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Geographic Information Systems for Submerged Cultural Resource Managment

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Abstract

One of the most important aspects of effective data management is the ability to collect, store, and recall information. Traditionally submerged cultural resource managers have collected data in the form of literature, reports, photographs, maps, plans, and artifact collections. That type of information management system has been based on extensive hard copy files, a library of associated literature, and collections of historical and contemporary maps. Most state wide collections require considerable space and extensive personnel experience to function with any degree of efficiency. While those systems survive into the 21st century, the rapid development of Geographic Information Systems (GIS) provides managers with a highly effective tool for resource management. A GIS can eliminate the necessity for maintaining cumbersome hard copy collections and dramatically reduce the time it takes to identify and recall the data necessary to support management decisions.

During the past decade Tidewater Atlantic Research, Inc. (TAR) and the Institute for International Maritime Research, Inc. (IIMR) have developed a number of GIS projects for both state and federal submerged cultural resource management programs. An examination of the various attributes of the programs developed by TAR and IIMR provides insight into how valuable a tool it can be for submerged cultural resource management programs and site-specific investigations. A review of the programs also illustrates the beneficial nature of this computer-based system of data storage, recovery and analysis. In a climate when budgets and personnel are being reduced and in many cases management responsibilities expanded, the benefits of using GIS becomes readily apparent. The increased ease with which a GIS can be created and utilized makes that system an even more attractive tool today.

***Key words**: GIS, Submerged cultural resource management*

Both state and federal agencies legislatively mandate submerged cultural resource management responsibilities. The single most important element of a submerged cultural resource management program is the *Section 106 Review Process*. Sections 106 and 110(f) of the *National Historic Preservation Act of 1966* (as amended) require that agencies assess the effects of federal, federally-assisted or federally-permitted projects on properties included in, or eligible for inclusion in the National Register of Historic Places. The *Section 106* process was designed to address historic preservation priorities. Information assessment is the initial step in the *Section 106* review process. Because many of the activities of regional and local government agencies are permitted by state and federal agencies, submerged cultural management is also a shared responsibility.

Effective submerged cultural resource management programs require extensive site file collections, associated cartographic inventories, and report document libraries. Systems based on those collections take up considerable space, require ongoing curation and function best with an experienced staff. Most American site location systems are based on U.S. geological survey quadrangle maps. A single state requires dozens of quadrangle maps annotated with site locations. Site file records that accompany the mapped site locations require hundreds of data folders that are rarely cross-referenced. Associated survey and research reports contribute to extensive library holdings. At best, this combination of data sets is difficult to maintain and access.

A functional and highly effective alternative to traditional site files can be found in Geographic Information Systems. Geographic Information Systems (GIS) are computer-based programs that can store, recover, display and mathematically analyze spatially related data. A GIS is like a "smart map" in which selected graphic features have associated data base information (see fig. 1). Graphic images such as maps, site plans, drawings, photographs and even video can be linked to tabular and text data. Because GIS information is stored in a computer it can be accessed almost instantaneously. Although early GIS programs were cumbersome, complex and difficult to work with, today's versions are much more functional and simpler to use. The potential uses of GIS in submerged cultural resource management and underwater archaeological research appears almost limitless.

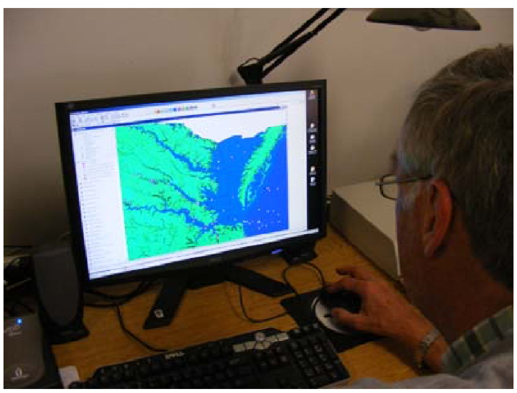

Figure 1. GIS "Smart Map" with associated wreck specific data base links.

