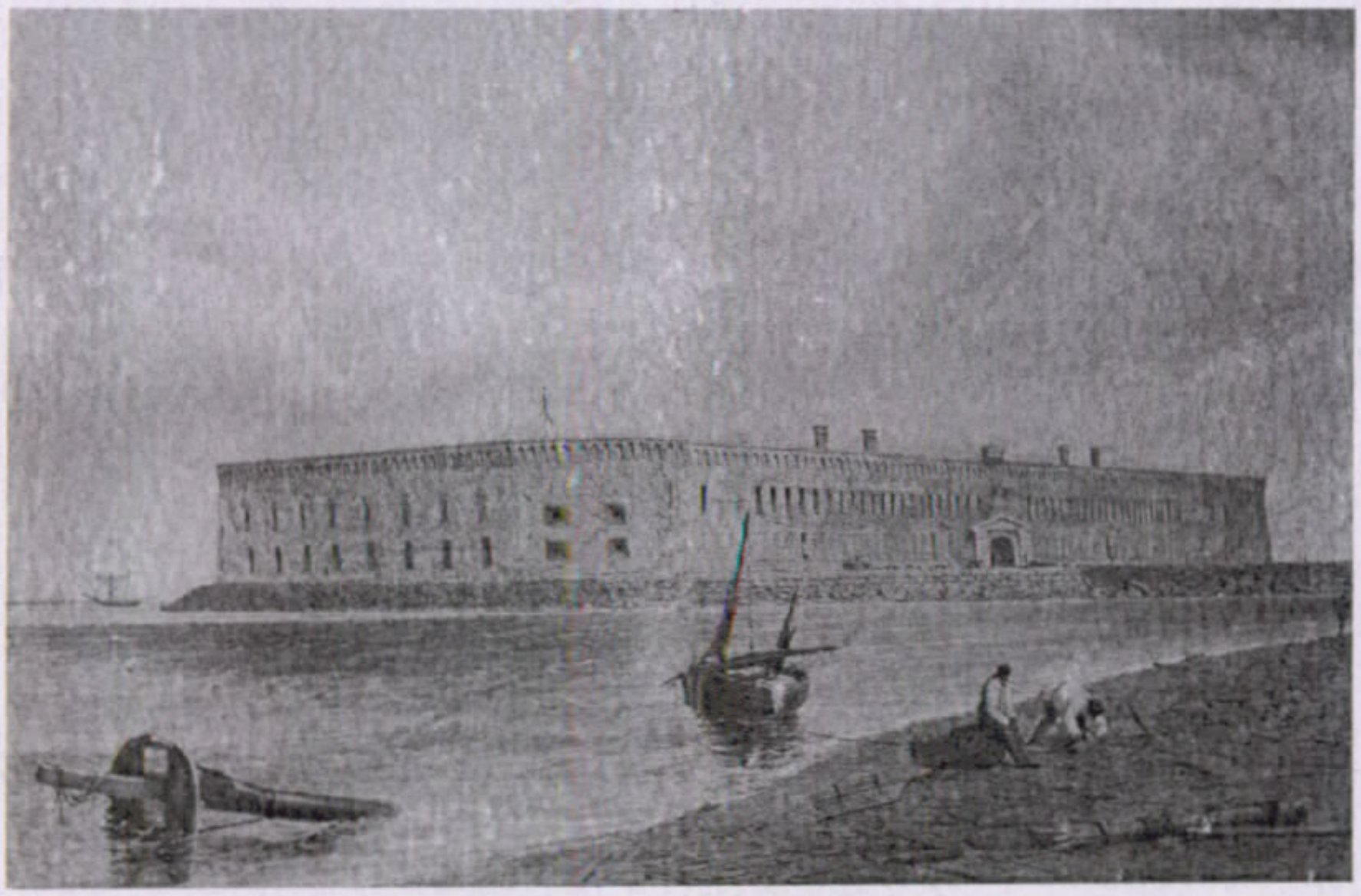
392/D-193

AUG 3 1 1998

FORT SUMTER NATIONAL MONUMENT
SUBMERGED CULTURAL RESOURCES SURVEY



MATTHEW A. RUSSELL
SUBMERGED CULTURAL RESOURCES UNIT
NATIONAL PARK SERVICE

FORT SUMTER NATIONAL MONUMENT

SUBMERGED CULTURAL RESOURCES SURVEY

Matthew A. Russell
Submerged Cultural Resources Unit

Submerged Cultural Resources Unit
Cultural Resources Management
Intermountain Support Office - Santa Fe
US National Park Service

Santa Fe, New Mexico
1998

TABLE OF CONTENTS

LIST OF FIGURES iii

ACKNOWLEDGMENTS iv

EXECUTIVE SUMMARY v

FORT SUMTER NATIONAL MONUMENT SUBMERGED CULTURAL RESOURCES SURVEY 1

- INTRODUCTION 1
- SURVEY OBJECTIVES 1
- SURVEY DESIGN AND RATIONALE 2
  - Geographic Information Systems (GIS) 3
  - GIS Data Archiving 4
  - Survey Blocks and Sample Intervals 4
  - Positioning 5
- SURVEY INSTRUMENTATION 5
  - Positioning 6
  - Magnetometry 6
  - Side Scan Sonar 7
  - Bathymetry 7
  - Hardware 8
  - Software 8
- SURVEY METHODOLOGY 9
- SURVEY OPERATIONS 9
- ANALYSIS AND RESULTS 11
- CONCLUSIONS AND RECOMMENDATIONS 16
- DISTRIBUTION 18
- REFERENCES 19

LIST OF FIGURES

1. Survey area 2
2. Magnetometer and Side Scan Sonar on the back deck of the NPS-SCRU survey vessel 8
3. Survey operations 10
4. Survey operations 11
5. Vessel tracklines for side scan sonar survey 12
6. NPS-SCRU survey vessel during survey 13
7. Fort Sumter from the NPS-SCRU survey vessel 13
8. Vessel tracklines showing individual data collection points during magnetometer survey 14
9. Contoured magnetometer data 15
10. Contoured bathymetric data 17

ACKNOWLEDGMENTS

This project was only possible with the assistance and support of many people. Fort Sumter National Monument staff were particularly helpful in planning the survey, including Superintendent John Tucker, Ann Childress, Mike Savage and Rick Hatcher. Marty Wilcox, Pete Wilcox and Brett Phaneuf from Marine Sonic Technology, Ltd. generously donated their time, equipment and expertise to produce side scan imagery of park bottomlands.

Project fieldwork was directed by Larry E. Murphy and conducted by Larry, David Conlin, Timothy Smith and Matthew Russell from the Submerged Cultural Resources Unit, and Christopher Amer from South Carolina Institute of Archaeology and Anthropology.

Matthew A. Russell, Archeologist
Submerged Cultural Resources Unit

EXECUTIVE SUMMARY

In May 1996, the National Park Service's Submerged Cultural Resources Unit (SCRU) conducted underwater survey and evaluation operations in Charleston Harbor on the remains of Civil War submarine *H.L. Hunley*. This project was completed in association with partners in the State Historic Preservation Office and US Naval Historical Center.

Because a fully equipped NPS underwater survey team was deployed in the vicinity, the Fort Sumter National Monument (FOSU) superintendent took advantage of the window of opportunity to request that SCRU survey submerged bottomlands adjacent to the fort. The survey results herein presented were obtained at no cost to the park.

Although most of the bottomlands within FOSU's administrative boundary were too shallow for the 32-foot SCRU survey vessel to safely enter, the federal and state waters adjacent to the monument were saturation-covered with magnetometer, depth sounder and side scan sonar instrumentation. Data were obtained in GIS compatible formats. This information can be used as a first building block in a long-term program to eventually establish a comprehensive, monument-wide GIS database.

A number of magnetic anomalies and side scan sonar contacts were detected that should eventually be ground-truthed by divers. Some were delineated during this survey, while others were found in the shallow waters during a pipeline survey some years ago. SCRU recommends that the park build into its long-range resources management plans a 1–2 day operation to complete the instrument survey in the shallows using a small boat with a boom-mounted terrestrial magnetometer followed by 2–4 days of ground-truthing by divers on results of these electronic examinations. This would essentially complete the parks requirements for a cultural resources inventory of its submerged lands.

The most cost-effective and scientifically sound way of planning such activity would be in the context of completing a general archeological survey of park lands. The magnetometer survey could then be simply extended to the terrestrial areas around the fort, many of which were submerged at various times over the past two hundred years. The park should coordinate such a program with its regional CRM specialists, currently located at the Southeast Archeological Center.

Daniel J. Lenihan, Program Manager
Submerged Cultural Resources Unit

FORT SUMTER NATIONAL MONUMENT SUBMERGED CULTURAL RESOURCES SURVEY

INTRODUCTION

In May 1996, the US Naval Historical Center (NHC) and South Carolina *Hunley* Commission asked the National Park Service's (NPS) Submerged Cultural Resources Unit (SCRU) to conduct an assessment and evaluation of a submerged archeological site outside Charleston Harbor, South Carolina, thought to be the remains of Confederate submarine *H.L. Hunley*. Before uncovering and documenting the site, SCRU conducted a predisturbance remote sensing site survey using its Differential-corrected Global Positioning System (DGPS)-based Archeological Data Acquisition Platform (ADAP) installed on a 32-foot NPS-SCRU research vessel. After completing survey operations on the *Hunley* site, SCRU conferred with staff at Fort Sumter National Monument (FOSU), who agreed that with the NPS assets in the area it was an ideal opportunity to conduct a submerged cultural resources survey around Fort Sumter. FOSU had been targeted by SCRU as one of many units of the National Park System in need of underwater archeological survey because of the potential for significant submerged cultural resources. Because SCRU combined this survey with a separate project funded by other agencies, and with a donation of personnel and equipment by corporate partners, the work was completed at no cost to FOSU. This interagency project combined public and corporate assets with remote sensing capabilities maintained by SCRU through NPS's System-wide Archeological Inventory Program (SAIP) funding.

