul W. Sammarco, researching the effects of the 3,600 offshore oil and gas platforms on the distribution and abundance of scleractinian corals in the northern Gulf of Mexico. She specialized in DNA purification of the corals, statistical analyses of data collected, computer graphics, field-trip preparation for research cruises, at-sea research assistance, and SCUBA diving. She has also worked as a safety diver and assistant instructor for offshore water survival and as an American Heart Association CPR instructor. She is currently a technician for an alarm company where she installs, programs, and troubleshoots alarm systems.

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# LONG-TERM MONITORING AT THE FLOWER GARDEN BANKS NATIONAL MARINE SANCTUARY, 2004–2008

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The coral reef ecosystems of the Flower Garden Banks (FGB) have been monitored since the late 1970s; the onset of this continuous monitoring coincided with the start of oil and gas production in the vicinity of the FGB. Since 1974, the Bureau of Land Management and later the Minerals Management Service (MMS) included topographic features stipulations in lease sale environmental impact statements and in biological stipulation map packages to prevent direct and indirect impacts of oil and gas operations on the FGB coral reef resources. The FGB were designated as a National Marine Sanctuary in 1992, which further increased the level of protection afforded to these national treasures. Early on the topographic features stipulation required the monitoring of the banks. While this requirement was relaxed when no effects were observed, the MMS instituted the long-term monitoring of the FGB reef caps starting in 1988. Once the FGB became a sanctuary, the National Oceanic and Atmospheric Administration (NOAA) Sanctuaries Division became an equal funding partner of the monitoring program. Results of the ongoing monitoring show that the FGB coral reef ecosystems burst with life and

contrast with many moribund coral reef communities of the western Atlantic. Coral cover has remained high on the reef cap at about 45%. The edges of the reef cap boast even higher coral cover reaching in some places up to 100%. In recent years (since 2004) there has been evidence of change in the condition of the reef including incidences of widespread bleaching and the winter occurrence of plague-like coral disease. Further, since 2005 the FGB reef cap (and in particular the East Flower Garden Bank) has been subject to the mechanical damage caused by the passage of two hurricanes, Hurricane Rita in 2005 and Hurricane Ike in 2008. Other naturally-induced stress that affected the coral reefs of the FGB included the unusual and prolonged seawater warming that took place in the summer of 2005 and the winter of 2006. This warming resulted in extensive bleaching of corals and unprecedented levels of diseased coral tissue. Despite this succession of recent stresses, coral cover on the reef caps remains high and coral colonies appear to have recovered from the bleaching and diseases. A watchful eye must be kept on these unique ecosystems; however, as they begin to weather more frequent natural stresses. Protective measures must be maintained and perhaps heightened to promote the continued resilience of these ecosystems. Results from the long-term monitoring effort combined with those of other studies at the FGB should be used to design future policy. Natural resource managers of the FGB probably need to reformulate applied research questions that will best support their task in managing the FGB in light of a changing marine environment and continued exploitation of oil and gas resources in the vicinity of the FGB.

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Ken J.P. Deslarzes, Project Manager, Senior Marine Ecologist, has a multidisciplinary graduate scientific foundation (oceanography, zoology, botany, and ecology) and specializes in coral reef science. Since 1987, he has been a project manager, principal investigator, co-principal investigator, and/or participant in over 35 marine and terrestrial ecological research projects conducted in the United States (Gulf of Mexico outer continental shelf, Florida Keys, Oahu); Caribbean nations (Saba, Puerto Rico, St. Croix), and the British Indian Ocean Territory (Diego Garcia). He has more than 15 years of experience in managing and contributing to natural science research projects, National Environmental Policy Act (NEPA) documentation, and marine resource documentation for federal, academic, private, and non-governmental organizations. While at Geo-Marine, Inc., Dr. Deslarzes developed his technical expertise and project management in the following areas: baseline coral reef assessments and coral reef monitoring; essential fish habitat assessment; mitigation and restoration: submerged aquatic vegetation; damage assessment; marine resource assessments; integrated natural resource management plans; and natural resource characterization. He has published and publicly presented studies about natural changes on reefs; long-range dispersal of coral larvae; and protected marine ecosystems.

Richard B. Aronson received his A.B. in biological sciences from Dartmouth College in 1979 and his Ph.D. from Harvard University in biology in 1985.He is currently Head of the Department of Biological Sciences at Florida Institute of Technology. Dr. Aronson has been working on coral reefs for decades, focusing on disease, climate change, and other large-scale factors that cause turnover of reef faunas. He pioneered the use of videographic methods for

surveying coral reefs, and he developed the univariate and multivariate statistical approaches needed to analyze the data. Dr. Aronson's techniques are now being used by reef managers throughout the western Atlantic and Caribbean region. His research combines survey and monitoring work with paleoecology to understand the history, present status and future of coral reefs.

William F. Precht is a carbonate sedimentologist and has studied coral reefs since 1978. From 2002–2007, he was the Chief Scientist of the Long-Term Coral Reef Monitoring Study at the Flower Garden Banks. Since completing his graduate degree in marine geology and geophysics from the University of Miami's Rosenstiel School of Marine and Atmospheric Science, he has worked as an environmental scientist specializing in the restoration and rehabilitation of various coastal resources, especially coral reef, seagrass, and mangrove systems. Mr. Precht also maintains status as a Visiting Research Scientist with the Smithsonian Institution's Caribbean Coral Reef Ecosystem Program in Belize and as an adjunct faculty member with Northeastern University's East/West Marine Science Program. He has published over 225 peer-reviewed scientific journal articles and abstracts and has presented over 100 invited lectures to universities, professional societies, and organizations. Mr. Precht is currently the manager of the Damage Assessment and Resource Protection Program for NOAA's Florida Keys National Marine Sanctuary in Key Largo, Florida.

Martha Robbart is Senior Marine Scientist at Dial Cordy and Associates, an environmental consulting firm that specializes in marine assessment, monitoring, mitigation and restoration projects. Martha has over ten years of experience in coral reef biology of the Caribbean, Florida and the Gulf of Mexico. Martha is interested in the physiological response to thermal stress of scleractinian corals, their symbionts, and other coral reef invertebrates. Her education included a master's degree where she investigated differential expression of heat shock proteins to thermal stress in two Caribbean agaricid species.

Beth Zimmer is a member of the Ecological Sciences Group in PBS&J's Miami, Florida, office. Ms. Zimmer received her B.S. in marine science/biology from the University of Miami and is currently enrolled in the M.S. program at Florida International University where she is studying coral disease. Ms. Zimmer is experienced in a wide array of ecological services, ranging from NEPA documentation to seagrass and coral mitigation/restoration projects. She is particularly interested in marine habitats, including reef/hard bottom and seagrass.

Leslie Duncan is an environmental scientist for the Ecological Sciences Group at PBS&J in Miami, Florida. She received her B.S. in marine biology/chemistry from the University of Miami in 2005. Leslie has worked on a variety of ecological projects ranging from wetland delineations and seagrass surveys to coral reef and water quality monitoring programs. In January 2008, Leslie assumed the lead responsibility of data management and contract compliance for the Flower Garden Banks Long-Term Monitoring project, which is jointly funded by the MMS and NOAA.

Les Kaufman is Professor of Biology and Associate Director for the Boston University Marine Program. He also holds the post of Senior Principal Investigator for the Marine Management

Area Science Program at Conservation International. Les is a marine biologist with a broad interest in evolution, community ecology, and conservation of marine and freshwater systems, with a specialization in coral reefs. His current research is focused on management area effects on food webs and community dynamics. He enjoys collaborative research with fishermen and local coastal stakeholders, and serves on the Science and Statistics and the Research Steering committees for the New England Fishery Management Council. Les also writes for popular magazines and television, and currently teaches two courses: Marine Megafaunal Ecology of Stellwagen Bank National Marine Sanctuary, and Biological Design for Sustainability.

G.P. Schmahl is the superintendent of NOAA's Flower Garden Banks National Marine Sanctuary. As Sanctuary superintendent, he is involved with an array of Marine Protected Area management issues including research, education, and resource protection. After obtaining an M.S. degree in zoology from the University of Georgia, G.P. held a variety of positions relating to marine research, coastal management, resource planning, and environmental regulation. His primary interest is the ecology and management of coral reefs and associated ecosystems.

Emma L. Hickerson has held the position of research coordinator of the Flower Garden Banks National Marine Sanctuary since 1997. She began her career at the Sanctuary while still a graduate student at Texas A&M University, conducting satellite tracking studies on loggerhead sea turtles living on the reef. During her tenure in the current position with the Sanctuary, she has coordinated over 100 research cruises, including SCUBA, ROV, and submersible operations. Her interests have expanded beyond sea turtles, to include most ecological and biological aspects of the Sanctuary, with recent efforts being placed on the deepwater habitats of the Sanctuary and adjacent areas.

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# POST-HURRICANE ASSESSMENT OF SENSITIVE HABITATS OF THE FLOWER GARDEN BANKS VICINITY

**Donald R. Deis**
**PBS&J Environmental Sciences**

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The most active hurricane season on record in the Atlantic and Gulf of Mexico occurred in 2005, fueled by higher than normal sea-surface temperatures (National Climatic Data Center 2005). Eleven tropical cyclones entered the Gulf of Mexico in 2005, including Hurricane Rita (a Category 5 storm on the Saffir-Simpson Scale). Hurricane Rita was a Category 3 storm when it passed near the shelf edge banks on 23 September 2005 and produced wind speeds of 110–120 knots (126.7–138.3 mph). Hurricane force winds extended 139-km (86-mi) and tropical storm force winds extended as far as 333-km (207-mi) from the center of the storm (National Hurricane Center 2007).

Several sensitive habitats within the northwestern Gulf of Mexico were close to the path of Hurricane Rita, including Sonnier Bank (24-km or 15-mi east), McGrail Bank (12-km or 7-mi west), Geyer Bank (58-km or 36-mi west), Bright Bank (75-km or 47-mi west) and the East Flower Garden Bank (EFGB) (93-km or 58-mi west). Hindcast hydrological models estimated wave heights at 20-m or higher on these banks. This may have exposed some bank caps, even at 20-to 30-m depth. The implications for benthic community structure could have been catastrophic, and MMS considered it essential to characterize the banks in their post-hurricane state. In order to understand the potential wave and current conditions present in the vicinity of Sonnier, McGrail, Geyer, Bright, and East Flower Garden Banks during the passage of Hurricane Rita, PBS&J conducted a wave hindcast study. On the cap at Sonnier Bank (22-m depth) and Bright Bank (33-m depth), significant wave heights during the passage of Hurricane Rita were estimated at ~13-m and ~20-m, respectively. Greater wave heights may have occurred at banks with caps located in deeper water, regardless of the bank's distance from the storm track. Thus, McGrail and Geyer Banks, which have caps located at deeper depths, may theoretically have experienced larger wave heights than Bright and Sonnier Banks. These larger wave height conditions were hindcast based on the potential effects of wave focusing, shoaling, and breaking. The estimated wave height at both McGrail and Geyer Banks was 26-m. The maximum hindcast bottom velocity was 4-m/s or ~8-kn for all four banks.

This study characterized and compared the benthic habitats of four banks (Sonnier, McGrail, Geyer, and Bright) and recorded possible hurricane damage at these banks and the EFGB. At Sonnier, McGrail, Geyer, and Bright Banks, videographic records were collected by SCUBA and ROV in April and May 2007, at four depth ranges to assess benthic cover to the lowest possible taxonomic level: 22- to 27-m, 30- to 36.5-m, 45- to 50-m, and 55- to 60-m. Video transects were qualitatively assessed for evidence of hurricane damage. To document recovery from Hurricane

Rita at the existing long-term monitoring site on the EFGB, repetitive quadrats and perimeter line surveys were conducted in November 2005 and compared to data collected subsequently in June 2006.

Sonnier Bank, the only bank located east of the storm track, exhibited the least live cover at all depth ranges (~2–38%) when compared to McGrail, Geyer, and Bright Banks (~17–86%). Qualitative analysis of video footage collected by divers at Sonnier Bank in 1996, 2002, and 2005 showed differences in benthic cover compared to video collected in 2007. In previous years, more live cover of a mix of algae and sponges (predominantly *Neofibularia* sp. and *Ircinia* spp.) was obvious. Another notable difference was the apparent disappearance of *Xestospongia muta* colonies, which were present in 1996 (~50 colonies), declined to one individual in 2002, and then were not recorded in 2005 or 2007. The single colony recorded in 2002 exhibited disease-like characteristics, with discoloration and an eroded pinacoderm.

McGrail Bank was approximately 12-km (7-mi) from the track of Hurricane Rita and has the deepest reef cap of any bank in this study (45-m depth). Live cover at McGrail Bank ranged from 17–38% and was dominated by macroalgae (red, green and brown), nodules of red coralline algae, and coral (predominately *Stephanocoenia intersepta*). Previous videos were not available for qualitative analysis. No apparent hurricane damage, in the form of overturned or injured corals, was observed.

Live cover at Geyer Bank was mostly colonized by brown macroalgae (specifically *Sargassum* spp.), corals, and sponges. Brown macroalgae, the dominant component, ranged from 22–42%. Corals (0–10%) and sponges (1–4%) were less prominent. According to transect video, Geyer Bank is the only bank in this study with an established population of the invasive, non-hermatypic coral *Tubastraea coccinea*. It is important to note that scientists have observed one or two colonies of *Tubastraea coccinea* at Sonnier Bank (Hickerson 2008); however, *T. coccinea* colonies were not observed in our Sonnier Bank transect video. Diver video collected at Geyer Bank in 2003 showed similar benthic cover to the video that was recorded in 2007. Again, no obvious signs of hurricane damage were observed.

Bright Bank exhibited the highest live cover (86%) and was dominated by macroalgae (57%), turf algae (12%), and corals (8%). Coral species observed included *Diploria strigosa, Millepora alcicornis, Montastraea cavernosa*, and *Stephanocoenia intersepta.* Diver video taken in September 2003 from Bright Bank revealed mostly bare substrate, low macroalgal cover, and few large colonies of *Millepora alcicornis* and *Diploria strigosa*. Sponge species were also observed, including *Agelas clathrodes*, *Ircinia* spp., and *Xestospongia muta*. At Bright Bank no hurricane damage was observed.

The Shannon Weiner Diversity Index (*H'*) was calculated for each bank at each depth range using the lowest taxonomic groupings possible (species or genus). The highest diversity of these four banks was at Sonnier Bank from 22- to 27-m (*H'* = 2.86), largely due to the variety of sponges present there. Geyer and McGrail Banks exhibited their highest diversity values in the 45- to 50-m depth range, (*H'* = 2.13 and *H'* = 2.08, respectively). The high species richness of

brown macroalgae accounted for these high diversity values. At Bright Bank *H'* = 1.81 in the 30- to 36.5-m depth range.

Multivariate statistical analyses were performed using benthic cover data at Sonnier, McGrail, Geyer, and Bright Banks. Analysis of Similarity (ANOSIM) tests showed significant differences between banks (Global $R = 0.54$, $P = 0.001$). Within site comparisons showed less dissimilarity between depths. Multidimensional scaling (MDS) highlighted the dissimilarities among banks, with depths within sites grouping more closely.

Repetitive quadrat stations were photographed at the EFGB in November 2005 and June 2006 to document recovery from Hurricane Rita. Coral cover remained consistently high from November 2005 to June 2006, at 61.34% ± 2.75 SE and 62.87% ± 2.32 SE, respectively. Macroalgae increased from November 2005 to June 2006 by ~5.4%, while CTB decreased by ~6.9%. Approximately 1.5% of coral colonies photographed within repetitive quadrats at the EFGB were missing in November 2005, most likely due to the effects of Hurricane Rita. However, this did not notably affect estimates of coral cover. The most obvious difference in November 2005 repetitive quadrats was the high level of bleaching: 9.74% ± 1.07 SE of assessed coral points were bleached. Paling and fish biting measurements were low at 2.1% or less. The June 2006 data showed a decrease in the level of bleaching (0.62%) compared to November 2005 and a slight increase in the amount of fish biting (2.31%).

The perimeter lines around the EFGB study site were videotaped in November 2005 and June 2006 to document change at known locations along the perimeter and within the study site. Lower levels of bleaching and paling were seen in June 2006 compared to November 2005. These qualitative observations corroborate the quantitative results from the repetitive quadrat data.

The unique biological characteristics of the benthic communities of Sonnier, McGrail, Geyer, Bright, and East Flower Garden Banks highlight their intrinsic value within the northwestern Gulf of Mexico ecosystem. The differences in the benthic biotas strongly suggest that these habitats are truly sensitive, because nearest neighbors may not be the source of recruitment. With predicted wave velocities of 8 knots or more acting on these banks during the passage of Hurricane Rita, the effects on the benthic communities could have been catastrophic. Sonnier Bank suffered a loss of benthic cover and hardbottom associated with the hurricane, but the community was recovering, with algae and sponges dominating live areas by April/May of 2007. McGrail, Geyer, and Bright Banks did not exhibit any obvious hurricane damage in the surveys; given that these banks are dominated by algae and sponges, any damage to the living benthos may be hard to detect after the eighteen months between the passage of the storm and the survey. McGrail Bank, with its large *Stephanocoenia intersepta* colonies, exhibited no apparent damage to corals, which may have been protected by their considerable depth (45-m).

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- William F. Precht, NOAA, Florida Keys National Marine Sanctuary
- James Sinclair, MMS, Gulf of Mexico Region
- Emma L. Hickerson, NOAA, Flower Gardens banks National Marine Sanctuary
- G. P. Schmahl, NOAA, Flower Gardens banks National Marine Sanctuary
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# HOLOCENE CLIMATE CHANGE AND THE HISTORY OF *ACROPORA* SPP. AT THE FLOWER GARDEN BANKS

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The first living colonies of *Acropora palmata* were discovered on the Flower Garden Banks (FGB) in 2003 and 2005 (Zimmer et al 2006). Those discoveries, coupled with a known history of bank flooding since the last glacial maximum, led us to predict that *Acropora*-dominated reefs underlie and form the structural foundation of the living reef community at the FGB. In June 2006, while scuba diving on the southeast corner of the East FGB, we examined an open cave at 21 m depth, which exposed a 3-m vertical section of the reef subsurface just below the living community. Within that exposure we discovered large branches and trunks of *A. palmata* (>1 m in height) in growth position. Radiocarbon dating of a branch from a colony at the top of the section yielded a date of 6,330 ± 60 14Cyr (radiocarbon years before 1950), corresponding to a calibrated age of 6,780 calbp. Follow-up surveys in June 2007 revealed an *A. palmata* dominated under story dating between 10-6 ky on both banks. The discovery of fossil *A. palmata* has profound implications for understanding the history of reef development at the FGB. The banks supported a shallow, warm-water, reef-coral assemblage up until ~6,000 years ago. This community lagged behind rapidly rising sea level in the middle Holocene. As sea temperatures cooled in the late Holocene the reef was capped by a eurythermal deeper-water assemblage dominated by massive corals, which persists to this day. During our 2007 surveys we also found the first fossils of *Acropora cervicornis* on the East FGB. This species appears to have persisted (and flourished) until the Little Ice Age in deeper water on the flanks of the Bank. Follow-up studies are proposed to document and explain the turn-on and turn-off mechanisms for *Acropora* reef development on these isolated reef complexes.

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# RECENT RESEARCH ON SOUTH TEXAS TOPOGRAPHIC FEATURES: MAPPING

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## Introduction

The South Texas continental shelf lies between tropical coral reefs of the southern Gulf of Mexico and the reefs and banks of the Texas/Louisiana Shelf. Approximately 20 mid-shelf banks occur on a relict carbonate continental shelf between Corpus Christi and Brownsville, bounded by the Brazos/Colorado to the north and the Rio Grande lowstand delta to the south (Bright and Rezak 1976, Lindquist 1978, Belopolsky and Droxler 1999) (Figure 3B.1). The South Texas banks were presumably thriving tropical coral reefs adjacent to a Late Pleistocene to Early Holocene shoreline approximately 12,000–18,000 years ago, that abruptly perished between 10,000 and 11,000 years ago due to cooler waters or increased coastal turbidity (Rezak et al. 1985, Belopolsky and Droxler 1999). Currently, the South Texas shelf experiences a seasonal, wind-driven cycle of an increased nepheloid layer, high turbidity and sedimentation during the winter and spring, typically followed by clear oceanic conditions during summer and fall months (Shideler 1978, 1981). These drowned reefs are now partially buried in Holocene sediments of the South Texas shelf and outcrop in depths between 68–84 m (Belopolsky and Droxler 1999) and are surrounded by an extensive mud blanket (Shideler 1978). Recent visual surveys using a towed camera system documented extensive carbonate reef outcrops, coarse carbonate sediments, and a complex surface topography associated with the historical coral reef community. The Harte Research Institute for Gulf of Mexico Studies conducted multibeam and visual surveys of select banks on the South Texas shelf to support future habitat mapping and faunal/ecological surveys of these features.

## Methods

Five of the South Texas banks (North Hospital, Aransas, Southern, Dream, Blackfish) were mapped on 1–3 November 2006, using a Reson 8125 multibeam echosounder equipped with an Applanix Pos MV motion sensor. Water column profiles were measured using a CTD meter to determine sound velocity. Resulting data were exported in XYZ format and imported into ArcGIS software. Raw soundings were interpolated into 0.5 or 1.0 m resolution bathymetric grids using the Spatial Analyst extension of ArcGIS 9.1, and corresponding hillshades produced to enhance 3D relief. Depth contours were plotted at 2 m intervals to further delineate morphology of the features (Figures 3B.2–3B.5).