Over the past 12 years, Tidewater Atlantic Research, Inc. and the Institute for International Maritime Research, Inc., have undertaken the development of a number of Geographic Information Systems for both regional and site-specific submerged cultural resource management and research. One of the first was constructed for the Charleston Harbor Project a five-year special area management plan developed to focus management attention on the impact of development on the Charleston Harbor estuary system, Charleston, South Carolina. A similar GIS was developed for the United States Army Corps of Engineers, Norfolk District to assist that agency with identification and management of submerged cultural resources in Hampton Roads and the James River. The Naval Historical Center in Washington, D.C. shares management responsibility for federally owned shipwrecks in state waters with a number of state agencies. To facilitate cooperative management, GIS were developed for shipwrecks in Virginia and Georgia. A state-wide submerged cultural resource GIS was developed for the Georgia Department of Natural Resources to address resources not included in the GIS prepared for federally owned and managed shipwrecks.

For over 300 hundred years, Charleston has been one of the most important seaports and maritime centers in the south. As a result, Charleston Harbor and the surrounding river systems became an important repository of submerged cultural resources. In order to better plan for development and identify impacts of construction activities the Charleston Harbor Project included a submerged cultural resource GIS that covered the harbor, Ashley, Cooper, Wando and Stono rivers (see fig. 2). The Charleston Harbor Project GIS included an analysis of known submerged cultural resources, as well as the identification of potentially sensitive archaeological areas. It provided resource managers with a quick and efficient means of accessing computerized data regarding submerged cultural resources in the project area.

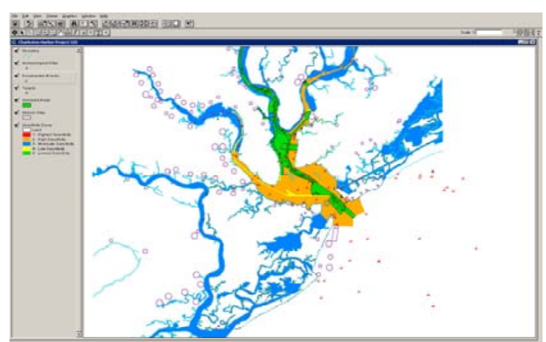

Figure 2. Geographical extent and sites identified in the Charleston Harbor Cultural Resource GIS.

In Virginia, the United States Army Engineer District, Norfolk, has the responsibility for maintaining and developing navigation channels in one of the most historically sensitive waterways in the United States. Since the first permanent English settlement was established at Jamestown in 1607, the James has been one of the most important river systems in the eastern United States. As a result of continuous development and the military activities associated with the American Revolution, the War of 1812 and the Civil War, the James River and its tributaries are an important repository of submerged cultural resources. Those resources preserve a significant physical record of national, regional and local maritime activity. To more effectively coordinate their historic preservation responsibilities the U.S. Army Corps of Engineers Wilmington and Norfolk districts, cooperated in the development of a long-term Historic Properties Treatment Plan for the James River Navigation Project (see fig. 3). The project area included the James River from below the fall line at Richmond to the Chesapeake Bay at Hampton Roads.

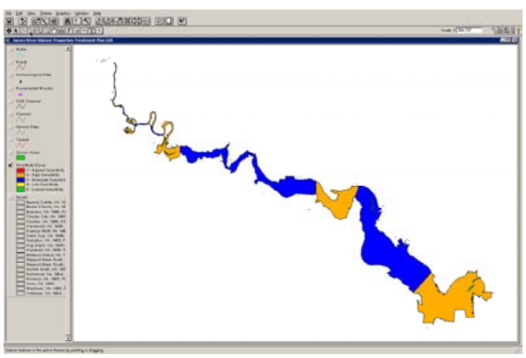

Figure 3. James River GIS submerged cultural resource sensitivity zones from Richmond in the west to Hampton Roads in the east.

Objectives of the Historic Properties Treatment Plan for the James River Navigation Project were to provide both a historical and cultural background for the James River, an inventory of known historic and archaeological resources, and the identification of priorities and methodologies for remote-sensing survey and archaeological research designed to locate and assess submerged cultural resources that could be impacted by continued maintenance dredging activity. In order to formulate a functional plan, the project design identified a series of priorities including the development of a submerged cultural resource management document, and a computer based Geographic Information System for the James River.

