Deepwater Program: The Archaeological and Biological Analysis of World War II Shipwrecks in the Gulf of Mexico: A Pilot Study of the Artificial Reef Effect in Deepwater.

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LONG-TERM GOALS

This multidisciplinary study focused on the archaeological and biological aspects of the seven designated World War II era shipwrecks in the north-central portion of the Gulf of Mexico in water depths that ranged from 328 feet to 6,500 feet: the tanker *Virginia* (285 feet water depth), The tanker *Halo* (470 feet water depth), The tanker *Gulfpenn* (1820 feet water depth), the Steam Yacht *Anona* (4100 feet water depth), the German U-boat, *U-166* (4780 feet water depth), The passenger freighter *Robert E. Lee* (4890 feet water depth) (Figure 1), and the Cargo Freighter *Alcoa Puritan* (6440 feet water depth). The long-term goals of this study were to determine the potential for man-made structures or objects to function as artificial reefs in deepwater and evaluate criteria to aid the federal government in managing these and other culturally significant deepwater sites.

Figure 1: Telegraph from the bridge of the* Robert E. Lee *standing up right on the seafloor, 200 feet way from the main shipwreck structure.

OBJECTIVES

Archaeological Objectives

1. Positively identify each shipwreck and establish its type and date of construction, nationality, ownership (past and present), use history, mission and cargo at time of loss.
2. Determine each vessel's past and present condition, state of preservation, assess any environmental impacts caused by the wreck, and make observations relating to its rate of deterioration and future research potential.
3. Determine the horizontal extent of the debris field surrounding each shipwreck.
4. Analyze imagery and historical documentation to determine potential eligibility to the National Register of Historic Places.
5. Assess the impacts of bio-fouling communities to these shipwrecks to determine the stability of these sites.

Biological Objectives

1. Characterize the environment at each site.
2. Determine the biological effects of shipwreck artificial reefs at selected sites, to include detailed imagery surveys of shipwreck sites at a variety of scales.

3. Determine the extent of physical and biological modification of sediments in the immediate area of wreck sites compared to sediment conditions at sites distant from wreck areas. Sampling will include sediment coring close to and distant from wrecks.
4. Conduct limited sampling of fauna attached to hard substrate for taxonomic and other potential analyses such as isotope studies.
5. Analyze imagery and sample collection to address spatial heterogeneity of any fouling community and motile fish and invertebrate association with wrecks.

APPROACH AND WORK PLAN

1) Technical Approach

The field approach and plan consisted of combining standard archaeological and biological methodology with proven industry technology. The field operations were conducted using an acoustically positioned Remote Operated Vehicle (ROV). The vehicle utilized was Sonsub's Triton XL 3000 meter ROV. The ROV was equipped with the necessary equipment to obtain high quality imagery and accurate measurements of artifacts and organisms, as well as seafloor conditions or features, and water column attributes (i.e. depth, temperature, pH, salinity, etc.). The ROV's position was constantly tracked using a Sonardyne Ultra Short BaseLine (USBL) acoustic system. At each location a site-specific briefing was held prior to beginning operations. The first operation at each site was a through reconnaissance of the main hull structure. Following the visual reconnaissance each area was systematically investigated using a pre-established survey grid extending out from the main wreck structure to determine the site boundaries and document the sea life near and away from the wreck site. The line spacing for the visual survey was adjusted according to conditions at each site and expanded as need to cover the entire debris field associated with each shipwreck. The ROV survey was designed to maximize the efforts and time for both the archaeologists and biologists at each site. Next vertebrate and invertebrate traps were set for biological collection. This was followed by a photo mosaic (either profile and/or plan view) of the main hull structure. After the mosaic lines were complete four sediment cores were taken at each shipwreck locations. The cores were taken at various distances from the wreck (near to far). As time allowed, the biology team collected additional biological samples using collection tools on the ROV. Before finishing the operation at each site a check was conducted to insure all operations were completed before the traps, sediment cores, and ROV were recovered and the team transited to the next location.

The science team operated 24 hours on a 12-hour shift rotation. There were at least two biologists and two archaeologists on shift at all times. There were two observers in the ROV control room rotating out in four-hour segments within each 12-hour shift rotation. The observers were responsible for directing the ROV pilots and keeping the science logs of all biological and archaeological items observed during the operation.