SURVEY OBJECTIVES

Survey objectives included conducting DGPS-positioned magnetometer, side-scan sonar, and bathymetric survey within FOSU jurisdictional boundaries accessible to the survey vessel (Figure 1). SCRU designed the survey to detect magnetic anomalies possibly representing submerged cultural resources, such as historical shipwrecks and material associated with construction and use of Fort Sumter; and to image the seabed to locate features above the sea floor of potential historical interest. Historical documents suggest at least one important shipwreck may lie in or near park waters. On June 29, 1776, the 28-gun sixth rate British warship HMS *Acteon* grounded and was burnt to avoid capture in Charleston Harbor during an attack on Sullivan's Island. According to South Carolina Institute of Archaeology and Anthropology (SCIAA) site files, this incident occurred on the same bar upon which Fort Sumter was later built (SCIAA Underwater Site Information Summary Form Number 38CH269, 1983). Three guns were raised from the site in 1887 and sold to a group in St. Louis, Missouri. The guns are now (or were in 1968) on display

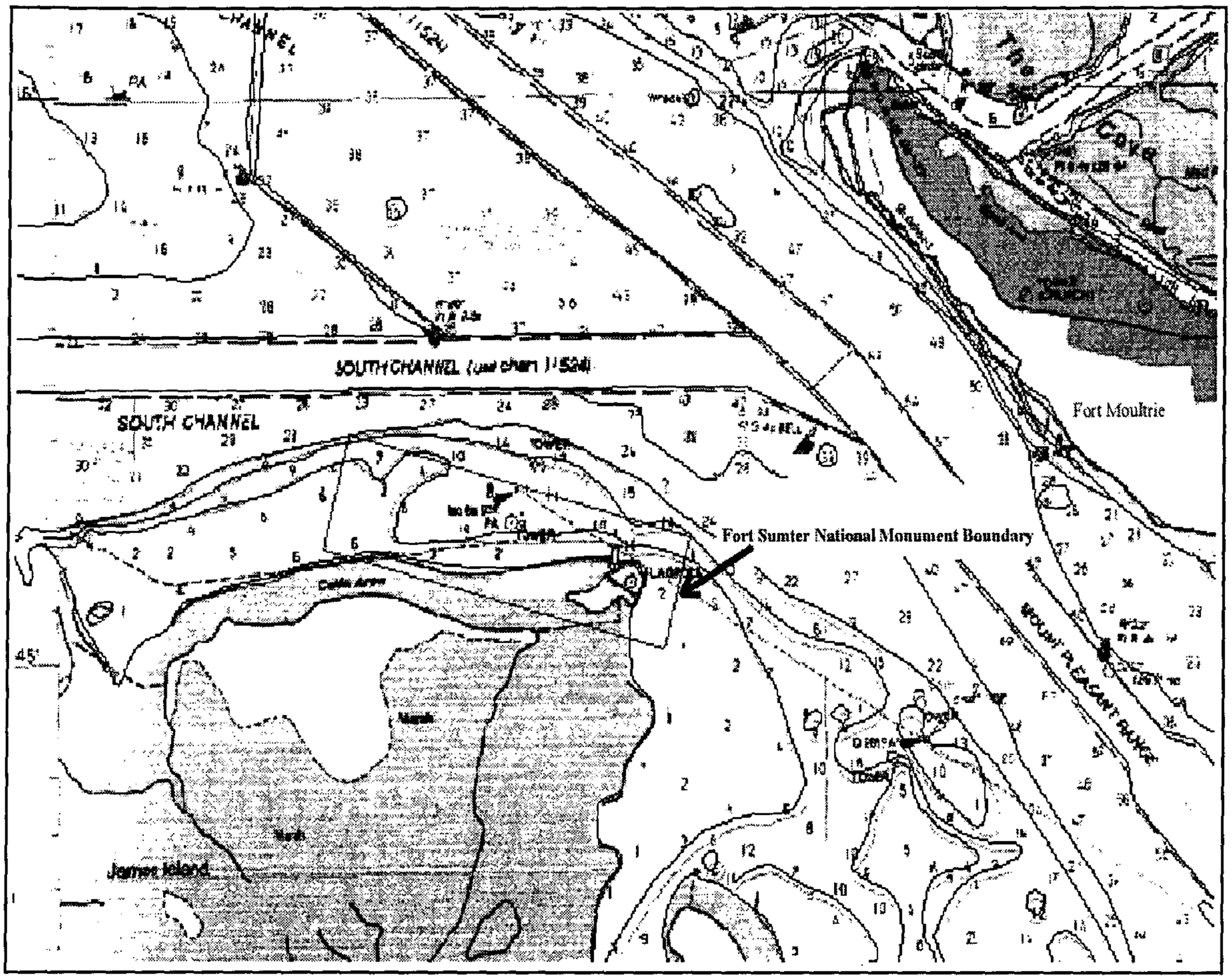


Figure 1. Area map showing Fort Sumter National Monument boundary.

in Lafayette Park, St. Louis (Acting Superintendent, Jefferson National Expansion Memorial, to Superintendent, FOSU, 1968). This recovery indicates the wreck was still accessible after Fort Sumter's construction, at least until 1887. Recent attempts to locate the site have been unsuccessful, and location of *Acteon*'s remains is unknown (SCIAA 1983).

SURVEY DESIGN AND RATIONALE

SCRU designed the FOSU survey to produce a comprehensive data set that would be accessible to FOSU managers for planning and interpretation. The survey design was based upon wide-area archaeological survey methodology developed by SCRU during the NPS SAIP survey of Dry Tortugas National Park beginning in 1993 (Murphy 1997a; Murphy and Smith 1995; Shope et al. 1995).

Data collection, post-plotting, analysis and presentation were designed to be utilized in a Geographic Information System (GIS) database to facilitate their use by managers and incorporation into permanent archives. This approach results in an electronic product that can incorporate available digital data, such as aerial imagery and digitized historical maps, so they can be combined with project-specific results and be analytically manipulated to examine relationships that would otherwise be extremely difficult to observe. The project GIS

data set was generated to provide a standardized, permanent, cumulative, computer-accessible product for multiple applications by managers, interpreters, researchers, the public and those involved in planning and conducting future submerged cultural resource operations within the park.

GEOGRAPHIC INFORMATION SYSTEMS (GIS)

GIS is the use of multiple, spatially referenced databases to produce maps that graphically depict user generated combinations of variables presented as themes, layers or coverages. Spatially referenced data are basic to archeological inquiry, but it has only been in the last few years that technological advances in software and hardware have overcome difficulties in collecting, collating, storing, editing, querying, depicting and manipulating the large amount of data generated by marine remote sensing survey. FOSU submerged cultural resources survey results were formulated to be incorporated into a GIS product easily transferrable to park managers.

GIS provides a methodology to compare variables among many sets of spatial data, such as artifact categories, remote sensing results and natural environmental characterizations, to examine distribution and change over space, and, if sufficient data are available, over time. Rapid manipulation of scale and variables can allow pattern recognition that may not be apparent at other levels. Examination of combined variables is instant because they are presented graphically, greatly simplifying analysis by precluding the necessity of generating mathematical and statistical models to characterize patterned relationships. Current computer and software speed allow rapid manipulation of multiple variable combinations, which allows generation of associations and relationships that might otherwise be unanticipated. Hypotheses can be quickly generated and tested through seamless graphical display. Data manipulation can easily be done by researchers or managers with basic GIS software familiarity, which does not require sophisticated mathematical ability.

GIS data sets can be presented as tabular database files or themes that can be generated, analyzed, scaled, combined, superimposed and displayed through direct user access in unlimited variations. Data themes are presentations of nonspatial data referenced to a common location expressed as geographic coordinates. One way of looking at themes is to consider them X-Y horizontal locations that share a category of variable Z values, which represent discrete, quantifiable attributes. Analytical techniques include statistical and spatial analysis, measurement, and comparisons that can be used to create additional themes reflecting analytical results useful for additional hypothesis testing.

GIS can be contrasted with computer-assisted design (CAD) systems that are generally limited to graphic output such as drawings, pictures and maps and contain no relational database capability nor the ability to generate new data sets based upon analytic functions. CAD systems generally contain no interrogative capability and are unable to manipulate nonspatial database attributes (Murphy 1997b).

Two problems make creation of GIS data sets expensive and time consuming: accuracy determination and conversion of various data sets to an appropriate format. Mixing different accuracy levels among data sets degrades overall GIS accuracy and gives a false sense of comparability that can lead to serious analytical problems in data interpretation. Data set conversions must consider fundamental geodetic concepts such as geoid, ellipsoid, datum, coordinate system and projection. Geodesy factors vary over time and space, and each variation is critical to conversion accuracy (Smith 1997). Few archeologists record a chart's datum and projection when generating coordinates. For example, latitude/longitude coordinates in North American Datum 1927

(NAD 27) and those in World Geodetic System 1984 (WGS 84) can vary from tens to hundreds of meters – confusing these datums introduces serious error. Being given coordinates in NAD 27 and trying to relocate the point with an instrument reading in WGS 84 is an easy and common mistake to make. All data generated during the FOSU submerged cultural resources survey were based on the WGS 84 datum. Other data not collected by SCRU during the project and not already in WGS 84 datum were converted from their original datum before incorporation into the FOSU survey GIS database.