The State of Georgia and the Commonwealth of Virginia share submerged cultural resource management responsibilities with the Naval Historical Center (NHC) in Washington, D.C. The remains of federally-owned vessels, foreign warships and other vessels with sovereign immunity do not meet the criteria of abandonment as established in the *Abandoned Shipwreck Act of 1987*. However, accords negotiated with individual states and nations make protection and investigation of those vessels a responsibility of NHC and the states in whose waters they now lie. In order to develop and carry out effective management of those resources, resource specific GIS were developed for both Virginia (see fig. 4) and Georgia (see fig. 5). Both GIS focused on the wrecks of naval vessels and foreign ships with sovereign immunity in state and offshore waters. The Georgia Department of Natural Resources also contracted for a state-wide GIS that addressed submerged cultural resources other than shipwrecks owned and managed in concert with NHC.

The remains of the USS *Monitor*, one the first ironclad warships to be tested in combat, lie off the coast of North Carolina. After successfully engaging the Confederate ironclad CSS *Virginia* at Hampton Roads, Virginia on 9 March 1862, the John Ericsson designed warship sank in a gale off Cape Hatteras. In 1973, the remains of the *Monitor* were located and identified by a research team operating from the Duke University research vessel *Eastward*. Two years later the *Monitor* was designated as the nation's first Marine Sanctuary and the National Oceanic and Atmospheric Administration assumed management responsibility for the wreck. Although management of the *Monitor* National Marine Sanctuary involves a single shipwreck, that task requires storing, organizing and accessing volumes of data necessary to facilitate effective management and decision-making. In order to facilitate stewardship and research a site specific GIS was developed that included site plans, underwater photographs, video, historic engineering plans and an artifact catalog.

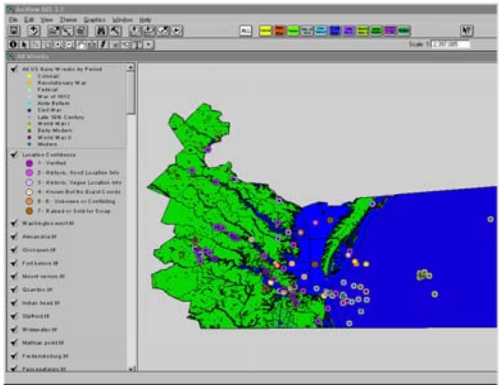

Figure 4. Geographical extent of the Virginia naval vessel GIS showing site distribution.

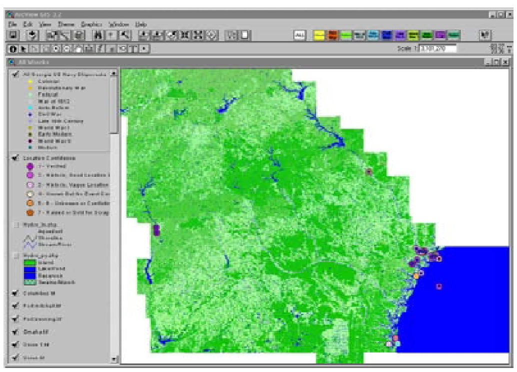

Figure 5. Geographical extent of the Georgia naval vessel GIS showing site distribution.

To construct these GIS, archaeologists and historians from Tidewater Atlantic Research and Institute for International Maritime Research used several computer software packages to construct the various GIS projects. AutoCAD by Autodesk, and ArcCAD 11.4, ArcView 3.2 and ArcGIS 9.2 by Environmental Systems Research Institute were the main GIS construction tools. Image processing software developed by Hitachi was also employed. ArcView 3.0 and ArcGIS 9.2 provided the principle means of displaying and analyzing GIS data in a user-friendly environment. With this program, archaeological data, historical literature and images could be retrieved, displayed, and analyzed almost instantaneously. The programs are easy to use, relatively inexpensive and can be installed on virtually any modern PC or Apple computer.

With the exception of the GIS developed for the *Monitor* National Marine Sanctuary, all of the GIS projects were based on readily available maps and charts. The base maps were downloaded from Virginia and Georgia GIS sites. Accurate shorelines developed for natural resource and conservation management provided excellent representations for overall site location identification (see fig. 6). Each GIS also included digital USGS 7.5 Minute Topographic maps that covered the waterways where submerged cultural resources were known or anticipated. Zooming in to specific areas automatically brought up the associated quadrangle maps (see fig. 7).