2) Key Personnel

The Project was subdivided into three primary sections: archaeology, biology, and education. The U.S. department of the Interior, Minerals Management Service (MMS) over saw the scientific operations for the project. Dr. Jack Irion, Contract Officers Technical Representative over saw the archaeology on behalf of the MMS and Daniel (Herb) Leedy over saw the biology on behalf of the MMS. Robert A. Church with C&C Technologies is the Chief Scientist and Project manager for the project as well as the Principle Investigator for the archaeological component. Daniel J. Warren with C&C Technologies was the Co-Principle Investigator for the archaeological component. Field archaeologists and Ph.D. candidates Peter Hitchcock (Texas A&M University) and Jimmy Moore

(University of Rhode Island) also provided invaluable participation in the project. The biology is sub-divided into three specialties: microbiology, invertebrate zoology, and vertebrate zoology. Lori Johnston along with Dr. Roy Cullimore with Droycon Bioconcepts are the Principle Investigators for the microbiology component. Dr. Thomas Shirley with the University of Alaska is the Principle Investigator for the invertebrate zoology component along with field biologists and graduate students Morgan Kilgour and Aaron Baldwin and Co- Principle Investigator Dr. William Schroeder of the Dauphin Island Sea Lab. Dr. William Patterson with the University of West Florida is the Principle Investigator for the vertebrate zoology component along with field biologist and graduate student Nicole Morris. Dr. Annalies Corbin with the PAST Foundation heads up the education outreach component of the project along with the assistance of website coordinator Andy Hall and film producer and professor Dr. Dennis Aig of Montana State University and film assistant Dr. Keene Haywood.

3) Plans for the upcoming year.
In the upcoming year the Report of Findings will be completed and published. The project film documentary will be produced. Education curriculum will be completed and made available for distribution to schools across the nation.

WORK COMPLETED

Between July 29 and August 15, 2004 we completed the fieldwork portion of the project. During the field operations we collected more than 300 hours of video footage, physical samples, and twenty-six sediment cores for laboratory analysis. The video footage collected is being used by the scientists to analyze each site and will be used to produce a professional film documentary of the project. One historic artifact was collected from the *Alcoa Puritan* site, a 105 mm shell casing fired by the German U-boat, *U-507* (Figure 2). The shell casing was conserved at Texas A&M University and is now on display at the National D-Day Museum in New Orleans, Louisiana. To date approximately 85% of the data analysis is complete and the Report of Findings is currently being prepared.

Figure 2: 105mm Shell casing recovered from the* Alcoa Puritan *site.

A project website was established, that included information about the history of the wrecks, general background about U-boat activity in the Gulf of Mexico, information about the science being conducted at the sites and the scientists conducting the work. An important purpose of the website is to put the website visitor "on the boat," by including daily updates from the research team. These updates took the form of written journals, or narratives, describing each day's activities, and were written by a different member of the project team each day. The narrative was supplemented by still images and, every other day, a short but professional video produced onboard by the PAST Foundation Documentary Unit.

RESULTS

Each shipwreck was positively identified and the full existent of the site boundaries, including associated debris, was determined. The state of preservation and rates of deterioration of the wreck site were estimated in conjunction with the microbiology data. For example, the Alcoa Puritan appears to be following a parallel track to the *RMS Titanic* (sunk thirty years earlier in 1912) with the growths of rusticles probably showing a close approximation to what the *Titanic* would have looked like in 1974, eleven years before discovery of the *Titanic*.

A deep-water species of coral (*Lophelia pertusa*) was discovered in abundance on the *Gulfpenn* site. The size of the colony was unexpected (Figure 3) and supported several important reef fishes. Statistical analysis of community structure estimates revealed significant differences existed among wreck sites and among sample locations within sites. At the three shallowest sites (285, 470, and 1820 feet depth, respectively) reef- or structure-associated fishes were predominant over wreck sites. At the shallowest site, the community was dominated by snapper (*Lutjanid*) species. The fish community at 470 feet site was dominated by small sea basses (*Serranidae*) associated with the branching coral (*Oculina*), but large numbers of amberjack (*Seriola dumerili*) and several large Epinephelus groupers also were present. The slimehead (*Hoplostethus occidentalis*), and structure-associated scorpionfishes dominated the community at the 1820 feet site, which was covered with *Lophelia* coral thickets (Figure 3). Fish communities over deep wrecks consisted mostly of *Ophidiiformes, Halosaurid, Macrourid* and *Anguiliformes* species, listed in order from highest to lowest relative abundance.

