Dimitri Lutchenkov
Director, Environmental Affairs

750 East Pratt Street, Suite 1600
Baltimore, Maryland 21202

UniStar
NUCLEAR ENERGY

June 14, 2011

UN#11-171

Ms Elizabeth Cole, Administrator
Project Review and Compliance
Office of Preservation Services
Maryland Historical Trust
100 Community Place
Crownsville, MD 21032

Subject: Supplemental Submerged Cultural Resources Survey
Calvert Cliffs Unit 3, Calvert Cliffs Nuclear Power Plant Site

Reference: Greg Gibson (UNE) to Elizabeth Cole (MHT), October 8, 2010, *Request for Cultural Resources Consultation, Calvert Cliffs 3, Calvert Cliffs Nuclear Power Plant Site, Lusby, Maryland.*

In 2008, archaeologists conducted an intensive submerged cultural resources remote sensing survey for UniStar Nuclear Energy, LLC (UNE), on behalf of Calvert Cliffs 3 Nuclear Project, LLC, of the proposed offshore construction impact area associated with construction of a new nuclear generation unit at the Calvert Cliffs Nuclear Power Plant located in Calvert County, Maryland. Survey results were transmitted by the referenced correspondence. The survey recorded four potentially significant magnetic anomalies within the offshore area. Subsequent to completion of the archaeological investigation, UNE identified modifications to the proposed offshore facilities, requiring additional archaeological investigations. A supplemental comprehensive remote sensing survey of the new 300 ft by 700 ft construction/restoration area for a proposed barge dock/slip, as well as archaeological diving investigations to identify the sources of the four magnetic anomalies located during the 2008 survey, was conducted by Panamerican Consultants, Inc. under contract with GAI Consultants.

Results of the comprehensive remote sensing survey identified a total of three magnetic anomalies. One of the magnetic anomalies met established criteria and was considered potentially significant for the purpose of this investigation, and was further investigated as part of the diving phase.

A total of five targets were investigated and assessed by archaeologists from Panamerican Consultants, Inc., including the four magnetic anomalies located during the 2008 survey, and the one potentially significant magnetic anomaly located during the comprehensive remote sensing survey. All of the targets were determined to consist of modern debris and other objects that are not considered historically significant, are not eligible for listing on the National Register of Historic Places under any criteria, and so are not recommended for further investigation.

UNE requests concurrence from your office regarding the enclosed report and recommendations associated with the proposed Calvert Cliffs Nuclear Power Plant Unit 3 project, located adjacent to Constellation Energy Nuclear Group, LLC's Calvert Cliffs Nuclear Power Plant near Lusby, Maryland.

If you have any questions concerning the attached document, please call me at (410) 470-5524.

Sincerely,

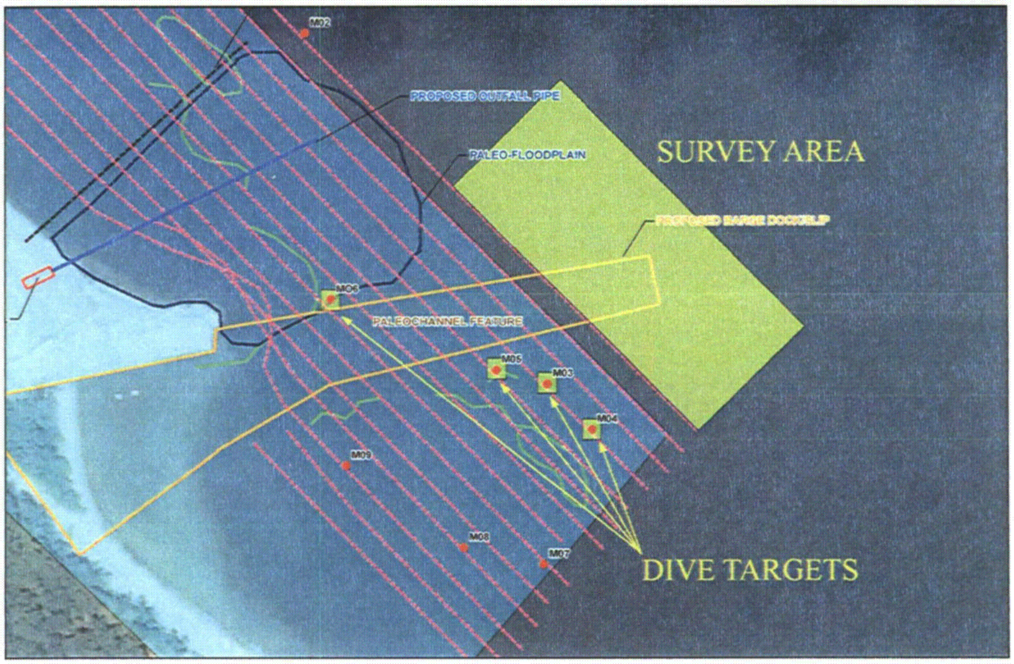
Dimitri Lutchenkov

Enclosure – Submerged Cultural Resources Survey, Calvert Cliffs Unit 3 (CC3), Calvert Cliffs Nuclear Power Plant Site, Calvert County, Maryland, May 2011

cc: Woody Francis – US Army Corps of Engineers
Susan Gray – Power Plant Research Program (w/o enclosure)
Laura Quinn – NRC Project Manager, Environmental Projects Branch 2

REPORT OF FINDINGS

SUBMERGED CULTURAL RESOURCES SURVEY
CALVERT CLIFFS UNIT 3 (CC3)
CALVERT CLIFFS NUCLEAR POWER PLANT SITE
CALVERT COUNTY, MARYLAND



SUBMITTED TO:

GAI Consultants, Inc.
385 East Waterford Drive
Homestead, Pennsylvania 15120

SUBMITTED BY:

Panamerican Consultants, Inc.
91 Tillman Street
Memphis, Tennessee 38111

MAY 2011

REPORT OF FINDINGS

SUBMERGED CULTURAL RESOURCES SURVEY
CALVERT CLIFFS UNIT 3 (CC3)
CALVERT CLIFFS NUCLEAR POWER PLANT SITE
CALVERT COUNTY, MARYLAND

Prepared for:

GAI Consultants, Inc.
385 East Waterford Dr.
Homestead, Pennsylvania 15120

Conducted Under:

GAI Project No. C081163.65

Prepared by:

Panamerican Consultants, Inc.
91 Tillman Street
Memphis, Tennessee 38111
PCI No. 31122

Authored by:

Andrew D. W. Lydecker, Michael K. Faught, and Stephen R. James, Jr.

Andrew D.W. Lydecker, RPA
Principal Investigator

MAY 2011

ABSTRACT

In 2008, archaeologists with Panamerican Consultants, Inc. of Memphis, Tennessee conducted an intensive submerged cultural resources remote sensing survey for UniStar Nuclear Energy, LLC of a proposed offshore construction impact area associated with construction of a new nuclear generation unit at the Calvert Cliffs Nuclear Power Plant located in Calvert County, Maryland. The survey recorded four potentially significant magnetic anomalies within the offshore area. Subsequent to completion of the archaeological investigation, UniStar identified modifications to the proposed offshore facilities, requiring additional archaeological investigations. Under subcontract to GAI Consultants, Inc. of Homestead, Pennsylvania, Panamerican Consultants, Inc. was tasked with conducting a comprehensive remote sensing survey of the new 300-x-700 foot construction/restoration area for a proposed barge dock/slip, as well as archaeological diving investigations to identify the sources of the four magnetic anomalies, M03, M04, M05, and M06, located during the 2008 survey, and any potentially significant anomalies located during the current survey.

Results of the current remote sensing survey identified a total of three magnetic anomalies and no sidescan sonar targets. One of the magnetic anomalies met established criteria and was considered potentially significant for the purposes of this investigation, and was further investigated as part of the diving phase.

A total of five targets were investigated and assessed, including magnetic anomalies M03, M04, M05 and M06, located during the 2008 survey, and magnetic anomaly M101, located during the current survey. Target M05 was accounted for by the presence of a large rudder and propeller; M03 by the presence of a length of 16-inch diameter steel pipe; M04, not relocated during refinement remote sensing survey and presumed removed or mobilized; and M06, probed via hydroprobe to a depth of 7 feet, was determined to likely consist of a large amount of isolated marine related debris. M101 was probed to a depth of 2 feet, where a large oyster shell layer was encountered. The source of M101 is considered to be a large amount of isolated marine debris above this layer. None of the targets are considered historically significant and no further work is recommended.

ACKNOWLEDGEMENTS

Panamerican Consultants, Inc. would like to thank the following people for their assistance during this project. First and foremost, we would like to acknowledge Ms. Barbara Munford of GAI Consultants Inc. for allowing us the opportunity to conduct this investigation. Mark Hunter and the staff at the Calvert Cliffs Nuclear Power Plant deserve acknowledgement for ensuring the efficiency and safety of this project.

The crew deserves acknowledgment for their hard work, dedication, and attention to detail in conducting this project effectively and safely. Members included Andrew Lydecker, Matt Elliott, James Duff, and Michael Murray.

In-house Panamerican Consultants, Inc. personnel who must also be thanked include Kate Gilow, office manager, and Anna Hinnenkamp-Faulk, report editor.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

In 2008, archaeologists with Panamerican Consultants, Inc. of Memphis, Tennessee (Panamerican) conducted an intensive submerged cultural resources remote sensing survey for UniStar Nuclear Energy, LLC (UniStar) of a proposed offshore construction impact area associated with construction of a new nuclear generation unit (CC3) at the Calvert Cliffs Nuclear Power Plant (CCNPP) located in Calvert County, Maryland (Figure 1). Located north of both Solomons Point and the mouth of Patuxent River, the survey recorded four potentially significant magnetic anomalies within the offshore area (Faught 2009). Subsequent to completion of the archaeological investigation, UniStar identified modifications to the proposed offshore facilities, requiring additional archaeological investigations. Under subcontract to GAI Consultants, Inc. of Homestead, Pennsylvania (GAI), Panamerican was tasked with conducting a comprehensive remote sensing survey of the new 300-x-700 foot construction/restoration area for a proposed barge dock/slip, as well as archaeological diving investigations to identify the sources of the four magnetic anomalies—M03, M04, M05, and M06—located during the 2008 survey (Figures 2 and 3), and any potentially significant anomalies located during the current survey.

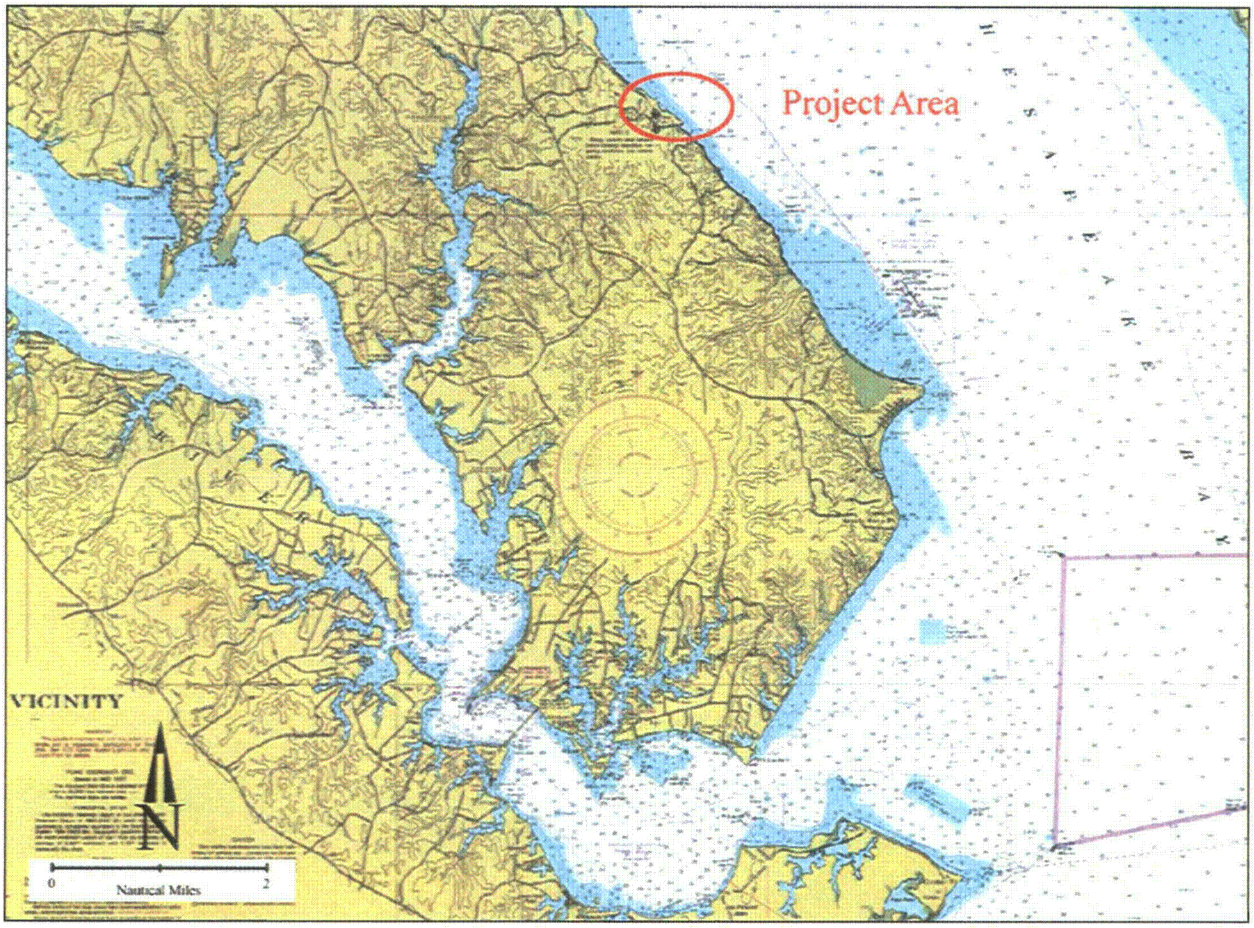


Figure 1. Project area location map (excerpt from NOAA Navigational Chart "Patuxent River and Vicinity, MD," Chart No. 12264).

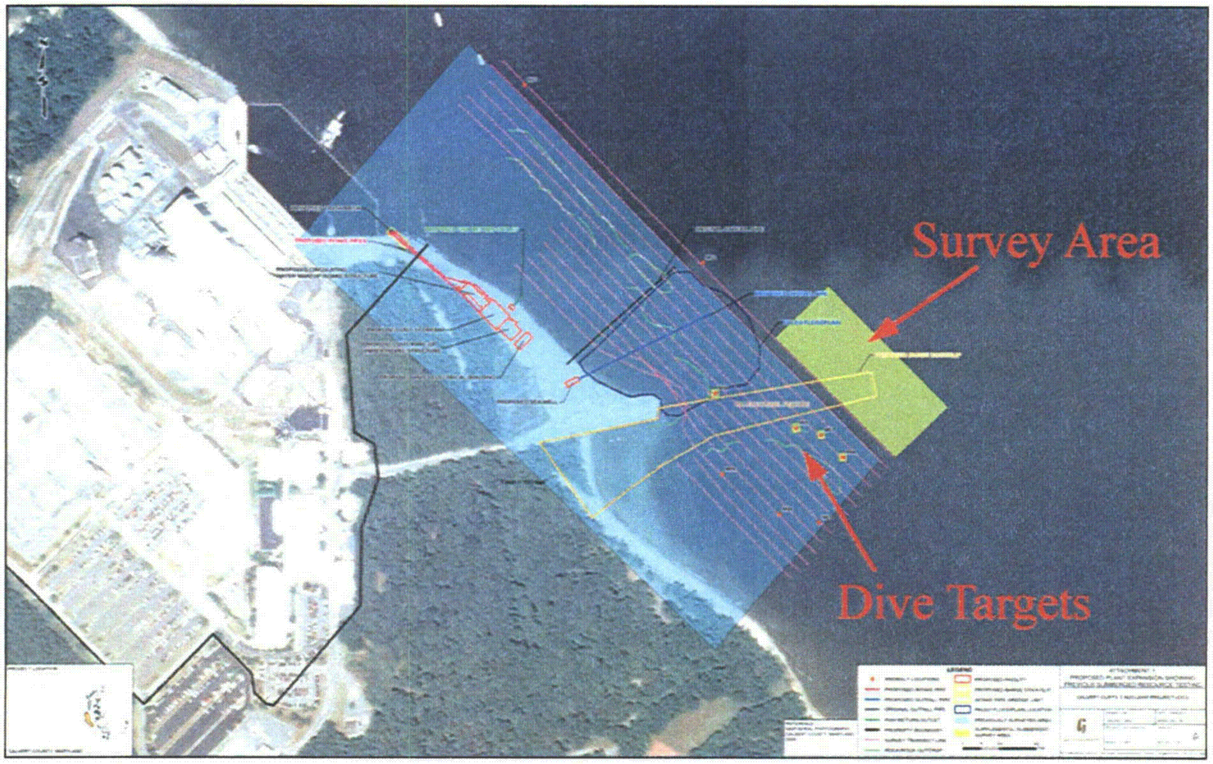


Figure 2. Calvert Cliffs Nuclear Plant with 2008 study area and dive targets, as well as the new 2011 Survey Area (yellow; base map courtesy of GAI).