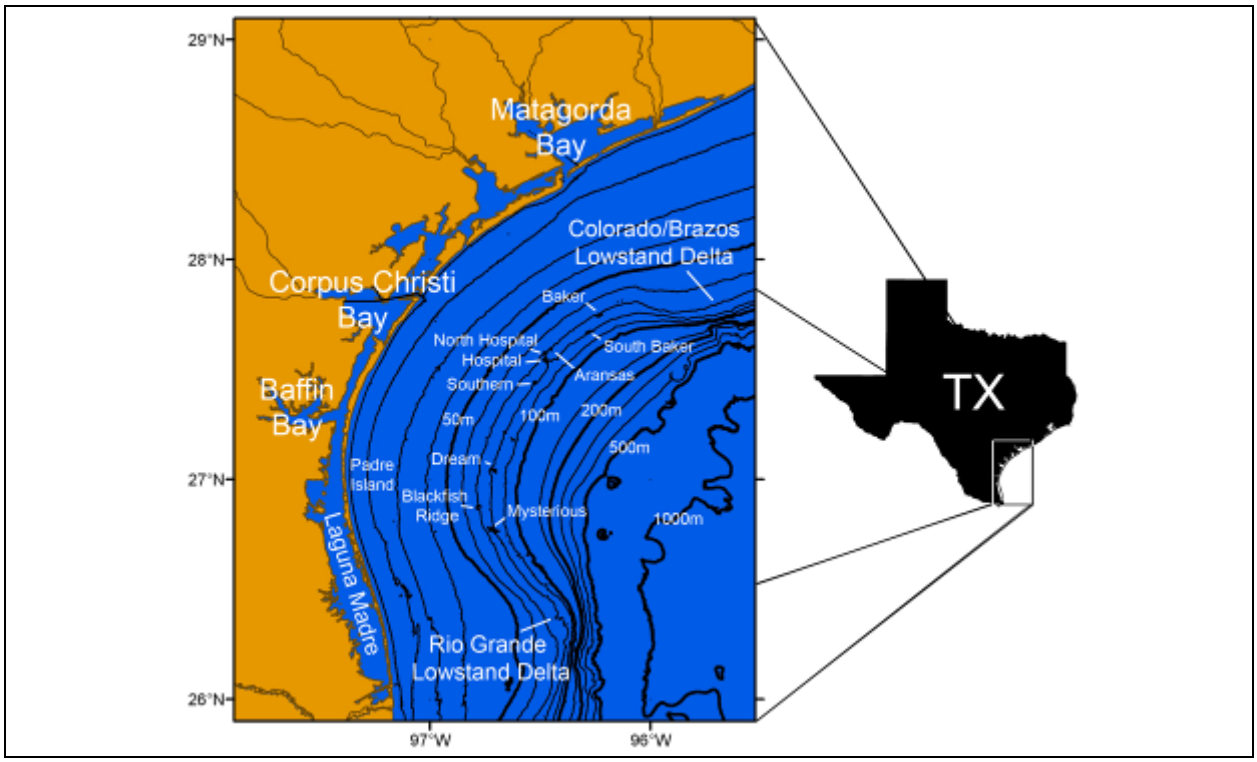


**Figure 3B.1. Location of the South Texas banks.**

## Results

Three of the five banks (North Hospital, Aransas, Southern) follow the conceptual model for these features developed by Lindquist (1978), based on geological data and submersible observations made at Southern Bank, and include the following: 1) A relatively circular feature, up to 1,400 m in diameter and up to 20 m of topographic relief; 2) A 2 m marginal trough occurring along the eastern edge of the feature, with the western edge of the trough bordered by steep rocky slopes; 3) A broad terrace starting at 68 m and cresting at approximately 60 m.

Aransas, North Hospital, and Southern Bank (Figures 3B.2–3B.4) have similar base and crest depths, but differ in overall size and shape. While Aransas and North Hospital have rather broad, continuous terraces with small crests, Southern Bank (Figure 3B.2) has discrete terraces from 76 to 72 m, 70 to 66 m, and a well defined crest from 66 to 59 m. Dream Bank follows a shape similar to the conceptual model, but only exhibits 12 m of vertical relief with a deeper crest at 68 m, and bears a northeastern marginal trough (Figure 3B.5). Blackfish Ridge, unlike the other four features, bears a highly irregular margin with numerous deep patch reefs, lacks a clearly defined terrace and eastern depression, and gradually slopes to a crest of 62 m (Figure 3B.6).

The overall morphology of the South Texas Banks resembles the nearshore reefs of the Tuxpan Reef System, as illustrated by the Isla de Lobos Reef (Tunnell et al. 2007). Both sets of features range between approximately 500 m and 2 km in diameter, have a similar overall shape, and are 20–25 m in vertical profile. The Tuxpan reefs are characterized by well developed lagoons with

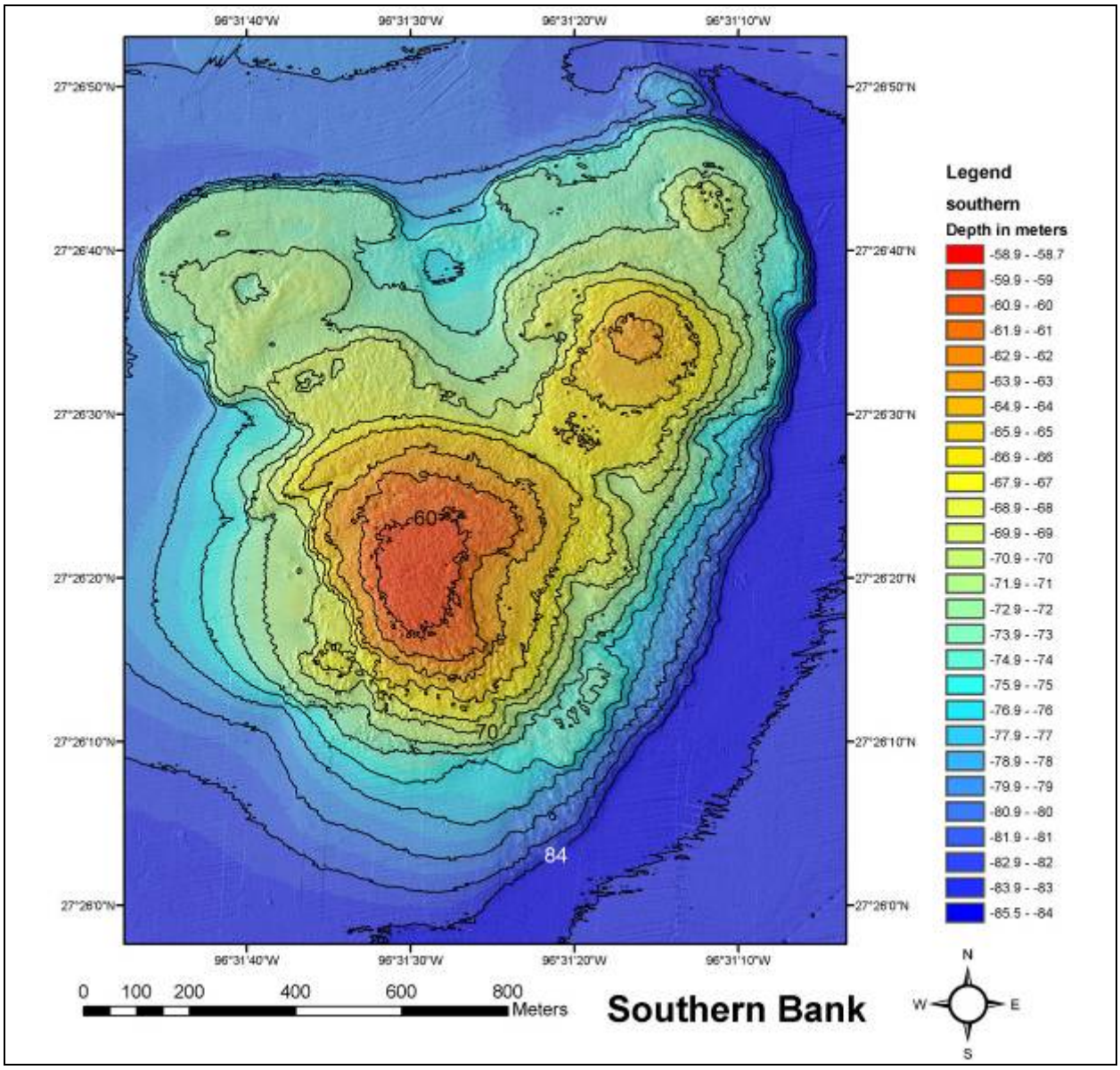


**Figure 3B.2. Multibeam bathymetry of Southern Bank, gridded at 0.5-m resolution.**

central patch reefs or islands and prominent reef crests along their margins, corresponding to the flat terraces, steep eastern margins, and central crest features of the South Texas Banks. The southeast sides of the Tuxpan Reefs are exposed to prevailing winds and heavy surf, with spur and groove reef structures present on both the windward and leeward sides, and massive corals dominating the communities on both steep slopes (Tunnell et al. 2007). The overall thickness of the reef structure ranges from 40–45 m, similar to that reported from seismic surveys of Southern Bank (Belopolsky and Droxler 1999), and also reported for other reefs of the southern Gulf of Mexico, including Alacran Reef (Tunnell et al. 2007).

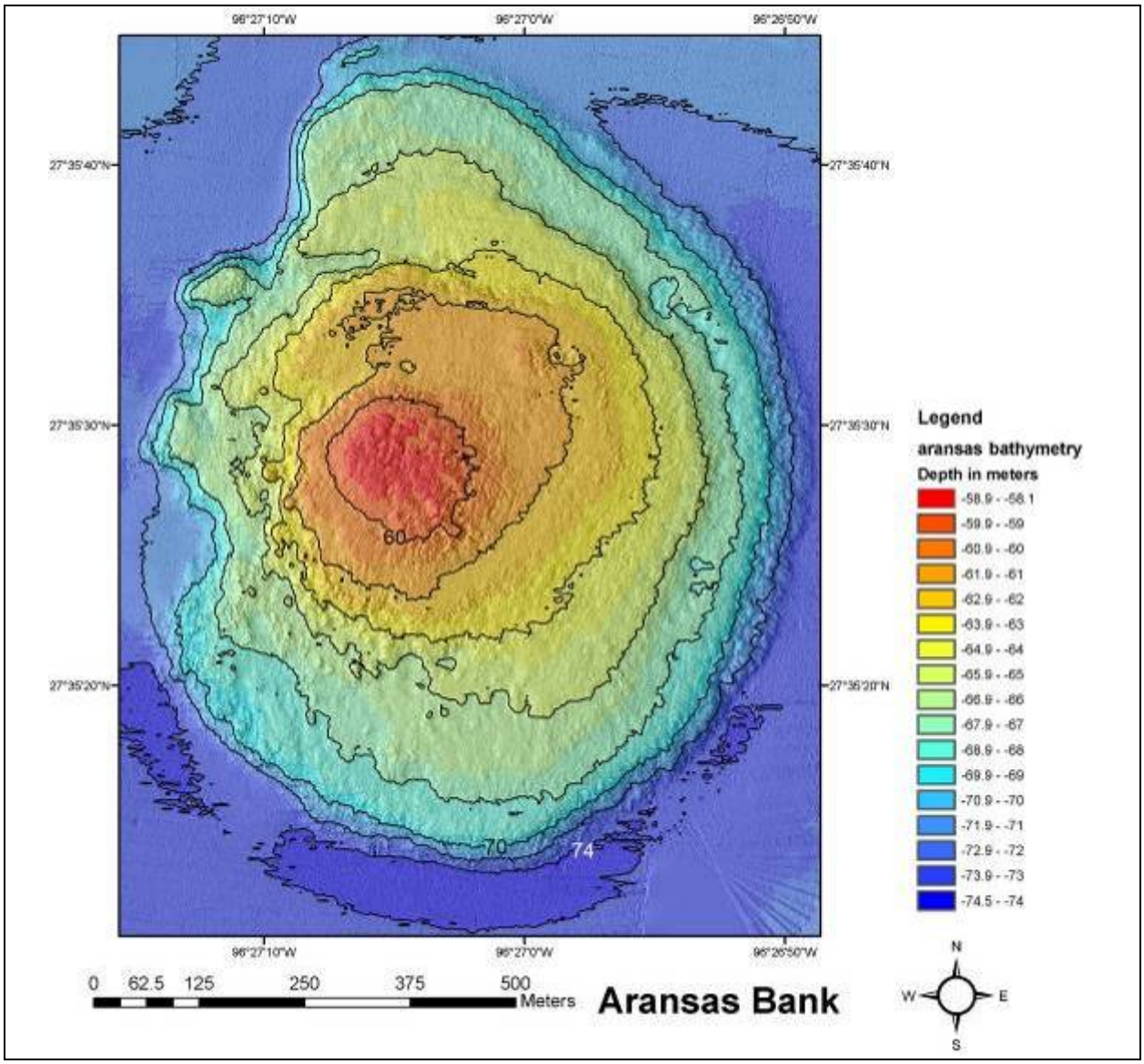


**Figure 3B.3. Multibeam bathymetry of Aransas Bank, gridded at 1-m resolution.**

## Summary

The overall size, shape, and surficial topography of the South Texas Banks resemble modern coral reefs of the southern Gulf of Mexico, bearing distinct marginal reef crests and buttress zones, broad, flat lagoons, and scattered patch reefs or small elevated islands. Small (0.5 to 1.0 m high) scattered carbonate rock outcrops and coarse carbonate sediments on the crests of North Hospital and Southern banks resemble individual coral heads or small patch reefs that once occupied a lagoonal reef system (D. Weaver, personal observation). The margin of the terrace at both banks surveyed are characterized by massive carbonate structures up to 15 m in width with 1–3 m relief, indicating an ancient reef crest, buttress zone, or spur and groove geomorphology separated by channels of coarse carbonate sands and fine sediments.

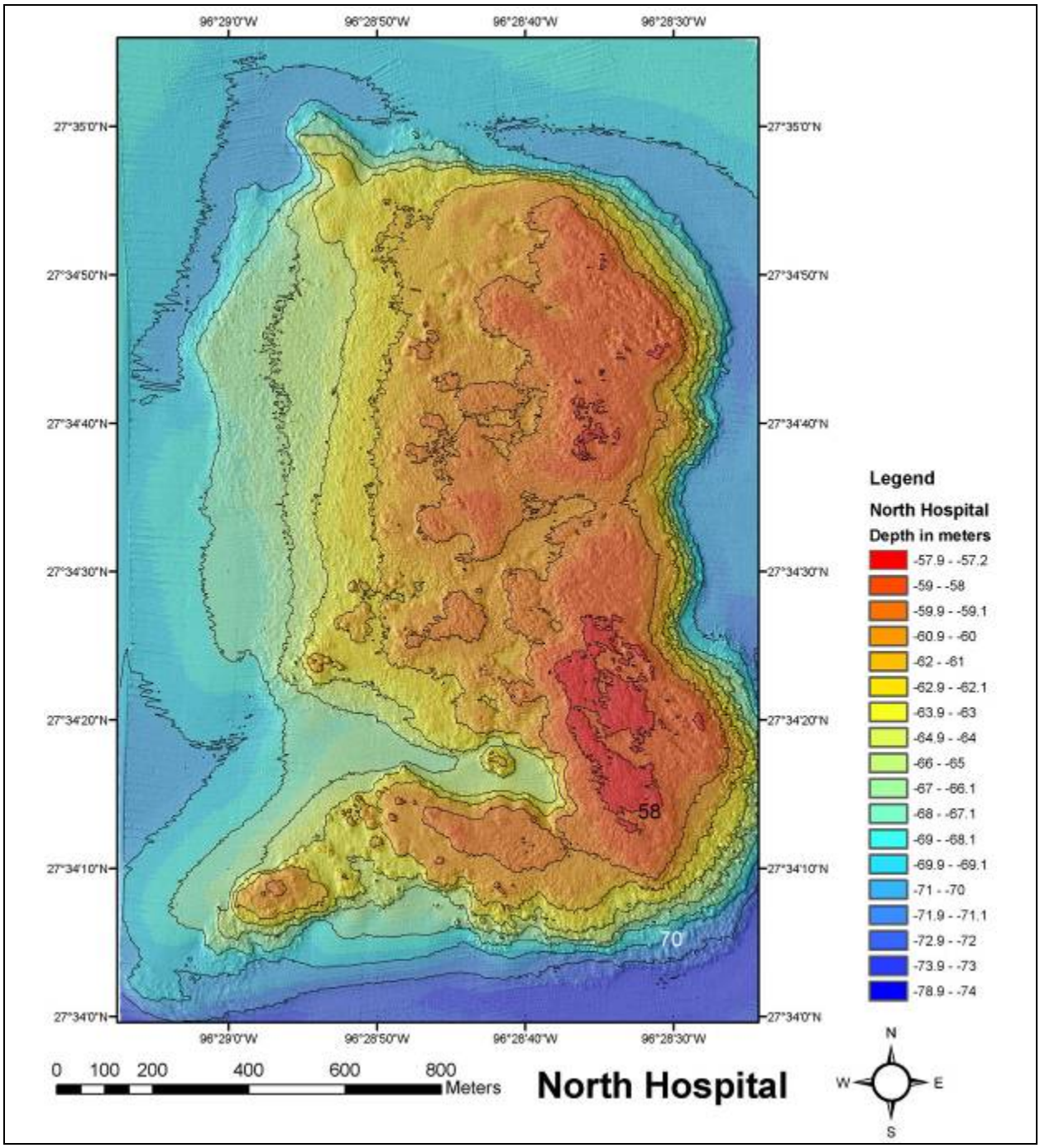


**Figure 3B.4. Multibeam bathymetry of North Hospital Bank, gridded at 0.5-m resolution.**

Dredge samples reported by Bright and Rezak (1976) contained fragments of small finger, plate, or cup corals of the genera *Madracis*, *Agaricia*, and *Paracyathus*. These species typically currently occur on the deeper portions of living coral reefs such as the Flower Garden Banks, are not resistant to strong wave action or storm surge, and would not have built the massive reef

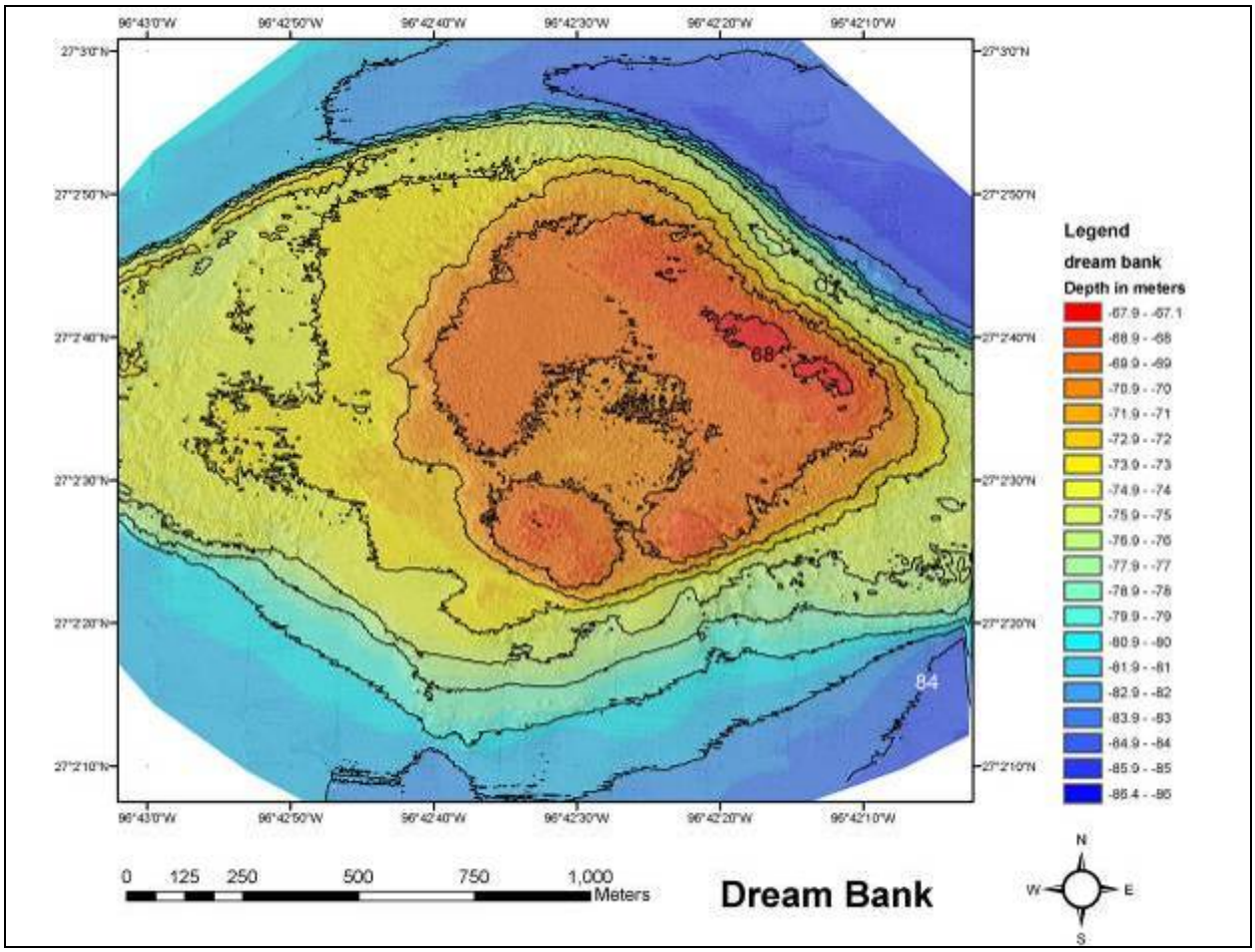


**Figure 3B.5. Multibeam bathymetry of Dream Bank, gridded at 1-m resolution.**

structures observed on the margins of Southern and North Hospital Banks, nor formed the patch reef structures observed on the crests of both features. Massive corals such as the *Montastraea annularis* complex, *Colphophyllia natans*, or *Diploria* spp. are the more likely frame-building species, if these communities resembled the modern platform reefs of the southern Gulf or the present day reef crest community at the East and West Flower Garden Banks during their active growth phase. A seasonal increase in turbidity appears to inhibit coralline algal growth during the winter, resulting in a lack of coralline algal nodules or pavements that characterize similar water depths in the Northwestern Gulf of Mexico. We therefore hypothesize that the carbonate outcrops present on the South TX banks were once thriving platform reefs comparable to modern day coral reefs of the Tuxpan/Veracruz reef systems (Tunnell et al. 2007), and had well-developed lagoonal/reef crest/buttress zone communities dominated by massive corals. Oceanic water masses from the southern Gulf of Mexico, impinging on these features in summer months, appear to sweep away suspended sediments that accumulate during periods of high turbidity (Weaver, personal observation). Currents from the southern Gulf not only clear fine sediments from the relict coral reef structure, providing habitat for reef-associated fishes and invertebrates, but also carry larvae from a tropical Caribbean assemblage known from the Tuxpan and Veracruz platform reefs to colonize the crests of these features.