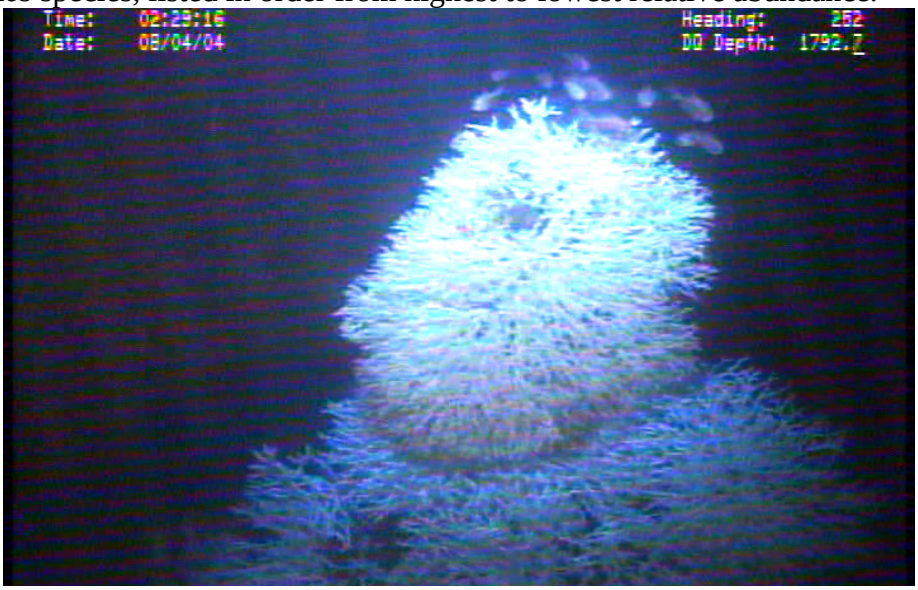

Figure 3: Lophelia coral thicket (approximately 120 inches at the base) with a school of slimehead gathered near the top.

At several of the wreck sites, particularly the Halo, several species of mollusks were collected that were not previously known to exist in the Gulf of Mexico. Among these were the closest-known examples of a mollusk species previously thought to have been lost. The full results from the study will be included in the final Report of Findings scheduled for completion in June 2005.

IMPACT AND APPLICATIONS

Economic Development

The direct economic effect of the study is to determine if it is beneficial to leave in place deep-water structures such as abandoned oilrigs or if they should be removed, as is currently required by law. Leaving deep-water structures in place will be a considerable economic savings to the industry, if it is also ecologically beneficial to do so.

The secondary economic effect is in determining the stability and rate of deterioration of steel structures in a deep marine environment. Understanding the stability factors is a first step in better designs in manufacturing and materials that will allow longer life to structures and vehicles that operate in a deep marine environment.

Quality of Life

The U.S. government plays a major role in cultural resource management. This study directly results in increasing our knowledge of the existent and stability of these and similar historical sites and has a direct benefit for the federal government's ability to better manage these and other culturally significant properties in U.S. waters.

This study also enhances the quality of life by providing a clearer understanding of the fisheries ecology at the mid and deep ocean depths. The sites investigated during the study clearly indicate habitat for several commercial species of fish and invertebrates.

Science Education and Communication

Four Ph.D. students (two in archaeology/oceanography, one in biology, and one in film) and four masters level students (two in biology and two in film) participated in the project.

The project website setup by the PAST foundations developed content to provide as much information about the project and its context to a wide audience, that would include archaeologists, biologists and other researchers; K-12 and university students; and the general public.