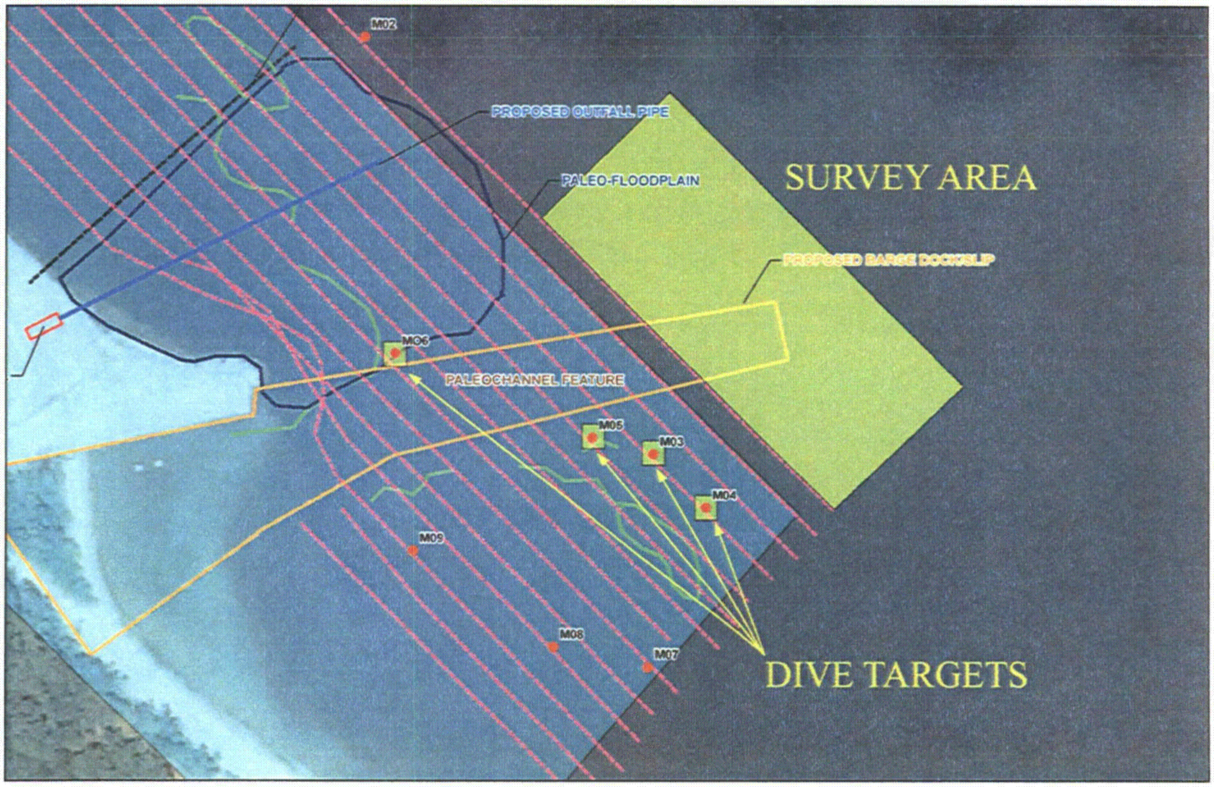


Figure 3. Close up of the new 2011 Survey Area (yellow) and four potentially significant anomalies, M03, M04, M05 and M06 (base map courtesy of GAI).

The current project was comprised of a magnetometer, sidescan sonar, and subbottom profiler survey of the new 300-x-700 foot construction/restoration area for a proposed barge dock/slip. The primary focus of this remote sensing survey was to determine the presence or absence of additional anomalies representative of potentially significant submerged cultural resources eligible for listing on the National Register of Historic Places (NRHP), which, if present, might also require diver assessment. The diving investigation was conducted to assess the identity of the four potentially significant anomalies (M03, M04, M05, and M06), as well as any newly recorded anomalies within the new survey area, and determine their significance, if any, based on NRHP criteria. The project was conducted relative to UniStar's responsibilities under various federal and state statutes and was performed in compliance with Section 106 of the National Historic Preservation Act of 1966 (NHPA), as amended (36 CFR 800, *Protection of Historic Properties*); the Abandoned Shipwreck Act of 1987 (*Abandoned Shipwreck Act Guidelines*, National Park Service, *Federal Register*, Vol. 55, No. 3, December 4, 1990, pp. 50116-50145); as well as the Maryland Historical Trust (MHT)'s Standards and Guidelines for Archaeological Investigation in Maryland.

Results of the current remote sensing survey identified a total of three magnetic anomalies and no sidescan sonar targets. One of the magnetic anomalies met established criteria and was considered potentially significant for the purposes of this investigation, and was further investigated as part of the diving phase.

A total of five targets were investigated and assessed, including magnetic anomalies M03, M04, M05 and M06, located during the 2008 survey (Figures 2 and 3) and magnetic anomaly M101, located during the current survey. Target M05 was accounted for by the presence of a large rudder and propeller, M03 by the presence of a length of 16-inch diameter steel pipe, M04 was not relocated during refinement remote sensing survey and presumed removed or mobilized, and M06, probed via hydroprobe to a depth of 7 feet, was determined to likely consist of a large amount of isolated marine related debris. M101 was probed to a depth of 2 feet, where a large oyster shell layer was encountered. The source of M101 is considered to be a large amount of isolated marine debris above this layer. None of the targets are considered historically significant and no further work is recommended.

II. HISTORICAL BACKGROUND

Limited archival investigations were conducted for this project to understand the potential for both historic (shipwreck) resources and submerged prehistoric resources. Presented below, the background information has been divided into descriptions of the local environmental setting and cursory historic period and prehistoric period potentials.

Panamerican reviewed company reports dealing with Maryland maritime history, visited the Calvert Marine Museum in Solomons seeking information about known shipwrecks in the area or the potential for their existence, and interviewed local geoarchaeologist Darrin Lowery with regard to known locations of submerged prehistoric sites and the potentials for the same.

No shipwrecks were known for the area and it was considered low potential that they might occur along the straight, exposed shoreline. No submerged prehistoric sites were known for the area, but the potential for Paleoindian through Archaic remains was considered likely.

ENVIRONMENTAL SETTING

Most of the Maryland shoreline is broken and sinuous because sediments of the coastal plain offer little resistance to erosion and low-lying portions are easily inundated. Only the bay shore of Calvert County is marked by higher banks, or relatively straighter shorelines, and the eroding sediment hills.

Calvert Cliffs are hillocks of Miocene sediment beds shaped by erosion and sheared by calving (Figures 4 and 5). The unlithified sediments that comprise the cliffs are sequential facies of transgressive and regressive deposits including beds of clays, silts, sands, and gravels. These have been divided into three formations at the project location (Kidwell 1997): *Calvert*, the oldest, at the base; *Choptank*, in the middle; and *St. Mary's*, at the top, representing middle and late Miocene time. Sidescan sonar acoustic backscatter images resembling this "layering" were observed on the mosaiced sidescan record, indicating either slumped sediments from calving or additional, but earlier, Miocene deposits (http://www.mgs.md.gov/esic/geo/cal.html).

The nearest ice sheet to Chesapeake Bay was approximately 200 km north of Maryland during the last continental glaciation (approximately 25,000 BP). Sea level changes and sediment deposits around Chesapeake Bay are the indirect effects of this nearby glaciation.

Chesapeake Bay is the result of the Holocene drowning of the drainage system of the ancestral Susquehanna River (PaleoSusquehanna). The evolution of the bay includes the continued submergence of this feature. Evidence suggests that Chesapeake Bay is very young, perhaps no more than 8,000–10,000 years old, depending on when isostasy and sea level rise coincided to breach the mouth of the bay. The bay and the lands that surround it are the result of changes in sea levels associated with the fluctuations of major ice sheets during the Pleistocene.

There are rich records locally of prehistory, protohistory, colonial history, and United States history, but these are only outlined here for purposes of brevity.

Figure 4. Viewing approximately west, toward the CCNPP in the center and the barge jetty to the left.

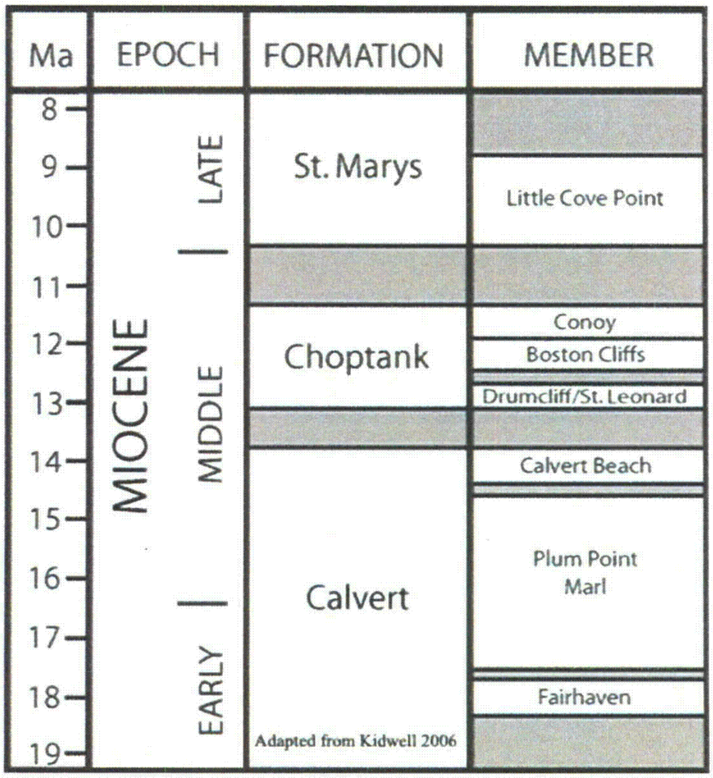


Figure 5. Members of the Miocene formations of Calvert Cliffs at the project location (adapted from Kidwell 2006).

PREHISTORIC POTENTIALS

Prehistorically, the record of Maryland includes a full sequence from the Paleoindian era through Archaic, Woodland, Protohistoric, and Colonial times for Native Americans (Snow 1980). With regard to estimating sea level changes within the Chesapeake embayment, relevant to the project area, Lowery notes, "During the early portions of the Early Archaic period ca. 11,600 BP, sea levels were approximately 65 meters (211 feet) lower and at the terminus of the Early Archaic period, sea levels were approximately 35 meters (114 feet) lower than present" (2008:31). This would have put sea levels up to the mouth of the modern embayed area and flooding would have mostly occurred after this. There is potential for Paleoindian through late Early Archaic.

Lowery again states, "around 8,000 year ago, sea levels were approximately 24 meters (78 feet) below current ... and at the terminus of the Middle Archaic period, sea levels were approximately 10 meters (32 feet) lower than present. Clearly, the Middle Archaic period was a time of rapid sea level rise and rapid ecological change. Again, virtually all of the known terrestrial Middle Archaic sites in the coastal plain are in areas that were upland settings ... 6,800 years ago" (2008:33). Sites would be predicted on paleolandscapes now submerged around this time, 6800 BP.

Since sea levels have risen over the time that people were in the area, the potential exists for submerged prehistoric sites in Chesapeake Bay and at the project location in particular (Blanton and Margolin 1994; Lowery 2003, 2008). These sites can be predicted to occur in paleolandscape situations similar to terrestrial landscape settings where sites are known to occur on land (i.e., on river terraces, near chipping stone outcrops, etc.). There is a paleochannel feature near the project impact zone whose floodplain margins meet these criteria.

Potential prehistoric components include Paleoindian, Early Archaic, and Middle Archaic remains. Woodland and later remains would only be flotsam or jetsam, which would be interesting but not significant, save for remains of canoes or fishing weirs and the like (Blanton and Margolin 1994; Lowery 2008).

HISTORIC POTENTIALS

Since its discovery and exploration, the Chesapeake Bay area has seen the development of a rich maritime history, with several maritime museums and displays in different states around its margins. Much of this history is with regard to various kinds of sail-powered vessels; however, steam-powered vessels were introduced by 1813. Nevertheless, the exposed coastline of the Calvert Cliffs remote sensing survey project area is not as conducive to vessel abandonment and scuttling as the inlets. Thus, catastrophic encounters with the coast provide greater potential for ship remains, although none are known (Dodds personal communication 2008). Known vessel types within Chesapeake Bay include the following (Lydecker and Krivor 2004):

- Brig/brigantine
- Barkentine
- Clipper Ship
- Canoe, Brogan and Bugeye
- Sailing work vessels
- Sloop
- Schooner, Pungy, Baltimore clipper
- Skiff
- Skipjack
- Sharpie
- Steamboats

Of the 11 types of vessels listed above, most would have been scuttled or otherwise abandoned inside more protected waters such as up in the Patuxent River and not on the windward and waveward side of Chesapeake Bay.

PROJECT AREA ENVIRONMENT

Figure 6 conveys the environment of the project area and illustrates the working conditions of the survey area. Both the survey and diving operations were conducted at a time of relatively light winds and calm conditions. Vessel traffic was nonexistent with the exception of a scheduled tug and barge arrival.

Figure 6. Project area westward from survey vessel toward the barge dock area.

PROJECT PERSONNEL

The personnel assigned to this project met training and qualification requirements outlined in the U.S. Army Corps of Engineers Safety and Health Requirements Manual (EM 385-1-1). All team members were current in their Red Cross training for first aid, cardio-pulmonary resuscitation (CPR), and oxygen administration. Andrew D.W. Lydecker served as the maritime archaeologist. Lydecker is a maritime archaeologist with a graduate degree in Anthropology (Archaeology), and has extensive experience in remote sensing surveys. Jim Duff, Matt Elliott, and Michael Murray served as archaeological divers.

Safety was of paramount concern during the remote sensing and diving phases of this project. Panamerican personnel worked closely with safety personnel at CCNPP

REMOTE SENSING SURVEY EQUIPMENT

The remote sensing survey was conducted with equipment and procedures intended to facilitate the effective and efficient search for magnetic and/or sidescan sonar anomalies and to determine their exact location. The positioning system used was a Trimble DSM12/212, Integrated 12-

channel Global Positioning System (DGPS). Remote sensing instruments included a Marine Magnetics SeaSPY overhauser magnetometer, a Marine Sonic Technology sidescan sonar, and an Edgetech 424 subbottom profiler system.

Differential Global Positioning System

A primary consideration in the search for magnetic anomalies is positioning. Accurate positioning is essential during the running of survey tracklines and for returning to recorded locations for supplemental remote sensing operations or ground-truthing activities. These positioning functions were accomplished on this project with a Trimble Navigation DSM12/212 global-based positioning system (Figure 7).

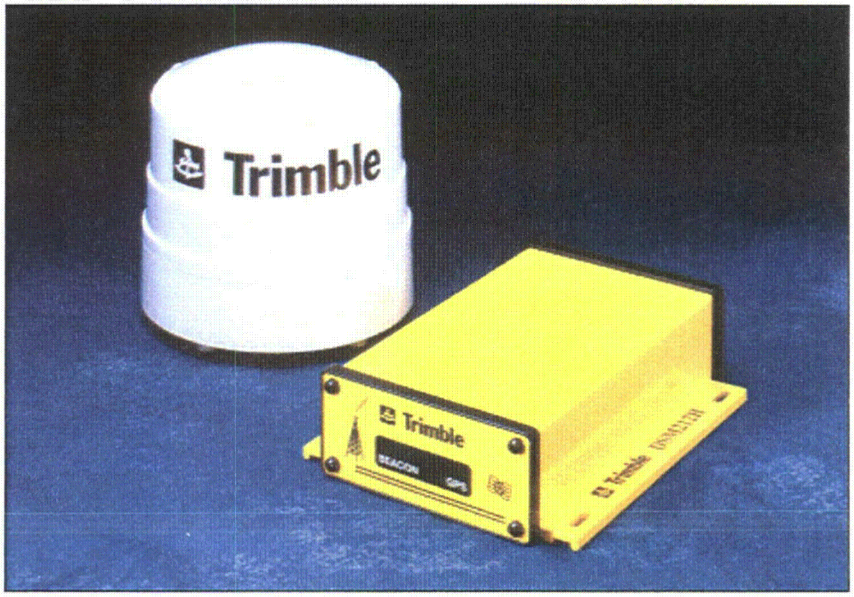


Figure 7. Trimble Navigation DSM 12/212 global-based positioning system used during the investigation.

The DSM12/212 is a GPS that attains differential capabilities by internal integration with a Dual-channel MSK Beacon receiver. This electronic device interprets transmissions both from satellites in Earth's orbit and from a shore-based station, to provide accurate coordinate positioning data for offshore surveys. This Trimble system has been specifically designed for survey positioning. The differential system corrects for the difference between received and known positions. The DGPS aboard the survey vessel constantly monitored the navigation beacon radio transmissions in order to provide a real-time correction to any variation between the satellite-derived and actual positions of the survey vessel.

For this project, the magnetometer and DGPS data were integrated with a Sony VAIO laptop computer via NMEA protocols, utilizing Hypack Max® software applications for survey control, data storage, and data analysis. Hypack Max® was developed specifically for marine survey applications by Coastal Oceanographics, Inc. The computer and associated hardware and software calculated and displayed the corrected positioning coordinates every second and stored the data along with magnetic readings at that location. The level of precision for the system is considered by the manufacturer to achieve sub-meter accuracy (Trimble Navigation Limited 1998:1-2).

