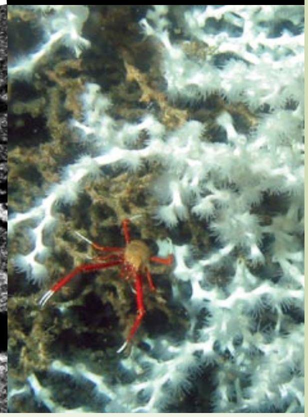
BY JAMES J. KENDALL JR., THOMAS E. AHLFELD, GREGORY S. BOLAND, JACK B. IRION, AND JOHN J. MCDONOUGH

Ocean Exploration

DISCOVERY AND OFFSHORE STEWARDSHIP



THE TIME IS August 2, 2007, and a blue, white, and red titanium flag rests on the soil of an alien world. The explorers who planted it, tucked safely within the confines of their twin vehicles, are safe from a deadly temperature and pressure differential but miles from any other human contact. Moments later, both craft lift off and head skyward, mission accomplished, but the risks are far from over as they head upward, looking to dock with their mother ship.

These were not outer-space vehicles landing on a world orbiting another star or even our own, but vehicles exploring Earth's inner space—the seafloor beneath the North Pole. The submersibles, *Mir-I* and *Mir-II*, and the explorers they protected, were the first ever to visit this hostile and unforgiving landscape. Having reached a depth of over 4,200 m, the submersibles made their way back to the surface to locate the break in the ice from which they started. Not finding this point of entry would have the same ramifications of being marooned on a far, distant world.

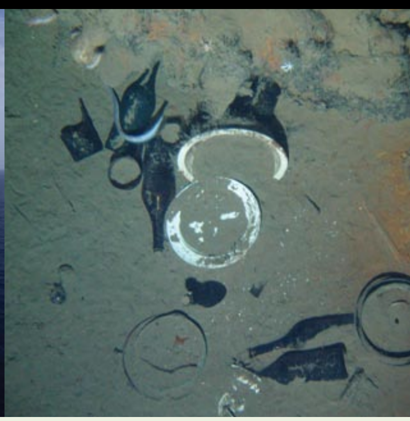
This expedition was much more than an act of national pride and was not without precedent. According to Russian Foreign Minister Sergei Lavrov, this spectacular, and then controversial, journey was an attempt "to show that our shelf reaches to the North Pole."[1] This voyage covered an area far beyond what is now formally recognized as Russia's continental shelf and is believed to hold vast reserves of oil, gas, and minerals. Article 76 of the United Nations Convention of the Law of the Sea (UNCLOS) enables coastal States[2] to establish their continental shelves beyond 200 nautical miles and control living and nonliving resources on and beneath the seabed.[3]

[1] http://www.cnn.com/2007/WORLD/europe/08/02/arctic.sub.reut/index.html

[2] *State*–with an uppercase "S," refers to a nation state or country; *state*–with a lowercase "s," refers to a state within the United States.

[3] Living resources include clams, crabs, scallops, and sponges but rights to conventional (nonsedentary) fish stocks beyond 200 nautical miles are not included.



While the United States is not yet a party to UNCLOS, we accept the substantive provisions of Article 76 as reflecting customary international law. At the time of this writing, the United States was in the process of establishing a program to delineate the US Extended Continental Shelf (ECS) estimated to exceed 1 million square kilometers and to include energy and mineral resources with an estimated value in excess of $1 trillion (Murton et al., 2001). While the US ECS program, the criteria necessary to submit a claim, and the requisite research are not the direct subjects of this paper, recent events demonstrate a direct link between ocean exploration and a nation's ocean and coastal resources. Here, we describe some of our own experiences of utilizing exploration as a tool to support better stewardship of the United States' ocean resources. We also describe the invaluable partnerships we have forged as we move towards a more ecosystem-based management approach. While the examples discussed here pertain to the management and utilization of nonliving resources (i.e., oil and gas), similar examples would undoubtedly be found for living marine resources as well. It is our intent that our examples be used to look for other synergies and partnerships and build upon them.

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Figure 1. Minerals Management Service Outer Continental Shelf Planning Areas.

