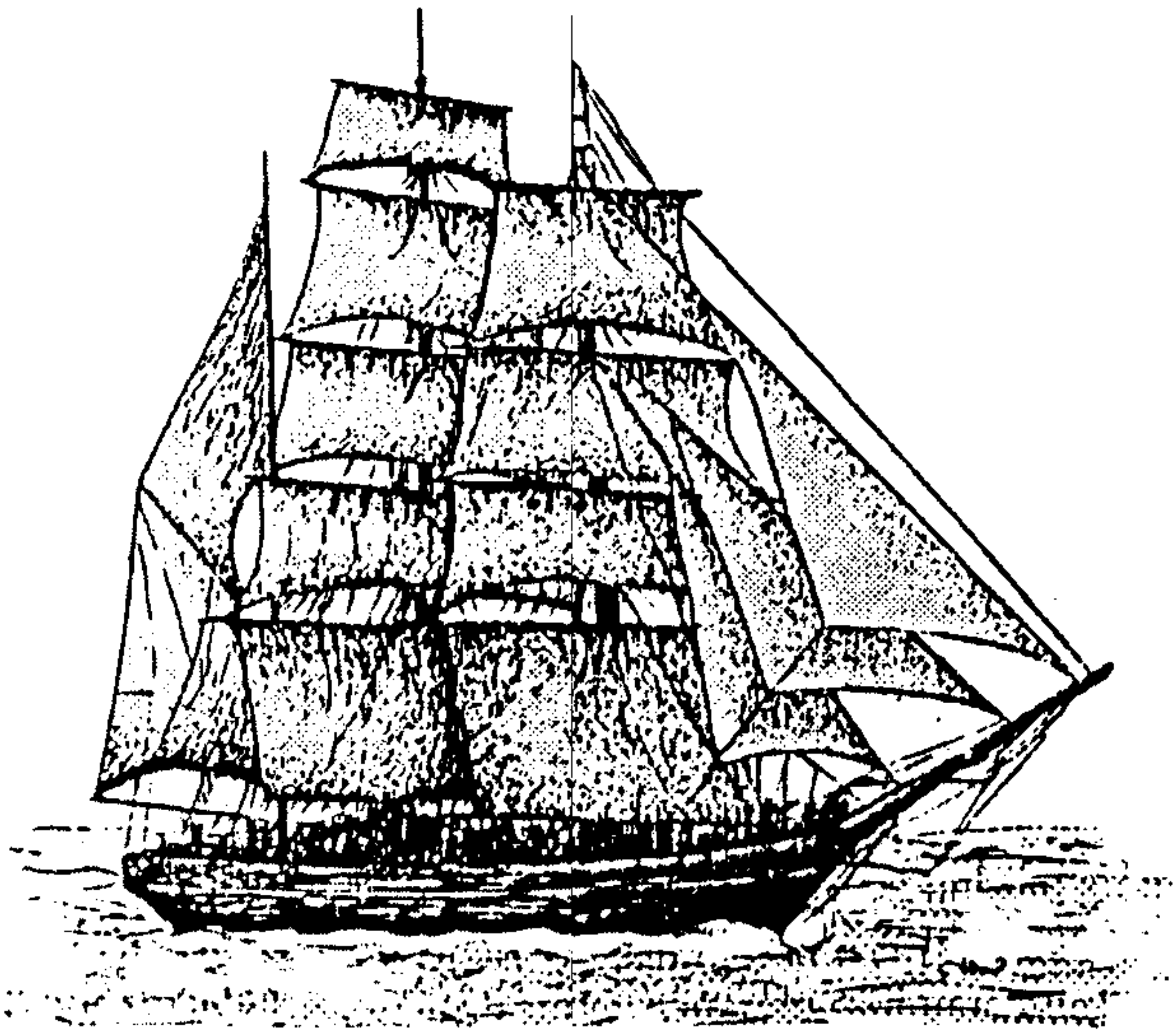
Archaeology on the Gulf of Mexico Outer Continental Shelf

A Compendium of Studies



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

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PREFACE

The following is a compendium of archaeological papers presented at the Minerals Management Service, Gulf of Mexico's, annual Information Transfer Meetings from 1980 to 1987. For additional information concerning these presentations or for additional copies, please contact the following:

Rik Anuskiewicz or
John R. Greene
Staff Archaeologists, LE-5-2
Minerals Management Service
Gulf of Mexico OCS Region
1201 Elmwood Park Blvd.
New Orleans, Louisiana 70123-2394
Telephone: (504) 736-2796 or
FTS 680-9796

Gulf of Mexico OCS Region

OCS Study
MMS 88-0035

Proceedings: Eighth Annual Gulf of Mexico Information Transfer Meeting

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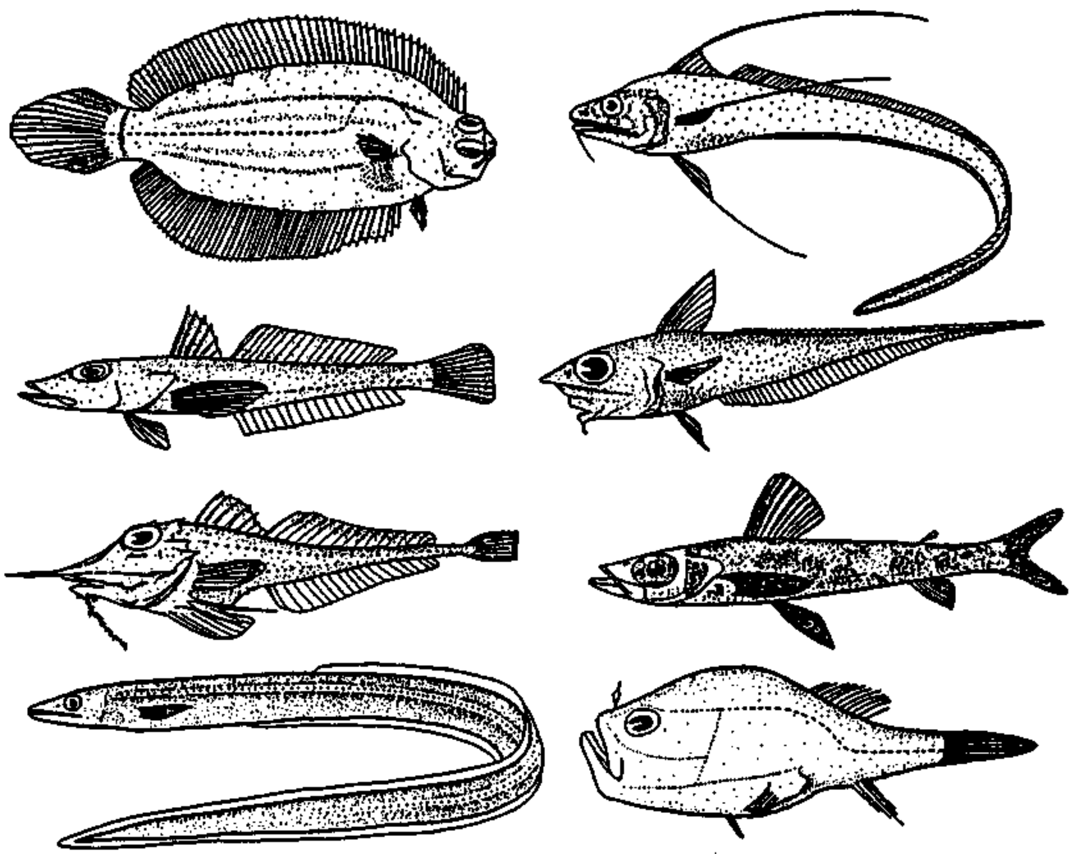

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Chair: Mr. Richard J. Anuskiewicz

Date: December 3, 1987

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Current Prehistoric Archaeological Research in the Coastal Regions of Florida: Session Overview

Mr. Richard J. Anuskiewicz
Minerals Management Service
Gulf of Mexico OCS Region

The MMS of the Department of the Interior is responsible for all OCS minerals activities and their potential for impacting natural and archaeological resources. In order to fulfill its responsibilities for archaeological resources management, MMS has developed a program to inventory, manage, and protect valuable, nonrenewable, prehistoric and historic resources. The MMS meets its goal of archaeological resource protection through a multilevel analysis system. The MMS conducts Regional baseline studies to determine where on the OCS archaeological sites are most likely to occur.

The MMS baseline studies have concentrated on the central and western Gulf of Mexico because most of the oil and gas exploration and production has occurred in this area of the Gulf. However, the recent past has seen the projection of exploration and development of natural resources in the eastern Gulf of Mexico. Regionally-specific archaeological resource management models were originally derived from this baseline data for analysis and management of prehistoric archaeological resources potentially located in the western and central Gulf of Mexico. However, the models are not completely applicable for archaeological analysis in the eastern Gulf of Mexico. In an attempt to resolve this problem, MMS has enlisted the aid of archaeologists conducting current prehistoric research in the coastal regions and offshore Florida. This has been done in order to examine new information from their current research that may be applicable to the MMS cultural resource management program for the eastern Gulf of Mexico.

The focus of this session is to report on the current status of prehistoric archaeological research in the coastal regions of Florida and then to determine if the present analytical models used by MMS, derived from previous baseline studies, are appropriate for performing the requisite MMS cultural resource management analysis.

The first speaker in our session was Ms. Melanie J. Stright of MMS. Ms. Stright began the session by giving an archaeological overview of inundated archaeological sites in the coastal regions of Florida. She reported that 17 inundated archaeological sites have been documented within the coastal area of Florida. These sites became inundated as a result of glacio-eustatic and glacio-isotatic adjustments during the late Wisconsinan glacial epoch and during the Holocene. The distribution of sites should not be considered representative of the true distribution of inundated archaeological sites. There is a strong bias towards shallow water sites since activities such as dredging and sport diving generally concentrate in shallow waters and have led to the discovery of many of the sites.

Diagnostic artifacts recovered include lithics and pottery and span all cultural periods from Paleo-Indian through the Woodland. Human skeletal material from Paleo-Indian and Late Archaic Periods have been recovered, as well as numerous species of late Pleistocene fauna.

The inundated archaeological sites discovered thus far within the coastal areas of Florida suggest that there will be an abundance of archaeological material found off the coast of Florida and that these materials (including organics) will often be well preserved. Sites will probably concentrate in the vicinities of sinkholes, relict fluvial channels, relict estuarine deposits, and outcrops of cryptocrystalline rock. Information contained in these sites may provide important information on prehistoric human migration, settlement patterns, subsistence, and cultural contacts across now submerged landmasses.

The next speaker was Dr. Glen Doran of Florida State University. His paper focused on the preservation potential of organic materials at prehistoric archaeological sites located in wet or saturated environments. He defined these types of archaeological sites, or "wetsites," as locations where remnants of past human activities are preserved in saturated or nearly saturated settings. These types of sites can be found in river channels, coastal marine settings, and within lakes, ponds, and springs. However, there may be some problems in locating wetsites because of their almost invisible nature and the frequent necessity of entering a "hostile" environment to locate them. Wetsites are either underwater, or they are difficult to identify because of water-saturated conditions.

The potential preservation of organic materials is largely due to the presence of moisture, which reduces the physical stress on organic materials by limiting the frequent hydration/dehydration cycle that promotes deterioration of organic remains by expansion and contraction. There are many other factors that contribute to the preservation potential of materials. These factors include the dynamics of water and/or soil chemistry, oxygen levels in the soil and water, temperature, physical stability, and integrity of the soil matrix. When all of the environmental conditions are right, there is also a good potential for preservation of plant material like stems, seeds, leaves, and pollen. Additional soft tissue that can survive includes preserved brain tissue. At the Windover archaeological wetsite, which Dr. Doran has been excavating since 1983, Dr. Doran states that the preliminary analysis of preserved brain tissue indicated a replacement process, that resulted in elevated sulfur levels. Microscopic and macroscopic features of the brains are still preserved, as are some molecular structures. Elemental analysis of bone samples indicates an abnormal absorption of strontium, obviating some studies of dietary composition based on strontium levels. At the same time, some proteins appear well preserved enough for researchers to attempt to develop a biological profile of the 7,000 year old population being studied.

The uniqueness of the preservation of organic materials at wetsites like Windover also presents some unique problems in material preservation. Waterlogged conditions of archaeological material recovered necessitated special conservation techniques. Saturated faunal and human bone was treated with bulking agents which replaced the water. Polyetholglycol (PEG) was initially used, but an acrylic emulsion, Rhoplex, proved more satisfactory. Floral materials (seeds, leaves, wooden artifacts, etc.) involved a variety of conservation procedures including refrigeration, alcohol saturation, treatment with PEG and Damar, and other compounds. Brain tissue was rapidly removed, placed in plastic bags, flooded with nitrogen gas, sealed, refrigerated for transport, and frozen at -70 degrees centigrade within 24 hours to minimize possible degradation and to maximize future analysis possibilities.

Many scientific and archaeological accomplishments were realized at the Windover prehistoric wetsite. The collection, representing a minimum of 155 adults and subadults, is one of the largest samples of human skeletal material and associated cultural materials of this antiquity in the New World. The collection dates between 7,000 and 8,000 years Before the Present (B.P.) and represents an Archaic Period hunting-gathering population. Data on health, diet, disease, demography, etc., in some ways, represent "baseline data," useful in looking not only at human adaptation, but providing an abundance of archaeological, climatological, and environmental data.

Mr. Wilburn A. (Sonny) Cockrell, Director of the Warm Minerals Springs Archaeological Research Project, was the next speaker, and he described his archaeological site as a 70-meter deep spring-fed sinkhole, located 16 kilometers inland from the Gulf of Mexico in Sarasota County, Florida. Saline anaerobic water enters the sinkhole at the 70-meter depth at a temperature of 32-34 degrees centigrade. The source of the springs' water is the Floridian Aquifer some 1,000 meters below the surface. Approximately 19.4 million gallons of natural, hot mineral water flow through the spring each day.

The sinkhole's limestone walls are draped intermittently with dripstone formation zones from 4 to 30 meters below the surface. In addition, some of the underwater sediments are producing a tufa-like formation. This sedimentary rock, composed of calcium carbonate, is formed by evaporation as a thin, surficial, soft, spongy, cellular or porous, semifriable incrustation around the mouth of a hot spring. The limestone matrix of the spring is representative of the Hawthorn Formation, which dates back to the Miocene Period.

Current research is being conducted on a 13-meter ledge, and at the sinkhole's debris cone at a depth of 50 meters. The archaeological diving is being conducted by utilizing both SCUBA and surface supplied air systems. The technology utilized at Warm Mineral Springs reflects both standard underwater excavation methods at the 13-meter ledge and some new and innovative techniques at the 50-meter level where deep diving is required.

There are three archaeological foci at the Warm Mineral Springs archaeological site. They include (1) a terrestrial site located around the rim of the sinkhole, (2) archaeological material at the 13-meter ledge deposited prior to the present level of inundations, and (3) a stratified matrix of undisturbed natural sediments and archaeological materials located in the existing sediment cone at the 50-meter level.

Archaeological material excavated at Warm Mineral Springs ranges from the present to the Formative Period (approximately 2,500 years B.P.), from the Formative to the Archaic Period (approximately 2,500 B.P. to 8,500 B.P.), and from the Archaic Period to the Paleo-Indian Period (approximately 8,500 B.P. to 11,000 B.P.). Archaeological materials excavated from the Paleo-Indian period have been radiocarbon dated to approximately 11,000 B.P. Stratigraphic and chronologic analysis of the archaeological materials excavated indicates that human and other animal faunal remains, such as the ground sloth, saber-tooth tiger, horse and camel, were found to coexist during the same time period. Analysis of preserved botanical remains has provided a continuous paleo-environmental record extending back approximately 30,000 years B.P. In addition, there have been unsubstantiated reports that cave divers in the early 1960's removed a skull from the 13-meter ledge area of the spring and that this skull contained preserved brain material.

Planned future excavations of the anaerobic sediment cone at the 50-meter level may provide a complete time continuum of this archaeological site and, perhaps, provide more preserved faunal material and preserved soft tissue.

The fourth speaker was Mr. Michael Faught, a graduate student from the University of Arizona. His topic involved locating and excavating underwater prehistoric archaeological sites in the Apalachee Bay area of Florida, located in the northeastern area of the Gulf of Mexico. Mr. Faught suggested that anthropologists are somewhat puzzled by the archaeological reconstruction of the cultural transition from the Paleo-Indian Period to the Archaic Period. In the same vein, Quaternary geologists are having similar problems reconstructing the geolomorphical transition from the Pleistocene to the Holocene Period. Both disciplines are acutely aware of the need to study sea level changes and the need to continue to collect paleo-environmental data from the continental shelf. The missing archaeological and geological data includes information about relict geomorphology, prehistoric settlement patterns, and the timing and effects of sea level change on these factors. There has been much written in the archaeological literature about sea level curves; however, very little archaeological research has been conducted on the continental shelf to locate inundated sites to substantiate or dispute existing sea level curves for finding additional prehistoric sites of a terminal Pleistocene age (Paleo-Indian Period).

Mr. Faught further stated that the continental shelves represent a missing and potentially large data set where it is extremely difficult to find either relict topographic and geologic features or submerged archaeological sites. Wave action destruction, subaerial erosion, Holocene alluviation, and neritic sedimentation are significant natural processes that could obscure the Pleistocene geology and continental shelf archaeology.

The search for submerged or drowned prehistoric terrestrial sites by Mr. Faught began after careful examination of onshore settlement pattern models for late Archaic and Paleo-Indian Periods. Research was focused on upland areas of high-density, extinct faunal remains and their associated lithic artifacts and on a potential offshore survey area that exhibited minimal alteration to the natural geology since the Pleistocene. A preliminary predictive model and research design were developed to search for lithic procurement stations, theorizing that lithic cultural material would have the best possibility of surviving natural destructive forces of sea level changes through time. The selected survey area included nearshore regions of the St. Marks, Aucilla, and Econfina Rivers of the Apalachee Bay because the alluvial sedimentation in these rivers is extremely low due to the solutional characteristics of the karst drainage.

The results of the initial survey located four lithic procurement stations in the five areas examined. Three sites were found close to shore in approximately 2 meters of water.

The fourth site was located 4.02 kilometers offshore at a depth of 3.7 meters and produced a large number of modified lithic materials including bifacially trimmed cores and associated flakes. Associated with the lithic debris were pieces of cypress wooden, which radiocarbon dated to 5,160 ± 100 years B.P.

The preliminary results of offshore archaeological surveys in the Apalachee Bay region indicate that by utilizing the developed predictive model, drowned prehistoric archaeological sites can be located. By examining relict features in the inundated karst region and concentrating on surveying the associated rock outcrops, site location is highly predictable.

Mr. Rik Anuskiewicz of MMS was the next speaker, and he reported preliminary archaeological investigations at Ray Hole Spring, a submerged karst feature located on the OCS. The MMS, in cooperation with the Florida Bureau of Archaeological Research, conducted preliminary underwater archaeological investigations at Ray Hole Spring. This submerged karst feature is located approximately 88.5 kilometers southeast of Tallahassee, Florida, and about 38.6 kilometers from the nearest Florida landfall. The Spring is a typical karst feature probably formed during the Pleistocene as a result of the surface limestone collapsing because of either solutional or mechanical action caused by underground drainage.

A 1976 Florida Bureau of Geology bulletin, titled "Springs of Florida," describes Ray Hole Spring as an occasional flowing spring lying in 11.6 meters of water, measuring 7.6 meters in diameter. The north side of the sink slopes southeast with the southeast side of the sink having a nearly vertical limestone wall to a depth of 18 meters. A cave strikes down and southeast from the 18-meter depth to approximately 30 meters.

The October 1986 investigation of the spring revealed a completely different environmental setting at the site. The diving reconnaissance indicated that the spring had almost completely filled in with recent (since 1976) marine shell detritus. Only about 3 meters of relief existed in the southeastern end of the sink. The archaeological investigation of the site included diver swimming reconnaissance, mapping, attempts at coring, and waterjet excavation of selected test units. Coring was discontinued because the coring tool made very little penetration in the shell matrix as a result of the small core diameter and the large size matrix of the marine shell detritus. After negative results from Test Units 1 and 2, and Core Tests 1 and 2, testing was moved to the outer rim of sink. One dive team began excavating with the waterjet at a large crevice. It was theorized that if this were an archaeological site, cultural material may have fallen or have been washed into a crevice and become trapped. The crevice was approximately 15 cms in width and ran in a southwesterly direction towards the rim of the sinkhole. Waterjet excavation approximately 15 to 20 cms into the crevice recovered several poor quality limestone or chert flakes. This material was immediately returned to the surface for examination. Continued waterjet excavation of the crevice yielded a lens of articulated whole oyster shell at the 75 cm level; at the one-meter depth, waterlogged wood was encountered. Samples of the shell and wood were collected, returned to the surface, and stabilized for future analysis. Below where the wood samples were recovered, the crevice narrowed and bottomed out. Excavation was terminated as was the initial archaeological testing.

In April 1987, analysis was conducted on the oyster and wood samples to identify the species and to obtain a radiocarbon date of this organic material. The wood species was identified as live oak, and radiocarbon dates for the oyster shell and wood dated 7,390 ± 60 years B.P. and 8,220 ± 80 years B.P., respectively. The wood sample, dating approximately 800 years older than the oyster shell and being recovered in a lower stratigraphic level than the oyster shell, suggests that these materials were deposited _in situ_.

Preliminary analysis of the data collected at Ray Hole Spring suggests that this sinkhole may be a prehistoric archaeological site. Several factors (environmental and possibly cultural) tend to support this initial contention. The radiocarbon dates obtained at Ray Hole Spring in combination with the regional sea level curve indicate that for approximately 8,200 years B.P. the sinkhole was a freshwater site supporting freshwater flora. Some time after 8,200 B.P., sea level began to rise, and by 7,400 B.P., the Ray Hole Spring area was supporting a shellfish population in a brackish water environment.

In addition, a cultural manifestation may exist at Ray Hole Spring. The two large limestone/chert flakes collected were examined by five archaeologists. They all seem to agree that the way the flakes were removed from the lithic core suggests that they could have been made by prehistoric man. However, they also agree that two flakes usually do not make an archaeological site.

Obviously, there is more work to be done to fully verify if Ray Hole Spring is an authentic archaeological site. An intensive testing program includes remote sensing studies to determine the true depth and profile of the sink hole, coring of the sediment cone to gather paleoenvironmental data, more organic sample collecting for radiocarbon analysis, and the recovery of diagnostic lithic artifacts.

The final speaker of our session was Mr. James Dunbar, archaeological field supervisor with the Florida Bureau of Archaeological Research, Department of State. Mr. Dunbar began his comments by stating that prehistoric archaeological sites inundated by the sea are the most elusive sites to locate. The sites may be deeply buried and inaccessible in some regions of the continental shelf and shallow, but difficult to identify in other areas. The karstic area of the Florida Gulf Coast represents a unique archaeological area where Paleo-Indian remains are highly concentrated and sedimentation has been minimal.

Given the difficulties associated with locating offshore sites, a model based on the type and distribution of sites on the adjacent coast was developed for the Apalachee Bay region of the Gulf of Mexico. Offshore survey work (report by Faught and Anuskiewicz this session) incorporated the assistance of fisherman and sport divers familiar with the project areas. In three days, Mike Faught's survey located four archaeological sites from one to four miles offshore. Rik Anuskiewicz and others surveyed Ray Hole Spring some 24 miles offshore and discovered evidence of what may prove to be a drowned archaeological site.

Mr. Dunbar found from his research that prehistoric site distributions in Florida occurred in changing patterns not only linked to evolving technologies but to fluctuations in the regional surface water systems. The availability of potable water in relation to other needed resources helped dictate possible site locations through time. Ninety percent of the Paleo-Indian sites containing Clovis, Suwannee, or Simpson projectiles are located near karst depressions that penetrate the Tertiary limestones of Florida. Some sites are located around isolated sinkholes and solution depressions, but most occur in areas where multiple karst features occur together and dominate the topography. The largest site clusters are located in and around mature karst river channels with smaller but significant clusters centered around karstified lakes, bays, and prairies.

1. At given points in time, from 15,000 to 5,000 years B.P., can absolute sea level stands be identified to allow chronologically evolving site predictive models?

2. Do archaeological sites exist in the eastern Gulf of Mexico that have stratigraphic integrity despite Holocene sea level transgression and marine erosive conditions?

3. What is the functional variety of archaeological sites encountered?

4. Once prehistoric offshore sites are located, can remote sensing instruments provide diagnostic signatures of the known sites?

Mr. Richard J. Anuskiewicz obtained his B.A. in 1972 and his M.A. in 1974 from California State University at Hayward. He was employed with the U.S. Army Corps of Engineers from 1974 to 1984 as a terrestrial and underwater archaeologist. In 1982 Mr. Anuskiewicz completed all requirements for his Ph.D., except for his dissertation, at the University of Tennessee at Knoxville. In 1984, he accepted a his current position at MMS, Gulf of Mexico OCS Region.

Inundated Archaeological Sites of the Florida Coastal Region: A Regional Overview

Ms. Melanie J. Stright
Minerals Management Service
Gulf of Mexico OCS Region

At least seventeen archaeological sites, inundated as a result of late Wisconsinan and early Holocene glacio-eustatic and glacio-isostatic adjustments, have been documented within the coastal area of Florida (Figure 12.1). The distribution of reported sites is more reflective of shallow-water activities, such as dredging and sport diving, which have resulted in the discovery of the sites, rather than the true distribution of sites.

Three of the reported sites--the Saxon-Holland Site, Warm Mineral Springs and Little Salt Springs--lie inland of the present coastline within the karst area of central Florida. During periods of lower sea level, the karstic topography was better drained, resulting in lower water levels at these inland lake and sinkhole sites.

SAXON-HOLLAND SITE (SITE NO. 1)

The Saxon-Holland Site is located in Blue Cypress Lake in Indian River County, Florida (see Figure 12.1). Archaeological materials and human remains ranging in age from 11,000 to 500 B.P. occur between 2 and 3 meters below present lake level (W.A. Cockrell, personal communication 1987). There is a direct relationship between the depth of the material and its age, with the oldest material being found in the deeper portions of the lake.

WARM MINERAL SPRINGS (SITE NO. 2)

Warm Mineral Springs is a sinkhole approximately 19.3 kilometers southeast of Venice, Florida, in Sarasota County. Paleoenvironmental data indicate that the spring would have been an important fresh water source during the late Pleistocene and early Holocene when the climate was more arid and local water tables were lower. The excellent preservation of organic materials in the anaerobic waters of the spring offer a unique opportunity to study the late Pleistocene environment and, also, early man. A detailed discussion of this site is provided in Mr. Wilburn A. Cockrell's paper, included in these proceedings.

LITTLE SALT SPRINGS (SITE NO. 3)

Little Salt Springs, a water-filled collapse limestone sinkhole, lies 4.8 kilometers northeast of Warm Mineral Springs in Sarasota County, Florida. The site is an Archaic village and cemetery (ca. 7,000 to 5,000 B.P.) which extends into the sinkhole to a depth of 10 meters below the present water level (Cockrell, 1980).

A wooden mortar, two firepits (one near the mortar), food remains, and unidentified carved wooden implements were discovered within the sinkhole at a depth of about 10 meters below present water level. At a depth of 27 meters, the shell of a giant land tortoise with two wooden stakes stuck between the plates of the shell was found. A radiocarbon date of 13,000 B.P. was obtained from one of the stakes (C. Clausen, unpublished report, 1979).

Human remains from a total of 50 individuals, dating approximately 7,000 to 5,000 B.P., have been recovered from the site. Pleistocene faunal remains recovered from the sinkhole include giant ground sloth, giant land tortoise, and bison (C. Clausen, unpublished report, 1979).

A burned log dating 10,000 ± 200 B.P. was located in a cave at the springhead, 24 meters below the present surface of the sinkhole (Lazarus 1965). Although the remains of seven humans also have been found in the cave, direct association with the burned log has not been demonstrated. No artifacts have been removed from the cave.

Like Warm Mineral Springs, Little Salt Springs would have provided an important fresh water source during the late Pleistocene and early Holocene when the climate was more arid and local water tables were lower.

THE DOUGLAS BEACH SITE (SITE NO. 4)

The Douglas Beach Site extends from the beach to approximately 600 meters offshore in the vicinity of Ft. Pierce, Florida in water depths of 3 to 12 meters. The base of the site is formed by coquina of the Anastasia Formation. Sediment-filled depressions occur within the coquina. Sand forms the lowest sediment layer within these depressions across part of the site. The sand layer, or where it is absent, the coquina rock, is overlain by a dark gray-green clay, which is capped by a dark gray peat. Organics within this peat layer gave an average radiocarbon date of 5,000 B.P. (J. Dunbar, personal communication 1987).

In 1979, a human maxilla with six teeth, a portion of the palate, and part of the sinus cavity was recovered from a pocket of shell hash in the coquina. The find had no provenience. Newnan age projectile points were found out of context, but, due to their known time range, probably came from the clay layer which lies beneath the 5,000 year-old peat layer. Wooden stakes, possibly sharpened at one end, were found within the peat layer. Glades Plain ceramics have been found at the surface of the site. This material is apparently eroding from a nearby land site and being redeposited offshore (J. Dunbar, personal communication 1987).

Although remains of extinct Pleistocene fauna have been found at the site, and artifacts of stone, shell, and bone (bone pins) and human remains have been recovered, direct association between the two components presently cannot be demonstrated. This site is important in demonstrating that intact Pleistocene deposits and associated archaeological deposits can be preserved offshore of high-energy coastline.

THE VENICE BEACH SITE
(SITE NO. 5)

This site extends from the present beach at Venice, Florida, out into the Gulf of Mexico. The site consists of a complex of shell middens, with at least two on the beach and one offshore. The top of the offshore midden lies at 2.23 meters below present mean sea level. The offshore midden produced large quantities of shell, Perico Islands Period potsherds, burned and unburned fishbones, land mammal bones, and charcoal. The matrix of the midden was clayey sand. An in-situ sample of charcoal from 20 to 31 cm below the top of the midden gave a radiocarbon date of 1981 $\pm$ 85 B.P. (Ruppe', 1980). Approximately 100 meters seaward of the offshore midden, in 5.5m of water, a number of Middle Archaic stone tools have been found lying on the seafloor.

A test pit in one of the beach middens revealed the same types and frequencies of materials as those recovered from the underwater midden; however, the pollen from the beach midden indicated a marsh environment, while the pollen from the offshore midden reflected a predominance of arboreal species such as pine and oak (Ruppe', 1980). It is assumed that some change in eustatic sea level within the last 2,000 years has caused inundation of this site.

TERRA CEIA BAY SITE
(SITE NO. 6)

Clay dredge material from Terra Ceia bay in Manatee County, Florida, was used to build a beach on the northeastern side of the bay. Subsequently, archaeological material and Pleistocene faunal material was discovered eroding from the clay beach.

The archaeological material includes projectile points; plano-convex turtle back scrapers; a hammerstone; chert flakes; and plain, sand-tempered, black pot shreds. Six of the ten projectile points recovered represent types similar to an Alabama Dalton Complex dating approximately 9,300 B.P. (Warren and Bullen, 1965). Three of the points are Greenbrier points, a Florida variation of the Dalton point.

The projectile points recovered from this site suggest a late Paleo-Indian to early Archaic site; while the pottery suggests a Woodland component.

Well-mineralized Pleistocene faunal remains recovered from the site include bison horn cores, fragments of mammoth teeth, turtle shell, manatee rigs, fragments of mastadon teeth, and shark teeth (Warren and Bullen, 1965).

No information on the paleogeography or stratigraphy of the bay at the dredge site was provided in the literature.

APOLLO BEACH SITE
(SITE NO. 7)

Dredge material from Tampa Bay, Florida, used as fill for a real estate development at Apollo Beach on the east side of the bay, has produced artifactual and some Pleistocene faunal materials. The dredge material came from a zone ranging between 1 meter below mean high tide (bay bottom), to 5.5 meters below mean high tide (the maximum depth of dredging).

Lithic material recovered from the dredge fill site includes projectile points, scrapers, knives, bifacial core choppers, unifacial core planes, one drill, flakes, worked flakes, and cores. Thirty-four of the 37 projectile points recovered were angle-notched and bifacially worked with little secondary retouching. Pot sherds representing the Orange (fiber-tempered), Transitional, Deptford and Perico Island Periods were also found at the Site (Warren, 1968 (a)). The artifactual material suggests that the original archaeological deposits in the bay is late Archaic to Woodland.

TURTLECRAWL POINT SITE
(SITE NO. 8)

Channel dredging to a depth of approximately 3 meters in Boca Ciega Bay, near St. Petersburg, Florida, produced Early Archaic and Middle to Late Archaic artifacts from apparently _in-site_ archaeological deposits within the bay (Goodyear, et. al., 1980).

The base of the site, at approximately 3 meters below present mean sea level, is marked by the middle Miocene Hawthorn Formation, which locally contains abundant chert. A blue-green clay overlies the Hawthorn Formation and contains residual chert from that formation. Quartz sand overlies the clay layer. The stratigraphy of the dredge spoil pile matches the original geologic stratigraphy, indicating that the dredge first encountered the clay, then the overlying sand. This was explained by the fact that the dredge had intersected the clay deposit in the sloping valley wall of an ancient river channel, then, moving laterally and upward, had contacted the overlying sand deposit.

The Early Archaic material included four Bolen Beveled Point, Two Clear-Fork Gouges, a hafted spokeshave with graver spurs, flake scrapers, and three denticulates. A bifacially flaked adze was found that is similar to Early Archaic Dalton adzes.

The Middle to Late Archaic material included one Marrow Mountain Point, one Newnan Point, and two Florida stemmed Archaic points. Two columella shell gouges and the distal portion of a dagger-shaped tool made from a deer metapodial were also assigned to this late Archaic occupation. The shell gouges were radiocarbon dated to approximately 4,400 B.P. (A.C. Goodyear, personal communication, 1987).

Most of the lithic material is not of the local Hawthorn chert but of a chert foreign to the site. None of the lithics were water-worn, indicating that they had been dredged from _in-situ_ archaeological deposits.

Shell material, mainly _mercenaria_, was present in the spoil pile. A subbottom profiler run just offshore of the point produced a low-amplitude, domed reflector immediately above the clay reflectors (S.B. Upchurch, personal communication, 1987). This was interpreted as a possible midden deposit and the probable source of the _mercenaria_ found in the spoil pile.

Regional sea level curves indicate that sea level was 12 to 22 meters lower than present during the Early Archaic occupation, making this component an inland site approximately 13 to 28 km east of the coastline. The Early Archaic site is interpreted to have been a lithic procurement and tool manufacture area.

The Middle to Late Archaic component (ca. 7,000 to 4,000 B.P.) was probably coastal. If the domed reflector, observed on the subbottom profiler data, does represent a shell midden, the site function may have been shellfish procurement and processing.

TAMPA BAY SHELL DEPOSITS (SITE NO. 9)

Shell dredging in Tampa Bay has produced Pleistocene vertebrate fossils, artifacts, and one well-mineralized midsection of a human femur (Warren, 1972(b)). A survey of public and private roads constructed from the Tampa Bay shell resulted in an inventory of artifacts including flakes, scrapers, knives, and projectile points. Two of the projectile points, a side-notched Bolen point and a Beveled Bolen point are diagnostic of the Paleo-Indian Period in Florida. The shell itself is probably derived from prehistory shell middens in the bay.

CALADESI CAUSEWAY SITE (SITE NO. 10)

Draglines, dredging to a depth of 5.5 meters below mean high tide in St. Joseph's Sound near Clearwater, Florida, brought up artifactual material suggestive of a Paleo-Indian of Early Archaic lithic workshop. The dredge material was used to construct a causeway.

The ground surface of the causeway was covered with flakes and cores of silicified limestone, and three test pits dug into the fill material showed the lithic debitage to be extremely dense. Artifacts included hammerstones and crude, percussion-flaked knives (Warren 1968(b)). The only diagnostic artifact was the base of a crude, percussion-flaked Suwannee Point. Two other projectile points could not be precisely identified. One was made of mineralized bone, and the other resembled a Bolen Beveled Point, but also had characteristics of a stemmed Archaic point.

The crude percussion flaking of the artifacts and the base of the Suwannee Point suggest that the site represents a Paleo-Indian to Early Archaic Workshop. Like the Turtlecrawl Point Site, with sea level at 12 to 22 meters lower than present, this site would have been well inland of the coast at the time of occupation.

STORM HARBOR MARINA SITE (SITE NO. 11)

Just north of the Caladesi Causeway Site, and approximately 3 miles south of Tarpon Springs, Florida, another channel dredging operation produced artifactual material. The channel was dredged to a depth of 5.5 meters, and the fill was used as land fill adjacent to the dredge site. The surface of the fill material was littered with flakes and artifacts.

Artifacts recovered from the site include small bifacially worked tools (probable scrapers), a small drill, a thin, plano-convex knife or scraper, a high-crowned plano-convex scraper, two non-diagnostic stemmed points, and two small hammerstones. Diagnostic artifacts include Hernando Points, a Clear Fork Gouge, and two non-beveled Bolen Points, or Greenbrier Points (Warren, 1972(a)).

The original stratigraphy of this site has not been studied; therefore, the elevation of the stratum from which the artifactual material was derived is uncertain. The few diagnostic artifacts found in the dredge fill material range from Paleo-Indian to Late Archaic; therefore, the original archaeological deposit may be multicomponent. The debitage suggests a workshop area; however, a broader function of the site is not precluded.

ONE FATHOM SITE
(SITE NO. 12)

The One Fathom Site is a shell midden that lies approximately 0.5 miles seaward of the present beach near New Port Richey, Florida.

Archaic lithic material and Deptform Period shreds have been recovered from the midden deposit. This midden would have been subaerial until approximately 2,600 B.P. A minor sea level reversal would have re-exposed the midden deposit between 2,050 B.P. and 1,650 B.P. (Lazarus, 1965). The dates derived from the sea level curve are completely compatible with the diagnostic artifacts recovered from the midden deposit, and indicate that the site was probably abandoned due to rising sea level at approximately 2,600 B.P.

CHASSAHOWITZKA RIVER SITE
(SITE NO. 13)

This site is situated on the drowned bank of the Chassahowitzka River, Citrus County, Florida, at its confluence with a former tributary. The site has been severely deflated by tidal currents. All that remains are concentrations of archaeological material within pockets in the limestone bedrock at elevations of 0.5 meters to 2.5 meters below present mean sea level (R.J. Ruppe', personal communication, 1987).

Artifacts recovered from the site include Middle Archaic through Late Archaic projectile points, and ceramics dating approximately 1,400 to 1,100 B.P. (R.J. Ruppe', personal communication, 1987)

Results of the research on this site will be published in an upcoming issue of the Florida Anthropologist.