Each of the remote sensing devices was measured for "layback," which is their orientation relative to the antenna (Figure 8). This information is critical in the accurate positioning of targets during the data analysis phase of the project and in repositioning for any subsequent archaeological activities. The magnetometer was run 50 feet off the stern, the sidescan amidships the port side, and the subbottom amidships the starboard side.

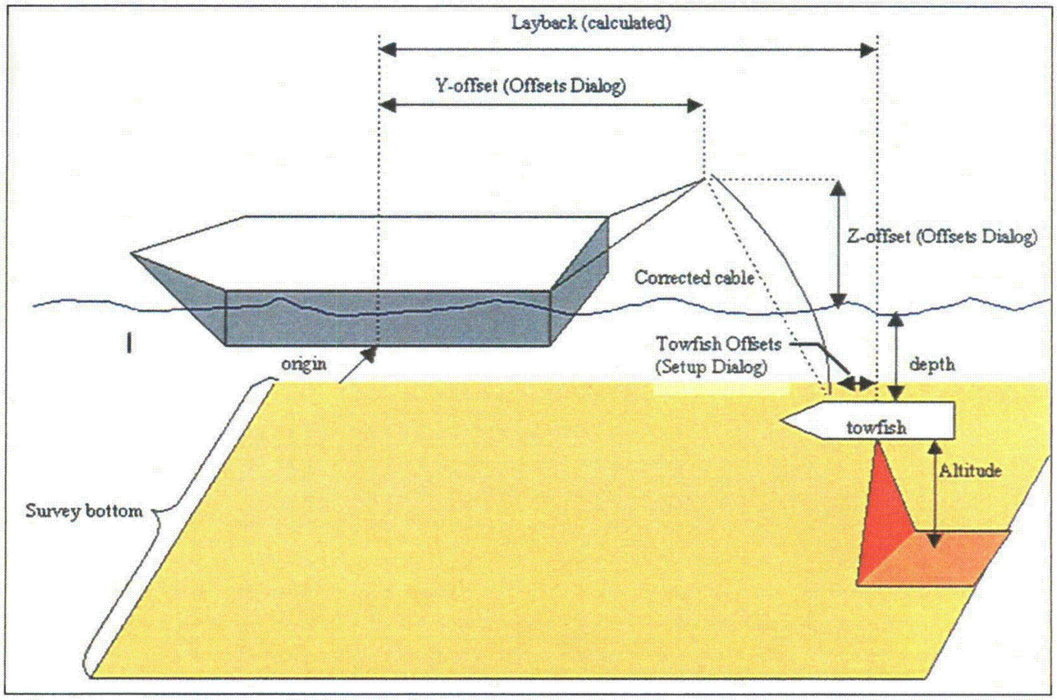


Figure 8. Equipment schematic illustrating layback (courtesy of Coastal Oceanographics, Inc.).

MAGNETOMETER

The remote sensing instrument used to search for ferrous objects on or below the ocean floor of the survey area was a Marine Magnetics SeaSPY overhauser magnetometer (Figure 9). The magnetometer is an instrument that measures the intensity of magnetic forces. The sensor measures and records both the Earth's ambient magnetic field and the presence of magnetic anomalies (deviations from the ambient background) generated by ferrous masses and various other sources. These measurements are recorded in gammas, the standard unit of magnetic intensity (equal to 0.00001 gauss). The SeaSPY is capable of sub-second repeatability, but data was collected at 1-second intervals both digitally and graphically, providing a record of both the ambient field and the character and amplitude of anomalies encountered. This data was stored electronically in the navigation computer and backed up to CD-ROM.

The ability of the magnetometer to detect magnetic anomalies, the sources of which may be related to submerged cultural resources such as shipwrecks, has caused the instrument to become a principal remote sensing tool of marine archaeologists. While it is not possible to identify a specific ferrous source by its magnetic field, it is possible to predict shape, mass, and alignment characteristics of anomaly sources based on the magnetic field recorded. It should be noted that there are other sources—electrical magnetic fields surrounding power transmission lines, underground pipelines, navigation buoys, metal bridges and structures—that may significantly affect magnetometer readings. Interpretation of magnetic data can provide an indication of the likelihood of the presence or absence of submerged cultural resources. Specifically, the ferrous components of submerged historic vessels tend to produce magnetic signatures that differ from those characteristics of isolated pieces of debris.

While it is impossible to specifically identify the source of any anomaly solely from the characteristics of its magnetic signature, this information, in conjunction with other data (historic accounts, use patterns of the area, diver inspection), other remote sensing technologies, and prior knowledge of similar targets, can lead to an accurate estimation. For this project, the height of the magnetometer above the seafloor was within 10 feet of the bottom, and line spacing was 50 feet, thus ensuring total horizontal coverage.

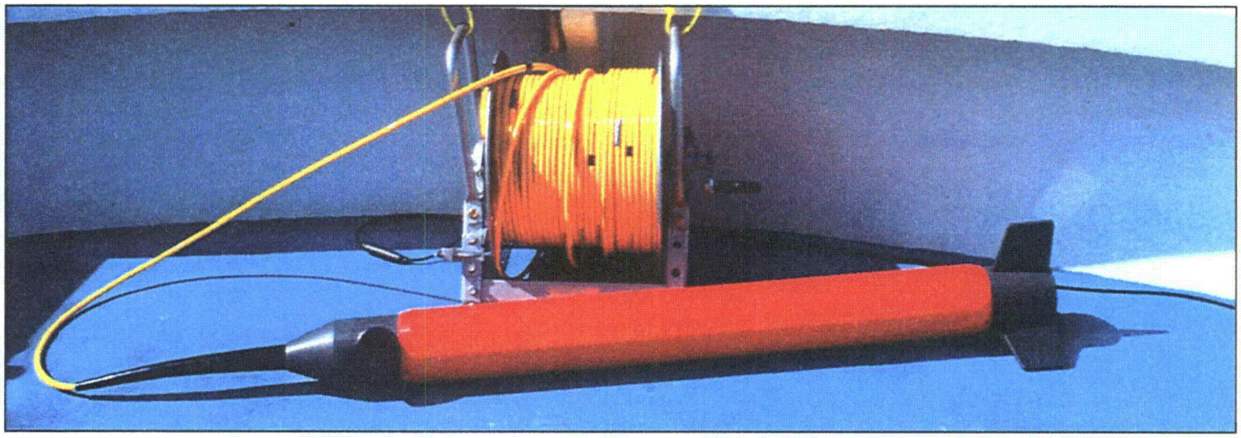


Figure 9. Marine Magnetics SeaSPY overhauser magnetometer used during the survey.

Sidescan Sonar

The remote sensing instrument used to search for physical features on or above the ocean floor was a Marine Sonic Technology (MST) Sea Scan sidescan sonar system (Figure 10). The sidescan sonar is an instrument that, through the transmission of dual fan-shaped pulses of sound and reception of reflected sound pulses, produces an acoustic image of the bottom. Under ideal circumstances, the sidescan sonar is capable of providing a near-photographic representation of the bottom on either side of the trackline of a survey vessel. This range was set at 40 meters during the Calvert Cliffs survey.

The MST Sea Scan sidescan sonar unit utilized on this project was operated with an integrated single frequency 600 kHz towfish. The Sea Scan PC software has an internal capability for removal of the water column from the instrument's video printout, as well as correction for slant range distortion. This sidescan sonar was utilized with the navigation system to provide manual marking of positioning fix points on the digital printout. Sidescan sonar data are useful in searching for the physical features indicative of submerged cultural resources. Specifically, the record is examined for features showing characteristics such as height above bottom, linearity, and structural form. Additionally, potential acoustic targets are checked for any locational match with the data derived from the magnetometer and the subbottom profiler.

The MST Sea Scan PC software sidescan sonar was linked to a towfish that employed a 600 kHz power setting and a variable side range of up to 100 meters-per-channel (meters/channel; 200 meters of coverage per line) on each of the run sidescan lines. The 40 meters/channel setting was chosen to provide detail and enough overlapping coverage with the 50-foot line spacing to insure full coverage of the survey area. The power setting was selected in order to provide maximum possible detail on the record generated; 600 kHz was the preferred frequency. The 40 meters/channel selection made it possible to collect acoustic data over an 80-meter wide area on each line that the sidescan sonar was employed, ensuring multiple overlap and multiple views of any targets.

The sidescan sonar record included 71 files of data, which were mosaiced on the project grid using Hypack Hyscan® software. These images were combined with other data in ArcMap 9.2®.

Figure 10. Marine Sonic Technology (MST) Sea Scan sidescan sonar system.

SUBBOTTOM PROFILER

The survey crew deployed an Edgetech 424 multiple frequency towfish with topside processor (Figure 11). This system included a Model 3100-G Topside Processor with laptop computer and DISCOVER Subbottom software.

Subbottom profilers generate low frequency acoustic waves capable of penetrating the seabed and then reflecting off boundaries or objects within the subsurface. These returns are received by hydrophone or hydrophone array operated in close proximity to the source. The data are then processed and reproduced as a cross section scaled in two-way travel time (the time taken for the pulse to travel from the source to the reflector and back to the receiver). This travel time can then be interpolated to depth in the sediment column by reference to the travel time of the sound (averaging 1,500 meters-per-second). These seismic cross sections can be studied visually and the shapes and extent of reflectors used to identify bottom and subbottom profile characteristics.

There are several types of subbottom profilers: sparkers, pingers, boomers, and CHIRP systems. Sparkers operate at the lowest frequencies and afford deep penetration but low resolution. Boomers operate from 0.5–5 kHz and can penetrate to between 30–100 meters with resolution of 0.3–1.0 meter. Pingers operate from 3.5–7 kHz and penetrate seabeds from a few meters to more than 50 meters depending on sediment consolidation, with resolution to about 0.3 meter. CHIRP systems operate around a central frequency that is swept electronically across a range of frequencies between 3–40 kHz and resolution can be on the order of 0.1 meter in suitable near-seabed sediments. The Edgetech system used for the Calvert Cliffs survey was operated at a range of 4–16 kHz for best penetration of sand.

Unconformities and other strata contacts can be determined by seismic remote sensing since these surfaces make acoustic impedance contrasts when printed (or projected). In general, high and low amplitude reflectors (light and dark returns) indicate the presence of stratigraphic beds while parabolic returns indicate point source objects of sufficient size to be sensed by the wavelength and frequency of the power source. Erosional or non-depositional contacts can be identified by discontinuities in extent, slope angle, and shape of the reflector returns. This latter fact is important when identifying drowned channel systems and other relict and buried fluvial system features (e.g., estuarine, tidal, lowland, upland areas around drainage features).

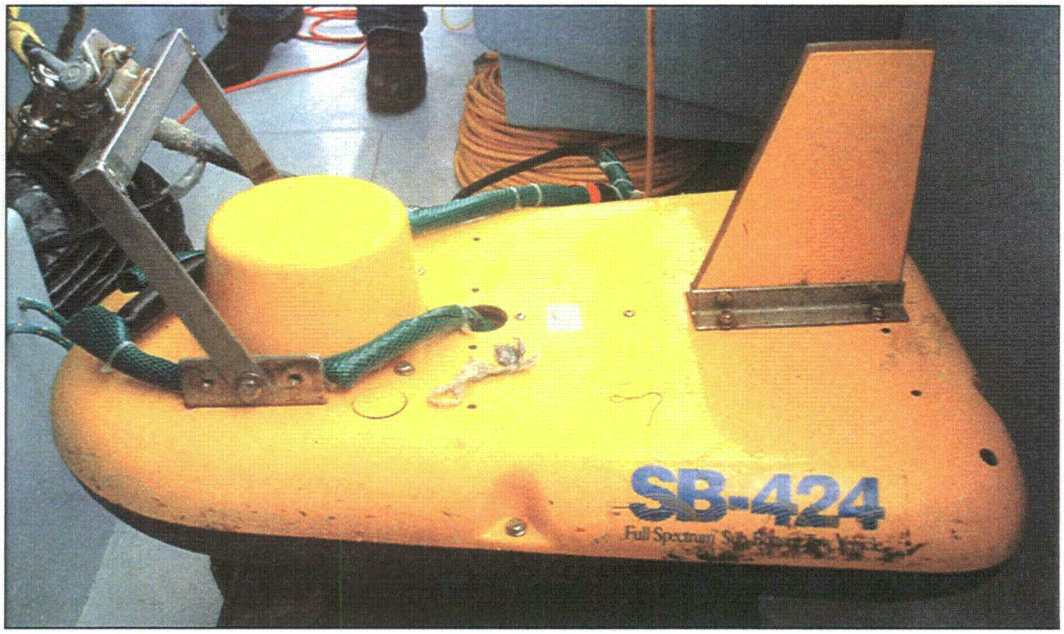


Figure 11. The EdgeTech subbottom 424 towfish employed in the survey.

There are five types of spurious signals that may cause confusion in the two dimensional records: direct arrivals from the sound source, water surface reflection, side echoes, reflection multiples; and point source reflections. Judicious analysis is required to identify them.

Sand is notoriously difficult to penetrate with frequencies equal to 4 kHz or higher. Much of the Calvert Cliffs sediment beds appear to be sand or pebbly sand, and sedimentary rocks probably composed of sand. There was no need to penetrate these beds because of their age.

SURVEY VESSEL

The vessel used for the survey was Panamerican's 25-foot *Parker* (Figure 12). The vessel meets all U.S. Coast Guard requirements for safety equipment. There is abundant covered deck space for the electronic gear, generator, and towfish. Mr. Duff drove the vessel during the remote sensing operations.

Figure 12. Panamerican's 25-foot *Parker* employed for the investigation.

Figure 13. Survey instruments employed during the investigation include (from left to right) the subbottom profiler, the sidescan sonar and the magnetometer. Honda generator employed to power the instruments is in the background adjacent to the transom.

SURVEY PROCEDURES

Coordinates for the proposed survey area were entered into the navigation program Hypack® and pre-plotted tracklines were produced (Figure 14). Nine pre-plotted tracklines with a 50-foot interval were programmed to adequately obtain total horizontal coverage for the additional area.

The magnetometer, sidescan sonar, and DGPS were mobilized and tested; finding them operational, the running of pre-plotted tracklines began. The helmsman viewed a video monitor linked to the DGPS and navigational computer to aid in directing the course of the vessel relative to the individual survey tracklines. The monitor displayed the real-time position of the path of the survey vessel along the trackline.

As the survey vessel maneuvered down each trackline, the navigation system determined vessel position along the actual line of travel every second. One computer recorded positioning and magnetometer data every second while a separate computer recorded all sidescan sonar returns during the survey. Vessel speed was maintained between 3 and 5 miles-per-hour, acquiring magnetic readings every second. The positioning points along the line traveled were recorded on the computer hard drive and the magnetic data were stored digitally.

Each trackline was run until completed. Any navigation errors, problems with the remote sensing instruments or with the positioning system during the running of a line resulted in the termination of that run. Significant off-line errors in navigation resulted in the immediate repetition of that line. Problems with remote sensing instruments were resolved before repeating the run of an aborted line. Upon completion of the magnetometer survey, the raw positioning and magnetometer data were edited within Hypack®. The edited file was input into the system's contouring program to produce magnetic contour maps. The maps, field notes, and magnetometer digital strip charts were then analyzed to create a list of magnetic anomalies that were indicative of potentially significant cultural resources. Afterwards, the sidescan sonar data was reviewed for any evidence of submerged cultural resources.