Figure 2. Anadarko's Independence Hub platform installed at the world-record water depth of 2,439 m. *Photo Courtesy of Anadarko Petroleum Corporation*

US OUTER CONTINENTAL SHELF ENERGY RESOURCES

Simply put, one man's (agency's) exploration is another man's (agency's) environmental assessment. The current US Outer Continental Shelf (OCS)[4] (Figure 1) encompasses 1.76 billion acres with undiscovered technically recoverable resources[5] estimated at 85.88 billion barrels of oil and 419.88 trillion cubic feet of natural gas (Minerals Management Service, 2006a). In areas where oil and gas operations have already occurred, our knowledge of the marine environment has often increased substantially, well beyond those areas where energy resources have not been sought. In the mid-1990s, partly due to technological advances (e.g., three-dimensional seismic data and the rapid evolution of autonomous underwater vehicles) and also to the growing worldwide need for energy, exploration for and development of oil and gas in the Gulf of Mexico were taking place in water depths inconceivable just a decade earlier. Utilizing technologies rivaling those of the US space program, by the end of 2007, natural gas was being produced from facilities located in over 2,000 m of water (Figure 2), and exploration was occurring in water depths over 3,000 m. Consequently, the US Department of the Interior's Minerals Management Service (MMS) found itself on the front lines of describing and protecting areas never before seen by humans. These responsibilities included, for example, the protection of some communities so unique and alien that they have been considered potential models for extraterrestrial life that may have evolved beneath the frozen surfaces of Jupiter's moons.

The federal management process that regulates and ensures that offshore OCS activities are conducted in a safe and sound manner is also tasked with the protection of the environment. The OCS Lands Act (43 U.S.C. 1344), as well as other environmental laws (e.g., the National Environmental Policy Act, National Historic Preservation Act, and Endangered Species Act), directly apply to these activities, and thus the question of "what's out there?" becomes much more than an academic exercise.

EXPLORATION FOR STEWARDSHIP: THE EVOLUTION OF A NEED

Following the 1984 discovery of chemosynthetic communities associated with hydrocarbon seeps in the northern

[4] The term "Outer Continental Shelf" (OCS) is a legal term created by federal statute and is distinct from the geographic term "continental shelf." There is no scientific definition of the OCS. Legally, the OCS comprises that part of the submerged lands, subsoil, and seabed lying between the seaward extent of the states' jurisdiction and the seaward extent of federal jurisdiction.

[5] Undiscovered technically recoverable resources (UTRR) refer to oil and gas that may be produced as a consequence of natural pressure, artificial lift, pressure maintenance, or other secondary recovery methods, but without any consideration of economic viability. They are primarily located outside of known fields.

BOX 1. BUSH HILL

Contributed by Gregory Boland, MMS Biological Oceanographer

One of the most significant and exciting periods of my research career was in the mid-1980s when I was involved with the first discoveries of chemosynthetic communities in the Gulf of Mexico. Large chemosynthetic animals were unknown to science until 1977 when they were first discovered at Pacific Ocean hydrothermal vents. The first discoveries of these animals in the central Gulf of Mexico were made by two separate groups of researchers essentially at the same time in November 1984. The MMS funded a special cruise using the Harbor Branch Oceanographic Institution submersible *Johnson Sea-Link I* to dive on locations where chemosynthetic animals had been trawled up. I had the privilege of being the scientific observer in the submersible's acrylic sphere during its first dive.

Anxious anticipation occupied the long ride to the seafloor at 1,800 feet. When we reached the bottom, instructions from the surface guided us toward a large elevated mound in the distance. As we slowly cruised up the slope of the hill, we suddenly came across an area of tubeworm clusters. My first words were, "Wow! Look at all the bushes of tube worms, there are bushes everywhere!" My colleagues on the surface heard this on the radio and immediately decided upon a good name for the first chemosynthetic site in the central Gulf—"Bush Hill." We saw dense clusters of tubeworm "bushes" and mussel beds throughout a large area of many acres, and the mussels were seen for the first time living directly on active gas vents. It was certainly a memorable experience and the beginning of many studies of chemosynthetic communities in the Gulf of Mexico.