OFFSHORE CHERT OUTCROPS
(SITE NO. 14-17)

Archaeological investigations of chert rock outcrops within the coastal marsh and shallow offshore areas of the Apalachee Bay Region, Florida, identified ten prehistoric quarry sites. Six of the sites occur on the edge of the coastal marsh, but extend below the low tide line. Of the four offshore sites, three are partially exposed at low tide, and the fourth, the Econfina Channel Site (8TA531), occurs 5.5 kilometers offshore in the relict channel of the Econfina River. A detailed discussion of this site is provided in Mr. Michael Faught's paper, included in this proceedings.

Numerous coastal rivers in Florida have produced Pleistocene faunal material and Paleo-Indian artifacts. The best documented of these drowned river sites are the Page-Ladson Site in the Aucilla River whose basal levels are at 8.5 meters below present river level (J. Dunbar, personal communication, 1987); the Piney-Island Site in the Oklawaha River at 0.5 to 1 meter below present river level; and the Tarpon Point Site in the Mayakka River reported to lie at mean sea level, but which is inundated at high tide (L. Murphy, personal communication, 1987).

Like Warm Mineral Springs and Little Salt Springs, many other inundated Florida sinkholes have produced Pleistocene faunal material and archaeological material. Among these are Wakulla Springs, Silver Springs, Hornsby Springs, Devils Den, and Jughole Springs of the Ichetucknee River. With the possible exception of the Silver Springs Site (Hoffman, 1983), the association of faunal and archaeological material has not been demonstrated (Cockrell and Murphy, 1978(b)).

The sites discovered thus far suggest that there will be an abundance of archaeological material found off the coast of Florida and that these materials (including organics) will often be well preserved. The sites will probably concentrate in the vicinities of sinkholes, relict fluvial channels, relict estuarine deposits, and outcrops of cryptocrystalline rock. Information contained in these sites may provide important information on prehistoric human migrations, settlements patterns, subsistence strategies, and cultural contacts across now-submerged landmasses.

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Ms. Melanie J. Stright earned a B.A. in anthropology at Ohio State University in 1976. From 1976 to 1978, she was district archaeologist for the Rawlins District of the Bureau of Land Management in Rawlins, WY. In 1978, she became the staff archaeologist for the Gulf of Mexico Outer Continental Shelf Office, where she has worked on developing the marine archaeology program and geophysical survey requirements for oil and gas related high-resolution surveys. Her current research interests are the archaeological applications of remote-sensing methods, paleoenvironmental reconstruction, and Holocene sea level change.

A Consideration of Archaeological Wetsites

Dr. Glen H. Doran
Florida State University
Department of Anthropology

INTRODUCTION

Archaeological "wetsites" are by definition locations where remnants of past human activities are preserved in saturated or nearly saturated settings. The biggest contrast to the typical terrestrial site is in the often excellent preservation of organic materials, difference in excavation techniques, and the necessity of careful conservation (chemical treatment) of virtually all recovered materials.

Archaeological materials can enter saturated settings in several ways. Materials can be intentionally placed in saturated settings such as apparently occurred at Windover, a burial area in east central Florida. Materials can be accidentally discarded or lost in wet settings. In some cases, originally dry sites can be covered with water or organic or other soils that effectively seal the moisture in and limit decay.

PRESERVATION IN WETSITES

Preservation of organic materials, in particular, is what provides much of the scientific potential of many wetsites. The nature of materials recovered in wetsites is dependent upon both what materials are deposited and what materials survive. In many terrestrial sites, organic materials do not survive unless they are carbonized.

Wooden artifacts, stakes, grinding tools, awls, canoes, nets, carvings, baskets, fabrics, etc., appear to be preserved in acidic, basic, and chemically neutral saturated soils (Cushing, 1987; Gilliland, 1975; Beriault et al., 1981; Sears, 1982; Purdy, 1979,1981,1987; MacDonald and Purdy, 1982).

Preservation of soft tissue, in the form of the bog bodies of Europe, is characteristic of acidic bogs where a natural tanning process takes place. Stomach contents, leather, fabric, and other materials may survive (Fischer, 1980; Glob, 1969). Although such acidic bogs exist in the New World, chemical differences, perhaps related to the plants comprising the bog habitat itself, have not produced tanned bodies. Efforts to extract DNA from an English bog body failed and indicate acid bog settings are not conducive to some of the kinds of research that are possible with New World materials (Hughs et al., 1986).

Virtually the only New World parallels in the preservation of soft tissue in wetsites are in the preservation of brain tissue in a number of Florida locations--Windover, with over 90 individuals; Warm Mineral Springs (Royal and Clark, 1960); Bay West (Beriault et al., 1981); Republic Groves (Wharton et al., 1981); and the historic St. Marks Cemetery (Dailey et al., 1972.)

Plant materials (stems, seeds, leaves, pollen, etc.) are common in wetsites and can provide excellent archaeological, climatological, and environmental data (Alexander, 1986; Brooks et al., 1979; DePratter and Howard, 1981; Levathes, 1987; Watts, 1971,1975,1986; Spackman, 1987; Stout, 1986). Preservation of bone, antler, and shell generally requires pH conditions approximating neutrality (Nabergall, 1987).

Stone and ceramic artifacts survive in most wet or dry settings with very little if any deterioration.

WHERE ARE WETSITES FOUND?

Wetsites are more abundant in areas where human activity concentrated, and they can be found in river channels, particularly large, relatively slow moving streams with sand or muddy bottoms that may provide some physical protection to any deposited materials (Cockrell, 1980; Dunbar and Waller, 1983; Waller, 1969). Within the floodplain of water courses, the lower levels of some terrestrial sites may be saturated and can also be classified as wetsites (Purdy, 1987; Jahn and Bullen, 1978).

Some coastal sites are saturated as a result of inundation after deposition (Ruppe', 1980) while others represent events and activities that took place in coastal waters (Cockrell and Murphy, 1978). Shipwrecks are clearly not the only type of coastal wetsites, though they have received the bulk of the attention (Marmelstein, 1975; Marx, 1969).

Wetsites can also be found within lakes, ponds, and springs (Cockrell, 1973; Clausen et al., 1975; Clausen et al., 1979). The Windover materials were approximately 10 ft. below pond bottom in a small 1/4 acre freshwater pond on the east central coast of Florida (Brevard County-Doran, 1986; Doran and Dickel, 1986).

Saturated, but not necessarily submerged, organic soils (peats in particular) are characteristic of wetlands, and the past bogs of Europe are also well known for their archaeological productivity.

At the simplest level, the presence of moisture reduces the physical stress on materials (particularly organic materials) by limiting the frequent hydration/dehydration cycle, which promotes deterioration by expansion and contraction (Stone et al., 1986).

The dynamics of water and/or soil chemistry are also critical in preservation. At Windover and Warm Mineral Springs, Florida, very hard, highly mineralized waters promote preservation. Highly acidic saturated peats have already been mentioned with respect to soft tissue preservation, but at the same time, very acidic conditions can "dissolve" the underlying bone as well as the molecular integrity of some molecules such as DNA (Hughs et al., 1986).

Low oxygen levels (reducing environments) also enhance preservation by limiting the biological activity of decomposing bacterial and fungal organisms.

The physical stability and integrity of the matrix (soil) in which such materials are deposited is also important. Increased movement of materials downslope or across coarse surfaces increases destruction, as will water movement and wave action. At Windover, no fabrics and relatively few articulated skeletal segments were recovered from sloping pond areas. In these locations materials were slowly but inexorably sliding downslope. Where the pond bottom was flatter, approximately 100 articulated burials were recovered, and 37 burials contained had woven fabrics.

Other factors, such as temperature, may also be important. Decay processes of fungi and microbes are reduced at lower temperatures, and this may partially explain the preservation of bog bodies in Europe. Some materials, such as stone artifacts and pottery, are relatively stable, but organic materials are subject to the interplay of changes in moisture levels, temperature, water, and soil chemistry.

Some chemical changes, referred to as digenetic changes, can be precursors to fossilization and involve absorption or depletion of compounds and elements from the soil matrix (Walker and DeNiro, 1986). If the mineralogical component is depleted (demineralization), rapid deterioration can occur. Mineral compounds can also replace organic compounds, and this mineralization, while promoting physical survival, may preclude some chemical and elemental analysis (Buikstra and Mielke, 1985).

At Windover, preliminary analysis of preserved brain tissue indicates a replacement process elevated sulphur levels. Microscopic and macroscopic features are still preserved, as is some molecular structure (Doran et al., 1986). Elemental analysis of bone samples (Hancock, 1987) indicates an abnormal absorption of strontium, obviating some dietary inferences based on trace element analysis (element reference). At the same time, some bone proteins appear well preserved enough for researchers to attempt to develop a biological profile of this 7,000 year old population (Tuross, 1987).

In some wooden artifacts the long fibers providing structural integrity breakdown and conservation becomes difficult. Warping, splitting, checking, and deterioration became problematic. Materials less than 2,000 years old seem to exhibit relative stability while the materials from Windover are more difficult to preserve (Gardner, 1986).

WETSITE DISCOVERY

Archaeological sites (both wet and dry) are often accidentally discovered as a result of construction or other ground disturbing activities. It could be argued that proportionately greater numbers of wetsites escape the attention of archaeologists than dry sites, simply because they are less visible and less accessible.

In addition to accidental discovery, many dry sites are found during archaeological surveys that are designed to identify sites prior to construction or development, as part of cultural resource management programs. Archaeological assessments or surveys are legally required in cases where state or federal property is involved (Tesar, 1986). Survey programs are less effective in wetland and underwater settings.

A large problem in locating wetsites lies in their almost invisible nature and the frequent necessity of entering a "hostile" environment to locate them. Wetsites are either underwater, thus creating problems of simple access, or they are difficult to identify because of the water saturated conditions existing in bog, marsh and lake settings. Literally millions of dryland acres have been surveyed by archaeologists, but only a fraction of the areas with potential wetsites have been effectively studied.

CONSERVATION NECESSITIES OF WETSITE INVESTIGATION

Wetsite investigation is often more difficult and involved than the investigation of a typical terrestrial site. Different excavation strategies may be needed, and the waterlogged condition that preserves materials necessitates special conservation techniques. Some of the Windover procedures will be presented as examples of the conservation requirements necessitated by analytical goals as well as the nature of the materials.

Saturated faunal and human bone was removed from the field in plastic bags and, as rapidly as possible, treated with bulking agents that replaced the water. Initially, polyethylene glycol (PEG) was utilized, but an acrylic emulsion, Rhoplex AC-33 (Conservation Materials, Sparks, Nev.), proved more satisfactory. Small samples of human bone were also removed and frozen for specialized chemical and protein analysis. Concern that molecular changes were continuing to take place even after conservation prompted removal of larger bone samples, which were frozen at -70 centigrade (Tuross, 1987).

Floral materials (seeds, leaves, wooden artifacts, etc.) involved a variety of conservation procedures including refrigeration; alcohol saturation; and treatments with PEG, Damar, and other compounds (Stone et al., 1986). Refrigeration (in sealed containers) reduces the possibility of bacterial or fungi decay and minimizes dehydration. Woven fabrics (made from plant materials) and wooden artifacts undergo a multistep procedure similar to that applied to wooden artifacts. This procedure involves refrigeration, removal of mineral salts by soakings in deionized water, and replacement of water with alcohol/ethulose/PEG solutions. None of the fabric materials has completely passed through the conservation sequence as of December 1987, even though some began treatment over a year ago (Adovasio, 1986).

Brain tissue was rapidly removed, placed in plastic bags, flooded with nitrogen gas, sealed, refrigerated for transport and frozen at -70 centigrade within 24 hours to minimize possible degradation and maximize future analysis possibilities.

Clearly, one of the most profound obligations wetsite investigation entails is a willingness to ensure that the materials recovered are conserved properly, not only for current research needs, but also for future research (Purdy, 1974; Stone et al., 1986).

ACCOMPLISHMENTS OF WET SITE INVESTIGATION--WINDOVER AS AN EXAMPLE

Some have estimated that over 80 percent of most societies' "artifacts" are organic and may not survive in normal archaeological settings. The opportunity to study materials from wetsite settings can provide a much greater understanding of earlier populations and are illustrated by the multidisciplinary research efforts of the Windover Archaeological Research Project.

Excavation at Windover required installation of an extensive wellpoint system (approximately 160 wellpoints between 11-21 ft. in length) which pumped 700 gallons of water per minute 24 hours a day for the first several months of excavation. This demonstrates that dewatering of some wetsites is possible and practical.

The collection, representing a minimum of 155 adults and subadults, is one of the largest samples of human skeletal material of this antiquity in the New World (Taylor et al., 1985; Smith, 1976; Protsch, 1978). The collection dates from between 7,000 and 8,000 years B.P. (before present - A.D. 1950) and represents an Archaic hunting-gathering population (Milanich and Fairbanks, 1980; Smith, 1986; Steponaitis, 1986; Ford, 1985). Data on health, diet, disease, demography, etc., in some ways, represents "base line data" useful in looking not only at human adaptation in this early time, but also as a valuable comparative reference point for understanding later populations' adaptation (Dickel, 1987).

The fabrics from Windover, exhibiting seven different twining and manufacturing techniques, are the oldest fabrics in the southeastern United States and are regarded by some as the largest, most complex set of fabrics of this time period in the New World (Adovasio, 1986). Analysis of the fabrics, bone, antler, stone and wooden artifacts will provide new insights to early craft sophistication.

Plant remains identified as the semidomesticated bottle gourd (Lagenaria siceraria; Newsom, 1987) are the oldest known bottle gourd materials in North America (Smith, 1986; Conrad et al., 1984; Richardson, 1972; Kay et al., 1980). These findings support the proposition that the earliest North American domesticates are tropical plants, and, even at this early date, relations between populations may have been more complex than realized (Ford, 1985).

Identification of preserved human mitochondrial DNA from Windover brain tissue yielded the oldest identified human genetic materials indicating that in some situations molecular analysis of archaeological materials may be possible (Doran et al., 1986).

Study of the preserved bone proteins and amino acids, including (but not limited to), osteonection, transferrin, albumin, IGG, IGN, IGA, methionine, and cystine, provide a unique opportunity to develop a new type of biological profile of an archaeological population. Further studies of these materials should expand our understanding of prehistoric human biology and population relationships (Tuross, 1987).

Detailed analysis of faunal and floral materials are providing data critical to understanding hydrological, climatological, and environmental changes in east central Florida for the last 11,000 years (Newsom, 1987; Nabergall, 1987; Holloway, 1985a, 1985b; Stout, 1986; Spackman, 1987; Flowers, 1985; Frazee, 1986).

THREATS TO WETSITE SURVIVAL

Wetsites, like all archaeological sites, are consistently being destroyed by both natural and human agencies. Natural changes in hydrology and water and matrix chemistry, as well as natural exposure of wetsites by wave action, erosion, etc., can destroy archaeological sites. Some of these destructive agents are beyond normal human control. Some destruction is, however, avoidable, if the importance of the unwritten saga of human experience is recognized, and steps to protect and study such sites are taken.

Urbanization, pipeline construction, dredging, and other coastal and wetland modification are increasingly involving areas containing archaeological materials. If sites can be recognized and activities shifted to avoid sites, such construction may be beneficial in that wetsite locations may be better understood. Furthermore, if such accidentally discovered sites can be investigated, we all benefit.

An invisible threat exists when large scale hydrological patterns are changed for farming, ranching, and other land use needs, and previously saturated areas are dehydrated (Coles, 1984). Archaeological materials below the surface begin to undergo an inexorable dehydration that can eventually lead to total destruction. The loss of these invisible resources is in some ways the most frightening prospect of all. In some areas of the world, such land use changes are associated with peat mining for electrical energy production. Coles has noted that most of the archaeological materials in the Irish National Museum were recovered from wetsite settings (Coles, 1986). As peat is mined without a consideration of the archaeological loss the prospects for understanding many aspects of Ireland's past become increasingly difficult. Coles fears that by the turn of the century the wetsites heritage of Ireland will be irrevocably lost.

Regrettably, intentional relic collecting, without a consideration of the archaeological significance, site integrity, or the potential contribution to our body of knowledge, continues in many areas. In some states, legally sanctioned salvage of archaeologically significant coastal wrecks amounts to little more than pot hunting when insufficient consideration of the scientific importance of the materials exists. This is especially graphic when materials are auctioned off to the highest bidder or the "booty" divided up among investors. Some states, such as Florida, have virtually assured continued pillage by treasure hunters. Other states, like Texas, deem the scientific value of coastal materials sufficiently important to restrict such activities within their coastal waters.

Archaeological sites on state and federal property are protected by state and federal antiquity statutes. Literally millions of dollars are annually spent on seeing that this priceless heritage is not wantonly destroyed. By and large, sites on private property are afforded virtually no protection. Regrettably, even when owners are cooperative, investigations are severely impeded by the lack of funds for proper scientific treatment of these important legacies of human experience.

ARE SOME AREAS MORE LIKELY TO PRODUCE WETSITES THAN OTHERS?

While reliable models capable of predicting wetsite locations are relatively crude, some generalizations about possible locations of wetsites may be helpful.

In North America, wetsites discovery would seem most likely in areas that have been submerged in the last 12,000 years and are, or were, in relatively low energy settings where conditions for preservation may be better. Areas that are rich in organic soils (peats and related soils) may contain significant archaeological materials. When such areas were frequently inhabited or visited by prehistoric and historic peoples, the possibility of wetsite occurrence increases. Submerged peatlands, stream channels, estuary and bay margins would be likely to contain saturated archaeological materials.

During the course of construction, dredging, etc., the following kinds of materials might be discovered:

- o large wooden artifacts (stakes, canoes, etc.)
- o human skeletal material (bones of the leg and skull are the largest and probably the most noticeable)
- o pot sherds, charred bone, fabrics, and small wooden artifacts (these would be very difficult to casually identify in dark peaty soils)
- o stone artifacts (although small, if they are a light color they could be distinct against a dark peaty soil)

Any observed materials should be collected and resubmerged in water; further impact to the site should be minimized if at all possible; the location or general area they came from recorded, and an archaeologist contacted as rapidly as possible.

Pragmatic observers have shrewdly noted the media attention that can result from such discoveries and subsequent investigations can create a very positive public image for a company or industry. Local business may also benefit from the increased tourism such sites may generate. Careful planning can also incorporate tours of the site by local dignitaries, school groups, civic organizations enhancing education about archaeological resources. We estimate in the three years of excavation (August - Jan.) between 10,000 and 15,000 people visited Windover. On the Open House Weekend at Windover over 4,000 people visited the site. Needless to say, such public interest requires forethought and planning.

This is almost the exact scenario that began in 1982 when the Windover site was discovered. The accidental discovery, shifts in construction routes, involvement of archaeologists, and the discoveries of the last three years have been reported worldwide. As a result, thousands of central Florida citizens are better informed and more aware of the rich Florida archaeological heritage.

Recognition of the significance of archaeological resources is no guarantee that they will be safe, but it is the first step. Only through enlightened management and understanding of the potential of wetsites to vividly and uniquely reveal the saga of human existence will our prehistoric heritage be safe.

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Dr. Glen Doran is an Associate Professor of anthropology at Florida State University at Tallahassee. He received his B.A. and M.A. from the University of Texas at Austin and his Ph.D. from the University of California at Davis. His primary research interests are in prehistoric human adaptation and paleodemography. His secondary research interests are in elemental analysis of archaeological materials. Dr. Doran has been the director of the Windover Archaeological Research since 1984 and has been studying a prehistoric cemetery dating between 7,000 and 8,000 years B.P.

Results and Implications of the Multidisciplinary Archaeological Research Project at Warm Mineral Springs, Florida

Mr. Wilburn A. Cockrell
Florida State University
Department of Anthropology

Warm Mineral Springs is a 70-meter-deep, spring-fed sinkhole 16 kilometers inland from the Gulf of Mexico in Sarasota County, Florida. Saline, anerobic water, originating in the Floridian Aquifer some 1,000 meters below surface, enters the cenote at a depth of 70 meters below water surface at a temperature of 32-34 degrees C. The principal hot water spring provides some 19.4 million gallons per day.

The cenote's limestone walls are draped intermittently with dripstone formation zones from 4 to 30 meters below surface; additionally, the underwater sediments have been producing exotic tufa specimens. The limestone matrix is of the Hawthorne Formation of the Miocene.

There are three archaeological components: 1) the remains located on land, 2) dry-laid deposits on the 13-meter-below surface ledge, and 3) deposits in the debris cone on the bottom below 40 meters.

Recovered archaeological deposits range from Formative Stage artifacts (ethnographic present back to approximately 2,500 B.P.) artifacts from the Archaic Stage (2,500 B.P. to approximately 8-9,000 B.P.), and Paleo-Indian Stage materials dating back thus far to 11,000 radiocarbon-years B.P.. The oldest human remains stratigraphically and chronologically coexist with ground sloth, saber cat, horse, camel, and extant species. Well-preserved botanical remains provide a continuous record extending back an estimated 30,000 years from the initial opening of the cavity during a time of lowered sea level.

Current research is principally conducted on the 13-meter ledge and on the debris cone 50 meters below surface. Both SCUBA and surface-supplied air have been used. Technology consists of time-honored archaeological techniques coupled with innovations, when need dictates. Mixed gas diving with surface decompression on oxygen is planned for the upcoming dive season in order to increase bottom time and diver safety.

Warm Mineral Springs and related sites have long been seen by the principal investigator as furnishing primary critical data for predictive modelling for site location on the Outer Continental Shelf. 1 In 1973 the Bureau of Land Management was first informed of the research value of this type site, and subsequent papers have continued to emphasize the technical and scientific applications of the Warm Mineral Springs research.

Phase I of the writer's research as principal investigator was conducted as Florida State Underwater Archaeologist from 1972-1983; Phase II began in 1983 and continues, funded by the Florida State Legislature currently through Florida State University's Department of Anthropology.

Mr. Wilburn A. Cockrell is the Director of the Warm Mineral Springs Archaeological Research Project, Florida State University. He holds a B.A. in anthropology (University of Alabama, 1963), an M.A. in anthropology (Florida State University, 1970) and has completed all but dissertation for his Ph.D. in anthropology at Arizona State University. He began Phase I research at the 12,000-year-old prehistoric site at Warm Mineral Springs as Florida State Underwater Archaeologist in 1972; Phase II of his research began in 1983 and continues, funded by the Florida State Legislature. He has published extensively on early man studies and submerged terrestrial sites, as well as shipwreck archaeology and related legal issues.

Some Archaeological Sites in the Apalachee Bay of Florida

Mr. Michael Faught
University of Arizona
Department of Anthropology

The results of our survey showed relevant lithic artifactual materials in 4 of 5 outcrops located. Of these, 3 are found close to shore, in more than 6 feet of water (WA 275, 267, JE654). More significantly, a relict channel of the Econfina River was identified in 12 feet of water 2.5 miles offshore, and significant numbers of artifacts, including bifacially trimmed cores and numerous flakes were found at its margins. In no cases were overlying neritic sediments more than 15 cm, and the relict channel was easily identified by its depression and the lack of plant material in it. Associated with the lithic debris were pieces of cypress wood which dated to 5,160 ± 100 bp (A-4696 University of Arizona and NSF grant BNS 8505083).

The results of this survey have substantiated our ideas of the ease of identity of relict features in inundated karst geomorphology, the technique of finding outcrops as lithic procurement areas, and the potential of finding other kinds of prehistoric settlements. The goals of our next season are to continue identification of relict channels, search for sea level standstills, and obtain core samples of river stratigraphies. Two other sites (JE 652, 653) have been added since our initial survey, and we expect to find many more.

Many anthropologists who are concerned with reconstructing the transition from Paleo - Indian to Archaic adaptations are in the same boat with Quaternary geologists who are interested in the transition from Pleistocene to Holocene time: both are acutely aware of the reality of sea level rise and the need for more data from now inundated continental shelves. Missing data include information about relict geomorphology, past human settlement patterns, and the timing and effects of sea level rise on them. While much work has been published about the extent, character, and timing of sea level change (Bloom, 1977, 1983; Morner, 1971; Ruddiman and Duplessey, 1985, for samplers), the archaeological literature is virtually empty of reports of the inundated shelf sites, particularly from late Pleistocene early Holocene context (see Flemming, 1983 for survey). This paper reports the findings of mid-Holocene relict geomorphology and archaeological sites in the Apalachee Bay of Florida, and suggests the high potential of finding many more, including terminal Pleistocene ones.

To suggest that continental shelves represent a missing and potential data set is not to understress the difficulty of finding either relict topographic, geologic features, or archaeological sites. Wave destruction, and Holocene alluvial, and nertic sedimentation are significant processes in the obscuring of Pleistocene details (Flemming, 1983; Emery and Edwards, 1966; Coastal Environments, 1977). These facts, in combination with the logistics of working underwater, can be offset by locating research in areas with minimal alteration since the Pleistocene, by relevant stratigraphic data, and by adequate archaeologic potential (i.e. high density sites of relevant time periods), thus ensuring cost-effective, multidisciplinary research activities. The Apalachee Bay of northwestern Florida is just such an area (Figure 12.2).

A pilot survey by J.S. Dunbar (Florida Department of State), M.K. Faught (University of Arizona), and PART of Florida (a competent amateur organization) was undertaken in July of 1986 to assess the potential of finding offshore archaeology and geomorphology. Our survey area included the nearshore regions of the St. Marks, Aucilla, and Econfina Rivers of the Apalachee Bay. The associated onshore region, the Ocala Uplift, is a raised karst feature with the Floridian aquifer at the surface. High density extinct faunal remains and Paleolithic to Archaic lithic artifacts are well known in the region (Neil, 1964; Dunbar and Waller, 1983), and are currently under professional underwater excavation (Dunbar, et al., In Press). Alluvial sedimentation in these rivers is rare because of the solution characteristics of karst drainage, and sinkholes within the onshore rivers collect quiet water peat and marl sediments, with a high degree of organic preservation. Most terrestrial rock outcrops are the loci of dense chert, and are likely spots for prehistoric lithic procurement. Our survey procedure was to locate inundated wreck outcrops and hand fan the neritic sediments while looking for artifacts. This kind of research was predicted, if not actuated, by the work of Ruppe' (1980), farther south in Venice, Florida.

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Mr. Michael Faught is a graduate student currently pursuing his doctoral degree at the University of Arizona. His research interests include problems of the peopling of the New World, Quaternary geology, and underwater archaeology. He is currently involved in the location and excavation of inundated archaeological sites in the Apalachee Bay area of Florida.

Preliminary Archaeological Investigations at Ray Hole Spring

Mr. Richard J. Anuskiewicz
Minerals Management Service
Gulf of Mexico OCS Region

In early October 1986, the Minerals Management Service (MMS), in cooperation with the Florida Bureau of Archaeological Research (FBAR), conducted a preliminary underwater archaeological investigation and testing program at Ray Hole Spring. FBAR first became interested in Ray Hole Spring through interactions with the sport diving community from the Tallahassee area. Several sport divers contacted Mr. James Dunbar of FBAR, suggested that the spring may be an archaeological site, and offered to take him to the spring. The MMS was working with the State of Florida and FBAR with mutual research interests in locating the prehistoric archaeological potential of Ray Hole Spring. The two agencies put together a low-budget, cooperative research effort to conduct a preliminary archaeological investigation.

Ray Hole Spring is a submerged karst feature located on the OCS approximately 88.5 kilometers southeast of Tallahassee, Florida, and about 38.6 kilometers from the nearest Florida landfall. The spring is a typical karst feature probably formed during the Pleistocene as a result of the surface limestone collapsing or solutional or mechanical action caused by underground drainage (Glossary of Geology, 1974).

A 1976 Florida Bureau of Geology bulletin titled "Springs of Florida" describes Ray Hole Spring as an occasionally flowing spring lying in 11.6 meters of water and measuring 7.6 meters in diameter. The north side of the sink slopes southeast and the southeast side of the sink has a nearly vertical limestone wall to a depth of 18 meters. A cave strikes down and southeast from the 18 meter depth to approximately 30 meters (Figure 12.3).

The October 1986 investigation of the spring by MMS and FBAR revealed a totally different environmental setting at the site. The diving reconnaissance indicated that the spring has almost completely filled in with recent (since 1976) marine shell detritus. Only about 3 meters of relief exist in the southeastern end of the sink. The archaeological investigation of the site included diver swimming reconnaissance, mapping, attempts at coring, and waterjet excavation of selected test units. Coring was discontinued because the coring tool made very little penetration in the shell matrix as a result of the small core diameter and the large size matrix of the marine shell detritus.

After negative results from Test Units 1 and 2 and Core Tests 1 and 2, testing was moved to the outer rim of the sink. The rim of the sink has a thin layer of carbonate sand underlain by limestone rock. The MMS and FBAR dive team began excavating with the waterjet at a large crevice. Our initial theory was that if this was an archaeological site that some cultural material may have fallen or may have been washed into one of the many crevices around the edge of the sink and become trapped. The crevice we selected measured approximately 15 centimeters in width and was oriented in a southwesterly direction towards the rim of the sinkhole. Waterjet excavation, approximately 15-20 centimeters into the crevice, recovered several probable, culturally-modified limestone or chert flakes. This material was returned to the surface for examination. Continued waterjet excavation of the crevice yielded a lens of articulated whole oyster shell at the 75 centimeters level; at 1-meter depth, waterlogged wood was encountered. Samples of the shell and wood were collected, returned to the surface, and stabilized for future analysis. Below the point where the wood samples were recovered, the crevice narrowed and bottomed out. Excavation was terminated as was the initial archaeological testing.

In April 1987, analysis was conducted on the oyster and wood samples to identify the species and to obtain a radiocarbon date of this organic material. The wood species was identified as live oak, and radiocarbon dates for the oyster shell and wood were dated 7,390 ± 60 years B.P. and 8,220 ± 80 years B.P., respectively. The wood sample dated approximately 1,000 years older than the oyster shell and was recovered in a lower stratigraphic level than the oyster shell, which suggests that these organic materials were deposited <u>in situ</u>.

Preliminary analysis of the data collected at Ray Hole Spring suggests that this sinkhole may be a prehistoric archaeological site. Several factors (environmental and possibly cultural) tend to support this initial contention. The radiocarbon dates obtained at Ray Hole Spring in combination with the regional sea level curve (Figure 12.4, CEI, 1983 and 1986) indicate that approximately 8,200 years ago B.P. the sinkhole was a freshwater site supporting freshwater flora. Some time after 8,200 B.P., the sea level began to rise, and by approximately 7,400 B.P., the Ray Hole Spring area was supporting a shellfish population in a brackish water environment.

In addition, a cultural manifestation may exist at Ray Hole Spring. The two large limestone/chert flakes that were collected were examined by five archaeologists. They all seem to agree that the way the flakes were removed from the lithic core suggests that these flakes could have been produced by prehistoric man. However, they also agree that just two flakes alone usually do not constitute an archaeological site (Figure 12.5, depicts one of the potential decortication flakes).

Obviously, there is more work to be done to verify Ray Hole Spring as an authentic archaeological site. This includes a proper level of funding to conduct an intensive testing program, remote sensing studies to determine the true depth and profile of the sinkhole, coring of the sediment cone to gather paleoenvironmental data, more organic sample collecting for radiocarbon analysis, and, hopefully, the recovery of diagnostic lithic artifacts.

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Mr. Richard J. Anuskiewicz obtained his B.A. in 1972 and his M.A. in 1974 from California State University at Hayward. He was employed with the U.S. Army COE from 1974 to 1984 as a terrestrial and underwater archaeologist. In 1982 Mr. Anuskiewicz completed all requirements for his Ph.D., except for his dissertation, at the University of Tennessee at Knoxville. In 1984, he accepted a his current position at MMS, Gulf of Mexico OCS Region.

Archaeological Sites in the Drowned Tertiary Karst Regions of the Eastern Gulf of Mexico

Mr. James S. Dunbar
Florida Department of State
Bureau of Archaeological Research

INTRODUCTION

Prehistoric archaeological sites inundated by the sea are the most elusive sites to locate. They may be deeply buried and inaccessible in some regions of the continental shelf and may be shallow but difficult to identify in others. The karstic area of the Florida Gulf Coast represents a unique archaeological area where Paleo Indian remains are highly concentrated and sedimentation has been minimal. The number of Paleo Indian sites located in inland freshwater and terrestrial locations is substantial, but few offshore sites have been located because marine growth and weathering have tended to conceal site locations.

Given the difficulties associated with locating offshore sites, a model based on the type and distribution of sites on the adjacent coast was employed in the Apalachee Bay region of the Gulf of Mexico offshore survey work (reports by Faught and Anuskiewicz this session), incorporating the assistance of fishermen and sport divers familiar with the project area. In three days, Mike Faught's survey located four archaeological sites from one to four miles offshore. Rik Anuskiewicz and Melanie Stright surveyed Ray Hole Spring some 20 miles offshore and discovered evidence of what may prove to be a drowned archaeological site.

ARCHAEOLOGICAL AND GEOHYDROLOGICAL BACKGROUND

As early as the late 1930s, unusual underwater discoveries, including partially articulated mastodon remains associated with stone tools, were being investigated in Florida (Jenks and Simpson, 1941). Almost thirty years later, Wilfred Neill (1964) introduced the "Oasis Hypothesis," proposing that some underwater artifact concentrations represented drowned terrestrial sites. Geologist Kelly Brooks (1973a & b) believed that the availability of surface water for drinking fluctuated so radically over the last 15,000 years that it impacted prehistoric populations. He proposed that potable water existed as climate-dependent, parched systems (intermittent ponds, lakes, etc.) or as exposures of the drought-tolerant Tertiary limestone aquifer system--the Floridian aquifer.

Perched water tables occur as localized systems in some areas of Florida, but quickly shrink if extended droughts starve modern water budgets. In geologic time, long term trends have shifted from arid to wet, and vice versa; thus perched systems have been intermittently turned on and off. When perched water systems existed, the abundance of surface water increased; therefore, settlement options and site distributions became more widespread (Dunbar and Waller, 1983).

Even though the massive Floridian Aquifer is drought tolerant, it has fluctuated with sea level, having low stands during glacial phases and near present or higher stands during the interglacial phases of the Pleistocene (Webb, 1974). Glacial stage water tables as low as 48 meters below present occurred prior to the human habitation of Florida (Brooks, 1967). Investigations of the inundated Devils Den and Little Salt Springs sites revealed that the aquifer was greater than 25 meters below present water level, when human activity was taking place (Webb, 1974 and Clausen et.al., 1979). Parched water systems were greatly reduced during dry climatic phases, and as a result, site distributions were restricted to areas with persistent supplies--mainly aquifer locations (Dunbar and Waller, 1983).

Prehistoric site distributions in Florida occurred in changing patterns not only linked to evolving technologies but to fluctuations in regional surface water systems. The availability of potable water in relation to other needed resources helped dictate possible site locations through time (Dunbar and Waller, 1983). There are three major geohydraulic regions in Florida (Bush, 1982) where potable water supplies varied with climatic changes:

1. The OUTLYING REGION, where the Tertiary limestones are buried by more than 35 meters of younger sediment. A region rarely breached by sinkholes, potable surface water occurs in local, climate dependent, perched systems. Lithic resources for tool production are rare to non-existent.
2. The MARGINAL REGION, where the Tertiary limestones are buried up to 35 meters deep. This region is breached by open sinkholes that penetrate the overlying sediment to expose the limestone. Limestone exposures may occur above but more often below present water tables. Lithic resources

include chert bearing Tertiary limestones and opalized inclusions in the Hawthorne Formation. Lithic resources are not abundant.

3. The TERTIARY KARST REGION, where the limestone occurs near or at the ground surface. The Tertiary limestones of Florida hold one of the nation's largest grown water systems--the Floridian Aquifer. The Tertiary limestones also contain the best and only major chert rock resource in Florida.

Ninety percent of the Paleo Indian sites containing Clovis, Suwannee or Simpson projectiles are located near karst depressions that penetrate the Tertiary limestones of Florida (155 of a total of 172 sites). The Tertiary Karst Region has 71 percent of the sites, the Marginal Region 17 percent of the sites, and the Outlying Region 12 percent of the sites (Figure 12.6). Some sites are located around isolated sinkholes and solution depressions (9 percent), but most occur in areas where multiple karst features occur together and dominate the topography (81 percent). The largest site clusters are located n and around mature karst river channels (60 percent) with smaller but significant clusters centered around karstified lakes, bays, and prairies (23 percent). In Florida, the distribution of Clovis/Suwannee sites indicates settlement patterns were centered where natural resources were most abundant, particularly drinking water and lithic supplies (Dunbar, 1987). For example, natural resource availability in karst river systems has been expressed as a hypothesis for archaeological testing:

"The river basins in the (two) Tertiary karst regions of Florida have the greatest concentration of Clovis/Suwannee Paleo Indian sites because unique environmental conditions created natural resource accumulations that complemented technology and subsistence behavior. Stable habitats in the karst regions supported grazing animals but drought intervals confined game herds to oasis locals. During droughts, oases in the karst river bottoms offered water, food, bone, and lithic resources for Paleo Indian exploitation. As a result, major site clusters in Florida became centered around rivers like the Santa Fe and Aucilla because multiple resources were available, and repeated exploitation could be supported. During wet periods when intermittent water sources existed above the river valleys, game herds dispersed, and with them mobile hunting groups. Thus a semi-sedentary Paleo Indian life way may have existed with prolonged river camp occupations and less frequent periods of high hunter/gatherer mobility" (Dunbar, 1987).

The geohydraulic history of the Tertiary Karst Region has been dynamic, including the Holocene (ca. 10,000 years ago to present) inundation of many former land areas by transgressing seas or inland water table rises. The Inundation of sites in karstic terrain has promoted good organic preservation and, as a result, promises to yield some of the most informative archaeological remains in the eastern United States. The potential for major archaeological discoveries seems as great offshore as those that have been made inland in sinkholes, springs, and in karst rivers like the Aucilla.

THE AUCILLA RIVER AREA AS A MODEL TO LOCATE OFFSHORE SITES

The Aucilla River is a limestone entrenched river system that flows into the central area of Apalachee Bay. The mouth of the river is located about 50 miles southeast of Tallahassee, Florida. Since 1983, several research expeditions have been conducted in the Aucilla River, including its tributary, the Wacissa River. Numerous land and underwater sites have been recorded. Major research has been conducted on the Page/Ladson site (8Je591) located in the Half Mile Rise section of the Aucilla River. The underwater component of the Page/Ladson site has reveled a stratified sequence some 4 meters thick with in-situ cultural levels 9,500 to 12,000 years old (Dunbar, et.al., In Press).

In the Aucilla River area, Paleo Indian site locations occur in predictable patterns. Large sites are located adjacent to and in river channel segments that are breached by sinkholes. Small or infrequently used sites occur in, around, and away from the river, sometimes around isolated sinkholes. Flint (chert) quarry areas are located in a number of locations, including in the river channel, around sinkholes, and in the surrounding karstic terrain, where erosion resistant chert boulders protrude above the flat coastal terrain.