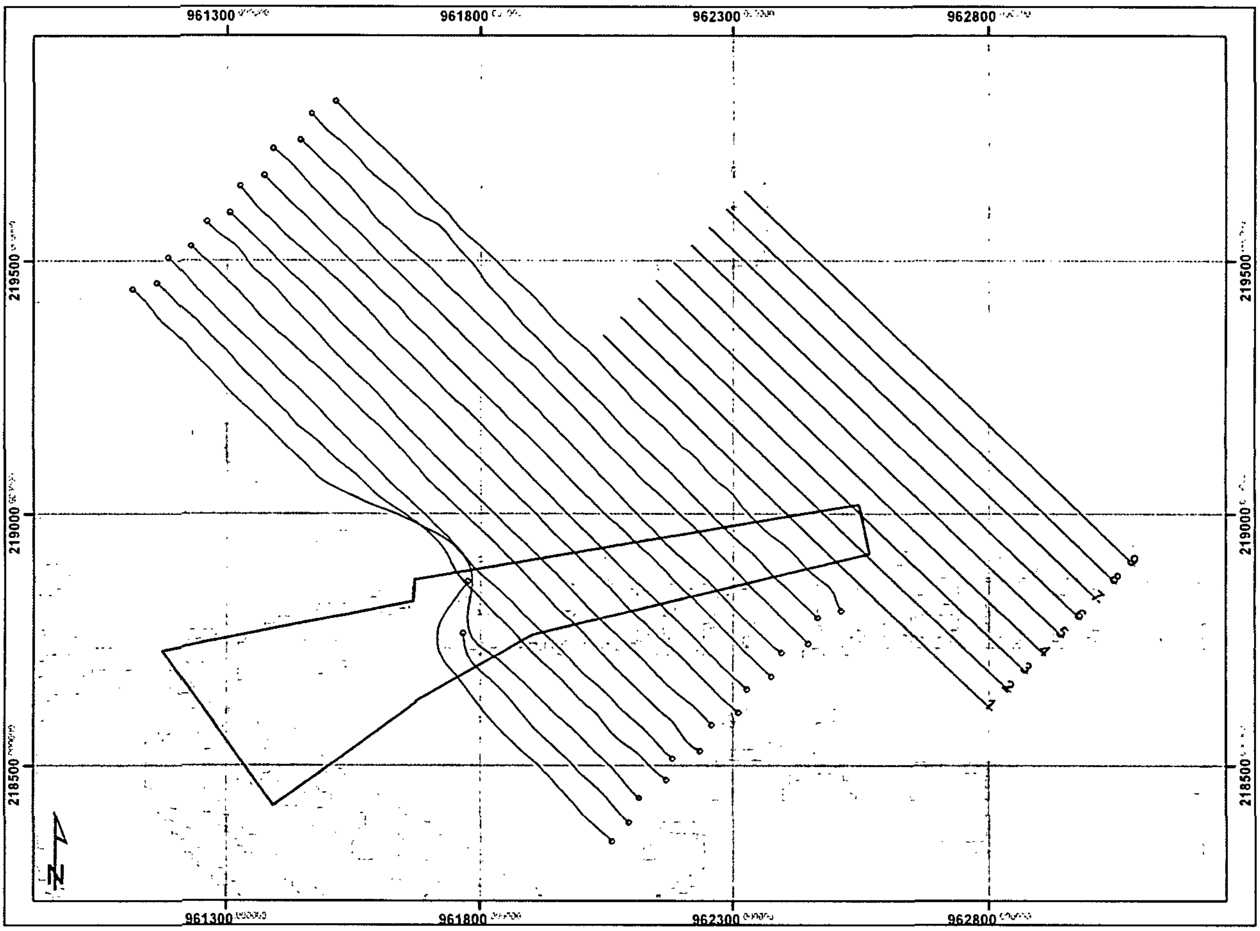


Figure 14. Nine pre-plot tracklines with 50-foot offsets were programmed for the additional Calvert Cliffs remote sensing survey area. Black lines indicate the previously surveyed area and the grey polygon indicates the maximum dredge area. As indicated on the map, gridlines are spaced at 500 feet.

It should be stated that before contour map production, a review of each survey trackline is conducted in Hypack®. Magnetic anomalies present on each survey trackline are labeled at this time, and locational information (Easting, Northing) and gamma deviations are taken from the electronic strip chart data and tabulated, the data table appearing in the report. Once all survey tracklines have been analyzed and all anomalies along each line have been labeled and tabulated, the contour map is produced.

The locations of targets found during the 2008 survey were resurveyed as part of the current project in order to relocate them and to further refine their locations.

DATA PROCESSING AND ANALYSIS

Once collected, survey data was processed and analyzed using an array of software packages designed to display, edit, manipulate, map, and compare proximities of raster, vector, and tabular data. These packages include Hypack® Hyscan for mosaicing sidescan sonar and subbottom profiler data, mapping target extents and generating target reports, figure details, and GIS layers; and Hypack® Single Beam Editor, Hypack® TIN Modeler, and Hypack® Export for tabulating anomaly characteristics and contouring magnetic data, and generating GIS data layers. ESRI ArcMap and ArcView are used to display the data on background charts, to conduct a "proximity analysis" for each of the three types of targets, and to create maps and figures.

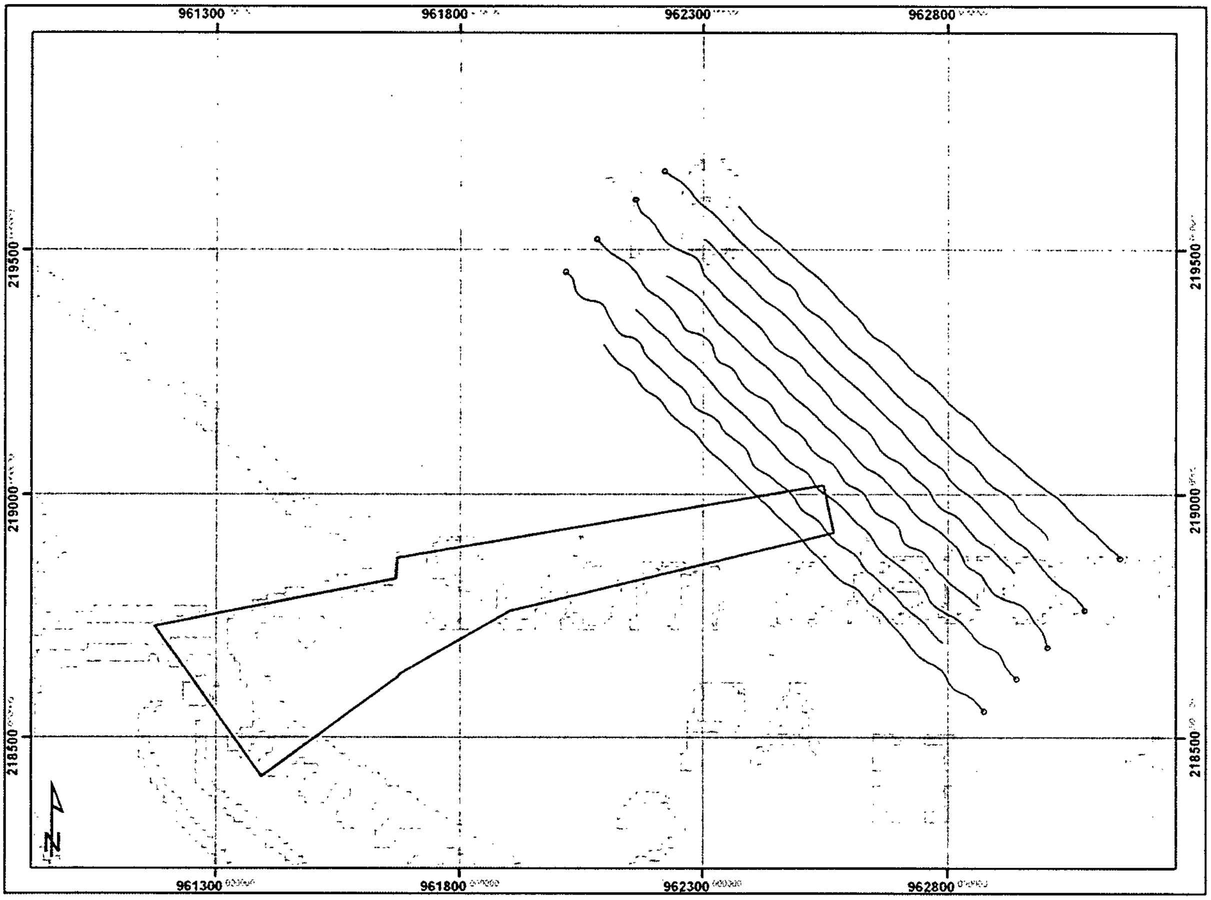


Figure 15. Post-plot survey lines. As indicated on the map, gridlines are spaced every 500 feet.

Upon completion of the remote sensing survey, the data were reviewed. This task essentially entailed the archaeologist analyzing the previously acquired and processed data. Sidescan and subbottom features and magnetic anomalies were tabulated and prioritized as to possible significance by employing signal characteristics (e.g., spatial extent, structural features, etc.). Magnetic data was presented in a magnetic contour map(s) with trackline format. Specific sidescan targets are also located on the map and are illustrated and discussed individually. The magnetic anomalies and/or sidescan targets shown on the map(s) are sequentially numbered and tabulated as to location (Northing and Easting), as well as magnetic deviation. The contoured/labeled targets are then compared with strip chart records and attendant sidescan data. Each magnetic anomaly or sidescan target, described with the proper terminology and locational and positional information, is included. If any of the remote sensing targets correlated with any documentary evidence, it was noted.

The evaluation of the potential cultural significance of targets was then conducted, which was dependent on a variety of factors including the detected characteristics of the individual targets (e.g., magnetic anomaly strength and duration, and sidescan image configuration), association with other sidescan or magnetic targets on the same or adjacent lines, relationships to observable target sources such as channel buoys or pipeline crossings, and correlation to the historic record. Magnetic anomalies were evaluated and prioritized based on amplitude or deflection intensity in concert with duration or spatial extent. Targets such as isolated sections of pipe can normally be immediately discarded as nonsignificant. Targets that were likely to represent potential historical shipwrecks or other potentially historic submerged resources were identified, and recommendations were made for subsequent avoidance or assessment by archaeological divers.

MAGNETIC DATA COLLECTION, PROCESSING, AND ANALYSIS

Data from the magnetometer is collected using Hypack Max® and stored as *.RAW files by line, time, and day. Raw data files are opened, and layback parameters are set. Contour maps are produced of the magnetic data with the TIN Modeler. The DXF file is saved and exported into the combined GIS database. The contour maps allow a graphic illustration of anomaly locations, spatial extent, and association with other anomalies. Magnetic data is reviewed by the Hypack® Single Beam Editor (Figure 16), and the location, strength, duration, and type of anomaly is transcribed to a spreadsheet along with comments.

Interpretation of data collected by the magnetometer is perhaps the most problematic to analyze. Magnetic anomalies are evaluated and prioritized based on magnetic amplitude or deflection of gamma intensity in concert with duration or spatial extent; they are also correlated with sidescan targets. The problems of differentiating between modern debris and shipwrecks based on remote sensing data have been discussed by a number of authors. This difficulty is particularly true in the case of magnetic data, therefore it has received the most attention in the current body of literature dealing with the subject. Pearson and Saltus state, "even though a considerable body of magnetic signature data for shipwrecks is now available, it is impossible to positively associate any specific signature with a shipwreck or any other feature" (1990:32). There is no doubt that the only positive way to verify a magnetic source object is through physical examination. With that said, however, the size and complexity of a magnetic signature does provide a usable key for distinguishing between modern debris and shipwreck remains (see Garrison et al. 1989; Irion et al. 1995; Pearson et al. 1993). Specifically, the magnetic signatures of most shipwrecks tend to be large in area and tend to display multiple magnetic peaks of differing amplitude.

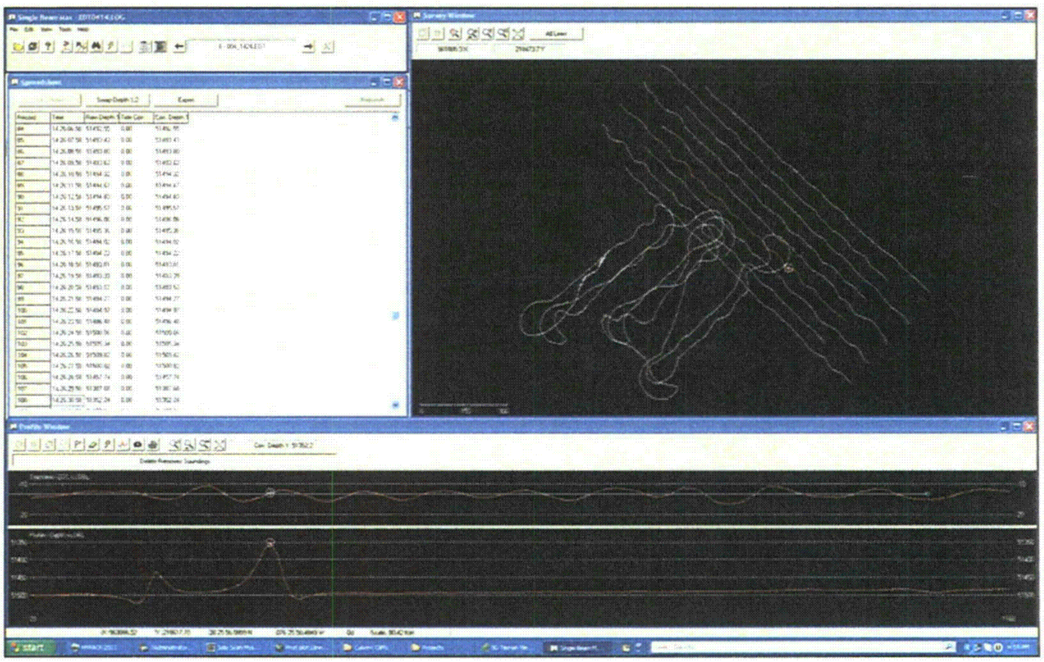


Figure 16. Hypack® Single Beam Editor magnetic data display of a survey line. Using these windows, one can analyze anomaly position, strength, duration, and type. The peaks of these variations are the locations of anomaly coordinates (cross in circle); their width is the duration. This anomaly is a dipole with a magnetic deviation of 156 gammas. It comprises the large central anomaly of M101.

The state of technology of iron-hulled or steam vessels may also be considered a factor in their potential for being detected by modern remote sensing techniques. The magnetometer detects ferrous objects that create deviations in the Earth's natural magnetic field. The greater the weight of iron in the remains of a shipwreck, the greater the likelihood the remains will be observed, at least theoretically. The mass of metal on iron-hulled or steam vessels is made up of the hull and/or boilers, pipes, valves, steam engines, hogging trusses and straps, deck gear, auxiliary engines, pumps, hoists, winches, and other pieces of equipment. As the state of steam technology advanced, boilers and engines got larger, and/or more were used for larger vessels. Larger locomotion systems contained more iron and therefore are more likely to have a detectable magnetic signature.

In a study of magnetic anomalies located in the northern Gulf of Mexico, Garrison et al. (1989) indicate that a shipwreck signature will cover an area between 10,000–50,000 meters squared. Applicable to the Gulf Coast and based on large vessel types, the study's findings are not entirely relevant to wooden sailing vessels in the pre-steam era. However, criteria from the Garrison et al. (1989) study and others developed to identify the signatures of larger vessel types are applicable. Using the Garrison et al. (1989) study, as well as years of "practical experience," in an effort to assess potential significance of remote sensing targets, Pearson et al. (1991) developed general characteristics of magnetometer signatures most likely to represent shipwrecks. The report states, "the amplitude of magnetic anomalies associated with shipwrecks vary [*sic*] considerably, but, in general, the signature of large watercraft, or portions of watercraft, range from moderate to high intensity (>50 gammas) when the sensor is at distances of 20 feet or so" (Pearson et al. 1991:70). Using a table of magnetic data from various sources as a base, the report goes on to assert, "data suggest that at a distance of 20 feet or less watercraft of moderate size are likely to produce a magnetic anomaly (this would be a complex signature, i.e., a cluster of dipoles and/or monopoles) greater than 80 or 90 feet across the smallest dimension..." (Pearson et al. 1991:70).

While establishing baseline amounts of amplitude and duration reflective of the magnetic characteristics for a shipwreck site, Pearson et al. recognize, "that a considerable amount of variability does occur" (1991:70). Generated in an effort to test the 50-gamma/80-foot criteria and determine the amount of variability, Table 1 lists numerous shipwrecks as well as single- and multiple-source objects located by magnetic survey and verified by divers. All shipwrecks meet and surpass the 50-gamma/80-foot criteria, while all single-source object readings, with the exception of the pipeline, fall below the criteria. However, the signature of the pipeline should show up as a linear feature on a magnetic contour map and not be confused with a single-source object. While the shipwrecks and single-source objects adhere to the 50-gamma/80-foot criteria, the multiple-source objects do not. If all targets listed on the table had to be prioritized as to potential significance based on the 50-gamma/80-foot criteria, the two multiple-source object targets would have to be classified as potentially significant.

Table 1. Magnetic data from shipwrecks and nonsignificant sources.

Vessel (object)	Type & Size	Magnetic deviation	Duration (feet)	Reference
Shipwrecks				
Tug	wooden tug with machinery	-30257	176	Tuttle and Mitchell 1998
Mexico	288-ton wooden bark	1260	454	Tuttle and Mitchell 1998
J.D. Hinde	129-foot wooden sternwheeler	573	110	Gearhart and Hoyt 1990
Utina	267-foot, 238-ton wooden freighter	690	150	James and Pearson 1991; Pearson and Simmons 1995

Vessel (object)	Type & Size	Magnetic deviation	Duration (feet)	Reference
King Phillip	182-foot, 1,194-ton clipper	300	200	Gearhart 1991
Reporter	141-foot, 350-ton schooner	165	160	Gearhart 1991
Mary Somers	967-ton iron-hulled sidewheeler	5000	400	Pearson et al. 1993
Gen. C.B. Comstock	177-foot wooden hopper dredge	200	200	James et al. 1991
Mary	234-foot iron sidewheeler	1180	200	Hoyt 1990
Columbus	138-foot, 416-ton wooden-hulled Chesapeake sidewheeler	366	300+	Morrison et al. 1992
El Nuevo Constante	126-foot wooden collier	65	250	Pearson et al. 1991
James Stockton	55-foot wooden schooner	80	130	Pearson et al. 1991
Homer	148-foot wooden sidewheeler	810	200	Pearson and Saltus 1990
Modern shrimp boat	27-x-5-foot segment	350	90	Pearson et al. 1991
Confederate obstructions	various wooden vessels w/ machinery removed, filled w/ construction rubble	110	long duration	Irion and Bond 1984
Single-Source Objects				
pipeline	18-inch diameter	1570	200	Duff 1996
anchor	6-foot shaft	30	270	Pearson et al. 1991
iron anvil	150 pounds	598	26	Pearson et al. 1991
engine block	modern gasoline	357	60	Rogers et al. 1990
steel drum	55-gallon	191	35	Rogers et al. 1990
pipe	8-foot long, 3-inch diameter	121	40	Rogers et al. 1990
railroad rail segment	4-foot section	216	40	Rogers et al. 1990
Multiple-Source Objects				
anchor/wire rope	8-foot modern stockless/large coil	910	140	Rogers et al. 1990
cable and chain	5-foot	30	50	Pearson et al. 1991
scattered ferrous metal	14-foot	100	110	Pearson et al. 1991

(after Pearson et al. 1991)

Although data indicate the validity of employing the 50-gamma/80-foot criteria when assessing magnetic anomalies, other factors must be taken into account. Pearson and Hudson (1990) have argued that the past and recent use of a body of water must be an important consideration in the interpretation of remote sensing data, and in many cases it is the most important criterion. Unless the remote sensing data, historical record, or specific environment (e.g., harbor entrance channel) provide compelling and overriding evidence to the contrary, it is believed that the history of use should be a primary consideration in interpretation. What constitutes "compelling evidence" is to some extent left to the discretion of the researcher; however, in settings where modern commercial traffic and historic use are intensive, the presence of a large quantity of modern debris must be anticipated. In harbor, bay, or riverine situations with heavy traffic, this debris will be scattered along the channel right-of-way, although it may be concentrated at areas where traffic would slow or halt; it will appear on remote sensing surveys as small, discrete objects.