Greg Boland enters *Johnson Sea-Link I* prior to the first dive on the first hydrocarbon seep chemosynthetic community observed in the Gulf of Mexico, September 1986. *MMS file photo*

Gulf of Mexico, MMS sponsored two significant multiyear studies designed to provide an understanding of their distribution and functioning. Results of the first project (MacDonald et al., 1995) provided MMS with the information necessary to develop and apply mitigation measures to protect these communities (see Ahlfeld et al., in press). Additional information from a follow-on program (MacDonald, 2002) allowed MMS, through an adaptive approach to management, to develop more specific requirements and further refine its mitigation measures. These measures are where "the rubber meets the road" and set specific avoidance distances from features, or areas, that could support high-density chemosynthetic communities. Specific avoidance distances are required for discharges of solid wastes from drilling oil and gas wells (i.e., drill cuttings and associated drilling muds) and for all other related seafloor disturbances, including anchors, anchor chains, wire ropes, seafloor template installations, and pipeline construction (Ahlfeld, 2002).

As research and management strategies evolved for chemosynthetic communities, information was also collected that suggested expanding research and supporting protective mitigations of another poorly known associated community, deep-sea corals (e.g., *Lophelia pertusa*). Deep-sea coral reef systems have been receiving increased attention worldwide, notably regarding commercial fishing activities (Chuenpagdee et al., 2003; National Research Council, 2002). Although petroleum-development activities would generally disturb only small areas of the seafloor, they could result in significant impacts to deep-sea coral communities if mitigation measures were not employed. Anchoring, structure emplacement, pipeline construction, and the remote potential of a seafloor blowout could all cause localized physical disturbances affecting deep-sea corals. Anchors from support boats and ships (or from any buoys set out to moor vessels), floating drilling units, pipe-laying vessels, and pipeline repair vessels also cause severe disturbances to small areas of the seafloor with the aerial extent related to the size of the mooring anchor and length of chain that rests on the bottom. Discharges of solid wastes could also cause negative impacts to deep-sea corals. A summary of the potential impacts on deep-sea coral communities resulting from oil and gas exploration and extraction is provided in Morgan et al. (2006) and the recent MMS Environmental Impact Statement for Gulf of Mexico lease sales (MMS, 2006b).

A research program sponsored collaboratively by MMS and the US Geological Survey (USGS) investigated six sites with known deepwater coral (*Lophelia pertusa)* aggregations (Continental

Photo courtesy of the U-166 expedition team and the National Oceanic and Atmospheric Administration, Office of Ocean Exploration and Research

BOX 2. "WE FOUND THE *U-166*!"

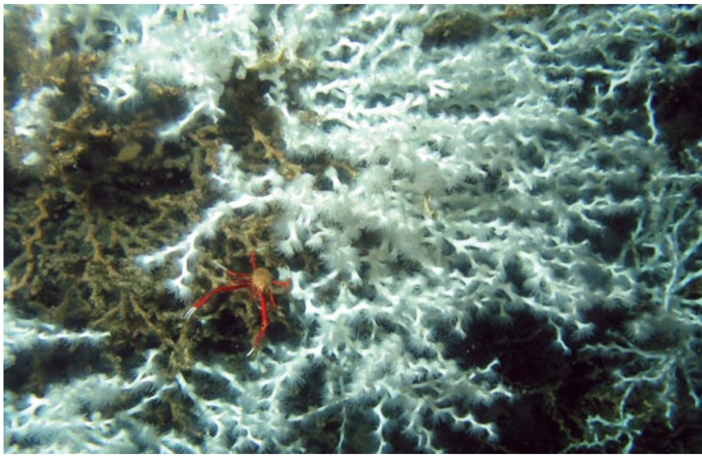
Contributed by Jack Irion, MMS Marine Archaeologist