Prehistoric sites in the flat terrain near the Aucilla River are difficult to locate. Fortunately, any of the most interesting sites are located around obvious features such as chert rock outcrops, sinkholes, and in the river basin.

THE PREDICTABILITY OF OFFSHORE SITES IN APALACHEE BAY

The search for offshore sites becomes much easier if one can locate inundated sinkholes, river channels, and chert rock outcrops as convenient guide posts. The irregular topography associated with these features attracts fish and other marine life which, in turn, attract fishermen and sport divers. Many potential site locations have already been pinpointed. In Apalachee Bay and along the Gulf Coast to Tampa Bay, there are hundreds, probably thousands, of topographic targets to inspect.

The need to conduct offshore archaeological research is overdue. Other than our cursory survey (which did demonstrate numerous sites exist), no meaningful work has been attempted in the Tertiary Karst Region of the Florida shelf. Much of the karst area is environmentally sensitive with numerous sea grass beds and rock outcrops representing breeding areas for marine life. The knowledge we have gained about the marine environment, in all its subtle detail, has been gathered by extensive scientific investigation. Conversely, the archaeological resource has been ignored and is rarely acknowledged and almost never studied.

If we are to fully understand the archaeological potential in the Tertiary Karst Region of the eastern Gulf of Mexico, basic archaeological research questions must be answered. Not only are these research questions important to archaeology in general but also to resource managers who need information to properly manage offshore resources. Therefore, future research on the karstic Florida shelf should consider the following questions:

1. At given points in time from 15,000 to 5,000 years before present, can absolute sea level stands be identified to allow chronologically evolving site predictive models? Coring sinkholes to obtain dateable freshwater and saltwater sediments should provide an absolute sea level curve and

paleo-environmental data to answer this research question.
2. Do archaeological sites exist in the eastern Gulf of Mexico that have stratigraphic integrity despite Holocene sea level transgressions and marine erosive conditions? This question is of particular importance to the limestone sediment starved study area. Conducting limited test excavations to determine site integrity should answer this research question.
3. What is the variety of archaeological sites encountered?--For example, resource procurement vs. habitation sites, coastal oriented vs. inland, major base camp vs. small habitation areas? This questions may also be answered by limited test excavation.
4. Once prehistoric offshore sites are located, can remote sensing instruments provide diagnostic signatures of the known sites? Can prehistoric sites be located with remote sensing equipment once known sites have been scanned? Can it locate several sites in a variety of marine settings and conduct remote sensing surveys to determine if diagnostic signatures are obtainable? If so utilize, this data in an attempt to locate sites with remote sensing equipment.

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Mr. James Dunbar is the underwater archaeological field supervisor for the Florida Department of State, Bureau of Archaeological Research. He has acted in this capacity since 1976. Mr. Dunbar is a graduate of the University of Florida, at Gainesville, and prior to attending college, was an oil field commercial diver. His research interests include the study of Paleo-Indians in Florida and the effects of paleohydrology and sea level change on prehistoric sites.

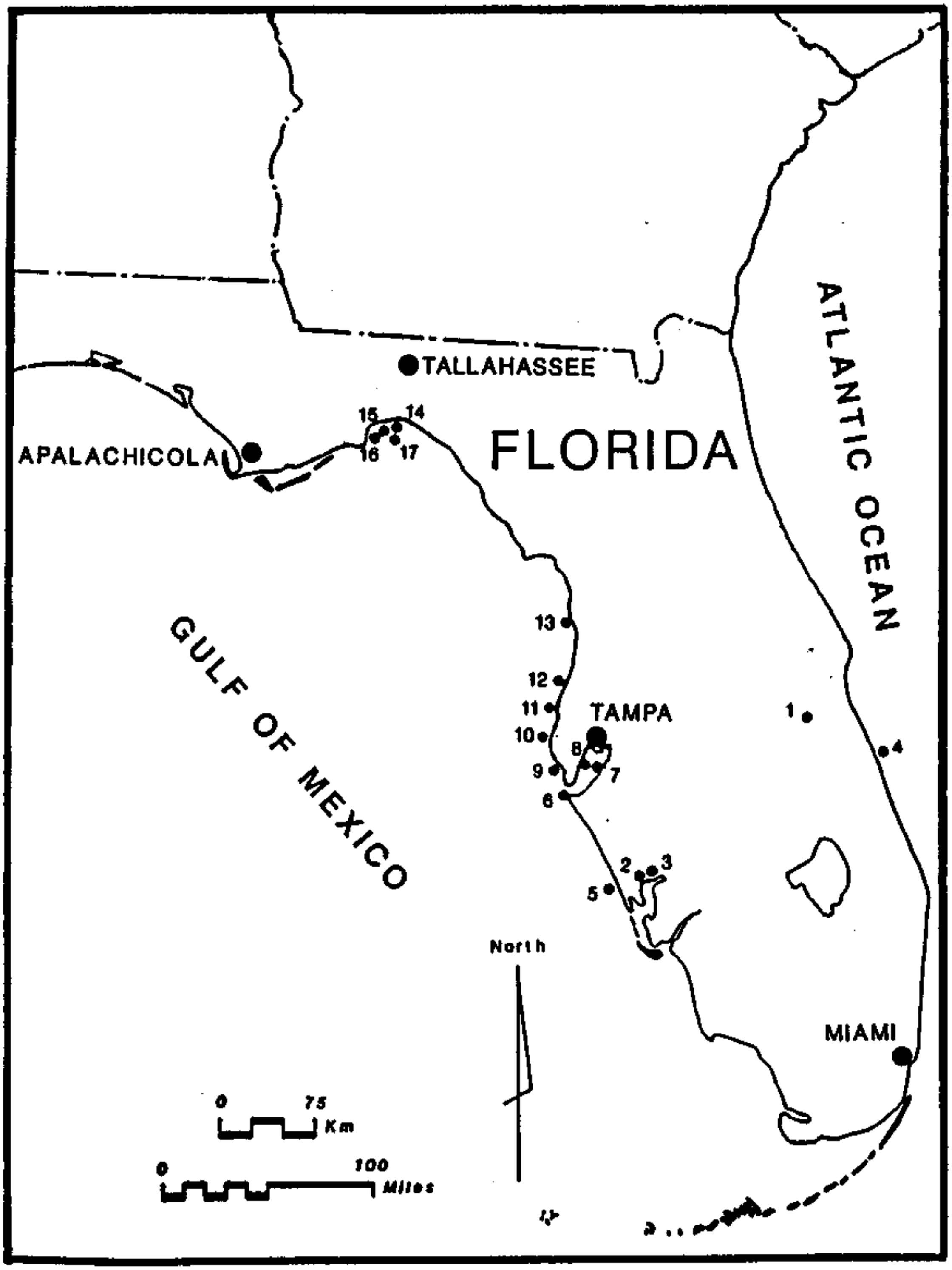

Figure 12.1.--Inundated archaeological sites of coastal Florida.

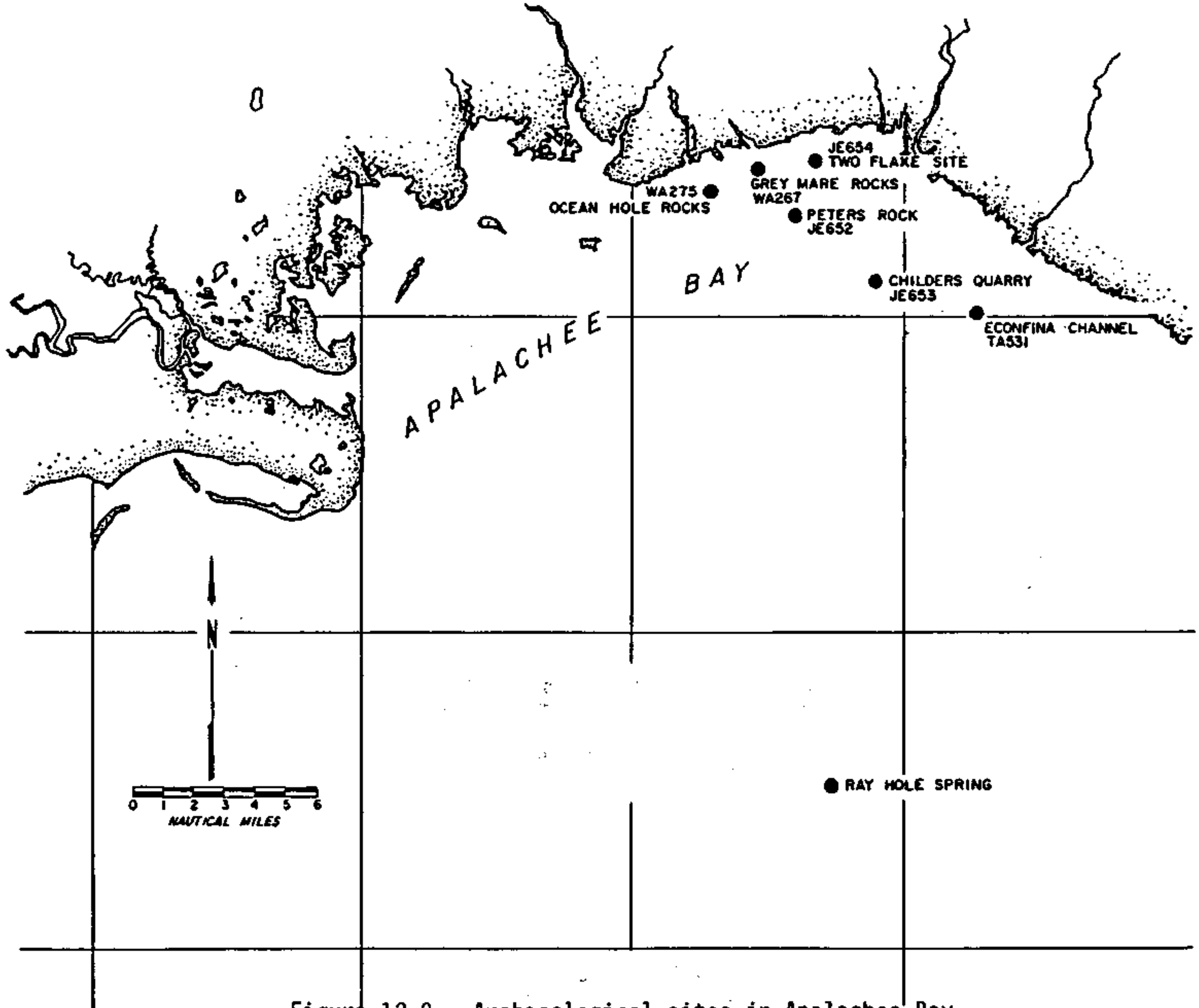

Figure 12.2.--Archaeological sites in Apalachee Bay.

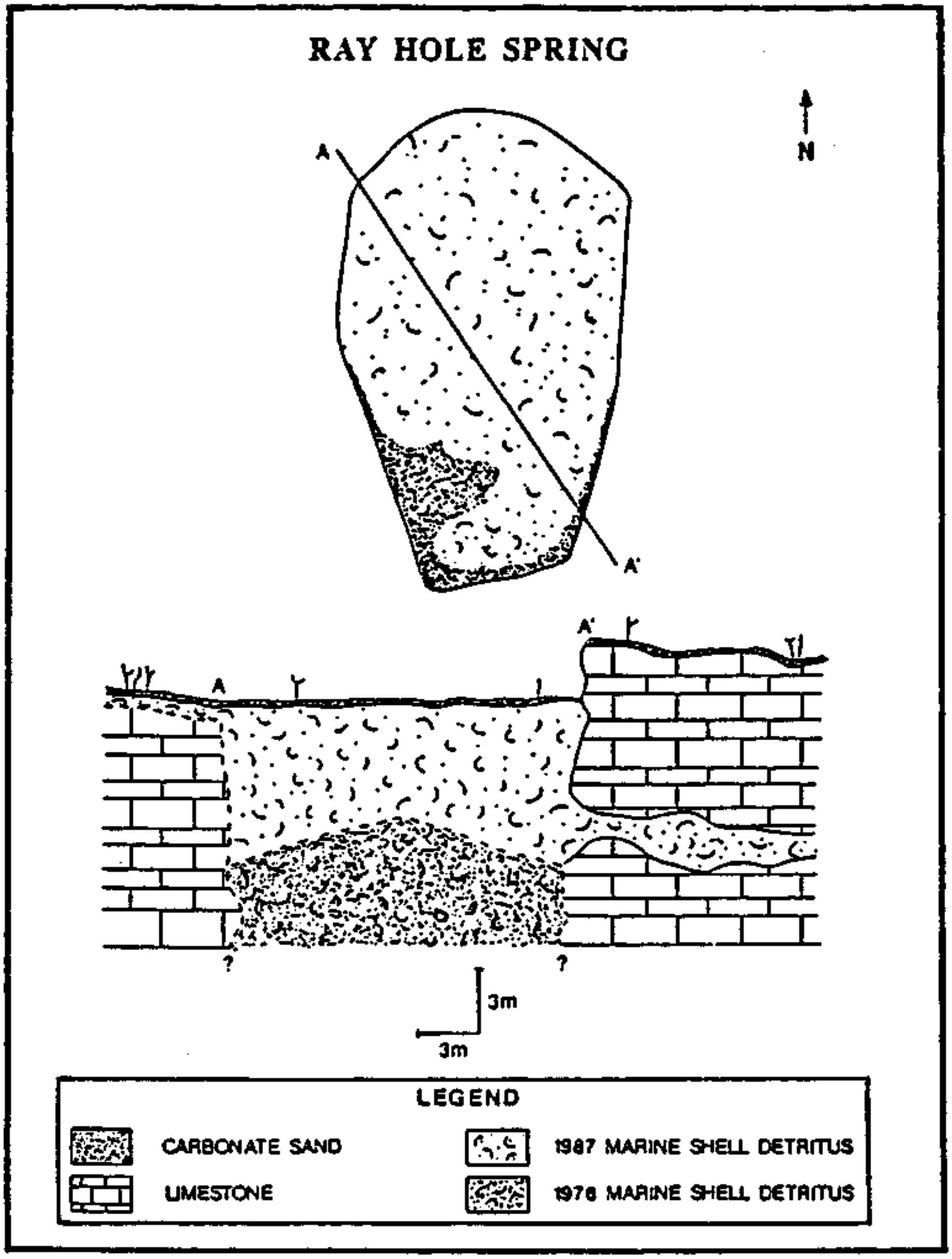

Figure 12.3.--Cross-section drawing of Ray Hole Spring.

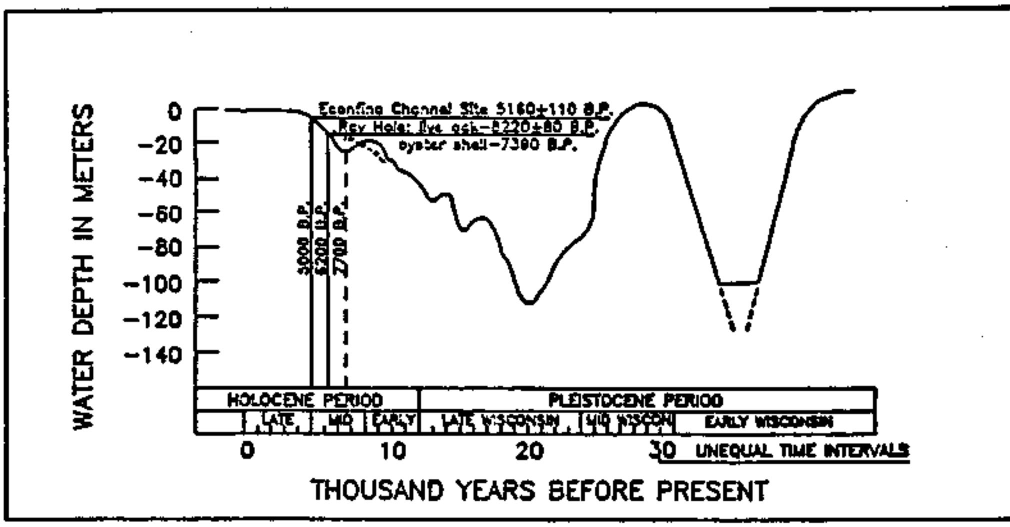

Figure 12.4.--Sea level curve for the Gulf of Mexico.

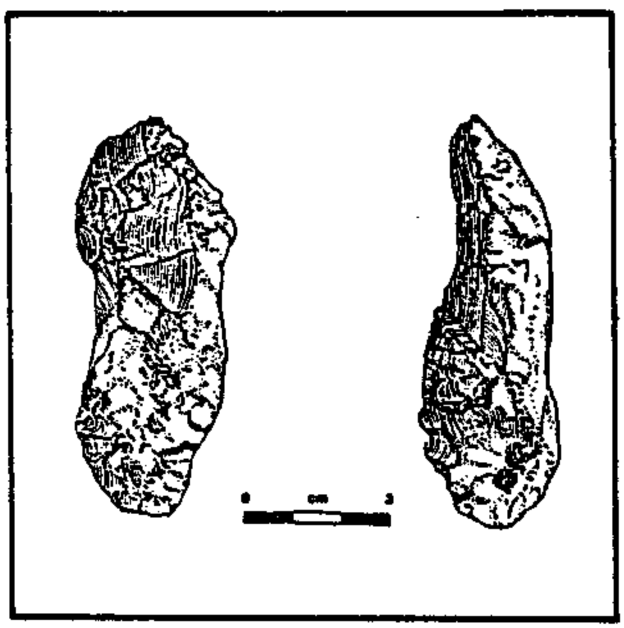

Figure 12.5.--Possible decortication flake associated with Ray Hole Spring.

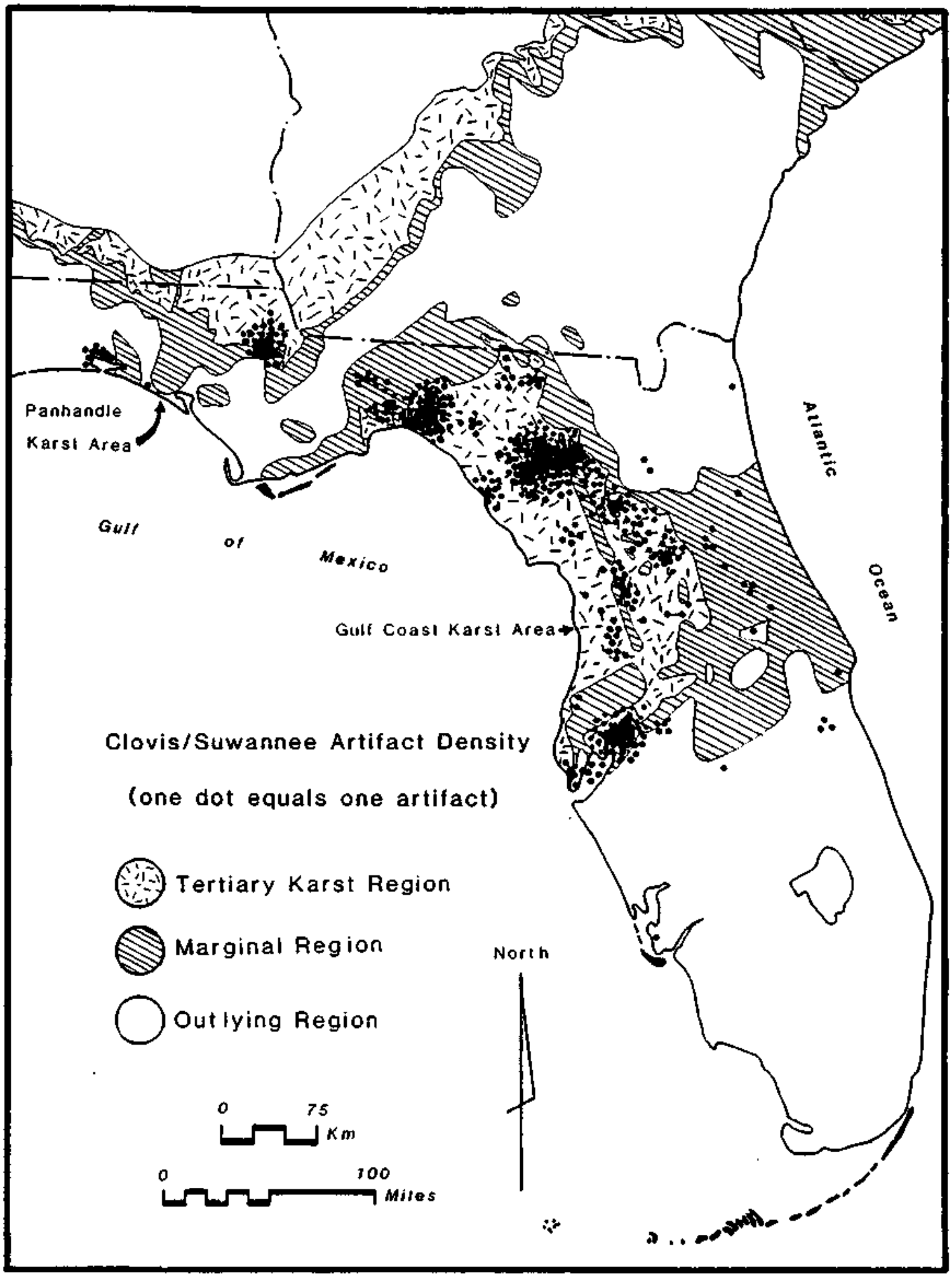

Figure 12.6.--Distribution pattern of diagnostic Clovis, Suwannee, and Simpson artifacts in the Outlying, Marginal, and Tertiary Karst Regions of Florida.

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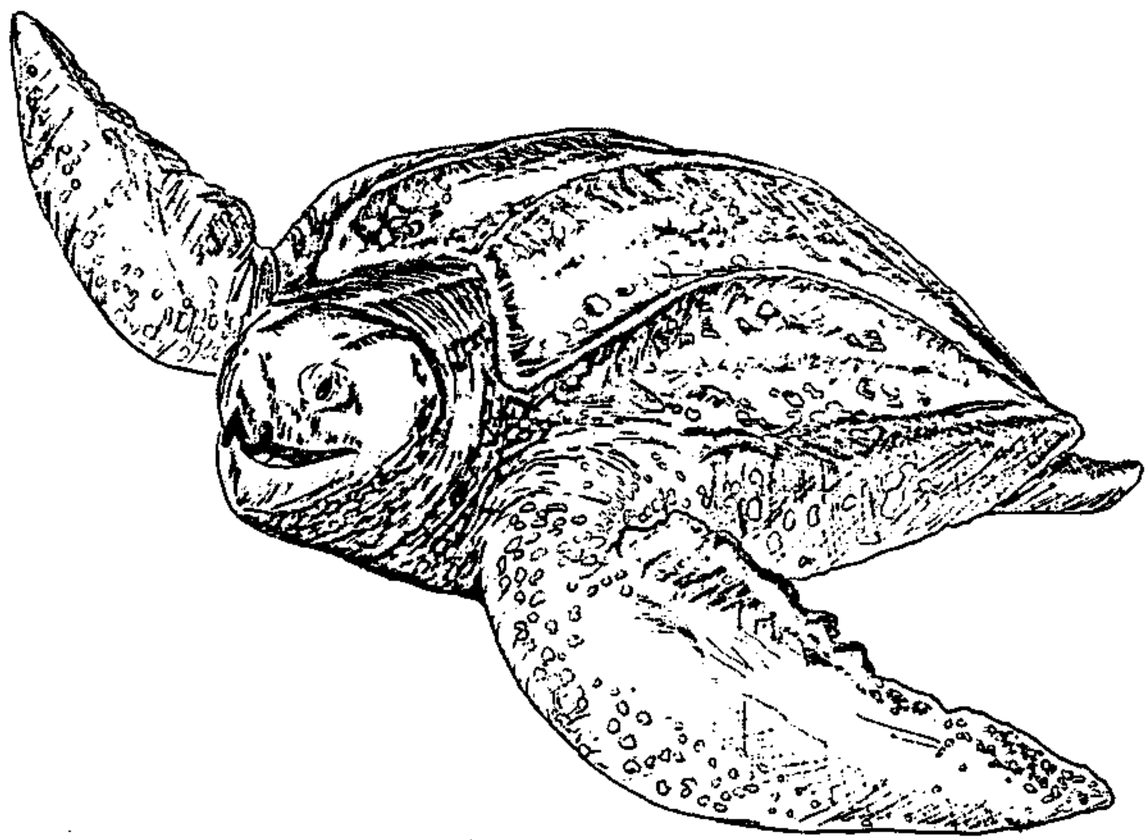

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Chair: Mr. Richard J. Anuskiewicz

Date: November 6, 1986

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Marine Archaeology: A Problematic Approach to Resolution of Unidentified Magnetic Anomalies: Session Overview

Mr. Richard J. Anuskiewicz
Minerals Management Service

Every year Minerals Management Service (MMS) archaeologists review hundreds of geophysical - archaeological reports containing geological interpretations and an archaeological assessment of lease blocks located in Federal OCS waters of the Gulf of Mexico. As a part of the archaeological review for these lease blocks, a historic analysis is conducted to assess the potential impact of future oil and gas development on possible historic shipwrecks located within these lease blocks. In the process of reviewing the geophysical - archaeological reports yearly, MMS archaeologists look at thousands of unidentified magnetic anomalies recorded during marine magnetometer surveys presented in these reports. These thousands of unidentified anomalies are scrutinized and an attempt is made to discriminate between a potential historic shipwreck and modern marine debris.

In order to attempt to develop a better analytical capability to discriminate between potential historic shipwrecks and modern marine debris, a panel of experts--experienced in theory, method, instrumentation deployment, and data interpretation of magnetometer remote sensing -- was formulated.

The panel members were given two geophysical - archaeological lease block survey examples for review, and copies of MMS's Notice to Lessees (NTL 75-3, Revision No. 1), and Letters to Lessees (July 17, 1984 and March 5, 1986) which detail MMS's magnetometer survey requirements for OCS archaeological surveys.

The marine archaeology sessions focused on specific analytical factors that provide the existing interpretive framework in MMS's analysis of magnetometer data for archaeological reports. MMS archaeologists have been reviewing magnetometer data and using these analytical factors in an attempt to discriminate between potential historic shipwrecks and modern debris. Hopefully, these sessions will expand the present state of knowledge in marine magnetic interpretive skills to better increase discriminative capabilities. Listed below are the analytical factors used in MMS's present archaeological interpretive framework: (a) anomaly amplitude in gammas; (b) signature width and/or duration in time; (c) signature asymmetrical characterization; (d) sensor height above the seafloor; (e) spatial occurrence of anomaly due to existing oil and gas production facilities, designated anchorage areas, shipping fairways, and military warning areas; (f) the existence of predetermined high- and low-probability zones for the occurrence of historic shipwrecks; and (g) whether or not the anomalies correspond to existing geologic features.

Given MMS's 150-meter magnetometer survey line spacing interval, the panel discussants began the session.

Dr. John W. Weymouth, University of Nebraska, had several thought provoking suggestions for both magnetic data acquisition and data interpretation of survey data. Within the existing 150-meter survey methodology, Dr. Weymouth suggested: a) providing copies of all chart recordings of magnetic anomalies; b) all information available to include, factor translating time on charts to horizontal distance, time at the start of each run, magnetic amplitude, and horizontal distance between readings to estimate size and nature of the magnetic source; c) use of the "full width, half maximum" (FWHM) number which is obtained from a simple profile by measuring the width of the profile at an amplitude halfway between the maximum value and background; d) the concept of "anatomy of anomalies" should be studied within the framework of an examination of anomalies produced by actual shipwrecks and non-shipwrecks that have been tested by excavation and by model calculations using realistic sources and simulating the survey methods being used; and e) within the existing survey methodological framework add another magnetometer in a side-by-side array at a separation distance roughly comparable to the anticipated sensor-to-source distance.

J. Barto Arnold III, the state marine archaeologist for Texas, pointed out a basic flaw in plan in MMS's existing 150-meter line spacing methodology, and drew on his past experience, suggesting that the distance between lines is too great to develop patterns of readings on neighboring survey tracks which are essential in recognizing a shipwreck. He further stated that even assuming adequate coverage by close survey tracks, it may be there are too many independent variables to ever be completely sure about anomaly causes without physical visual inspection. Current MMS survey line spacing requirements present an insurmountable barrier to better interpretation of the magnetic records. There are, nonetheless, some actions that should be taken to immediately vastly improve the (archaeological) reports. A gathering and analysis of anomaly signatures which have subsequently been ground truthed would be a big step towards seeing what can be done and how far we can go with our interpretations and the confidence level appropriate in those interpretations. In addition, the section of magnetometer strip chart showing every anomaly recorded should be submitted with the archaeological report for review and interpretation.

Dr. Ervan G. Garrison, Texas A&M University, talked about an experimental magnetometer survey he conducted over a 19th century historic shipwreck. This well-known and diver-surveyed Civil War shipwreck, the "Will O' Wisp," lies approximately 300 meters off Galveston Island, Texas. A total of six survey transects, one directly over the wreck and thence out to 150 meters at 25-meter line spacing intervals, was run. The six separate transects were then analyzed for the relative discriminatory power of the three parameters of amplitude (intensity), signature (shape), and duration (period). The set of magnetic survey data, taken with high precision, was evaluated using these three parameters. Typically used in MMS's standards for evaluatory purposes, these parameters were analyzed for their relative discriminatory power in characterizing magnetic anomalies. Based on the preliminary results of the study, only one--duration--was instrumentally significant over survey transects a hundred meters distant from the anomaly source: in this case, a 19th century historic shipwreck.

Professor Allen R. Saltus said that MMS archaeologists should be commended for their attempt to utilize all available data to the fullest, but their interpretive framework should not be used in formulating a final determination as to the cause of any magnetic occurrence, including debris from shipwrecks. In doing so they could be writing off cultural resources without knowing anything of their nature or significance. However, given sufficient data, the interpretive factors could be useful for planning purposes. The only method of determining cause and significance of magnetic data is through ground truthing (i.e., diver verification, underwater television, and sometimes die scan sonar). This statement is based on a discussion of survey methodology used to gather this magnetic data and the seven interpretive factors used by the MMS archaeologists.

He continued by saying that the magnetic data gathered to fulfill the MMS guidelines is generated at 150-meter (492.39 feet) line spacings. Using this methodology, no known pre-World War II watercraft is guaranteed to be detected. Actually, most vessels have less than a one in four (25%) chance of being located. Smaller watercraft have less than a one in five (20%) chance of being located. At 150-meter line spacing, the survey can only be considered an exploratory or sample survey from which further investigations can be determined and/or planned, and budgetary needs established for the next phase of investigation. The MMS archaeologists are attempting to short cut this process using analytical methods which do not seem to have any acceptable degree of significance or reliability regarding their criteria for differentiating debris from shipwrecks.

In summary, Professor Saltus suggested that he hoped that the criteria established by the MMS archaeologists will not be used. To do so could create a situation in which a Federal agency may write off significant cultural resources by using both an unacceptable database and manipulating this data using criteria which do not have an acceptable degree of reliability or significance. Using this approach would lend credence to the term used by critics of this program, "Archaeofolly."

Dr. Bruce W. Bevan of Geosight stated that magnetic surveying has been a successful procedure for locating shipwrecks, but many false indications from modern discarded iron are also found. It is possible that changes from current survey techniques could increase the reliability of distinguishing shipwrecks from trash on the seafloor. Triaxial vector magnetic measurements have greatly aided the search for magnetic materials from boreholes. These same procedures could be applied to estimating the depth of iron in the sediment and therefore could suggest its age.

Handheld metal detectors have been applied to search for artifacts at shipwrecks, but other instruments could be more suitable for large area investigation of insulators and conductors. Electrical resistivity measurements can be made on the seafloor by dragging an electrical cable with several connection points exposed to the seawater. Magnetotelluric surveys typically measure to a great depth, but might be suitable for this survey.

Old iron could be significantly different from modern iron in its magnetic properties. An electromagnetic induction system which measures the electrical conductivity of the seafloor could also determine its AC magnetic susceptibility. Measurements at one or more frequencies might allow different ferrous materials to be distinguished. With the vector magnetometer mentioned above, it could be possible to separate the remnant and inducted magnetization of iron objects by determining the net direction of polarization. The ratio of remnant to inducted magnetization, the Koenigsberger ratio, might distinguish old iron from modern steel.

Richard J. Anuskiewicz obtained a B.A. in 1972 and an M.A. in 1974 in anthropology/archaeology from California State University at Hayward. He was employed with the U.S. Army Corps of Engineers from 1974 to 1984 as a terrestrial and marine archaeologist and worked in San Francisco, New England, and Savannah Corps of Engineers District Offices before accepting a position with the Minerals Management Service Gulf of Mexico OCS Regional Office in 1984. Mr. Anuskiewicz took a year's leave of absence for graduate school at the University of Tennessee in Knoxville, and in February 1982 he was advanced to doctoral candidacy. His current research interests are marine remote sensing and underwater archaeological site reconstruction in a blackwater environment.

Summary of Thoughts of Theoretical and Practical Considerations for the Improvement in the Interpretations of Magnetic Survey Data

Dr. John W. Weymouth
University of Nebraska

The meeting was a panel and audience discussion of theoretical and practical considerations for the guidance and improvement in the acquisition and interpretation of magnetic survey data of lease blocks for the purpose of mitigating the impact on archaeological resources.

1. Within Existing Methodology

Although the present form of obtaining magnetometer data (running traverses 150 m apart with one magnetometer and side scan sonar) can only provide anywhere from 10% to 30% coverage of possible shipwreck indications, it is realized that there are severe economic restrictions to providing greater coverage. Within this framework, several things can be done to improve the interpretation potential of the data that are obtained.

a. Copies of all chart recordings of magnetic anomalies should be provided. In order to extract the fullest possible information from the data, it is not sufficient to have just the maximum and total length of the anomaly. It is necessary to see the shape and structure of the anomaly profile. Having the original profile will aid in separating simple sources from complex sources.
b. Full information should be provided, and this includes sensor distance above bottom, factor translating time on charts to horizontal distance, and time at the start of each run. The magnetic amplitude and horizontal distance between readings can be used to estimate size and nature of source. The time of recording the anomaly can be used in conjunction with the geomagnetic information provided by NOAA (Preliminary Report and Forecast of Solar-Geophysical Data) to account for possible deviations from the normal magnetic diurnal curve.
c. If a "width" number is going to be used, it should be the "full width, half maximum" or FWHM. This number is obtained from a simple profile by measuring the width of the profile at an amplitude halfway between the maximum value and background. The width should be expressed in horizontal distance along the traverse. This measure is less ambiguous than duration of anomaly and is widely used (M. Aitken, Physics and Archaeology, 2nd Edition, 1974, p. 217; J. Weymouth, Chapter 6, Advances in Archaeological Method and Theory, M. Schiffer, Ed, Vol. 9, 1986, p. 344).
d. The "anatomy of anomalies" should

be studied in relation to these data. This should include 1) an examination of anomalies produced by shipwrecks and non-shipwrecks that have been subsequently tested by excavation, 2) model calculations using realistic sources and simulating the survey methods being used.

e. Within the framework it should be possible to add another magnetometer without a large increase in cost. The two sensors should be run side-by-side at a separation distance roughly comparable to the anticipated sensor to source distance. This should provide valuable information as to the lateral direction of sources as well as some clues as to the size of the sources.

2. Beyond the Existing Methodology

a. Obviously the single most important step beyond the present method would be to reduce the distance between traverses. In fact, the ideal would be to have that spacing equal to the sensor-to-source distance. This is unrealistic, but any reduction in distance would be an improvement.
b. Bruce Bevan's suggestion of using vector measurements of the anomalous field should be examined, first with mathematical model calculations, then with testing, to see what additional information this would provide.
c. I do not think that a base station is needed in most situations. Such a station would be operated continuously on the shore in the general area of the survey. This would provide data for correcting the temporal variations in the magnetic field during the time of the survey. This would eliminate spurious or false anomalies that could arise from brief, sharp spikes in the magnetic field occurring during a survey. This would not happen very frequently, and considering the nature of the data that is obtained, it probably is not urgent. If the expense of establishing a base station is not great, it could be tried, and the results obtained on geomagnetic active days could be examined for any improvement.

Dr. Weymouth obtained his B.S., M.S. and Ph.D. degrees from the University of California, Berkeley (Ph.D. in 1952). He is currently a Professor in the Department of Physics and Astronomy, University of Nebraska. He also holds an appointment in the Anthropology Department at UN. His original field of research was solid state physics, but in 1971 he turned to archaeometry. After some work with x-ray diffraction and x-ray fluorescence, he concentrated particular emphasis on magnetics. He has been involved in surveys in over ten states in the USA, plus surveys in Japan, France, and Hungary.

Resolution of Unidentified Anomalies and Related Matters

Mr. J. Barto Arnold III
Texas Antiquities Committee

Several factors cause a problem relating to the identification of the causes of magnetic anomalies when we are limited to only the magnetometer records in making the interpretation. For the OCS surveys the first and foremost problem is the lane spacing. The 150 m distance required is too great to develop the patterns of readings on neighboring tracks which are essential in recognizing a shipwreck. Many marine archaeologists have pointed this out through the years in various articles and papers including previous MMS-ITM meetings (Arnold 1982 Appendix I). Given this basic flaw in the survey design, the only conclusion one can draw is that <u>any</u> anomaly <u>could</u> be caused by an historic shipwreck. Indeed, cases exist demonstrating that anomalies from substantial shipwrecks might be missed altogether at 150 m track spacing (Arnold 1982 -Appendix I, Arnold 1982 - Appendix II). Nevertheless, there are things to look for in the data that would indicate a more promising anomaly. A large multipeaked anomaly would be indicative of a possible wreck (Arnold 1982 - Appendix III). The trouble is that small single peak anomalies cannot be discounted due to the overly wide lane spacing. And, of course, a multipeaked anomaly could just as possibly be caused by a complex assemblage of modern debris.

Even assuming adequate coverage by close survey tracks it may be that there are too many independent variables to ever be completely sure about anomaly causes without physical visual inspection. The orientation of an object in the vertical and horizontal planes relative to the earth's field causes variation in the anomaly and, therefore, the magnetometer strip chart signature. So does the direction of the sensor as it crosses the object or the anomaly. There are also indications that anomalies produced by historic wrecks may not be detectable at as great a distance as one would predict from the inverse cube rule (Arnold, in press-Investigation of a Civil War Anti-torpedo Raft - Appendix II).

It must be said, however, that an experienced marine archaeologist <u>can</u> and does develop a sense of which anomalies look more promising than others.

To improve this situation there is at least one step that could be taken immediately. The section of magnetometer strip chart showing every anomaly reported in an OCS-CRM report should be illustrated. The same is true for side scan targets and subbottom profiler features. The reports would then become useful. The data analysis could be easily checked. In the past, original remote sensing data has not been archived like other archaeological data must be. Now many survey and oil companies have disappeared due to the decline of the domestic oil and gas industry. What has become of the data gathered by those companies? I fear that much of the data has been disposed of and, therefore, can never be reanalyzed or rechecked.