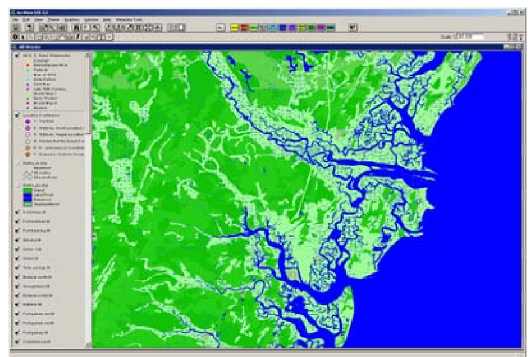

Figure 6. Georgia shoreline GIS basemap detail.

Rather than performing manual searches, each GIS was constructed to allow computerized site information to be accessed by selecting on-screen symbols displayed against the digitized quadrangle maps (see fig. 8). Information regarding identified archaeological and historic sites, past and present channel alignments, dredge cuts, known wrecks and obstructions, archaeological surveys, remote-sensing targets, and submerged cultural resource sensitivity zones were all available.

Known sites were identified by circular symbols. Each site location was dual color-coded to expedite data interpretation (see fig. 9). The first color code, designated by the inner circle, represented the chronological designation for the time period in which the ship sank. The center of each circle was located in accordance with the best coordinates available for each individual site. The second site-specific designation was the outer-colored circle. The color of this circle depicts the confidence in

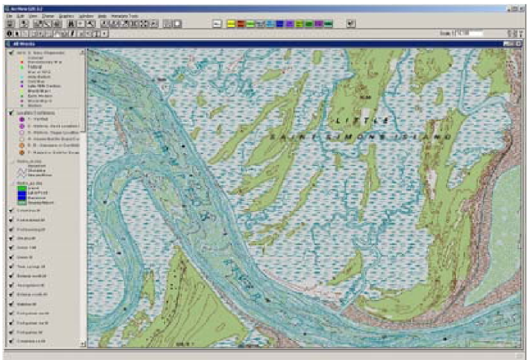

Figure 7. Georgia digital quadrangle map detail opened by zooming into specific areas of interest.

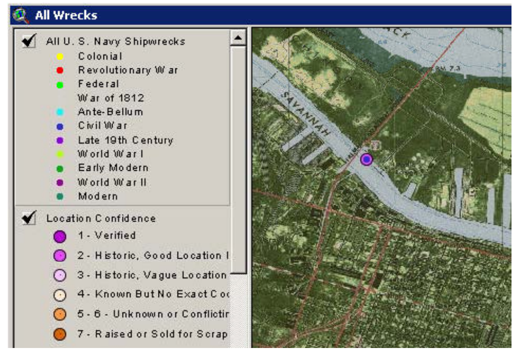

Figure 9. Georgia GIS wreck symbol color code for quick reference to historical period and location data confidence.

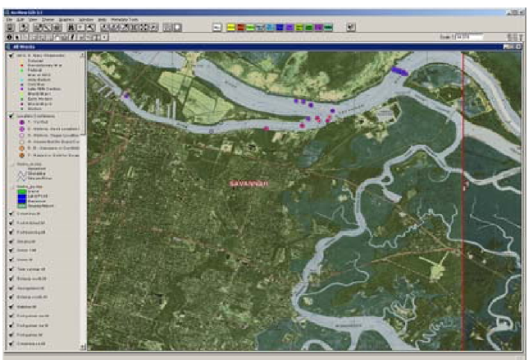

Figure 8. Quadrangle level view of Savannah, Georgia with historic shipwreck location symbols.

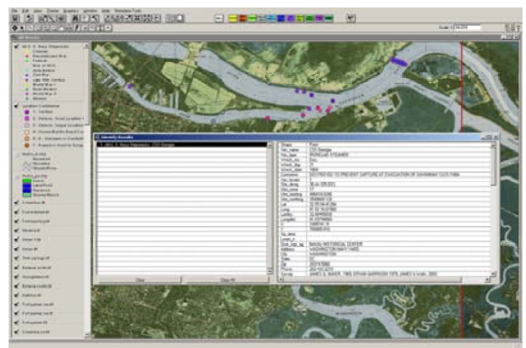

Figure 10. Quick reference data base information associated with wreck specific symbols.

and source of the information used to locate the vessel in the GIS. Querying the wreck period designation or location confidence theme with the identify tool displayed data from the database used to create the GIS in a tabular format (see fig. 10).