GIS DATA ARCHIVING

Raw and processed hydrographic survey field data and GIS information archiving is as much a concern as any archeological data archiving, and it must be planned in advance. FOSU remote sensing survey electronic data archiving is in a nonproprietary format, primarily DOS ASCII text, which ensures long-term data accessibility by many scientific disciplines, managers, archeologists and other researchers. All results are stored in latitude/longitude and Universal Transverse Mercator (UTM), WGS 84. SCRU stores archive data in latitude/ longitude coordinates so that the database can be easily converted if future alterations or corrections are made to WGS 84; it is more difficult to convert grid coordinates after a datum revision. Most current computer programs require grid coordinates, so GIS themes are also archived in this form. Upon report completion, FOSU staff will be provided a CD-ROM (some media now have 100-year archival quality) containing all pertinent field data and GIS coverages. This CD-ROM will be directly accessible through ArcView, a readily available PC-based GIS program that is the current NPS standard.

SURVEY BLOCKS AND SAMPLE INTERVALS

Hydrographic survey is conducted in area blocks through which the survey vessel travels along preplotted transects, or lanes, at investigator-defined intervals selected to ensure complete instrumental coverage of the study area. Lane spacing depends upon the survey questions and remote sensing instrument attributes. The FOSU survey was conducted with a preplotted block to maximize remote sensing coverage. Standard SCRU practice is to label survey blocks with the four-letter park acronym followed by a numerical designation, in this case "FOSU001."

The survey block designed for the magnetometer and bathymetry survey (FOSU001) was constructed with 30-meter transects running northwest-southeast, between south channel and Fort Sumter. Standard SCRU survey methodology for wide area survey requires 30-meter transects, which have been demonstrated to provide cost-effective magnetic coverage for discovering most colonial-period shipwrecks (Murphy 1984:90–95; Murphy and Saltus 1990: 93–95).

GPS provides a position every second, and all instrument data were collected at intervals 1½ seconds or less and collated with the appropriate DGPS position. At a typical boat speed of 6 knots, a sample is collected about every 4 to 6 meters along the transect, giving more than 3,100 sample points in this survey block.

The side scan sonar portion of the survey was not conducted along preplotted lanes. Instead, the side scan sonar data collection software's integrated navigational plotter, which depicts real-time DGPS position, vessel heading and swath width, was used to maneuver the survey vessel through navigable areas within and outside the park boundary and ensure complete side scan sonar coverage.

POSITIONING

Archeological hydrographic survey requires real-time positions with very rapid updates (1–2 seconds) for accurate vessel navigation to ensure complete, systematic coverage at the desired sample interval. GIS accuracy requirements are a 2–3 meter circle-of-error or less. Unlike terrestrial archeological survey and mapping, hydrographic survey usually has no landmarks; simply, on the water, it is very difficult to occupy and then reoccupy the same point and to continually know where you are without real-time positioning.

Accuracy is usually expressed as parts-per-unit (e.g., 1:10,000); plottable accuracy, the accuracy that a point can be plotted, less important now because of GIS digital entry and zoom capability; or circle of error, which is an ellipse whose largest radius represents the root mean square error of a set of measurements, and whose orientation shows directional uncertainty. The ellipse, centered on the true position, is typically at the 95% statistical confidence level.

Although several positioning systems are presently available, GPS offers several advantages over most others. GPS has become the state-of-the-art and will likely ultimately replace other systems for survey applications. The US Department of Defense (DOD) developed the GPS system for military purposes. This system uses trilateration of satellite-transmitted signals to determine position. GPS provides 1-second updates with global coverage from 24 satellites, meaning four or more space vehicles are continuously in view anywhere on the globe. The satellites produce two signals, known as C/A code and P code frequency, the latter encrypted and available only to military or government users. The GPS is close to an ideal positioning system; it is accurate and continuously available on demand anywhere in the world under any weather conditions.

The GPS and GIS combination has provided a solution for accurate positioning and analysis for archeological purposes, particularly in hydrographic remote sensing. However, some additions to the basic GPS system are necessary to achieve acceptable accuracy levels. Autonomous civilian GPS receivers produce circles-of-error of about 10–30 meters. Unfortunately, GPS instrumental accuracy is further reduced by "selective availability" (SA), which is intentional, random dithering of the C/A code GPS signals by DOD as a security measure that degrades the signal to a guaranteed accuracy of no more than 100 meters. However, real-time accuracy of 2–3 meters is possible by deploying a base station to compensate for SA through differential GPS (DGPS) correction. Ionospheric variables alter the satellite signal propagation times through the atmosphere and are an additional error source, which are also correctable with a differential base station. The base station, which is set up on a control point whose position is known to a very high accuracy, generates corrections for SA and transmits them via a radio modem datalink to the mobile survey instrument. Broadcast differential corrections are currently available in most coastal areas through the US Coast Guard navigational beacons and commercial suppliers, which provide differential corrections at various accuracy levels. For example, the US Coast Guard navigation beacons are guaranteed to 10-meter circle-of-error, although our tests indicate that accuracy levels are about 5 meters in most areas.

SURVEY INSTRUMENTATION

SCRU's DGPS-based ADAP survey system, designed and built by Sandia Research Corporation of Albuquerque, New Mexico, to SCRU specifications, was used during remote sensing operations at FOSU. The ADAP system automates and integrates field data collected with a variety of remote sensing instruments, and it accurately tags each data point with real-time differential GPS position and time

references. Data points combining position, instrument reading and time were collected every 1½ seconds or less for the survey. Generating survey blocks, navigating preplotted lanes, and collecting and postprocessing data were done with Coastal Oceanographic's Hypack hydrographic survey software. The data were then easily incorporated into a PC-based GIS, in this case ESRI's ArcView.

POSITIONING

Positioning accuracy was consistently within at least a 4-meter circle-of-error throughout the survey area. A Trimble Navigation, of Sunnyvale, California, Accutime II GPS receiver was used aboard the survey boat for positioning survey navigation and data collection. Differential corrections were provided real-time by a Trimble Navigation Navbeacon XL receiving US Coast Guard broadcast corrections.

MAGNETOMETRY

The principal cultural resource detection device used in the FOSU submerged cultural resources survey was a proton-precession magnetometer. The magnetometer has long been a standard archeological survey instrument (Arnold and Weddle 1978; Breiner 1973; Arnold and Clausen 1975; Shope 1997). A Geometrics, of Sunnyvale, California, model G-876 proton-precession magnetometer was used as part of SCRU's ADAP system. The magnetometer detects and quantifies magnetic fields. In hydrographic survey, ferrous or magnetic objects can be located by noting small perturbations or anomalies in the earth's ambient magnetic field. Ferrous objects cause a localized increase or decrease, usually both, in the ambient magnetic field. Objects in this context are typically of cultural origin associated with maritime casualty or depositional sites. The magnetometer output reading is the total magnetic field intensity and independent of sensor coil orientation, consequently, it makes an ideal detection device for submerged cultural resources.

Typical proton-precession magnetometer resolution is 1 gamma, and in special cases 0.1 gamma, in the earth's field of approximately 50,000 gammas (nanoteslas). Magnetic readings simply indicate the presence and possible mass of an object. There is no unique relationship between anomaly intensity and isogamma contour configuration and an object. Any number of combinations of objects can produce similar anomalies. The only way to determine anomaly sources is by visual investigation (Murphy and Saltus 1990).

The magnetometer is a valuable cultural resource detection instrument, and it is sensitive to many different types of artifacts associated with submerged shipwrecks. Ferrous ship components are prime targets. In a survey mode, shipwrecks are often difficult to detect by visual inspection or sonar-based instruments because marine life encrustation and sediment coverings can easily obscure a site.

The magnetometer sensor is towed 20–40 meters behind the survey vessel to eliminate influence from the survey vessel's magnetic field. The G-876 instrument generates a sensor depth and height-over-bottom (sensor altitude) and displays these data during the survey. Sensor height is important for consistent and reproducible magnetic data collection and interpretation.

Another feature of the G-876 important for high-resolution survey is that the computer processing instrument package is towed underwater 10 meters ahead of the magnetometer sensor. This instrument, which was designed for deep water survey, produces a remarkably low noise level because only processed data and power are transmitted over the tow cable. Proton magnetometers of traditional design have the computer on the surface and transmit the raw signal from the sensor to the surface, which creates a much

higher noise level because the cable acts like an antenna for extraneous noise-producing electrical energy. Noise is an issue because the gamma reading of a particular ferrous mass, which is proportional to the size of the mass, declines as a cube of the distance between the sensor and the mass. Noise in high-resolution magnetometer survey masks smaller anomalies that might be of archeological interest.

The industry standard (for example, Department of Interior, Minerals Management Service Guidelines for Offshore Lease Block Surveys) specifies a noise level of +/- 3 gammas or less. The G-876 typically produces less than 1 gamma of noise, which allows smaller anomalies to be accurately observed for archeological purposes. Reliable isogamma contouring for traditional magnetometer data display is rarely done on fewer than 5 gamma contours; the G-876 allows reliable contouring on 2 gammas. The G-876 permits discrimination and recognition of anomalies that are within the noise levels of most other proton magnetometers, consequently, very small anomalies may be recognized. Discrimination of the smallest possible magnetic anomalies is always desirable during archeological survey.

SIDE SCAN SONAR

In addition to the magnetometer, side scan sonar is the principal remote sensing instrument used in submerged archeological survey. Side scan sonar uses sound waves to image the sea floor and objects laying on it or protruding above it. Normally a towed system, a side scan sonar transmits a microsecond-pulsed, vertically narrow acoustic beam to each side of the tow vessel's path at multiple times per second. The beam propagates through the water and across the sea floor, reflecting incident sound energy back to the sonar sensor. A sonar data processor converts the reflections' intensity and time delays to a visual image for display. The end result is an image of the sea floor of near photographic quality showing areas of dark (strong reflection) and light (areas of lower reflectivity or shadow areas).