SIDESCAN SONAR DATA COLLECTION, PROCESSING, AND ANALYSIS

Post-processing of sidescan sonar is accomplished using Hypack Hyscan, a product that enables the user to view the sidescan data in digitizer waterfall format, pick targets, and enter target parameters including length, width, height, material, and other characterizations into a database of contacts (Figure 17). In addition, Hyscan "mosaics" the sidescan data by associating each pixel (equivalent to about 10 centimeters) of the sidescan image with its geographic location determined from the DGPS position (layback rectified) and distance from the DGPS position (Figure 18). The results are exported from Hyscan as geo-referenced *TIFFs for importing to the GIS database of the project.

By contrast, analysis of sidescan sonar data is less problematic than magnetometer analysis. The primary factors considered in analyzing sidescan data included linearity, height off bottom, size, associated magnetics, and environmental context. Since historic resources in the form of shipwrecks usually contain large amounts of ferrous compounds, sidescan targets with associated magnetic anomalies are of top importance. Targets with no associated magnetics usually turn out to be items such as rocks, trees, and other non-historic debris of no interest to the archaeologist. In addition, since historic shipwrecks tend to be larger, smaller targets tend to be of less importance during data evaluation. In addition, the area in which the target is located can have a strong bearing on whether or not the target is selected for further work. If a target is found in an area with other known wreck sites, or an area determined to have high probability for the location of historic resources, it may be given more consideration than it would have otherwise. However, every situation and every target located is different, and all sidescan targets are evaluated on a case-by-case basis.

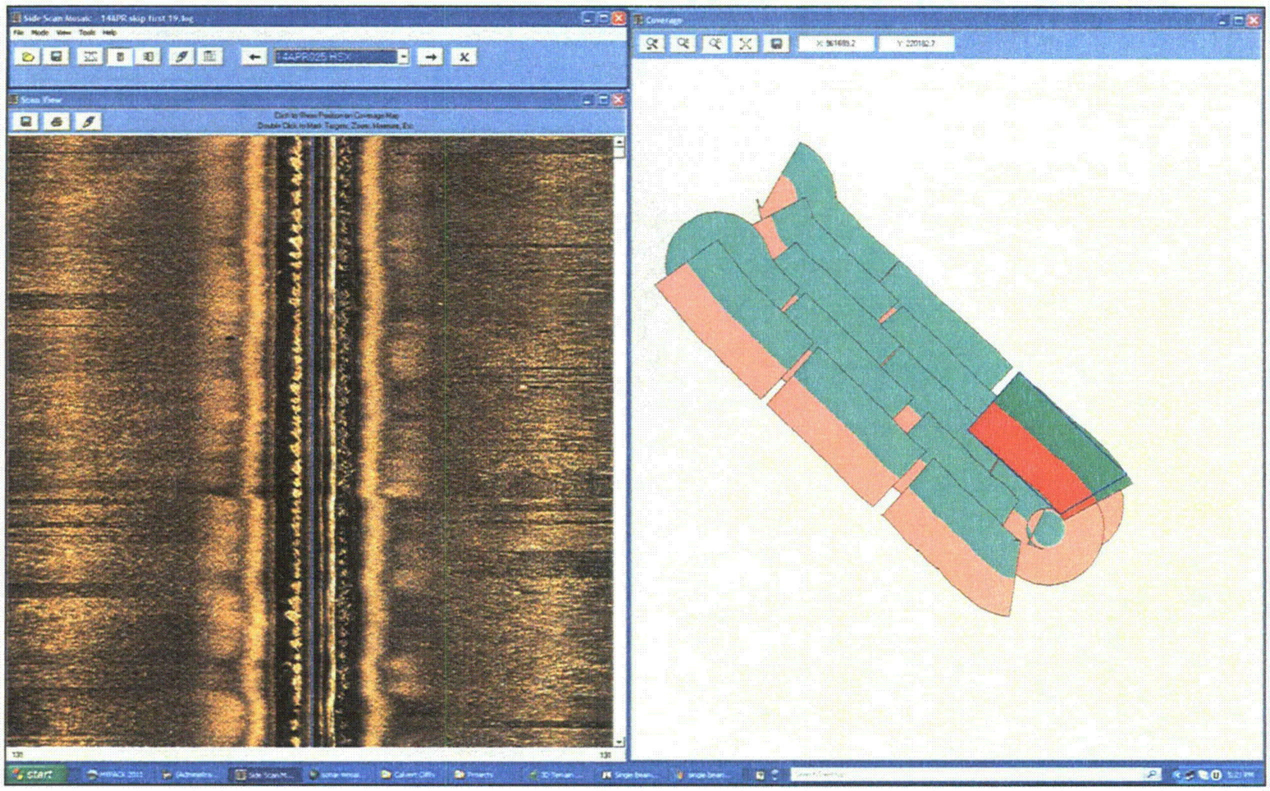


Figure 17. Hypack® Hyscan display of the survey area. Using these windows, one can analyze all aspects of the sonar data, pick targets, and export a mosaic.

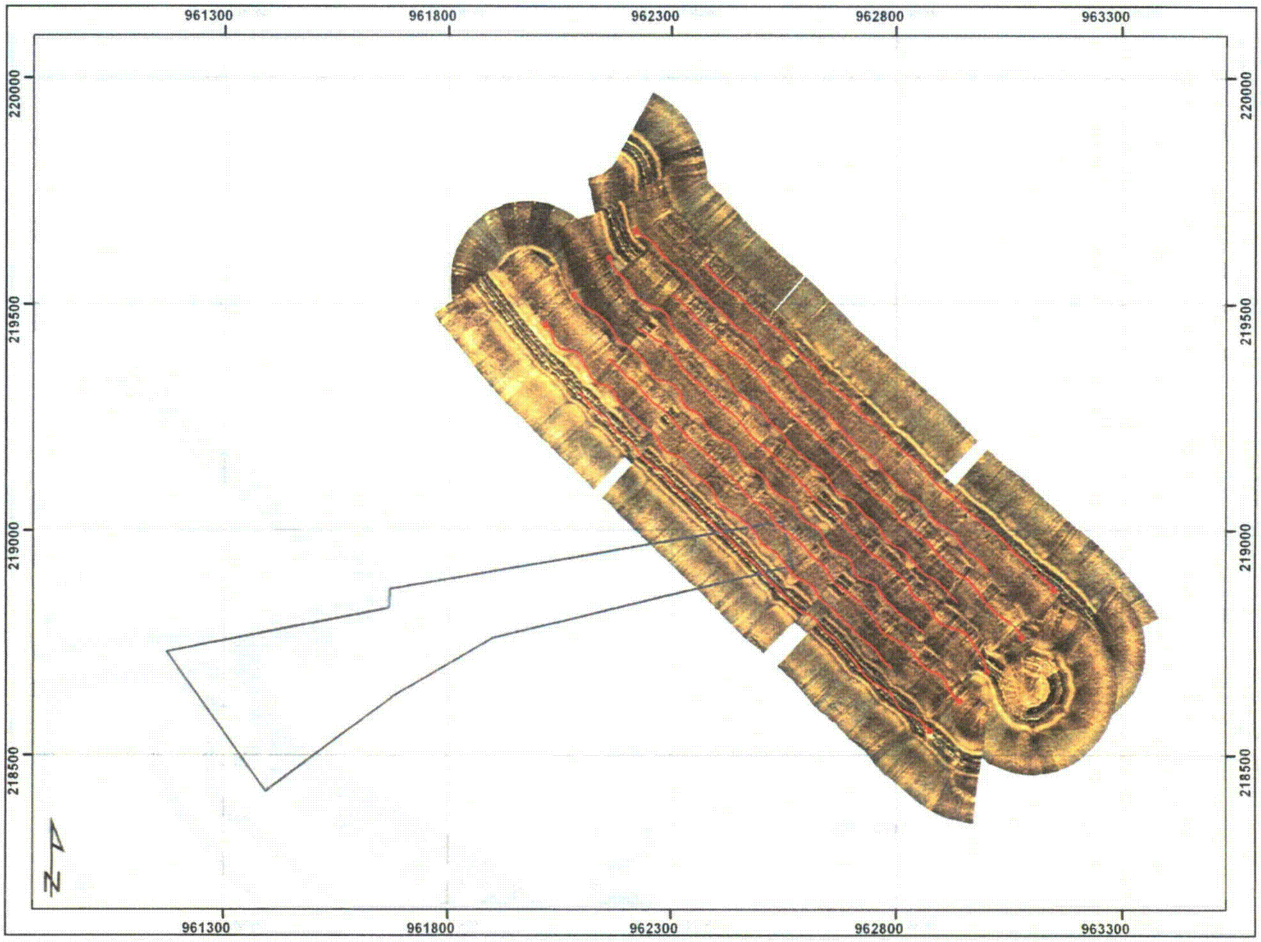


Figure 18. ArcMap 9.2 with mosaic of survey area created in Hyscan.

SUBBOTTOM PROFILER DATA PROCESSING AND ANALYSIS

Post-processing of subbottom profiler data, like the sidescan data, is done with Hypack Hyscan, which in this case enables the user to view the subbottom data in a planar, trackline format. The user may view the data in a digitizer window as a waterfall format, allowing the digitizing of subbottom features of interest, linear extent, depth, and type. Hyscan batch processes waterfall images to *.JPG formats in order to generate figures (Figure 19). Sidescan mosaics and the contact databases are exported to the GIS database as *.SHP files. Hyscan also allows the user to calculate the amount of sonar coverage and illuminate gaps to ensure full coverage of the project area.

For the presence of a wreck, expectation in the subbottom record would be high amplitude returns as wood components, in a constrained pattern, coincident with the magnetometer contours. Work in the United Kingdom with remote sensing of known wreck sites indicate that wooden wrecks may be imaged by a suitable subbottom profiler operating under appropriate survey conditions. They showed the buried wreck structure of *Invincible* as a high amplitude reflector (dark returns compared to the surrounding sediments) including structural angles in some passes (Quinn et al. 1997; 1998). They note that "owing to the nature of seismic data acquisition, the ability to image wooden artifacts is dependent not only upon the acoustic impedance contrast that exists between the artifact and the burial sediment, but also upon the size of the target."

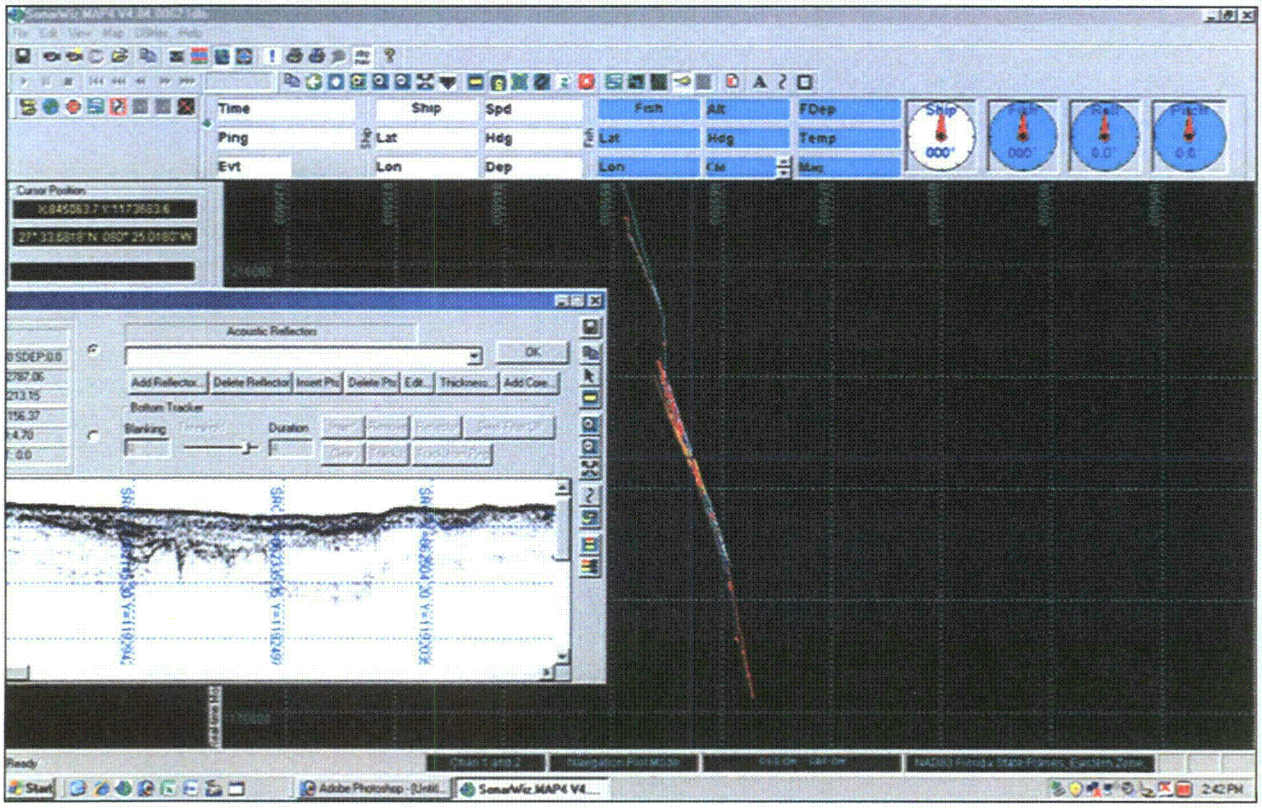


Figure 19. SonarWiz.MAP Subbottom waterfall example image showing the seismic profile-digitizing window.

Subbottom profilers generate low frequency acoustic waves that are capable of penetrating the seabed and then reflecting off boundaries or objects within the subsurface. These returns are received by hydrophone or hydrophone array operated in close proximity to the source. The data are then processed and reproduced as a cross section scaled in two-way travel time (the time taken for the pulse to travel from the source to the reflector and back to the receiver). This travel time can then be interpolated to depth in the sediment column by reference to the travel time of the sound down (averaging 1,500 meters-per-second) and forward (speed of the vessel).

These seismic cross sections can be studied visually and the shapes and extent of reflectors used to identify bottom and subbottom profile characteristics. In general, high and low amplitude reflectors (light and dark returns) distinguish between stratigraphic beds; parabolic returns indicate point-source objects of sufficient size to be sensed by the wavelength and frequency of the power source. Erosional or non-depositional contacts can be identified by discontinuities in extent, slope angle, and shape of the reflector returns. This latter fact is important when identifying drowned channels systems and other relict and buried fluvial system features (e.g., estuarine, tidal, lowland, upland areas around drainage features).

Seismic stratigraphy is a form of stratigraphic correlation. The reflection characteristics (e.g., as amplitude, continuity, wipeout [erosion], and bedform geometry) of regional unconformities and strata surfaces are used to estimate rock or sediment properties, facies relationships and some stratigraphic details to infer structural evolution and paleo-environmental histories (Mitchum et al. 1977; Vail et al. 1977).

There are five types of spurious signals that may cause confusion in the two dimensional records: direct arrivals from the sound source, water surface reflection, side echoes, reflection multiples, and point source reflections. Judicious analysis is required to suspect them. This is particularly true when the bottom or subbottom being traversed has considerable deformation or point source anomalies.

Subbottom in the Identification of Shipwreck Sites

Previous research (Quinn et al. 1997, 1998) has shown that wooden wreckage can be recognized, dependent on the type of wood (hard woods better), size of the remains, and context (sand or silt, etc.). The strategy for identifying historic wrecks was to identify seismic features in the strata that might be coincident with magnetometer fluctuations, and thus indicate buried wreckage. In addition, the subbottom profiler record includes data on precise depth to bottom, and so can be used to reconstruct bathymetry.

This output record is a visual representation of density differences in the geologic bed and sound wave velocity of the device. In general, high and low amplitude reflectors (light and dark returns) distinguish between stratigraphic beds; parabolic and "spot" returns indicate point-source objects of sufficient size to be sensed by the wavelength and frequency of the power source. Erosional or non-depositional contacts can be identified by discontinuities in extent, slope angle, and shape of the reflector returns. This latter fact is important when identifying drowned channels systems and other relict and buried fluvial system features (e.g., estuarine, tidal, lowland, upland areas around drainage features), but not necessarily of value with respect to shipwreck remains.