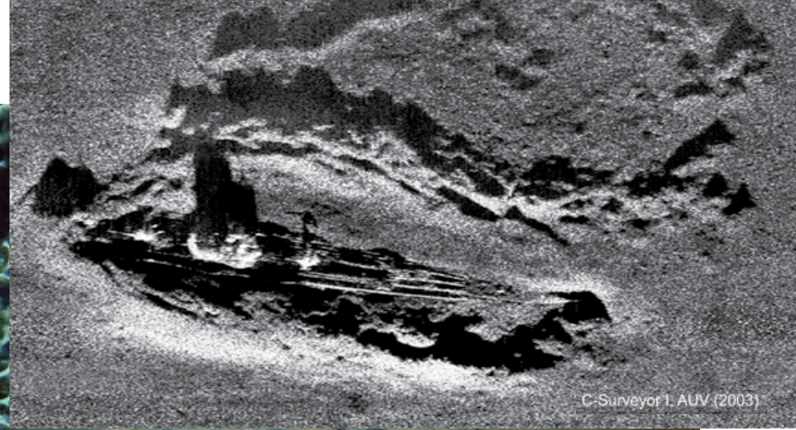
I was on the bridge of a ship stationed in the Gulf of Mexico nearly a mile above an object discovered during a pipeline survey. Video feeds throughout the ship were connected to the control van of the robotic eyes of our remotely operated vehicle (ROV). The excitement among the entire crew was electric as the ROV descended on its tether through the eternal blackness of sunless seas to the seafloor 5,000 feet below. After nearly an hour, the lights of the ROV picked out the muddy seafloor in the darkness. As the pilot cautiously moved the vehicle forward, its powerful headlamps suddenly illuminated a solid wall of steel. We drifted slowly up and over this wall, and then the interior of the conning tower of a German Type IXC U-boat materialized. A cheer went up from the entire vessel: "We found the *U-166*!" Our elation was only temporary, however, as we surveyed the stricken sub, remembering that we were seeing the iron coffin of 52 young men. While they had been our nation's enemies, there was a sadness about the sacrifice of these men, boys really, that tempered our joy. It was an experience I shall never forget.

Shelf Associates, Inc., 2007). A USGS draft report on this work has been completed. Submersible dives were conducted in 2004 and 2005 to characterize nonchemosynthetic megafauna and macroinfaunal communities found in Gulf of Mexico hard-bottom areas at water depths between 310 m and 686 m. An emphasis of the project was to investigate and describe the environmental conditions that correlate with the development and distribution of areas characterized by extensive *Lophelia* aggregations. One of the study areas was located 53 nautical miles due east of the Mississippi River delta in 460–470 m of water, the largest known *Lophelia* habitat in the Gulf (Figure 3).

Although knowledge of the occurrence and distribution of deep-sea coral communities in the northern Gulf of Mexico has increased in the last decade, data are lacking on what regulates the observed patchy distribution and how extensive deep-sea coral banks form. Hovland et al. (1998) pose several hypotheses on coral bank formation. Other little understood aspects of deepwater coral ecology include reproductive strategies and how widely separated communities are connected. In addition, available data regarding coral ages and the degree to which there is an obligate deep coral fauna are equivocal. For these reasons, locating and mapping deep corals and conducting basic biological research in these habitats are priorities established by recent reviews of deep-sea coral research (McDonough and Puglise, 2003).

Developing along a parallel track with the growing understanding of the potential for and extent of deepwater biological communities was a growing realization that the deep Gulf also contains a rich record of man's past in the form of historic shipwrecks. Prior to 2000, a handful of sonar targets had been detected during deep-tow surveys that were suggestive of shipwrecks, but none had been confirmed as significant. That was to change with the survey of a BP pipeline using a new instrument, an autonomous underwater vehicle (AUV). The spectacular images recorded by this device over a previously known amorphous sonar target showed it, unmistakably, to be the remains of the only German U-boat, *U-166*, sunk in the Gulf of Mexico during World War II (Figure 4). The discovery of the U-boat along with its last victim, the passenger steamer *Robert E. Lee*, solved a 60-year old mystery, made international press, and properly gave credit for the sinking to the US Navy. The discovery of *U-166* was quickly followed by other shipwreck discoveries as proposed pipeline routes were surveyed in deepwater oil and gas fields known as the Mississippi Canyon and Viosca Knoll located off the Louisiana/Mississippi/Alabama coasts. After a half-dozen discoveries, including several 200-year-old sailing ships (Figure 5) and a rare early twentieth-century luxury steam yacht, the entire area was declared an archaeological high-probability zone