For the FOSU survey, Marine Sonic Technology, Ltd., of Gloucester, Virginia, provided a Sea Scan PC side scan sonar and operator. The Sea Scan PC is a digital, high-resolution side scan sonar system that uses a Windows-based personal computer for all control, display, analysis and storage functions. The reflected signal is converted to digital information, which is preferred because it allows images to be filtered and enhanced for improved analysis, and it can be processed into mosaics and incorporated into GIS as an image layer, much like aerial photography. The digital format facilitates archival data storage because it is directly transferable to CD-ROM medium.

The Sea Scan PC includes an integrated navigational plotter, using standard DGPS input, that allows all parts of the acoustic image to be automatically correlated with correct geographic position. During the FOSU survey, a 600-kilohertz (KHz) towfish was used for maximum resolution. The higher the frequency of the sonar signal, the higher its resolution. This instrument was selected because prior deployment by SCRU proved it was a robust, easily deployed instrument that produces very high resolution images in a digital format amenable to GIS applications. The Sea Scan PC meets or exceeds resolution of side scan sonar systems costing many times more than this instrument.

BATHYMETRY

Bathymetric data was collected using a Furuno Model LS-6000 LCD Video Sounder. Sounding area is a function of transducer beam width, which is generally a function of frequency. Usually, the higher the frequency, the narrower the beam width. Most depth sounders use a frequency of about 50 KHz, which has a beam width of approximately 46° and samples a circular area with a 42-meter diameter in a depth

of 50 meters. The Furuno depth sounder uses a 200 KHz transducer, which provides a high-resolution sample area and reduces bubble noise. The 200 KHz beam width is about 10°, which provides coverage of about 17 percent of the water depth. The area covered in 50 meters water depth is a circle with a diameter of 9 meters, or an area of 64 square meters. In shallower depths, the sample area is reduced accordingly.

HARDWARE

Austin 486DX2/66 PC laptops were used for field data collection and manipulation, and a Comtrade Pentium 166 PC workstation was used for office data manipulation and generation of GIS coverage. Trimble Navigation's Accutime II generated positioning during survey operations; Trimble Navigation's NavBeaconXL differential GPS beacon receiver produced real-time differential corrections. A Geometrics G-876 proton precession magnetometer, Marine Sonic Technology, Ltd. Sea Scan PC side scan sonar, and Furuno depth sounder were the primary instruments used during surveying operations (Figure 2).

SOFTWARE

SCRU used several off-the-shelf, PC-based software for cultural resource hydrographic survey operations: AutoCAD by Autodesk (Sausalito, CA); QuickSurf by Schrieber Instruments (Denver, CO); Hypack, hydrographic data collection software by Coastal Oceanographics, Inc. (Durham, CT); ArcView, a geographical information system by ESRI, Inc.

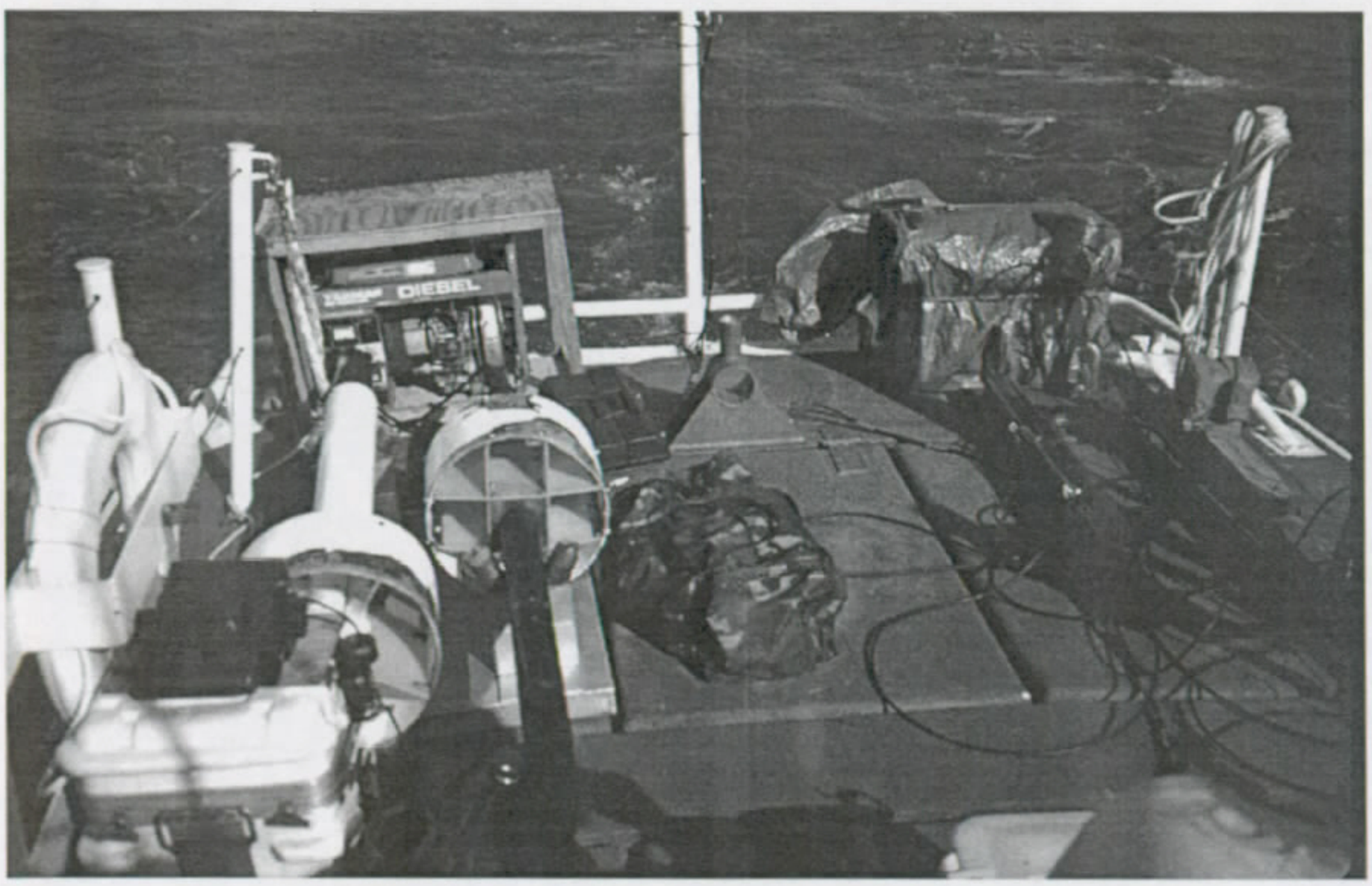


Figure 2. Survey instrumentation on the deck of the NPS-SCRU survey vessel. The magnetometer is on the left, the side scan sonar on the right. NPS photo by Tim Smith.

(Redlands, CA); and Sea Scan PC Review by Marine Sonic Technology, Ltd. (Gloucester, VA). All are PC-based and provided quick and easy access to field data in a MS-DOS/Windows environment.

SURVEY METHODOLOGY

Initial survey preparation took place at SCRU headquarters in Santa Fe, New Mexico, with assembling background data. Current and historical charts and maps were procured and prepared for inclusion into an ArcView GIS database project. Digitized charts of the general survey area were used to create survey blocks and provided a computer screen background to aid survey operations and navigation to and from the survey area. The survey block was constructed in the desired area, and computer software was used to generate survey lanes with beginning and ending X-Y coordinates at 30-meter transect intervals throughout the survey block.

Side scan sonar survey covered as much area inside park boundaries as navigable with repeated sweeps north of Fort Sumter. Preplotted survey lanes were not used during side scan sonar operations. Instead, the side scan data collection software's integrated navigational plotter was used to ensure complete coverage of all navigable park bottomlands. In addition, two sweeps of non-NPS bottomlands offshore Fort Moultrie and between Fort Sumter and the main navigation channel were also covered.

General methodology included DGPS positioned survey with a marine magnetometer, side scan sonar, and depth sounder with differential corrections provided by US Coast Guard broadcast corrections from Sullivan's Island. Because of the proximity of the Coast Guard beacon to the survey area, uninterrupted contact with the beacon was maintained for the duration of the survey.

Magnetic survey was directed toward locating ferrous material associated with historical shipwrecks or materials related to construction and occupation of Fort Sumter. Side scan sonar survey would locate any material laying on or protruding above the seabed. Bathymetric data provides water depth and environmental context for magnetic anomalies and objects observed with side scan sonar.

Magnetic and bathymetric data were post-processed in Hypack hydrographic data collection software, which produces an XYZ ASCII file, with X and Y representing UTM coordinates and Z representing the full-field magnetic value or water depth. The magnetic data were further reduced by performing a running two-point subtraction to isolate the value change between each data point, producing a Z value of magnetic gradients. The XYZ files were imported into QuickSurf, a surface modeling module of AutoCAD, and contoured. The contoured data were incorporated into a PC-based ArcView GIS database, producing a cumulative data set that will provide a baseline for future work.

Side scan sonar imagery can be viewed with Sea Scan PC Review software. Images are collected as individual files, 1000-pixel lines long. The general location of each of these images, including filenames, is included as a theme in the ArcView GIS project.