Wooden objects of sufficient density and size can be sensed with CHIRP systems, but the image is dependent on "the orientation of the incident compression wave relative to the axis of the woods elastic symmetry cellular structure" (Quinn et al. 1997:27). In other words, the ability of the sensor to detect buried shipwreck remains is dependent on which angle the wood is approached with the sound waves, the character of the burial sediment, and the size of the remains (Quinn et al. 1997:33).

GEOGRAPHIC INFORMATION SYSTEMS ANALYSIS

A project GIS database is constructed using geo-referenced images and layers generated during the magnetometer, sidescan, and subbottom data analyses. Other layers can be added, such as orthophoto quads or navigation charts (Figure 20). Several important things are accomplished by GIS compilation. First, the collected data is compared to one another and evaluated for accuracy and consistency of the positioning information. Secondly, magnetic, sidescan, and other remote sensing targets are compared for relationship (proximity analysis). Employing the data in GIS, one can easily zoom in to further analyze spatial relationships as well as magnetic signature characteristics.

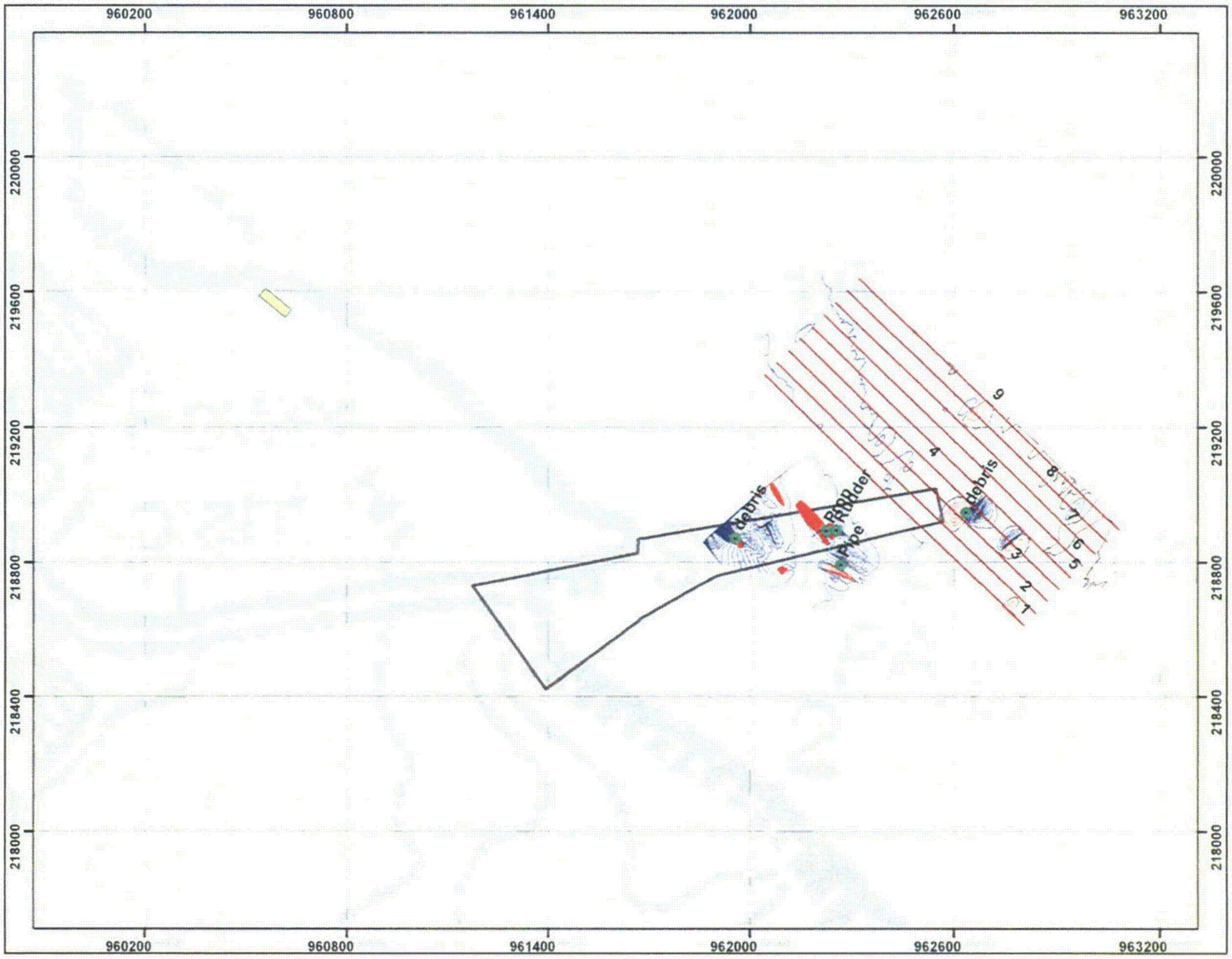


Figure 20. GIS database of the survey area showing magnetic anomalies, magnetic contour map, and NOAA RNC data layers. Grid squares are 400 feet as indicated.

DIVE INVESTIGATIONS

The second phase of the present project included an on-site diver investigation of the five selected anomalies that had the potential to represent significant submerged cultural resources eligible for listing on the NRHP, including four previously identified targets (Table 1, Figure 1) and one currently identified (Table 2). Prior to this second phase of the project, a Dive Operations Plan was submitted to the CCNPP prior to the diving operations. The Dive Operations Plan outlines procedures to (1) ensure the safety of project divers and (2) effectively and efficiently complete project goals and objectives. Diving operations for this project met all federal requirements for safe diving. All diving activities were in accordance with the strictest provisions of the U.S. Army Corps of Engineers, U.S. Navy, and Panamerican diving safety manuals and diving guidelines. During all diving operations, all persons diving and working under the auspices of Panamerican abided by this Dive Operations Plan.

Surface Supplied Air (SSA) was chosen as the most efficient and safe method of conducting investigations within the project area. Divers employed a Kirby-Morgan Superlite-17 dive helmet connected to a surface-supplied air source, radio communications cable, safety tether, and pneumo hose (Figure 21). On the surface, various individuals and pieces of equipment ensured safe diving operations. A dive tender was required to aid the diver in donning and doffing equipment and to tend the diver while submerged and moving about the sea floor. The radio communications operator kept in constant contact with the diver and relayed messages between the diver and the surface support team. A suited, standby diver was required on site in the event of an emergency situation that would require aid to the primary diver. Finally, a dive supervisor was present on site at all times to coordinate the activity of the diver and surface support team to achieve the project goals.

Table 2. Previously identified magnetic anomalies.

Anomaly	E	N
M03	962289.5	218826.3
M04	962344.8	218770.1
M05	962209.2	218842.9
M06	961956.3	218874.2

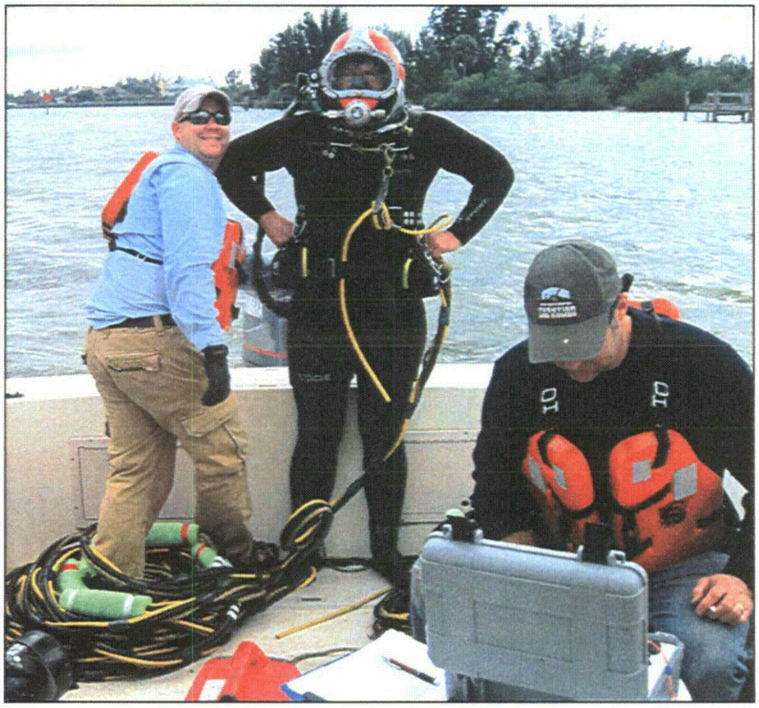


Figure 21. Surface supplied-equipped diver. Communications operator is in the foreground right with "com box". Note the yellow pneumo hose on the diver, which is employed for depth readings in low and zero visibility environments.

Air for SSA diving was provided by a cascade system of three 80-cubic-foot SCUBA bottles, opened to supply air one at a time. Pressure gauges and check valves were included in the air supply system. Two levels of redundant backup air supply were used, including an aluminum 80-cubic-foot SCUBA cylinder linked to the SSA cascade system and a 50-cubic-foot aluminum SCUBA cylinder worn by the diver and connected to the dive helmet. The dive supervisor acted as timekeeper, monitoring the air supply system during each dive to ensure that air pressure was correctly maintained and adequate reserve air was always available, as well as make notes of diver descriptions of the bottom type, excavation progress, stratigraphic details, when sampling subbottom (i.e. prehistoric) targets. A certificate of air quality was obtained from the air supplier and submitted to Mark Hunter, UniStar Safety Officer, for approval prior to commencement of diving activities.

Prior to commencement of diving operations, a Pre-Dive Safety Meeting was held with all members of the dive team and vessel crew. All safety and diving procedures were discussed in detail. Diving commenced upon completion of the meeting.

The purpose of the diving phase of the project was to attempt to locate the source of the five selected anomalies or targets, either through visual or tactile methods. Each target was buoyed at its respective coordinate location. Prior to anchoring, the direction of the tidal current and wind direction relative to each target buoy had to be ascertained, so that when anchored, the distance from and the orientation of the survey vessel's stern to the buoy were optimal.

The standard operating procedure for the diver was to enter the water and be directed to the buoy location. He then conducted a visual and/or tactile inspection of the sea floor for the source of the sidescan target or anomaly, or began dredging excavations at a subbottom target. If a magnetic or side scan target was not immediately located, the diver was swung on arcs to cover all cardinal directions from the buoy. With respect to magnetic targets, the diver conducted the arcs with a metal detector or hydraulic probe. Once the target was located, the diver conducted an assessment of identity and significance through either tactile or visual methods, verbally passing target and environmental data to the communications operator on the surface. Measurements were taken of targets encountered and photography was conducted when visibility permitted. It should be stated that all targets were easily located in this manner, with most directly at or adjacent to the buoy weight.

Environmental conditions encountered during the diving phase were benign with the exception of cold water temperatures that were in the high 40°F to approximately 50°F range mandating a dry suit be worn. Water depths, for the most part, were fairly shallow ranging between 12–16 feet with no current. Visibility was generally 3 feet, and the bottom type encountered was sand over bedrock with the shelf-like bedrock exposed in several locations.

National Register of Historic Places Evaluation

The purpose of a diver investigation is to gather enough information regarding each target to determine if it is historically significant, and if it is, to determine the character of that significance. This is done by applying four criteria of significance developed by the National Park Service as mandated by the Historic Preservation Act.

As stated in National Register Bulletin 15, *How to Apply the National Register Criteria for Evaluation* (National Park Service n.d.), and Bulletin 20, *Nominating Historic Vessels and Shipwrecks to the National Register of Historic Places* (National Park Service 1985), "the quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association." To be considered significant and therefore eligible for nomination to the NRHP, the property must meet one or more of the four NRPH criteria:

A. Be associated with events that have made a significant contribution to the broad patterns of our history; or

B. Be associated with the lives of persons significant in our past; or

C. Embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. Yield, or likely to yield, information important in prehistory or history [National Park Service 1985:5-6].

Properties found potentially eligible, eligible, or listed on the NRHP must be considered within the framework of the proposed action. If adverse impact to such a property is possible, alternatives to the proposed action, i.e., avoidance, must be evaluated. If avoidance is not practical, additional activities relative to the evaluation of the resource may be required.

A vessel's significance, as stated in Bulletin 20, is based on a "representation of vessel type and (its) association with significant themes in American history and comparison with similar vessels" (National Park Service 1985:4). Of the five basic types of historic vessels that may be eligible for NRHP nomination as stated in National Register Bulletin 20, *Nominating Historic Vessels and Shipwrecks to the NRHP*, the remains located during this survey fall into the defined category of "shipwrecks." Bulletin 20 defines a shipwreck as "a submerged or buried vessel that has foundered, stranded, or wrecked. This includes vessels that exist as intact or scattered components on or in the seabed, lakebed, riverbed, mud flats, beaches, or other shorelines, excepting hulks" (National Park Service 1985:3). The significance of shipwrecks, as opposed to intact vessels (i.e., hulks), requires that the wreck display sufficient integrity to address architectural, technological, and other research concerns.

Extensive archival and records research was not requested as part of the Calvert Cliffs survey. Instead, Panamerican reviewed internal company reports dealing with the maritime history of Maryland and visited the Calvert Marine Museum in Solomons to inventory known shipwrecks in the area (there were none), and potentials for the same (considered low, as discussed in Chapter II). In addition, Panamerican had a conference call with local geoarchaeologist Darrin Lowery with regard to any known locations of submerged prehistoric sites (none are recorded) and the potentials for such (considered). In summary, potential for shipwreck remains within the project area is considered low, but potential for submerged prehistoric remains in the project area is considered possible to good, depending on the paleotopographic (sea level regressed) setting.

Geodetic parameters for the project are Maryland State Plane coordinates (MD-1900), 1927 North American Datum (NAD 27) in feet. Sea conditions were slightly choppy to smooth, allowing for good to excellent sidescan and subbottom profiler imagery. The magnetometer towfish and data recording is not as affected by sea conditions as the acoustic data.

MAGNETOMETER RESULTS

Nine lines of magnetometry data were recorded and processed for contouring and analysis of anomalies. Figure 22 below shows magnetic strength contours at the Calvert Cliffs survey area. Contour intervals are at 10 gammas, blue contours are below background (50,500 ±10), and red contours are above background. Details of the individual target characteristics are presented in Table 3.

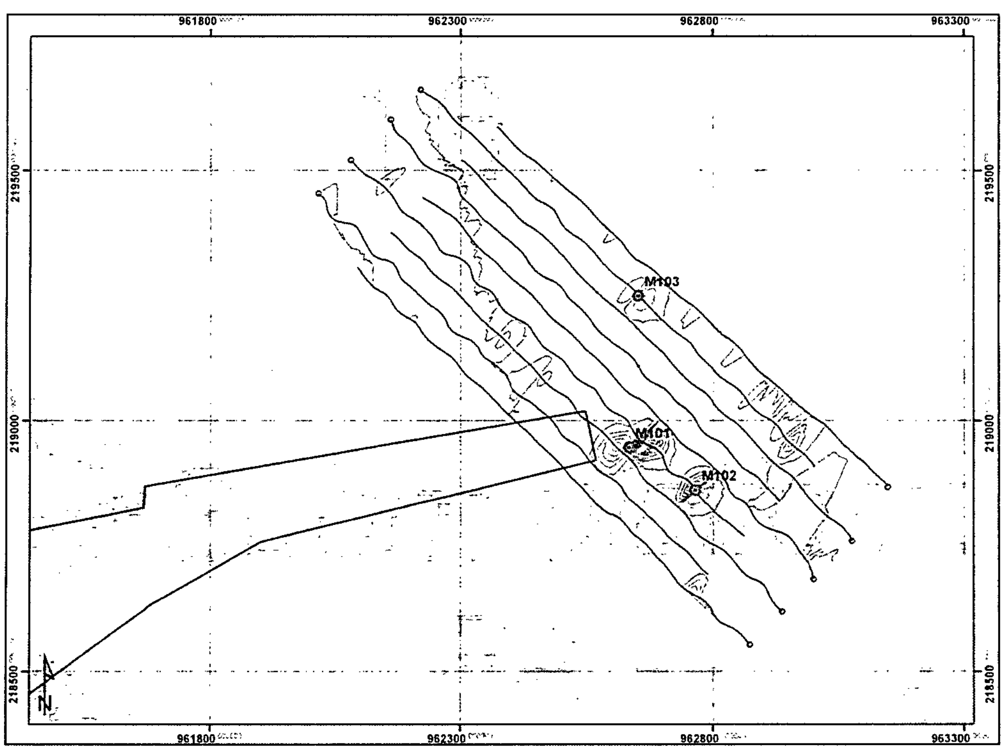


Figure 22. Tracklines, magnetic strength contours, and anomalies at Calvert Cliffs survey area. Proposed pipeline alignment in red; contour intervals 10 gammas, blue contours below background, red contours above. As indicated on the map, gridlines are spaced every 500 feet.

All of the anomalies located during the survey fall outside the APE of the proposed dredging area as shown on Figure 22. Of the three anomalies listed in Table 3, only one occurs over two or more lines. All other targets appear to be isolated single-source items that are likely ferrous materials. One anomaly, M101, meets the criteria established in Chapter III for existence of potentially significant submerged cultural resources. M102 meets criteria for strength and duration, but is present on only one survey line, and so likely represents isolated ferrous debris. M103 does not meet any criteria.