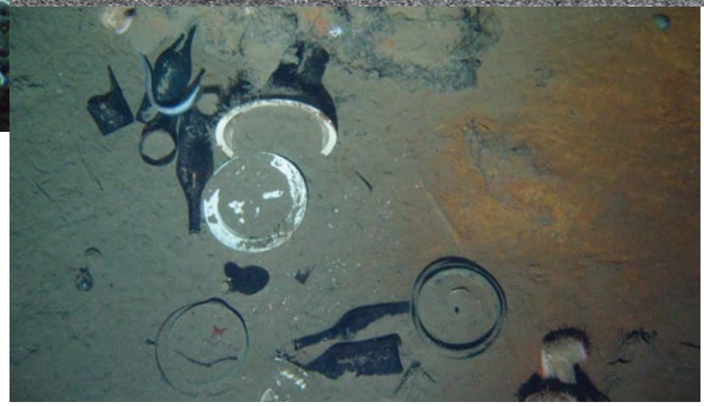


Figure 3 (above). Dense *Lophelia pertusa* colonies and galatheid crab at depth of 457 m in Gulf of Mexico Viosca Knoll Block 826. *Image from Continental Shelf Associates, Inc. acquired during MMS Contract 27323*
Figure 4 (top right). Side-scan sonar image of the World War II German submarine *U-166* acquired using an AUV. *Courtesy of C&C Technologies, Inc.*
Figure 5 (bottom right). Artifacts, including a sand clock, two compasses, bottles, and ceramic bowls on the seafloor at the early 19th century "Mardi Gras Shipwreck" site. *Photo courtesy Texas A&M University*

(MMS, 2006c) and required sonar surveys for all bottom-disturbing activities, not just pipelines.

THE POWER OF MULTIDISCIPLINARY PARTNERSHIPS

As our management strategies and the protection of chemosynthetic communities, deep-sea corals, and historic shipwrecks evolved, there was another evolution occurring along the way. Traditional boundaries between academic disciplines and between applied and basic research were falling away just as fast as, if not faster than, our developing knowledge base was expanding. For example, while MMS was acquiring the information necessary to conduct its stewardship responsibilities associated with the exploration, development, and production of oil and gas on the continental slope, it was also found that attention needed to be directed towards understanding the potential long-term impacts that manmade structures may have in the deep waters of the Gulf.

On the continental shelf, the conversion of offshore oil and gas structures to artificial reefs has been well accepted as a benefit to fisheries (Wilson et al., 2003; Love et al., 2005)[6]. In the not-too-distant future, decisions will also be required concerning the fate of structures located in much deeper continental slope waters. While options for removal at shallower depths include "reefing" structures in place, or moving them to designated artificial reef sites, at the depth of the slope (and deeper), little, if any, information was available to support such an option. Teaming up with the National Oceanic and Atmospheric Administration's Office of Ocean Exploration (NOAA OE) and under the auspices of the National Oceanographic Partnership Program (NOPP), MMS investigated the deepwater artificial reef effect of ships sunk in Gulf waters (Church et al., 2007). Shipwrecks with known histories served as de facto artificial reef experimental sites. Results of that project include documentation of large "thickets" of *Lophelia* growing on a steel-hulled vessel, *Gulf Penn*, sunk by Germany's *U-506* in 1942 to a depth of 538 m. This observation was significant to the understanding of *Lophelia* distribution and growth in the Gulf, particularly with the known maximum growth period of just 62 years.

While this information will prove invaluable in the next decade when issues pertaining to the decommissioning of deepwater oil and gas structures are addressed[7], what also resulted was a clear example of the benefits of linking an applied research program directly with more basic research and ocean exploration endeavors. This single program may turn out to be the "gold standard" of interdisciplin-

[6] A total of 244 structures were converted to artificial reefs from a total of 2,207 structures removed between 1990 and June 2007.

[7] MMS regulatory, management, and environmental responsibilities are "cradle-to-grave," from the initial offering of leases; through exploration, production, and development; to decommissioning and the relinquishing of leases.

ary research. Biologists, archaeologists, historians, metallurgists, ROV pilots, filmmakers, and educators from two continents, spanning the entire range of government-academic-private sectors, set a new standard for collaboration.[8] Furthermore, and as recommended by the Committee on Exploration of the Seas (NRC, 2003), this project incorporated a strong education and outreach program from the onset. During the first few days of Internet broadcast from the research vessel during the field component, worldwide public interest in this project was so great that it crashed the EarthLink server!