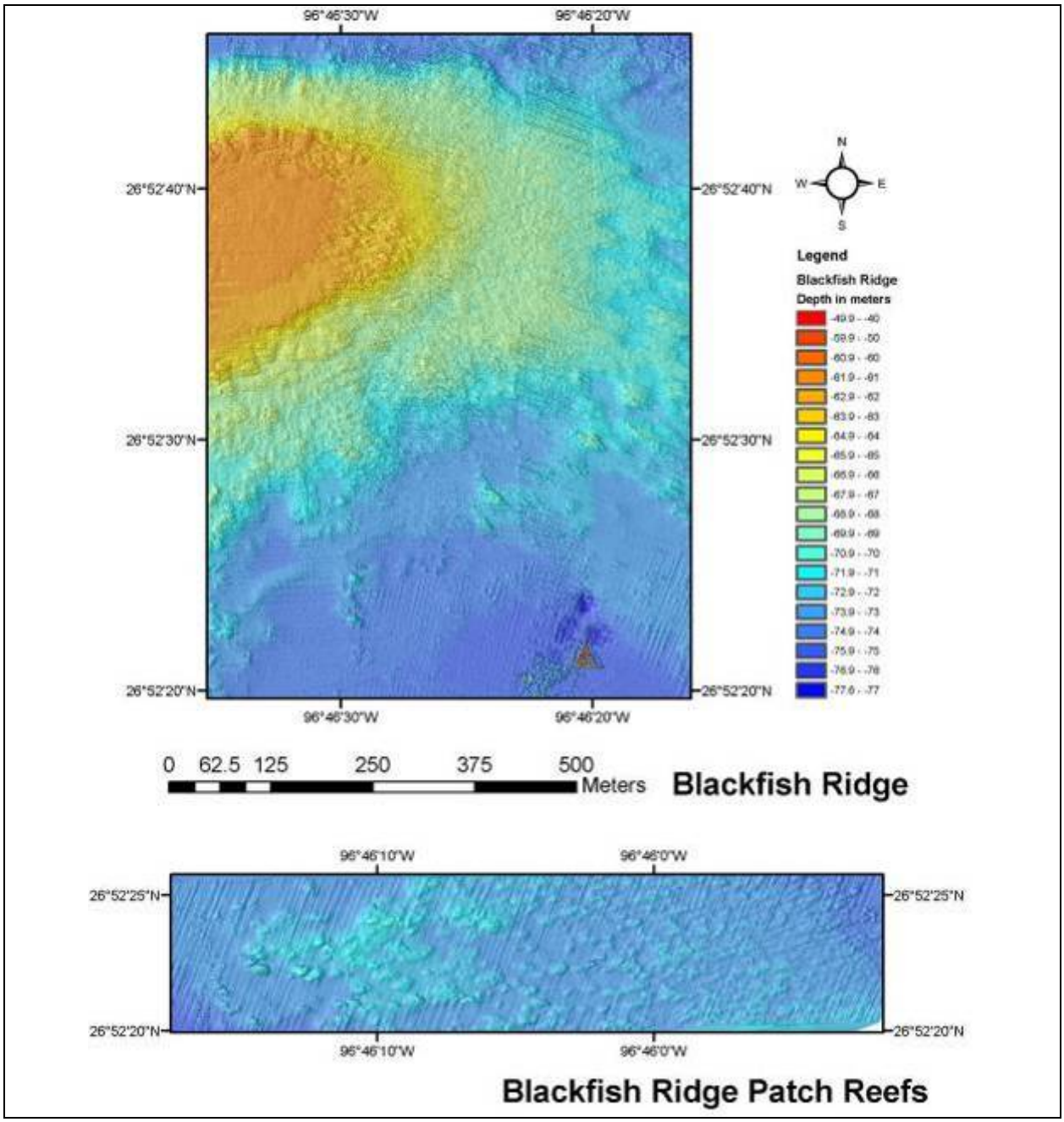


**Figure 3B .6. Mul tibeam bathymetry of Blackfish Ri dge, gridded at 1.0-m resolution. Due t o logistical problems encountered during surveys, a partial map of the bank is presented (top), including a section of deep patch reefs occurring along the eastern edge of the bank (bottom).**

While lacking active coral growth, the current reef community provides the structural complexity to support a relatively diverse tropical deep reef fish fauna, which in turn provides the prey base for many commercially and recreationally important fishes (primarily snappers and groupers). The overall reef fish community resembles similar assemblages currently found at depths of 40–80 m at Stetson, Sonnier, and the Flower Garden Banks in the northwestern Gulf of Mexico.

Future studies will focus on complete mapping of all of the major banks of the South Texas shelf, habitat mapping and sampling of massive carbonate reef structures, and detailed faunal studies identifying habitat association and ecology of the dominant fishes and invertebrates occurring on these features.


## Acknowledgments

We thank Captain Frank Wasson and the crew of the M/V *Spree* of Gulf Diving Associates, and Captain Charles Doolin of the M/V *Point Glass* and the Sea Scouts for field support during multibeam and tow camera surveys, respectively. We also thank Al Oswalt for providing timely technical support in the field.


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# RECENT RESEARCH ON SOUTH TEXAS TOPOGRAPHIC FEATURES: ECOLOGY

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**Harte Research Institute for Gulf of Mexico Studies**
**Texas A&M University-Corpus Christi**

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## Introduction

The biota and ecology of the South Texas relict carbonate reefs are poorly studied. Approximately 20 of these drowned coral algal reefs exist on the relict carbonate continental shelf between Corpus Christi and Brownsville (Bright and Rezak 1976, Rezak et al. 1985, Belopolsky and Droxler 1999). These mid-shelf banks were apparently living reefs near a Late Pleistocene to Early Holocene shoreline about 12,000–18,000 years ago (Rezak et al. 1985). With a relief of 1–22 m, today they are heavily influenced by the nepheloid layer, a layer of chronic high turbidity and sedimentation, and consequently are difficult to study visually. Earlier dredgings and submersible observations on the banks revealed mostly dead coral or coralline algal substrate with scattered populations of selected invertebrates and fishes. Recent surveys using a towed camera system reveal some living coral and abundant and diverse fish populations on North Hospital and Southern banks, two of the banks with the highest relief. The Harte Research Institute for Gulf of Mexico Studies is initiating a program to study and map these little-known structures.

## Regional Setting

An imaginary line drawn across the continental shelf from Matagorda Bay to the shelf edge divides the Texas continental shelf into an area of drowned coral algal reefs to the south and an area of banks situated atop salt diapirs to the north (Rezak et al. 1985). To the south a band of approximately 20 relict coralgal reefs extends about 140 km between the Brazos/Colorado and Rio Grande lowstand deltas (Belopolsky and Droxler 1999) (Figure 3B.7, Table 3B.1). These drowned reefs are now partially buried in Holocene sediments of the South Texas shelf and outcrop in depths between 68–84 m. A highly persistent nepheloid layer probably affects biotic distribution of the entire lower relief banks and the slopes of the higher relief ones (Rezak et al. 1985). Water clarity is best during the warmer months of the year when northerly currents move clear, tropical, oceanic water over the banks from May–November.

## Biota and Ecology

Recent interest in establishing a network of marine protected areas (MPA) within U.S. waters, and particularly within the Gulf of Mexico (Richie and Keller 2008), have heightened the need for biotic information on banks and reefs. The South Texas Banks are some of the least known in

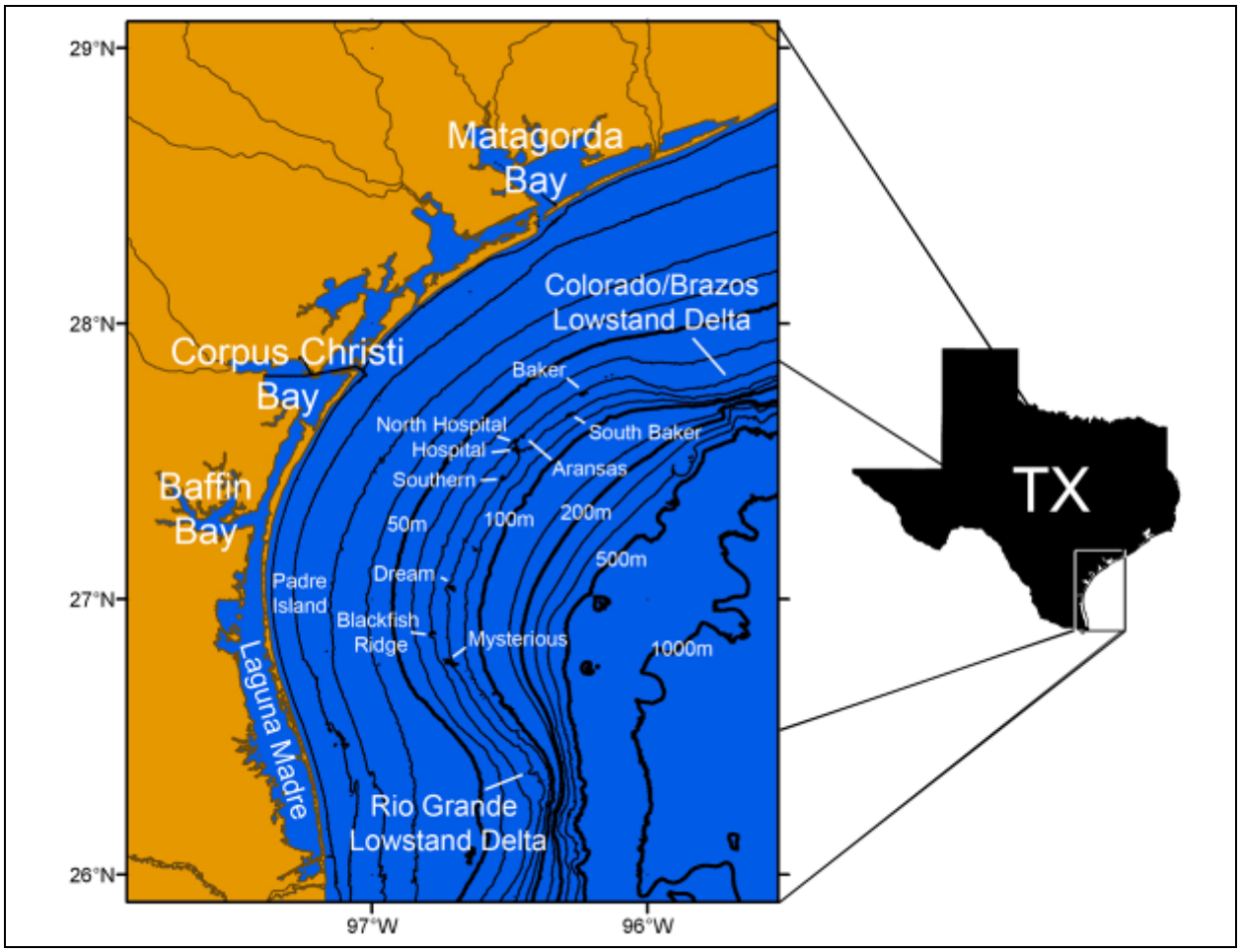


**Figure 3B.7. Site map of relict coral reefs along the South Texas Outer Continental Shelf, located in a 140-m long band between the lowstands of the Rio Grande and the Colorado/Brazos deltas.**

**Table 3B.1.**

**Name, size, and depth of selected South Texas Banks (listed from North to South). From Circé and Tunnell (1987) and Bright and Rezak (1976).**

| | Name | Depth to Base m (ft) | Depth to Crest m (ft) | Relief m (ft) | Size ($km^2$) |
|---|---|---|---|---|---|
| 1. | Baker | 74 (243) | 58 (190) | 16 (53) | 2.09 |
| 2. | South Baker | 82 (269) | 64 (210) | 18 (59) | ? |
| 3. | Aransas | 70 (230) | 58 (190) | 12 (39) | 0.67 |
| 4. | North Hospital | 68 (223) | 58 (190) | 10 (33) | 1.60 |
| 5. | Hospital | 78 (256) | 56 (183) | 22 (72) | 5.22 |
| 6. | Southern | 80 (262) | 60 (197) | 20 (66) | 1.27 |
| 7. | Dream | 84 (276) | 70 (230) | 14 (46) | 2.95 |
| 8. | Big Adam | 66 (217) | 60 (197) | 6 (20) | 0.37 |
| 9. | Blackfish | 72 (236) | 60 (197) | 12 (39) | 1.12 |
| 10. | Small Adam | 66 (217) | 60 (197) | 6 (20) | ? |
| 11. | Mysterious | 80 (262) | 72 (236) | 8 (26) | 20.87 |

the recently proposed MPA network in the Gulf of Mexico, the "Islands in the Stream" (Richie and Keller 2008). The concept that these banks are an important link, orseries of "biotic stepping stones" in connectivity between the coral reefs of the southern Gulf (Tunnell et al. 2007) and the northwestern Gulf requires investigation.

Parker and Curray (1956) were the first to point out the tropical affinities of the South Texas Banks reflected in taxa other than corals or coralline algae. They listed 87 and 72 species of mollusks from dredgings on Baker and Southern banks, respectively, noting the West Indian and Caribbean distributions for many species. Further dredgings and submersible observations in the 1970s classified the upper parts of the banks as the Antipatharian Zone because of the conspicuous and abundant large, white, spiral antipatharian coral *Cirrhipathes* (Bright and Rezak 1976, Rezak et al. 1985). Epibenthic invertebrates and fishes of this zone on the South Texas Banks were similar to those in the same depth range on the mid-shelf carbonate banks of north Texas and Louisiana (e.g., 32 Fathom, Coffee Lump, Fishnet) and lower slopes of the Flower Garden Banks. Abundance and diversity of epifauna were noted to decrease sharply below about 70 m because of the Nepheloid Zone (Rezak et al. 1985). Consequently, the lower relief banks of the southernmost South Texas Banks (Small Adam, Big Adam, Blackfish and Mysterious) suffer from chronic high turbidity and sedimentation from crest to base (Rezak et al. 1985).

Other obvious fauna included the vase like sponge *Incinia compana*, a comatulid crinoid of the family Antedontidae, the gorgonian sea fan *Thesea*, and the large thorny oyster *Spondylus americanus*. Due to its abundance and ubiquitous distribution, the latter was suggested as a potential chemical-physiological "indicator organism" for petroleum hydrocarbons and contaminants (Bright and Rezak 1976).

These same epibentic invertebrates were also observed in recent video tows using a drop camera system (Figure 3B.8, fall 2008) on the crests of North Hospital and Southern banks (D. Weaver). Bathymetry during these tows revealed areas of small (0.5 m) scattered carbonate rocks to larger and more massive structures with 1–2 m relief. Several "grooves," perhaps relict coral reef spur and groove geomorphology, revealed 2–3 m of reef rock above the sandy/muddy bottom groove. Epibenthos was most abundant on the hard substrate areas, but many burrows and some gastropod trails occurred in soft substrate areas between rocks. The sea cucumber *Isostichopus* was also conspicuous.

A total of 239 invertebrate species were discovered during dredging and submersible observations (Rezak et al. 1985). These included 65 species of sponges (many identified only to genus or family), two hydroids, eight scleractinian corals (no shallow water species, mostly solitary), five gorgonians, two antipatharians, fifteen polychaetes, one chiton, four gastropods, eleven bivalves, one brachiopod, one leptostracan, seven natant decapods (shrimp), nine reptant decapods (crabs), one isopod, four tanaidids, six amphipods, 85 bryozoans, 9 ophiuroids, one echinoid, one holothuroid, and one crinoid.

Reef fish populations are similar in composition and abundance to those in the Antipatharian Zone of the Flower Garden Banks and deeper zones of other northwestern Gulf banks (Rezak et

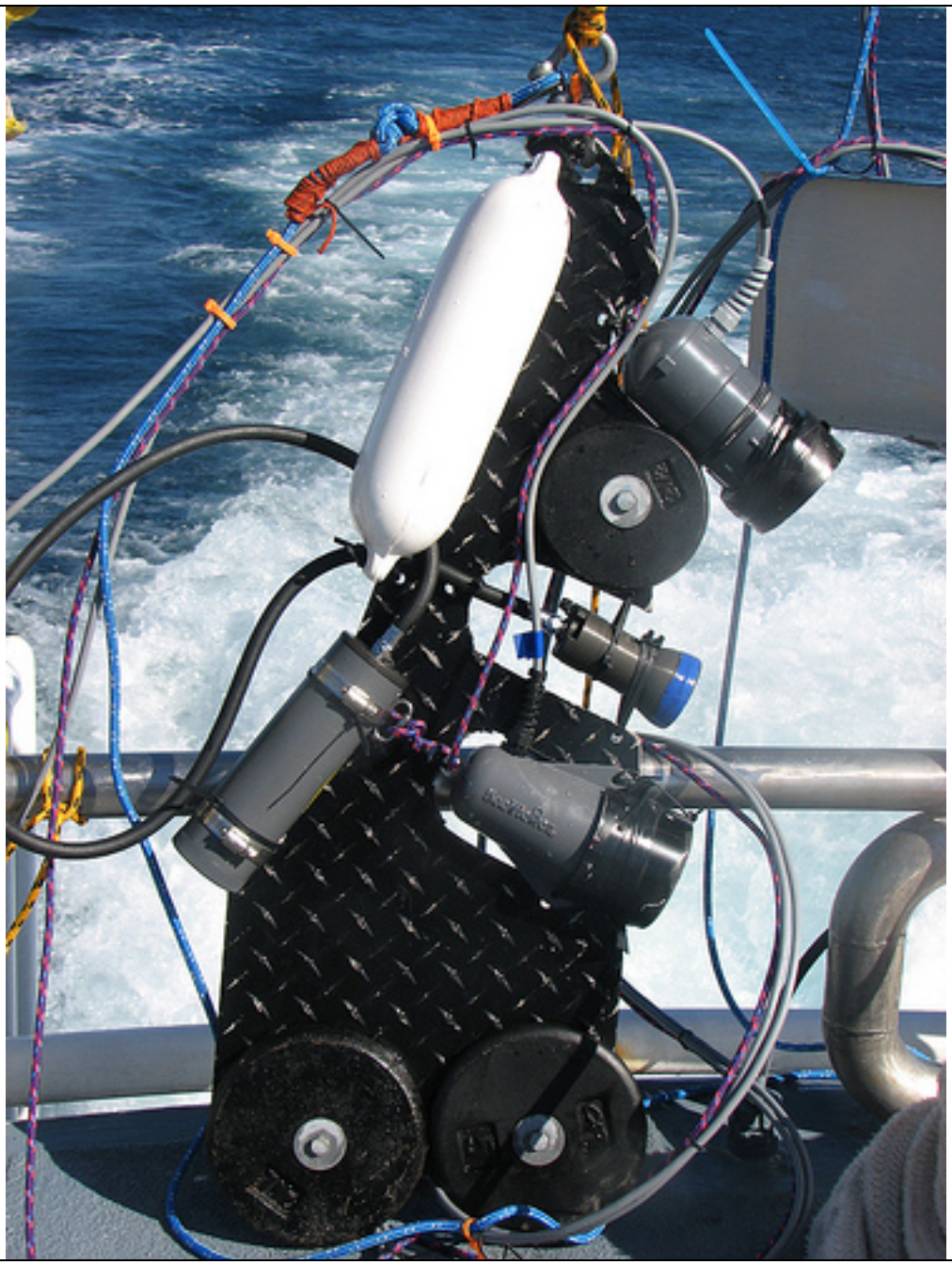

**Figure 3B.8. Tow camera system with color video camera, black and white camera, and HID canister light with diffuser for illumination used on South Texas Bank surveys.**

al. 1985). A total of 70 species of fishes were reported by Bright and Rezak (1976) during their dredging and submersible studies in the 1970s. Characteristic resident species were *Chromis enchrysurus*, *Pronotogrammus* (*Holanthias) martinicensis, Bodianus pulchellus, Chaetodon sedentarius, Liopropoma eukrines, Priacanthus arenatus, Serranus phoebe, Ioglossus calliurus,* and *Holacanthus bermudensis,* listed in order of apparent abundance (Bright and Rezak 1976).

**Table 3B.2.**

**New fish species recorded in fall 2008 video surveys of Southern and North Hospital Banks on the South Texas shelf (D. Weaver).**

| | Common Name | Scientific Name | Relative Abundance |
|---|---|---|---|
| 1. | Sunshinefish | *Chromis insolata* | Abundant |
| 2. | Gray snapper | *Lutjanus griseus* | Common |
| 3. | Greenband wrasse | *Halichoeres bathyphilus* | Common |
| 4. | Bar jack | *Caranx ruber* | Common |
| 5. | Striped grunt | *Haemulon striatum* | Occasional |
| 6. | Glasseye snapper | *Heteropriacanthus cruentata* | Occasional |
| 7. | Bigtooth cardinalfish | *Apogon affinis* | Occasional |
| 8. | Rock beauty | *Holacanthus tricolor* | Occasional |
| 9. | Yellow goatfish | *Mulloidichthys martinicus* | Occasional |
| 10. | Longsnout butterflyfish | *Prognathodes aculeatus* | Rare |
| 11. | Doctorfish | *Acanthurus chirurgus* | Rare |
| 12. | French angelfish | *Pomacanthus paru* | Rare |
| 13. | Rock hind* | *Epinephelus adscensionis* | Rare |
| 14. | Warsaw grouper** | *Epinephelus nigritus* | Rare |

*Caught with hook and line, this study
**hook and line, Neahr 2008

Most of these fishes congregated around the larger, carbonate reefal structures, but *Priacanthus arenatus* and *Pristogenys alta* seemed to prefer areas on flatter portions of the bank, perhaps the former reef lagoon. They considered the rough-tongue bass *P. martinicensis* as probably the most characteristic fish of the banks, but yellowtail reeffish *C. enchrysurus* was observed in schools of over a hundred. Interestingly, few large groupers (*Mycteroperca*) or hinds (*Epinephelus*) were observed on the banks.

Non-resident, larger, migrating fish species over the banks included: the important recreational and commercial fishes, red snapper (*Lutjanus campechanus*) and vermilion snapper (*Rhomboplites aurorubens*), amberjack (*Seriola dumerili*), barracuda (*Sphyraena barracuda*), small carcharinid sharks, and, cobia (*Rachycentron canadum*).

Our recent visual surveys of Southern and North Hospital Banks confirm Bright and Rezak's (1976) earlier observations, but indicate a more speciose and diverse tropical assemblage than previously reported (Table 3B.2). Fourteen new fishes were recorded through video surveys or hook and line angling on two brief research cruises. Along with yellowtail reeffish, the sunshinefish, *Chromis insolata*, was the numerically dominant species observed on most areas of the reef crest. Roughtongue bass or juveniles of other streamer basses were occasionally observed in extremely large schools (over 3,000 individuals) on the crest of Southern Bank, and were abundant on the deeper flanks of both North Hospital and Southern Banks. Large predators observed included scamp, *Mycteroperca phenax*, red snapper, lane snapper, *Lutjanus synagris*, vermilion snapper, and gray snapper, *Lutjanus griseus*. Despite heavy fishing pressure on Southern Bank, large predators were relatively abundant on the crest of the feature. Preliminary analysis of video data suggests that surveys of additional banks and/or use of higher resolution

cameras with a remotely operated vehicle or digital still camera will result in the documentation of many more species of reef fishes.