Table 3. Magnetic anomalies from the Calvert Cliffs remote sensing survey.

Anomaly	E	N	Strength (γ) +	Strength (γ) -	Duration (ft)	Type	No. of lines
M101	962667	218954	16	140	105	dipole	2
M102	962766	218862	30	66	93	dipole	1
M103	962653	219249	21	12	65	dipole	1

Sidescan Sonar and Subbottom Profiler Results

No isolated objects indicative of potentially significant submerged cultural resources were identified in the sidescan record. The sidescan record also revealed the rocky nature of the bay bottom, and that the layering of the cliffs nearby seems to continue below the waterline. Figure 23 (mosaic with mag contour overlay) illustrates the sidescan record.

The sidescan record reveals the layered nature of the bay bottom along Calvert Cliffs, which is that the facies sediment beds continue below the waterline, showing different areas of rocky and less rocky appearance. These beds created high backscatter returns (bright areas with and without shadows) indicating rocky and sandy areas. Lower backscatter areas (dark areas) indicate silty or clayey sediments. Whether these are eroded, calved beds in secondary deposition or exposed Miocene beds was not determined. A large area of dark return is associated with the paleochannel feature identified with the subbottom profiler (see discussion below).

Subbottom Profile Record

The subbottom profiler was employed to penetrate the sediment beds, with the possibility that paleochannels, paleolandscape settings, or mounded midden features might be sensed. However, much of the Calvert Cliffs sediment beds are sand (or pebbly sand), silt, and clay beds that preclude deep penetration. The device was generally effective to a depth of more than 2 meters. Either these beds are the result of calved and collapsed beds of the cliff face, or they are exposed portions of similar but earlier beds below. Examination of the subbottom data revealed the presence of numerous rock outcrops; but no paleochannels, buried surfaces, or buried objects. Figure 24 shows a typical subbottom profile for the additional survey area.

Refinement of Previous Targets

Prior to diver investigation of the four magnetic anomalies located in the previously surveyed area during the 2008 investigation, the target locations were refined using magnetometer and sidescan sonar. Refinement was undertaken to relocate the targets, confirm they were still present, refine and better pinpoint their locations to enable easier location by divers. Magnetic refinement relocated the four previous targets (Figure 25), indicating they were still *in situ*. Based on analysis of the refinement data, more specific locations of the targets were determined. These are presented in Table 2 and on Figure 25.

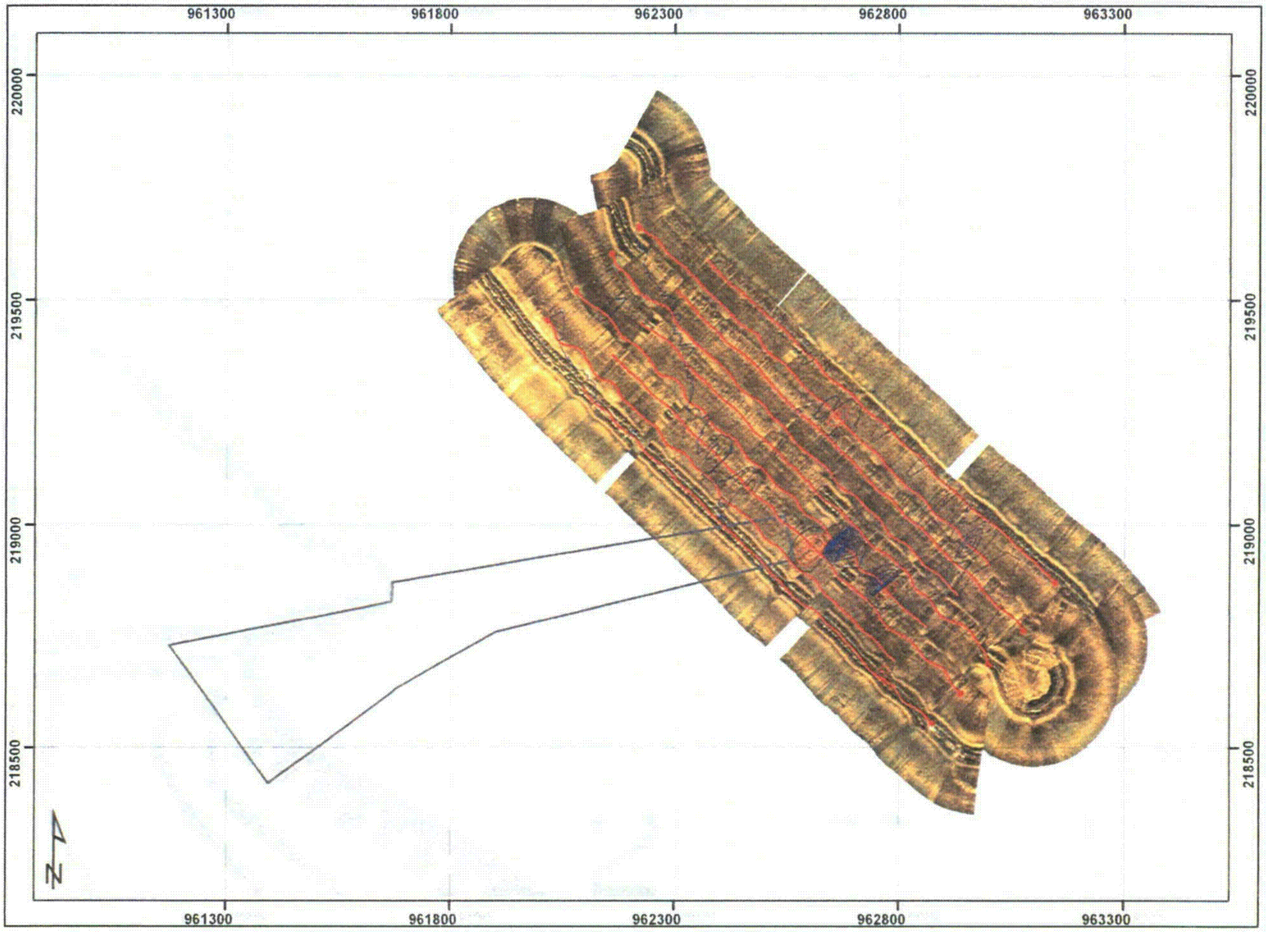


Figure 23. Mosaic of sidescan sonar data with magnetic contours.

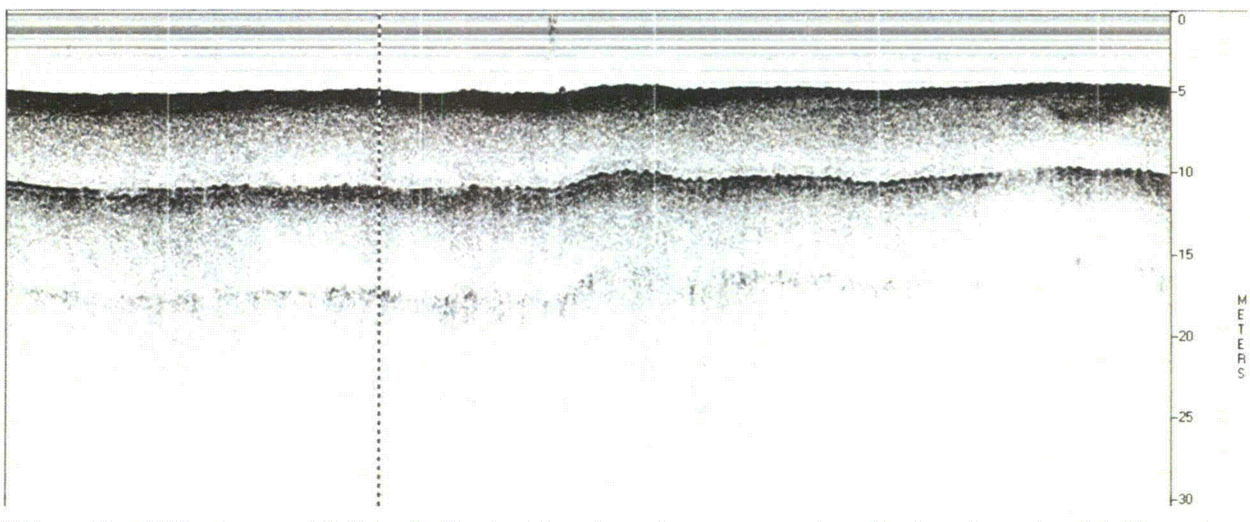


Figure 24. Subbottom profile Line 5. Vertical lines have 30-meter spacing, depth scale to the right in meters.

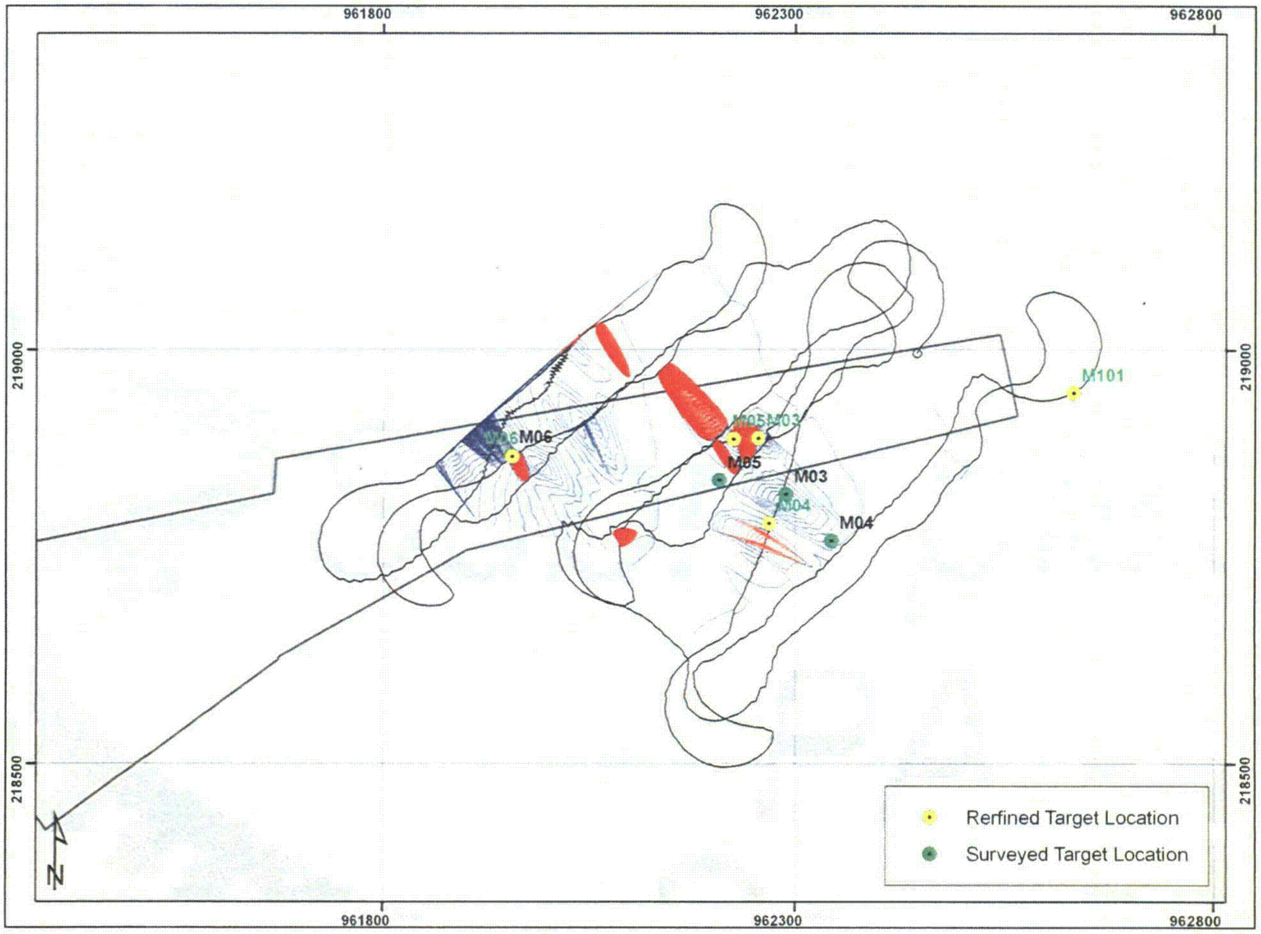


Figure 25. Magnetic refinement contour map of previously located targets.

TARGET INVESTIGATIONS

A total of five target locations were investigated as part of the current project, including four previously identified anomalies (Table 2) and one identified during the current survey (Table 3). Each target is discussed in turn in the following paragraphs.

M05

The refinement of M05 located a dipole magnetic anomaly with a total magnetic deviation of 8,450 gammas and a total duration of 95 feet (Figure 25) in the vicinity of the original anomaly. The strength of the refinement anomaly is significantly larger than the original 155-gamma dipole. However, this difference is easily explained via the proximity of the magnetometer sensor to the target. During the survey, the true target location—as determined during the current investigation—fell between two survey lines, with the result being the sensor did not pass very close to the target source. During the refinement, the sensor passed directly over and was likely within a few feet of the target source for several seconds, resulting in a much larger anomaly reading.

Sonar imagery collected at the same time indicated the presence of two objects – what appears to be a four-blade propeller alongside a larger rectangular object (Figure 26). Diver investigation of the anomaly and object indicated the presence of a 10-foot diameter propeller with four blades and a large rudder immediately adjacent to it. Discussions with Mark Hunter from the Calvert

Cliffs Nuclear Power Plant indicated that a tugboat had lost its rudder and propeller near the barge dock prior to the 2008 survey (Mark Hunter, personal communication 2011). Both objects at this location are not considered historically significant and no further work is recommended.

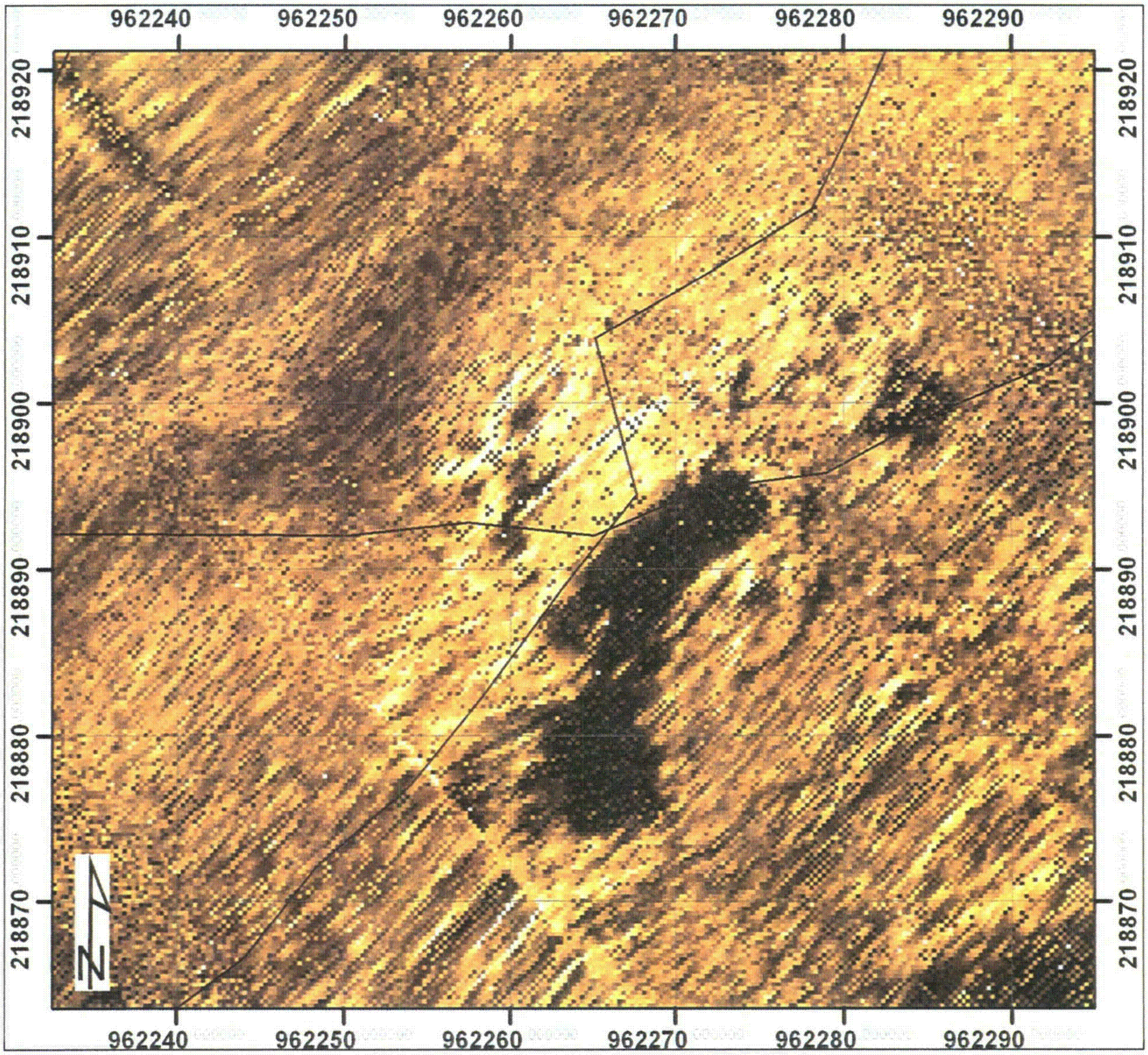


Figure 26. Refinement sonar image of anomaly M05, consisting of what appears to be a four-blade propeller 10 feet in diameter (just upper right of center) and a large rectangular object approximately 12-x-6 feet (center).