SURVEY OPERATIONS

Constant DGPS positioning was employed in all survey operations for an overall accuracy of a 4 meter or less circle of error throughout the survey area. For the magnetometer/depth sounder survey, preplotted lanes were followed using navigation information provided by the DGPS and displayed in Hypack (Figure 3). A computer monitor mounted near the helm provided the boat pilot with current position as well as navigation information such as cross-track error, speed, course, distance to end-of-

Figure 3. Survey vessel interior during survey operations. NPS photo by Tim Smith.

line and bearing to end-of-line. In addition to tabular information, a graphical display showed real-time boat position, movement and survey lanes superimposed over a digitized area chart.

Data were stored to the hard drive of an onboard computer as it was collected (Figure 4). Data collection was continuous; no buoys were used to mark anomalies. Data were backed-up nightly to an external Iomega Bernoulli drive and processed in the field.

Survey operations began on May 4, 1996. The SCRU survey vessel, equipped with the ADAP system and Marine Sonic Technology's side scan sonar and operators Marty and Peter Wilcox, completed survey operations on the *Hunley* site and began side scan sonar survey offshore Fort Sumter and Fort Moultrie. Preplotted lanes were not used. Instead, the real-time plotting feature of Sea Scan PC data collection software was used to maintain proper lane spacing and ensure total coverage of the survey area. In total, five passes were made at varying distances through and offshore the FOSU boundary. Survey boat tracklines during side scan sonar survey are shown in Figure 5.

A second side scan sonar survey was conducted east of Fort Sumter on May 24 between the fort and the main navigation channel to locate the remains of USS *Patapsco*, a Union ironclad monitor sunk during the Civil War. Several runs were made through the area, from northwest to southeast. In addition, one sweep as close to shore as possible adjacent to Fort Moultrie was conducted. Preplotted lanes were not used; once again the real-time plotting feature of the side scan collection software was used to ensure total coverage of the desired area.

On May 28, the SCRU survey vessel conducted magnetic and bathymetric survey between south channel and the FOSU boundary (Figures 6 and 7). The survey block (FOSU001) contained 20 1,400-meter-long lanes 30 meters apart, oriented northwest-southeast. The survey block filled the area between south channel and

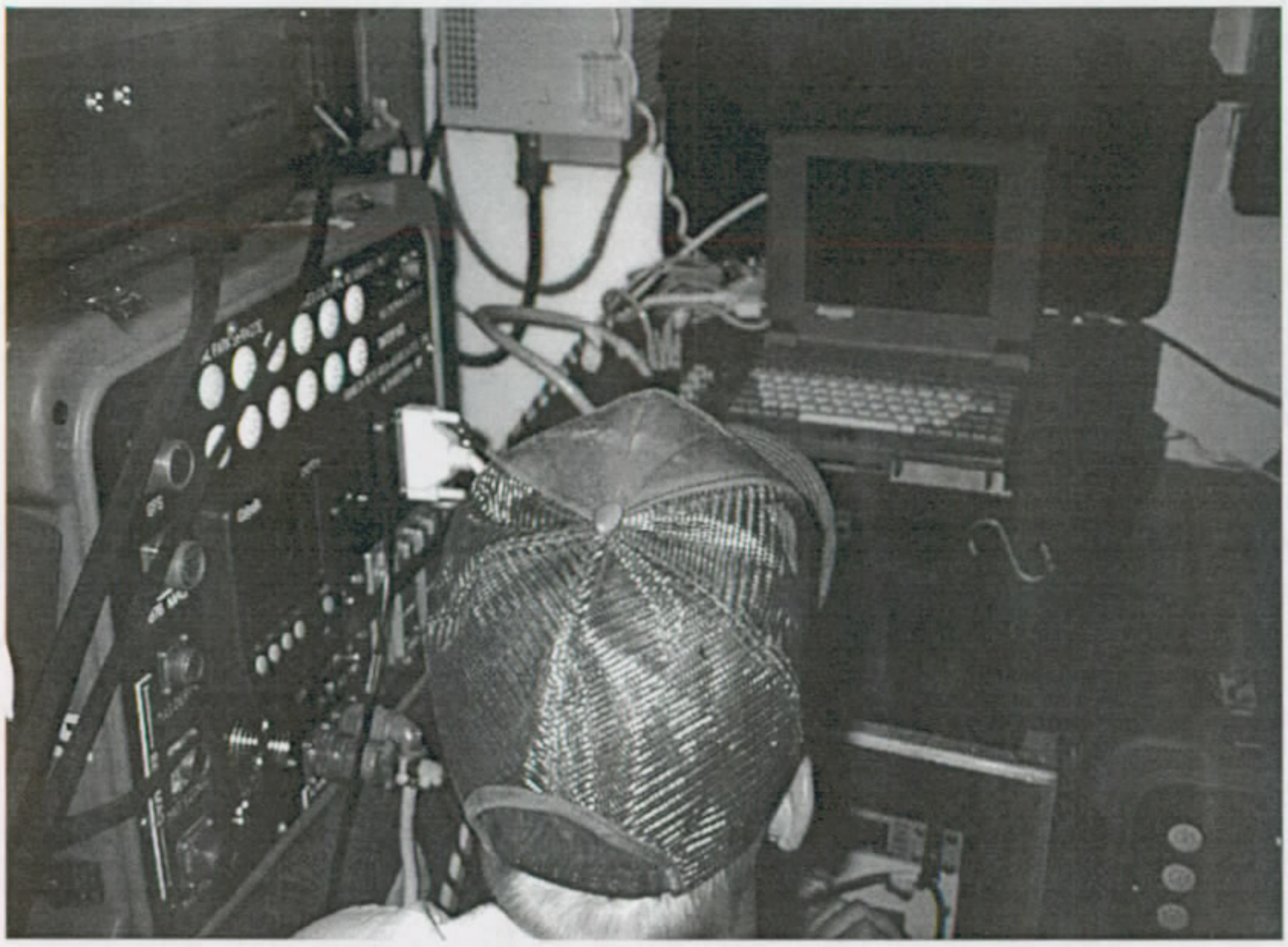


Figure 4. Data being collected during survey operations. NPS photo by Tim Smith.

the shallows west of Fort Sumter, for the length of the FOSU boundary (Figure 8). Because of the irregular shape of the survey area, lanes on the southern side of the block were 1,400 meters long (the length of the park boundary) but got progressively shorter to the north as they were cut off by south channel. The northern-most lane was only 150 meters long. Once inside the park boundary, shallow water prevented following preplotted lanes precisely, so only areas deep enough for the survey boat to navigate were covered. No survey was conducted shallower than 2 meters, low tide depth. Magnetometer coverage of the primary survey area, FOSU001, was completed the afternoon of May 28. Data were processed that evening to ensure full coverage.

ANALYSIS AND RESULTS

Magnetometer coverage in the primary survey area resulted in more than 3,100 sample points (Figure 8). Lane spacing between south channel and the FOSU boundary adhered to strict 30-meter preplotted lanes. The survey covered approximately 90 acres of state bottomlands adjacent to the park. Inside the park boundary, most areas were too shallow for survey coverage. Several passes were made in the deeper areas, but strict 30-meter lane spacing could not be followed. The result was approximately 20 acres of instrument coverage near the northern park boundary.

Because of three navigation towers in the survey area, which produced a great deal of magnetic noise, the magnetometer data were contoured on 10 gammas using a horizontal gradient calculation. This method eliminates diurnal changes and facilitates incorporation of magnetic data into GIS. Approximately 25 anomalies greater than 10 gammas were recorded within the survey area (Figure 9). These do not include the very large anomalies caused by the navigation towers. These 25