To make accessing associated information much more efficient and user-friendly, a script was created to allow the use of the ArcView/ArcGIS hotlink tool to access a site-specific Adobe Acrobat report. Those reports include information from the database in an easy to interpret format. They also include other available information such as photographs (see fig. 11), ships plans, historic maps (see fig. 12), archaeological reports, reference materials (see fig. 13), and sidescan sonar images (see fig. 14).

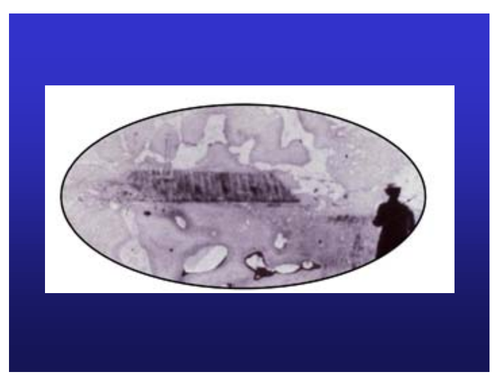

Figure 11. Image of a Confederate ironclad, possibly CSS *Georgia*.

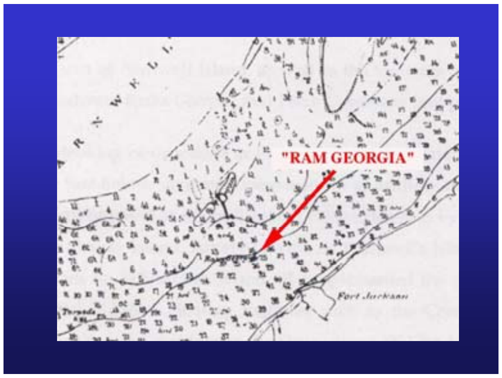

Figure 12. Digitized image of a historical map showing the location of CSS *Georgia*.

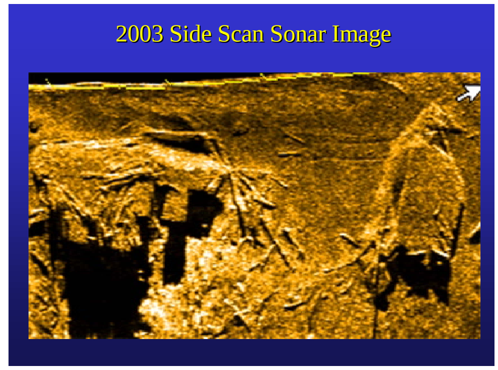

Figure 14. Digital sonar image of the remains of CSS *Georgia* accessed through the GIS.

Figure 13. Digital copy of a report on CSS *Georgia* accessed through the GIS.

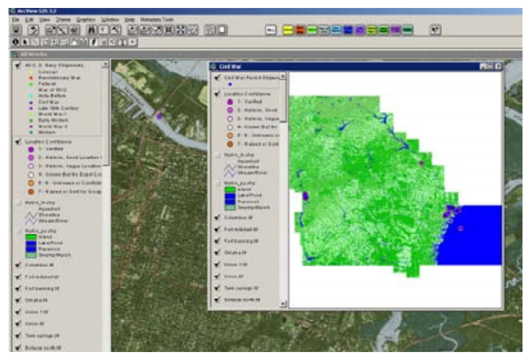

Figure 15. View options for the Georgia naval vessel GIS.

In order to facilitate the viewing of period-specific subsets of sites, scripts were written and separate views were created in which only wrecks from each chronological period are displayed. These separate views could most readily be accessed through the use of the buttons on the right side of the top toolbar. The views could also be accessed directly from the view list (see fig. 15).