## Future Plans

Multibeam mapping of selected South Texas Banks during 2006 (W. Tunnell), and subsequently generated 3-D maps will allow us to conduct detailed faunal surveys at different depth ranges and on different relict reef types (interior lagoon, reef crest, fore reef zones). Our recent video transects (fall 2008, D. Weaver) on North Hospital and Southern banks indicate that the rank abundance and species richness of fish may be greater than that reported by Bright and Rezak (1976) and Rezak et al. (1985) (Table 3B.2). In addition, 2006 SCUBA surveys on Seven and One-half Fathom Reef (Tunnell and Causey 1969, Tunnell and Chaney 1970, Thayer et al. 1974, Felder and Chaney 1979), a nearshore, relict lacustrine bank in the same region, revealed an approximate 7% increase in known tropical fish species, compared to 40 years earlier (Causey 1969 and Causey 2008). This latter bank is the only well-studied one in South Texas, but all of those studies were 35–40 years ago. Its relationship and ecological importance to the other South Texas banks is unknown.

The habitat complexity provided by the relict and living corals and emergent epifauna provide habitat for a high diversity and abundance of nektonic and demersal fish and invertebrates. The South Texas relict carbonate reefs, as well as other nearshore banks, oil and gas platforms (artificial reefs), and southern Gulf of Mexico coral reefs, are biodiversity 'hotspots' in comparison to the surrounding level bottom communities. We advocate additional investigations to explore the role of the South Texas Banks in the general ecology of the Gulf of Mexico, and their possible role as stepping stones for southern Gulf of Mexico and Caribbean fauna to the northern Gulf of Mexico.

## Acknowledgments

We thank Captain Frank Wasson and the crew of the M/V *Spree* of Gulf Diving Associates, and Captain Charles Doolin of the M/V *Point Glass* and the Sea Scouts for field support during mapping and tow camera surveys, respectively.

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# A LIFE HISTORY REVIEW FOR RED SNAPPER IN THE GULF OF MEXICO WITH AN EVALUATION OF THE IMPORTANCE OF OFFSHORE PETROLEUM PLATFORMS AND OTHER ARTIFICIAL REEFS

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(Full article in *Reviews in Fisheries Science* 17(1):48–67. © Taylor and Francis Group 2009)

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## Introduction

In this study, we reviewed the literature describing the life history, distribution, and ecology of the red snapper in the Gulf of Mexico. We also examined the role and relative importance of offshore oil and gas platforms and other artificial reefs as factors affecting the Gulf of Mexico red snapper population. We begin by noting that red snapper is characterized as a reef fish, and their reef association begins almost immediately after they leave the planktonic stage and settle to the bottom (e.g., Szedlmayer and Howe 1997, Szedlmayer and Conti 1999, Workman et al. 2002). This association has been well documented for ages 0–8, but it may weaken considerably at older ages (e.g., Render 1995, Nieland and Wilson 2003, Szedlmayer 2007). We also note that, on a spatial basis, reef habitat is a relatively scarce commodity in the northern Gulf where red snapper occur (Ludwick 1964, Parker et al. 1983). In this context, we also examine the issue of habitat limitation (or compensatory mortality) and the life stages at which habitat limitation may be important.

## Summary of Review

Red snapper mature as early as age 2, have high fecundity (a 10-year-old female produces 60 million eggs per year), and may live for over 50 years (SEDAR7 2005). Spawning extends from April through September with peak spawning occurring in June–August (Render 1995, Bradley and Bryan 1975, Futch and Burger 1976, Collins et al. 1996). Eggs, larvae, and post-settlement juveniles typically show high rates of natural mortality. For example, of the 60 million eggs produced annually by a 10-year-old female, only about 450 would survive to 5 cm, the size at which they enter the shrimp fishery. Changes in abundance by size and age appear to be

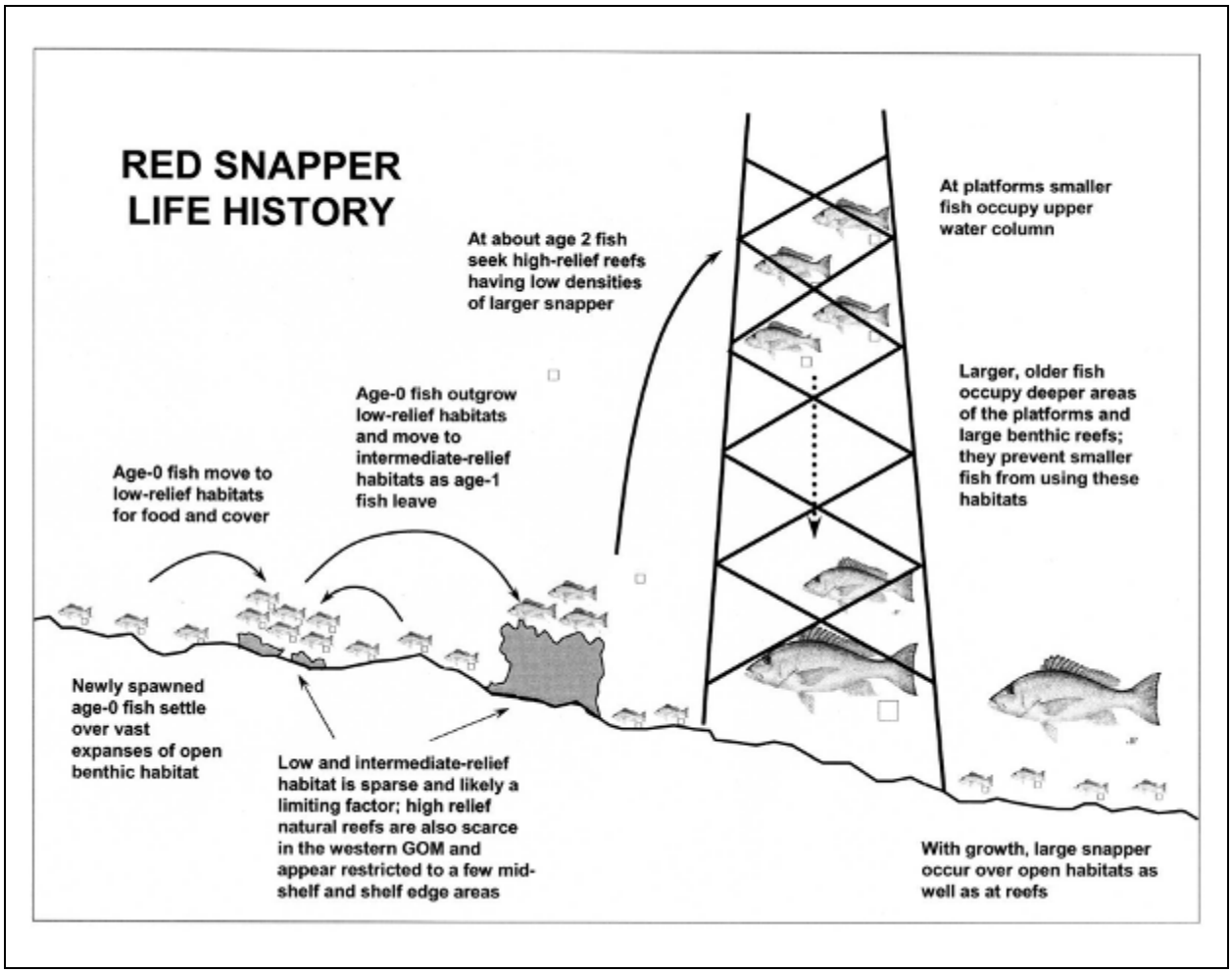


**Figure 3B.9. An overview of the life history of red snapper in the northern Gulf of Mexico.**

consistent with density dependence in survival rate from ages 0 to 1 and likely ages 0 to 2, suggesting habitat is a limiting factor for these age groups (Gazey et al. 2008).

Red snapper are attracted to structure or reef habitat at all ages, but larger, older fish also occur over open habitat once they have reached a size that renders them largely invulnerable to predation (Figure 3B.9). Artificial reefs comprise a small fraction of the overall high-relief reef habitat, but may harbor a large fraction (estimates suggest > 70%) of the present-day age 2 red snapper populations. Prior to the proliferation of artificial reefs in the northern Gulf, age 2 red snapper may have historically occurred mainly over open-bottom, sand-mud benthic habitat where natural and shrimp trawl bycatch mortality was high. Age 2 fish dominate red snapper populations at artificial reefs, whereas the age composition of red snapper at natural reefs along the shelf edge and over soft bottoms at depths between 55 and 92 m (Mitchell et al. 2004) usually show older ages are dominant. Highest larval abundance occurs at depths between 50 and 100 m (Lyczkowski-Shultz and Hanisko 2007) which generally corresponds to the distribution of large adult fish.

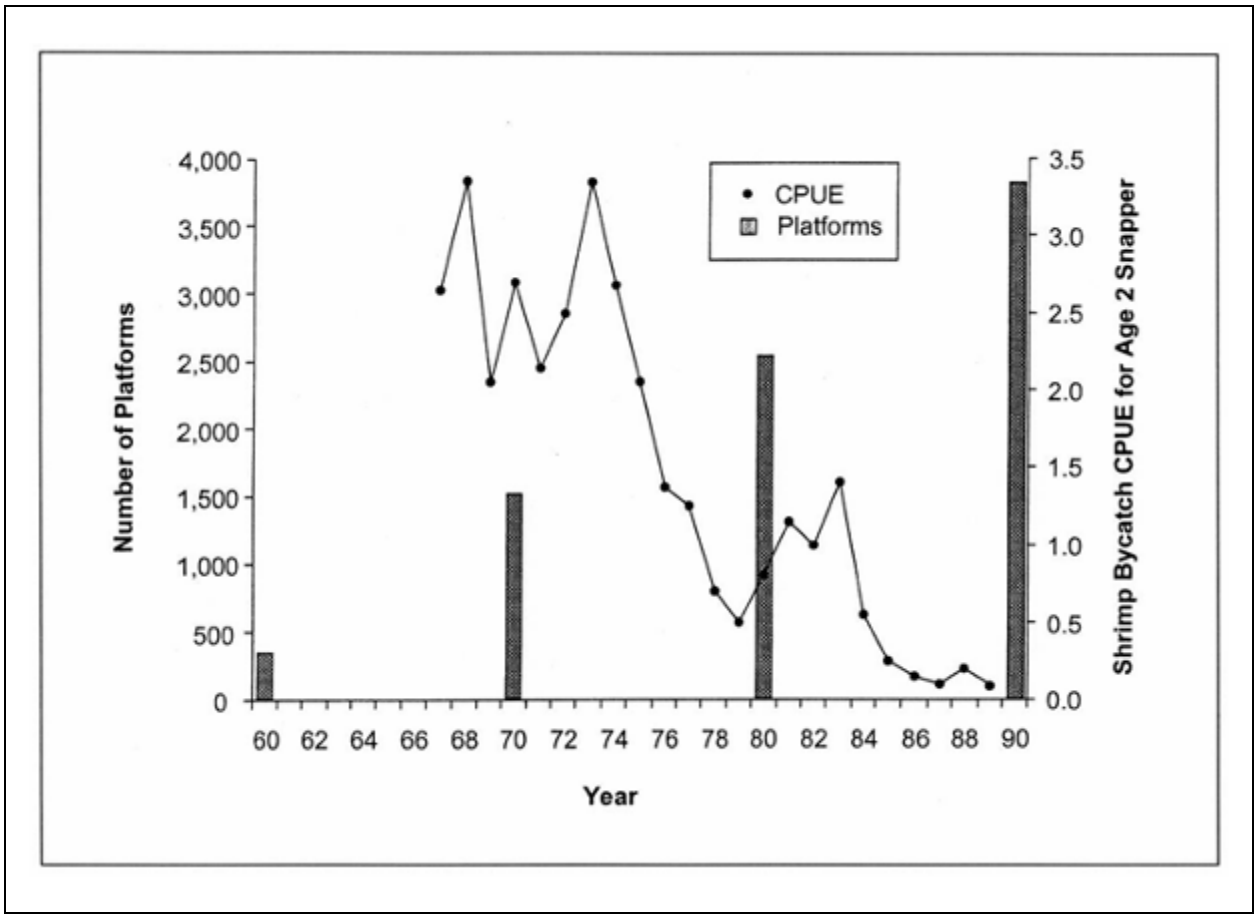


**Figure 3B.10. Trawl catches of age-2 red snapper in shrimp trawls versus offshore platform abundance.**

The present day red snapper fishery is heavily dependent on catches at artificial reefs. Evidence is presented that suggests red snapper production in the northern Gulf likely has been increased by the establishment of significant numbers of artificial reefs (Figure 3B.10).

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Benny J. Gallaway is the President of LGL Ecological Research Associates, Inc. which has its main offices in Bryan, Texas. He has been a senior fisheries and marine ecologist with LGL since 1974 and has over three decades of experience dealing with a wide variety of environmental and fishery management issues in the Gulf of Mexico. Dr. Gallaway holds a Ph.D. in Wildlife and Fisheries Sciences from Texas A&M University. He has served as Adjunct Professor at Texas A&M University and presently serves on the Graduate Committee for The University of British Columbia. He is a member of the Kemp's Ridley, Loggerhead, and Atlantic Leatherback Turtle Expert Working Group for the NOAA, and the Ad Hoc Shrimp Effort Expert Working Group for the Gulf of Mexico Fishery Management Council. Dr. Gallaway has authored over 60 publications in peer-reviewed literature.

Stephen T. Szedlmayer, Professor, Marine Fish Laboratory, Department of Fisheries and Allied Aquaculture, Auburn University, received his Ph.D. from the Department of Fisheries, School of Marine Science, College of William and Mary, his M.S. in fisheries ecology from the University of South Florida, and his B.A. in biology from Millersville University. Dr. Szedlmayer's research addresses the fisheries, ecology and behavior of marine fishes. These studies have included age and growth, reproduction, early-life-history, predator-prey relations, diet analyses, movements, behavioral interactions, and in general the effects of habitats both natural and artificial on the fish and invertebrate populations in the northern Gulf of Mexico.

William J. Gazey is the principal of W.J. Gazey Research located in Victoria, British Columbia. He has been actively involved as a contractor in natural resource applications since 1978 and has authored numerous reports and publications. Mr. Gazey holds an M.Sc. from the Institute of Animal Resource Ecology, University of British Columbia. His current interests are the application of Bayesian methodologies to natural resource problems and practical applications for ecosystem models.

# SESSION 3C

# ALTERNATIVE ENERGY

**Chair:** **Gary Goeke, Minerals Management Service**

**Co-Chair:** **Elizabeth Burkhard, Minerals Management Service**

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## ALTERNATIVE ENERGY REGULATIONS AND AE INTERIM POLICY

**Gary Goeke**
**Minerals Management Service**

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In 2005, the Energy Policy Act of 2005 (EPAct) amended the Outer Continental Shelf Lands Act (OCSLA) to give the responsibilities of the Federal Offshore Alternative Energy and Alternate Uses of the Outer Continental Shelf (OCS) to the Department of the Interior, Minerals Management Service (MMS). Under this authority, the Secretary of the Department of the Interior (Secretary) has the authority to grant leases, easements, or right-of-ways (ROW) for alternative energy uses on OCS lands.

Following the passage of EPAct, a Final Programmatic Environmental Impact Statement (PEIS) was prepared. The final PEIS examined the potential environmental effects of the program on the OCS and identified policies and best management practices that may be adopted for the program. Based on the recommendations in the PEIS, a Record of Decision (ROD) was published in January 2008.

Under this new authority, MMS implemented an Interim Policy (IP) for limited leasing. This allowed for a five-year limited lease on the OCS for the installation of offshore data collection and technology testing facilities. However, this does not give priority rights for subsequent commercial development.

After the initial IP announcement, in April 2008 MMS received 40 site nominations from developers in areas proposed for limited leasing off the west and east coasts. Out of these proposals, fifteen proposed lease areas were indentified as priority areas. Currently, MMS is proceeding with IP lease issuance for areas off New Jersey, Delaware, Georgia, and southeast Florida.

On 9 July 2008, MMS published a Proposed Rule in the Federal Register. This regulation provided an outline of MMS's role as the lead agency for alternative energy activities on the OCS. In the Proposed Rule, the regulation established the following: the methods for sharing revenue generated by the program with nearby Coastal States, leasing process and issuance plans, conduct of approved plan activities, payments, and decommissioning of the projects. Following the proposed rule, a 60-day comment period was issued and MMS received 280 comments, primarily from private citizens. These comments were addressed in the Final Rule, which was published April 29, 2009.

Gary Goeke is the Chief of the Environmental Assessment Section with the Office of Leasing and Environment at MMS in New Orleans.

## ALTERNATIVE ENERGY PROGRAM STUDIES

**Elizabeth Burkhard**
**Minerals Management Service**

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The presentation covers the development of information needed to support the new alternative energy program within MMS. Environmental studies address issues relating to aquatic resources, flying animals, physical oceanography, air quality, social science and economics. As the program is so new, only a few studies are complete at this time, but many more are under way and planned for the coming years. Studies are planned for all regions and are designed to form an integrated suite that builds the information necessary to support safe and environmentally sound decisions regarding the alternative energy program.

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Elizabeth Burkhard is a marine biologist in the MMS Environmental Sciences Branch. She holds a B.S. degree in biology from the College of William and Mary and an M.S. degree in marine science from the University of South Florida, St. Petersburg. Ms. Burkhard works with developing alternative energy information needs for the Studies Program and is involved in program policy. She also serves on the interagency committee to implement the Executive Order on Marine Protected Areas.

## CAPE WIND AND LONG ISLAND OFFSHORE WIND PARK

**Barry Obiol**
**Minerals Management Service**

Click here to view the slide show that accompanied this presentation.

The Cape Wind Energy and the Long Island Offshore Wind Projects are proposed energy producing facilities located on the Outer Continental Shelf (OCS). The Minerals Management Service's authority to approve, deny, or modify the Cape Wind and Long Island Energy Projects derives from the Energy Policy Act of 2005. Section 388 of the Act amended the OCS Lands Act by adding subsection 8(p), which authorizes the Department of the Interior to grant leases, easements or right-of-ways on OCS lands for activities that produce or support production, transportation, or transmission of energy from sources other than oil and gas, such as wind power. The proposed actions require environmental reviews for federal approval under Subsection 8(p) of the Outer Continental Shelf Lands Act. The National Environmental Policy Act provides the framework under which federal agencies perform environmental review of projects which they would be authorizing, funding, or undertaking on their own behalf. In this instance, the proposed federal action resulting in the need for environmental review under the National Environmental Policy Act is the issuance of a lease, easement or right-of-way and related approvals by the Minerals Management Service for authorizing the construction, operation and eventual decommissioning of these projects.

The Cape Wind project proposes to install 130 turbines to develop a 468 MW capacity offshore wind power project located at Horseshoe Shoals in Nantucket Sound. Cape Wind proposes to provide power to ISO-NE grid through two 115kv AC transmission lines coming ashore in Yarmouth, Massachusetts. The Long Island project proposed to install 40 turbines to develop a 140 MW capacity offshore wind power project located offshore of West Amityville, NewYork. The Environmental Impact Statement (EIS) for the Cape Wind Energy Project was published in January 2009, however, the Long Island project was withdrawn by the applicant prior to the completion of the EIS. These two projects represent the initial attempts to place the first wind power energy producing facilities in the country on the OCS. To date, the Long Island project is no longer being considered for a lease, and MMS has not made a final decision on the Cape Wind project.

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Barry Obiol has held professional positions in the environmental field for over 30 years with local, state and federal governmental agencies, as well as, the private sector. His experiences include land use planning, regulatory, engineering, and application of the National Environmental Policy Act (NEPA). Mr. Obiol obtained a B.S. in forestry at the University of New Orleans and Louisiana State University. He is currently the NEPA coordinator for the Cape

Wind Energy Project and holds the position of senior environmental scientist with the Department of the Interior, Minerals Management Service.

## AE INTERIM POLICY PROJECTS ON THE EAST COAST

**Thomas Bjerstedt**
**Gulf of Mexico Region**
**Minerals Management Service**

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In November 2007 MMS announced the Interim Program (IP) for installing meteorological towers or marine data-collecting facilities for OCS alternative energy projects. The IP was designed to bridge developers' desire to get resource assessment projects into salt water and MMS completing the rulemaking for alternative energy on the Outer Continental Shelf (OCS) authorized by the Energy Policy Act of 2005. Developers nominated 40 areas on the OCS, from which MMS culled a subset of 15 areas on the east and west coasts in April 2008 to be considered for limited leasing under the IP.

Limited leases under the IP could not involve competition for the same area; they give no preferential rights for future commercial development; and they are limited to a facility lifecycle of five years. IP projects proposed on the west coast, though accepted for consideration under the IP, are now inactive. On the east coast, seven projects were proposed from 8–17 miles offshore in water 40–100 feet deep to assess the potential for wind energy off the coasts of New Jersey and Delaware, and one off the coast of Georgia. Four areas off the Atlantic south Florida coast were proposed for ocean current energy projects.

Meteorological towers would consist of bottom-founded monopoles or jacketed towers with instrumentation packages fixed at various heights. Instrumentation for current energy projects involve emplacement of acoustic Doppler current profilers on the sea bottom. Developers for the seven projects off New Jersey and Delaware have submitted applications and MMS completed a multi-project environmental assessment for these proposals in June 2009. MMS anticipates that limited leases in these areas should be let by 2Q 2009. MMS has yet to receive applications for the meteorological tower(s) off Georgia and the four current energy projects off the south Florida coast.

Renewable portfolio standards (RPS) instituted by law in most mid-Atlantic states appears to be a significant driver for these projects. States bordering the south Atlantic coast, for the most part, have RPS expressed as goals rather than as requirements. Capitalization for small developers and their familiarity with operating on the OCS may challenge developers seeking to test current energy technologies, a nascent technology on offshore shelves anywhere in the world.

Dr. Thomas Bjerstedt joined MMS in 2002 where he works in the Environmental Assessment Section preparing environmental evaluations performed under the National Environmental Policy Act for oil and gas exploration and development projects, gas hydrates research, sand leasing, and alternative energy on the outer continental shelf. He received his Ph.D. in geology from West Virginia University in 1986. Before joining MMS, Dr. Bjerstedt was a deepwater exploration geologist on Texaco's Gulf of Mexico team from 1997–2001.

# SESSION 3D

# AIR QUALITY II

**Chair:** **Holli Ensz, Minerals Management Service**

**Co-Chair:** **Stacie Merritt, Minerals Management Service**

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# SYNTHESIS, INTEGRATION, AND ANALYSIS OF METEOROLOGICAL AND AIR QUALITY DATA

**Jay Haney and Sharon Douglas**
**ICF International**

**Betsy Davis-Noland and Joe Adlhoch**
**Air Resource Specialists, Inc. (ARS)**

Click here to view the slide show that accompanied this presentation.