Furthermore, the synergy that resulted from the relationships formed among the researchers, marine technicians, educators, and the ship and ROV crews were not fully appreciated until after the program was concluded. Then it became obvious that the complexity of the questions being addressed, the quality of the data, and the quantity of the results pertinent to both management and to our basic understanding of the deepwater environment far exceeded the financial support provide by the two funding agencies. For example, the scientific need to know the seagoing history of the vessels, their subsequent demise during World War II, and their potential status under the National Historic Preservation Act led to discussions not only among archaeologists and historians but also among the descendents of the vessels' crews and passengers. While it is well known that shipwrecks are a popular subject among laymen, connecting their study with the natural sciences (e.g., deep-sea coral biology) was found to be an added benefit. Site-formation processes, rates and causes of deterioration, and long-term preservation potential of archaeological sites in deep water only now are beginning to be understood, thanks to the proactive involvement of the natural sciences in studying the archaeological site as an artificial reef.

There are ample opportunities to nourish this relationship in the deep Gulf. The MMS is required under the National Historic Preservation Act to consider the effects of its actions and permits on the cultural heritage of the United States. In order to fulfill this mission, the MMS, in turn, directs industry to conduct remote-sensing surveys using side-scan sonar and other tools to ensure that their construction activities will not impact a historic site. Now home to a variety of marine organisms, the wrecks are also time capsules of American history; both aspects have important lessons for scientists today.

Continuing the theme of multidisciplinary research and the partnering of applied science to basic research and ocean exploration, another multi-agency, multisector partnership was initiated in 2005 to investigate deep-sea chemosynthetic and other hard-bottom communities in the Gulf in water depths between 1,000 and 3,000 m. Some of these communities were previously known, but additional sites were chosen for exploration based on remote-sensing data held by MMS. Again, MMS and NOAA OE, and now USGS, collaborated to develop an interdisciplinary, multiyear project under the auspices of NOPP (now incorporated into the new ocean governance structure [see MMS, 2006d])[9]. This ongoing project focuses on exploration, survey, and experimental work on chemosynthetic communities and hard-bottom habitats located in water deeper than 1,000 m. Although the emphasis of this study is on chemosynthetic communities, objectives also include the investigation of other types of hard-bottom communities (in particular, deepwater corals) and determining the comparative degree of sensitivity to anthropogenic impacts. A variety of approaches such as rarity, unique taxonomy/biodiversity, or other environmental risk-assessment methodologies are also being applied. The manned submersible *Alvin* was employed during the first year of field sampling completed in 2006, and the state-of-the-art ROV *Jason 2* was used in 2007 during the second year of field sampling. Remarkable discoveries were made during these cruises, including extensive deepwater coral habitats at a depth of 1,450 m and huge methanotrophic mussel beds at a depth of over 1,200 m. The results of this study will expand our understanding of sensitive biological communities throughout all depths of the Gulf of Mexico in advance of continuing exploration and development of energy resources now possible at any depth found in the Gulf. Results from the recent *Lophelia* studies (Continental Shelf Associates, Inc., 2007), together with the more recent broader understanding of hard-bottom habitats in still deeper areas of the Gulf, will enable augmentation of existing measures to specifically target the protection of *Lophelia* and other rare deepwater hard-bottom communities. USGS scientists currently are preparing a final report to MMS titled "Characterization of Northern Gulf of Mexico Deepwater Hard Bottom Communities with Emphasis on *Lophelia* Coral."

[8] This project received the Secretary of the Interior's 2005 Cooperative Conservation Award and the 2006 National Oceanographic Partnership Program's Excellence in Partnering Award.

[9] This project received the Secretary of the Interior's 2007 Cooperative Conservation Award.

SCIENCE TO STEWARDSHIP

The results of these and other deepwater studies are being used to describe the environment potentially affected by offshore energy exploration and development and to better manage any possible environmental consequences. The information is also being used to develop protective measures designed to prevent impacts or to minimize and mitigate unavoidable impacts. Such protective measures have become standard operating procedures in areas where there are high-density assemblages of benthic organisms and natural hydrocarbon seepage (Ahlfeld, 2002) as well as where historic shipwrecks have been discovered during industry surveys (Irion, 2002). Likewise, NOAA uses this same information on the location and characteristics of deepwater habitats to manage commercial fishing activities that may cause damage. Specifically, through authorities such as the Magnuson-Stevens Fishery Conservation and Management Act, NOAA works with Regional Fishery Management Councils to identify appropriate management measures, including gear restrictions, as well as Essential Fish Habitats that may result in restrictions on fishing activity.