An urgent effort to salvage and retrieve the data gathered by now-defunct firms should be a top priority of the MMS.

In addition to this new report requirement, there should be an additional new requirement to archive a legible copy of all data with the MMS.

Another idea productive of a better interpretive situation vis-a-vis magnetometer strip chart data would be to gather the anomaly records of sites that have subsequently been ground-truthed by diver examination and/or test excavation. An example of a paper presenting such data is presented in full in Appendix III (Arnold 1982). Many underwater archaeologists have such data. It should be systematically gathered by the MMS or a contractor and then analyzed.

A minor matter that could easily be improved involves the references required for use in preparation of OCS-CRM reports (cited in Sieverding letter of 17 July 1984 - (LE-51 LE-2)). A number of additional later publications than the Calusen and Arnold article cited are included in Appendix II. These should be added along with others by other authors.

I noticed in the advanced material for this meeting that a copy of one of the Archaeological Report Reviews prepared by the MMS staff archaeologists was sent to the appropriate SHPO. Is this done regularly, and is a copy of the report itself sent? They should be.

In conclusion, current OCS survey lane spacing requirements present an insurmountable barrier to better interpretation of the magnetic records. There may be too many independent variables to ever get very far with or be very confident of interpretations based on the magnetometer alone. There are, nonetheless, some actions that should be taken to immediately vastly improve the reports. A gathering and analysis of anomaly signatures which have subsequently been ground-truthed would be a big step toward seeing what can be done and how far we can go with our interpretations and the confidence level appropriate in those interpretations.

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J. Barto Arnold III is a native of San Antonio, Texas. He received his B.A. and M.A. in anthropology/archaeology from the University of Texas at Austin. He is the State Marine Archaeologist for Texas and has served in that position since 1975.

An Analytical Consideration of Three Interpretative Anomaly Parameters - Amplitude, Signature, and Duration

Dr. Ervan G. Garrison
Texas A&M University

A set of magnetic survey data taken with high precision was evaluated using these three parameters. Typically used in Minerals Management Service (MMS) standards for evaluatory purposes, these parameters were analyzed for their relative discriminatory power in characterizing magnetic anomalies. Based on the results of the study, only one--duration--was instrumentally significant over survey transects a hundred meters distant from the anomaly source: in this case, a 19th century historic shipwreck.

EXPERIMENTAL CONDITIONS

A set of magnetic survey data representing six separate transects over a 19th century shipwreck was analyzed for the relative discriminatory power of the three parameters--amplitude (intensity), signature (shape) and duration (period). The data were obtained under optimized conditions of environment and survey. Every attempt was made to maximize the precision of the data in terms of repeatability for survey and instrumental conditions over the study. The anomaly was a well-known and diver-surveyed Civil War shipwreck, the Will O' The Wisp, lying 300 meters off Galveston Island, Texas, in three meters depth of water.

A total of six survey transects, one directly over the wreck and thence out to 150 meters, were run. The data appear in Tables 10.1, 10.2, 10.3, 10.4, 10.5 and 10.6 and represent a sequence of survey lines of 0, 50, 75, 100, 125 and 150 meters distance, respectively, from the wreck. These data were evaluated graphically and numerically for the discriminatory value as regards the characterization of a magnetic anomaly by amplitude, signature or duration.

ANALYSIS AND RESULTS

1. Amplitude -- The maximum intensity of the anomaly was scaled to the earth's field value for that time and plotted versus distance (in meters) from the wreck. Table 10.7 shows these values.

   The data show an expected fall in the intensity, roughly on the order of magnitude, expected for relation of amplitude to the inverse cube of the distance. Intensity falls markedly after 50 meters.
2. Signature -- These data were graphically analyzed at the same scale, +3000 to -3000 nanoteslas (lines 1-6), and a scale of +50 to -50 nanoteslas for lines 2-5. The key element examined was signature shape in the relatively scaled lines. Inclusion of lines 1-6 data showed the large dipolar signature of the line 1 anomaly at the expense of the clear visualization of the anomaly on lines 2-6. The removal of the line 1 trace allowed a better appreciation of these signatures at an equivalent scale.

   Individually, scales were adjusted to maximize shape discrimination, and each line's signature was evaluated.

   The results are summarized in Table 10.8. The results show delineation of a repeatable signature up to 50 meters. The signature at 75 meters is clearly discernible, but showed little similarity to that seen on lines 1 and 2.
3. Duration -- Again plotted graphically, duration of the anomaly was scaled from first detection of a consistent instrumental deflection to the loss of same. The total time of the anomaly was plotted as the duration and is shown in Table 10.9.

   Examined statistically, there was no significant difference between the values seen for duration over lines 1-4. Taken with the values for lines 5 and 6, the fall-off in the value of duration is significant at the .95 level.

CONCLUSIONS

Of the three variables examined,

1. Amplitude was found to be not diagnostic after 75 meters.
2. Signature repeatability was not observed after 75 meters.
3. Duration was observed at the same level of repeatability at 100 meters.

Duration was found to be the most reliable variable in detecting the anomaly over distance.

Dr. Ervan G. Garrison is an archaeologist and a lecturer and associate research scientist of civil engineering at Texas A&M University. His research interests include the application of geophysical instrumentation to the study of archaeological problems onshore and offshore.

Response to a Problematic Approach to Resolution of Unidentified Magnetic Anomalies

Mr. Allen R. Saltus, Jr.
Southeastern Louisiana University

Archaeologists for the Minerals Management Service (MMS), Gulf of Mexico Region have been reviewing magnetometer data and have proposed to use analytical factors in an attempt to discriminate between historic shipwrecks and modern debris. The analytical factors used for this interpretive framework include

1. Anomaly amplitude, in gammas.
2. Signature width and/or duration in time.
3. Signature asymmetrical characteristics (i.e. dipole and monopole).
4. Sensor height above seafloor.
5. Associated anomaly occurrence (anchorage, shipping fairway, military warning areas, gas- and oil-producing facilities and pipelines).
6. Anomalies corresponding with geological features.

The MMS archaeologists should be commended for their attempt to utilize all available data to the fullest, but the above criteria should not be used in formulating a final determination as to the cause of any magnetic occurrence. In doing so, they could be writing off cultural resources without knowing anything of their nature or significance. However, given sufficient data, the above factors could be useful for planning purposes. The only method of determining cause and significance of magnetic data is through ground-truthing, i.e., diver verification, underwater television and, sometimes, side scan sonar. This statement is based on the following discussion of survey methodology used to gather this magnetic data and the seven factors used by the MMS archaeologists.

The magnetic data gathered to fulfill the MMS guidelines is generated at 150 meter (492.39 feet) lane spacings. Using this methodology, no known pre-World War II watercraft is guaranteed to be detected. Actually most vessels have less than a one in four (25%) chance of being located. Smaller watercraft have less than a one in five (20%) chance of being located. Table 10.10 is a list of selected magnetic anomalies for which we have fully executed magnetic contour maps of magnetic source areas and amplitudes. The table includes single magnetic sources, multiple magnetic sources, and wrecks. The table lists the height of sensor from the object(s) being detected, size of object(s) being detected, magnetic area being magnetically affected at that sensor height, and maximum magnetic inflection produced by the object(s) being detected. At 150 meter lane spacing, the survey can only be considered an exploratory or sample survey from which further investigations can be determined and/or planned, and budgetary needs established for the next phase of investigation (Murphy 1980; Murphy and Saltus 1981). The MMS archaeologists are attempting to short-cut this process using analytical methods which do not seem to have any acceptable degree of significance or reliability regarding their criteria for differentiating debris from shipwrecks.

The seven MMS criteria for determining wreckage from modern debris using the magnetic data generated at these line spacings all have varying degrees of problems. These problems will become apparent by discussing each criterion's limitations, using the table of selected magnetic anomalies and other pertinent magnetic examples.

The anomaly's amplitude, in gammas, is a function of both the distance of the sensor from the object(s) being detected and the chance occurrence of the transect over the magnetic field. The amplitude is not only determined by the distance of the sensor head to the magnetic source, the mass of the object, and the magnetic quality of the magnetic source, but also by the magnetic sources orientation in the earth's magnetic field. This last factor has particular importance for linear objects. If the linear object is lying in an east/west direction opposed to a north/south direction, then the area below the earth's ambient magnetic field (magnetic low) could increase and constrict the area above the earth's magnetic field (magnetic high), thus making the detection of the "full" magnetic amplitude even harder to detect even if closer lane spacing were used. The chance of the transect passing in the area to record the maximum magnetic high and low area is far greater than the chance of detecting the material itself. In reviewing Table 10.10, it is apparent that single objects can produce a far greater and sometimes smaller magnetic amplitude than some shipwrecks. Without knowing over what portion of the magnetic field the transect was run and how far the sensor is from the source, the size of the mass cannot be determined, much less whether the mass is a shipwreck or debris.

The signature width and/or duration in time may also be a function of chance depending upon where the survey transect crossed the magnetic field along with the unknown factors of: (a) orientation of the object(s) within the earth's magnetic field; (b) magnetic quality or qualities of the material being detected; and (c) the accumulative magnetic effect of the association and orientation of cultural material to the survey transect. An examination of the selected magnetic anomalies in Table 10.10 indicates an apparent spatial overlap in the size of the magnetic field areas produced by single and multiple objects, by multiple objects and shipwrecks, and by single objects and shipwrecks.

Signature asymmetrical characteristics (i.e., monopole or dipole) are, again, a function of chance determined by location of the transect over the magnetic field, orientation of the source of the magnetics, and nature of the source single object, multiple objects, orientation and association of these objects. In the case of the Star of the West (Saltus 1976) and the schooner James Stockton (Saltus 1985) there are areas below the ambient magnetic field on either side of an area of above the ambient readings. If on a single pass, one of these magnetic low areas were encountered there would be no way of anticipating, predicting, or knowing the nature of the total magnetic area, and it would have to be classified as a monopole when it is neither a monopole or a dipole but a complex magnetic anomaly area. Also there would be no way of determining on which side of the magnetic low (below ambient magnetic field) the magnetic high (above the magnetic ambient field) is located as in the cases of the two above mentioned wrecks.

Sensor height above the seafloor as a criteria is also a function of sensor distance from the magnetic source. If there is collaborating data such as a feature on the side scan sonar record, then analytical interpretation may be possible, but using the magnetic data alone, there is no way to know the sensor-to-magnetic-source distance, therefore, making any type of analysis futile for the above-mentioned rationale regarding amplitude.

Associated unidentified magnetic anomaly occurrences which may be located in anchorage areas, shipping fairways, military warning areas, and gas and oil field and pipeline production areas, represent a broad interpretative category. Gas and oil field pipeline production areas provide an existing magnetic anomaly data base of large and/or liner magnetic fields represented by well heads, platforms and pipelines and oil field platforms which could very easily mask historic shipwrecks. Elimination of anomalies related to shipping fairways could also eliminate possible shipwrecks lying in one of the high wreck probability areas.

Anomalies corresponding with geological features can also mask the presence of cultural material when viewed on a single pass. When the magnetics of the steamer Spray, 1852 construction date, is examined it is apparent that its magnetic field is incorporated with the magnetic field caused by pyrite nodule refuse. Only through a magnetic contour map is the vessel apparent (Saltus 1982). Hematite nodules found in remnant stream channels could conceivably produce low magnetics (J. Harding, personal communication). These magnetics could be within the magnetic amplitude and spatial area range of smaller shipwrecks. Drainage channels in some forms of clay with magnetic qualities have been observed producing 15 to 20 gamma anomalies (D. Bryant 1986). This too could be mistaken for a shipwreck using the MMS lane spacing.

There is no apparent degree of significance to any of the MMS criteria to differentiate debris from shipwrecks. Any such determination is subject to probability and chance, inherent in both the present methodology and the nature of magnetics as it applies to cultural material and, more specifically, multiple cultural material which occur in shipwrecks. If all the variables for interpretation were known, i.e., magnetic moments of the material(s) causing the anomaly, orientation of this material, masses of this material, distance of this material from one another, and the magnetic sensor head, etc., then we could better address the problem as to whether the nature of the magnetics was caused by debris or shipwreck. In almost all cases the anomalies, would have to be ground-truthed even if this agency were to use the 30-meter lane spacing developed by another federal agency, the National Park Service, as adequate for their needs to protect and manage cultural resources (Murphy 1982). Examples of magnetic conflicts between debris and shipwreck occur in fully mapped and contoured magnetic areas. An archaeological river landing site, 16EBR68, produced significant magnetic anomaly areas all of which upon diver investigation produced modern trash and debris while another river landing site, 16LV71, produced one anomaly which was considered relatively less significant than those produced at 16EBR68. Upon diver investigation, this less significant anomaly revealed three watercraft. A keeled vessel, scow barge, and section of a raft, were found, all more or less lying in a pile (Saltus 1986). A small coastal vessel found in the Wando River has less magnetic spatial area and magnetic amplitude than an anchor found in the same survey. Both of these historic materials were magnetically dwarfed by a World War II naval refuse, debris, located and diver identified (Watts 1979).

For the above reasons, it is hoped that the criteria established by the MMS archaeologists will not be used. To do so could create a situation in which a federal agency may write off significant cultural resources by using both an unacceptable database and manipulating this data using criteria which do not have an acceptable degree of reliability or significance. Using this approach would lend credence to the term used by critics of this program, "Archaeofolly."

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Allen R. Saltus, Jr. obtained a B.A. in history in 1967 from Florida Atlantic University, Boca Raton, Florida, and a M.S. in anthropology in 1972 from Florida State University, Tallahassee, Florida. He has worked for the Florida Department of State, Division of Archives, History and Records Management, Bureau of Historic Sites and Properties, Underwater Archaeological Research Unit for seven years and for Gulf South Research Institute for five years. In May 1978, he founded his own firm, Archaeological Research and Survey. ARS has consulted with numerous local, state, and federal agencies as well as with private firms. Mr. Saltus joined the faculty of Southeastern Louisiana University in 1984. He holds an appointment as researcher-in-residence in the Center for Regional Studies and is Curator of Collections. During this period, he has received three grants to study the submerged cultural material in the Maurepas Basin.

Geophysical Search Techniques for Distinguishing Shipwrecks from Trash

Dr. Bruce W. Bevan
Geosight

There are several possible ways of distinguishing old shipwrecks from recent trash on the sea floor. Several ideas are presented here; these ideas are not necessarily original and may not be practical.

It is possible that the AC magnetic properties of old iron are different from modern steel. Steady magnetic fields would almost surely not aid this distinction.

The depth of iron below the sediments could approximate its age. Vector magnetic measurements along a single tow line might allow a determination of the distance of iron below the sensor.

If individual iron artifacts or clusters could be detected, identification of a shipwreck would be more certain. The spatial resolution of the magnetic survey would probably have to allow separation of objects spaced by 1-2 m.

High electrical resistivity could be associated with earlier wrecks having wood and ballast stone. This could be measured with a drag cable resistivity system, electromagnetic induction, or magnetotellurics. A single-source, multiple-sensor electromagnetic system could give high resolution measurements of conductivity and magnetic susceptibility.

Magnetic surveying has been a successful procedure for locating shipwrecks (Arnold and Clausen 1975; Hall 1972), but many false indications from modern discarded iron are also found. It is possible that changes from current survey techniques could increase the reliability of distinguishing shipwrecks from trash on the sea floor.

The high spatial frequency caused by the many iron artifacts at a wreck could aid its identification; the depth of burial within the sediments could be another guide. A wreck could also contain nonmagnetic, but conductive, metals and could have electrically resistive material such as ballast stone. It is also possible that old iron can be distinguished from recent steel trash by differences in magnetic properties resulting from differences in chemical composition and metallurgical structure.

Current magnetic search procedures have a sensor height of 3-6 m above the sea floor and a measurement interval of about 1 m. If the sediment surface is flat and unobstructed, it could be possible to lower the magnetic sensor and decrease the measurement spacing to allow objects 1-2 m apart to be separately resolved.

Triaxial vector magnetic measurements have greatly aided the search for magnetic materials from boreholes (Silva and Hohmann 1981). These same procedures could be applied to estimating the depth of iron in the sediment and, therefore, could suggest its age.

Handheld metal detectors have been applied to search for artifacts at shipwrecks (Colani 1966), but other instruments could be more suitable for large area investigation of insulators and conductors. Electrical resistivity measurements can be made on the sea floor by dragging an electrical cable with several connection points exposed to the seawater (Orellana 1982, p. 386; Terekhin 1962). Magnetotelluric surveys typically measure to a great depth (Moose 1981, Gregori and Lanzerotti 1979), but might be suitable for this survey. Other techniques for measuring sea floor conductivity are also possible (Bannister 1968, Coggon and Morrison 1970).

Old iron could be significantly different from modern iron in its magnetic properties. An electromagnetic induction system which measures the electrical conductivity of the sea floor could also determine its AC magnetic susceptibility. Measurements at one or more frequencies might allow different ferrous materials to be distinguished. With the vector magnetometer mentioned above, it could be possible to separate the remnant and induced magnetization of iron objects by determining the net direction of polarization. The ratio of remnant to induced magnetization, the Koenigsberger ratio (Parasnis 1979, p. 13), might distinguish old iron from modern steel.

While all of the ideas mentioned here have been applied in geophysics, further investigation will be needed to see if any of them could really aid the geophysical search for historic shipwrecks.

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Bruce Bevan is a geophysicist who does terrestrial surveys for archaeological and geotechnical engineering applications. Through his company, Geosight, he applies magnetics, electromagnetics, and ground-penetrating radar to high resolution, shallow depth surveys. He has an M.S. degree in electrical engineering and a Ph.D. in geology.

Table 10.1

Line #1 - Run Directly Over Wreck of Will O' Wisp*

#	Amplitude (nanoteslas,nt)	Time (sec)	Duration (sec)
1	0	0	0
2	0	10	0
3	0	20	0
4	0	30	0
5	0	40	0
6	+6	50	10
7	+7	60	10
8	+7	70	20
9	+18	80	30
10	+56	90	40
11	+216	100	50
12	+2659	110	60
13	-311	120	70
14	-122	130	80
15	-33	140	90
16	-14	150	100
17	-6	160	110
18	-3	170	120
19	-4	180	130
20	0	190	0
21	0	200	0

*Tow depth: surface
Target depth: 3 meters
Tow speed: 3.5 knots
Sensitivity: ± 1 nt

Table 10.2

Line #2 - 50 Meters South of Will O' Wisp

#	Amplitude (nanoteslas,nt)	Time (sec)	Duration (sec)
1	0	0	0
2	0	10	0
3	0	20	0
4	-1	30	0
5	-4	40	10
6	-9	50	20
7	-9	60	30
8	-3	70	40
9	+18	80	50
10	+48	90	60
11	+46	100	70
12	+25	110	80
13	+18	120	90
14	+11	130	100
15	-4	140	110
16	-3	150	120
17	-4	160	130
18	-5	170	140
19	0	180	0
20	0	190	0
21	0	200	0

Table 10.3

Line #3 - 75 Meters South of Will O' Wisp

#	Amplitude (nanoteslas,nt)	Time (sec)	Duration (sec)
1	0	10	0
2	0	20	0
3	0	30	0
4	0	40	0
5	-2	50	0
6	0	60	10
7	0	70	20
8	-3	80	30
9	-5	90	40
10	+3	100	50
11	+2	110	60
12	+9	120	70
13	+11	130	80
14	+8	140	90
15	+8	150	100
16	+6	160	110
17	+4	170	120
18	+7	180	130
19	+5	190	140
20	+3	200	150
21	0	210	0

Table 10.4

Line #4 - 100 Meters South of Will O' Wisp

#	Amplitude (nanoteslas,nt)	Time (sec)	Duration (sec)
1	0	10	0
2	0	20	0
3	0	30	0
4	0	40	0
5	0	50	0
6	-2	60	0
7	-5	70	10
8	-9	80	20
9	-4	90	30
10	-2	100	40
11	-1	110	50
12	0	120	60
13	-3	130	70
14	0	140	80
15	-1	150	90
16	0	160	100
17	+1	170	110
18	+1	180	120
19	+1	190	130
20	+2	200	140
21	+1	210	150
22	+1	220	160
23	0	230	0

Table 10.5

Line #5 - 125 Meters South of Will O' Wisp

#	Amplitude (nanoteslas,nt)	Time (sec)	Duration (sec)
1	0	0	0
2	0	10	0
3	0	20	0
4	0	30	0
5	0	40	0
6	+6	50	10
7	+7	60	10
8	+7	70	20
9	+18	80	30
10	+56	90	40
11	+216	100	50
12	+2659	110	60

Table 10.6

Line #6 - 150 Meters South of Will O' Wisp

#	Amplitude (nanoteslas,nt)	Time (sec)	Duration (sec)
1	0	10	0
2	0	20	0
3	0	30	0
4	0	40	0
5	0	50	0
6	+1	60	10
7	+2	70	20
8	0	80	30
9	+2	90	40
10	-1	100	0
11	0	110	0
12	0	120	0
13	0	130	0
14	0	140	0
15	0	150	0

Table 10.7

Amplitude Values

Line #	Amplitude (nanoteslas)	Distance (meters)
1	2659	0
2	46	50
3	11	75
4	9	100
5	4	125
6	2	150

Table 10.8

Signature Values

Line #	Signature	Distance (meters)
1	dipolar	0
2	dipolar	50
3	monopolar	75
4	dipolar(?)	100
5	monopolar	125
6	monopolar	150

Table 10.9

Duration Values

Line #	Time (sec)	Distance (meters)
1	2659	0
2	130	50
3	140	75
4	150	100
5	70	125
6	40	150

Table 10.10

Selected Magnetic Anomalies

SINGLE OBJECTS

Sensor Height in feet	Object	Size of Object in feet	Magnetic Area in feet	Inflection in Gammas
3	cable	70 x 1 in.	173 x 89	380
15	camshaft	20 x 2 in.	50 x 45	45
4	cast iron soil pipe	10; 100 lbs.	65 x 45	1407
4	anvil	150 lbs.	26 x 26	598
4	kettle	22 in. dia.	26 x 26	59
16	anchor	6 foot shank	270 x 80	30
3	pipe	3 in. dia.	45 radius	550*
8	pipe	20 x 10 in. dia. 10 in. dia.	160 x 90	180

MULTIPLE OBJECTS

Sensor Height in feet	Object	Size of Object in feet	Magnetic Area in feet	Inflection in Gammas
5	pipe & bucket	8 x 1 in. dia.	60 x 50	250
15	cable & chain	60 in. @	50 x 40	30
5	burn pile charcoal	8 dia. x 3 in.	40 x 30	20
6	burn area charcoal	30 x 20 x 1	120 x 70	15
10	pyrite	noduals	350 x 150	310
10	metal stairs & "I" beam	14 x 3 x .8 10 x 1	150 x 140	100
15	scattered ferrous metal	90 lbs.	110 x 90	100
20	WW II naval refuse (paint buckets, 55 gal drums, mop pails, cable, etc.)	mixed	550 x 450	361

Table 10.10 (cont'd)

Selected Magnetic Anomalies

WRECKAGE

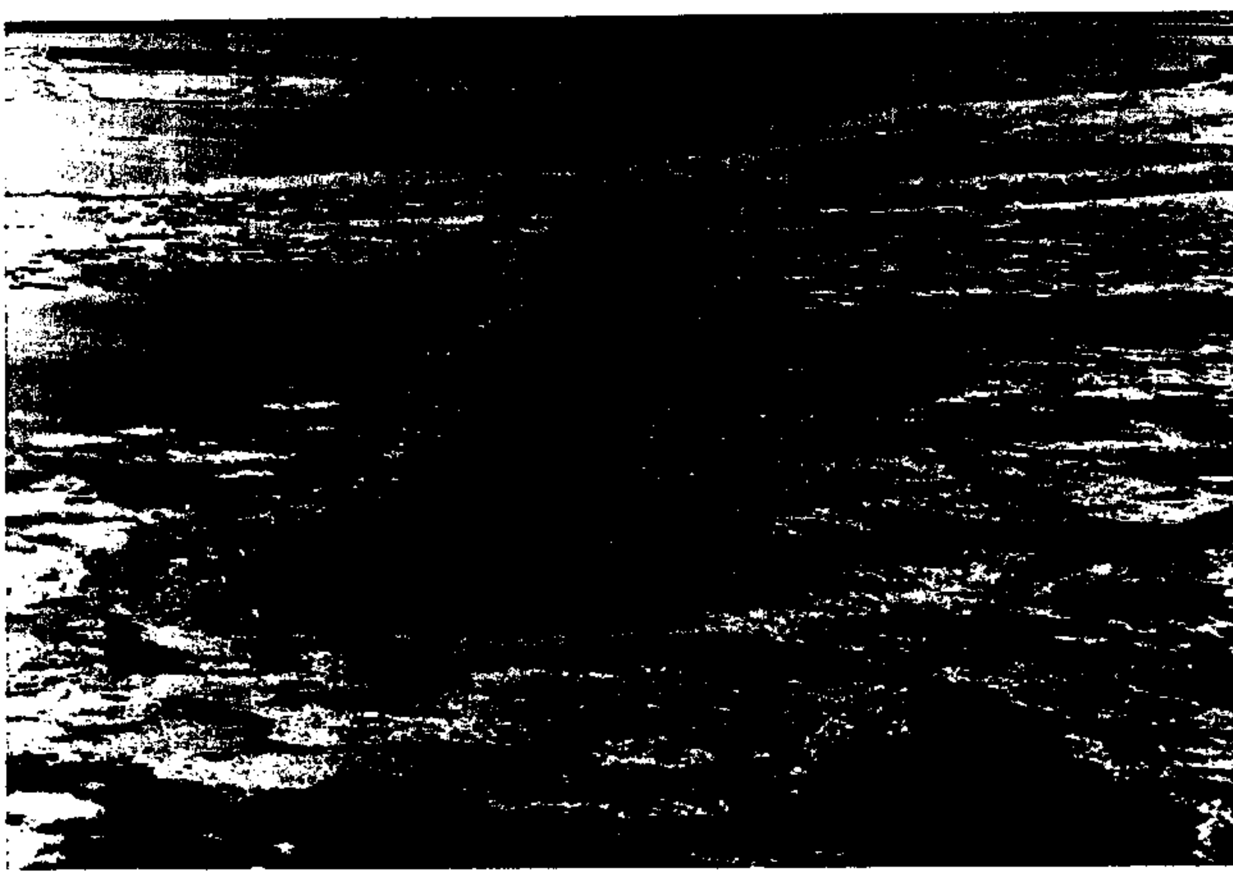
Sensor Height in feet	Object	Size of Object in feet	Magnetic Area in feet	Inflection in Gammas
4	Star of the West ocean going side-wheel steamer	228 x 32	350 x 350	7650
16	Wando River wreck coastal trader	90 x 20	250 x 150	35
8	gas sternwheel boat	50 x 10	200 x 140	450
12	Lotawana river steamboat	180 x 47	350 x 300	310
20	Constante merchant sail	128 x 26	250 x 150	60
10	Steamer Spray	140 x 19	180 x 160	520
8	James Stockton schooner	55 x 19	130 x 90	80
20	CSS Tuscaloosa ironclad	150 x 40	300 x 200	4000
3	segment of a shrimp boat	27 x 5	90 x 50	350
12	keeled barge	92 x 22	250 x 250	180
8	river trader sail	44 x 13	120 x 100	100
12	1840's tow boat	65 x 13	110 x 60	110

All values in feet unless otherwise noted. * Denotes monopole; all other anomalies are dipolar (A.R. Saltus 1986).

OCS STUDY
MMS 86-0073

PROCEEDINGS

Sixth Annual Gulf of Mexico Information Transfer Meeting



U.S. DEPARTMENT OF THE INTERIOR/MINERALS MANAGEMENT SERVICE

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Chairmen: Ms. Melanie Stright
Mr. Rik Anuskiewicz

Date: October 23, 1985

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Cultural Resources I - Current Research in the Gulf of Mexico: Session Summary

Ms. Melanie Stright
Minerals Management Service

The locations of historic shipwrecks, like any archaeological site, are governed by common factors which lend a certain predictability to their occurrence.

Where historically active shipping areas such as major shipping routes, ports, and harbors coincide with environmental factors such as shoals, reefs, and historic hurricane paths, the probability for locating shipwrecks is high.

The presentation by Mr. James Parrent, Texas A&M University, outlines a study proposal to evaluate these various cultural and environmental factors to predict better where shipwrecks might have occurred in the Gulf of Mexico.

The U. S. Army Corps of Engineers intensively investigated one such high probability area, Mobile Bay, AL, in order to locate any historic resources present within a proposed harbor deepening project area. The Corps of Engineers contractor, Espey, Huston & Associates, conducted an extensive magnetometer survey within the project area and investigated all unidentified magnetic anomalies to determine their source. The results of this investigation were presented by Mr. Clell Bond of Espey, Huston & Associates, and Ms. Dorothy Gibbons of the Corps of Engineers, Mobile District.

After shipwrecks are located, accurate mapping and recording of the site sometimes requires years of intensive effort.

Dr. Glen Williams, Texas A&M University, reported on a high resolution ultrasound underwater triangulation mapping system which allows rapid, accurate mapping of a shipwreck site, even in a blackwater environment. The system utilizes three ultrasound receivers, a stationary ultrasound transmitter, and a mobile transmitter linked to an IBM PC portable computer at the surface. After calibrating the positions of the receivers, the computer can calculate the position of the mobile transmitter through triangulation as it traces objects on the seabed. The rapidness and accuracy provided by this mapping system may make obsolete the present time-consuming and subjective underwater site mapping techniques such as hand sketching and photomosaics.

The locations of prehistoric archaeological sites, like historic shipwrecks, are governed by common factors which make their occurrence somewhat predictable. The cultural resources baseline study for the northern Gulf of Mexico (CEI, 1977) established criteria for predicting prehistoric site locations in the offshore environment. A 1982 study by the National Park Service established sedimentary criteria which would allow site/non-site determinations to be made from core-sized sediment samples in the offshore environment. These two studies provided the baseline data necessary to locate prehistoric archaeological deposits on the OCS. In 1983 MMS funded a study to test the predictive and sedimentary criteria established by the 1977 and 1982 studies. The final results of this 1983 study entitled "Prehistoric Site Evaluation of the Northern Gulf of Mexico: Ground Truth Testing of the Predictive Model" were reported by Dr. Charles Pearson of Coastal Environments, Inc.

Of the types of geomorphic features representing high probability areas for prehistoric site occurrence, only karst areas were not included in MMS's 1983 study. Freshwater springs, which often occur in association with these karst areas, provided not only a water source, but also a concomitant increase in plant and animal food resources for prehistoric man during periods of drier climatic conditions and lower standing sea level. Dr. Ervan Garrison, Texas A&M University, presented a proposal to locate submerged karst features (sinkholes) with associated springs offshore in the eastern Gulf of Mexico using infrared scanners and high-resolution side scan sonar systems. These sinkholes would then be investigated for the presence of associated archaeological deposits.

Coastal Environments, Inc. 1977 *Cultural Resources Evaluation of the Northern Gulf of Mexico Continental Shelf.* Prepared for Interagency Archaeological Services, Office of Archaeology and Historic Preservation, National Park Service, U.S. Department of the Interior. Baton Rouge, LA.

Coastal Environments, Inc. 1982 *Sedimentary Studies of Prehistoric Archaeological Sites.* Prepared for Division of State Plans and Grants, National Park Service, U.S. Department of the Interior. Baton Rouge, LA.

Melanie J. Stright obtained a BA in Anthropology from Ohio State University in 1976. From 1976 to 1978 she was District Archaeologist for the Rawlins District of the Bureau of Land Management in Rawlins, WY. In 1978 she became the staff archaeologist for the Gulf of Mexico Outer Continental Shelf Office, where she has worked on developing the marine archaeology program and geophysical survey requirements for oil and gas related high-resolution surveys. Her current research interests are the archaeological applications of remote-sensing methods, paleoenvironmental reconstruction, and Holocene sea level change.

The Archaeological Significance of Sinkholes in the Eastern Gulf of Mexico

Dr. Ervan G. Garrison
Civil Engineering Department
Texas A&M University

Inundated karst features such as sinkholes exist on the Outer Continental Shelf of the Eastern Gulf of Mexico. Terrestrial counterparts of these geological features have demonstrated clear evidence of prehistoric man's association with them, particularly in Western Florida. Holocene occupation of Little Salt Springs and Warm Mineral Springs by Archaic Period peoples is currently under archaeological study at these important sites. Occupation of these sinkhole springs occurred during periods of lowered sea stand. This is especially true for Warm Mineral Springs where Cockrell has dated skeletal remains to over 8500 years before the present (B.P.).

Since large areas of the now inundated Outer Continental Shelf were open to settlement as early as 18,000 years B.P., it is reasonable to assume that sinkhole springs active in the early Holocene should have had similar occupations by nomadic hunting and gathering peoples of this period. Springs are an exception to the scenario of fill by marine transgressional processes by the simple discharge of an amount of fresh water sufficient to offset the hydrostatic pressure of sea water and deposition of current transported sediments. Further, in areas of the Outer Continental Shelf such as that off Western Florida (Figure IIIF.1), sediment starvation regimes active there have resulted in little deposition of sediments like that typically observed in the central and western portions of the Gulf of Mexico.

Location of these submarine sinkhole springs presents a challenge to instrumental techniques typically used for other geophysical and remote sensing purposes. Two promising techniques for the location of submerged springs are (1) infrared scanning of the sea surface in the 8 to 12.5 micron band and (2) acoustical survey of the sea bottom with high resolution side scan sonar systems (100-500KHz). Both these techniques have proven successful in the detection of active and inactive submarine sinkhole springs off Jamaica and Western Florida.

An infrared scanner capable of sensing the sea surface infrared emission radiation in the 8 to 12.5 micron band by use of a mercury cadmium tellutide (trimetal) detector can map sea surface temperature to 0.2°C from an airplane flying at an elevation of 1000 to 2000 feet. To obtain only emission radiation rather than emission plus reflection, it is best to fly just before dawn or at night. A mrad detector will give a ground (sea) resolution of (pixel size) 1 foot by 1 foot when flown at 1000 feet of elevation. Band 6 (10.4 to 12.5 micron) of the Thematic Mapper of Landsat 4 yields only a 30m by 30m pixel size, which is far too large for the detection of submarine springs.

The detection of submarine sinkholes has been successfully accomplished off Western Florida using high resolution side scan sonar and digital recording/playback color depthfinders. A sonograph of such a sinkhole is shown in Figure IIIF.2. With instrumentation such as CTD probes (conductivity-temperature-dissolved oxygen sensors) mounted on ships and submersibles, it is further possible to locate precisely the submarine feature for archaeological exploration. If it is not an active spring, reliance on only acoustical detection gear coupled with precision navigation has resulted in the finding and relocation of such sinks as that shown in Figure IIIF.2.

No extensive investigations of these exciting offshore geological features have been conducted to date. The research discussed here has identified and field deployed these technologies successfully in the location of these sinkholes. Continued research may produce verifiable evidence of prehistoric man's early location and use of these same phenomena.

Dr. Ervan G. Garrison is an archaeologist and a lecturer and associate research scientist of Civil Engineering at Texas A&M University. His research interests include the application of geophysical instrumentation to the study of archaeological problems onshore and offshore. Of particular interest to Dr. Garrison is the clear demonstration of early man's presence on the now inundated continental shelf during the Late Quaternary.

Cultural Resource Investigations of Magnetic Anomalies in Mobile Bay

Ms. Dorothy Gibbens
U.S. Army Corps of Engineers
and
Mr. Clell L. Bond
Espey, Huston & Associates, Inc.

The U.S. Army Corps of Engineers, Mobile District, was authorized in the mid-1960's to examine the feasibility of deepening Mobile Harbor, Alabama. A feasibility report was completed in 1980 recommending channel deepening to 50 ft.

The proposed improvements include the following items: turning basin and anchorage area, transshipment facility, channel deepening to 55 feet at existing 400-ft width, passing lane, upper channel widening, disposal of new work material in Wilson Gaillard Island, and disposal of new work material in the Gulf of Mexico.

In compliance with current federal cultural resources laws and U.S. Army Corps of Engineers regulations, cultural resources investigations were initiated for the Mobile Harbor deepening project in 1982. Work performed in 1982 included archival and historic research on the prehistory and history of the study area, and a remote-sensing survey of all proposed work items. A total of 603 magnetic anomalies were recorded by the survey. However, correlation of magnetic data with side-scan sonar imagery revealed that most of the anomalies were produced by cable, pipe, and other modern ferrous debris.

In 1983, underwater archaeological investigations of the anomalies recommended for evaluation were initiated. One of the anomalous areas located within the limits of the proposed new turning basin proved to be part of the western arm of obstructions built by the Confederate engineers as part of the defenses of the City of Mobile during the Civil War. The remainder of the anomalies investigated in 1983 proved to be modern ferrous debris. Subsequendy, in 1984, additional archaeological testing of the obstructions was completed. As a result of the 1984 testing program, the remains of a mid-19th century steamboat, the *Cremona*, and a wooden flat loaded with brick were documented. Additionally, the remains of a third vessel, believed to be the *Carondelet*, also sunk as part of the western arm of obstructions, were encountered. The Confederate obstructions, designated submerged historic site 1Mb28, have been determined eligible for inclusion in the National Register of Historic Places.

During the 1984 field season, three trenches placed at the bow, stern, and amidship of the *Cremona* were excavated. The hull, though broken in several places, was found to be in an excellent state of preservation. The hull was filled to varying depths with brick and other rubble. In addition to documenting the dimensions and construction of the *Cremona*, a trench placed to the north of that vessel identified a simply-constructed wooden flat loaded with brick. The lines of wooden pilings demarcating the western arm of obstructions were also delineated running diagonally from southeast to northwest across the turning basin. Planking and bricks were encountered exposed above the bay bottom at the southern end of the line of obstructions. This material is believed to represent the remains of the *Carondelet*.

In 1985, twenty-one anomalies within and adjacent to the Mobile Harbor Ship Channel were evaluated. Five were no longer in place in their positions as reported in 1982. The remaining 16 were identified as modern ferrous debris. In addition to identifying the anomalies located along the ship channel, the western end of the southern line of obstructions and southern end of the western line of obstructions were delineated by underwater archaeologists and recorded with side-scan sonar, magnetometer, and survey fathometer.