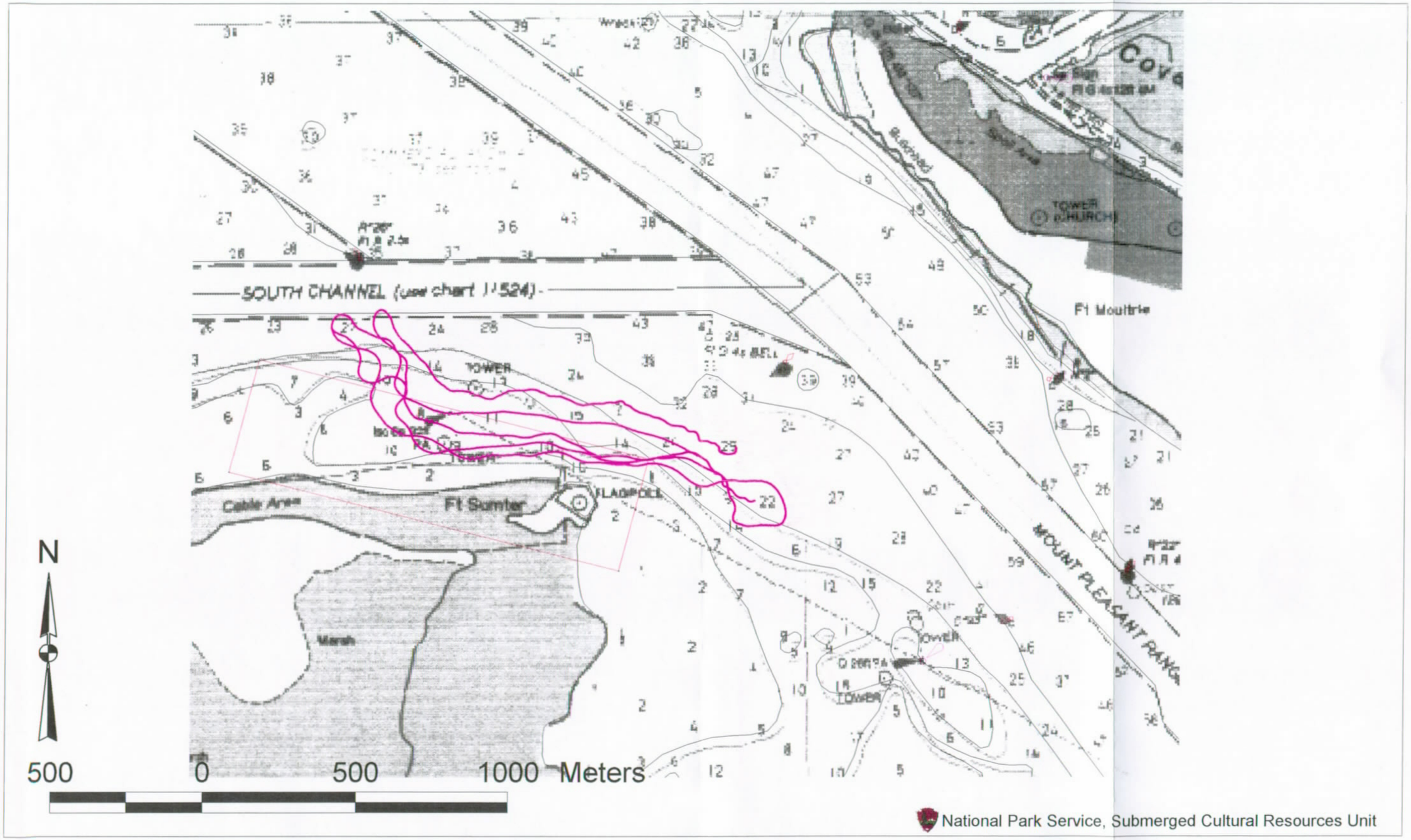


Figure 5. Boat tracklines for side scan sonar survey.

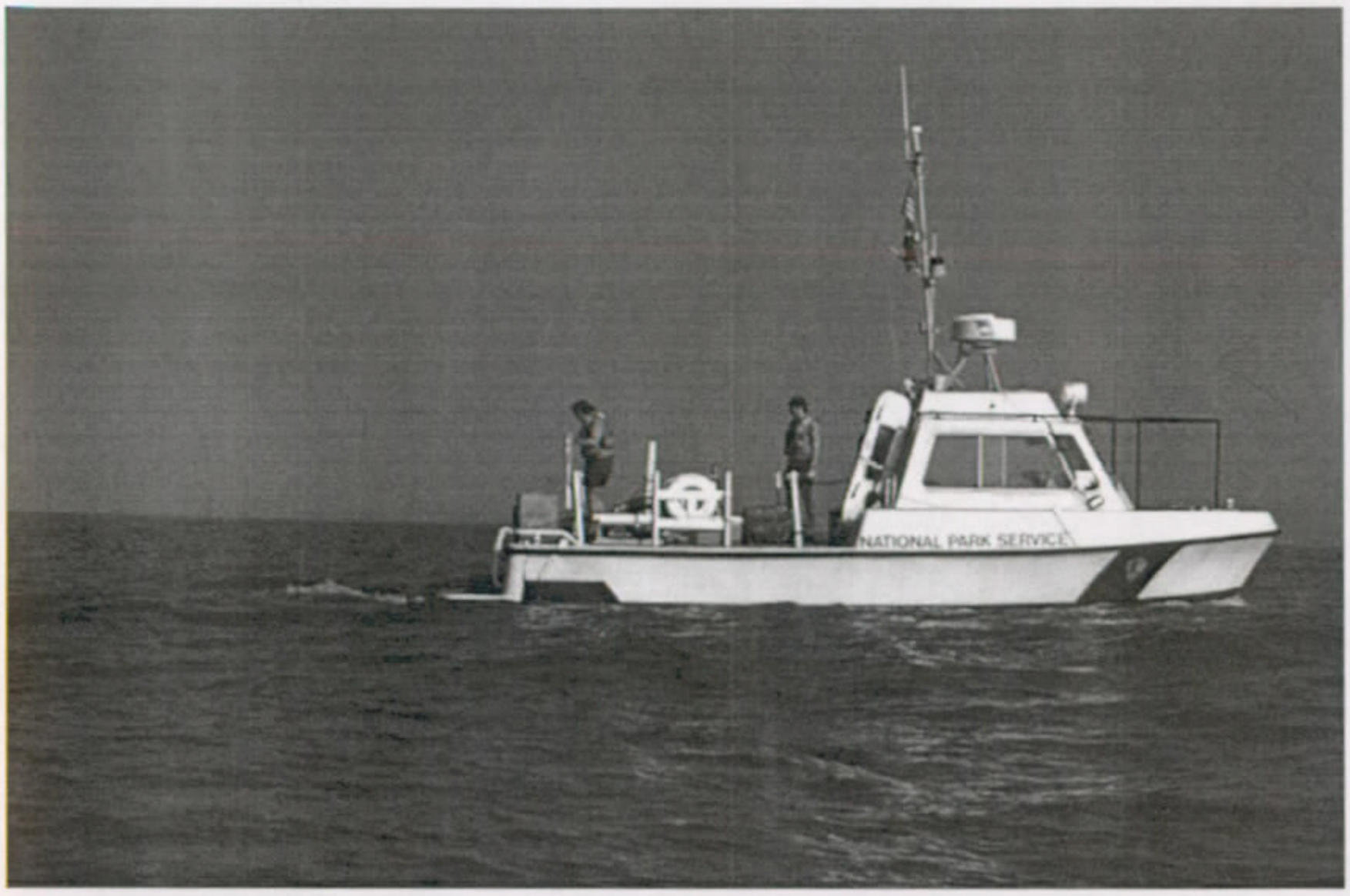


Figure 6. NPS-SCRU vessel during survey operations at FOSU. NPS photo by David Conlin.

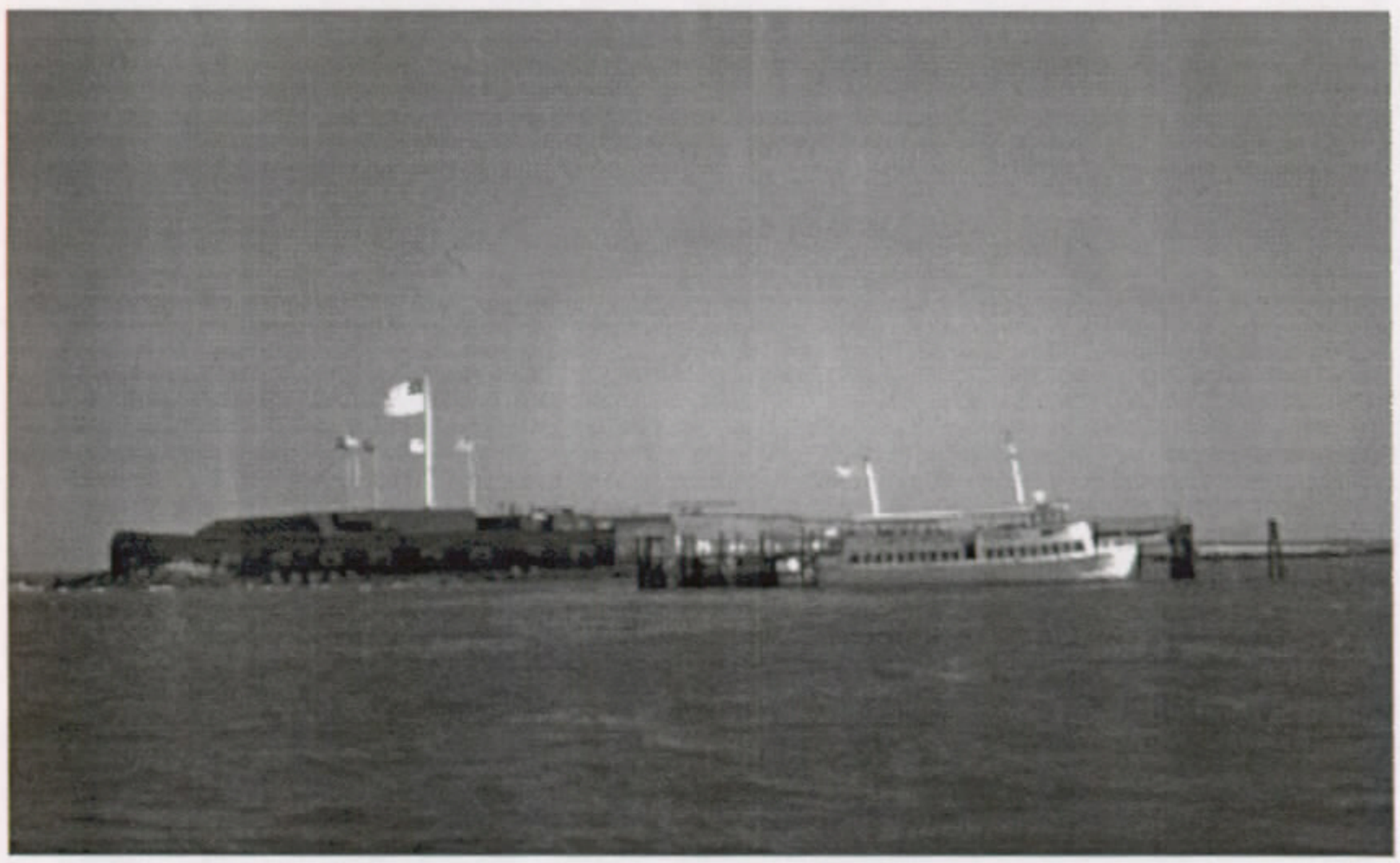


Figure 7. Fort Sumter from the survey vessel during survey operations. NPS photo by Tim Smith.