## Introduction and Background

The Minerals Management Service (MMS), together with the oil and gas industry, has collected a variety of meteorological, air quality and emission inventory data for the Gulf of Mexico (GOM) region. These data span the years 1988 to present and have been used to support various air quality related data analysis and modeling activities. The focus of this data synthesis study was to assemble these data, as well as other data available from federal, state, and oil and gas industry studies and databases, into a coherent dataset, so that an integrated analysis of the data could be conducted. It is expected that this integrated dataset will provide the basis for an improved understanding of the relationships between meteorology, emissions, and air quality in the Gulf of Mexico region and support future regulatory data and modeling analyses related to ozone, fine particulate matter ($PM_{2.5}$) and regional haze.

The data synthesis study also included some basic analysis of the data, which was conducted in order to ensure the integrity and usability of the dataset. The analyses were also intended to provide new information about meteorological and air quality conditions in the GOM region. The study was initiated in September 2006 and will continue through March 2009. Air Resource Specialists, Inc. (ARS) has assisted ICF in the development of the database and the interactive database interface tool for the study.

The database incorporates data from several MMS-sponsored studies including the 1993 Gulf of Mexico Air Quality Study (GMAQS), the Atmospheric Boundary Layer (ABL) study (spanning 1998-2001), and the recent offshore activities and emissions data for the Breton area and the entire Gulf of Mexico (2000 and 2005 Gulfwide Emission Inventories). Data collected as part of the Breton Aerometric Monitoring Program (BAMP) (October 2000–September 2001), co-sponsored by MMS and the offshore oil and gas industry, are also included. To support the conduct of air quality related analysis, data from the U.S. Environmental Protection Agency (EPA) Air Quality System (AQS), the National Weather Service (NWS), the National Data Buoy Center (NDBC) and other sources have also been included.

The data synthesis study area is shown in Figure 3D.1. It includes portions of several states as well as the GOM and Outer Continental Shelf (OCS) areas. The study area includes the Houston

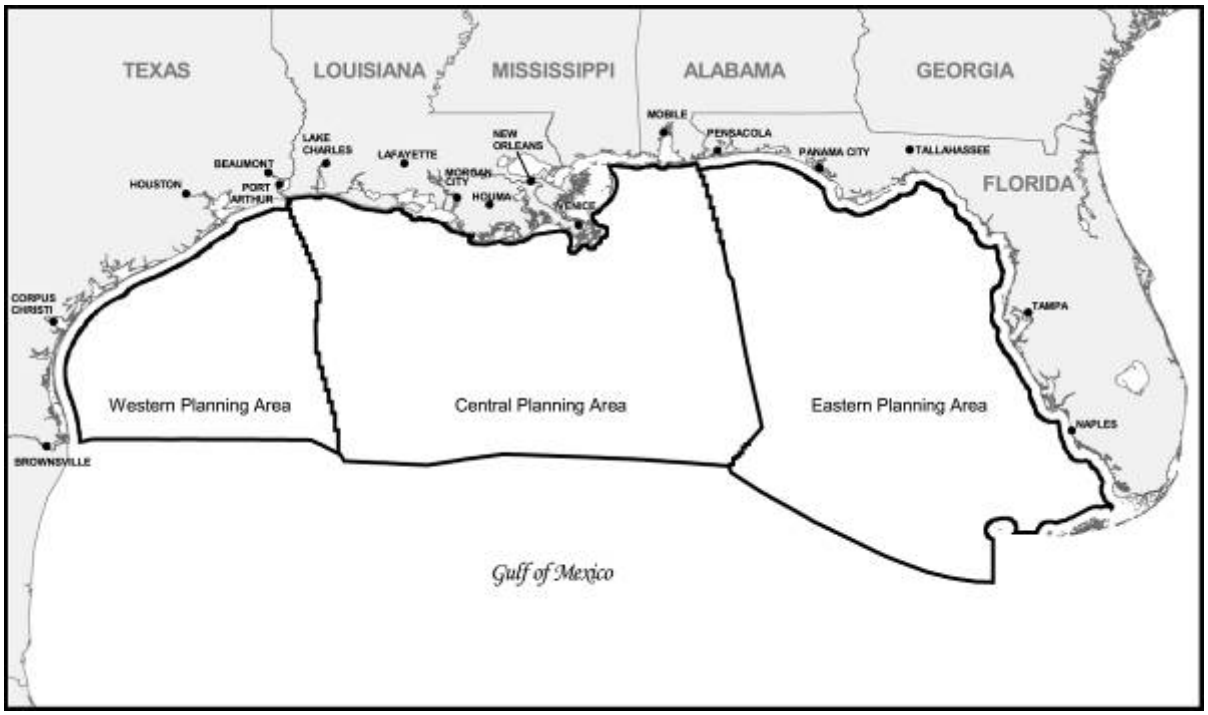


**Figure 3D.1. MMS Data Synthesis Study Area.**

metropolitan area as well as several other moderate to small urban areas such as Baton Rouge and New Orleans in Louisiana; Gulfport, Mississippi; Mobile, Alabama, and Pensacola and Tampa, Florida. The offshore Western, Central, and Eastern OCS Planning Areas stretch west to east across 1,000+ miles of the Gulf of Mexico from Brownsville, Texas to the Florida Keys and encompass an area that extends 200 miles offshore of the coastal states.

## Data Assembly, Integration, and Evaluation

The resulting Gulf of Mexico Air Quality Database (GMAQDB) is a relational database that contains hundreds of millions of data points. An interactive database tool has been designed to provide users with easy-to-use query capabilities to retrieve specific subsets of the data based on a variety of criteria such as date range, location and parameter type. The graphical user interface (GUI) consists of menus, forms and reports developed with Microsoft Access 2003. The form controls, such as list views, drop-down list boxes, command buttons, etc., are standard controls used in many Microsoft Windows applications and should be familiar to most users.

## Data Analyses

A variety of data analyses were conducted in order to “mine” the integrated GMAQDB and ensure the integrity and usability of the dataset. Statistical and graphical summaries were prepared to provide an overview of the meteorological, air quality and emissions data and to

highlight key features/components of the integrated dataset. Among the air quality issues revealed by the data, ozone is the greatest concern for most (monitored) areas along the Gulf Coast. $PM_{2.5}$ concentrations tend to be relatively low (e.g., compared to national standards), but some high values have been observed recently in the Houston area.

Classification and Regression Tree (CART) analysis and other data analysis techniques were used to probe the relationships between meteorology, ozone, $PM_{2.5}$ and visibility (regional haze) at the Breton NWA. The CART analysis results for ozone reveal that high ozone days for most areas along the Gulf Coast are characterized by low relative humidity, low wind speed, little or no precipitation and stable conditions, compared to lower ozone days. Within each monitored area, however, different combinations of regional meteorology, local meteorology and carryover and/or transport of ozone comprise an ozone episode. The CART results also indicate that meteorological data are reasonably good indicators of ozone concentration for areas along the Gulf Coast. The CART results for $PM_{2.5}$ reveal that on an annual basis, high $PM_{2.5}$ concentrations occur in connection with a regional build up of $PM_{2.5}$ concentrations, low wind speed and stability. However, different mechanisms lead to high $PM_{2.5}$ concentrations during different times of the year. Specifically, the regional build up of $PM_{2.5}$ is an important mechanism during the warmer months, while local factors such as low temperatures, low wind speeds and stability are important during the colder months. For Class I area along the Gulf Coast (the Breton, St. Mark's and Chassahowitzka National Wilderness Areas), the worst visibility days occur under a variety of conditions. The predominant conditions include very high $PM_{2.5}$ and low to moderate relative humidity, high to moderate $PM_{2.5}$ and relative humidity, and low $PM_{2.5}$ and high relative humidity.

Meteorologically adjusted trends for ozone, $PM_{2.5}$ and visibility were developed based on meteorological typing provided by CART analysis. The meteorological adjusted values show less variation from year to year than the actual values. For most areas, the results for ozone indicate that observed high ozone for 2000 and low ozone for 2002 are attributable to the effects of meteorology. The year-to-year trend in ozone is relatively flat between 2000 and 2004. The results for $PM_{2.5}$ indicate a slight upward trend in $PM_{2.5}$ concentrations for Houston and a downward trend for all other areas between 2000 and 2004. The meteorologically adjusted values confirm the tendencies indicated by the actual data. For visibility, there is a slight upward tendency in extinction coefficient (toward poorer visibility) for Breton between 2000 and 2004, and a downward tendency for the other coastal Class I sites.

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Jay L. Haney is Director of the Air Quality Modeling Group at ICF International. He is a Certified Consulting Meteorologist and has an M.S. in meteorology from Saint Louis University. He has 29 years of experience in the application and refinement of data analysis and modeling techniques applied to the study of tropospheric ozone, carbon monoxide, particulate matter, and mercury.

Sharon G. Douglas is a Senior Project Manager in the Air Quality Modeling Group of ICF International. She has an M.S. in meteorology from Penn State University and more than 20 years of experience at ICF in the area of air quality modeling. Her areas of specialization include meteorological data analysis, air quality forecasting, and development and application of model-based source attribution tools for ozone, particulates, and mercury.

# YEAR 2005 AND 2008 GULFWIDE EMISSION INVENTORY STUDIES

**Darcy Wilson and Richard Billings**
**Eastern Research Group, Inc. (ERG)**

Click here to view the slide show that accompanied this presentation.

## Introduction

MMS is currently sponsoring the fourth air quality emissions inventory study effort for the Gulf of Mexico. The studies are designed to assess the potential impacts of air pollutant emissions from offshore oil and gas exploration, development, and production sources in the Outer Continental Shelf (OCS). The current study, *The Year 2008 Gulfwide Emission Inventory Study*, serves as an update to *The Year 2000 Gulfwide Emission Inventory Study for the Regional Haze and Ozone Modeling Effort* (Wilson et al. 2004), and *The Year 2005 Gulfwide Emission Inventory Study* (Wilson et al. 2007). The MMS Gulfwide inventories are air pollution emission inventories of all OCS oil and gas production-related sources in the Gulf of Mexico, including non-platform sources. Pollutants covered in the inventories are the criteria pollutants—carbon monoxide (CO), nitrogen oxides ($NO_x$), sulfur dioxide ($SO_2$), particulate matter-10 ($PM_{10}$), $PM_{2.5}$, and volatile organic compounds (VOC); as well as greenhouse gases—carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$). The methods to collect the monthly platform activity data, develop the platform and non-platform source emission estimates, and allocate the non-platform mobile source emission estimates throughout the OCS are discussed in detail in each study report, and the resulting emission estimates are presented and evaluated. The reports and emission inventory data sets are available online at http://www.gomr.mms.gov/homepg/regulate/environ/airquality/goads.html.

The 2008 Gulfwide emission inventory will correspond with the next U.S. Environmental Protection Agency (EPA) onshore periodic emissions inventory, and will be available to assist states and regional planning organizations to conduct modeling for State Implementation Plan (SIP) demonstrations. The inventory will also be used to enhance the MMS National Environmental Policy Act (NEPA) process by providing an inventory to compute emissions trends and to perform necessary air quality impact assessments.

## Year 2005 Gulfwide Emission Inventory Study Results

[When reviewing the results of the *Year 2005 Gulfwide Emission Inventory Study*, it is important to keep in mind the widespread damage in the Gulf of Mexico caused by Hurricanes Katrina and Rita, which impacted the inventory results for September through December.] As shown in Table 3D.1, the year 2005 inventory results indicate that OCS oil and gas production platform and non-platform sources emit the majority of criteria pollutants and greenhouse gases in the Gulf of Mexico on the OCS, as opposed to non-production sources such as commercial marine vessels, the Louisiana Offshore Oil Platform (LOOP), and vessel lightering. Oil and gas production

platforms account for the majority of the CO (natural gas engines) and VOC (fugitives and cold vents) emissions. Non-platform OCS oil and gas production sources (support vessels) emit the majority of the estimated $NO_x$, PM, and $SO_2$ emissions. For greenhouse gases, platform sources account for almost all of the $CH_4$ emissions, and non-OCS oil/gas production sources emit the majority of the $N_2O$ emissions. The greenhouse gas emission estimates for the central and western areas of the Gulf of Mexico OCS total 26,988,784 metric tons $CO_2$ equivalents ($CO_2e$), or 0.37% of the U.S. total for 2005.

**Table 3D.1.**

**Base Year 2005 Emission Estimates**

| Source Category | CO (tpy) | $NO_x$ (tpy) | $PM_{10}$ (tpy) | $SO_2$ (tpy) | VOC (tpy) | $CH_4$ (tpy) | $CO_2$ (tpy) | $N_2O$ (tpy) |
|---|---|---|---|---|---|---|---|---|
| OCS Oil/Gas Production Platform Emissions | 89,813 | 82,581 | 746 | 1,961 | 51,241 | 214,499 | 8,848,779 | 130 |
| OCS Oil/Gas Production Non-Platform Emissions | 27,597 | 199,979 | 3,812 | 27,520 | 5,257 | 72 | 11,178,620 | 510 |
| Total OCS Oil/Gas Production Source Emissions | 117,410 | 282,560 | 4,558 | 29,481 | 56,498 | 214,571 | 20,027,399 | 649 |
| Non-OCS Oil/Gas Production Source Emissions | 4,885 | 110,402 | 1,530 | 11,078 | 24,434 | 1,913 | 4,307,048 | 2,154 |
| Total Emissions (tpy) | 122,295 | 392,961 | 6,088 | 40,559 | 80,933 | 216,484 | 24,334,447 | 2,803 |

## Comparison of 2000 and 2005 Emission Estimates

An overall comparison of pollutant-specific emission estimates for platform and non-platform sources is presented in Table 3D.2. The CO and VOC emission estimates vary slightly from 2000 to 2005. Large differences are seen, however, in the $PM_{10}$ estimates (52% increase), the $NO_x$ estimates (93% increase), and the $SO_2$ estimates (52% increase).

**Table 3D.2.**

**Comparison of Total Platform and Non-Platform Criteria Pollutant Base Years 2000 and 2005 Emission Estimates**

| Base Year | CO Emissions (tpy) | $NO_X$ Emissions (tpy) | $PM_{10}$ Emissions (tpy) | $SO_2$ Emissions (tpy) | VOC Emissions (tpy) |
|---|---|---|---|---|---|
| 2000 | 113,303 | 203,349 | 4,016 | 26,760 | 85,008 |
| 2005 | 122,295 | 392,961 | 6,088 | 40,559 | 80,933 |
| Percent Difference | +8% | +93% | +52% | +52% | -5% |

The emission estimation methods for platform sources are relatively unchanged between the 2000 and the 2005 inventories, the exception being the boilers/heaters/burners, flare-pilot, and natural gas turbine PM emission factors. Otherwise, any changes in emission levels, then, are due to the number of platforms included in the inventory, increases or decreases in activity levels, fuel type (for combustion sources), and how well the operators interpreted and completed the requested fields in the Gulfwide Offshore Activities Data System (GOADS) activity data collection software.

For platform sources, only $SO_2$ shows a large difference in the emission estimates from 2000 to 2005. The $SO_2$ estimate shows a 43% decrease in 2005 emissions; the majority of the reductions are in the amine unit emission estimates, which are unaffected by the number of platforms included in the inventories, but impacted by the hurricanes in September and October. Emission estimates for drilling activities also contribute to this reduction. Platform estimates for CO are relatively steady, with an overall decrease of 3%. CO emission levels increased for some source categories such as diesel engines, natural gas turbines, and combustion flares, but decreased for drilling activities for all months in 2005. Platform estimates for $NO_x$ are also somewhat steady, with an overall increase of 6%. Diesel engines, combustion flares, and natural gas turbines showed increases in activity (hence, increases in $NO_x$ emissions), but these increased emissions are again offset by decreased drilling activity. Platform estimates for $PM_{10}$ show a slight decrease of 5% in total emissions, with decreased emission estimates for a number of source categories including boilers/heaters/burners (most likely due to the updated emission factor for natural gas usage), drilling activities, and natural gas turbines (again due to the emission factor). $PM_{10}$ estimates from diesel engines increased due to increased activity levels. For VOCs, the 14% reduction in emission estimates is due in large part to the fugitive sources, with a decrease in 2005 emissions of 12,000 tons. Some of this change reflects MMS' goal to include only major platform sources in the inventory. In 2000, fugitive records were provided by 2,880 platforms, compared to 1,585 in 2005. Reductions are also seen in the emission estimates for losses from flashing; this is primarily due to activity or reporting reductions. In the 2000 inventory, over 200 records were processed for losses from flashing. In the 2005 inventory, only 92 records were flagged as "active," with the majority of emissions routed to system, vented (remotely), or flared (remotely). Emission estimates were developed only for active records, vented (or flared) locally.

For non-platform sources, emission estimates for all criteria pollutants show increases in the 2005 inventory compared to the 2000 inventory. Non-platform sources account for the overall 2005 $PM_{10}$ increase of 52%, most of the overall 2005 $NO_x$ increase, and the overall 2005 $SO_2$ increase of 52%, shown in Table 2. For the most part, emissions from non-platform sources are higher in the 2005 inventory relative to the 2000 inventory for two reasons: 1) more up-to-date emission factors were used in calculating marine vessel emissions, these new emission factors tend to be higher than the older EPA marine vessel emission factors; and 2) new, more accurate activity data were used in the 2005 inventory for support helicopters, support vessels, survey vessels, and commercial marine vessels (CMVs), which tended to be higher than the 2000 values. For $SO_2$, support vessels and CMVs accounted for the majority of the increase. Vessel lightering is a category where some emissions are noted as declining; this is primarily due to the use of more accurate (and reduced) activity data for escort vessels.

Higher emission estimates associated with the new marine diesel engine emission factors affect all pollutants, with most dramatic changes noted with $NO_x$ and VOC. An evaluation was performed of the EPA emission factors used in the 2000 Gulfwide inventory and the Swedish emission factors used in the 2005 Gulfwide inventory. Variance between the two sets of emission factors suggested that they were similar except for $NO_x$, which was consistently higher in the Swedish factors for slow and medium speed diesel engines. Though the variance was similar for VOC, most of the emission factors used in this study are at the higher end of the range, while most of the factors used in the previous 2000 study are at the lower end of the range. EPA emission factors were higher for at-sea maneuvering, but this only occurred for a limited number of cases, such as vessel lightering and product offloading at the LOOP. There are also a number of cases where the emission estimates are lower in the 2005 inventory; these tend to be due to declining activities as noted for commercial fishing vessels, pipelaying operations, and the LOOP. When the reduced activity data are combined with the more recent emission factors, however, some pollutant emission estimates for these sources categories show an increase due to the fact that the new emission factors have values greater than the old factors.

## Plans for the 2008 Inventory

### *Platform Sources*

To initiate the data collection effort for OCS oil and gas production platforms, Notice to Lesses (NTL) No. 2007-G25, "Production Activities Information Collection and Reporting for Calculations of Air Emissions in the Western Gulf of Mexico," was issued 24 September 2007. The NTL notified operators that they must collect platform activity data for calendar year 2008 using the GOADS-2008 software.

Information on the 2008 Gulfwide emission inventory effort can be found online at:
http://www.gomr.mms.gov/homepg/regulate/environ/airquality/goads-2008.html

The GOADS-2008 software was released 17 October 2007, and a workshop was held in New Orleans on 24 October 2007, to discuss the data collection requirements and the GOADS software. GOADS is a Visual Basic program for the collection and submittal of monthly activity data. Operators use the GOADS software to record activity data for amine units, boilers/heaters/burners, diesel engines, drilling equipment, fugitives, combustion flares, glycol dehydrators, loading operations, losses from flashing, mud degassing, natural gas engines and turbines, pneumatic pumps, pressure/level controllers, storage tanks, and cold vents. The reporting deadline for the 2008 platform activity data is 17 April 2009. Similar to the base year 2000 and 2005 inventory efforts, these activity data will undergo significant QA/QC, and then be used to calculate emissions estimates using the Gulfwide Oracle database management system (DBMS). Ultimately, database users will be able to query the database by pollutant, month, equipment type, platform, etc.

In an effort to facilitate data reporting, MMS has provided a number of frequently asked questions (FAQs) and responses. Upon request, MMS also provided base year 2005 data files for

the "static" platform and production equipment data required in GOADS. These data, such as the structure's 2005-submitted area, block, locational coordinates, and sales gas composition and equipment-specific information such as stack parameters, fugitive component counts, and fuel sulfur content and heating value were provided as import files for GOADS-2008. These import data files were requested for approximately 1,110 platforms, or 70% of the platforms in the 2005 inventory. MMS also asked operators to submit platform information (type of structure, structure ID, complex ID, area, block, lease number, and locational coordinates) for minor sources that are exempt from reporting. MMS is requesting this information in an effort to continue to streamline the detailed GOADS reporting requirements to the more major platform sources, yet collect data that will aid in the development of "surrogate" minor source emission estimates for a comprehensive emissions inventory that includes all emission sources.

### *Non-Platform Sources*

For non-platform sources, the 2008 inventory development efforts build upon the foundation developed by ERG and MMS in previous MMS inventories. With each inventory, significant improvements have been made to the estimation methods and activity data gathering methods for non-platform source categories. For example, for the 2005 Gulfwide inventory, emission factors for marine diesel engines were obtained from the Swedish Environmental Agency. These emission factors were developed from a large population of vessels using recent test methods.

One of the most significant non-platform source categories of note for the 2008 inventory is CMVs. Through our work with the Texas Commission on Environmental Quality (TCEQ) on an emission inventory of Houston's CMV activities, it was apparent that the EPA's National Emissions Inventory (NEI) data significantly underestimate vessel emissions. The EPA is in the process of revising the marine vessel inventories using European emission factors similar to those ERG used for the 2005 inventory. They are also using state-of-the-art procedures to spatially allocate emissions that better account for the actual routes that vessels travel, in contrast to using U.S. Army Corps of Engineers shipping lanes which are not accurate representations of vessel traffic patterns. These improved EPA inventories will be available in early 2009, and they will be incorporated into the 2008 Gulfwide inventory. In addition to CMVs, there are a large variety of vessels not involved in freight movement, such as offshore support, fishing, and military vessels. For offshore support vessels, ERG recently completed a study for the EPA pertaining to vessels equipped with medium-sized diesel propulsion engines (Category 2). This study included all of the vessel types considered in the MMS inventories, especially offshore support vessels, the most significant emission sources for Category 2 vessels. They are equipped with some of the larger engines in this category and operate nearly continuously throughout the year. ERG will integrate this new EPA data into the 2008 Gulf inventory.

ERG has also recently completed a study for TCEQ to quantify vessel activity in state waters using satellite tracking data. Unfortunately, the national vessel tracking system focuses on near-shore vessel activities, providing limited data related to traffic patterns in federal waters. Still, the Texas coast data provides insight into the operations of offshore support and fishing vessels that can be used to improve upon the 2005 assumptions about offshore vessel traffic patterns.