The highly variable environment of Mobile Bay, its considerable different water depths, and especially its potentially hazardous diving conditions, necessitated a flexible approach in terms of field methodology. The techniques and equipment of the investigations were continually refined during the 1983, 1984, and 1985 field seasons. In the areas of investigation, water depths varied from three to over 50 feet, and visibility, while typically limited by extreme turbidity to less than a foot, reached as much as 20 feet in the lower bay. Bottom conditions included mollusk reefs, as well as consolidated and unconsolidated silts and clays. The range of work platforms necessary to meet the various work tasks and Bay conditions included inflatable and rigid-hull skiffs, small steel barges, outboard power work boats, and diesel-powered crew boats. Underwater inspection of the anomalies was conducted using both open circuit SCUBA, as well as a surface-supplied air system.

The investigation of each anomaly involved up to eight steps: 1) Initially, the suspected position of each anomaly, as identified during the 1982 survey, was relocated, using a line-of-sight radio-positioning system, and buoyed; 2) after the positioning, the area was reinspected with the magnetometer to determine the strength, size, shape and characteristics of the magnetic signature; 3) after refining and rebuoying the suspected location, the position was again recorded using both the line-of-sight system and Loran C; 4) the area was then subjected to an initial diver inspection and tactile search; 5) if the divers failed to locate the anomalous object, additional magnet prospections were initiated using a diver-manipulated sensor; 6) after final location was made, a program of systematic probing was used to penetrate bottom sediments, with solid probes being used to penetrate to depths of eight feet and hydraulic probes penetrating up to 20 feet of sediment; 7) excavations were then conducted, depending on conditions, using propwash deflectors, hydraulic dredges and hydraulic jets; 8) where possible, the anomaly source was either then archaeologically documented and/or brought to the surface for inspection and removed from the area.

The Mobile Bay investigations have thus far documented a significant portion of American history, identifying both specific cultural resources of the Civil War as well as providing details of ship and harbor defense construction techniques. The investigations have also provided additional information on the interpretation of magnetic signatures.

Ms. Dorothy Gibbens is a cultural resource specialist with the U.S. Army Corps of Engineers, Mobile District. Obtaining her master's degree from Louisiana State University, she has conducted archaeological investigations in Central America and served with the Louisiana State Historic Preservation Office. For the past seven years, Ms. Gibbens has been with the Mobile District specializing in southeastern prehistory and marine survey archaeology.

Mr. Clell Bond is employed by and directs the cultural resources program of Espey, Huston & Associates, Inc., an engineering and environmental consulting firm headquartered in Austin, Texas. Actively engaged in cultural resources management for the past 15 years, his special interests are in historical and nautical archaeology.

A Computerized High Resolution Underwater Ultrasound Triangulation Mapping System

Dr. Glen N. Williams
Computer Science Department
Texas A&M University
and
Dennis A. Hahn
Shell Oil Company

A computerized high resolution ultrasound underwater triangulation mapping system has been developed for the Institute of Nautical Archaeology. This system determines the position of a mobile ultrasound transmitter using a stationary calibration ultrasound transmitter and three ultrasound receivers. All three receivers and both transmitters are hardlinked to the surface via data lines connected to an IBM PC portable computer. The receivers provide sixteen bits of resolution (1/2 millimeter) to the computer for calibration/triangulation purposes. The computer determines the location of the mobile transmitter at a frequency of ten hertz, time stamps the observations, graphically displays them in real time for shipboard/diver interactive communications, and optionally archives them for future post-processing and analysis.

Of keen interest to nautical archaeologists is the ability to record accurately the visual appearance of their underwater excavations. Currently, the techniques employed range from freehand sketches by underwater artists to more sophisticated stereoscopic photographs and videotaping. However, each of these methods has inherent disadvantages. First, the excavation must be at least partially visible for the artists/cameras to properly operate; in addition, the later translation of individual pictures to large mosaics includes an intrinsic amount of subjectivity by the artist. Finally, and most importantly, the large quantity of time to perform the recording is expensive. An alternative method minimizing both subjectivity and time would improve the efficiency and accuracy of the excavation recording tasks.

One such possible solution is electronic triangulation. By utilizing ultrasound pulses, instead of light, as the (primary) source of information, the stringent visibility requirement intrinsic to artists and cameras is removed. Also, the triangulation computations are performed by computer, thus assuring mathematical objectivity. Lastly, the construction of individual pictures and large mosaics is acomplished in real time during the survey and can be redrawn efficiently after a diving session, thus enabling timely reviews of the excavation progress.

The electronic hardware used with the computerized triangulation system consists of three ultrasound receivers, two ultrasound transmitters, and an integrated circuit control module designed to fit a long slot of an IBM PC portable computer.

The three ultrasound receivers are small objects; they measure approximately one inch in diameter and twelve inches in length. Their purpose is to filter digitally all incoming sound frequencies to detect the ultrasound pulse wave. When a receiver detects the designated ultrasound frequency, the receiver transmits a signal to the control module via an attached coaxial cable, acknowledging the arrival of the pulse.

The stationary ultrasound transmitter has approximately the same dimensions as the receivers. It is also attached to the control module via a coaxial cable. When instructed by the control module, the transmitter emits an ultrasound pulse for the receivers to detect.

The mobile ultrasound transmitter is similar to the stationary transmitter in control attachment and control. However, there exist two major differences. Although the electronics within the mobile transmitter are the same size as the stationary transmitter, the mobile transmitter is housed in a longer body with an attached handle for the diver to grasp; the general shape resembles an oversized revolver. In addition, the mobile transmitter has a small trigger switch with a red light emitting diode (LED) for simple diver/computer communications. The diver presses the switch when he is ready to trace an object, while the computer activates the light when it is ready for an object to be traced.

Lastly, the control module measures the time delays required for the mathematical geometric computations. Upon computer operator control, the control module simultaneously instructs the transmitter to emit an ultrasound pulse and counts the number of elapsed clock cycles until the return signals from the individual receivers are obtained. The counts are maintained in a series of sixteen-bit registers. If the elapsed number of clock cycles exceeds (2**16 - 1), the control module stops the counting process. This condition is hereafter referred to as a flooded gate response; a value of (2**16 - 1) is assigned to the time delay counter, a semaphore signaling the software that a valid time delay was not obtained. When all three time delays have been calculated, the computer control module signals the software of the availability of the delay values.

The computerized triangulation procedure consists of four major components: initialization, data input, point determination, and graphical display. When the program is started, the system geometry (transmitter/receiver relationships) is initialized, either from preset conditions or new survey parameters. The program stores the new parameters and proceeds to the data acquisition phase. On the decision of the operator, the initialization procedure can be re-executed to relocate the position of a receiver or completely establish a new underwater relative coordinate system.

The first phase of the data acquisition cycle consists of the data input. When invoked, this section of code performs a series of polls to the ultrasound transmitters and receivers via the computer control module. First, the mobile transmitter is instructed to emit a pulse. Next, the respective receivers will supply the experienced time delays as the number of clock cycles for the pulse to traverse the water. If a flooded gate response is experienced by any of the three receivers, the program displays an error message on the console and requests that the mobile transmitter emit another pulse. This cycle continues until eventually no flooded gate responses are recorded.

Next, the stationary transmitter will emit a pulse to be detected. Again, the receivers supply the time delays or record flooded gate responses. A series of five valid time delays are averaged to reduce the amount of variability within the observations.

After the time delays between the transmitters and receivers have been established, the position determination routine is invoked. First, the sound travel rate and mass flow vector are calculated using the averaged time delays from the stationary transmitter via the calibration equations. Next, the location of the mobile transmitter is computed by translating the time delays experienced from the mobile transmitter. Then, the calculated coordinates are stored in an archive file for future reference. Finally, control is passed to the graphic display section.

Subsequent to the computation of the location of the mobile transmitter, the calculated point is graphically displayed within the XY-plane of the relative coordinate system in real time for the operator to view.

The computerized ultrasound triangulation mapping system is designed for and implemented on an IBM PC portable computer. The computer software is written in MicroSoft BASIC and is executed in compiled form with an 8087 Math coprocessor. A ten hertz control module sampling rate was experienced with this configuration. While the software was being written at Texas A&M, the hardware was being designed and built by Martin Wilcox of Applied Sonics, Inc. The hardware and software components were generated and debugged independently.

The first version of the computerized triangulation procedure was tested in a swimming pool with the surveyed object being a brick. A following test was performed at a Civil War wreck site in the York River, Virginia, and the system functioned as designed.

A second version of a computerized triangulation procedure is currently being designed with modifications to both hardware and software components. The stationary ultrasound transmitter and three ultrasound receivers will be replaced by four ultrasound transducers, capable of both transmitting and receiving ultrasound pulse waves.

The computerized ultrasound triangulation mapping system is a more feasible and economically better system of recording the physical characteristics of underwater excavations than are artist's sketchings and stereoscopic photography. This has been proven by the ease of operation of the mapping system during the preliminary tests. However, as with any new developments, future research can greatly aid the evolvement of the computerized triangulation system. In addition, sensitivity and parametric tests are required to establish the limits of the software and hardware components.

Dr. Glen Williams is an associate professor of computer science at Texas A&M University. His primary areas of interest include computational algorithms in numerical methods and computer graphics and their applications to the oceanic engineering environment. Contributional areas include surface/sub-surface oil spill transport and diffusion, submarine slope stability and geologic process simulation and modeling. He received his BS, ME, and PhD degrees in Civil Engineering from Texas A&M University.

Evaluation of Minerals Management Service Archaeological Management Zone 1

Mr. James Parrent
Department of Anthropology
Texas A&M University

Archaeological studies are conducted in the Gulf of Mexico (GOM) as part of the offshore oil and gas leasing program because of the great number of historic shipwreck sites located there. Accordingly, the Minerals Management Service (MMS) Manual for Archaeological Resource Protection (draft) requires that archaeological baseline studies be updated as new data become available. These baseline studies, containing predictive models which deal with the location of both prehistoric and historic cultural resources, are the foundation for MMS decisions on where to invoke the archaeological survey requirement. No systematic evaluation of historic archaeological resource data has been accomplished since Coastal Environments, Inc., (CEI) completed a report titled "Cultural Resources Evaluation of the Northern Gulf of Mexico Continental Shelf (CEI 1977)." The CEI study was utilized by MMS to establish the present cultural resource management zones.

The present study will compile information collected since 1977 and will consider additional factors which contribute to site location and preservation on the GOM Outer Continental Shelf (OCS). It is anticipated that the present study will more clearly define historic archaeological resource areas on the GOM OCS, thereby avoiding costly surveys in areas where the potential for archeological sites is low.

Volume II of CEI's 1977 report addresses the historic cultural resources which may be found on the GOM OCS. Questions concerning the validity of certain aspects of this volume and the archaeological management program on the OCS have been raised by industry, Gulf Coast State Historic Preservation Officers, the Sierra Club, and the professional archaeological community. Industry, for example, has expressed concern over the amount of money and effort spent on the required lease block surveys in Archaeological Management Zone 1 (AMZI) versus the sparsity of information gained about historic shipwrecks. Another point was raised by the Sierra Club when they responded to the call for comments on the Draft Environmental Impact Statement (DEIS) for 1984. They questioned the following statement in the DEIS: "Due to the general lack of a data base for OCS cultural resources, the expected impact from offshore development is uncertain." In their written response, the Sierra Club asked (1) "What are you going to do about the lack of a data base for OCS cultural resources?" and, (2) "How will you alleviate this problem?" (MMS 1983).

Archaeologists from academia, federal agencies, and state agencies have raised the following questions: (1) Why has so little information about historic shipwrecks been recovered from the lease block surveys in Zone 1? (2) In view of what is known about GOM prevailing wind and ocean current directions, are the sailing routes depicted in CEI's report accurate? (3) How do factors such as bottom sediment types, depth of unconsolidated sediments, water depth, and energy zones affect the state of preservation and integrity of shipwreck sites? (4) Why does the Zone 1 boundary follow, for the most part, the 20-m bathymetric curve, disregarding the influences of such major ship concentrating factors as important historic ports, major harbors, and inland waterways? (5) What is the correlation between historic shipping lanes and historic hurricanes, and how has this correlation affected the shipwreck pattern in the GOM? These questions plus others will be addressed by the present study.

The question about the lack of historic shipwrecks found as a result of lease block surveys can be explained by the fact that industry chooses to avoid almost all magnetic anomalies located during the surveys rather than identifying them. Other questions are not so easily answered. However, new data germaine to the issues are available. For example, preliminary investigation of GOM prevailing wind and currents, coupled with a review of historic maps, suggests that historic shipping routes were different than previously thought. However, it must be emphasized that many maps and historic documents must be examined before any conclusions are reached by the present study.

Another question deserving attention is whether or not shipwrecks will be preserved in high energy zones in the GOM. Claims by some that historic shipwrecks, in areas of high energy, will be scattered and of minimum historic value are not supported by recent investigations. In August 1984, an historic shipwreck located in the GOM Eastern Planning Area was investigated by MMS personnel. Site reports, on file at the Florida Division of Archives, History, and Records Managment Office in Tallahassee, show that, when first discovered, the shipwreck was very well preserved, even though it was in an area of high energy (Parrent 1984). It is well documented that preserved historic shipwrecks can be found in very high energy zones (Arnold and Weddle 1978, Bass 1975, Hoyt 1984, and others). However, before conclusions can be reached by the present study, environmental conditions in the various areas of the GOM must be examined thoroughly to determine their role in the preservation or destruction of shipwreck sites.

Clearly there remains a need to examine the various factors affecting the occurrence and preservation of historic shipwreck sites. These factors need to be analyzed, weighed, and developed into a framework which will assist in determining where the most probable locations of preserved sites are on the OCS. This new and comprehensive approach may lead to recommendations for changing the boundary of AMZ1 in the GOM. In general, archaeologists would like to see the area of Zone 1 increase while other individuals would like for the area to decrease or perhaps not to exist at all. Only through rigid scientific investigation can the concerns of industry, as well as those of the archaeological community, be addressed. Ideas or boundaries not supported by scientific data will always be open to criticism.

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Mr. Parrent is a research scientist/archaeologist with the Department of Anthropology at Texas A&M University. For the past year he has been working with the Minerals Management Service Gulf of Mexico Region through an Interagency Personnel Agreement. Mr. Parrent's responsibilities included the re-evaluation of the historic cultural resource zone in the Gulf of Mexico. He received the BA in Anthropology from Wright State University, and the MA, specializing in nautical archaeology, from Texas A&M University.

Evaluation of Prehistoric Site Preservation on the Outer Continental Shelf: The Sabine River Area, Offshore Texas

Dr. Charles Pearson
Coastal Environments, Inc.
and
Louisiana State University

For the past decade there has been an increasing interest in the prehistoric cultural resources potential of the continental shelves of the world. Many would agree that given certain conditions, prehistoric sites established on the continental shelf during periods of lower sea stand would have withstood the effects of rising seas and now remain preserved on the submerged portions of the shelf. One of the settings which provides that set of conditions conducive to site preservation is a filled stream valley -- especially the larger valleys which with sea level rise develop into estuaries and slowly fill with sediments before being completely inundated. Archaeological deposits can become covered by and encapsulated in estuarine sediments and remain intact beneath the erosive impacts of transgressive seas. Developing statements concerning the occurrence and distribution of archaeological deposits in these offshore settings requires, first, the projection of a culture history for the area with its attendant settlement patterns probably best drawn from onshore analogies; second, an assessment of the geologic history of the area; and third, the identification of the geomorphic processes which have occurred relative to their effect on archaeological site preservation.

To date several studies relying on these types of data have produced what appear to be reasonable models of site occurrence and preservation in large stream valleys on the North American continental shelf (Belknap and Kraft 1981; Coastal Environments, Inc. 1977; Kraft Belknap and Kayan 1983; Masters and Fleming 1983). Testing these models, however, is another and more complicated problem. It requires a technology that permits the identification of submerged and buried landforms which have a high likelihood of containing cultural remains and it also requires a method for collecting samples from these landforms. In essence it demands a practical geological/geophysical approach to an archaeological problem. Fortunately, this technology is today available in the form of a variety of instruments which permit refined mapping of the shallow subsurface geology and in a range of coring devices which can collect an analyzable sample from a submerged target landform.

This paper discusses a project undertaken by Coastal Environments, Inc., to test a predictive model of site occurrence and preservation developed in an earlier baseline study of the cultural resources potential of the OCS (Coastal Environments, Inc. 1977). This project is being sponsored and funded by the Minerals Management Service of the Department of the Interior.

The project was conducted in two phases. The first phase involved the collection, evaluation, and synthesis of archaeological, geological, seismic, and bore hole data from the study area. The second phase involved the collection and analysis of vibracore samples taken from target areas which had been identified from the seismic records as potential cultural resource locales.

The region selected for implementation of this study is a 35-mile-square area in the offshore Sabine-High Island region of eastern Texas and western Louisiana containing the relict- filled channels of the late Pleistocene to Holocene age Sabine River Valley (Figure IIIF.3). This late Pleistocene river system provided an ideal research universe for the present study largely because a series of published works is available which provides information on the present setting and geologic history of the trench area. Of particular importance is the published work of H. F. Nelson and E. E. Bray (1970) which delineates the Pleistocene river system and the subsequent changes it underwent with sea level rise. In addition to the work of Nelson and Bray, an extensive body of seismic and bore hole data collected relative to oil industry activities is available from the area, and the regional geology has been well studied (Aronow 1971; Aten 1983; Bernard 1950; Bernard and LeBlanc 1965; Bernard LeBlanc and Major 1962; Berryhill 1980; Curray 1960; Nelson 1968).

Other factors which make the buried Sabine Trench conducive in the search for submerged sites are (1) the river system was active and the region was subaerially exposed when prehistoric populations occupied the region; (2) the river system was active for at least 12,000 years, sufficient time to permit the accumulation of an extensive archeological record, possibly including multicomponent, stratified sites; (3) relict features having a high probability for both site occurrence and preservation had been identified within the valley system; and, (4) importantly, these landforms are often not deeply buried and many are within the range of vibracoring, the sampling technique used in this study.

Working from the base provided by Nelson and Bray, we have augmented and refined their model of the geology of the area using previously collected seismic and bore hole records. Information from over 100 lease block surveys, 23 pipeline rights-of-way surveys, and 35 borings were examined. An extensive amount of additional seismic data was collected within the study area in an effort to locate and map accurately landforms on which archaeological sites may occur. Added to this were 77 vibracores taken at five high probability locales. Samples were taken from these vibracores in an effort to refine further the local geology and to test for cultural deposits. Types of analytical techniques conducted included radiocarbon dating as well as grain size, point count, pollen, foraminifera, and geochemical analyses.

In every case, vibracores struck the target landsurfaces within one to three feet of the suspected depth derived from the seismic records. This indicated accuracy in terms of positioning and provided a satisfying measure of reliability in terms of our interpretation of features the seismic records.

The analysis of all of the collected seismic and core data has provided information on the geologic history of the study area and its archaeological potential. In most respects our findings correspond closely to those developed by Nelson and Bray relative to the configuration and age of the buried Sabine Trench. A major departure from Nelson and Bray is our identification of extensive areas of relict Deweyville floodplain within the Sabine Trench area.

On seismic records Deweyville surfaces usually appear as an initial hard reflector beneath which there is a void or little indication of variability in the sediments. This signal is distinctly different from that produced by the earlier Prairie/Beaumont Pleistocene features. The Prairie/Beaumont terrace is characterized by distinctive multiple parallel reflectors through which the pinger generally achieved considerable penetration, up to 100 feet.

The features identified from seismic and bore hole data have been interpreted through correlation with the known on-shore Sabine system. The data demonstrate that extensive areas of buried late Pleistocene/early Holocene landforms are preserved in the offshore study area. Many of the offshore settings identified are known on the basis of onshore archaeological data to be locales commonly associated with prehistoric settlement.

It is impossible here to discuss all five offshore areas from which vibracores were taken in the search for evidence of cultural activity. Rather a brief discussion of one of the locales is presented. The location discussed is about ten miles offshore in lease block Sabine Pass 6, along the eastern side of the former Sabine River valley. Figure IIIF.4 presents a plan view of the area derived from the seismic records. Contour lines are in feet below the seafloor to the identified Deweyville surface. The track of the seismic survey vessel and vibracore locations are also shown in Figure IIIF.4.

The basal deposits consist of Deweyville terrace clays and, in the stream and the modern Sabine Valley, pre-transgressive freshwater organic deposits. Immediately above these organic deposits is a fluvial silty clay facies which is interpreted as a submarine, possibly subaerial, river mouth deposit. Blanketing this deposit is a thin stratum of sandy to silty clay, heavily burrowed and containing numerous *Rangia cuneata* shells. The shells exhibit minimal wear, so disturbance has not been great. Foraminifera species in this deposit indicate moderate salinities. This facies is interpreted as a low-energy, transgressive deposit, probably formed with the initial expansion of estuarine systems into the area. The conditions when this stratum was formed were evidently conducive to *Rangia* growth. This blanketing disturbed zone was noted in all of the areas examined and is critical in marking the boundary of transgression. Archaeological materials are expected to be found primarily within or beneath this deposit.

Above this initial transgressive facies is a massive deposit of gray clay which represents bay/estuarine fill. The massiveness and homogeneity of this deposit suggest relatively rapid sedimentation. The uppermost stratum in the section consists of heavily-burrowed clay containing varieties of marine shell. This facies represents modern open gulf seafloor deposits.

The areas of critical importance are the organic deposits which rest atop the Deweyville terrace bordering the filled stream. These, shown in black, were contacted by three cores. Pollen samples from these deposits contain a high percentage of grasses and a diversity of arboreal types suggesting an upland/swamp interface. Point count analysis of samples from these deposits produced large quantities of charred wood and vegetation, nut hulls, seeds, fish scales, and bone. Much of the bone is carbonized and some is definitely calcined. In addition to fish bone are fragments from reptiles and other small animals. The quantity of bone fragments is extremely high. Some of the samples produced projected counts of over 700 fragments of bone per kilogram of sample.

The critical question of course is whether these are or are not cultural deposits. In the very small samples collected, we did not anticipate that finding an identifiable artifact would be a high probability. Rather, it is the sedimentary character and content of the deposit which are most likely to be useful in making this assessment. The basis against which a decision can be made as to the "siteness" of a deposit are the results of an earlier study by Coastal Environments which attempted to identify, through several types of analyses, the characteristics of coastal archaeological site deposits relative to natural deposits (Gagliano et al. 1982). That study indicated that the simple particle content, derived from point counts, provided useful parameters for distinguishing coastal archaeological sites from non-sites. We know of no other data set which provides the necessary comparative model for making this assessment.

That earlier study indicated that the simple co-occurrence of certain components in particular size fractions could be used to distinguish cultural from non-cultural deposits at a statistically reliable level. Owing to space limitations, only the quantitative results of the point count analyses are discussed here. In the two size fractions examined (-1 phi and 0 phi), the critical element for distinguishing between cultural and non-cultural deposits was the simple occurrence of bone alone or the presence of bone and charred organic material. These results suggest that the organic deposit in Sabine Pass 6 has a high probability of being a cultural deposit. Based on that previous model, that probability is very high, ranging from 88 to 100%.

We do, however, question the strength of this identification because of limitations in our comparative model. That model did not encompass all possible non-cultural coastal settings. Particularly relevant here are buried peat and organic deposits. Studies in coastal Louisiana indicate that bone can occur in these deposits, although in small quantities, and apparently no evidence of burned bone has been reported (Coleman 1966). The knowledge that bone can occur in buried natural deposits weakens the argument that the material is cultural; however, this may be offset by the presence of burned bone, the quantity of which seems to be inordinately high to be a natural occurrence. Thus we are left with the situation that while the deposit is suspected of being cultural in origin, we are unable to quantify that likelihood because of the narrowness of our comparative model.

Several other locations within our study area produced similar tantalizing examples of possible cultural remains. While the indicators for these being truly cultural in origin are strong in all cases, there is room for question. The results of geochemical analyses, not yet finalized, may allow for a more definitive identification.

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Dr. Charles E. Pearson is Senior Archaeologist for Coastal Environments, Inc., Baton Rouge, LA, and Adjunct Assistant Professor of Anthropology for the Department of Geography and Anthropology at Louisiana State University, Baton Rouge, LA. Dr. Pearson obtained the PhD in Anthropology from the University of Georgia in 1979 and the MA in Anthropology from the University of Georgia in 1976.

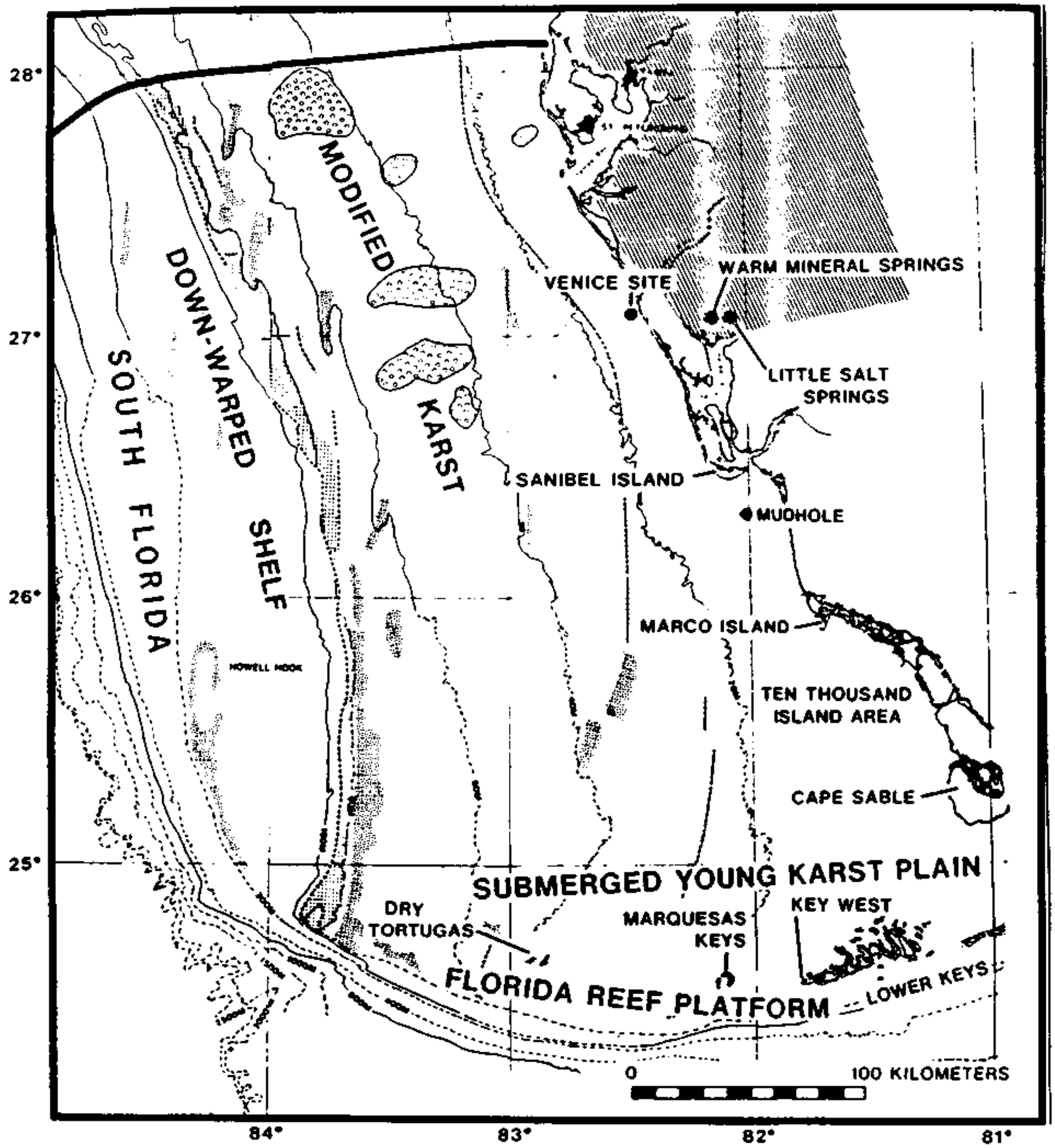


Figure IIIF.1 - Karst Plain-Western Florida Shelf

SONOGRAPH OF 96 FATHOM SINKHOLE, EASTERN GULF OF MEXICO, OCS 50/100 METER SCALES

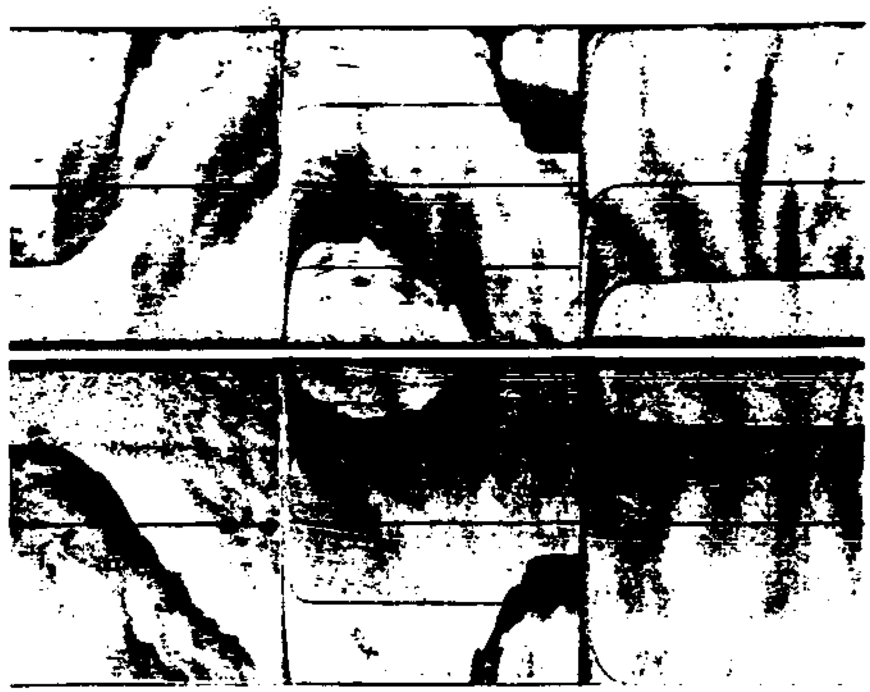


Figure IIIF.2 - Sonograph of 96 Fathom Sink

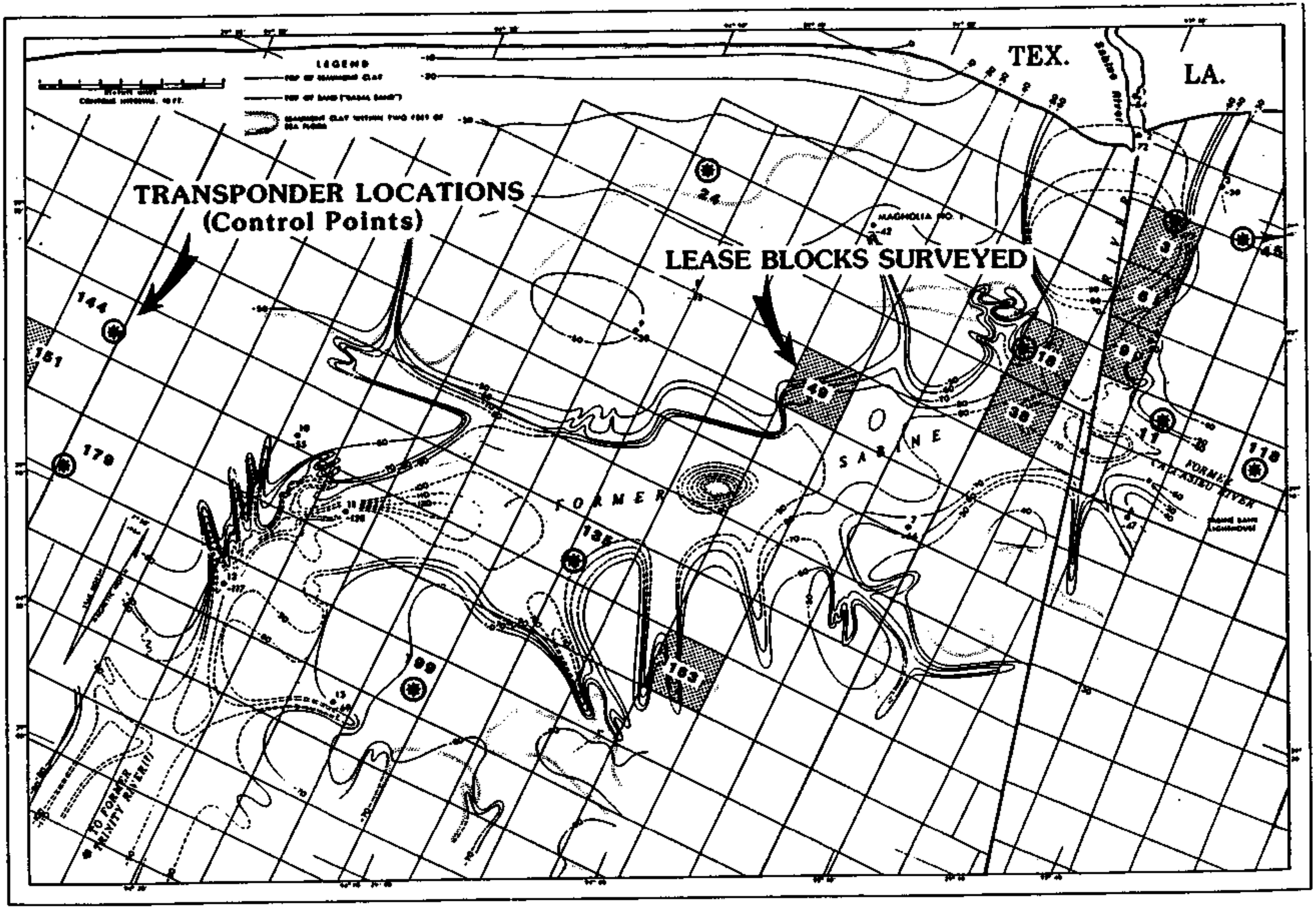


Figure IIIF.3 - The Study Area Showing the Lease Blocks Selected for Close Order Seismic Survey

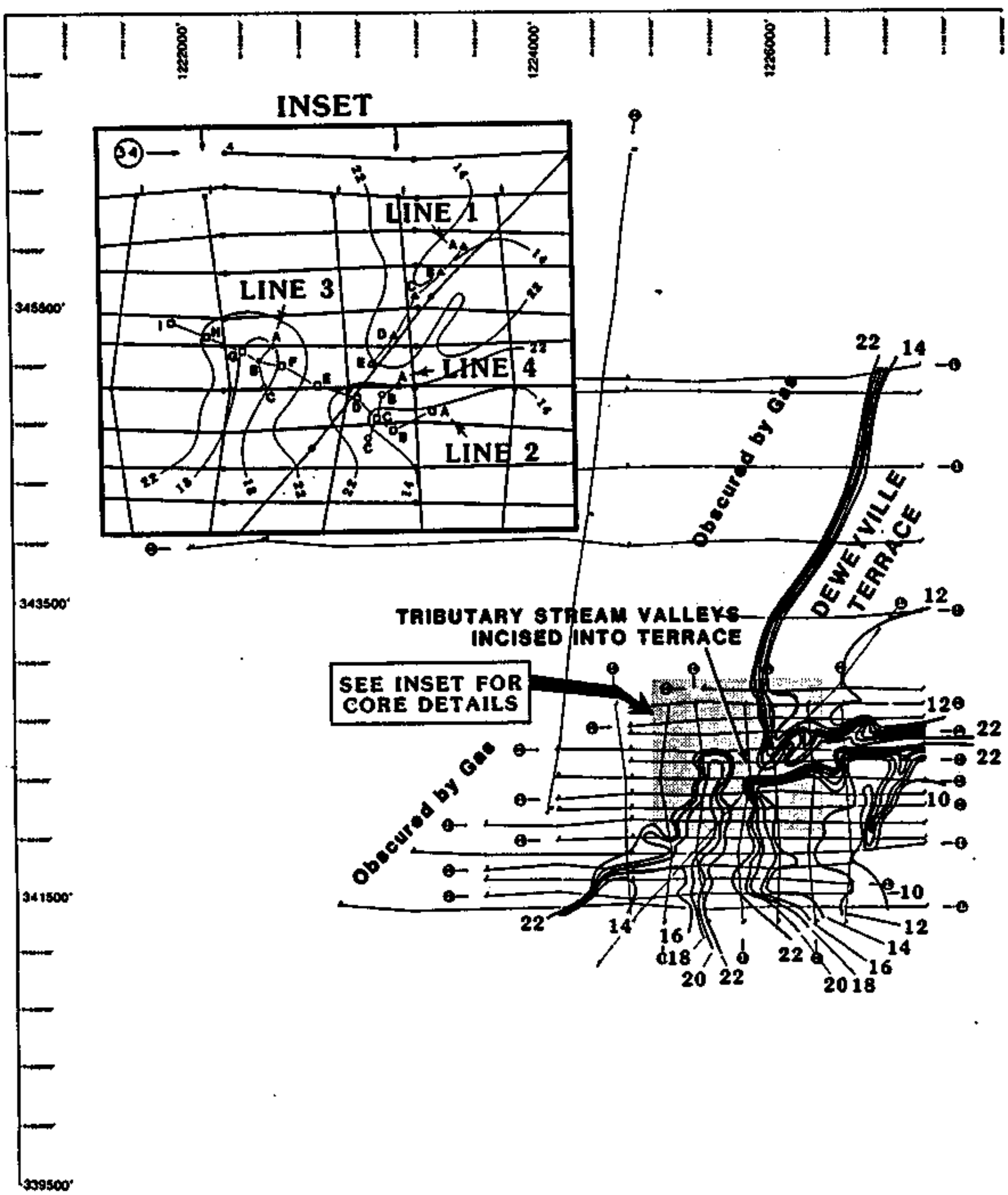


Figure IIIF.4 - Plan View of Pretransgressive Surfaces, Lease Block Sabine Pass 6

Session: CULTURAL RESOURCE II.
SYMPOSIUM ON REMOTE SENSING SURVEYS

Chairmen: Ms. Melanie Stright
Mr. Rik Anuskiewicz

Date: October 23, 1985

Presentation Title	Author/Affiliation
Session Summary	Ms. Melanie Stright Minerals Management Service

Cultural Resources II - Symposium on Remote Sensing Surveys

Ms. Melanie Stright
Minerals Management Service

This session had two primary goals. The first was to discuss recurrent problems in archaeological survey data quality and report adequacy, and the second was to obtain industry comments to planned revisions to Notice to Lessees (NTL) 75-3 (revision No.1).

Three major problems, all involving the magnetometer, were discussed.

The first problem involves the NTL requirement for recording magnetometer sensor tow depths. To meet this requirement, various companies in the marine survey industry have responded either by using depth sensors on the magnetometer sensor or cable, or by calculating tow depth based on vessel speed and the amount of cable out. The latter method results in an approximation of the magnetometer sensor tow depth for the entire survey. Although the sufficiency of this method was defended by one symposium participant, it does not approach the accuracy of continuous tow depth measurements from a depth sensor. Due to the importance of having the sensor as close to the seafloor as possible to detect the relatively small ferrous masses present in an historic shipwreck site, and due to the importance of knowing the position of the sensor in calculating potential ferrous masses from an anomalous signature, the use of mechanical depth sensors will be required by MMS for future surveys.