M03

The refinement of M03 indicated the presence of a 209-gamma dipole anomaly with a duration of 140 feet. This is smaller than the original 263-gamma anomaly, a difference that can easily be accounted for by the difference in sensor distance from target between the survey and the refinement. Review of the refinement sonar data did not indicate the presence of an object at the anomaly location; however, the location is close to the location of a target from the 2008 investigation (Figure 27). Diver investigation of the refined target location indicated the presence of a steel pipe 10 feet long and 16 inches in diameter. The pipe is considered sufficient to account for the magnetic anomaly. This pipe is not considered historically significant and no further work is recommended.

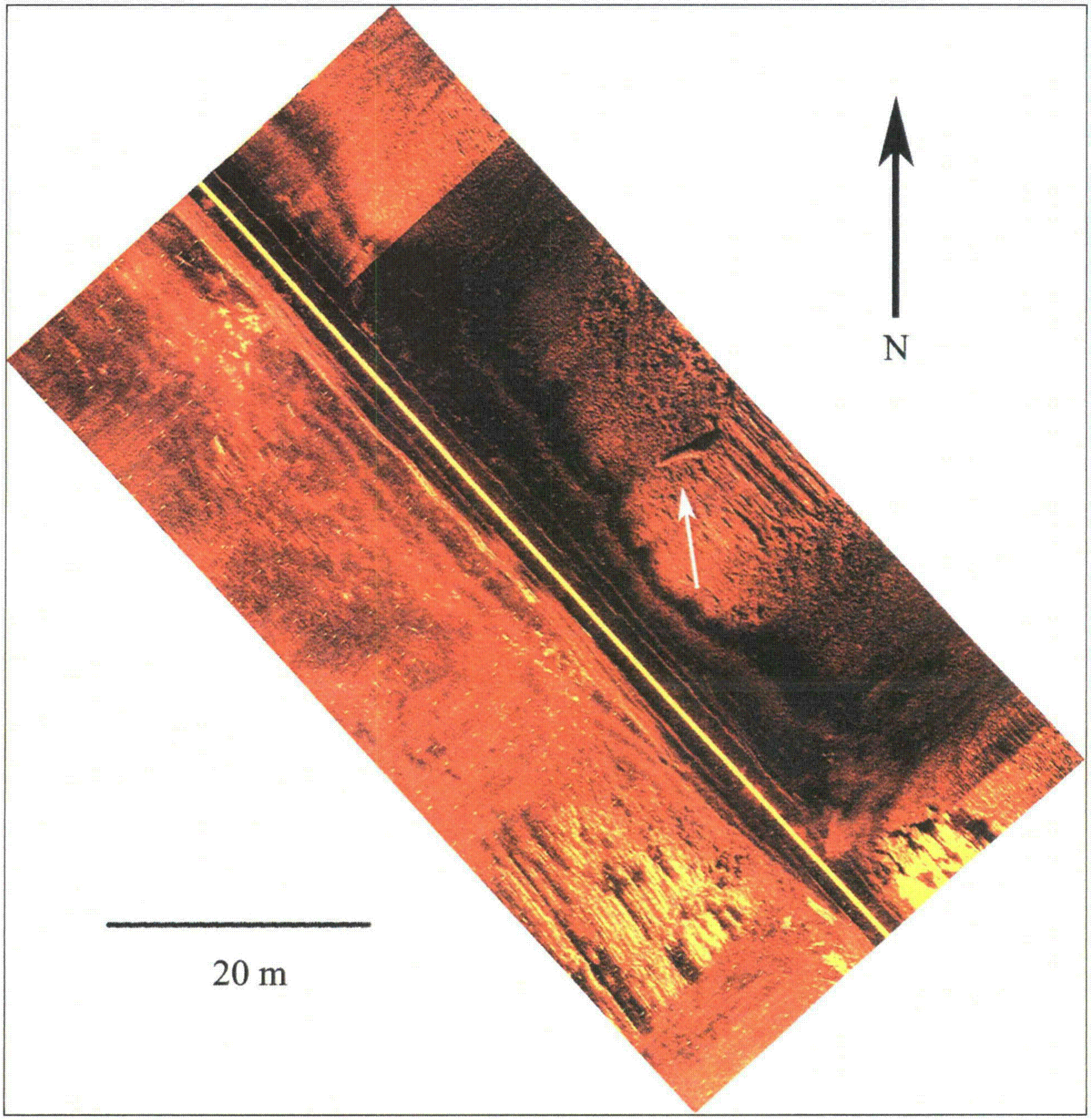


Figure 27. Object on bottom 1, as presented in Faught 2009.

M04

The refinement of M04 failed to relocate the anomaly, indicating that the source is no longer at that location as originally determined during the survey. This indicates the object has mobilized from the original location, and likely also indicates it to have consisted of some kind of modern ferrous debris not likely to be considered historically significant. No further work is recommended.

M06

The refinement of M06 indicated the presence of a 200-gamma monopole anomaly with a duration of 50 feet. A search of the bay bottom in the vicinity of the anomaly did not indicate the presence of any object or objects sufficient to account for the anomaly. A pattern of hydroprobes, spaced at 10-foot intervals in cardinal directions (out to 20 feet and to a depth of 7 feet), did not locate any objects sufficient to account for the anomaly. This failure to locate the object with a visual inspection and a pattern of subsurface probes indicates that the source object or objects consist of isolated marine debris such as wire rope, rather than a single large object. This target is not considered historically significant and no further work is recommended.

M101

The data for M101 indicated the presence of a 156-gamma dipole anomaly with a duration of 105 feet. A search of the bay bottom in the vicinity of the anomaly did not indicate the presence of any object or objects sufficient to account for the anomaly. A pattern of hydroprobes, spaced at 10-foot intervals in cardinal directions (out to 20 feet and to a depth of 2 feet), did not locate any objects sufficient to account for the anomaly. The hydroprobes indicated the presence of a shell layer at 2 feet below the bottom, which the probe was unable to penetrate. It is likely this shell bed represents a relict oyster bed and any cultural material is likely to be above this layer. Also, within 30 feet of the anomaly location was exposed rock, indicating a fairly shallow accumulation of sediment in the vicinity of the anomaly location. This failure to locate the object with a visual inspection and a pattern of subsurface probes indicates that the source object or objects consist of isolated marine debris such as wire rope, rather than a single large object. This target is not considered historically significant and no further work is recommended.

V. CONCLUSIONS AND RECOMMENDATIONS

In 2008, archaeologists with Panamerican conducted an intensive submerged cultural resources remote sensing survey for UniStar of a proposed offshore construction impact area associated with construction of a new nuclear generation unit (CC3) at the CCNPP located in Calvert County, Maryland. Located north of both Solomons Point and the mouth of Patuxent River, the survey recorded four potentially significant magnetic anomalies within the offshore area (Faught 2009). Subsequent to completion of the archaeological investigation, UniStar identified modifications to the proposed offshore facilities, requiring additional archaeological investigations. Panamerican was tasked with conducting a comprehensive remote sensing survey of the new 300-x-700 foot construction/restoration area for a proposed barge dock/slip, as well as archaeological diving investigations to identify the sources of the four magnetic anomalies, M03, M04, M05, and M06, located during the 2008 survey, and any potentially significant anomalies located during the current survey.

RECOMMENDATIONS

Results of the additional survey identified one magnetic anomaly and no sidescan sonar targets within the project area. This target, along with the four anomalies located during the 2008 survey, were investigated and assessed by archaeologists from Panamerican and determined to consist of modern debris and other objects that are not considered historically significant, are not eligible for listing on the NRHP under any criteria, and are not recommended for further investigation.

VI. REFERENCES CITED

Blanton, D.B., and S.G. Margolin
1994 *An Assessment of Virginia's Underwater Cultural Resources.* Resources Survey and Planning Report Series No. 3. William and Mary Center for Archaeological Research, Department of Anthropology, College of William and Mary.

Duff, Jim
1996 *Underwater Archaeological Investigation and Documentation of Three Anomaly Clusters Within Three Segments of Proposed Preferred Corridor for Replacement of Bonner Bridge, Oregon Inlet, North Carolina.* Panamerican Consultants, Inc., Memphis, Tennessee, under subcontract to Parsons, Brinckerhoff, Quade & Douglas, Inc., Morrisville, North Carolina. Submitted to the Federal Highway Administration and the North Carolina Department of Transportation.

Faught, Michael K.,Ph.D.
2009 *Submerged Cultural Resources Survey of a Proposed Outfall Pipe, Calvert Cliffs Nuclear Power Plant Unit 3 Construction, Calvert County, Maryland.* Prepared by Panamerican Consultants, Inc., Memphis, Tennessee. Prepared for MACTEC Federal Programs, Inc., Herndon, Virginia.

Garrison, E.P., C.P. Giammona, F.J. Kelly, A.R. Tripp, and G.A. Wolff
1989 *Historic Shipwrecks and Magnetic Anomalies of the Northern Gulf of Mexico: Reevaluation of Archaeological Resource Management Zone 1.* Vol. II: Technical Narrative. OCS Study 89-0024. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, Louisiana.

Gearhart, Robert L., III
1991 *Archaeological Remote-Sensing of Borrow Area I and a Proposed Groin Field, St. Simons Island Beach Renourishment Project, Glynn County, Georgia.* Espey, Huston & Associates, Inc., Austin, Texas. Submitted to the U.S. Army Corps of Engineers, Savannah District.

Gearhart, R.L., III, and S.A. Hoyt
1990 *Channel to Liberty: Underwater Archaeological Investigations, Liberty County, Texas.* Espey, Huston & Associates, Inc. Austin, Texas. Submitted to the U.S. Army Corps of Engineers, Galveston District.

Hoyt, Steven D.
1990 *National Register Assessment of the* SS Mary*, Port Aransas, Nueces County, Texas.* Espey, Huston & Associates, Austin, Texas. Submitted to the U.S. Army Corps of Engineers, Galveston District.

Irion, Jack B., and C.L. Bond
1984 *Identification and Evaluation of Submerged Anomalies, Mobile Harbor, Alabama.* Espey, Huston & Associates, Austin, Texas. Submitted to the U.S. Army Corps of Engineers, Mobile District.

Irion, J.B., S.B. Smith, P. Heinrich, S. Kilner, W.P. Athens, and D. Beard
1995 *Historical Assessment and Magnetometer Survey For Construction at Two Locations Along the Mississippi River, Jefferson and Issaquena Counties, Mississippi and East Carroll and Tensas Parishes, Louisiana.* R. Christopher Goodwin & Associates, Inc., New Orleans, Louisiana. Submitted to the U.S. Army Corps of Engineers, Vicksburg District.

James, Stephen R., and Charles E. Pearson
1991 *Magnetometer Survey and Ground Truthing Anomalies, Corpus Christi Ship Channel, Aransas and Nueces Counties, Texas.* Coastal Environments, Inc., Baton Rouge, Louisiana. Submitted to the U.S. Army Corps of Engineers, Galveston District.

James, Stephen R., Jr., C.E. Pearson, K. Hudson, and J. Hudson
1991 *Archaeological and Historical Investigations of the Wreck of the Gen. C.B. Comstock, Brazoria County, Texas.* Coastal Environments, Inc., Baton Rouge, Louisiana. Submitted to the U.S. Army Corps of Engineers, Galveston District.

Kidwell, Susan M.
1997 Anatomy of extremely thin marine sequences landward of a passive-margin hinge zone; Neogene Calvert Cliffs succession, Maryland, USA. *Journal of Sedimentary Research* 67(2):322-340.

2006 Challenges in Paleoenvironmental Interpretation of the Maryland Miocene. Paper presented at The Geology and Paleontology of Calvert Cliffs, A Symposium to Celebrate the 25th Anniversary of the Calvert Marine Museum's Fossil Club. Ecphora Miscellaneous Publications 1, http://www.calvertmarinemuseum.com/cmmfc/Paleo-Symposium.pdf

Lowery, Darrin
2003 *Archaeological Survey of The Atlantic Coast Shorelines Associated with Accomack County and Northampton County, Virginia.* Survey and Planning Report Series No. 7. Chesapeake Bay Watershed Archaeological Research Foundation. For Virginia Department of Historic Resources.

2008 *Archaeological Survey of the Coastal Shorelines Associated with Mathews County, Virginia: An Erosion Threat Study.* Chesapeake Watershed Archaeological Research Foundation, Inc. Report submitted to Virginia Department of Historic Resources, Survey and Planning Report Series.

Lydecker, Andrew D.W., and Michael C. Krivor
2004 *Underwater Archaeological Surveys in the Vicinity of James and Barren Islands in the Chesapeake Bay, Maryland.* Panamerican Consultants, Inc., Memphis, Tennessee. Prepared for Maryland Port Administration, Baltimore, Maryland, under contract to Maryland Environmental Services, Millersville, Maryland.

Mitchum, R.M., P.R. Vail, and J.B. Sangree
1977 Stratigraphic Interpretation of Seismic Reflection Patterns in Depositional Sequences. In *Seismic Stratigraphy-Applications to Hydrocarbon Exploration*, pp. 117-133. American Association of Petroleum Geologists Memoir 26.

Morrison, Peter, Stephen R. James, Jr., R. Christopher Goodwin, and Michael Pohuski
1992 *Phase II Evaluation of Three Submerged Vessels within Chesapeake Bay, Maryland.* Panamerican Consultants, Inc., Tuscaloosa, Alabama, under contract to R. Christopher Goodwin & Associates, Inc., Baltimore, Maryland. Prepared for the U.S. Army Corps of Engineers, New York District.

National Park Service
n.d. National Register Bulletin 15, *How to Apply the National Register Criteria for Evaluation.* U.S. Government Printing Office, Washington, D.C.

1985 National Register Bulletin 20, *Nominating Historic Vessels and Shipwrecks to the National Register of Historic Places.* U.S. Government Printing Office, Washington, D.C.

Pearson, C.E., B.L. Guevin, and A.R. Saltus
1991 *Remote Sensing Survey of the Lower Pearl and West Pearl River, Louisiana and Mississippi.* Coastal Environments, Inc., Baton Rouge. Submitted to the U.S. Army Corps of Engineers, Vicksburg District.

Pearson, C.E., and K.G. Hudson
1990 *Magnetometer Survey of the Matagorda Ship Channel: Matagorda Peninsula to Point Comfort, Calhoun and Matagorda Counties, Texas.* Coastal Environments, Inc., Baton Rouge. Submitted to the U.S. Army Corps of Engineers, Galveston District.

Pearson, C.E., S.R. James, Jr., K.G. Hudson, and J. Duff
1993 *Underwater Archaeology Along the Lower Navidad and Lavaca Rivers, Jackson County, Texas.* Coastal Environments, Inc., Baton Rouge. Submitted to the U.S. Army Corps of Engineers, Galveston District.

Pearson, C.E., and A.R. Saltus
1990 *Cultural Resources Investigation at Island 86, Mississippi River, Arkansas-Mississippi.* Coastal Environments, Inc., Baton Rouge. Submitted to the U.S. Army Corps of Engineers, Vicksburg District.

Pearson, C.E., and J.J. Simmons, III
1995 *Underwater Archaeology of the Wreck of the Steamship Mary (41NU252) and Assessment of Seven Anomalies, Corpus Christi Entrance Channel, Nueces County, Texas.* Coastal Environments, Inc., Baton Rouge. Submitted to the U.S. Army Corps of Engineers, Galveston District.

Quinn, R., J.M. Bull, and J.K. Dix
1997 Imaging wooden artifacts using Chirp sources. *Archaeological Prospection* 4:25-35.

1998 Optimal processing of marine high-resolution seismic reflection (CHIRP) data. *Marine Geophysical Researches* 20:13-20.

Rogers, R., S.D. Hoyt, C.L. Bond, L. Voellinger, and S.R. James, Jr.
1990 *Cultural Resources Investigations, Virginia Point, Galveston County, Texas.* Espey, Huston and Associates, Inc., Austin, Texas. Submitted to the U.S. Army Corps of Engineers, Galveston District.

Snow, Dean
1980 *The Archaeology of New England.* Academic Press, New York.

Trimble Navigation Limited
1998 *DSM12/212 Operation Manual.* Trimble Navigation Limited, Sunnyvale, California.

Tuttle, Michael C., and Amy M. Mitchell
1998 *Remote-Sensing Survey, Near-shore Project Area, Atlantic Coast of Long Island Jones Inlet to East Rockaway Inlet, Long Beach Island, Nassau County, New York Storm Damage Reduction Project.* Panamerican Consultants, Inc., Memphis. Prepared for the U.S. Army Corps of Engineers, New York District.

Vail, P., R. Mitchum, R. Todd, J. Widmier, S. Thompson, J. Sangree, J. Bubb, and W. Hatlelid
1977 Seismic Stratigraphy and Global Changes of Sea Level. In *Seismic Stratigraphy-Applications to Hydrocarbon Exploration*, edited by C.E. Payton, pp. 49-212. Memoir 26, American Association of Petroleum Geologists, Tulsa, Oklahoma.