Another interesting issue for the non-platform inventory concerns the activity period. For platform sources, activity data are compiled monthly, while for non-platform sources, annual estimates are developed. For many non-platform source categories, activity may be uniform throughout the year, such as the LOOP, where crude oil supplies are stored in large underground salt domes. However, activity for other source categories, such as tankers that provide crude directly to the refineries, varies monthly. As such, their shipments are impacted by annual refinery maintenance activities. As resources are available, ERG proposes to develop monthly activity adjustment factors for source categories where such data are readily available. This will make the platform and non-platform sources temporally more comparable and will facilitate more accurate temporal allocations by the dispersion modelers.

### *Schedule for Final Inventory and Report*

The schedule for the completion of *The Year 2008 Gulfwide Emission Inventory Study* calls for ERG to submit a draft report and inventory databases to MMS by 30 November 2009; and a final report and databases by 15 June 2010.

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Richard Billings, who has an M.S. degree in environmental science and engineering from Virginia Tech, has worked with Eastern Research Group (ERG) for 16 years. His work has focused on the quantification of air emissions from nonroad emissions sources such as marine vessels and helicopters. These nonroad projects have been developed for the U.S. EPA, Texas Commission for Environmental Quality, the Houston Advance Research Center, the California Energy Commission, and the California Air Resources Board, the Department of Transportation, as well as MMS. In addition to his mobile source activities, he has also developed emission estimates for platform emission sources and marine biogenic and geogenic sources.

# FIVE-YEAR METEOROLOGICAL DATABASE FOR THE OCD AND CALPUFF MODELS

**Jay Haney and Sharon Douglas, ICF International**

Click here to view the slide show that accompanied this presentation.

## Introduction and Background

The Minerals Management Service (MMS) is the designated federal agency with the authority to regulate oil and gas exploration and development activities in the central and western planning areas of the Gulf of Mexico (GOM) Outer Continental Shelf (OCS) region. In addition to managing oil and gas resources in the region, the MMS is also charged with environmental management responsibilities, including those related to air quality. The National Environmental Policy Act (NEPA) mandates the type of environmental reviews or assessments that need to be conducted in the area to assess potential on-shore air quality impacts of exploration, development, production and pipeline right of way activities. Some assessments require the application of air quality dispersion models to evaluate potential impacts. In this study, we have prepared an up-to-date, five-year meteorological dataset for the Gulf of Mexico OCS region that can be used to run air quality models for a variety of environmental assessments. Geographically, the dataset covers the GOM region, including both onshore and offshore areas. Given the disruption (to environmental monitors and activities) in the region caused by Hurricanes Katrina and Rita in late August 2005, the data were prepared for the period 2000–2004.

## Dataset Components

The five-year dataset consists of two subsets of files. One set of files is formatted for use with the CALMET/CALPUFF modeling system (Earth Tech 2006). The CALMET/CALPUFF input data files were constructed using a combination of onshore surface and upper-air data from the National Weather Service (NWS), offshore buoy data from the National Data Buoy Center (NDBC) and model output from the Rapid Update Cycle (RUC) model. The RUC output files were processed such that the results are divided into "tiles," each tile covering a portion of the GOM region. Ozone data were also compiled as part of this dataset and these data were obtained from the EPA Air Quality System (AQS).

The second set of files is formatted for use with the updated Offshore Coastal Dispersion (OCD5) model (Chang and Hahn 1997). The OCD5 files were prepared using onshore surface and upper-air data from the NWS, mixing height estimates obtained from the National Climatic Data Center (NCDC) and offshore buoy data from the NDBC.

The datasets are intended for use by MMS and the OCS oil-and-gas, sand-gravel or alternative energy industry to assess potential impacts of future offshore oil and gas development in the GOM region, using either the CALMET/CALPUFF or OCD5 modeling systems. The study area

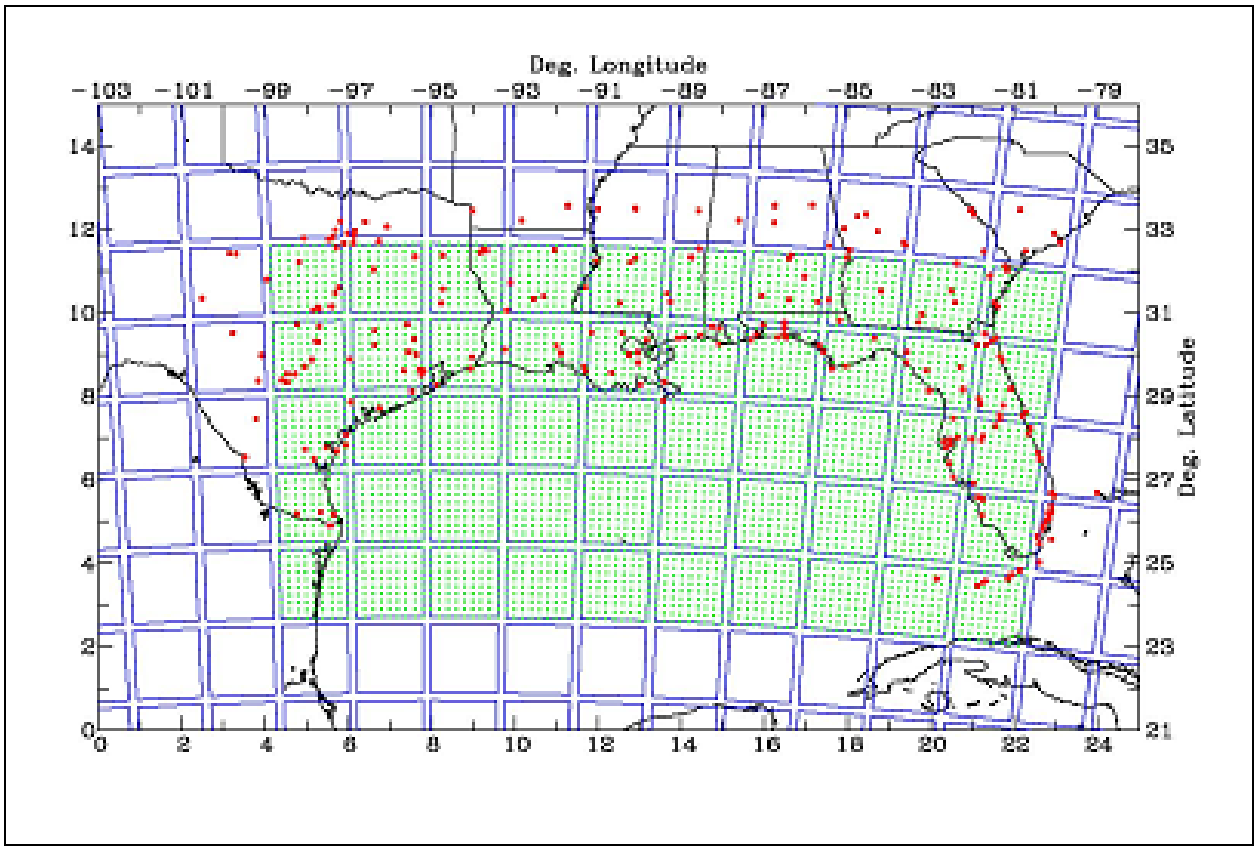


**Figure 3D.2. GOM Study Region for the 5-Year Meteorological Database.**

is shown in Figure 3D.2. This figure also depicts the RUC tiles and the locations of the onshore surface meteorological stations.

## References

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Earth Tech, Inc. 2006. Development of the Next Generation Air Quality Models for Outer Continental Shelf (OCS) Applications: Model Evaluation. 3 vols. U.S. Department of the Interior, Minerals Management Service, Herndon, VA. OCS Study MMS 2006-006.

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Jay L. Haney is Director of the Air Quality Modeling Group at ICF International. He is a Certified Consulting Meteorologist and has an M.S. in meteorology from Saint Louis University. He has 29 years of experience in the application and refinement of data analysis and modeling

techniques applied to the study of tropospheric ozone, carbon monoxide, particulate matter, and mercury.

Sharon G. Douglas is a Senior Project Manager in the Air Quality Modeling Group of ICF International. She has an M.S. in meteorology from Penn State University and more than 20 years of experience at ICF in the area of air quality modeling. Her areas of specialization include meteorological data analysis, air quality forecasting, and development and application of model-based source attribution tools for ozone, particulates, and mercury.

# NORTH AND CENTRAL ATLANTIC INFORMATION RESOURCES: DATA SEARCH AND LITERATURE SYNTHESIS STUDY UPDATE

**Bruce Kaplan**
**Mangi Environmental Group**

**Craig Swanson**
**Applied Science Associates**

Click here to view the slide show that accompanied this presentation.

This presentation offers an update of the status of an ongoing study being conducted for the Minerals and Management Service by Mangi Environmental Group.

## Project Objectives

1. Develop comprehensive information on human and environmental aspects of the region
2. Update understanding of ecological communities, dominant oceanographic and other processes driving the shelf and deep-sea ecosystems, and sensitivities of the area

## Annotated Reference Database—Overall Results

1. 1,264 total references—40% biological oceanography
2. Over 75% either reports or journal articles

## Biological Oceanography

*Project Scope*

- Marine mammals
- Marine birds, coastal birds, and bats
- Sea turtles
- Fish resources and essential fish habitat
- Benthic resources and seafloor habitats
- Areas of special concern

*Research Questions*

- How are important biological resources distributed over the study area in space and time?
- What are the distributions of endangered/threatened species?
- What marine resources are associated with unique topographical and hydrographic regions?
- What are the major living marine resource harvest areas (e.g., commercial and recreational)?

- Which habitats are currently protected (e.g., sanctuaries, seasonal closures)?
- How do marine bioresources respond to impacts?
- What are the key potential impacts of each type of alternative energy development?
- In what ways will the potential impacts be expressed?
- How might important biological processes be impacted by alternative energy development?

*Learnings/Data Gaps*

- Site-specific information (for all taxonomic groups) is patchy and sometimes outdated
- Limited information on spatial/temporal distribution for specific life stages – e.g., seasons
- Little information available for EMF, artificial reefs, birds/bats, artificial lighting/shading

### Physical Oceanography/Air-Sea Interaction

*Project Scope*

- Sea level, storm surge, currents, tides, waves
- Temperature, salinity, density
- Water masses, stratification
- Upwelling, downwelling, estuarine outflow, turbulence, air-sea exchanges
- Bathymetry, sediment transport

*Research Questions*

- What are the spatial horizontal, vertical, and temporal characteristics of each resource?
- What are the characteristics of natural processes that are also potentially impacted resources?
- What are the key potential impacts of each type of alternative energy development?
- What are the most important potential impacts on natural process resources?
- How would the potential impacts be expressed?

*Learnings/Data Gaps*

- Very few references include energy resource perspective or explore impacts POASI
- Poorly known footprint of alternative energy technologies (water column, atmospheric boundary layer, seafloor environment) limits understanding of potential impacts on POASI
- Few observation programs sustained more than a few months; long-term perspective lacking

### Geological Oceanography

*Project Scope*

- Marine geology, geohazards
- Sediment transport

*Research Questions*

- What is the bathymetry of the study area?
- What are the major geologic structures affecting the siting of alternative energy facilities?
- What are the sediments types and their respective geotechnical properties in the study area?
- What is the depth to bedrock or other load-bearing strata for potential foundations?
- What is the hazard associated with slope instability and mass movements?

*Learnings/Data Gaps*

- Almost complete lack of non-surficial sediment data
- Lack of seismic data (e.g. sub-bottom) in shallow water
- Lack of cooperation from some universities in sharing data

## Chemical Oceanography

*Project Scope*

- Water properties (inorganic and organic, dissolved and particulate distributions)
- Sediment properties
- Interfacial chemistry

*Research Questions*

- What are the most important potential impacts of each type of alternative energy development on chemical concentrations, distributions and processes in the study area?
- How can existing and future environmental chemical data collected by the Regional Associations of the emergent Integrated Ocean Observing System be fully utilized to monitor and characterize the spatial and temporal changes in chemical distributions in the study area?

*Learnings/Data Gaps*

- Understanding of chemistry limited by lack of direct observation to establish baseline data.
- The Coastal Ocean Observatories are often equipped with fundamental instrumentation (CTDs for oxygen, salinity, pH etc.) but observations of nutrient, metals and gas exchange are hindered by technical availability and temporal and spatial resolution.
- Unknown short-term effects of resuspended, contaminated sediments from excavation
- Unknown long-term effects of chemicals (lubricants, cleansers, anti-fouling) modulated during the construction, maintenance, and decommission of manmade structures

## R&D Technology

*Project Scope*

- Research and development activities
- Engineering challenges

- Spill technologies
- Storage technologies

*Research Questions*

- How will high currents, high winds, and high wave/water levels affect engineering design of structures and operations/maintenance of facilities?
- How will structure foundation siting and energy transmission routes be affected by geologic hazards (possibly including hydrates)?
- What methods and equipment would be available to minimize hazardous material spills or maximize spilled material recovery?

*Learnings/Data Gaps*

- No direct studies found that assess the environmental impact of hazardous material spills, including oil spills on the operation and construction of alternative energy facilities.

## Socioeconomics

*Project Scope*

- Causal factors and/or impacts associated with the development of alternative energy projects
- Relationship between causal factors/impacts and socioeconomic characteristics

*Research Questions*

- What significant socioeconomic impacts from alternative energy projects can be expected?
- Are there geographic or demographic areas of in regard to these socioeconomic impacts?
- Socioeconomic resources to be considered

*Learnings/Data Gaps*

- Very little socioeconomic research on *offshore* wind installations in U.S.
- UK, Denmark, Germany have done attitudinal research, some tourism research
- Very little empirical research on economic impacts in Europe
- Opportunities for well-designed experimental studies on socioeconomic impacts

## Remaining Project Schedule

- Draft Synthesis Report & Technical Summary: June 2009
- Final Synthesis Report & Technical Summary: October 2009

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Bruce Kaplan is a Senior Environmental Planner at Mangi Environmental Group, based in the Washington, DC area. He has a master's degree in environmental law and has managed a wide

range of environmental research and compliance projects. He also holds an MBA; his subject matter expertise is in socioeconomic analysis. Before entering the environmental field six years ago, he spent over 20 years conducting primary research in the electronic media industry.

Dr. Craig Swanson is a Senior Principal at Applied Science Associates, Inc., headquartered in Rhode Island. He holds a Ph.D. in ocean engineering from the University of Rhode Island and specializes in the development and application of hydrodynamic, water quality and sediment transport, and hazardous material spill computer models for rivers, lakes, estuarine, coastal and shelf use. Dr. Swanson has appeared as an expert witness in hydrodynamics and water quality before various agencies at quasi-judicial hearings and meetings as well as in legal proceedings.

## SESSION 3E

## PLATFORM AND HARD BOTTOM ECOLOGY II

**Chair:** **James Sinclair, Minerals Management Service**

**Co-Chair:** **Maureen Mulino, Minerals Management Service**

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# GULF SERPENT: EXPLORING LIFE IN THE MESOPELAGIC AND BATHYPELAGIC ZONES OF THE GULF OF MEXICO USING INDUSTRIAL ROVs

**Mark C. Benfield**
**Department of Oceanography and Coastal Sciences**
**Louisiana State University**

Click here to view the slide show that accompanied this presentation.

The SERPENT Project (Scientific Environmental ROV Partnership Using Existing Industrial Technology) is a global collaboration between academia and the petroleum industry designed to facilitate scientific research from offshore oil and gas facilities. The primary mechanism for this partnership is the use of industrial remotely operated vehicles (ROVs) to study marine life. In the Gulf of Mexico, the Gulf SERPENT Project focuses on planktonic and nektonic life in the mesopelagic (200–1000 m) and bathypelagic (1,000–4,000 m) zones. We are attempting to answer the following questions: (1) What organisms exist in the Gulf of Mexico? (2) Where do they occur both spatially and vertically? (3) When do they occur? (4) What are they doing? The project is coordinated from LSU and works with industrial partners BP and Chevron at approximately seven deepwater sites. In 2009 we anticipate increasing this to 12 sites through a new partnership with Shell. Survey protocols are developed by working with the ROV groups to take maximum advantage of each company's system. Through consultation with Oceaneering, Saipem-America, and Subsea7, we have developed three survey methodologies: post-riser inspections, dedicated surveys, and opportunistic observations. Video collected from the ROVs is sent to LSU where observations of different organisms are separated and preliminary identifications are performed. Video data and metadata are stored in a database. Examples of recent findings from the project including a sleeper shark, manefish, large scyphomedusan, and unique cephalopod behavior will be presented along with a short video summarizing 2008 project highlights. For more information about the project visit: http://www.serpentproject.com.

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Mark C. Benfield received his B.Sc. in biology from the University of Toronto, his M.Sc. in biological sciences from the University of Natal, and his Ph.D. in wildlife and fisheries from Texas A&M University. He is currently an Associate Professor in the Department of Oceanography and Coastal Sciences at Louisiana State University and a Guest Investigator in the Biology Department at the Woods Hole Oceanographic Institution. He serves as chair of the ICES Working Group on Zooplankton Ecology, Co-Chair of SCOR Working Group 130: Automatic Visual Plankton Identification, and Director of the Gulf SERPENT Project.

# INVESTIGATING THE LINKAGES BETWEEN MID-SHELF PETROLEUM PLATFORMS AND PELAGIC FISHES USING ULTRASONIC TELEMETRY

**Harmon Brown and Mark Benfield**
**Department of Oceanography and Coastal Sciences**
**Louisiana State University**

**Sean Keenan**
**Fisheries Independent Monitoring**
**Florida Fish and Wildlife Conservation Commission**

**Sean Powers**
**Dauphin Island Sea Lab**

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Petroleum platforms act as artificial habitat providing protection from predation, serve as a visual attractant for pelagic fishes, and provide enhanced opportunities for foraging. One of the most common pelagic fishes around platforms in the Gulf of Mexico is *Caranx crysos* (blue runner). This research was undertaken to understand why the abundance of blue runner is high around petroleum platforms. To do this, the site fidelity/home range of blue runner was estimated. In addition, the schooling behavior, nocturnal distribution, and behavior of blue runner were estimated.

The South Timbalier 151 platform complex is about 50km south of Port Fourchon, LA, encompassing approximately 35km$^2$ in water depths of 35–42m. In August 2005, a Lotek Wireless MAP 600 with eight hydrophones was installed at the six-platform complex at ST151. The hydrophones were installed approximately 10m below the water surface. Acoustic tags (76 kHz) were surgically inserted in forty-six blue runner, thirteen with a two-second ping rate and 33 with a four-second ping rate. In August 2006 Lotek Wireless MAP_RT hydrophones were installed on three satellite platforms and the five platforms at ST151 remaining after Hurricane Katrina toppled numerous platforms in 2005. Nineteen blue runner were tagged with 10-second ping rate acoustic tags.

The home range of blue runner ranged from 10,246 – 36,406 m2. A significant correlation was found between the fork length of the blue runner and the area of their 50% (core) home range calculated for the entire study period, but not their overall 95% home range. The daily home range of blue runner ranged from 3,082 – 14,333 m2. A significant correlation was found between the area of the mean 95% daily home range and the fork length of the blue runner, but not the mean daily core range. Home range was generally larger during the day than at night, though not significantly so. All but one of the blue runner released at satellite platforms in 2006

moved back to the main complex within 15 days following release and remained there for the duration of the study.

The Euclidean distance between each tagged blue runner was estimated to investigate schooling behavior. All tagged fish were found to school more during the day than at night. Individual fish were found to move between schools, but showed no preference for schooling with a particular fish. The blue runner did show a significant difference in schooling location relative to the platforms.

A significant difference was found in the vertical distribution of the tagged blue runner, typically spending the daytime hours in the upper 15m and nighttime hours below 20m. No clear pattern was seen in the distribution of the tagged blue runner relative to the platforms at night. The nocturnal swimming speeds were most often between 0–2 bl/s. The distribution of swimming speeds is indicative of passive foraging.

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Harmon Brown received his B.S. degree in biology from San Francisco State University and went on to earn his M.S. in marine biology at SFSU. He was a Board of Regents fellow in Natural Resource Economics at Louisiana State University. Harmon is currently a Ph.D. candidate in oceanography at Louisiana State University and works as a Coastal Resource Scientist at the Louisiana Department of Natural Resources.

Mark C. Benfield received his B.Sc. in biology from the University of Toronto, his M.Sc. in biological sciences from the University of Natal, and his Ph.D. in wildlife and fisheries from Texas A&M University. He is currently an Associate Professor in the Department of Oceanography and Coastal Sciences at Louisiana State University and a Guest Investigator in the Biology Department at the Woods Hole Oceanographic Institution. He serves as chair of the ICES Working Group on Zooplankton Ecology, Co-Chair of SCOR Working Group 130: Automatic Visual Plankton Identification, and Director of the Gulf SERPENT Project.

Sean F. Keenan is an Assistant Research Scientist with the Florida Fish & Wildlife Research Institute in St. Petersburg, Florida. He received his B.Sc. in zoology and his M.Sc. in oceanography and coastal sciences from Louisiana State University. He currently assists in coordinating offshore and estuarine fisheries research efforts for the fisheries independent monitoring program at FWRI. His research focuses on population dynamics and community structure of reef-fishes on the west Florida shelf.

Sean P. Powers received his Ph.D. in zoology from Texas A&M University in 1997. Following a John Knauss marine policy fellowship at the National Science Foundation and a post-doc at the University of North Carolina at Chapel Hill, he joined the faculty in the Department of Marine Sciences, University of South Alabama and the Dauphin Island Sea Lab. The majority of his research is focused on demersal fishes and benthic invertebrates in coastal and estuarine systems, particularly those that support commercial and recreational fisheries. The ultimate goal of the research program is to provide scientifically sound information to direct conservation and

restoration efforts of marine fisheries and habitats. He has published over 42 peer-reviewed articles in journals including *Science*, *Ecology, Limnology & Oceanography* and *Marine Ecology Progress Series*. His research program has generated over $4 million in extramural support from federal and state agencies including the National Science Foundation, National Marine Fisheries Service and Minerals Management Service.

# OIL PLATFORMS AND RED SNAPPER MOVEMENT

**Michael McDonough**
**Artificial Reef Program, Louisiana Department of Wildlife and Fisheries**

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**Department of Oceanography and Coastal Sciences**
**School of the Coast and Environment, Louisiana State University**

Click here to view the slide show that accompanied this presentation.

Understanding the behavior, including movement, of red snapper (*Lutjanus campechanus*), around and among the many oil and gas platforms in the northern Gulf of Mexico (GOM) is crucial to the management of this important commercial and recreational species. What role oil and gas production platforms play in the attraction vs. production continuum for red snapper is unknown, but it is certain these large structures have a role at some life history stage. We used the VRAP acoustic telemetry system to track red snapper around two platforms in the GOM in 2005 and 2006. Fish detections per hour generally decreased over the course of each experiment, and detections also fluctuated with strong periodicity. Spectral analysis revealed that red snapper had a 24-hour periodicity to their movements. Probability of presence of fish likewise fluctuated within a day, perhaps indicating foraging away from the platforms. Red snapper in this study showed much lower site fidelity than in previous studies of red snapper on artificial reefs. These results appear to support the hypothesis that platforms function largely as attracting devices.