The second problem discussed was the use of a "zero-mode" (level-mode) setting on the magnetometer for archaeological surveys. It has been stated by the company using this setting that since the primary function of the instrument is to search for anomalies by operating it in zero-mode, the low-frequency variations in the local field are eliminated and the system only responds to rapid anomalous changes from a central print position on the strip chart recorder.

A proton magnetometer records the frequency of the signal generated by precessing protons within a hydrocarbon fluid such as kerosene, alcohol, or water. The frequency of this precession can be directly related to the earth's ambient magnetic field and local magnetic disturbances (anomalies) within that field. When operating in zero-mode, the magnetometer is recording the average amplitude of the precession signal rather than the frequency. This operating mode was developed for use in areas having a steep magnetic gradient, such as exists around oil and gas structures, in order that smaller magnetic sources such as flow lines could be located. When operating in zero-mode, the average amplitude of the precession signal reaches a minimum value directly over a ferromagnetic object due to the quicker decay of the signal. The effect of averaging the amplitude of the precession signal would be to average background noise levels and low intensity, short duration anomalies out of the data recorded. Since an historic shipwreck often is represented only by a low intensity anomaly (e.g., 5-gammas), zero-mode is not considered an acceptable mode of operation for conducting archaeological surveys.

A third problem discussed is the use of magnetometer strip chart recording scales of greater than 100-gammas, full scale. Recordings at this scale do not permit easy identification of low-intensity anomalies or accurate determination of background noise levels. Therefore, strip charts using a single recording mode of greater than 100 gammas full scale are inadequate to ensure detection of low-intensity anomalies caused by historic shipwrecks. Strip charts using a dual recording mode are acceptable if one of the traces is 100 gammas or less, full scale.

On March 5, 1986, MMS issued a Letter to Lessees to clarify the above three points of the NTL survey requirements.

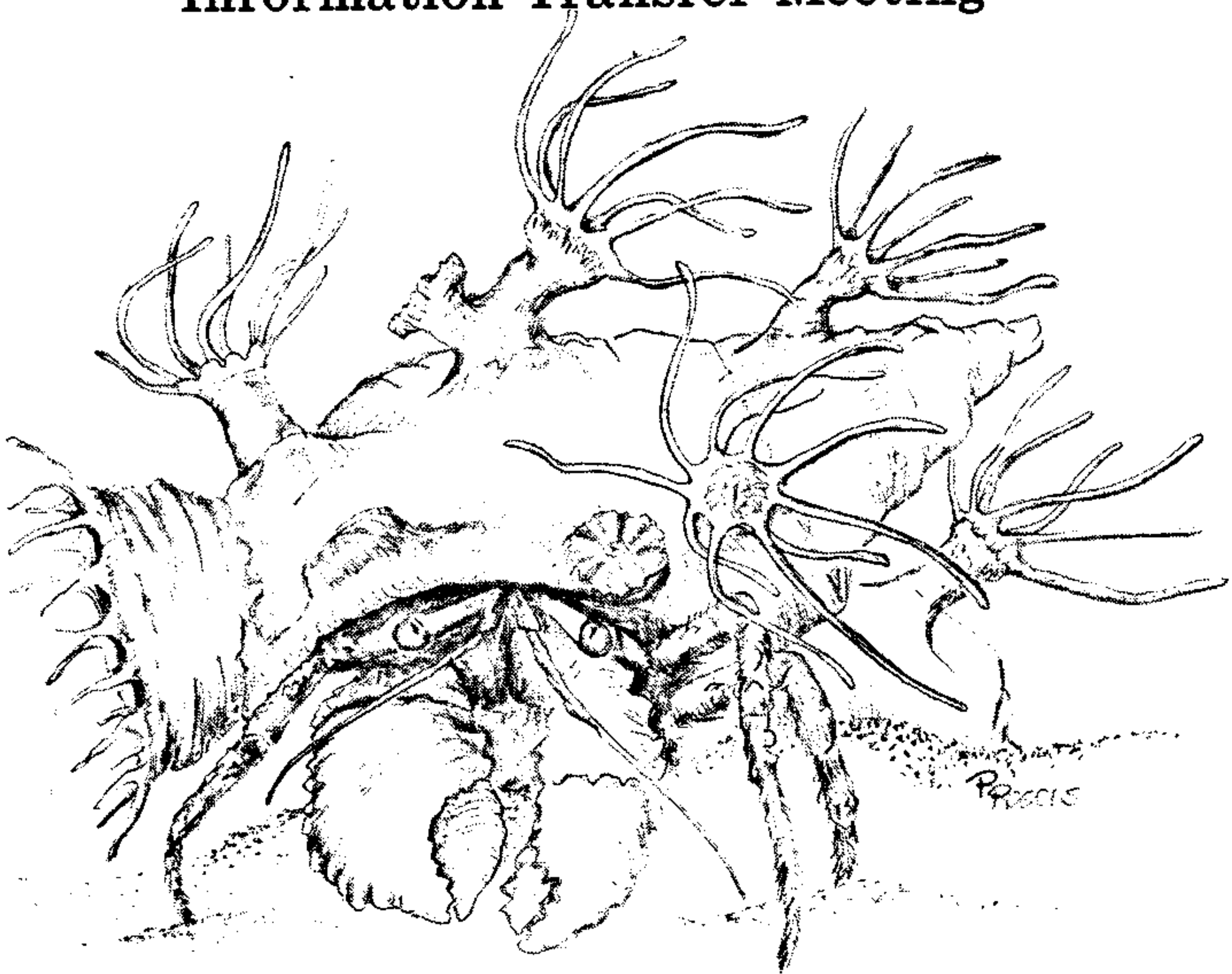
Another minor issue discussed by the symposium participants was the magnetometer sampling rate. It was agreed that a three-second sampling rate, which is being used by some marine survey companies, is inadequate to ensure detection of short-duration anomalies. A magnetometer sampling rate of one second will be required when MMS produces the second revision of NTL 75-3.

Biography: Please see Session III.F

OCS STUDY
MMS 85-0008

PROCEEDINGS

Fifth Annual Gulf of Mexico Information Transfer Meeting



U.S. DEPARTMENT OF THE INTERIOR/MINERALS MANAGEMENT SERVICE

OCS STUDY
MMS 85-0008

PROCEEDINGS
FIFTH ANNUAL GULF OF MEXICO
INFORMATION TRANSFER MEETING

International Hotel
New Orleans, Louisiana
27-29 November 1984

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Chairman: Ms. Melanie Stright

Date: November 28, 1984

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Geomorphological Research in the Atchafalaya Basin and Terrebonne Marsh	Dr. Lawson M. Smith U.S. Army Engineer Corps Waterways Experiment Station Mr. Thomas Ryan U.S. Army Engineer District, New Orleans
Survey, Mapping and Site Reconstruction in a Blackwater Environment: A Study in Methods	Mr. Richard J. Anuskiewicz MMS, Gulf of Mexico Region
Initial Geoarcheological Evaluation of the Texas City Channel Site (41 GV 81), Galveston County, Texas	Dr. Lawrence E. Aten National Park Service Ms. Carolyn Good U.S. Army Corps of Engineers, Galveston District

SESSION OVERVIEW: CURRENT STUDIES IN UNDERWATER ARCHAEOLOGY

Ms. Melanie Stright
MMS, Gulf of Mexico Region

Our session, Current Studies in Underwater Archaeology, consisted of two papers on historic shipwreck investigations and three papers on studies in prehistoric archaeology.

James Parrent, currently working in the Gulf of Mexico Regional Office on an inter-governmental personnel agreement from Texas A&M University, discussed the recent MMS investigations of 17th century English slave ship on New Ground Reef. This investigation was conducted at the request of the State of Florida for MMS to evaluate the site's eligibility for the National Register of Historic Places. As a result of the MMS on-site investigation it was discovered that there are still portions of the ship's hull in place on the sea floor. Various artifacts observed included two cannons, ivory, and two large metal boxes.

Based on our diver's evaluation of this site, MMS recommended that it not be nominated to the National Register for the following reasons: (1) only a limited number of diagnostic artifacts remain on the site; (2) the integrity of the site has been severely disturbed by treasure hunting activities; and, (3) the continuing activity on the site by treasure hunters will, undoubtedly, further degrade the site.

The second paper on shipwreck archaeology was given by Rick Anuskiewicz, Staff Archaeologist, MMS Environmental Operations Section, formerly of the Army Corps of Engineers in Savannah, Georgia. Mr. Anuskiewicz reported on seven years of work he's conducted on the USS GEORGIA off Savannah. This civil war shipwreck lies along the Corps of Engineers' dredge channel in a black water environment.

Mr. Anuskiewicz's paper demonstrated that not only can proper archaeological techniques be employed in underwater archaeological investigations but also that proper archaeological techniques can be employed in a black water environment. The initial investigation of the site was done by remote sensing, with depth sounders and side scan sonar. Based on the remote sensing data, the wreck site was mapped and a dive plan was formulated.

As work progressed, prior to removal of any objects from the wreck site, the objects were buoyed and shot in with transits in order that their proper locations could be recorded.

Mr. Anuskiewicz indicated that the Corps will have to do more work on this wreck and possibly excavate the entire site due to the Corp's plans to further widen the shipping channel in Savannah harbor. There may be no way to protect the wreck in-situ from future dredging activities.

Our first paper on prehistoric archaeology was delivered by Dr. Lawson Smith, a geomorphologist and Chief of Regional Geologic Studies with the Geotechnical Lab Waterways Experiment Station for the Corps of Engineers in Vicksburg, Mississippi. Dr. Smith reported on current archaeological and geomorphological research in the Atchafalaya Basin and Terrebonne Marsh. This study is designed to reconstruct the paleogeography of the Atchafalaya Basin and Terrebonne Marsh in order to provide the basis for management decisions regarding future archaeological survey requirements, including the level and type of survey which should be employed. The paleoenvironmental reconstruction and predictive modeling approach to prehistoric site location being used in the Corps of Engineers study is very much like the management approach being employed by MMS on the Gulf of Mexico Outer Continental Shelf. In both cases, existing remote sensing data, regional geologic studies, sea level curves, and foundation borings are used for paleogeographic reconstruction. These findings are then used to determine the potential for prehistoric site occurrence and preservation.

In summary, Dr. Smith's paper demonstrates that the archaeological techniques and methods being employed on land for prediction of site locations and for management decisions are identical to those being employed on the Outer Continental Shelf. Only the working environment differs.

Our second paper on prehistoric archaeology was delivered by Dr. Charles Pearson, Project Leader for a current MMS study entitled "Prehistoric Site Evaluation on the Northern Gulf of Mexico OCS: Ground Truth Testing of the Predictive Model." This study was funded by our Washington Office and is designed to test the predictive model for prehistoric site occurrence that's been used as the basis for MMS cultural resources management decisions in the Gulf of Mexico since the cultural resources baseline study in 1977. The study is also designed to test our current technology and methods for evaluation of potential prehistoric site locations on the OCS. During the first phase of this study, original seismic data were collected along the ancient Sabine River Valley, which trends offshore between Louisiana and Texas. Based on these seismic data specific areas having a high potential for prehistoric sites to occur and be preserved were outlined within the ancient river valley. High probability areas identified from the data include several levels of terraces, individual channel courses within the major river valley, point bars, and possible natural levee deposits. Based on these seismic data, more specific areas were identified where vibracores would be collected in order to obtain a soil sample from potential site locations. The vibracoring phase of the study has just been completed. The cores are currently being cut and photographed. The next phase of the study involves coarse-fraction and geochemical analysis of selected samples from the cores in an attempt to identify culturally deposited sediments and material.

The last paper was presented by Dr. Lawrence E. Aten, Chief of the Inter-agency Resources Division of the National Park Service in Washington, D.C. Dr. Aten reported on a site at the Texas City Channel in Galveston Bay, where a Corps of Engineers dredging project has turned up fossil material that appears to have been culturally modified by percussion flaking. Dr. Aten in consultation with Carolyn Good, archaeologist for the Corps of Engineers in Galveston, has determined that there are numerous artifact types present in the redeposited fossil material.

Apparently the fossilized material, rather than lithic material, was being used by prehistoric man in the local area as a source for tool manufacture. This site, and a site along the extreme eastern Texas coast, the McFadden Beach Site, show that prehistoric man was in the Gulf Coast Region at least 10,000 years ago. It should be noted that these sites are very close to the MMS study area offshore where similar sites would have been inundated as a result of Holocene sea level rise.

At the time these sites were formed, Galveston Bay and McFadden Beach were upland settings, with the shoreline at approximately the 30 meter bathymetric contour. These findings demonstrate that man was in the Gulf Coast area at least 10,000 years ago; and that prehistoric sites can be anticipated on the continental shelf at least out to the -30 isobath. The goal of MMS's current study is to produce evidence of these preserved inundated sites on the OCS.

NEW GROUND REEF SHIPWRECK INVESTIGATIONS IN THE EASTERN GULF OF MEXICO

Mr. James Parrent
MMS, Gulf of Mexico Region

In May 1984, an archaeologist working for Treasure Salvors, Inc., contacted the Florida Division of Archives, History and Records Management about the nomination of a shipwreck site to the National Register of Historic Places (NRHP). The shipwreck lies on New Ground Reef about 34 miles west of Key West, Florida. Since this area is outside of state waters, on the outer continental shelf (OCS), Florida officials contacted Dr. Friedman, Minerals Management Service (MMS) Consulting Archaeologist, Washington, D.C., for assistance in the nomination process. In turn, the MMS Gulf of Mexico Regional Office was directed to investigate the site to determine its eligibility for nomination to the NRHP.

I went to Tallahassee, Florida to consult with state archaeologists and conduct a file search on the wreck site. A file search revealed the following:

1. The site consists of a shipwreck dating from approximately 1689 to 1710. Portions of the site have been salvaged under State of Florida Contract S-13. When the site was examined in the early 1970s, large portions of the ship's wooden hull and portions of the ship's frames remained. Most of the wreck was in good physical condition and two cannons and two anchors were located.

2. Judging from the size of the wreck site and from the numbers and types of artifacts recovered, it is estimated that the ship was a small vessel weighing one hundred tons or less, lightly armed, and of English origin. The artifacts recovered included such unique items as pewter bottles of the "onion bottle" type, German silver drinking steins, elephant ivory, and iron shackles. In addition there were swords, small arms, cannon balls, silver spoons, leather fragments, an English copper

coin dated 1689, and a Spanish coin bearing no date.

3. An assessment of the geographic origin of the ship is based on the recovered artifacts. Spanish and Portuguese vessels of this period usually carried more ceramic containers than metallic. It is further speculated that it was either a merchant or pirate vessel, since the wreck site is in a major Spanish shipping corridor and vessels of foreign nationality are known to have preyed upon Spanish fleets. The uniqueness of this particular wreck, therefore, is that it is not a Spanish vessel and there are few recorded early English shipwrecks from this region during this time period.

Between August 1972 and June 1974, the site was worked extensively by treasure hunters under contract with the State of Florida. In 1976, a Supreme Court decision defining Florida State waters placed the wreck outside of Florida's jurisdiction. The shipwreck site lay undisturbed from 1974 until 1982, when Treasure Salvors, Inc., put a subcontractor on the site. It was in 1982 that a bell with the inscription "The Henrietta Marie 1699," was recovered from the site.

I conducted an on site investigation in September 1984. Leasing and Environment, GOM OCS Region (LE), staff members, Mr. Joe Christopher, Environmental Specialist; Mr. Joe Perryman, Oceanographer; and National Park Service (NPS) personnel, Mr. Jack Morehead, Superintendent of Everglades National Park, Mr. Jim Tillmont, Marine Research Scientist, Mr. Cliff Green, Captain of NPS boat ACTIVA; and Mr. David Moore, Archaeologist for Treasure Salvors, participated in the site investigation.

The site was located on the first day, September 14, 1984, and its perimeter was established. On September 15, 1984, artifacts visible on the seafloor were photographed and measured. Surface collecting has depleted the artifact assemblage reported by Larry Murphy in 1972. Mr. Murphy was a Florida State Archaeologist when the site was first discovered and is now a member of NPS Submerged Cultural Resource Unit in Santa Fe, New Mexico.

Our divers identified the following artifacts on the seafloor: 1) two wooden ship frames lying loose; 2) wood ship frames, dead wood, and planking, the upper portions of which protruded from the seafloor; 3) remains of two large metal box-like structures; 4) two ivory tusks, one of which is protruding from under the larger of the metal boxes; 5) two iron cannons about six feet in length; and 6) one pair of slave shackles.

To further complicate the status of the shipwreck site, a treasure salvor, Toney Kopp, on his boat ALLUSION met us at the site on our first day out, September 14, 1984. Mr. Kopp said that Mel Fisher, President of Treasure Salvors, Inc., had given him the Loran coordinates to the site. Mr. Kopp also stated that Mr. Fisher had given him the rights to the shipwreck.

Divers from the ALLUSION were first to discover one of the cannons and placed a buoy on it. The ALLUSION crew was friendly, helpful, and readily shared artifact locations with us. However, they began recovering artifacts from the site and said they planned on working the site for several days. Divers from the ALLUSION made no pretense of conducting any type of archaeological survey, but instead commenced to randomly search for and collect artifacts.

We departed the site Friday afternoon and returned on Saturday morning. The ALLUSION crew was in the water working with an air dredge and metal detector. I observed two divers, one with a metal detector and one with a collecting bag, searching the seafloor and collecting artifacts. There was no control grid or any other observable device which would offer any clue as to where the artifacts had lain before they were bagged. This incident raises questions about the motives and sincerity of Treasure Salvors' nomination of this site to the NRHP.

Wood samples from the ship's frames, strakes, and the bilge pump, which had been removed previously by Treasure Salvors, were sent to the Center for Wood Anatomy, U.S. Forest Products Laboratory, Madison, Wisconsin. The frame and strake were identified as white oak and the bilge pump was constructed from beech wood.

Based on the following reasons, the site was not recommended for nomination to the National Register for Historic Places: 1) only a limited number of diagnostic artifacts remain on the site; 2) the integrity of the site has been severely disturbed; and 3) the continuing activity on the site by treasure hunters will undoubtedly further reduce the artifact assemblage.

GEOMORPHOLOGICAL RESEARCH IN THE ATCHAFALAYA BASIN AND TERREBONNE MARSH

Dr. Lawson M. Smith
U.S. Army Engineer Waterways Experiment Station
Mr. Thomas Ryan
U.S. Army Engineer District
New Orleans

The geomorphic investigation of the Atchafalaya Basin and the Terrebonne Marsh of southern Louisiana is the initial step in a multi-phased approach to identifying and managing the area's prehistoric cultural resources. The geomorphic study is designed to provide an environmental framework for estimating site probability areas, to aid in establishing site significance, and to serve as a guide for planning future investigations. Results of the geomorphic study will also serve as the initial planning document for executing a programmatic memorandum of agreement with the Louisiana State Historic Preservation Officer and the Advisory Council on Historic Preservation.

An understanding of the evolution of the physical landscape and the basic landforming processes is critical to the identification and evaluation of the prehistoric cultural resources of a region. In support of future cultural resource surveys of the Atchafalaya Basin and the

Terrebonne Marsh, a geomorphic study of the area is being conducted to provide an outline of landscape evolution. There are two primary objectives of the study. The initial objective is to describe and delineate on detailed maps the geomorphic features (landscape elements) of the study areas. The second objective is to analyze the geomorphic development (landscape evolution) of the study areas, especially as landscape evolution relates to prehistoric man/land relationships.

Description and cartographic delineation of geomorphic features of the study areas was completed in August 1984. Twenty classes of geomorphic features were mapped on fifty-five 1:24,000 U.S. Geological Survey quadrangles. Data used to delineate the geomorphic features consisted primarily of various scales, dates, and types of aerial photographs and LANDSAT imagery. Additional data used to identify geomorphic features included historic maps, charts, and surveys and existing subsurface boring logs.

In pursuit of the second objective, a field investigation program was planned to provide detailed paleoenvironmental data at critical locations in the study areas. Subsurface samples were obtained by vibracoring at 31 locations (to depths of 9 meters) and by traditional rotary methods (to depths of 30 meters) at seven sites. Subsequent laboratory analyses of the cores, including characterization of depositional environment, complete x-radiography, biostratigraphic analyses, and radiocarbon dating, are yielding substantial paleoenvironmental data. These data are being integrated with existing data and the geomorphic maps to provide a geomorphic chronology for the evolution of the study areas during the Holocene.

At the present time, the analysis of field and geomorphic mapping data has just begun, with a preliminary draft of the report scheduled for March 1985. Major questions addressed include the following:

- o Is there a buried pre-Teche Holocene Mississippi River meander belt in the Atchafalaya Basin?
- o What are the depositional processes (and related

paleoenvironments) responsible for the Holocene sedimentary filling of the Atchafalaya Basin?

- What were the processes and chronology of closure of the Atchafalaya Basin during the Holocene?
- In the last several thousand years, what has been the history of Grand Lake in the Atchafalaya Basin?
- In the Terrebonne Marsh, what sedimentary cycles exist, and what are their times of formation?
- Have any of the Teche distributary channels been occupied later by the Lafourche distributaries or the Red River?
- Is there a pre-Teche Holocene distributary system in the Terrebonne Marsh?
- What is the origin of the shell ridges in the Terrebonne Marsh?

Answers to these questions have substantial significance to the development of an environmental framework necessary for the comprehensive and cost effective survey of prehistoric cultural resources in the study areas.

SURVEY, MAPPING AND SITE RECONSTRUCTION IN A BLACKWATER ENVIRONMENT: A STUDY IN METHODS

Mr. Richard J. Anuskiewicz
MMS, Gulf of Mexico Region

The basic research goals in underwater archaeology are the same as those in terrestrial archaeology: to pursue and document replicable information through the scientific method. The only differences between the two approaches to gathering information are the methods and the working environment. The focus of this paper will be on the development and operationalization of field techniques to survey, map, and reconstruct a shipwreck site in a blackwater environment. I define blackwater as the total absence of light as a result of suspended particulates, either organic or inorganic, in the water column. Working and conducting research in zero visibility poses some rater unique methodological problems. This paper will recognize and address many of the problems and offer solutions to a problematic approach to doing archaeology in blackwater. A survey, mapping, and site reconstruction model will be presented using the research data generated by the U. S. Army Corps of Engineers, Savannah District, in their intensive study of the sunken Confederate Ironclad, the C. S. S. GEORGIA. The model presented will include the compilation of traditional remote sensing data (i.e., magnetometrics, side-scan sonar, and sub-bottom profiler) with the integration of computer-generated graphics and the three-dimensional grid element contour display of site model bathymetric data.

INITIAL GEOARCHEOLOGICAL EVALUATION OF THE TEXAS CITY CHANNEL SITE (41 GV 81), GALVESTON COUNTY, TEXAS

Dr. Lawrence E. Aten
National Park Service
Ms. Carolyn Good
U.S. Army Corps of Engineers, Galveston District

Since the early 1900s, the U.S. Army Corps of Engineers has maintained a navigation channel from Texas City southeastward to the centerline of Galveston Bay on the upper Texas coast. This channel has been maintained by repeated dredging operations, creating the disposal bank known as the Texas City dike. For many years collectors have searched the dike for vertebrate fossils resulting in collections numbering thousands of specimens. Recently, examples of fossils have been recognized that appear to have been modified culturally into various tool-like forms. Determining whether these fossils are artifacts is a complicated taphonomic problem because the site and the materials have had a complex depositional and post-depositional history.

The focus of our ongoing research at the Texas City Channel Site is to identify the details of the locality's geologic history; to evaluate the nature and significance of these tool-like specimens from a cultural perspective; and to determine, among other things, whether such a site has implications for management of cultural resources on the continental shelf. This has entailed developing discriminating criteria for testing the characteristics of tool-like fossils so that a satisfactory conclusion may be drawn about their origin. If the outcome of this investigation supports the cultural nature of these materials, as now seems to be strongly indicated, the Texas City Channel Site (TCC) has major implications for documenting the cultural history of early populations on the northern Gulf Coast.

THE MATERIALS

We have examined three separate collections totaling approximately 4,000 fossil specimens. Of these, 42 display evidence of cultural modification. In addition, one of the collections included half of a fossil human femur. Lithic material is extremely rare on the dike; no chipped stone and only 3 unmodified pebbles are known to have been collected.

All of the modified fossils except two display convincing evidence that they were altered after they had become fossils. The criteria used to determine modification relate to surface condition; the color, arrangement, and the shape of flake scars; shape and alignments of cut marks, striations, and wear facets; and the relationship of abrasion wear on alternately hard and soft bone surfaces comprising certain specimens, especially teeth.

The physical character of the modified fossils that conform to our present criteria can be synthesized into 8 categories which we are treating as potential form/function classes. These are described below.

(1) Work platforms: flat, sometimes cylindrical bone surfaces usually bearing numerous cut marks oriented predominantly in one direction. (4 specimens).

(2) Unifacial cutting edge tools: usually flat bones unifacially chipped to a low angle bit of about 45 degrees. (4 specimens).

(3) Bifacial cutting edge tools: fossils with narrow but rounded natural edges that are bifacially flaked to create a typical biface cutting edge. (3 specimens).

(4) Incidental cutting tools: analogous to "used flakes"; usually small, naturally sharp fossil bone elements with unpatterned flakes, microflakes, abrasion, and striations along the used edge. (12 specimens).

(5) Bit scrapers: coarse-textured turtle plastron with a well-developed unifacial rasping bit (about 45 degrees); this tool has other wear facets suggesting it was hafted. (1 specimen).

(6) Mandible scrapers: horizontal ramus sections of carnivore and cervid mandibles on which the molar/premolar cusps have been abraded or shattered; high use angles (about 76 degrees). (7 specimens).

(7) Chopping tools: heavy bison metapodial with a wedgeshaped bit formed by the convergence of spiral fractures in the mid-section of the shaft; random microflaking occurs along the distal edge. (1 specimen).

(8) Pounding tools: usually an elongate bone or tooth with one end battered and the opposite end smooth. This group includes a hammerstone and pestle-like tools; others may be spent chopping tools. (8 specimens).

Two additional fossil bones appear to have been modified before fossilization and in a manner different from the probable artifacts described above. One was a horse radius that had been "whittled" to thin the compact bone of the shaft which was then snapped in half. The other appears to be a tapir metapodial which has deep V-shaped grooves cut in the center of the shaft and, again, the bone was snapped in half.

At least three separate types of fossilization are represented on the fossil bones we have examined: (1) those with bone replacement plus extensive secondary carbonate deposition; (2) bone replacement only; and (3) both previous types with pyritization as well. We believe that these correlate with key phases of the locality's geologic history, as will be discussed below. The majority of the tool-like specimens are fossilized either as type 1 or type 3; the human femur and the two bones that appear to have been modified before fossilization are now fossils of type 2.

THE SITE SETTING

The fossils have been collected from a section several miles long on the Texas City Dike. We have reviewed core logs from several borings made adjacent to the Texas City Channel, and from others made in the southern part of Galveston Bay. These reveal a sequence of deposition that is readily interpretable in terms of the general geologic framework of the bay. This local depositional history begins with a late phase of the Beaumont Formation--a meander belt of probable Farmdalian age (about 25,000 to 30,000 years ago); this is probably the source of the type 1 fossil bones. This zone is overlain by a basal transgressive sand followed by a sequence of marsh and estuarine deposits apparently representing upper bay facies superimposed by middle bay facies.

We have attempted to reconstruct the area's paleogeography at the time of the Pleistocene/Holocene transition by mapping topographic contours from core data on top of both the Beaumont Formation and the Deweyville channel sediments in the Trinity River trench. This indicates that the Texas City Channel is located near the crest of a ridge about 4-5 kilometers west of the large Deweyville-Trinity River floodplain. The ridge was underlain by Farmdalian Beaumont sediments and was deeply incised by ancestral Highland Bayou, a local drainage tributary to the Trinity. Because the Beaumont Formation meanderbelt ridges in the Galveston Bay area frequently are fossiliferous, we assume that the entrenched streams cutting the ridge exposed older fossil deposits that were collected or mined by early man. Because the Galveston Bay area has no indigenous lithic sources for tool manufacture, it is not unusual for alternative materials such as fossil bone to be collected and put to this use.

Although the age at which the ridge would have been submerged by the enlarging bay can be estimated at circa 5,000 to 6,000 years ago, the presence of extinct tapir and horse bones which appear to have been modified before fossilization (while the majority of other bones appear to have been modified long after fossilization) indicates the age of the cultural activity to be on the order of late Pleistocene, or about 13,000 to 10,000 years ago. Pyritization (type 3 fossils) then occurred after the locality was submerged by the advancing bay fringe marshes during the Holocene.

SITE RELATIONSHIPS

While we have not yet established the TCC Site as of unequivocal archeological origin, the evidence is mounting to the point that it may be contrasted to other sites of comparable age from the region. Three immediately come to mind: Owen, Salt Mine Valley, and McFaddin Beach.

The nature and significance of each of these sites has been reviewed in Aten (1983: 144-152). Briefly, paleogeographic reconstructions indicate that Owen probably reflects hunting camps in the interior woodlands, Salt Mine Valley reflects the coastal zone, and McFaddin Beach and TCC both reflect activities in the interior near the major riverine habitats of that day. These relationships are illustrated below.

```
< INTERIOR  ><            ><            ><  COASTAL >
< WOODLANDS><  RIVERINE  ><  PRAIRIE?  ><  ZONE     >
------------------------------------------------------
 * Owen Site   * TCC Site    * none known  * Salt Mine
               * McFaddin B.                 Valley
```

This lateral ecological differentiation is probably at least part of the explanation for tool assemblage differences between these early sites. TCC, if it can be verified, contained a diversified processing tool assemblage, not a hunting assemblage, and is unlike those from the other sites.

SITE IMPLICATIONS

If we assume, as a preliminary matter, that TCC is indeed an archeological site, its significance will be that it enables us to further describe the technological, settlement, and adaptive characteristics of Paleo-Indian cultures along the continental margin. These remain poorly known because of the inaccessibility of their sites which are now submerged or buried, or both. As a result, cultural reconstructions for that period are strongly biased toward concepts of uplands hunting adaptations.

For OCS management, TCC suggests several additional things. First, it provides new Gulf Coast evidence that archaeological sites may survive transgressions in at least some geomorphic situations; this is an excellent illustration of the lithosome preservation model of Belknap and Kraft (1981). Second, it lends support to the importance of searching for buried archeological sites along the valley margins of major floodplains submerged on the continental shelf as is now being done in the Minerals Management Service's submerged Sabine-Neches Valley ground-truth study. And third, the site setting of both TCC and the McFaddin Beach Site suggests the need to give greater attention to subbottom profile data interpretation of the dissected valley margins along major floodplains.

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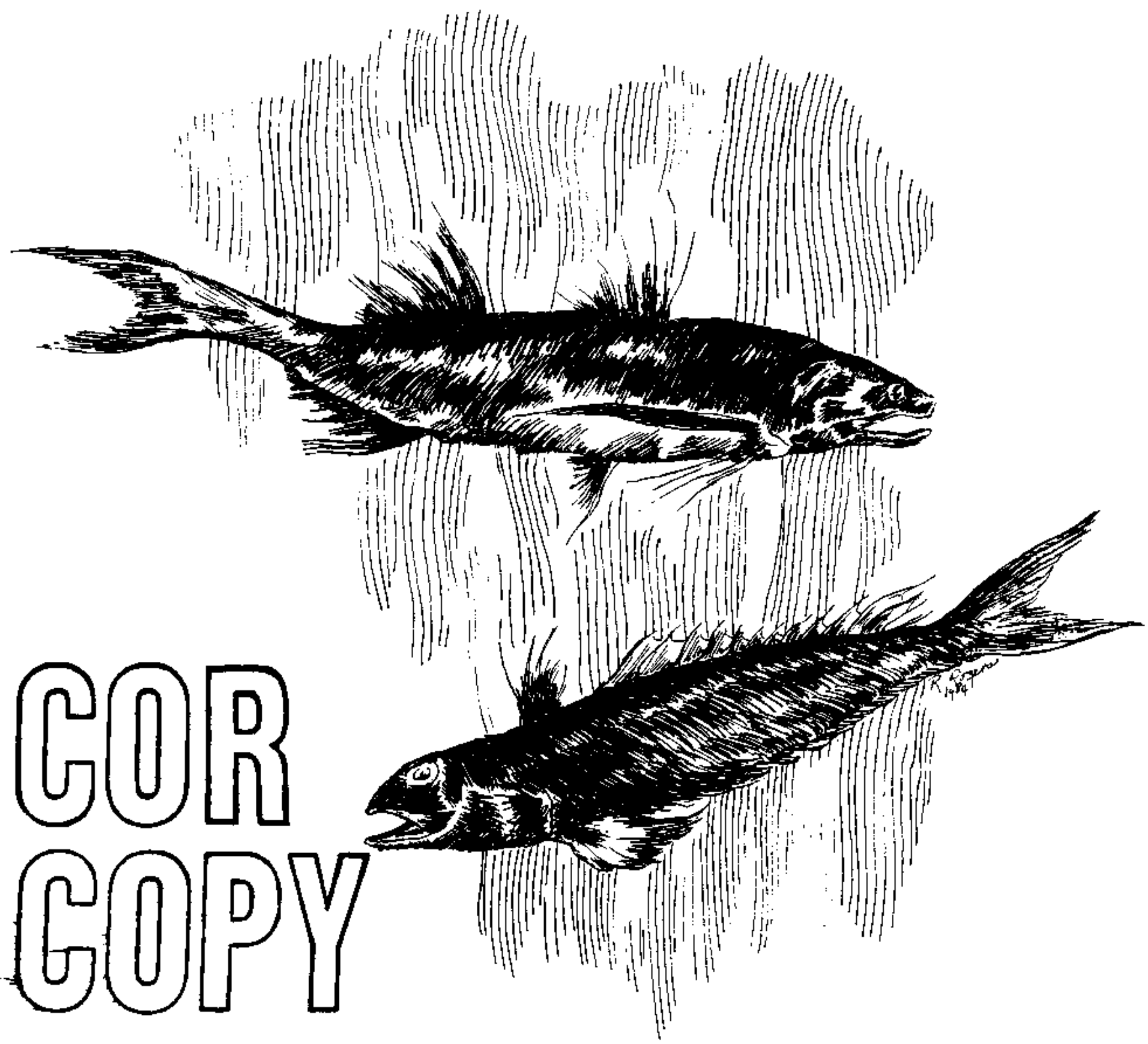

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DETECTION AND EVALUATION OF INUNDATED PREHISTORIC SITES

SESSION OVERVIEW

Ms. Melanie Stright
MMS, Gulf of Mexico Region

For the last decade there has been a growing awareness among the professional archaeological community, that for time periods prior to about 5,000 B.P. (when sea level reached its current high stand) the subaerially exposed continental land mass was much larger than at present. Therefore, prehistoric site patterns, cultural contacts, and subsistence strategies observable on the present land mass only represent a portion of the archaeological record.

In response to this growing concern for inundated historic and prehistoric sites, and in order to comply with the requirements of Section 106 of the National Historic Preservation Act of 1966, as amended, the Department of Interior began requiring remote sensing surveys for the detection of historic shipwrecks and inundated prehistoric archaeological sites prior to lease development on the Outer Continental Shelf.

The technology and methods for locating and evaluating submerged prehistoric sites have developed rapidly and employ techniques from many other fields, e.g., geophysics, geomorphology, sedimentology, oceanography, and chemistry. These techniques and methods are employed in three major lines of analysis:

1) potential for site occurrence
2) potential for site preservation
3) potential for locating and evaluating sites when they occur.

Last year's session on prehistoric archaeology centered on techniques for locating and evaluating sites within areas having a high potential for site occurrence and preservation. Papers this year concentrated on techniques for predicting site locations and preservation potential.

The models and techniques presented in this session were particularly important and timely since a study designed to locate submerged prehistoric sites in the Central Gulf of Mexico is currently underway. This study will test our ability to predict site locations on the now submerged shelf, and determine the applicability and adequacy of current methods and technology for testing and evaluating these potential site locations.

TESTING THE MODEL FOR PREHISTORIC SITE OCCURRENCE ON THE GULF OF MEXICO OUTER CONTINENTAL SHELF

Sherwood M. Gagliano
Coastal Environments, Inc.

It has been hypothesized that prehistoric archaeological sites are preserved in certain locales on the northern Gulf of Mexico Outer Continental Shelf. A model of settlement and site preservation has been presented which relies on factors of sea level change, potential for preservation of landform features during marine transgression, and the relationship between prehistoric site occurrence and landforms as derived from terrestrial analogs. Prospecting for drowned terrestrial sites is possible with available geophysical techniques and identification of cultural deposits can be achieved through analysis of core samples. The buried Sabine Trench off of the eastern Texas coast has been selected as a suitable area for testing the proposed settlement model. The trench contains buried preserved landforms of late Pleistocene and Holocene age which correspond to high probability areas of site occurrence as defined in the model. The potential for site preservation in the Trench was discussed. The data collection and analytical techniques to be used, which include fine scaled seismic survey and the collection of vibra-cores, were reviewed.

A PREDICTIVE MODEL FOR MARINE SITES IN WASHINGTON STATE

Jacqueline M. Grebmeier
University of Alaska

During the Pleistocene sea levels were lowered several hundred feet opening up large areas of the continental shelf for human occupation. For many years archaeologists have assumed that coastal sites of late Pleistocene age were destroyed by rising sea levels at the end of the glacial period. Recent advances in marine archaeology have suggested however, that such sites may still be accessible for archaeological study (Ruppe, 1980).

At the Center for Marine Archaeology we have been developing a model to predict submerged prehistoric site locations in the Puget Sound Lowland as part of an overall inventory and management plan for the State of Washington. The Center for Marine Archaeology is directed by Dr. William C. Smith of Central Washington University and partial support for this research was provided by the Washington State Office of Archaeology and Historic Preservation. Following a brief discussion of the concept of predictive modeling I will comment on the Northwest Pleistocene environment, the environmental and cultural parameters used for site prediction, the results thus far obtained, and some direction for further research.

Predictive modeling in site location operates in the following manner. It identifies known prehistoric sites in an area, determines their relationship to identifiable features of the natural environment and extrapolates these factors to an entire study area so as to predict where sites may occur. The work of Gagliano et al. (1977) on the continental shelf of the Gulf of Mexico is representative of predictive survey methods in the study of submerged sites. This study established predictive zones based on the analysis of submarine topography and geology, eustatic sea level changes, and onshore prehistoric settlement patterns.