Geophysical signatures obtained through remote-sensing techniques have proven to be related to the presence of high-density biological communities or, on occasion, a historic shipwreck. Required submission of this information by offshore operators is used both in archaeological and biological review processes to determine the need for avoidance of the locations of "potential" communities or historically significant archaeological sites. However, due to the imperfect correlation between geophysical signatures and the actual presence of living communities, the conservative approach of avoidance is mandated unless operators prove the absence of such communities using an in situ visual methodology (e.g., AUV, ROV, submersible). The same is true of archaeological sites where it is seldom possible to distinguish a Spanish galleon from a pile of modern debris. The conservative approach is always taken: without knowing that the target is *not* an archaeological site, it must be assumed that it could be. Recently, areas requiring high-resolution surveys for the purpose of avoiding impacts to historic shipwrecks have been expanded to include the deepwater approaches to the Mississippi River, historically high-traffic areas that have proven to be rich in submerged cultural heritage (Ball et al., 2007).

STAKEHOLDERS TO EXPLORERS

To gain a better understanding and to determine the effectiveness of the process for mitigating potential impacts, MMS implemented a broad-scale survey requirement throughout the Gulf of Mexico continental slope. The Gulf slope was divided into 18 segments based on three major biological depth regimes and an east-west division of six longitudinal sections (Figure 6). In these areas, operators are required to perform between five and ten ROV surveys spaced throughout each particular segment or grid so that each grid is well represented by depth and spatial coverage. ROV transects are performed by operators in a pattern of six spokes approximately 100 m in length radiating in equally spaced directions from a point of origin located near the center of the activity. While ROV operators are not expected to provide accurate identifications, they are asked to record the types of animals present and the appearance of the bottom, such as color and texture. Of particular interest is the observation of hard-bottom areas, or outcrops, with any attached animals. This requirement

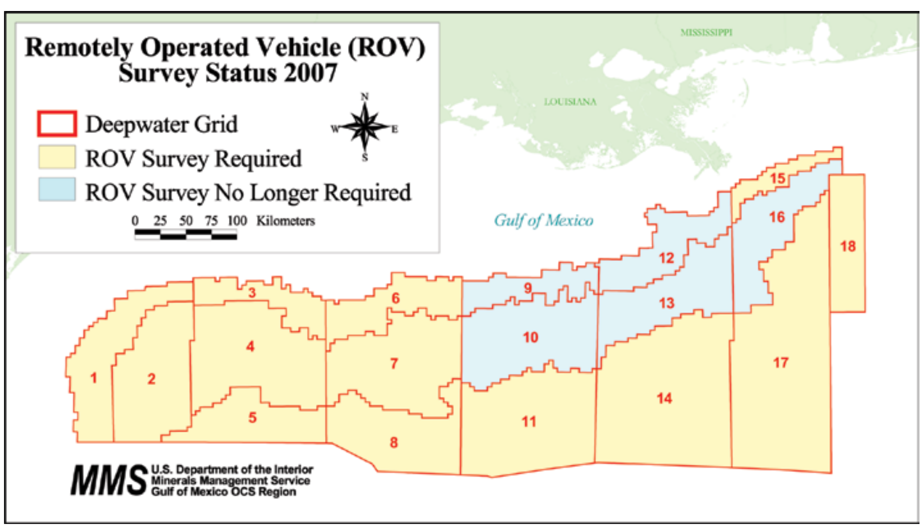


Figure 6. To gain a better understanding of the area and to determine the effectiveness of the process for mitigating potential impacts, the Gulf of Mexico slope was divided into 18 segments based on three major biological depth regimes and an east-west division of six longitudinal sections (Minerals Management Service, 2003). Five to ten ROV surveys are required in most of these segments so that each grid is well represented in terms of depth and spatial coverage.