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Michael McDonough was born in Harrisburg, Pennsylvania in 1978. He attended the University of Notre Dame beginning in the fall of 1996 and received a B.S. degree in biological sciences in the spring of 2000. He then moved to Baton Rouge, Louisiana, to work as a research associate in the Department of Biological Sciences at LSU. He began working on his M.S. degree in the fall of 2003 in the Department of Oceanography and Coastal Sciences and now works at the Louisiana Department of Wildlife and Fisheries in the Artificial Reef Program.

James H. Cowan, Jr., is a Professor in the Department of Oceanography and Coastal Sciences and the Coastal Fisheries Institute at Louisiana State University. He received his B.Sc. (biology) and M.Sc. (biological oceanography) degrees from Old Dominion University and his M.Sc. (experimental statistics) and Ph.D. (marine sciences) degrees from Louisiana State University. With almost 20 years of experience conducting fisheries research in marine and estuarine ecosystems and on artificial reefs, he has authored more than 90 refereed publications in the primary fisheries literature. Additionally, he has served an associate editor for *Estuaries*, the journal of the Estuarine Research Federation, for *Gulf of Mexico Science*, and for *Transactions of the American Fisheries Society*. He is currently editor for the section dedicated to Ecosystems Based Fisheries Management of *The Open Fish Science Journal*.

# PLATFORM RECRUITED REEF FISH, PHASE II: DO PLATFORMS PROVIDE HABITAT THAT INCREASES THE SURVIVAL OF REEF FISHES?

**James Cowan, Jr. and Michelle Zapp**
**Department of Oceanography and Coastal Sciences**
**School of the Coast and Environment, Louisiana State University**

Click here to view the slide show that accompanied this presentation.

During an initial pilot study, it was determined that Louisiana oil and gas platforms impart detectable signatures in otoliths. Unique signatures were also detected for artificial reefs east and west of the Mississippi River. The goals of the current study were to determine if oil and gas platform elemental signatures are geographically and temporally stable, and to examine the source of platform element incorporation into the otolith. During the summers of 2007 and 2008, 1,000 red snapper (*Lutjanus campechanus*) otolith samples were collected each year from oil platforms and other habitats in Louisiana, Texas and Alabama. Also during the summers of 2007 and 2008, 50 barnacle and 50 sediment samples were collected each year from Louisiana platforms to examine the source of element incorporation into the otolith. Otolith, barnacle and sediment samples will be prepared for total digestion and HR-ICP-MS analysis for 15 trace metals. The 2007 sediment samples have been analyzed, and based on initial results, the sediment samples show high levels of Zinc, Lead and Vanadium, which are the same metals that made up the Louisiana platform signature from the Phase I study.

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James H. Cowan, Jr., is a Professor in the Department of Oceanography and Coastal Sciences and the Coastal Fisheries Institute at Louisiana State University. He received his B.Sc. (biology) and M.Sc. (biological oceanography) degrees from Old Dominion University and his M.Sc. (experimental statistics) and Ph.D. (marine sciences) degrees from Louisiana State University. With almost 20 years of experience conducting fisheries research in marine and estuarine ecosystems and on artificial reefs, he has authored more than 90 refereed publications in the primary fisheries literature. Additionally, he has served an associate editor for *Estuaries*, the journal of the Estuarine Research Federation, for *Gulf of Mexico Science*, and for *Transactions of the American Fisheries Society*. He is currently editor for the section dedicated to Ecosystems Based Fisheries Management of *The Open Fish Science Journal*.

Michelle Zapp is a Ph.D. student at Louisiana State University. Her dissertation focuses on red snapper otolith microchemistry, primarily to determine the source of recruits to the Texas continental shelf and to examine whether oil and gas platforms impart detectable signatures in otoliths. She received a B.S. degree in marine biology from Texas A&M University at Galveston in 2004.

# LITERATURE SEARCH AND DATA SYNTHESIS OF BIOLOGICAL INFORMATION FOR USE IN MANAGEMENT DECISIONS CONCERNING DECOMMISSIONING OFFSHORE OIL AND GAS STRUCTURES IN THE GULF OF MEXICO

**William A. Richkus**
**Versar, Inc**

**Project Team:**

**J. Vølstad, E. Weber, and W. Richkus**
**Versar, Inc.**

**Gerald Ault**
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**James Cowan and Kenneth Rose**
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**Benny Gallaway**
**LGL Ecological Research Associates, Inc.**

**Milton Love**
**University of California Santa Barbara**

**Daniel Sheehy**
**Aquabio, Inc.**

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More than 4,000 structures associated with oil and gas production are in place on the continental shelf of the Gulf of Mexico (GOM), and the number of removals is expected to far outstrip the number of new platforms constructed during the next 10 years. Reducing the number of structures may have important effects on the Gulf ecosystem because they function as de facto artificial reefs. This project included compiling of a database of relevant literature; summarizing the ecology of platforms from prior synthesis documents and new literature; reviewing information to assess feasibility of evaluating ecological consequences of structure removal; reviewing issues relating to non-indigenous species (NIS) and GOM structures; and, identifying gaps in the state of knowledge and research needed to address such gaps. A total of 1,177 relevant publications and reports were identified and entered into a Reference Manager literature database. The utility of existing data bases for conducting large-scale analyses was first assessed. Existing data were not useful for evaluating the ecological role of platforms for a number of reasons: numerous studies were at individual structures or structure groups but generally site- or

species-specific; few studies at platforms included valid control data; and no studies were specifically designed to evaluate consequences of removal at large scale or on specific species stocks. The level of evaluation using literature was dependent on adequacy of information in the literature: Level 1 allowed for presence/absence documentation; Level 2 allowed for process-oriented conceptual models; Level 3 allowed for semi-quantitative conceptual models; and Level 4 allowed for quantitative ecosystem and community dynamics models. An example of potential application of levels to red snapper was developed because it was the only species for which sufficient data was available for exploratory analysis. The role of artificial structures in establishment and range expansion of NIS was reviewed. Fifteen NIS marine species have been documented in the GOM, and NIS issues could constrain options for use of decommissioned structures. Research needs identified included: Platform Ecology and Trophodynamics (diets of structure-oriented fish; influences of structures on primary production; magnitude of passive concentration of plankton and nutrients); population vital rates (recruitment, growth and survival of populations affected and not affected by structures); monitoring (statistically sound designs for BACI-type studies for areas in which structure removal is planned); and, NIS (monitoring for presence of NIS; characterizing vectors of establishment or range expansion; methods of prevention or control; NIS risk assessments when considering structure removal and re-use).

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William A. Richkus is Vice President, Operations Manager, Versar, Inc. Dr. Richkus received his Ph.D. in oceanography from the Graduate School of Oceanography, University of Rhode Island, an M.S. in oceanography from Scripps Institute of Oceanography at the University of California (San Diego), and his B.S. in zoology from the University of Rhode Island. He has worked as a consultant at Versar, Inc. for the past 34 years, specializing in estuarine and freshwater fisheries biology, ecology and management; sampling and analytical methodologies; resource management; impact assessment; and, program design, implementation and management, working primarily for local, state and federal agencies. He serves as project manager for Versar's Biology Integrator contract with the Maryland Power Plant Research Program, assessing ecological impacts of power generation and transmission facilities. He is currently managing, for the Norfolk District U.S. Army Corps of Engineers and the states of Maryland and Virginia, preparation of a Programmatic Environmental Impact Statement addressing alternatives for restoration of oysters in Chesapeake Bay, including introduction of the non-native Asian oyster. He also serves as principal investigator on an on-going project assessing technologies that may be effective in guiding migrating silver eels past hydroelectric generating facilities.

Dr. Jon Vølstad, Marine Research Institute, Bergen, Norway, has over 18 years of international research and consulting experience in quantitative fisheries biology and applied statistics, specializing in statistical survey methods and experimental design. His primary areas of expertise include statistical survey design and optimization, analysis of fisheries-dependent and fisheries-independent surveys and monitoring programs, variance estimation, computation and interpretation of biological statistics of fish populations and harvest, and fisheries management.

Dr. Edward Weber, currently with National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California, has 14 years of research experience in fisheries ecology and management, fish passage, experimental design, statistical analysis, population-dynamics modeling, database management, and technical writing. Much of his recent work has been on the development of a spatially-explicit population model of oysters in the Chesapeake Bay in support of a programmatic environmental impact statement for oyster restoration. He has worked on quantitative assessments and technical writing for a variety of projects at ESM including the Maryland Biological Stream Survey, U.S. Environmental Protection Agency wadeable-stream state integration project, Maryland Department Environment stream stressor identification project, National Oceanic and Atmospheric Administration summer flounder essential fish habitat study, and U.S. Minerals Management Service shoal survey.

Dr. Gerald Ault, Associate Professor of Marine Biology and Fisheries in the Division of Marine Biology and Fisheries (MBF), Rosenstiel School of Marine and Atmospheric Science (RSMAS), University of Miami, provides expertise in theoretical and applied population and community dynamics for fishery assessment and management in tropical marine ecosystems. He conducts regional fishery-independent field assessment studies on multispecies coral reef fish communities, pink shrimp, bonefish, tarpon, billfishes and tunas. These studies focus on the biophysical linkages reflected in fish ontogenetic migratory behaviors to better quantify optimal sampling surveys and define underlying empirical mechanisms in population dynamics and spatial grouping.

James H. Cowan, Jr., is a Professor in the Department of Oceanography and Coastal Sciences and the Coastal Fisheries Institute at Louisiana State University. He received his B.Sc. (biology) and M.Sc. (biological oceanography) degrees from Old Dominion University and his M.Sc. (experimental statistics) and Ph.D. (marine sciences) degrees from Louisiana State University. With almost 20 years of experience conducting fisheries research in marine and estuarine ecosystems and on artificial reefs, he has authored more than 90 refereed publications in the primary fisheries literature. Additionally, he has served an associate editor for *Estuaries*, the journal of the Estuarine Research Federation, for *Gulf of Mexico Science*, and for *Transactions of the American Fisheries Society*. He is currently editor for the section dedicated to Ecosystems Based Fisheries Management of *The Open Fish Science Journal*.

Dr. Kenneth Rose, Professor in the Department of Oceanography and Coastal Sciences and Coastal Fisheries Institute of Louisiana State University, serves with Dr. Cowan on the GOM Reef Fish Stock Assessment Panel and has extensive knowledge of reef fish population dynamics and the contributions of artificial structures in the GOM to those populations. He has also conducted assessments of other major exploited species in the GOM, such as shrimp.

Benny J. Gallaway is the President of LGL Ecological Research Associates, Inc. which has its main offices in Bryan, Texas. He has been a senior fisheries and marine ecologist with LGL since 1974 and has over three decades of experience dealing with a wide variety of environmental and fishery management issues in the Gulf of Mexico. Dr. Gallaway holds a Ph.D. in Wildlife and Fisheries Sciences from Texas A&M University. He has served as Adjunct

Professor at Texas A&M University and presently serves on the Graduate Committee for The University of British Columbia. He is a member of the Kemp's Ridley, Loggerhead, and Atlantic Leatherback Turtle Expert Working Group for the NOAA, and the Ad Hoc Shrimp Effort Expert Working Group for the Gulf of Mexico Fishery Management Council. Dr. Gallaway has authored over 60 publications in the peer-reviewed literature.

Dr. Milton Love, Research Biologist at the Marine Science Institute, University of California, Santa Barbara, served as Principal Investigator on a seven-year MMS-funded study of the ecological role of natural reefs and oil and gas production platforms on rocky reef fishes in Southern California. His expertise extends to the general contributions to fisheries and ecosystems of artificial reef enhancement programs.

Dr. Daniel Sheehy, Principal at Aquabio, Inc., is an internationally recognized expert in design, construction and assessment of artificial reefs. Dr. Sheehy has been involved in numerous artificial reef projects throughout the country in a wide range of marine habitats. Many of Dr. Sheehy's reef projects have involved the construction of reefs as mitigation for various types of natural resource damages.

# SESSION 3F

# MARINE ARCHEOLOGY

**Chair:** **Jack Irion, Minerals Management Service**

**Co-Chair:** **Greg Kozlowski, Minerals Management Service**

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## THE BATTLE OF THE ATLANTIC EXPEDITION, 2008

**David Alberg**
**NOAA *Monitor* National Marine Sanctuary**

Click here to view the slide show that accompanied this presentation.

The Battle of the Atlantic Expedition is a multi-year cooperative project designed to document historically significant shipwreck sites associated with World War II losses off the North Carolina coast. Known as the "Graveyard of the Atlantic," this area contains German U-boats, British naval vessels, and U.S. Merchant Marine ships that were lost during the war, many of which are within recreational diving depths. The 2008 expedition successfully documented the remains of three German submarines, U-82, U-352, and U-701. The project is dedicated to raising awareness of the war that was fought so close to the American coastline and to preserving our nation's maritime history. The project was organized by the National Oceanographic and Atmospheric Administration's (NOAA) Monitor National Marine Sanctuary, and it included participants from NOAA's Maritime Heritage Program, the Minerals Management Service, the National Park Service Submerged Resources Center, the University of North Carolina Coastal Studies Institute, and the East Carolina University Program in Maritime History.

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David Alberg joined the National Marine Sanctuary Program in the fall of 2005. As Sanctuary Superintendent for the *Monitor* National Marine Sanctuary, Mr. Alberg serves as the onsite manager for the sanctuary and as the primary point of contact between NOAA and The Mariners' Museum in Newport News, Virginia, which is conserving the thousands of artifacts recovered from the wreck of the USS *Monitor*. He has an extensive background in cultural resource management, museum work and exhibit development and has been involved in a number of high-profile museum projects. In 1992, Mr. Alberg began his museum career as the first curator for the Virginia Air and Space Center in Hampton, Virginia, and went on to serve as the Director of Exhibits and Collections for the U.S. Space & Rocket Center in Huntsville, Alabama. Most recently, he served as the Deputy Director for Nauticus, The National Maritime Center in Norfolk, Virginia, where he was instrumental in the expansion of the NOAA@Nauticus partnership. During his career, he has been involved in the development of a curation strategy for the Hanford Nuclear Reservation in conjunction with the Department of Energy and also led a major effort to preserve the Apollo One spacecraft, which was involved in the 1967 Apollo fire that took the lives of astronauts Virgil I. Grissom, Ed White, and Roger Chaffe. Preserving our Nation's history has always been a passion for Mr. Alberg. As Sanctuary Superintendent for the *Monitor* National Marine Sanctuary, he continues the work of protecting and preserving the history of the USS *Monitor*; works to assure that the remains of the USS *Monitor* are preserved for future generations; and works to promote and expand the work of the

National Marine Sanctuary Program. Mr. Alberg serves in the United States Navy Reserve and holds a bachelor's degree in museum studies from George Mason University and a master's degree in museum education from the College of William and Mary.

# VIEWSHED ANALYSES FOR ALTERNATIVE ENERGY PROJECTS

**Joel I. Klein**
**John Milner Associates, Inc.**

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This paper reviews some of the new challenges associated with evaluating the visual effects of offshore alternative energy development—especially offshore wind generation projects—on historic properties. At present, no offshore wind farms have been constructed in US waters. Empirical information from several European projects is presented and used to illustrate some of the problems with applying traditional methods of visual impact assessment to offshore alternative energy development.

The MMS, the federal agency with primary oversight responsibility for energy development on the Outer Continental Shelf, must comply with the provisions of Section 106 of the National Historic Preservation Act. Section 106 requires the identification of historic properties (properties on or eligible for the National Register of Historic Places) within a project's Area of Potential Effect (APE), and the evaluation of the impact of the development on those properties. Traditionally, the APE for projects has been defined as the area within which a proposed project will be visible. All historic properties located within the APE are considered to be adversely affected because the introduction of a new visual element constitutes a "change in setting" of the historic properties within the APE.

In the U.S., the assessment of visual impacts to historic properties from industrial wind farm development has been limited to land-based projects. Project reviewers have attempted to apply old models for assessing impacts—most notably those developed for evaluating telecommunications towers—even though those models are clearly not appropriate. Wind turbines—especially those developed for offshore use—are BIG, sometime as tall as 500 feet. They are developed in clusters over large geographic areas. They move. All of these factors contribute to the need for a qualitatively different approach.

Intuitively, we know that the farther away an object is the less visually intrusive it is. Yet interpretations of the current regulatory framework make no allowance for distance in evaluating visual impacts. If a wind turbine is visible within the setting associated with a historic property, the property is considered to have suffered an adverse visual impact. However, research in psychophysics suggests that viewers *do* make a distinction between views in which a wind turbine is visible and those in which an impact is felt to have occurred. This research provides a basis for the quantitative limitation of the diameter of the APE which should be considered when assessing the effects of offshore alternative energy development.

Evaluations of visual impacts to historic properties based on changes in associated setting have also failed to consider the degree to which setting contributes to the historic significance of the associated property. Offshore wind development will be visible from great distances because of both their size and the lack of intervening topography, which limits the visibility of land-based development. However, because their visual effect is actually upon a seascape, some analysts propose that special concern should be devoted to those historic properties that derive their significance, in some measure, from their association with a maritime setting/environment. Such properties include lighthouses, seacoast fortifications, seaside resort communities, and individual properties designed specifically to take advantage of ocean views.

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Joel I. Klein is an Associate Director of John Milner Associates, Inc. (JMA), a historic preservation consulting firm with offices throughout the eastern U.S. He received his Ph.D. in anthropology, with a specialization in North American archeology, from New York University in 1981. He joined JMA in 1997 after nearly two decades with Foster Wheeler Environmental Corporation and its predecessors, where he was Manager of the Cultural Resources Group and a Project Environmental Coordinator. He has been responsible for cultural resource studies associated with major energy (including fossil-fuel, hydroelectric and nuclear) and infrastructure projects throughout the United States. Dr. Klein is a principal author of FERC's *Guidelines for Reporting on Cultural Resource Investigations*; a Registered Professional Archeologist (RPA); a former president of the Professional Archeologists of New York City; and the former chairman of the Society for American Archaeology's Committee on Consulting Archaeology. Over the past five years he has supervised archeological and historic architectural surveys and impact assessments for more than a dozen wind energy projects, in the course of which he developed the "Klein Matrix" used to evaluate visual impact of wind energy projects on historic structures.

# DEEPWATER SHIPWRECKS: PRELIMINARY ARCHEOLOGICAL FINDINGS FROM 2008 FIELD SEASON OF THE REEFS, RIGS, AND WRECKS STUDY

**Robert A. Church, Daniel Warren, and Robert Westrick**
**C & C Technologies, Inc.**

Click here to view the slide show that accompanied this presentation.

An interdisciplinary research team of archaeologists and biologists set out on the first leg of the first cruise of the four-year Reefs, Rigs, and Wrecks Study sponsored by the MMS and NOAA OER. The cruise took place onboard NOAA's Research Ship *Nancy Foster* utilizing a Falcon SeaEye ROV from Sea Vision. The main objective of the first shipwreck cruise was to conduct a reconnaissance of eight shipwreck sites and assess the archaeological and biological potential of the wrecks for inclusion in the project. Five of the sites have not previously been explored. The eight sites for the reconnaissance included the "Ewing Banks Wreck" site, the *Gulfpenn* site (previously investigated), the tentatively identified *Gulfoil* site, the "Green Lantern" site (previously investigated), the tentatively identified *Holly Ann Vieser* site, the "Oval Shape" site, the "Steel Hull" site, and the "Viosca Knoll Wreck" site (previously investigated). Secondary objectives included photo mosaics of each site, visual area survey around the sites to determine the extent of artifact scatter, detailed imaging of coral colonies at each site, collecting coral samples, collecting four sediment cores at each site, setting temperature loggers at select coral sites on the wrecks, reexamining a microbiology experiment placed at *Gulfpenn* in 2004, setting microbiology experiments at two additional wreck sites, and locating the missing stern section of *Gulfpenn*.

Hampered by inclement weather and equipment problems, the team was only able to dive on four of the wreck sites that were planned: the Ewing Banks Wreck, *Gulfpenn*, the potential *Gulfoil*, and the Green Lantern Wreck. The greatest hindrance to the expedition was Hurricane Ike, which arrived in the middle of the cruise. The team was only able to investigate two of the sites before the storm and two sites after the storm passed. The dive at the Green Lantern Wreck Site, however, had to be aborted, because of poor visibility and stronger than normal current on the heels of the hurricane.

Despite limited dive time and adverse conditions, several project goals were achieved. The team confirmed that the two previously unexplored sites (the Ewing Banks Wreck and the potential *Gulfoil*) were historically and biologically significant sites. The *Gulfoil* site was identified and substantial *Lophelia* was discovered colonizing the surface of the shipwreck. The Ewing Banks Wreck was found to be a historic copper-clad sailing vessel with more *Lophelia* growing on it than has been found on other wooden shipwreck sites in the Gulf of Mexico. The lack of machinery, chain, or evidence of mast or rigging, however, left more questions than answers. In addition, a few of the secondary objectives were also met, including placing a temperature logger at *Gulfpenn*, locating her missing stern section, and reexamining the previously placed

experiment at the site. A good recognizance was conducted of the Ewing Banks Wreck and a small wood sample was collected, which is yielding promising results regarding microbial activity in the wood.

Future field work regarding the shipwreck component of the project should concentrate on sites that are both historically and biological significant, such as *Gulfoil*, *Gulfpenn* , the Ewing Banks Wreck, the Viosca Knoll Wreck, & the Green Lantern Wreck (most archaeological objectives have been meet at *Gulfpenn* as a result of Study MMS 2007-15). Two unidentified sites, referred to as "Steel Hull" and the "7,000-foot Wreck," remain a high priority for future investigation. During the next field season, the team plans to recover select diagnostic material remains from the older wreck site to aid in identification. Other goals include mapping the site boundaries and artifact field of *Gulfoil*, and placing additional microbial test platforms at select sites to analyze the deterioration rate.

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Mr. Robert Church is the senior marine archaeologist with C & C Technologies, Inc. of Lafayette, Louisiana. He has led numerous deepwater shipwreck investigations in the Gulf of Mexico, including the recently completed Deep Wrecks I Study (MMS 2007-015), the "Viosca Knoll Wreck" Project (MMS 2008-018), and the 2001 initial investigation of the *U-166* wreck site. Mr. Church has an M.A. degree in maritime history and nautical archaeology from East Carolina University and a B.A. degree in history with a minor in biology from the University of Arkansas at Little Rock. Mr. Church was the Chief Scientist for the first cruise leg of the MMS and NOAA's new deepwater Reefs, Rigs, and Wrecks Study.