To develop a workable model for the Puget Sound area it is important to have an understanding of the geological history of the region. In northwest Washington the last glacial phase was dominated by the Cordilleran ice sheet moving down from Canada. The major glacial episode in the Puget Lowland and Strait of Juan de Fuca during this time was the Vashon Stade of the Fraser Glaciation. The ice mass split into two lobes: the Juan de Fuca lobe that moved westward to the Pacific Ocean, and the Puget Sound lobe that extended just south of Olympia. Glacial erosion expanded pre-existing river valleys, forming fjord-like troughs to depths of about 300 meters below present levels (Thorson, 1980).

Ice began receding at the toes of both lobes prior to 14,000 B.P., with the Juan de Fuca lobe at a faster rate. Once the ice dam at Admiralty Inlet broke, about 13,000 B.P., marine waters entered Puget Sound depositing glaciomarine sediments on top of Vashon till. As Vashon ice thinned and was bouyed up by marine waters, land level relative to the sea was approximately 80-140 meters lower than present (Easterbrook, 1969).

Once free of the weight of ice, the land began to rise or "rebound," with the rate of uplift greatest during and soon after unloading. These rebound rates, in conjuction with sea level rise, have located glaciomarine drift up to 140 meters above present sea level in the northern Puget Lowland. Figure 27 shows curves of isostatic rebound rate, eustatic sea level rise, and relative sea level estimates for various time periods at Whatcom County in the northern Puget Lowland (Larsen, 1972).

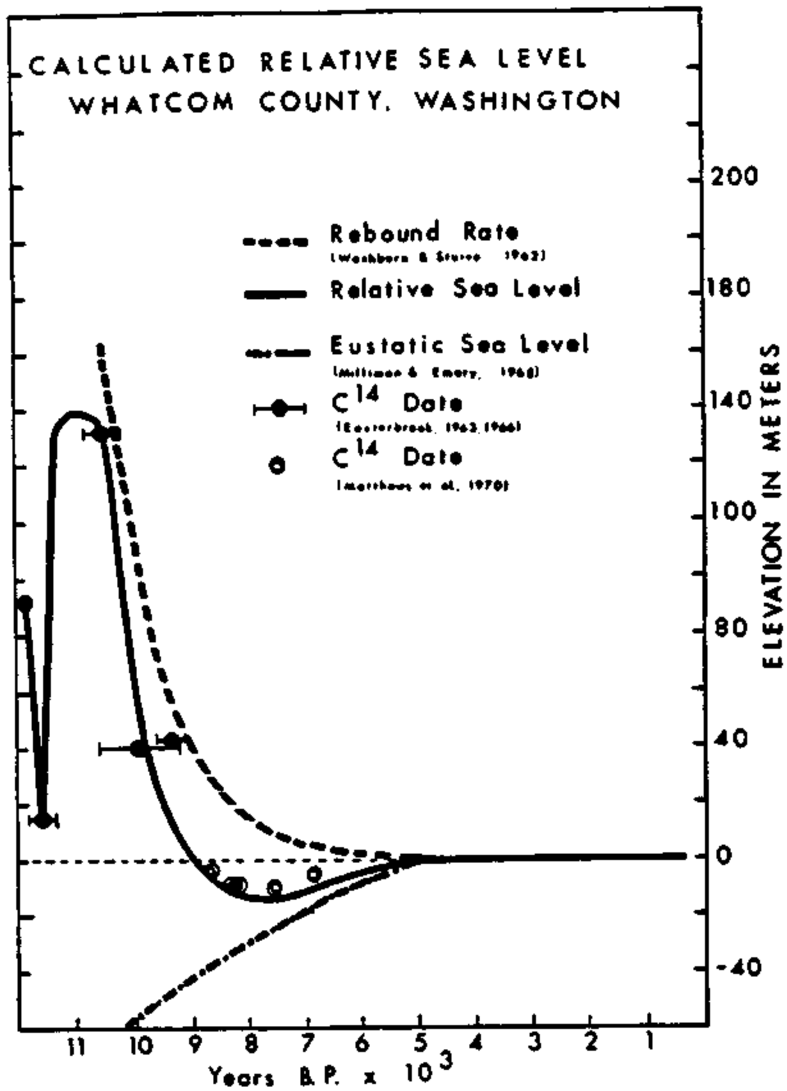

Figure 27. Calculated Relative Sea Level, Whatcom County, Washington. Reproduction by permission of author of graph.

It is important to note the major environmental changes--isostatic rebound, eustatic sea level rise, and to a minor degree tectonic movements--that occurred between 11,000 and 9,000 B.P. (Figure 27). A rapid relative sea level drop from 140 meters above present sea level at 11,000 B.P. to 10 meters below present sea level by 9,000 B.P. shows the dramatic effect where rebound rate exceeds sea level rise.

The goal of developing this predictive model is to delineate high probability areas for submerged prehistoric sites along the Strait of Juan de Fuca and Puget Sound Lowland. Present emphasis is on the northern Puget Sound.

In the development of the model certain assumptions and parameters were chosen as a baseline from which to work (Table 11). Ratings of 2, 1 and 0 are used to rank parameters as to their importance for site preservation and location. Two is considered the highest value. Prehistoric sites were rates as yes (2), and no (0), or unknown (1), depending on whether field data recorded the presence or absence of present coastal sites in the area. Unknown (1) rates are given to those areas where field observations are lacking. Bottom sediment type was divided into mud (2), sand (1), or gravel (0). A higher probability was assigned to fine-grained silt and mud sediment localities as they tend to provide better stability and likelihood of artifact preservation. Inundation rate was denoted as fast (2), intermediate (1), or slow (0), depending on bathymetery characteristics and their relationship to rate of inundation of shorelines by rising sea level. Exposure was listed as protected (2), seasonally variable (1), or open (0), to describe the physical relationship between site location and exposure to wind and wave action.

TABLE 11

RATING OF PARAMETERS TO DETERMINE PROBABILITY OF SITE LOCATION

PARAMETER	KEY	RATING
PREHISTORIC SITES:	YES	2
	UNKNOWN	1
	NO	0
BOTTOM SEDIMENT TYPE :	MUD	2
	SAND	1
	GRAVEL	0
INUNDATION RATE :	FAST	2
	INTERMEDIATE	1
	SLOW	0
EXPOSURE :	PROTECTED	2
	SEASONALLY VARIABLE	1
	OPEN	0

Data on the four parameters described, that is, prehistoric site location, bottom sediment type, inundation rate and exposure, as well as a projected lowered sea level contour of 10 meters from present, were plotted on baseline maps obtained from the University of Washington. Figure 28 is an example of one of these predictive maps for San Juan County. The lower sea level contours were drawn from Navy bathymetery maps and National Oceanic and Atmospheric Administration nautical charts. Bottom sediment data were analyzed from sediment maps from the University of Washington. Available data on prehistoric site distribution were obtained from the Washington State Office of Archaeology and Historic Preservation.

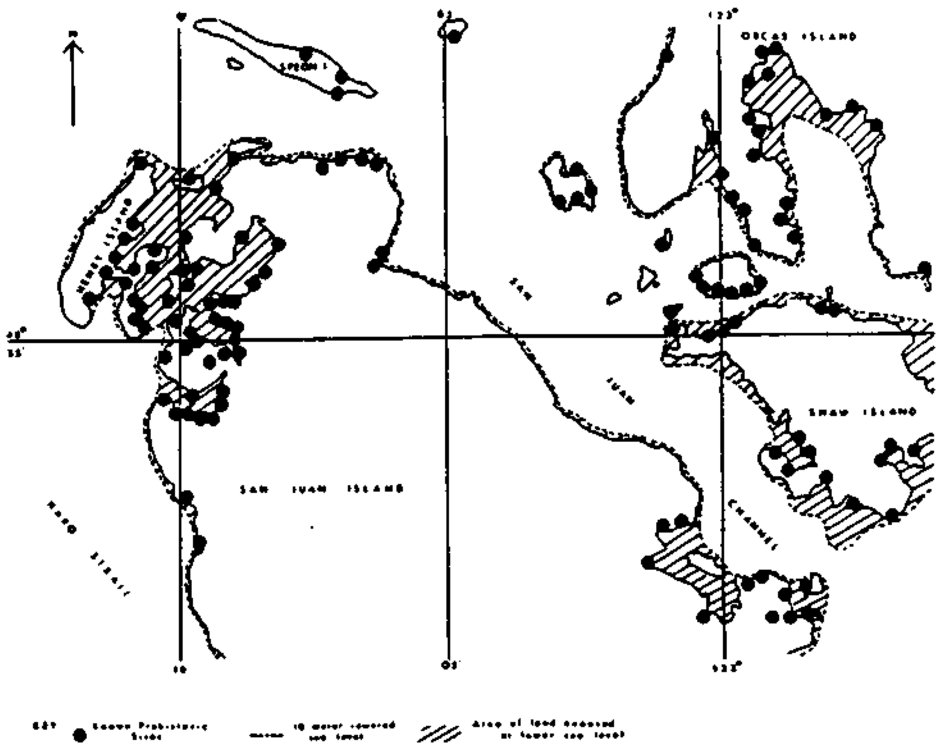

Figure 28. Predictive Map: San Juan Islands

Table 12 summarizes data related to various coastline sections in the Puget Sound Lowland. The four parameters of prehistoric site location, bottom sediment type, inundation rate and exposure were rated according to the data found for each section. Note that average values were given to bottom sediments depending on the variety of sediments found in a study zone.

Rating of probability of preservation was found by adding the values of the three environmental parameters of bottom sediments, inundation rate and exposure. The sum values were then rated as good, fair or poor. Probability of site location incorporates known prehistoric site information and environmental data; it is also rated good, fair or poor depending on the sum values. It should be noted that probability of site location nearly mirrors ratings for probability of preservation thus emphasizing the importance of environmental analysis for predicting site survival.

TABLE 12

PROBABILITY OF SITE LOCATION FOR ISLAND AND JEFFERSON COUNTIES (CHART 807)

( )= RATING

LOCATION	PREHISTORIC[a] SITES	BOTTOM[b] SEDIMENTS	INUNDATION[c] RATE	EXPOSURE[d]	PROBABILITY[b+c+d] OF PRESERVATION	PROBABILITY[a+b+c+d] OF LOCATION
DECEPTION PASS	YES (2)	GR.-SAND (.5)	S (0)	O (0)	(.5) POOR	(2.5) POOR
PT. PARTR.	NO (0)	GR.-SAND (.5)	F (2)	O (0)	(2.5) FAIR	(2.5) POOR
PENN COVE	YES (2)	SAND-MUD (1.5)	F (2)	P (2)	(5.5) GOOD	(7.5) GOOD
SEQUIM BAY	YES (2)	SAND-MUD (1.5)	F (2)	P (2)	(5.5) GOOD	(7.5) GOOD
PROTECTION IS.	NO (0)	GR.-SAND (.5)	S (0)	O (0)	(.5) POOR	(.5) POOR
PORT TOWNSEND	YES (2)	GR.-SAND (.5)	S (0)	SV (1)	(1.5) POOR	(3.5) FAIR
INDIAN I.	YES (2)	SAND-MUD (1.5)	F (2)	P (2)	(5.5) GOOD	(7.5) GOOD
MARROW-STONE I.	UN. (1)	SAND-MUD (1.7) GR.	S (0)	SV (1)	(2.7) FAIR	(3.7) FAIR

RATING PROBABILITY OF PRESERVATION:			RATING PROBABILITY OF LOCATION:	
	0-2.0	POOR	0-2.7	POOR
	2.1-4.0	FAIR	2.8-5.4	FAIR
	4.1-6.0	GOOD	5.5-8.0	GOOD

It is apparent from reviewing Table 12 that sites which have the characteristics of sand and mud bottom sediment types, in combination with a fast inundation rate and being located in a protected embayment, have a high probability for artifact preservation. One such site is Sequim Bay located along the Strait of Juan de Fuca.

Further research is needed in charting submerged river channels as a possible method for site location. Knowledge of sedimentation rates and geochemistry of sediment types for high site potential areas is required to determine the quality of site preservation and whether excavation would be feasible. Finally specific areas need to be investigated in the field to test the predictive capability of the model and to generate data in order to modify and refine it.

In conclusion the predictive model developed has generated a list of potential archaeological site locations under water in each of the Washington counties located along Puget Sound and the Strait of Juan de Fuca. The use of environmental characteristics of the area, coupled with known prehistoric sites, has enabled us to determine a preliminary evaluation of where potential underwater prehistoric archaeological sites may occur and the probability of site preservation. The next step is to carry out field investigations in specific regions of the Puget Sound Lowland to validate and upgrade the model. Only then can it develop into a viable research, as well as resource management, tool.

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THE GEOLOGIC CONTEXT OF THE MCFADDIN BEACH AREA, SOUTHEAST TEXAS

Saul Aronow
Department of Geology, Lamar University

McFaddin Beach on the upper part of the Texas coast lies between Sabine Pass and High Island, a salt dome-elevated Beaumont Formation inlier. The shoreline here is transgressive and the narrow beach deposits in successive hurricanes have moved inland over the Holocene marsh deposits that lie between the beach and the outcrop area of the Beaumont Formation to the northwest. The beach, especially after great storms and hurricanes, is the site of deposition of sparse vertebrate remains and prehistoric artifacts.

This portion of the Texas coast is about the only one in which a considerable width (1.5 to 15 km) of Holocene marsh separates the Beaumont outcrop area from the Gulf. Elsewhere the Gulf is bounded by barrier islands, peninsulas (long spits) or eroding Holocene delta plain deposits (Aronow and Kaczorowski, in press, and Morton 1979).

The Holocene marsh deposits in most places are probably less than 3 m thick and rest directly upon a shelf of Beaumont Formation. The seaward margin of the Beaumont outcrop area to the northwest has a digitate, highly crenulated pattern and represents a sequence of small birdsfoot deltas--the successive mouths of the laterally meandering paleo-Trinity River of Late Pleistocene age (Aronow, 1971, and Univ. Texas Bureau Economic Geology, 1968). The Beaumont Formation between the Holocene Neches River and Cedar Bayou (just east of the San Jacinto River) was laid down by a mainly suspended load (Galloway) paleo-Trinity River whose several deltas are roughly the size and shape of the modern delta of the Trinity.

This uniquely preserved--for the Texas coast--area may be explained by reference to the areal distribution and altitudes of the several portions of the Late Pleistocene Ingleside (Price, 1933, 1947, and Wilkinson, et al., 1975) barrier-strandplain system. South and southwest of West (Galveston) Bay the Ingleside is landward of and marginal to the several bays and lagoons of the Texas coast and is generally less than 3 m above sea level (Univ. Texas Bureau of Economic Geology, 1975). Northeast of Galveston Bay (Univ. Texas Bureau of Economic Geology, 1968) beginning at Smith Point the remnants of the Ingleside rise progressively from 3 m to more than 9 m above sea level and terminate in the vicinity of the Houston River in southwestern Louisiana (Price, 1947). With this increase in altitude the Ingleside is located increasingly inland from the Gulf and is enclosed by the Beaumont outcrop area. On the assumption that the fragments of the Ingleside were defined by the same water plane we may conjecture that either the local area has been uplifted or the rest of the Texas coast has subsided. In either case it led to the preserving of the McFaddin Beach area at the edge of the marsh. The beach and adjacent marsh area are underlain by a portion of the Beaumont that was offshore when the several Beaumont-age deltas to the northwest were deposited.

The vertebrate remains and prehistoric artifacts found along McFaddin Beach have been described (Long, 1977, and Russell, 1975). The vertebrate material, characterized as Rancholabrean, that is, post-Illinoian or Late Pleistocene, includes bones and teeth of large extinct mammals as well as smaller still extant forms from a variety of environments: South American tropical forest (e.g., capybara, jaguar, giant armadillo), grassland (e.g., bison, horse, mammoth), forest (e.g., mastadon), and arid to semi-arid (e.g., black-tailed prairie dog). These are believed to represent a temporal succession of environments rather than contemporaneously existing ones. The fossils and artifacts are transported to the beach as detritus by waves and currents and have not been found in place in any geologic unit.

Several scenarios for the source(s) of the fossils and artifacts can be suggested--bearing in mind that the offshore area was exposed from a sea-level "low" about 18,000 years B.P. to about 2500 to 3000 years B.P. when sea level was stabilized: (a) both artifacts and fossils derived from the Beaumont, (b) some of each derived from the Beaumont, and some of each from scattered surface sources when the continental shelf was exposed, (c) both fossils and artifacts from surface sources only, (d) some fossils from the Beaumont, and some fossils and all artifacts from surface sources, or (e) all fossils from the Beaumont and all artifacts from the surface sources. Scenarios (b), (c), and (d) are among the more plausible ones in light of a single radiocarbon date 11,100 + 750 years B.P. on an elephant tusk recovered from the beach (Long, 1977). The evaluation of the artifacts relative to these scenarios will not be attempted.

Because of the multiplicity of possible scenarios, the ages of the several geologic units in the region relative to a generalized Wisconsinan stratigraphic sequence (Beard et al., 1982) may be of interest.

The Beaumont Formation has yielded two sets of radiocarbon dates: (a) ~25,00 years B.P. to ~30,000 years B.P. and (b) greater than ~40,000 years B.P. and "dead." The younger dates might fall into the Farmdalian high-sea level stage; the older, the Mid-Altonian, or even the Sangamon high-sea level stages. The Ingleside depositional features could be placed in either of these older high-sea level stands. The radiocarbon dates for the Deweyville terrace complex (straths and large-radii meander scars, alluvial terraces containing relict channels with large-radii meanders) span~13,000 years B.P. to~25,000 years B.P., thus placing the unit partly in the Farmdalian high sea-level stage and partly in the Woodfordian low sea-level stage. These dates are all older than the Two Creekan (~11,500 years B.P.) and overlap the younger Beaumont dates. The Deweyville complex along the coast--at the mouths, for example, of the San Jacinto and Trinity Rivers--descends below sea level and was inundated by the post-18,000-year B.P. sea-level rise. Possibly some artifacts might be contemporaneous with part of the Deweyville complex. Should we choose to define the Gulf Coast Holocene as post-Deweyville, some fossils and artifacts might be considered as Early Holocene.

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ARCHAEOLOGY AND PALEOGEOGRAPHY OF THE MCFADDIN BEACH SITE, JEFFERSON COUNTY, TEXAS

Charles E. Pearson
Coastal Environments, Inc.

Archaeological and geological data from the McFaddin Beach site in eastern coastal Texas were examined in the context of the past 15,000 years of environmental history of the area. The site consists of wave-washed cultural deposits of Paleo-Indian age and later as well as large quantities of fossilized late Pleistocene faunal remains. The relationship of these materials to onshore and offshore late Pleistocene and early Holocene landform sequences were reviewed. The evidence suggests that cultural and faunal materials are being eroded from a number of locales on the surface of late Pleistocene, Trinity River deltaic formations and overlying Holocene deposits immediately offshore of the present beach. It is proposed that the Paleo-Indian cultural materials were associated with features such as the levees along channel courses, oxbow lakes, and marsh and swamp margins which remained as relict, though preferred, settlement habitats long after the Trinity River abandoned this area about 25,000 years B.P. It is highly likely that early man material will be found in association with similar relict deltaic features which are now exposed as the land surface just inland from the coast. It is anticipated, however, that these sites will be difficult to locate since they probably existed as brief, scattered occupations which have been obscured by processes of erosion and sedimentation.

THE EFFECTS OF SEA LEVEL RISE AND SUBSIDENCE ON PREHISTORIC SITES IN COASTAL LOUISIANA

Thomas M. Ryan
Corps of Engineers

The Mississippi Deltaic Plain hydrologic regime integreates a set of complex ecological processes which control biological productivity as well as community composition and extent. Since most of the deltaic plain lies at or near sea level, any changes in the position of the land and sea would alter community composition over hundreds of square miles of the deltaic plain.

Recent work by Colquhoun and Brooks combining both geological and archaeological data supports the occurrence of late Holocene sea level fluctuations along the South Carolina coast. The available archaeological data suggests relatively high sea level stands during the temporal intervals from 4,200-3,700 years B.P., 3,100-2,850 years B.P., 2,250-1,750 years B.P., and 1,600-1,000 years B.P. The geological data indicates lower sea level stands at 3,100 years B.P. and between 2,695 and 2,330 years B.P., with higher stands before and after these dates. The observed fluctuations are between 1 and 2 meters and occur with a frequency of approximately 400-500 years. The South Carolina data correlate with the transgressive and regressive phases reported from Northwest Europe and the authors propose glacio-eustatic mechanisms to explain the fluctuations recorded from both coasts.

Excavation of Big Oak Island, a Tchefuncte Period shell midden located in the deltaic plain east of New Orleans, revealed a stratigraphic sequence of natural and cultural deposits. The basal component consists of a peaty muck rich in cultural remains. The basal component is sealed by a massive sterile shell beach which is in turn covered by a Rangia Shell Midden. The basal component holds a radiocarbon date of 2,470 + 65 years

B.P. while the Shell Midden which overlies the beach has dates of 2,325 + 60 years B.P., 2,220 + 200 years B.P., and 2,185 + 70 years B.P. The beach is a transgressive feature and dates between approximately 2,470 and 2,325 years B.P.

According to the Colquhoun-Brooks oscillation curve, the interval between 2,695 and 2,330 years B.P. was characterized by a low sea level stand on the South Carolina coast. The Louisiana data support a transgression during this interval rather than a regression suggestive of the South Carolina curve. This discrepancy may be the result of high regional subsidence rates which characterize the Mississippi Plain.

POTENTIALS OF DISCOVERY OF HUMAN OCCUPATION SITES ON THE CONTINENTAL SHELF AND NEARSHORE COASTAL ZONE

Daniel F. Belknap

Department of Geological Sciences, University of Maine-Orono

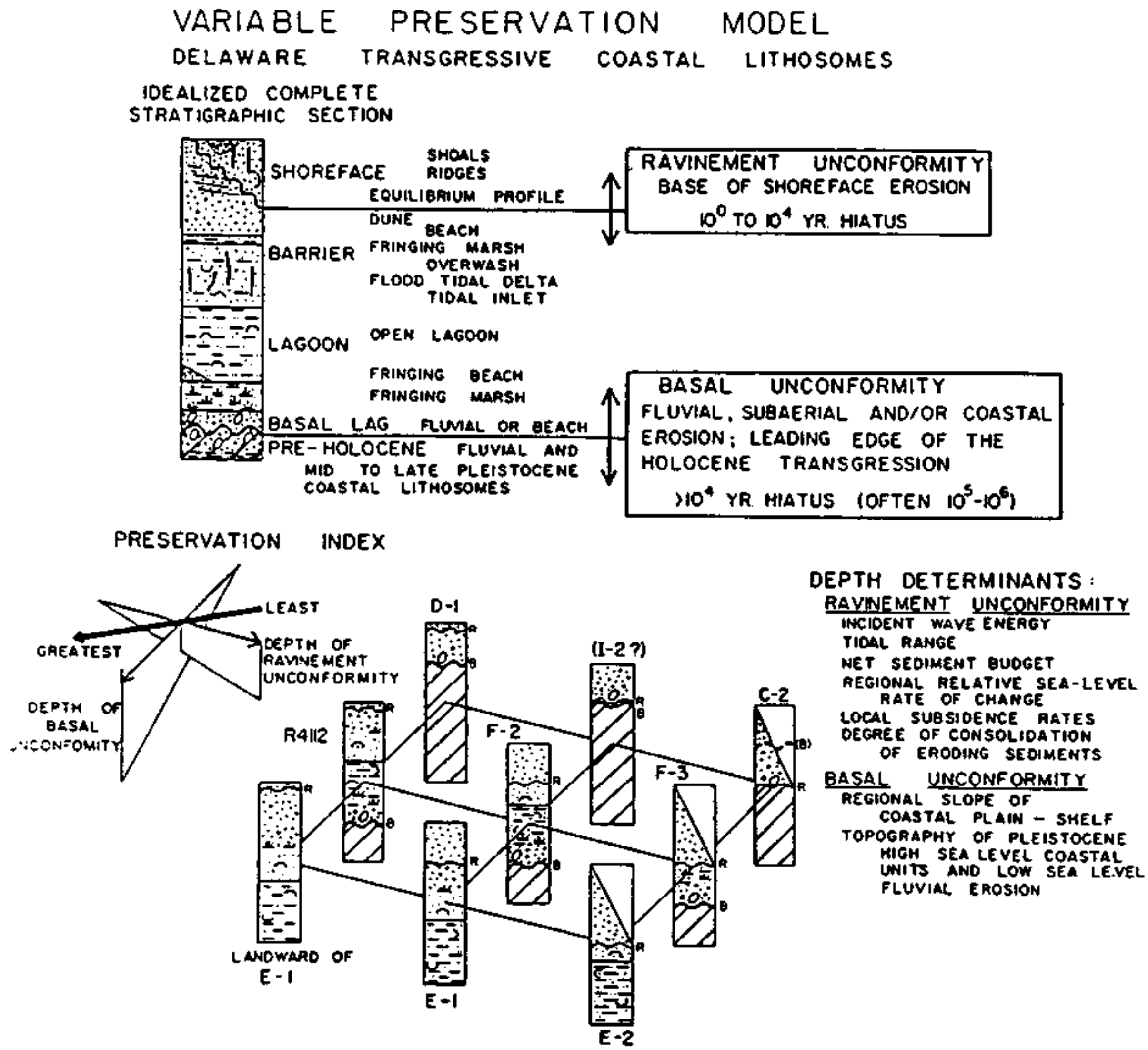
Archaeological sites on the continental shelf have been exposed to the Holocene transgression, as post-glacial sea level rose and drowned previously exposed sites. For these sites to be preserved the migrating zone of shoreface erosion must pass them by or they must be extremely resistant. Caves or quarried stone sites might be preserved in the eastern Mediterranean and elsewhere, but in the U.S. Gulf and Atlantic coastal plain it is extremely unlikely that middens and occupation sites on unconsolidated sediments would survive shoreface erosion.

To understand archaeological preservation potential general coastal lithosome preservation potential must be understood. Belknap and Kraft

(1981, 1984 in press) have modeled preservation potential of Delaware's transgressive barrier-lagoon and headland beach shoreline. Important factors in the model include rate of local relative sea-level rise, depth of shoreface erosion, which is in turn related to incident wave energy, tidal range, and sediment budget, and the factor of antecedent geology. The latter is a critical control. Deep pre-Holocene valleys contain more complete stratigraphic sections while there is no preservation of Holocene sediments over ancient interfluves now in the shoreface. Figure 29 is an idealized Holocene stratigraphic column for coastal Delaware which contains two unconformities: the ravinement surface (R) and the basal unconformity (B). The relative preservation potential (or, conversely, the length of hiatus in sedimentation) depends on position of these two unconformities. Below the idealized stratigraphic column are shown nine cores from the Delaware Atlantic shoreface which apply to this model, in a hierarchy of relative preservation. Maximum preservation occurs (Core E-1) where basal unconformity is deep, in pre-Holocene valleys, and where ravinement unconformity is shallow (shorthand notation B_dR_s). Conversely, minimum preservation occurs where basal unconformity is shallow and ravinement unconformity is deep (notation B_sR_d, Core C-2).

Seismic profiling and vibracoring on the shoreface and inner shelf off Delaware have allowed identification of the extensive paleofluvial Delaware River and its tributaries. The flanks of these valleys, filled with thick Holocene sediments, are the only likely locations for preserved archaeological sites offshore.

Figure 30 is a conceptual model of geologic evolution of coastal archaeological sites in the U.S. mid-Atlantic coast (from Kraft et al., 1983). The vertical axis represents the preservation potential of an archaeological site. The horizontal axis is a measure of the relative age of a site. For actual examples, this axis will stretch or shrink depending on rate of shoreline movement and original distance of the site from the shoreline. The relative shoreline position at present is shown below. The horizontal axis should not be misinterpreted as a strictly linear, quantitative measure of time. Similarly, the vertical axis is also relative: architectural ruins of



Depth of unconformities:

		RAVINEMENT		
		Shallow	Moderate	Deep
BASAL	Shallow	B_sR_s	B_sR_m	B_sR_d
	Moderate	B_mR_s	B_mR_m	B_mR_d
	Deep	B_dR_s	B_dR_m	B_dR_d

Figure 29. Variable Preservation Model for Coastal Lithosomes From Belknap and Draft, 1984 (in press).

quarried stone would be far more resistant to shoreline processes than Amerindian middens, but a midden or mound is more resistant to earthquakes. Thus, the relative preservation potentials are qualitative. Figure 31 shows 5 examples of archaeological sites in typical mid-Atlantic geographic settings. In addition, the positions of similar sites after sea-level rise and coastal erosion continue are shown within the faces of the block diagram.

On the mid-Atlantic coast, sites initially pass through a subaerial degredation phase (I, Figure 30; 1-5, Figure 31) in which running water, frost, and biological activity alter the site. Phase II is common for sites on the landward side of marshes and lagoons, such as Island Field, which are buried by tidal marsh or lagoon sediments with continuing sea-level rise (2',3',5', Figure 31). In these quiet environments preservation is enhanced (dashed line, Figure 30). Probability of discovery, however, falls with burial (dotted line). Phase III is as the erosive shoreface passes the site. Degree of preservation is dependent on the depth of scour, which reaches 10 meters on the Atlantic coast and 3 to 4 meters on the Delaware Bay coast. Thus, probability of destruction is dependent in part on whether a site is intersected by a deeply eroding oceanic shoreface (line a, Figure 30; e.g. Cape Henlopen lighthouse, 1926 or site 1', Figure 31) or a shallowly eroding estuarine shoreface (line b, Figure 30). Five to ten meters depth of scour is certainly sufficient to remove most Amerindian archaeological sites on a gently sloping coastal plain. Delayed arrival of the shoreface, however, such as in a valley floor on its flanks where it has been subsequently inundated by marsh or lagoonal mud (2', 3', 5', Figure 31) may allow preservation as the shoreface passes above the site. The zone of erosion passes above the site because sea level has risen in the interim. Discovery potential (dotted line, Figure 30) jumps briefly for buried sites if they are re-exposed at the shoreface, but declines as rapidly as a non-buried site thereafter.

These models have been used to predict locations of submerged archaeological sites on the U.S. mid-Atlantic coast and in the eastern Mediterranean (Kraft et al., 1983). To be useful, a detailed seismic profiling grid and long vibracores would be necessary to locate preserved sites. As

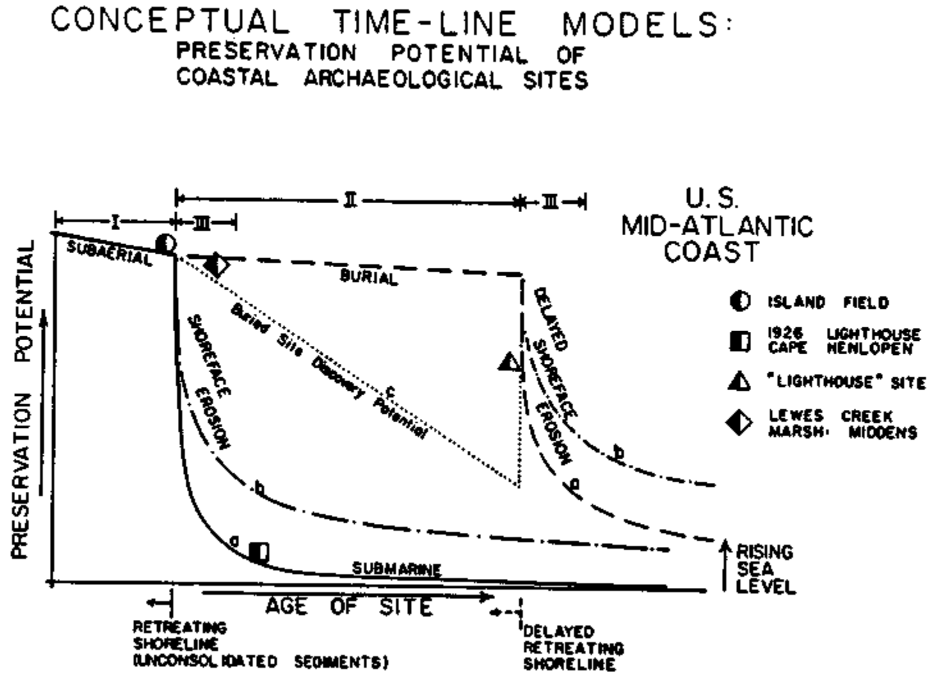


Figure 30. Archaelogical Site Preservation Model
From Kraft et al., 1983.

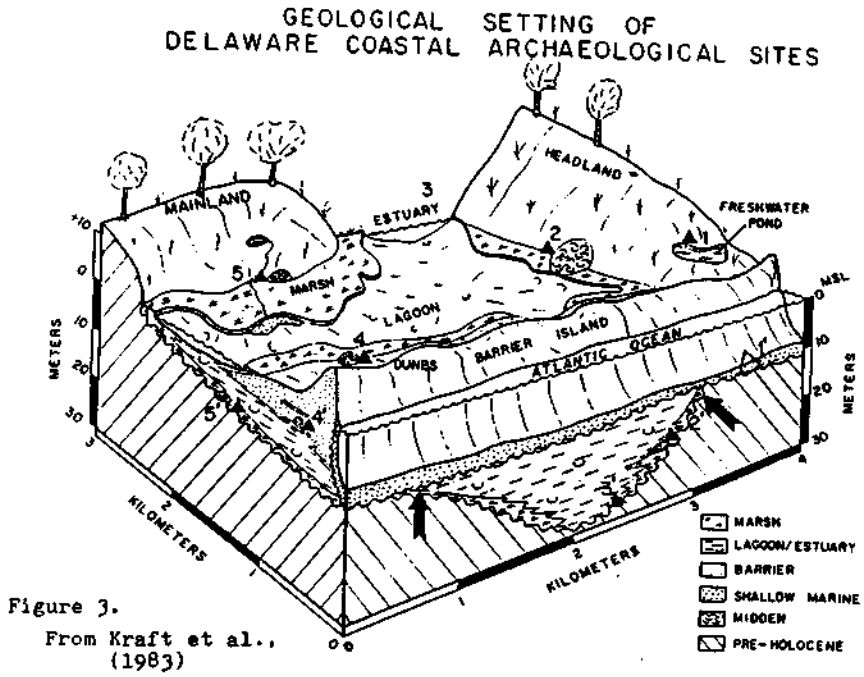


Figure 31. Archaelogical Site Geological Model
From Kraft et al., 1983.

yet this has not been attempted in the mid-Atlantic region. The model is clearly applicable to other areas, however, such as the Gulf coast. It is still unlikely that sites will be found, unless they are extremely densely distributed. Only likely potential sites for occupation or middens can be identified. It is extremely unlikely that a site exposed to shoreface erosion would survive. Only sites buried deep in valleys, bypassed by the shoreface erosion zone because of relative sea-level rise, will remain. Also, for these reasons older sites have a higher potential for preservation than younger sites.

This discussion has been based on several years of research at the Department of Geology, University of Delaware, and incorporates the ideas of co-authors John C. Kraft and Ilhan Kayan. The data was collected using Delaware Sea Grant, Office of Naval Research, and Delaware Department of Natural Resources and Environmental Control grants.

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SUBMARINE STONE AGE SETTLEMENTS IN DENMARK

Per Smed Philipsen
Danish Ministry of the Environment

INTRODUCTION

During the last decades, several submerged Stone Age settlements have been detected in the vast areas of shallow water surrounding Denmark. Unlike most land sites, the submarine sites are very rich in artifacts of organic material, manily because the artifacts are embedded in gyttja-layers (mud and turf) extremely deficient in oxygen, resulting in the preservation of the artifacts until the present day.

PROJECT HISTORY

Although Denmark is a very small country (approximately 26,000 square miles), because of the many inlets, creeks, coves, and islands, the total length of today's coastline is more than 4,500 miles. The many sheltered parts of the coast protect most of the inundated sites from washing out (erosion).

From well-preserved artifacts washed ashore along the coasts we have obtained a rough knowledge of the location of the sites, but not why the location was chosen. The latter problem required actual excavations.

POTENTIAL

So far only a few sites have been excavated. Methods of excavation are identical to those used on dry land: fixpoints and systems of coordinates are laid out and attached to the seabed. Every square meter is systematically excavated, plans and sections are drawn upon the seabed, and the location of each find is measured vertically and horizontally. The excvavation techniques differ considerably from land excavations: above the site a ship or a raft with pump gear is anchored. The pumps supply the airlifts and the injectors with air and water. Every square meter is excavated with a traditional trowel or by hand. The two types of pumps are solely used for transporting excavated material away and maintaining good visibility.

The stratigraphy of these sites is extremely good. The deposits alternate between thin layers of coarse sand and thick layers of organic mud, peat, and turf (gyttja) with varying consistency and compositon. In the gyttja-layers Stone Age artifacts of all kinds of material are embedded. Especially organic material is well preserved. That is material such as wood and bark, bone and antler, bast and senew plus nuts, acorns, roots, leaves, insects, etc.

The wooden objects dominate the finds: paddles (among them one completely ornamented), dug-out canoes, bows and arrows, leister prongs for fishing spears, handles, etc. Tools of bone and antler are very common as well: axes, knives, needles and points, fishing hooks (one with the line preserved). Bones are found in large quantities. From these sites the bones are mainly from red deer, wild boar, and roe deer, as well as furred animals such as pine marten, wild cat, otter, and pole cat. Many of them bear distinct marks of butchering or fur skinning. In addition to several isolated finds of human bones embedded in the gyttja layers, a few human graves have been revealed.

PROBLEMS AND PROSPECTS

Most of the settlements detected until the present day date back to late mesolithic in Denmark, which in terms of years is approximately 5,800 - 5,100 B.P. The sites are all located close to the coastline of today (50 - 1,200 feet) and are situated in shallow water (5-18 feet). Until now no early

Mesolithic coastal settlements have been found under water, but several isolated finds of antler, bone, and flint embedded in submarine bogs have been brought to the surface from somewhat greater depth in the course of fishing or extraction of raw materials from the seabed. These older sites still need to be located.

Unfortunately, the older bogs (and thereby the settlements) are most often covered by sand--and today the seabed is completely flat. Thus it is impossible for divers to detect them. This job requires other methods.

One of these methods is seismic registration, mapping a given area with a low frequency echo sounder. The Danish Ministry of Environment is currently running a project designed to detect submarine sites and wrecks by means of a sub-bottom profiler and a side-scan sonar. This part of the project is still quite new and as yet only at an experimental stage.

The electronic registration forms part of a nationwide registration. All archaeological information is being computerized, and in a very short time it will be possible for industry and others to order a computerplotted sea chart with the archaeologically important areas plotted out. The only information needed to order charts like this will be dimensions and co-ordinates of the map corners. Besides continued registration, future research will be concentrated on attempting to develop new models for the detection of depth and possible location of the prehistoric settlements. This work requires close cooperation between marine archaeologists and quarternary geologists as well as industries involved in exploiting the resources of the sea. This cooperation seems to ensure that the main parties concerned--archaeology and industry--are aware of the interests of one another and accept these.