BOX 3. MMS STUDY LEADS TO DISCOVERY OF THE "ICE WORM"

An important aspect of exploration associated with the MMS large field sampling efforts is the discovery of species new to science. The Smithsonian's National Museum of Natural History is the central repository for archiving most of the invertebrate specimens collected through the MMS studies. Type specimens of over 260 new invertebrate species from MMS studies have been accessioned into the Smithsonian collections (see table). As the MMS studies have moved to deeper, less-studied areas in the Gulf of Mexico, this number has steadily increased. The photo shows an example of an interesting new species collected in the Gulf of Mexico. It is an "ice worm, " a small polychaete annelid that was discovered in July 1997 living in depressions on methane hydrates at a previously studied chemosynthetic community in lease block Green Canyon 234 on the continental slope off the Louisiana coast.

PHYLUM	NUMBER OF NEW SPECIES
Annelida	168
Anthropoda	70
Chordata	2
Coelenterata	9
Echinodermata	6
Mollusca	1
Porifera	6
Total New Species	**262**

Table courtesy of K. Ahlfeld, National Museum of Natural History

The "ice worm" *Hesiocaeca methanicola* was discovered in July 1997 living in depressions on methane hydrate on the Gulf of Mexico continental slope. *Larger image by C. Fisher, inset by G. Boland*

has turned ROV operators into de facto explorers, making them more conscious of the role they play in protecting the environment (i.e., stakeholder buy-in). Many reports have come back to MMS indicating the enjoyment ROV operators experience doing additional work for science during what would normally be down time. Some operations feed the video from similar ROV work throughout the rig on cable TV, and one article reported a contractor saying, "It's like having our own in-house Discovery Channel" (Benfield, 2007). Videotapes are submitted, and reviews of both transcript logs and the tapes themselves are then performed by professional biologists. Should an ROV survey indicate that previously unknown, significant biological communities were encountered, adaptive decision-making may lead to future alterations in the biological review process and revisions to regulatory measures.

SUMMARY AND CONCLUSIONS

The multidisciplinary nature of the research discussed here involves the missions and expertise of federal agencies, academic partners, and the private sector, and provides the information necessary to pursue a more ecosystem-based management approach for US natural and cultural offshore resources. The MMS was recognized by both the US Commission on Ocean Policy and the Administration in the US Ocean Action Plan for leadership in protecting such resources, in particular the deep-sea coral communities. We have found that, as missions and expertise are partnered and collaborative opportunities explored, boundaries and disciplinary barriers melt away. As noted by the Committee on Exploration of the Seas (NRC, 2003), "proposals for interdisciplinary work are hampered by a funding bureaucracy that is also discipline-based." However, for the work described here, the need for management-relevant information far outweighed any need to preserve individual discipline "turfs" or discipline "stovepipes." From the onset, it was decided that one of the characteristics of acceptable proposals would be their success at breaking down such barriers.

While it may have been easy at one time to consider a management and regulatory programs' scientific initiatives as merely the application of the scientific principle to simple, linear management questions, our contributions to date have unquestionably yielded the discovery of new species, processes, biological habitats, and culturally significant historical sites. In addition, they have been critical to our understanding of how these systems function and to elucidating the potential effects of human activities. While it has been suggested that exploratory programs might contribute to the needs of management organizations "particularly if new living resources were identified" (NRC 2003), we have found that when a management agency actively makes exploration a priority strategy for acquiring the information it needs to make sound decisions, it is often discovery and basic science that are the beneficiaries. A management agency can easily state, without reservation, that it needs to know "what's out there and how it works" to effectively conduct its stewardship responsibilities. Making assumptions about what one will find in an area about which we know nothing and inadvertently restricting the kinds of investigations can only lead to overlooking unexpected and possibly groundbreaking discoveries.

ACKNOWLEDGEMENTS

This article was prepared while the senior author was detailed from the US Department of the Interior's Minerals Management Service to the NOAA Office of Ocean Exploration and Research. The support of these two ocean agencies is greatly appreciated. The authors would also like to thank James Cimato, Gregory Gould, and Robert LaBelle for helpful comments during the final preparation of this manuscript. Particular thanks go to Eileen Lear who provided organizational and editorial guidance.

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