Daniel Warren is the senior marine archaeologist with C & C Technologies, Inc. and Assistant Geosciences Manager in C & C's Houston office. He was the Co-P.I. for the MMS/NOPP's Deep Wrecks I Study (MMS 2007-015), and the Chief Scientists for the NOAA OE, U-166 mapping Project in 2003, and P.I. for the project to identify the steam yacht *Anona* in 2002. Mr. Warren has a B.A. degree in anthropology with a minor in history from the University of Illinois at Champaign-Urbana and a M.A. degree in maritime history and nautical archaeology from East Carolina University. He is the archaeology P.I. for the MMS and NOAA's new deepwater Reefs, Rigs, and Wrecks Study.

Robert Westrick is a marine archaeologist with C & C Technologies, Inc. of Lafayette, Louisiana. He has worked on a number of underwater archaeology projects, including the excavation of Blackbeard's *Queen Anne's Revenge*, and the excavation of *El Capitana El Rubi*, a Spanish galleon shipwreck from the 1733 plate fleet. He has a B.A. degree in business administration with a minor in history from the University of Toledo and an M.A. degree in maritime history and nautical archaeology from East Carolina University. Mr. Westrick was a field archaeologist on the first cruise leg of the MMS and NOAA's new deepwater Reefs, Rigs, and Wrecks Study.

# LIGHTS, CAMERA … SHIPWRECK!? – MULTIMEDIA AT 4,000 FEET

**Kimberly Eslinger**
**Marine Archaeologist**
**Geoscience Earth & Marine Services, Inc.**
**Nautilus Productions**

**Rick Allen**
**Documentary Producer**
**Nautilus Productions**

Click here to view the slide show that accompanied this presentation.

## Introduction

On 20 May 2007, a crew of film makers from Nautilus Productions joined the Mardi Gras Shipwreck Project archaeological team from Texas A&M and the Minerals Management Service to document the Mardi Gras Shipwreck Site. This technologically driven project had a few simple requirements from the Nautilus crew: 1) document everything that happened from the time the ship left Port Fourchon, Louisiana, until the artifacts finished conservation at Texas A&M and 2) create an educational documentary and web video about the effort that could be provided to the Louisiana State Museum, the MMS, and Texas A&M. While the archaeological team, ship's crew, and ROV pilots worked 24-hour days, the film crew worked beside them recording the decisions, research design, and research as it happened. Nautilus Production's mission was simple: document the project and then allow the archaeology to speak for itself to the general public. It is the purpose of this paper to show how the use of the electronic media can assist in documenting an archaeological site, support project goals, and enhance public education both during and after the project.

## Why Involve the Media?

As archaeologists, we know two very important things about our profession and the general public. First, without public outreach the public doesn't even know we exist and we end up with no funding. Second, If the public does have a passing knowledge of our science they equate us with the flash of the treasure hunts they see on the evening news, the History Channel, National Geographic, and the BBC.

We can solve both problems by learning to work with the electronic media and get their "buy-in" on our projects—both the spectacular and the less glamorous. To collaborate on an archaeological project with a media crew and allow them access to the "behind the scenes action" is a scary proposition. We are a profession that likes to hypothesize, debate, discuss, disagree, plan, alter the plan, excavate, recover, and conserve. At any moment during an archaeological project there will be disagreements, differing theories, and at times competing

plans. These moments saved for all posterity on video and then melded into a documentary can become the story that we don't want—a documentary that portrays us as indecisive, divided, and perhaps part of a soap opera. None of these things are who we are, or how we want to be portrayed. So it is natural to be hesitant about allowing television crews to follow us around filming every second of every decision.

Clearly, however, the benefits of promoting our projects outweigh the possible pitfalls. By working with the media we can educate larger audiences with our projects, disseminate more information, involve more stakeholders, and use the opportunity to promote responsible cultural resource management. There is always the potential that the people we work with will not be as excited as we are about the link between a blue mustard bottle and its identical match in Catherine Sullivan's "A Glass Glossary," but if you work with the right media crew they will be able to convey the importance of our work to far more people than we can reach with our published papers and presentations.

The treasure-hunting contingent realized many years ago that the way to generate revenue and interest was to involve the media in their "search for treasure." Archaeology has spurned that route and instead opted to continue to operate within the confines of its discipline to a large degree. Think of the scientists of tomorrow we can reach if we make our work widely available in a format they understand. The PAST Foundation did just that with the DeepWrecks Project (also in the Gulf of Mexico) and their pod casts this past year. Nautilus Productions has done that with the *Queen Anne's Revenge DiveLive* web casts. Even biologists at Duke University and NOAA host an *Estuary Live* event every year that reaches school children around the world. Public outreach is now a necessity for most archaeological grants. Utilizing the media as part of that is a smart step because it allows the project archaeologists to do their job without trying to be "TV guys" at the same time and allows archaeologists to help shape the message from the beginning. We don't expect the media to develop our field methodologies, so why should archaeologists try to create and produce documentaries?

## The Questions To Answer:

To avoid "ARCHAEOLOGY: THE REALITY SERIES," professional archaeologists and professional media need to meet on common ground. There has to be a way for both groups to communicate effectively. There are numerous problems that come into play when a collaborative effort like the Mardi Gras Shipwreck Project first begins between the archaeologists and the documentary team. These can range from "television issues" to "archaeological issues" to "personal issues" to "technical difficulties." I want to touch on a handful of these because they are germane to the project we are here to talk about.

There are several major problems or questions that must be answered when the media and archaeologists start to work together. First, what is the goal of the collaboration? What is it that the project archaeologists want to get out of the collaboration? Are they looking for web-based outreach? A documentary? A DVD for school children? A three-minute piece on the local news? What is it that you want the final product to be? That answer will drive the rest of the

collaboration with the media crew because it tells them what equipment they need, which in turn determines how many crew members they need, their needs for technical support and infrastructure, as well as helping them to clue in on the second question that must be answered.

What is the story and who is the audience? In other words, is this the story of the technical aspects of excavating a shipwreck in 4,000 feet of water? Is it the story of the archaeology? Is it a story about the ROV pilots and their expertise? Is it a story about the ship itself? Is it a story about one member of the team? Or is it a story that follows the project? What is the "Big Picture" that you want to have come out of the collaboration? Who do you want to view this documentary? Are you aiming for school children? Adults? The learning disabled? College students? Graduate students? The general public? History Channel fans? College professors? Granting agencies? Professional colleagues? This decision will determine how you work with the film crew and where they focus their efforts.

Once you know what your story is and who your audience is there is that small problem of discretion/cultural awareness that fear of "the treasure hunter mentality" that plagues every archaeologist. How much do you tell the documentary team? If the site's coordinates are protected, the media crew needs to know that and understand why the site is sensitive. There is the concern that a television crew will share what they know about the project because they do not understand the sensitive nature of the project, the artifacts, or even the political and/or archaeological landscapes. The concept of "treasure" is one that makes most archaeologists cringe; yet the media crew with you may ask you "what is the real treasure of this project?" This is not a nod to the treasure hunters nor an uninformed question—it's the opportunity archaeologists have been looking for—the chance to say, "the real treasure is not in the monetary items most people think of as treasure. The real treasure is the chance to study our past and the men and women whose lives were so impacted by this site." When that question comes along—answer it. This is our opportunity to promote the cultural awareness we need the general public to have about archaeology and history.

The personality issues that can come into play when you involve a media crew, a team of archaeologists, a ship's crew that may or may not speak fluent English, and a technical ROV crew can be daunting. Imagine if you will all the players in one room—each team well aware of its requirements to handle the job safely and efficiently but unaware of what the other players bring to the table. The ROV crew knew they were there to "dig up" a shipwreck, but they were hesitant about being shown on camera on the off chance they broke something. The archaeologists understood the excavation plan and methodology, but few had experience working on an oil and gas industry vessel or understood how delicate the ROV pilots could be when excavating and retrieving fragile artifacts. Still fewer of the team knew what questions to ask to get the answers they needed to pursue their goals, or wanted to be seen on camera as "hogging the limelight." Then there was the ship's crew who spoke minimal English but wanted desperately to understand what was going on. The Nautilus team had a difficult job—we had to document the archaeology and ship's activities 24/7 while staying out of the way of the archaeologists, ROV and ship's crews, yet still manage to film day and night until the job was done.

### Proper Planning:

On the Mardi Gras Shipwreck Project, Nautilus Productions had the unique opportunity to be included almost from the start of the planning for the project. Typically, our involvement is not part of the pre-project planning, and this lack of involvement can create obstacles during the project itself. Texas A&M University's early incorporation of Nautilus Productions allowed Producer Rick Allen to get answers to the technical questions regarding power, space, crew accommodations, and ROV capabilities long before they became issues offshore. Our ability to talk with Veolia Environmental, Sea Lion Shipping, Texas A&M, the Florida Public Archaeology Network, UTEC, and the Minerals Management Service allowed Nautilus to plan for the worst and anticipate the best without needing a helicopter supply lift to the Gulf of Mexico.

Another critical hurdle was overcome early in the process when Allen and Project Director, Peter Hitchcock, agreed that the documentary crew would have any access it needed and that for better or worse the video crew would record all activities without interference. If something questionable arose it could be dealt with after the project and before the final edit when tempers might be more even and hindsight provided a clearer view of events. Additionally, even bad experiences provide learning opportunities, and documenting those events would be helpful to A&M staff on later projects. It was a leap of faith for both Allen and Hitchcock but as Allen says, "It's all about the shipwreck." From the Nautilus perspective, A&M has been an outstanding partner.

Nautilus had specific technical needs for this documentary production—we needed dependable power to run our battery chargers, power to run our tape decks, power to recharge our cameras, power to run the computers, and power to keep the cameras dry and dehumidified. TOISA VIGILANT outputs 220V power to most of its electrical systems, which meant that some of our American equipment could not plug into it without power converters. A minor detail, but one that could have stopped us dead in the water on the very first day had we not known in advance since Fourchon, Louisiana, isn't known for its electronics shops.

Nautilus also needed a way to record all of the ROV footage from 4,000 feet above the site and 50 feet aft of the ROV control van. To accommodate this need, Nautilus ran video and audio cables from our "mini television studio" on the back deck to the ROV Control Van. Nautilus collected underwater video from the Triton ROV with no telemetry or informational data on it. A microphone was also installed in the ROV van and piped into a recording deck inside the Nautilus van. This way critical moments of the excavation could be recorded and referenced to underwater activities for later inclusion in the documentary. Likewise, critical moments for the archaeological staff could be documented on tape for later analysis. The Nautilus crew logged the important moments in the excavation while noting conversations that we didn't want to record for broadcast use.

There was the potential for five issues to create problems during the filming at this stage: the lack of understanding of the big picture; sea sickness; the idea that somehow being interviewed or allowing the camera crew to work around the project team was "demeaning" or "silly," the

"just let me do my job" mentality, and the "arrogant expert" who couldn't take the time to discuss what was happening in a way that anyone without a degree could understand. Happily, none of these problems materialized.

In the best of circumstances you want the media crew to move among the different teams and be invisible. The media crew should be part of the project, but be flies on the wall rather than flies in the ointment. What we also quickly discovered was that while the ship's crew could speak little English, they were very interested in what the archaeologists were up to on the Bridge Deck. Rather than bother the archaeologists with "silly" questions, the ship's crew and the ROV crews quickly turned to watching the video feeds in the Nautilus van and asking us questions. Once they figured out what the archaeologists were so excited about they began modifying their tools to better assist the delicate excavations. The sense of pride and excitement that the ship and ROV crews brought to the table became an integral part of the project. They were often the first to see the new artifacts that came to the surface, and they quickly came to understand the value of protecting these fragile resources. All archaeologists remember the excitement when those first artifacts came to the surface on their first excavation. When we brought artifacts up through 4,000 feet of saltwater and heavy seas that first night, team member Laura Landry said to me "This is why we became archaeologists!" That excitement, that passion for this field was passed on to the rest of the crew and it is that passion that you want to excite in viewers when they finally see the documentary. As always though, proper planning guarantees success.

## How Did It Work?

The Nautilus crew went to Fourchon, Louisiana, with a filmmaker (Rick Allen), a marine biologist and filmmaker (Lawrence Taylor), and an archaeologist (myself). To meet our goals we split into three overlapping shifts so that no one was ever on their own for an entire eight-hour shift, and we divided the shooting responsibilities so that when two cameras were needed we had what was necessary.

We documented the activities of the ship's crew and captain, the ROV crew, the deck crew, the archaeologists, and the conservators. We followed the artifacts from the seafloor to the ship's deck and into conservation tanks. We asked questions, taped interviews, recorded the ROV feed, helped troubleshoot the ROV's camera problems, and lent a hand when we could to the National Geographic photographer. A couple of weeks before project mobilization date, Della Scott-Ireton at FPAN asked if we could provide her with video for her daily blogs. This was not originally part of the A&M requirements for the documentary, but Allen was happy to take on this extra duty. From Ireton's request came one-minute video updates that showcased every aspect of the excavation from the recovery of artifacts to the documentation efforts. These updates were then compressed and FTP'd to FPAN's server for inclusion on the Mardi Gras website. The mini-production studio Allen created in the Nautilus van became the cornerstone of our work on the ship. If something needed work, or a camera needed a tape change—this was where you would find us.

Filming on a 250-foot long, steel oil and gas ship is not a simple matter—there's saltwater, seasickness, background noise, bad lighting, and a rolling deck to contend with. Making it look and feel easy was the fact that the Nautilus team combined has over 50 years of experience working on, under, and around the sea. Taylor's background in marine biology allowed him to assist in identifying the sea life on the wreck site and begin hypothesizing about the use of deepwater wreck sites as biological "hot spots" for everything from bacteria to large pelagic fish (much like deepwater whale falls). Allen's experience over the last ten years working as the videographer at the *Queen Anne's Revenge* Project gave him a unique understanding of the critical moments in the project. He understood when to leave the private decision-making discussions to the archaeologists and when to film.

The documentary and the project evolved at the same time. Nautilus and TAMU had a plan for where they wanted the story to go, but the plan evolved as portions of the project unfolded. Unlike many documentary companies Nautilus prefers to focus on what happens instead of prescripting activities or scenes. The ongoing artifact conservation at Texas A&M is a large component of the documentary because it's key to the overall project. While the documentary will continue in the shooting and editing stages until some of the more important artifacts are completed this year, the project has been a success. Footage has been made available to the interested parties at this time, and although the project took place well out in the Gulf of Mexico and far from the eyes of the general public, the FPAN website allowed everyone from archaeologists to school children to watch the project progress.

## What You Should Know

There are a few things to consider before you invite a media crew to your project. Archaeologists accept that when they run a project they will be collecting all of their notes, drawings, and research into one collection for posterity. Often we forget that when we bring a video crew with us that video is also part of the documentary record.

Second, a contract needs to exist between the project staff and the production staff. There need to be clear cut lines about who owns what in the footage and how it can be used. For example, a television crew will want rights to the footage in perpetuity. In other words, they want to own the footage so that when another documentary is made and that footage is desired the network will need to pay the original producer to gain access to it. This is standard in the television industry; it is not something that hampers the archaeologist's use of the footage for research or educational purposes. It simply means that the archaeological staff cannot turn over the footage to a for profit based enterprise. If that footage is requested by a museum for an exhibit, by a school for curriculum, or by another scholar, the archaeologists can turn it over. The staff can use the footage in podcasts, webcasts, or on their website—it simply cannot be used to make a profit. Likewise, the production company should be limited in how it can use the footage. They should not be able to sell the video to make a soda commercial or for other exploitive purposes. The footage can only be sold and kept within the project's context. Consideration should also be given to where and how the footage is used on the web. Once your production hits the world

wide web you lose almost all control of the content. Think about the ways to watermark and protect your footage.

Third, it is important to remember that no matter how wonderful the project or how good the documentary, when all is said and done—you may not ever see it on the History Channel, PBS, or Discovery. Funding in the media world is every bit as difficult as it is in the archaeological community and the ability of a production company to sell the documentary to a major network is never guaranteed. The production company you work with should make every effort to get the documentary broadcast, but you need to realize that unless Discovery or National Geographic bought the rights to the project early on, you may never see your "show" air.

Fourth, you need to hire a crew that can work with you and appreciate what you are trying to do. We all know how hard it is to work on a rolling, pitching deck, but imagine staring through a two-inch by two-inch eyepiece for 10 hours a day on a rolling deck trying to hold steady. It's a recipe for seasickness. Your crew needs to be able to work in the rain, in the salt, in the noise, in the confined spaces, and have an endless capacity to embrace change. Working with a land-based crew that has little to no experience on a ship is not a recipe for success. The team you hire should have the experience to adapt to the environment and work through technical difficulties. Working with a media crew that understands archaeology or sensitive science will also make the process much easier. Having a good media crew is like having another set of eyes and ears on the project—they can see and record things that you can't.

Fifth, know what your funding limits are and your goals. Be honest from the start about what you want, what you need, and how much money you have to spend. It is difficult enough to do archaeology on a shoestring but bringing in a media crew without budgeting for them takes away from the archaeology and the opportunity to educate the public about your work. Tell them what you need and how much you can spend. You might be surprised at what you can work out. Your video partner may also have innovative ideas or skills that will help broaden your educational outreach.

Last, if you have questions or concerns about how the media—archaeology partnership will work, bring them up. The only way to make sure that you get the product you want is to voice your concerns and ideas. Never be afraid to point out what you think or offer insight into the archaeology for your media team—they may or may not know what is "really going on." The more you share with the media team about where the action is coming from, or what is going to happen next the more capable they will be of capturing that moment on film. Make the media crew part of the project team—the more they understand about the project and the archaeology the more of a stakeholder they become. They will be your project's public voice—give them the information and support they need to be that voice and you will insure that your project's story is told with the same care and respect with which your final report will be written.

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Kimberly Eslinger holds a B.A. in history from Roanoke College in Salem, Virginia, and an M.A. from East Carolina University, Greenville, North Carolina, from the Program in Maritime Studies. She spent two years with North Carolina's Blackbeard Shipwreck Project, three years with the Ponce Inlet Lighthouse Association as Principal Investigator for the Commodore Project, and two years with the St. Augustine Lighthouse & Museum and the Lighthouse Archaeological Maritime Program as Field Director. Eslinger has worked with Nautilus Productions since 2000 as a consulting marine archaeologist, maritime historian, and field producer. At present she is a marine archaeologist with Geoscience Earth & Marine Services, Inc. (GEMS) in Houston, Texas, where she works on undersea surveys and interprets survey data in the Gulf of Mexico. She serves as a member of the Advisory Council for Underwater Archaeology (ACUA) and as chairperson for the Society for Historical Archaeology (SHA) Technology Committee.

Rick Allen, broadcast video producer and videographer has been producing documentaries and shooting video since 1983. As a video producer, director and videographer his work has appeared on ABC, A&E, BBC, CBS, Discovery, TLC, National Geographic, 48 Hours, ESPN, Lifetime, Turner and more. He has followed SWAT teams through the door on drug busts, traveled from Cuba to Kazakhstan with the 82nd Airborne, weathered live broadcasts during hurricanes, gone nose-to-nose with 14 foot Great White sharks during underwater expeditions and is the project videographer on the Blackbeard Shipwreck Project. After 12 years in broadcast television Allen opened his own video production company focused on documentary production as well as freelance videography and underwater video services to broadcast clients. Nautilus Productions has produced documentaries for National Geographic International, the Canadian History Channel, North Carolina Public Television, Texas A&M and the Minerals Management Service. His stock footage can regularly be seen during Shark Week on the Discovery Channel.

# EXAMINING AND TESTING PREHISTORIC ARCHAEOLOGICAL FEATURES ON THE OCS

**Patrick Hesp, Amanda Evans, Graziela Miot da Silva, Barry Keim, and Jennifer Gardner**
**Louisiana State University**

Click here to view the slide show that accompanied this presentation.

This funded project addresses methodologies for accurately locating and identifying submerged prehistoric archaeological sites on the outer continental shelf, northern Gulf of Mexico. This paper will review progress to date and the summer 2008 field work. The project is concerned with the identification of prehistoric archaeological sites, but requires an explicit understanding of geomorphology within the GOM to assess site preservation potential. Two components necessary for accurate site preservation modeling will be detailed in this presentation including an accurate understanding of oceanographic conditions impacting study sites, and an accurate model of sea-level rise at each given study area.

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Amanda Evans is an underwater archaeologist with ten years of experience, primarily focusing on the Gulf of Mexico and Caribbean. She serves as the Senior Marine Archaeologist for Tesla Offshore, LLC., a full-service geophysical survey company based in Baton Rouge, Louisiana. Amanda holds an M.A. degree in anthropology from Florida State University and is completing her Ph.D. at Louisiana State University. She is the lead archaeologist for a multi-disciplinary team investigating submerged prehistoric sites in the northwestern Gulf of Mexico.

## HURRICANE IMPACTS ON SHIPWRECKS

**Robert Gearhart**
**PBS&J**

Click here to view the slide show that accompanied this presentation.

In January 2007, MMS contracted PBS&J of Austin, Texas, to study the effects of hurricanes on historic shipwrecks. The objectives of this study were: (1) to conduct remote sensing surveys in order to document the macro-scale post-storm condition of the sites; (2) to compare and contrast pre- and post-storm remote-sensing data from each site; (3) to carry out diver investigations of selected sites to document areas, which had changed during the period between pre- and post-storm surveys; (4) collection of sedimentary samples to characterize the substrate; (5) estimation of peak storm conditions on the seafloor at each site based on wave-current interaction models; and (6) conducting archival and historical research of the primary study sites to fill gaps in their histories. Preliminary conclusions suggest that shipwrecks might suffer more large-scale damage from hurricanes soon after the time of their sinking than from all subsequent storms combined.

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Robert Gearhart has worked as a nautical archaeologist since 1984 and has managed PBS&J's Nautical Archaeology and Remote Sensing Program since 1998. He has worked on behalf of state, federal and private entities in Alabama, Arkansas, California, Florida, Georgia, Louisiana, Nevada, North Carolina, Oregon, South Carolina, Texas, Virginia, Washington state, and the Gulf of Mexico. Mr. Gearhart has played a key role on five IDIQ contracts for historic properties investigations awarded by the U.S. Army Corps of Engineers, Galveston District since 1989, involving nearly 70 task orders. He has served as Principal Investigator on three major archaeological studies for MMS, including *California, Oregon, and Washington Archaeological Resource Study* (MMS 90-0087); *Study to Conduct National Register of Historic Places Evaluations of Submerged Sites on the Gulf of Mexico Outer Continental Shelf* (MMS 2006-036), and *Impacts of Recent Hurricane Activity on Historical Shipwrecks in the Gulf of Mexico Outer Continental Shelf* (report in progress).

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## The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

## The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.