GIS and Underwater Archaeology
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Introduction
In its broadest sense, archaeology is the study of the human past through physical remains. Information about the location and orientation of archaeological sites and artifacts in relation to each other and the world must be known for the archaeologist to interpret and analyze them effectively. GIS has therefore developed into an essential tool for archaeology. The use of GIS for terrestrial archaeology has however surpassed that of underwater archaeology over the past twenty years in both theory and practice. This is a curious paradigm; in some ways underwater archaeological sites are more complex and are in greater peril, as they are increasingly influenced by coastal development, recreational activities, and a host of other natural and anthropogenic impacts, and are therefore in need of a comprehensive strategy for research, conservation and management. This paper presents the development of GIS for terrestrial archaeology and examines how lessons learned in this arena can be applied to GIS and archaeology underwater.

Terrestrial archaeology
Terrestrial archaeology relies on a plethora of data sources that are inherently tied to changes in physical space over some period of time [Limp 2001]. These sources include, but are not limited to, the use of landscape data, such as topography and land cover [Llobera 2001; Davis et al. 1997], environmental information, such as vegetation communities and their pollen deposition and dispersal [Fyfe 2005], remote imaging, such as aerial photography and spaceborne imaging radar data [Neubauer 2001; Holcomb 2001], geophysical prospection, such as magnetic susceptibility, resistivity, and ground penetrating radar [Aubry et al. 2001; Neubauer 2001], and of course the more traditional excavation. Time periods over which archaeologists study changes in can vary from days to millennia.

The use of maps with some simple computer programs and datasets, such as digital elevation models (DEMs), began in the early 1970s, and led to the utilization of GIS for archaeology in the 1980s. One of the primary purposes in the early days of GIS was to inventory large numbers of sites for both research archaeology and cultural resource management. The use of map-based datasets was viewed to be a useful and intuitive way to represent large amounts of geospatial data [Wheatley & Gillings 2002]. Analysis and computation soon followed the simple visualization of sites as archaeologists wanted to answer more analytical questions, such as statistical distribution of sites, landscape visibility, environmental factors leading to settlements, regional variations over time, and modeling land use [Maschner 1996; Brandt et al. 1992; Kvamme 1990; Fry et al. 2004]. For example, one might look at the locations of rivers and fertile soils to predict the positions of prehistoric settlements [Harris 2002]. Today, GIS is assisting archaeologists in location models and prediction, environmental reconstruction, catchment and territorial analysis, viewshed analysis and cognitive analysis [Wheatley & Gillings 2002].

Underwater archaeology
Alongside the development of GIS over the past twenty years, advances in marine technology have revolutionized underwater archaeology. We now have a suite of geophysical tools and remotely operated vehicles (ROVs) that are capable of collecting
gigabytes of data per day. Unfortunately, these tools are not widely available to the archaeological community, and there are few underwater archaeologists able to process and use their resulting data; as a result, GIS seems to have remained in the ‘inventory’ phase of development when used for underwater archaeology. Like GIS and terrestrial archaeology in the 1980s, most archaeological GIS databases today tends to focus on inventory, cultural heritage management and hazard avoidance.

Datasets that are crucial for underwater archaeology are extremely diverse. One of the most important on a large-scale is geophysical survey. Multibeam sonar, side scan sonar, sub-bottom profilers and magnetometers are all used for archaeological surveys, each providing different advantages and disadvantages in terms of resolution, efficiency, and cost. Video and still imaging with ROVs is a more familiar way of visualizing sites, but can only be used for small-scale applications. Environmental data such as sediment type, water temperature, salinity, and dissolved oxygen are important factors in the potential preservation of a site. Excavated artifacts must be catalogued, described, and conserved. GPS and underwater navigation systems, such as long baseline, short baseline and ultrashort baseline, are used to tie data into real-world coordinates. Finally historic records such as maps and charts must also be incorporated to put sites into a historic and archaeological perspective.

All of these types of data are easily imported into a variety of GIS software packages, yet quality databases with most of these data are few and far between. National databases, such as the Automated Wreck and Obstruction Information System (AWOIS) in the US [OCS 2002], the National Inventory of Maritime Archaeology for England (NIMA) [RCHME 1996], and the National Monuments Record of Scotland [Oxley 2001], for example, simply consist of a point (Lat/Lon) and, at times, a brief historic description of the site. There is little or no information about the environment, let alone imagery or geophysical data. Granted, oceanographic data is difficult and expensive to collect, but there is a great deal that has been collected to date; archaeologists must make an effort to synthesize already existing data with their research to create more comprehensive, georeferenced maps that can be used for more analytical purposes.