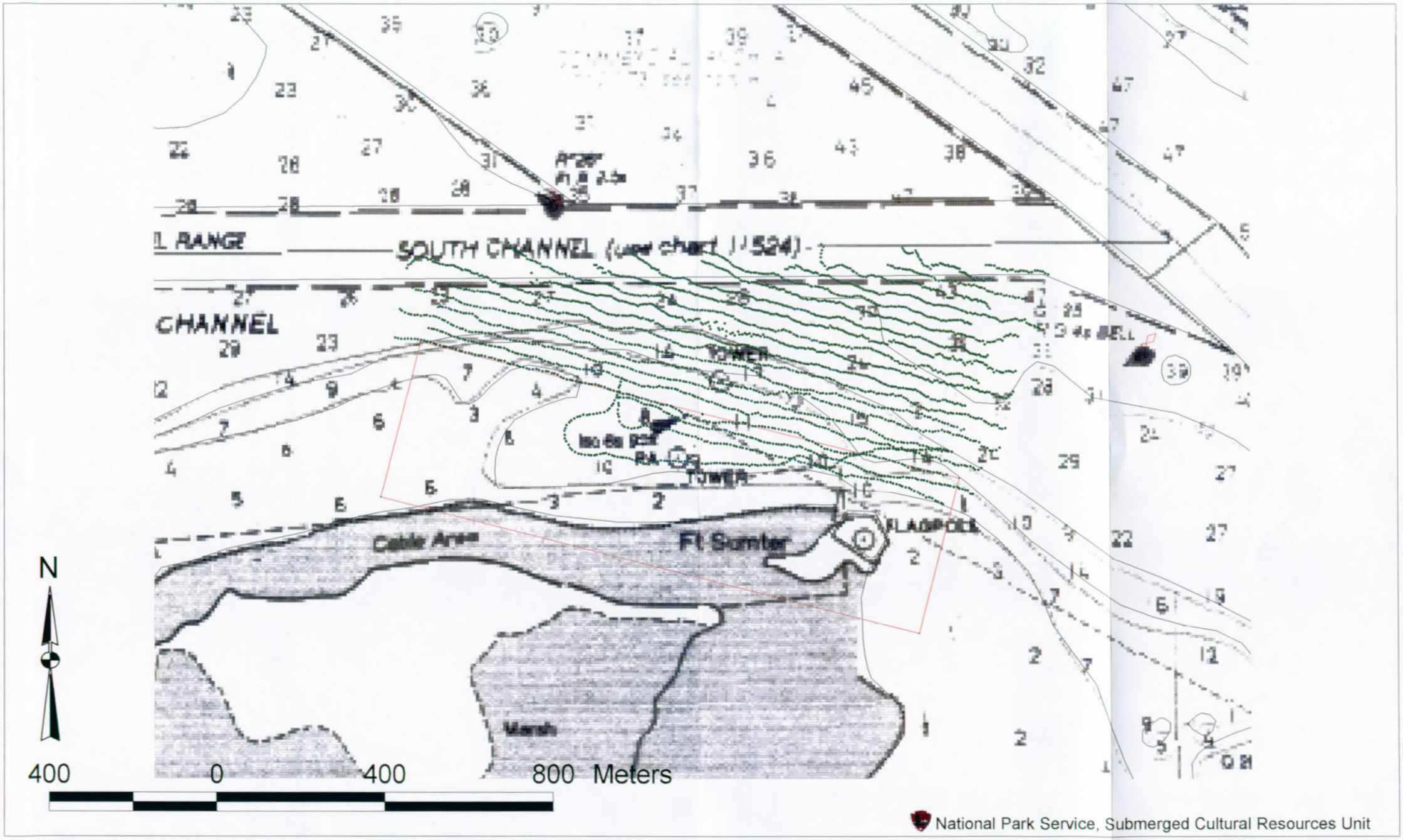


Figure 8. Boat tracklines showing individual data collection points.

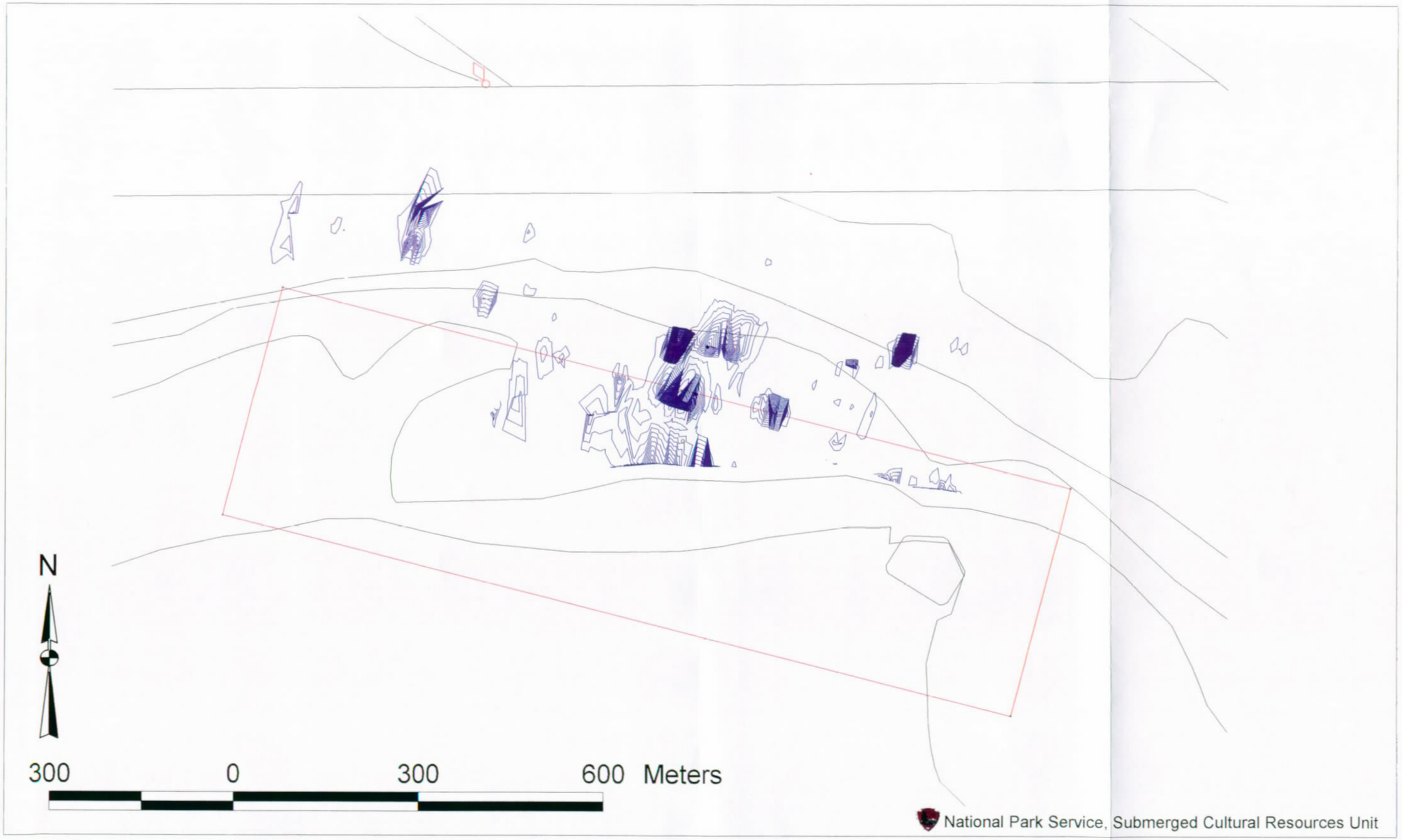


Figure 9. Magnetometer data - 10 gamma gradient contours.

anomalies should be the priority for examination during anomaly investigation. According to a model for submerged historical site survey developed by Murphy and Saltus (1990:94), at 30-meter lane spacing, any 10 gamma anomaly for a 15 meter duration potentially represents submerged watercraft.

In general, SCRU survey results corroborate the results reported by Wes Hall (1995). That survey, conducted by Mid-Atlantic Technology, detected several anomalies in shallow water not accessible to SCRU. In deeper, more accessible areas, SCRU's survey detected several more anomalies than the 1995 survey.

Bathymetric data indicates steadily shallowing water from north to south, with the deepest point more than 16 meters deep, and the shallowest areas less than 3 meters deep (Figure 10). Most of the area inside park boundaries are less than 3 meters and, therefore, too shallow to survey with the SCRU survey vessel.

Side scan sonar survey revealed a variety of objects above the sea floor. None of the objects in the vicinity of Fort Sumter could be identified from the side scan record as historically significant, but should be investigated visually. The most interesting objects were located offshore from Fort Moultrie, including dock structures and Bowman's jetty, near the locally well-known remains of Civil War blockade runners *Celt* and *Stono* (Ragan 1995:133).

CONCLUSIONS AND RECOMMENDATIONS

The FOSU submerged cultural resources survey should be viewed as an intermediate step in understanding the park's submerged archeological sites. The survey vessel could only navigate limited portions of park bottomlands, leaving shallow areas yet to be covered. The next step should be use of a shallower-draft vessel to complete magnetometer, bathymetry and side scan sonar coverage of NPS bottomlands. A traditional survey using towed sensors will still leave a large portion of the park unsurveyed. To finish survey coverage, a small skiff using a boom-mounted magnetometer sensor should be utilized.

Once complete instrument coverage of the park has been conducted, the next step should involve ground-truthing anomalies with diver investigation. This step would involve divers visually examining each anomaly to determine origin and significance. In some cases, it may be that the object or objects causing the magnetic disturbance are buried by bottom sediments. In these cases, it may be necessary to conduct limited archeological test excavation to determine origin of the magnetic anomaly. Any site disturbance should be conducted by NPS archeologists or qualified contractors.