Education curriculum is currently under development that will provide learning modules with a science focus aimed at Middle School level students. The lessons also meet the National Educational Standards criteria for these grade level and subject focus. The topics of the lesson plans are *Pressure at Depth*, *Garbage Underwater*, and *Who goes along on a Scientific Expedition?* As an example for the module of *Pressure at Depth*, the scientific team sent down a collection of everyday objects over a mile deep to the seafloor to document how they respond to the increased pressure at great depth. In addition, multiples (such as 700 styrofoam cups) were sent down with each experiment so that teachers can request and be sent real examples along with the web based learning module. This provided the

student with a unique hands-on approach to learning about the dramatic effects of the physics of pressure.

TRANSITIONS

Economic Development

The multidisciplinary approach is a more economical solution to deep-sea and shipwreck exploration. Conducting work at sea, particularly in deepwater, is an expensive endeavor, but often yields rewarding result that cannot be achieved in shallow water. For example, by having biologists and archaeologists working together for common project goals, research money from different funding sources can be pooled for a common project and enables the research to be conducted at a reduced cost for each participating organization of agency. In addition having government, industry, academics, and nonprofits organizations working together allows each group to pool there resources, knowledge, and experiences. This approach worked quite well on the 2003 U-166 Project (NOAA OE) and the 2004 Deep Shipwrecks Project (NOPP, NOAA OE, & U.S. MMS). The partial success of these projects was due to the various science groups "working together" for the bigger goals of the project and not merely "waiting in line onboard the research vessel" for their turn to conduct their research.

This type of multidisciplinary approach is being adopted on a biology/geology project in the Gulf of Mexico this year by Mississippi State University, Droycon Bioconcepts, and Deep Ocean Expeditions. Also the same approach is being proposed for the *Lusitania* Project this year. The *Lusitania* Project began as a biology driven project, but through C&C Technologies previous partnership with Droycon Bioconcepts, the project will now include an integrated archaeological component as well.

RELATED PROJECTS

In October 2003, C&C Technologies partnered with Droycon Bioconcepts and the PAST Foundation to conduct a detailed study of the *U-166* wreck site under a grant from NOAA Ocean Exploration. The project was a multidisciplinary study consisting of archaeology, microbiology, and education and the results from the *U-166* Project were directly tied into to current deep shipwrecks study under NOPP. The *U-166* Project web site is "http://www.pastfoundation.org/U166" and the Report of Findings can be found at http://www.pastfoundation.org/U166/U166_final.pdf.

In the Fall of 2005, Droycon Bioconcepts, Inc., and C & C Technologies, Inc. plan to team up again with others to conduct a similar study on the RMS *Lusitania*. The methodology developed on the deep shipwreck studies in the Gulf of Mexico will directly benefit the work on the *Lusitania*.

In addition to these, the results of the Deep Shipwreck Project tie into a number of other ongoing biological work being conducted at the University of west Florida, University of Alaska, and Dauphin Island Sea Lab.

PUBLICATIONS

Public presentations on the Deep Shipwrecks Project have currently been presented at three venues.

1) Deepwater Archaeology Symposium of the Marine Technology Society Conference in Houston, Texas in September 2004

- Paper presented by Robert A. Church and Daniel J. Warren entitled *The Archaeological and Biological Analysis of World War II Shipwrecks in the Gulf of Mexico: A Pilot Study of the Artificial Reef Effect in Deepwater*.

2) Deepwater Archaeology Symposium of the Society for historical archaeology conference in York, England in January 2005.

- Paper presented by Robert A. Church and Daniel J. Warren entitled *Analysis of World War II Era Shipwrecks in the Gulf of Mexico: A Deepwater Pilot Study*.
- Paper presented by Andrew W. Hall entitled *Looking Over the Archaeologists' Shoulders: Using Web-Based Technology for Public Access to Deep Wrecks*.
- Paper presented by Dr. Dennis Aig and Dr. Keene Haywood *Videography at 1,000 Fathoms: Documenting the Deepwater Gulf Project*.
- Paper presented by Dr. Roy Cullimore and Lori Johnston entitled *Microbiology of Concretions, Sediments and Mechanisms influencing the Preservation of Submerged Archeological Artifacts*.

3) Presentation to the American Petroleum Intuition in Lafayette, Louisiana.

- Paper presented by Robert A. Church and Daniel J. Warren entitled *Analysis of World War II Era Shipwrecks in the Gulf of Mexico: A Deepwater Pilot Study*.

Other substantial publications and a documentary film are in progress.