The future of GIS and underwater archaeology

The future of GIS and archaeology lies in three areas: the further development of underwater archaeological GIS databases to include more environmental, geophysical, and image-based data; the synthesis of terrestrial and underwater datasets; and, the use of GIS for more rigorous archaeological analysis, such as three-dimensional and object-oriented GIS and a merge with virtual reality for modeling and simulation [Mather & Watts 2002; Lock 2002; Wheatley & Gillings 2002]. These analytical applications will however be severely hindered if data and metadata are not standardized within the archaeological community; underwater archaeologists should therefore work toward an open-GIS based system that allows for sharing of archaeological, oceanographic and geographic resources.
References


Annotated bibliography


Harris presents an excellent overview on the use of GIS for archaeology. He first reviews the types of data that could be used for an archaeological database and then goes on to describe various ways in which a GIS could be applied. In particular, these applications include viewshed analysis, three-dimensional imaging, landscape changes over time, archaeological site prediction, and virtual reality. This paper is brief, yet informative, and provides a number of images that effectively illustrate the applications about which Harris writes.


Maschner’s book provides a compilation of papers that describe theory and application of GIS for archaeology in the mid-1990s, by both GIS developers and users. Some topics include data analysis and visualization; cost surfaces, viewshed, and site catchments; and, site location and environmental modeling. Of particular interest are the first and last chapters, which describe the state of GIS in archaeology in 1996, and the theory, technology and future of GIS and archaeology ten years ago. Worthy of note is that many of the ‘problems’ at that time have now been overcome, while some of the noted future research areas have yet to be realized.


This article broadly overviews the use of GIS for underwater archaeology, and presents four applications: survey, cultural resources management, site-specific investigations and predictive modeling and exploratory data analysis. Mather and Watts first give a brief history of GIS and underwater archaeology, and describe types of data, hardware and software that can be used. They then describe the four aforementioned applications of GIS, using case studies where possible; the primary focus lies on cultural resource management and site-specific investigations, largely because of a dearth of underwater archaeological projects that have comprehensively integrated survey data with their research, and projects that have employed rigorous analysis and predictive modeling.


The National Ocean Service (NOS), a division of the National Oceanic and Atmospheric Administration (NOAA), implemented the Automated Wreck and Obstruction Information System (AWOIS) in 1981. The purpose of this database was to catalog and store reported wrecks and obstructions that are considered navigational hazards in the US. Sites are allocated a unique 5-digit AWOIS number, a name, NOAA chart number, area, cartographic code, depth, geographic position, and history/reference information. The database can be searched using Microsoft Access, or through a pdf document. Although
it is intended for navigational purposes, this resource can and should be used by archaeologists, as it is the most comprehensive database of underwater archaeological sites in US internal and territorial waters.


This paper is effectively a proposal to undertake a large-scale cultural resource management project using GIS. Oxley introduces the problem through describing the prevailing shipwreck management issues, contemporary approaches for solving them, Scotland’s underwater archaeological resource, and the surrounding administrative and legal frameworks in which he must work. He then presents his proposal for undertaking research in cultural resource management on three levels – national, regional, and local – and the ways in which he plans to accomplish his goals. Central to his proposal is the development of a comprehensive, integrated GIS that would allow for complex analysis of data, relationship examination between different types of datasets, and site interpretation for lay audiences.


Although now three years old, this book seems to be the most up to date and thorough presentation of GIS in archaeology. To do so, Wheatley and Gillings describe the relationship between archaeology and GIS, including georeferencing, spatial databases, and acquiring and integrating data. They then go on to explore ways in which GIS can be used to manipulate and analyze geospatial data for archaeology, including the use of digital elevation models, quantifying spatial patterns, modeling and prediction, interpolation, and visibility analysis. A work such as this would not be complete without a chapter on cultural resource management and future directions of GIS and archaeology. Wheatley and Gillings provide the most technical, yet understandable, contribution to the field that I have discovered thus far.