In addition to identified wreck sites and historically documented, but not located vessel remains, each GIS identified areas of submerged cultural resource sensitivity. Those areas were designated on the digitized quad maps using colored polygons that conformed to the navigable waters of each state. By overlaying the various historic, archaeological, dredging, and remote-sensing survey coverages, the relationship between areas of historic significance, the level of possible site disturbance, as well as the level of archaeological survey could be compared. While the random nature of vessel losses associated with storms and other unpredictable catastrophes cannot be fully quantified, an examination of the historical record associated with settlement patterns, regional economics, and the environment provided insight into areas of potentially high sensitivity for associated submerged cultural resources. Sensitivity ratings assigned to various areas of the GIS project included: 1) highest sensitivity (National Register eligible sites), 2) high resource sensitivity 3) moderate resource sensitivity, 4) low resource sensitivity, and 5) lowest resource sensitivity (areas that had been surveyed and reliably demonstrated not to contain potentially significant submerged cultural resources) (see fig. 16).

Areas disturbed by dredging and channel maintenance activities were also identified in the GIS (see fig. 17). Those activities are well documented in the Annual Reports of the Chief of Engineers. Polygons based on Corps activity and permits defined the limits of bottom disturbing activities. Similar polygons identify areas that had been surveyed for submerged cultural resources. By querying the polygon, the GIS was designed to bring up a digitized version of the survey report and geo-referenced magnetic contour maps and sonar mosaics.

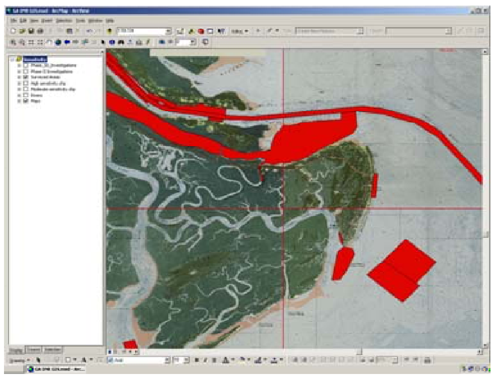

Figure 16. Areas previously surveyed for submerged cultural resources identified in the Georgia naval vessel GIS.

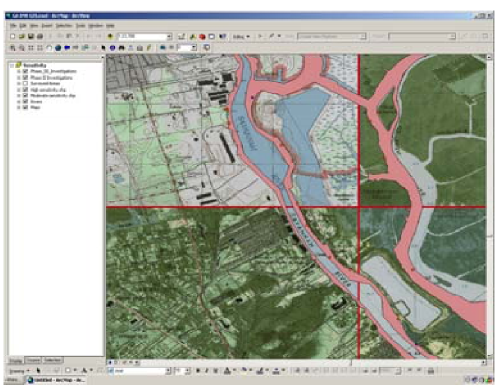

Figure 17. Savannah River sensitivity zone with dredged channels excluded.

The *Monitor* National Marine Sanctuary GIS was developed for the National Oceanic and Atmospheric Administration, and represents one of the first attempts to realize the potential of GIS technology for site-specific archaeological research. The system was designed to store and display archaeological and historic data associated with the remains of the USS *Monitor*. The GIS was based on the geographical location and extent of the sanctuary (see fig. 18).

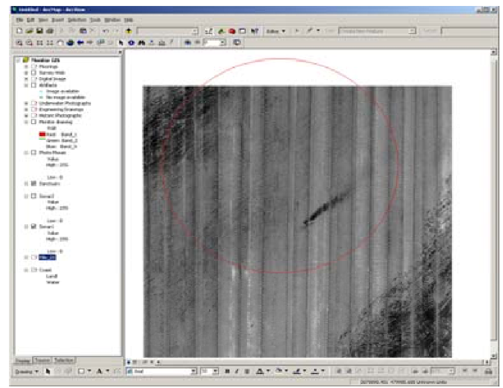

Figure 18. Digital sonar mosaic showing the bottom conditions in the *Monitor* National Marine Sanctuary.

The *Monitor* GIS included two sanctuary specific coverages. The first, comprised a circle representing the one nautical mile in diameter sanctuary boundary. The center of this circle was located in accordance with the coordinates established by the U.S. Congress for the sanctuary. The second coverage comprised a sonar mosaic of the sanctuary compiled in 1985. In order to generate a GIS coverage and plan view of the *Monitor*, a photo mosaic of the wreck was digitized. When scaled and rotated, the resulting CAD drawing was used to develop GIS coverage of the wreck and its main features (see fig. 19). Data supplied by NOAA was employed to locate the wreck in real world coordinates. Historic engineering drawings along with the known dimensions of features such as the turret and armor belt were used to scale and manipulate the raster image. The scale, location and orientation of all subsequent GIS vector and raster coverages of the *Monitor* were controlled using the same coordinates and assumptions.