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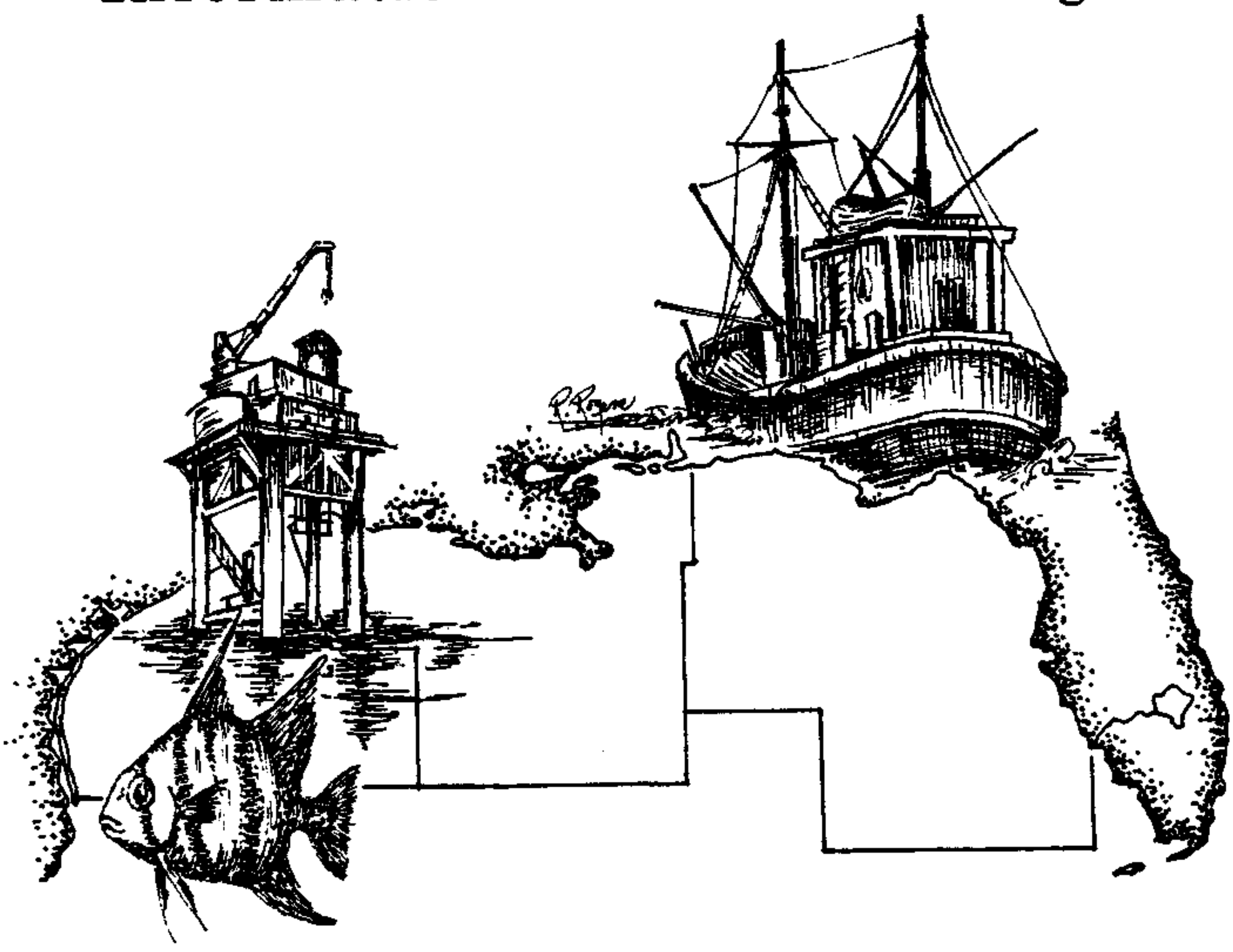
GULF OF MEXICO
OUTER CONTINENTAL
SHELF REGIONAL OFFICE

PROCEEDINGS

Third Annual Gulf of Mexico Information Transfer Meeting



December 1982

U.S. DEPARTMENT OF THE INTERIOR / MINERALS MANAGEMENT SERVICE

PROCEEDINGS:
THIRD ANNUAL GULF OF MEXICO
INFORMATION TRANSFER MEETING

August 24-26, 1982
New Orleans, LA

Sponsored by the
Minerals Management Service
Outer Continental Shelf Office
New Orleans, LA

Arrangements Handled by
Texas A&M University
Through the
Texas A&M Research Foundation
TAMRF-MMS Contract AA851-CT1-55

December 1982

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SESSION SUMMARY

Ms. Melanie Stright
MMS, Gulf of Mexico OCS Region

The cultural resources session was subdivided into prehistoric and historic archaeology sessions.

The major questions addressed by the participants in the prehistoric archaeology session included:

1. Where will prehistoric sites occur on the OCS?

2. Under what conditions will sites be preserved?

3. In what circumstances are prehistoric archaeological data recoverable?

4. What technology is available for data retrieval?

5. What type of site data is recoverable without complete excavation?

As a result of the presentations and discussions in the prehistoric archaeology session, four study needs were identified:

1. synthesize existing high resolution shallow seismic data on the OCS to more precisely delineate high probability areas for the occurrence, preservation, and retrieval of prehistoric archaeological data in the Gulf of Mexico;

2. physically test relict landforms already identified through cultural resources surveys and evaluated as having a high probability for site occurrence, preservation, and data retrieval;

3. test the validity of geochemical test results from terrestrial sites on marine inundated sites; and

4. continue perfecting localized late Pleistocene/Holocene sea level curves for the northern Gulf of Mexico.

The historical archaeology session focused on management factors affecting preservation of known sites, and on the use of magnetometer data vs. side-scan data for identifying sites. Seven problems and study needs were identified:

1. Central storage locations are needed for remote sensing survey data so that these data will be accessible for future reference and analysis.

2. Peer review of contract archaeological reports is necessary to ensure the professional quality of the reports.

3. Federal agencies need more field-level archaeologists to handle the work load and to ensure quality control of the contract archaeology work.

4. Survey line spacing and tow fish height need to be regulated and tailored to the location of significant shipwrecks.

5. Federal legislation is needed to remove historic shipwrecks from consideration under admiralty salvage law and put them under antiquities legislation.

6. Groundtruthing of a selected sample of unidentified anomalies should be conducted.

7. Information should be compiled on horizontal and vertical distribution of wreck debris in sediments of varying thickness and composition, in order to determine what type of signatures, if any, should be expected on the various remote sensing instruments.

MANAGEMENT STRATEGY FOR PREHISTORIC SITES ON THE OCS

Ms. Melanie Stright
MMS, Gulf of Mexico OCS Region

As an introduction to the prehistoric session, Ms. Stright briefly outlined MMS's management strategy for prehistoric sites in the Gulf of Mexico. The 1977 cultural resources baseline study for the northern Gulf of Mexico proposed a series of management zones. These zones differ in the probability for occurrence of significant cultural resources on the OCS. According to existing sea level curves, the area of the shelf defined by zones 1 and 2 was subaerially exposed until approximately 12,000 B.P. As such, these two zones have potential for occurrence of prehistoric sites dating from 12,000 B.P. to 3,000 B.P. (depending on the position of the area on the shelf).

High resolution shallow seismic profilers are the primary instruments used in locating relict landforms with a high probability for associated prehistoric sites on the OCS. Remote sensing surveys conducted on OCS leases have recorded numerous examples of such relict landforms; however, virtually no further investigation of these landforms has been conducted. Therefore, no prehistoric sites have been identified on the OCS as a result of remote sensing surveys.

MARINE GEOLOGIC MAPPING

Mr. Henry Berryhill
MMS Office of Marine Geology, Corpus Christi, TX

Henry Berryhill reported results from regional habitat mapping studies funded through the BLM studies program. Possible archaeological applications of the results were also addressed.

Original high resolution seismic data were collected on three-mile and four-mile grids across large portions of the central and western Gulf of Mexico. From these data a series of interpretive maps was constructed. The most useful maps from this series are those showing post-Wisconsin sedimentation patterns and the paleogeography of the continental shelf during former periods of low sea stand.

These interpretive maps provide a regional geologic framework which serves as an interpretive base for data collected during cultural resource surveys. This regional framework allows data interpretation to go beyond a statement that a relict landform occurs within a survey area, to an assessment of its archaeological potential in terms of its general age, the type of system to which it belongs, and the geologic processes which formed and modified it.

The maps of post-Wisconsin sedimentation patterns, for example, help identify the depth below the seafloor of the late Wisconsin erosional surface and help identify the depth of sediments which would have to be penetrated to test for archaeological sites in association with this surface. The situation should never be oversimplified, however, by categorically excluding all post-Wisconsin (Holocene) sediments as "archaeologically sterile." In some circumstances, such as short reversals in sea transgression and deltas prograded to a level of subaerial exposure, surfaces inhabitable by prehistoric man may occur within the Holocene sequence. Likewise, maps of early and late Wisconsin fluvial systems help in interpretation of the general age of such features observed in the cultural resources survey data. From this information, it can be determined whether these features fall within the time frame of human occupation of the area.

Mr. Berryhill indicated that erosion has probably destroyed most prehistoric archaeological sites across the Gulf, and that thick accumulations of Holocene muds would probably preclude the discovery and evaluation of sites over some portions of the Gulf, particularly off of south and central Texas.

From the audience, Dr. Gagliano pointed out that although erosion is evident at the late Wisconsin surface, site preservation would be excellent in areas which subsided or were covered by sediment prior to transgression. Site materials may also be incorporated into the sedimentary sequences and preserved in point bar deposits, natural levee deposits, back-barrier lagoons, or channel fill material.

SEDIMENTARY STUDIES OF PREHISTORIC ARCHAEOLOGICAL SITES

Dr. Sherwood Gagliano
Coastal Environments, Inc., Baton Rouge, LA

Dr. Gagliano reported the results of his recent study for the National Park Service. Although numerous examples of relict landforms having a high probability for associated prehistoric archaelogical sites have been identified on the OCS, the resolution and line spacing of data currently being collected do not permit identification of actual sites on the records. The limited physical testing of these landforms has generally been unsuccessful in identifying sites. This failure is attributed to the extremely low probability of recovering artifactual material in a core-sized sample, and to the lack of established parameters defining cultural deposits with which to compare the soil matrices of the physical samples taken.

Based on the assumption that cultural processes, like natural processes, influence the physical and chemical makeup of sediments, this study was designed to develop procedures and criteria for distinguishing cultural deposits from natural deposits using core-sized samples.

Box cores were taken from 15 selected onshore prehistoric sites. Off-site control samples were also obtained. The sampled sites from Mississippi, Louisiana, and Texas represented eight different coastal landform types and conformed to the following criteria:

1. site is associated with a relict landform type identifiable on the shelf;

2. site is commonly associated with that type of landform; and

3. site occurs in a location which may be preserved on the OCS.

These samples were subjected to four levels of analysis from the least complex to the most complex:

<u>Level 1</u>: lithology and minor sedimentary structures;

<u>Level 2</u>: point count and grain size analysis;

<u>Level 3</u>: geochemical analysis; and

<u>Level 4</u>: evaluation of all data.

The findings of this study indicate that systematic analysis of core-type sediment samples provides a basis for distinguishing cultural deposits with a high degree of certainty. In addition, study results suggest that there is a high probability of being able to positively identify a cultural deposit as such prior to the need for geochemical analysis (Level 3). Further, the study results indicate that 1) the statistical reliability of the 10 to 20 sized fraction analysis (Level 2) in yielding positive site identification may preclude the necessity for the smaller sized fractions in most cases; 2) grain size analysis is the least useful in sites where the soil matrix has a large proportion of greater-than-sand-size particles; and 3) bone or bone and charred material consistently separate site from non-site samples.

CORE SAMPLING OF A HOLOCENE MARINE SEDIMENTARY SEQUENCE AND UNDERLYING NEOLITHIC CULTURAL MATERIAL OFF FRANCHTHI CAVE, GREECE

Dr. John Gifford
University of Minnesota

Dr. Gifford reported the results of his work in Koiladha Bay off of Franchthi Cave, Greece during the 1981 field season.

A Neolithic settlement, the Paralia site, which lies downslope from Franchthi Cave on the shoreline of Koiladha Bay, was excavated by T.W. Jacobsen in 1973-1974. It was hypothesized that this Neolithic settlement extended farther downslope, beneath the waters of the bay, which formed during the post-glacial sea level rise. Records obtained with a 3.5 kHz acoustic profiler indicated that a river channel formerly cut through the present bay area, and that a wedge of Holocene sediment up to 5 m thick presently overlies the subaerially formed late Wisconsin surface with which the Neolithic site would be associated. To establish the presence or absence of this extension of the onshore Neolithic site, Dr. Gifford obtained two cores through the bay fill material, using a diver operated pulsing auger.

At the base of one core, 5.5 m below the present bay bottom, a stratum rich in mollusc shell fragments and subangular limestone pebbles was found to rest on a hard rock substrate. Thirty pottery shards were also recovered in the core from this stratum. Other materials recovered from this stratum through coarse fraction analysis included mud-building plaster, oxidized copper fragments, carbonized wheat grain, charred fish vertebrae, and a small burin. Dr. Gifford attempted to determine whether these cultural materials were downslope wash from the onshore Neolithic site, or were in situ materials from an underwater extension of the site.

Pot shards from the excavated portion of the onshore site which had been exposed to weathering and transport for only a few years were compared to the shards from the core sample. The marked angularity of the shards from the core in comparison to the shards from the onshore site indicates that the material from the core had been subjected to very little or no weathering and, therefore, was probably in situ.

Dr. Gifford's work has several important applications to the Gulf of Mexico. First, it establishes the presence of a preserved in situ cultural deposit in a bay fill situation. Second, the location of the site was predictable based on paleogeographic reconstruction and information provided by high resolution shallow seismic data. Third, the coring apparatus and methodology used are applicable in certain areas of the Gulf (depending on water depth and bottom sediment type). Fourth, the amount of site material and site information obtainable in a core-sized sample from a site buried by 5.5 m of sediment was demonstrated.

THE QUANTITATIVE ANALYSIS OF SOIL PHOSPHATE

Dr. William Woods
Southern Illinois University

Dr. Woods' paper detailed his work with geochemical analysis of soil samples in locating and evaluating terrestrial archaeological sites. This analysis is particularly useful in intrasite delineation or in locating sites with no surface expression. Although many soil components are evaluated, phosphate is one of the most useful indicators of cultural deposits because it is always present in high concentrations in areas utilized by humans, and because of its physical and chemical stability. Dr. Woods gave many examples of the success of geochemical analysis in delineating sites, distinguishing functional areas within a site, and determining site type. Experimental use of phosphate levels in estimating site population densities through time was also discussed.

The group discussed the possibility of using soil phosphate levels to locate buried sites on the OCS. Members of the group asked about the cost of obtaining soil samples. Dr. Woods indicated that the cost of lab analysis for a full battery of geochemical tests is only about $20 a sample, but the cost of collecting the samples offshore runs about $10 per foot, plus shiptime at about $6,000 per day. The question was then raised as to whether existing soil borings, collected by industry, could be used. Another question concerned the condition of the uppermost levels of deep soil borings, and whether sufficient stratigraphy would be preserved to permit archaeological analysis. The group agreed that these questions would have to be explored.

A second line of questioning was whether the results of the geochemical tests of terrestrial sites would apply to sites subjected to marine inundation. What would be the effect of the high phosphate levels of seawater on the use of phosphate levels as a site indicator? Dr. Woods stated that although the natural soil phosphate levels on the OCS may be high, they would result in a uniformly high background level from which even higher concentrations associated with cultural deposits could be distinguished.

Dr. Gagliano suggested that comparative core analysis be undertaken to determine the effects of saltwater inundation on the geochemical test results.

MANAGEMENT STRATEGY FOR HISTORIC SITES ON THE OCS

Ms. Melanie Stright
MMS, Gulf of Mexico OCS Region

As an introduction to the historic session, Ms. Stright briefly outlined MMS's management strategy for shipwrecks in the Gulf of Mexico.

The 1977 cultural resources baseline study for the northern Gulf of Mexico proposed a series of management zones having different probabilities for the occurrence of significant cultural resources on the OCS. Zone 1, closest to the shoreline, has a high probability for the occurrence of historic shipwrecks. Within this zone, MMS requires that a remote sensing survey be conducted at 150 m line spacing prior to development of a lease area, or as a condition of inter-lease pipeline permits.

The two principal instruments for shipwreck detection are the magnetometer and the side-scan sonar. At 150 m linespacing the magnetometer gives about 25 to 30% coverage of the seafloor which constitutes only a sampling survey. At this linespacing, however, side-scan sonar can cover well over 100% of the seafloor, with good resolution.

Conducting surveys at 150 m line spacing for the protection of historic shipwrecks is based on the premise that avoidance of all unidentified magnetic anomalies and side-scan contacts recorded within a survey area will result in the avoidance, and therefore the protection, of historically significant shipwrecks. This assumes either that all parts of a shipwreck are ferromagnetic and would be recorded by the magnetometer, or that all nonferromagnetic parts of a wreck would be evident on the side-scan records. Neither is necessarily the case.

In areas with a relatively hard bottom or in areas with only a thin veneer of unconsolidated sediments, it is probable that there would be some evidence on the side-scan sonar records of any shipwreck within the survey area. However, over large portions of the Gulf of Mexico, the thickness of unconsolidated sediments is sufficient to completely conceal debris from most pre-20th century wrecks of wooden or composite construction. The primary instrument for shipwreck detection in this case would be the magnetometer.

According to the results of studies conducted by the state underwater archaeologists for Texas and North Carolina, at 150 m linespacing it is possible to pass by an historically significant shipwreck with no indication whatsoever on the magnetometer record.

In addition to these survey limitations, Ms. Stright indicated that in areas where the magnetometer is the principal instrument for shipwreck detections, the 25 to 30% coverage does not allow any definitive statements concerning patterning of anomalies, or distinctions between modern debris and probable shipwrecks. These limitations result in recommendations for identification or avoidance of numerous anomaly locations. Ms. Stright concluded by stating that very little further investigation of unidentified anomalies is undertaken. Industry generally prefers to avoid the anomaly locations when developing their leases.

NATIONAL PARK SERVICE: MANAGEMENT OF SHIPWRECK SITES

Dr. Daniel Lanihan
Submerged Cultural Resources Unit, Santa Fe, NM

Dr. Lanihan discussed the management strategy for shipwreck sites in areas under National Park Service jurisdiction. Approximately 23 of the 45 submerged resource areas under Park Service jursidiction have potential for shipwrecks. These areas are actively inventoried by the Park Service. A key concept in the inventory of these resources is the identification of all unidentified anomalies recorded during the survey, with as little time lapse as possible. This provides immediate positive feedback into the system for the dollars spent.

The second major concept in the National Park Service's management of shipwreck sites is maximum data retrieval with minimum disturbance of the resource. This reflects both the emphasis on conservation of the resource and the third major management concept: interpretation of the resource for the public.

The smaller, well defined areas of National Park Service jurisdiction on the OCS make intensive survey techniques more practical. The fact that the Park Service also owns the resources within these well-defined areas makes protection of the resource possible.

Using the example of the Liberty ship, Dr. Lanihan stressed how rapidly we are losing our nation's maritime heritage and how important conservation and management of this resource is. During World War II, the Liberty ship was mass produced from identical plans. Today, only one unmodified example of the Liberty ship remains.

Even with the major differences in the management situations between the National Park Service and Minerals Management Service, Dr. Lanihan believes that the combined management of natural and cultural resources is an optimal and workable management strategy for both agencies.

CULTURAL RESOURCE MANAGEMENT FACTORS FOR THE OCS

J. Barto Arnold III
Texas Antiquities Committee
Austin, TX

Two significant government funded studies have appeared since the last Information Transfer Meeting, in 1981: "Sedimentary Studies of Prehistoric Archeological Sites" by Gagliano et al. (1982) and "An Assessment of Cultural Resource Surveys on the Outer Continental Shelf" by Ruppe (1982). These reports contain many suggested improvements which deserve support. Actual cultural resource management practices remain much the same, however. The recent reorganization of the Outer Continental Shelf (OCS) Offices under the Minerals Management Service represents an opportunity to make improvements in the management realm. A few suggestions regarding that topic are presented herein. Topics to be covered include line spacing, the relevance of the lack of side-scan sonar targets, archaeologists on federal agency staffs, archiving survey data, dissemination of reports, historic shipwreck management factors, and the need for ground truth studies.

Line spacing for the survey coverage on the OCS has been a perennial topic of discussion. It is now widely acknowledged that the 150 m line spacing used for years is not to be considered "complete" coverage, but only a sample relative to magnetometer data. An example comes from magnetometer data from a survey in Texas (Arnold 1979, 1980a, and In Press) from two tracks spaced at 100 m. The magnetometer data showed small anomalies on the order of 3 and 7 gammas. When these were ground truthed, over 1550 gammas were measured at the anomaly's center. The measurement of 1550 gammas was made at least 40 feet vertically above the target. This demonstrates the sampling nature of the 150 m line spacing. At 150 m this anomaly could have been missed altogether. The 300 m line spacing some propose would be a small sample indeed. Even so, a small, area-wide sample might be acceptable if a close-grained survey, on the order of 50 m line spacing, were performed in the more limited area where actual bottom disturbance is to take place. The matter of carefully controlling the distance of the magnetometer sensor from the bottom is of importance as well. A maximum of 30 feet for this distance would be ideal.

Apparently there are those who advocate the belief that if there is no side-scan sonar target then there is no wreck. The idea is that side-scan sonar survey tracks can be spaced much wider than magnetometer survey tracts and still obtain complete coverage. However, in ground truthing 47 significant anomalies in Texas waters, only six cases, or about 13%, showed any debris protruding above the bottom (Arnold 1976, 1977, 1978a, 1979, and In Press). Of course there would be no side-scan target if there is no debris standing proud of the sediments.

Returning to more mundane cultural resource management matters, let us consider the matter of qualified archaeologists on the staffs of the federal agencies involved in monitoring the OCS cultural resource program. It is absolutely essential that the number of archaeologists in the OCS offices and especially in the agency headquarters offices be increased. The few archaeologists currently employed in this capacity are greatly overworked and must often be loaned to other offices which have no archaeologist at all. One of the Minerals Management Service's new management guidelines calls for non-archaeologists to review data and reports resulting from the OCS cultural resource program. This can in no way be considered an adequate execution of the agency's responsibilities to protect cultural resources.

The archiving of the strip chart records or copies of those records is another area of concern. With each report on cultural resources to the MMS should come either the original data or a complete copy in some acceptable format. If these data are to be of use in the future for further study or synthesis, the data must be permanently archived in the same way that other archaeological collections are curated.

Regarding the archaeological reports generated by the OCS program, publication or other dissemination is a major problem. There has been some concern about the quality of many of these reports. This might be in part a self-correcting situation if MMS required that the reports be published. At an absolute minimum, copies should go to the National Technical Information Service, the relevant State Historic Preservation Office, State Archaeologist and/or State Marine Archaeologist, and perhaps the State Archives or a major state university library. In fact, an effort on the part of MMS to assemble microfilm or other copies of the backlog now on file and have them appropriately distributed should be a high priority and would correct a major deficiency in the program.

Historic shipwrecks present several management problems. The U.S. urgently needs a law asserting sovereign prerogative or ownership of historic shipwrecks in federally controlled waters (Arnold 1978b, 1982). This would remove such sites from the jurisdiction of admiralty salvage law, the law which has enabled commercial treasure hunters to pile up a dramatic string of court victories over the historic preservation interests of the state and federal government. Additionally, the compilation of a central historic wreck reference file complemented by a file of the anomalies already located through the OCS program would provide much needed management tools (Arnold 1980b).

Finally, ground truthing studies on anomalies located and simply avoided by industry during the OCS program should be a high priority. The MMS has a responsibility to find out what it is protecing. A sample of promising anomalies should be investigated and their causes identified.

The above represents a brief summary of a series of complex and convoluted factors related to the OCS cultural resource managment program. It is not an all inclusive list, but implementing these suggestions would significantly improve the situation.

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Texas A&M University

Department of

OCEANOGRAPHY

PROCEEDINGS:
GULF OF MEXICO
INFORMATION TRANSFER MEETING

held
12 - 13 May 1980
New Orleans, LA

Sponsored by
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Prepared through
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Technical Report #80-T-11
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Planning and Logistics Handled Through
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Under the Direction of
Mr. Joseph U. LeBlanc, BLM Program Manager
(713/845-2153)
and
Dr. Robert M. Rogers, BLM Project COAR
(504/589-6541)

Department of Oceanography
Technical Report #80-T-11

October 1980

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II. SPECIAL SESSION (Continued)

Archaeology

Participants

The archaeology sessions were attended by the following:

Barto Arnold	State of Texas Antiquities Committee, Austin, TX
Henry Berryhill	USGS, Marine Geology, Corpus Christi, TX
Arnold Bouma	USGS, Marine Geology, Corpus Christi, TX
Gordon Burton	USGS, Reston, VA
Donna Byrne	BLM, New Orleans OCS Office, LA
W.A. Cockrell	State of Florida, Department of State, Division of Archives, History and Records Management, Tallahassee, FL
Jim Coleman	Louisiana State University, Baton Rouge, LA
Robert Floyd	John Chance and Associates, Inc., Lafayette, LA
Ed Friedman	USGS, Reston, VA
Sherwood Gagliano	Coastal Environments Inc., Baton Rouge, LA
Jim Hauser	Odom Offshore, Baton Rouge, LA
Jack Hill	Oceanonics, Houston, TX
Bob Hoff	Decca, Houston, TX
Lori Hughston	ARCO Oil and Gas, Houston, Tx
Dana Larson	Exxon, Houston, TX
Murice Rinkel	State of Florida OCS Representative, St. Petersburg, FL
Reynold Ruppe	Arizona State University, Tempe, AZ
Jim Sides	John Chance and Associates, Inc., Lafayette, LA
Brent Smith	USGS, Metairie, LA
Melanie Stright	BLM, New Orleans OCS Office, LA

Introduction

The Archaeology session on May 12 was opened by Melanie Stright of the New Orleans OCS Office. She indicated that the overall purpose of the meeting was to obtain feedback for the EIS process. The four basic questions to be addressed were:

(1) What is the legal and regulatory basis for the cultural resources program on the OCS?

(2) What are the potential impacts to significant cultural resources from oil and gas development?

(3) Which impacts are the most significant?

(4) What changes should be made in the cultural resources program to improve it?

Three major concerns with the current cultural resources program on the OCS are:

(1) Shipwreck Archaeology--is the magnetometer effective in locating and/or avoiding historically significant shipwrecks with present line spacing?

(2) Prehistoric Archaeology--what are the capabilities for site identification and information retrieval using current coring techniques (penetration, core analysis, spacing, and configuration)?

(3) What is the overall cost/benefit ratio of the cultural resources program on the OCS?

Ms. Stright stated that in her opinion an initial change in the program which would be beneficial to both industry and archaeology would be to reduce the broad high probability area where archaeological surveys are currently being required by using existing geophysical data to outline areas of increasingly lower probabilities for site occurrence, locatability, and recoverability.

Evaluation of the Current Cultural Resources Program
Speaker: Reynold Ruppé, Arizona State Univ., Tempe, AZ

Dr. Reynold Ruppé talked on the results of his study conducted during a six month IPA appointment with BLM. This study was designed to evaluate the effectiveness of the current cultural resources program on the OCS in meeting the intent of the law. It involved assessment of the quality of the marine survey archaeological reports over the last six years. Dr. Ruppé brought up the following major problems with the current program:

(1) There are basic conflicts between federal agencies, particularly USGS and BLM, regarding their specific responsibilities and authorities under the current program.

(2) Report quality is not assured because there is no "peer review" of the marine survey archaeologists' reports. The result is that in the reports reviewed by Dr. Ruppé, neither the geophysicists nor the marine survey archaeologists are doing adequate assessment. A related problem is that most survey jobs and archaeological assessments are contracted to the "low bidder." Two possible solutions to problems with quality assessments were offered: (a) send examples of what are thought to be inadequate reports to the Society of Professional Archaeologists (SOPA) grievance committee for review; and (b) have BLM and USGS require that the reports be published.

(3) The ultimate legality of the program is in question: (a) the Antiquities Act of 1906 was ruled inapplicable to the OCS as per the 1978 "Atocha decision," and (b) the question has been raised as to the applicability of the National Historic Preservation Act of 1966 to the OCS. Dana Larson of Exxon made the point that the OCS Lands Act, as amended,

specifically states that "Exploration will not . . . disturb any site, structure, or object of historical or archaeological significance."

(4) Responsibility for further investigations is in question. Should the federal government or the lessee have this responsibility?

(5) Adequacy of the program cannot be assessed without ground truthing of selected anomalies.

Dr. Ruppé's presentation was interrupted by numerous comments and discussion. After the question of the legality of the program was discussed at length, it was mutually agreed by all present that to proceed with any meaningful discussion of the cultural resources program, the legality of the program would be assumed.

As the result of Dr. Ruppé's presentation, and the extensive discussions it produced, four major concerns were raised:

(1) After six years and over 1,000 marine survey reports, no real archaeological information has been collected in the Gulf of Mexico as a result of the present program.

(2) Are the archaeological surveys currently being required in the Gulf of Mexico effective in identifying and/or avoiding significant cultural resources in terms of technology, assessment quality, and the amount and type of further investigations being conducted?

(3) Use and transfer of data being gathered are inadequate. There is very little sharing of data, and there is no central storehouse for the data.

(4) There is no professional review of marine survey archaeologists' work outside the federal agencies.

<u>The Predictive Model for Prehistoric Site Occurrence</u>

Speakers: Sherwood Gagliano, Coastal Environments, Inc., Baton Rouge, LA
Robert J. Floyd, John Chance and Associates, Inc., Lafayette, LA

After the general discussion session, Dr. Sherwood Gagliano gave a short presentation on the predictive model for prehistoric site occurrence presented in his 1977 cultural resources baseline study for the northern Gulf of Mexico. He also spoke briefly on the progress and preliminary findings of a study he is currently doing under contract with HCRS entitled "Sedimentological Studies of Archaeological Deposits."

The basic tenets and findings of Dr. Gagliano's studies indicate that areas of high probability for the occurrence of drowned prehistoric archaeological sites may be located on sub-bottom profiler records by using the terrestrial analogue of site association with specific features of coastal geomorphology. These areas of high probability can then be investigated further through core analysis. The preliminary findings of his sedimentological studies indicate that certain sedimentological parameters may be identified which can distinguish a cultural deposit from a naturally occurring deposit.

Robert J. Floyd presented additional evidence supporting Dr. Gagliano's position by showing specific sub-bottom profiler records of well defined relict geomorphology which, using the terrestrial analogue of Avery Island, Louisiana, would indicate areas of high probability for prehistoric site occurrence.

Alternative Courses of Action

As a result of Monday's discussions, the following four courses of action for the OCS cultural resources program surfaced:

(1) Status Quo--continue the OCS cultural resources program in its present form (requiring surveys within the high probability area at 150 m line spacing).

(2) Eliminate the requirement for an archaeological survey at 150 m line spacing. Work more closely with the oil industry and use the geophysical data being gathered at 300 m line spacing as the basis for "in-house" archaeological assessments by USGS and BLM, calling in consulting archaeologists when the need arises. Geophysical data would also be used to identify areas for further archaeological studies, which would be jointly funded by the government and industry.

(3) Continue the archaeological survey requirements at 150 m line spacing, but eliminate the contract archaeologist by routinely requiring that all magnetic anomalies, side-scan sonar contacts, and certain relict geomorphology be avoided by oil and gas activities.

(4) Continue the archaeological survey requirements at 150 m line spacing, but eliminate many areas from the archaeological survey requirements by using existing geophysical data to outline areas of increasingly lower probability for site occurrence, locatability and recoverability, within the currently broad high probability area.

On Tuesday, May 13, the opening session was geared to this fourth alternative. Reports were given on two recent geological studies in the Gulf of Mexico and the applicability of the results of these studies towards the deletion of large areas from the archaeological survey requirement.

Subaqueous Sediment Instabilities in the Offshore Mississippi Delta
Speaker: Jim Coleman, Louisiana State Univ., Baton Rouge, LA

Dr. Jim Coleman reported on the results of a recent BLM study entitled "Subaqueous Sediment Instabilities in the Offshore Mississippi Delta." Side-scan sonar and seismic data compiled for the active delta region indicate that the current Mississippi Delta area is covered by a thick sequence of Recent sediments, and that faulting, slumping, and mass sediment movement are widespread. Recent disturbed sediments within the survey area ranged from zero to more than 200 feet thick. Dr. Coleman stated that the depth of sediments deposited in the survey area over the last 100 years alone averages about 40 feet thick.

Mr. Robert Floyd, in commenting on the archaeological implications of this information, combined with his own diving experience in the active delta, stated that he felt further archaeological investigations, even for historic shipwrecks, in the active Mississippi Delta are not feasible. J. Barto Arnold III, State Underwater Archaeologist for Texas, took exception to Mr. Floyd's assessment. Arnold stated that the Mississippi Delta area is an extremely high probability area for the occurrence of historic shipwrecks, and that it therefore should not be deleted from the archaeological survey requirements. He further stated that even though further investigations may not be feasible, ferromagnetic remains of wrecks could still be located and avoided by oil and gas activities.

Dr. Coleman's response to this argument was that the mass sediment movement throughout the historic period would probably have completely destroyed and scattered any ships which might have gone down in the area. Dr. Gagliano commented that should Mr. Floyd's suggestion be adopted, the near-shore submerged historic sites off the mouth of the Mississippi should not be "written off." These sites, however, lie in waters under the jurisdiction of the State of Louisiana, and management decisions made on the OCS would not affect such sites.

No final consensus was reached on the recommendation by Robert Floyd to delete from the archaeological survey requirement the blocks covered by Dr. Coleman's data.

BLM's Geological Mapping Program in the Gulf of Mexico
Speaker: Henry Berryhill, USGS, Corpus Christi, TX

Dr. Henry Berryhill reported on his ongoing geologic mapping program for the BLM in the Gulf of Mexico. His work involves constructing a series of regional geologic base maps from existing USGS preleasing shallow seismic data at 1.5 mile line spacing and collecting new seismic data on a three-mile grid to tie in existing data. It was Dr. Berryhill's position that maps produced by the study would be useful in redefining high probability areas for the occurrence, locatability, and preservation of archaeological sites.

Maps on the series which may provide useful information for this purpose include:

(1) Water Circulation--Rates of Sedimentation
(2) Paleogeography and Depositional Environments, Late Pleistocene and Holocene
(3) Post Wisconsin Sedimentation Patterns and Tectonism
(4) Structure of the Continental Terrace--Salt Diapirs

Dr. Gagliano qualified the usefulness of these maps by stating that both the geomorphology detailed on the maps and the time intervals covered by the maps are of too gross a scale for direct application to archaeological problems. Dr. Gagliano expressed a desire to work directly with the original data to compile maps more useful for the archaeological problems at hand.

Procedures and Problems in Archaeological Remote Sensing Surveys
Panel Discussion: Joint Session, Geophysicists and Archaeologists

The second session on May 13 was a joint session of geophysicists and archaeologists to discuss the procedures and problems involved in the archaeological remote sensing surveys. Discussion focused on the capabilities of the current surveys at 150 m line spacing for locating historic shipwrecks and prehistoric archaeological sights. As a result of the panel discussion, the following major points were brought out:

(1) The technology and methodology exist to locate historically significant shipwrecks; however, the general survey mode of the present surveys probably will not locate all historically significant wrecks.

(2) The present surveys at 150 m line spacing were designed as sampling surveys. The concept was to avoid all evidence which may indicate the presence of a shipwreck (all unidentified magnetic anomalies and side-scan contacts) by the distance to the next survey line (150 m).

(3) Designing archaeological surveys with a search mode and 100% magnetometer coverage would not be economically feasible on a routine basis.

(4) All present agreed that some ground truthing of magnetic anomalies is absolutely necessary to further evaluate the effectiveness of the current survey methodology. Barto Arnold indicated that one-third of all promising magnetic anomalies in state waters without any side-scan sonar confirmation, when investigated, have been related to shipwrecks. However, he also stated that this correlation on the OCS would probably be much lower.

(5) Dr. Berryhill asked whether any evidence of shipwrecks might be observed on sub-bottom profiler records. After some discussion, the general consensus was that no such evidence would be observed due to the interference in the shallow returns of seismic signals.

(6) Evidence of relict geomorphology, which would indicate areas of high probability for prehistoric site occurrence, is observable on sub-bottom profiler records; however, evidence of specific sites generally is not observable, due to the relatively small size of most prehistoric sites.

(7) It would be possible to improve survey methodology to actually locate evidence of extremely large cultural deposits; however, once again this was thought to be not economically feasible.

Opinions on the effectiveness of the existing archaeological surveys ranged from the feeling that they are absolutely useless to the opinion that they are gathering useful information for future studies and that as a result of the surveys, numerous archaeological sites both historic and prehistoric, are probably being avoided by oil and gas activities.

It was Dr. Berryhill's suggestion that technological capabilities and economic feasibility be the main factors considered in determining our survey requirements and methodology. Dr. Berryhill strongly supported the option of using available information to refine high probability areas where archaeological surveys are required down to areas of "highest probability," where more intensive surveys, further investigations, and future study efforts should concentrate.

At the end of this session Barto Arnold offered the following resolution for adoption by the group:

Given that:

(1) neither industry nor the archaeological community are satisfied with the current OCS cultural resources survey requirements;
(2) both industry and the archaeological community wish to avoid disturbing objects causing magnetic anomalies and to avoid certain sub-bottom geological features which may be high probability locations for prehistoric sites and hazardous to rig stability; and
(3) analysis and synthesis of existing data are inadequate and basic field research under-funded.

Be it resolved that:

(1) means be developed to accomplish the avoidance mentioned in #2 above in a more reasonable, mutually satisfactory manner; and
(2) BLM and industry fund more basic research and synthesis on OCS cultural resources on a high priority basis.

This resolution was seconded by Dr. Gagliano. No opposition to the resolution was expressed.

As a result of the meeting, two specific proposals for future studies were offered:

(1) A study to ground truth selected magnetic anomalies in order to determine what types of ferromagnetic objects produce what types of signatures, and what types of objects are being located and avoided as a result of surveys. Thousands of anomalies have been located and simply avoided by oil and gas operations, with no further confirmation or investigation, and therefore no further archaeological information on the Gulf.

(2) A study to run intensive surveys and do extensive data collection and testing of a specific high probability area for prehistoric site occurrence in order to actually locate prehistoric sites on the OCS and to help establish characteristic site signatures.