A complete Submerged Cultural Resources Assessment should eventually be completed for FOSU. This should include an historical context study and a geomorphological study to determine how the area has changed over time and how that has affected site-formation processes. The assessment would be a complete evaluation of submerged cultural resources in the park.

An interesting thematic study would be an archeological investigation of Civil War vessels related to Fort Sumter and the Civil War in Charleston. Known wrecks might include Union ironclad monitors USS *Keokuk*, *Weehawken*, and *Patapsco* all sunk near Charleston. Another vessel related to Fort Sumter that could be included is *Star of the West*, whose remains are in the Tallahatchie River, Mississippi. *Star of the West* was attempting to resupply Fort Sumter, when it was fired upon from Morris Island. These were actually the first shots of the Civil War. Later during the war, the vessel was captured by the Confederates and entered into their navy as CSS *St. Philip*. It was scuttled in the Tallahatchie River on March 11, 1863, to block the progress of Federal gunboats approaching Fort Pemberton. *Star of the West*'s

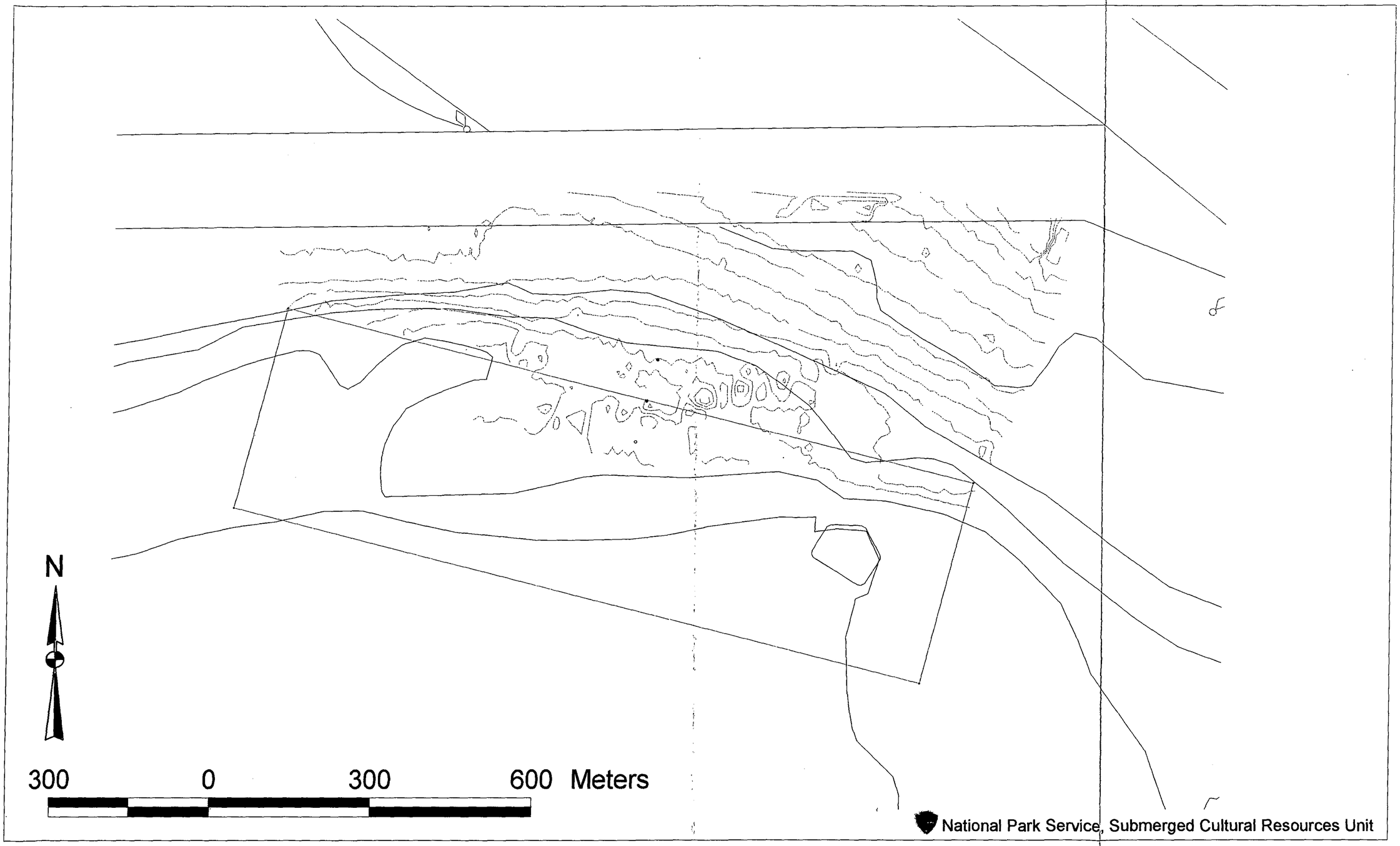


Figure 10. One meter bathymetric contours.

remains were surveyed in 1976 by Gulf South Research Institute, and placed on the National Register of Historic Places (GSRI 1976). FOSU would be the logical focal point from which to launch a thematic study to tie together widely-dispersed shipwreck sites historically connected to Fort Sumter.

The GIS project developed for this project has been produced to be seamlessly integrated into an existing or future park database. If a GIS database has not been created for the park, the present project can serve as a basis for adding additional data themes.

The FOSU submerged cultural resources survey is an example of a cost effective project utilizing available resources and involving interagency cooperation and government/ corporate partnerships. This project used an infrastructure maintained by SCRU through NPS's SAIP funding. Travel and per diem was funded by the NHC, which allowed SCRU to extend the project to complete the FOSU survey. In addition, the project benefitted from a substantial donation of time, equipment and personnel by side scan sonar manufacturer Marine Sonic Technology, Ltd.

DISTRIBUTION

Copies of this report and accompanying CD-ROM (including the ArcView GIS database and archived raw and processed survey data) were distributed to Fort Sumter National Monument and the Southeast Archeological Center (SEAC). In addition, it is standard SCRU practice to retain a copy of the report, GIS database and survey data at the SCRU office in Santa Fe, New Mexico, for archival purposes.

REFERENCES

Arnold, J. B., III and R. Weddle
1978 *The Nautical Archaeology of Padre Island: The Spanish Shipwrecks of 1554*. Academic Press, New York.

Arnold, J. B., III and C. J. Clausen
1975 A Magnetometer Survey with Electronic Positioning Control and Calculator Plotting System. *International Journal of Nautical Archaeology* 3:353–366.

Breiner, S.
1973 *Applications Manual for Portable Magnetometers*. EG&G Geometrics, Sunnyvale.

Gulf South Research Institute
1976 *Magnetic Survey of the* Star of the West (*Tallahatchie River, Greenwood Area, Mississippi*) GSRI Project No. 215–838–11. Ms. on file, Submerged Cultural Resources Unit, Santa Fe.

Hall, W.
1995 A Remote Sensing Survey for a Proposed Pipeline Route between Fort Johnson and Fort Sumter, Charleston Harbor, Charleston, South Carolina. In *Archaeological Testing of a Proposed Waterline Easement, Fort Johnson (38CH69), Charleston County, South Carolina*, by Eric C. Poplin and Todd McMakin. Brockington and Associates, Mount Pleasant.

Murphy, L. E.
1984 Phase I Remote Sensing Survey. In *Submerged Cultural Resources Survey of Portions of Point Reyes National Seashore and Point Reyes-Farallon IslandsNational Marine Sanctuary*, edited by Larry E. Murphy. Southwest Cultural Resources Center Professional Paper Number 1, pp. 85–140. National Park Service, Santa Fe.

1997a Shipwrecks, Satellites, and Computers: An Underwater Inventory of Our National Parks. *Common Ground* 1(3/4):47–51.

1997b Geographical Information System (GIS). In *Encyclopaedia of Underwater and Maritime Archaeology*, edited by James P. Delgado, pp.166–168. British Museum Press, London.

Murphy, L. E. and A. R. Saltus
1990 Consideration of Remote Sensing Limitations to Submerged Historical Site Survey. In *Underwater Archaeology Proceedings from the Society for Historical Archaeology Conference*, edited by Toni L. Carrell, pp. 93–95. Society for Historical Archaeology.

Murphy, L. E. and T. G. Smith
1995 Submerged in the Past: Mapping the Beguiling Waters of Florida's Biscayne and Dry Tortugas National Parks. *GeoInfo Systems* 5(10):26–33.

Pfanz, H. W.
1968 Letter from Acting Superintendent, Jefferson National Expansion Memorial, to Superintendent, Fort Sumter National Monument. On file, South Carolina Institute of Archaeology and Anthropology, Charleston.

Ragan, M. K.
1995 *The Hunley: Submarines, Sacrifice, & Success in the Civil War.* Narwhal Press, Charleston, S.C.

Shope, S. M.
1997 Magnetometer. In *Encyclopaedia of Underwater and Maritime Archaeology*, edited by James P. Delgado, pp. 253–254. British Museum Press, London.

Shope, S. M., L. E. Murphy and T. G. Smith
1995 Found at Sea: Charting Florida's Sunken Treasures. *GPS World* 6(5):22–34.

Smith, T. G.
1997 Geodesy. In *Encyclopaedia of Underwater and Maritime Archaeology*, edited by James P. Delgado, pp. 166. British Museum Press, London.

South Carolina Institute of Archaeology and Anthropology
1983 Underwater Site Information Summary Form, *Acteon* (38CH269). Ms. on file, South Carolina Institute of Archaeology and Anthropology, Charleston.