One of the key elements in the *Monitor* National Marine Sanctuary GIS was the development of a spatially-related artifact inventory (see fig. 20). This coverage identified the location of all artifacts that had been recovered from the wreck since on-

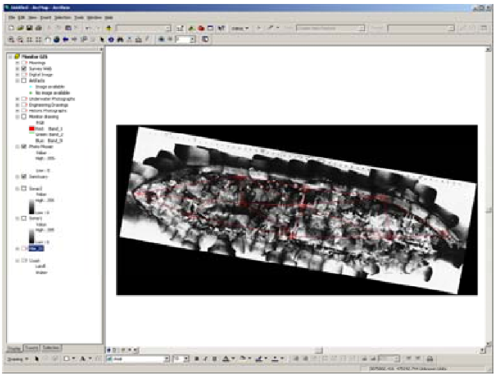

Figure 19. 1974 image of the *Monitor* used as the basis for the wreck specific GIS.

site investigation began in 1973. The location of each recovered artifact was entered into the GIS and represented by a symbol. By selecting the symbol the end user was then able to access data base information including provenience, condition, date recovered, associations, as well as drawings and photographic images pertinent to the artifact.

In order to demonstrate the further potential of GIS for managing site-specific data within the *Monitor* National Marine Sanctuary, coverages linked engineering drawings, historic photographs and underwater photographs to appropriate areas of the wreck. As the *Monitor* GIS is developed, the entire spectrum of data associated with the vessel's historic career, archaeological investigation, and engineering efforts to recover material from the wreck, or perhaps the wreck itself, can be stored within the framework that has been established.

Geographic Information Systems are proving to be valuable management tools for both cultural resource managers and site-specific investigations. These systems are being used to preserve, store, display, and analyze multivariate spatial data sets, and to access instantaneously information which was hitherto often difficult or cumbersome to acquire. Yet the potential uses for GIS in archaeology far exceed any goals thus far realized. As with any technological advancement, user adaptation has been slow, but through continued development and research, GIS implementation will prove to be extremely beneficial. One of the most important aspects of GIS use, is that design, implementation, and maintenance become part of an ongoing process that constantly expands and updates the system. Once the geographical foundation has been developed, the amount of data that can be associated with specific features is limited only by ever expanding computer capacity. GIS will no doubt be adopted as the primary reference for Section 106 decision-making.

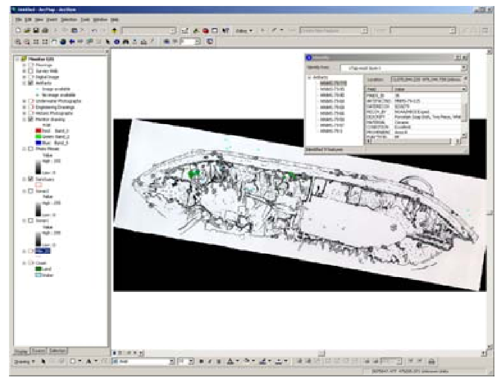

Figure 20. GIS illustration of the distribution of recovered artifacts and associated data base information that includes object images and description data.

While GIS will probably never entirely replace hard copy site documentation, the continued development and use of this technology in site-specific research appears inevitable. Excavation and documentation records lend themselves to coverages that can be sufficiently complex to build an electronic image or reconstruction of the entire site. Specific diagnostic features can be linked to detailed drawings, photographs, historical records, literature references and data from comparative sites. Artifacts, samples and other material associated with on-site features can be cataloged in association with those features. Artifact photographs, drawings, and historical and comparative analytical data can be tied to specific symbols associated with layers of the master site plan. As more archaeological sites are preserved in GIS format an increasing number of cultural resource managers will adopt spatial databases to enhance their effectiveness. The widespread adoption of GIS will also increase opportunities for inter-site and intra-site comparative analysis.