A GIS-BASED MODEL FOR PREDICTING THE LOCATION OF SUBMERGED PREHISTORIC ARCHAEOLOGICAL SITES IN NEW YORK HARBOR

A Final Report to the Tibor T. Polgar Fellowship Program

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Merwin, D. and D. Bernstein. 2003. A GIS-Based Model for Predicting the Location of Submerged Prehistoric Archaeological Sites in New York Harbor. Section VII: 24 pp. *In* J.R. Waldman & W.C. Nieder (eds.), Final Reports of the Tibor T. Polgar Fellowship Program, 2002. Hudson River Foundation.

ABSTRACT

The Hudson River has been the focus of human activity for millennia, from the earliest colonization by Native American peoples approximately 12,000 years ago to modern times. The archaeological resources of the estuary and surrounding lands are very rich, diverse, and have significant research potential. However, a portion of the prehistoric human record of the lower Hudson River Valley is virtually invisible using traditional archaeological methods. Sea level rise has resulted in the submergence of land which was once habitable by prehistoric peoples, especially in the area around New York Harbor and portions of the Atlantic Ocean adjacent to the Hudson Canyon.

The spatial analysis capabilities of GIS (Geographic Information Systems) are well-suited to investigating the problem of locating submerged prehistoric archaeological sites. In this study, the patterning of known terrestrial archaeological sites was used to assess underwater archaeological potential in and around New York Harbor. Computer models developed from a GIS database of terrestrial archaeological site information revealed geographical relationships, and identified a suite of landscape features (e.g., distance to fresh water, distance to lithic resources, slope, aspect, and soil type) that best characterized the location of most prehistoric sites. This suite of features, along with a consideration of site preservation factors and post-depositional processes, was then used to identify areas of high sensitivity for the presence of submerged prehistoric sites. Future work will entail the investigation of high sensitivity areas with remote sensing techniques and scuba diver inspection.

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INTRODUCTION

The Hudson River has been the focus of human activity for millennia, from the earliest colonization by Native American peoples approximately 12,000 years ago to modern times. The archaeological resources of the estuary and surrounding lands are rich, diverse, and have significant research potential. Several authors have developed cultural historical frameworks for understanding human adaptations to the changing Hudson River landscape through time based on extensive archaeological surveys and excavations along the river's banks (Claassen 1995; Eisenberg 1978; Funk 1976; Kraft 1991; Ritchie and Funk 1973; Salwen 1975). However, a portion of the prehistoric human record of the lower Hudson River Valley is virtually invisible using traditional archaeological methods. Sea level rise has inundated portions of the continental shelf that are likely to have witnessed prehistoric occupation, especially in the New York Harbor region and areas of the Atlantic sea floor adjacent to the Hudson Canyon.

Researchers have long recognized the potential for the presence of prehistoric sites on the inner continental shelf in eastern North America (Cockrell 1980; Emery and Edwards 1966). Large expanses of the continental shelf in North America were dry during the last glacial maximum, about 20,000 years ago (Figure 1). During the Late Pleistocene and Early Holocene, water from melting glaciers caused global sea level rise, flooding portions of the continental shelf. Global seas have risen 90 to 130 meters over the last 18,000 years, drowning what was once inhabitable land and presumably countless archaeological sites. Rates of sea level rise have varied through both time and space, but slowed by 6,000 to 3,000 years ago, when shorelines were close to their current positions in eastern North America (Oldale 1986). The significance of lower sea levels for archaeological research is that models regarding prehistoric lifeways for any period prior to the establishment of the modern coastline are not complete without a consideration of the total exposed land mass.

Archaeological sites submerged by rising sea levels following the last glacial maximum may be an invaluable source of information regarding Native American

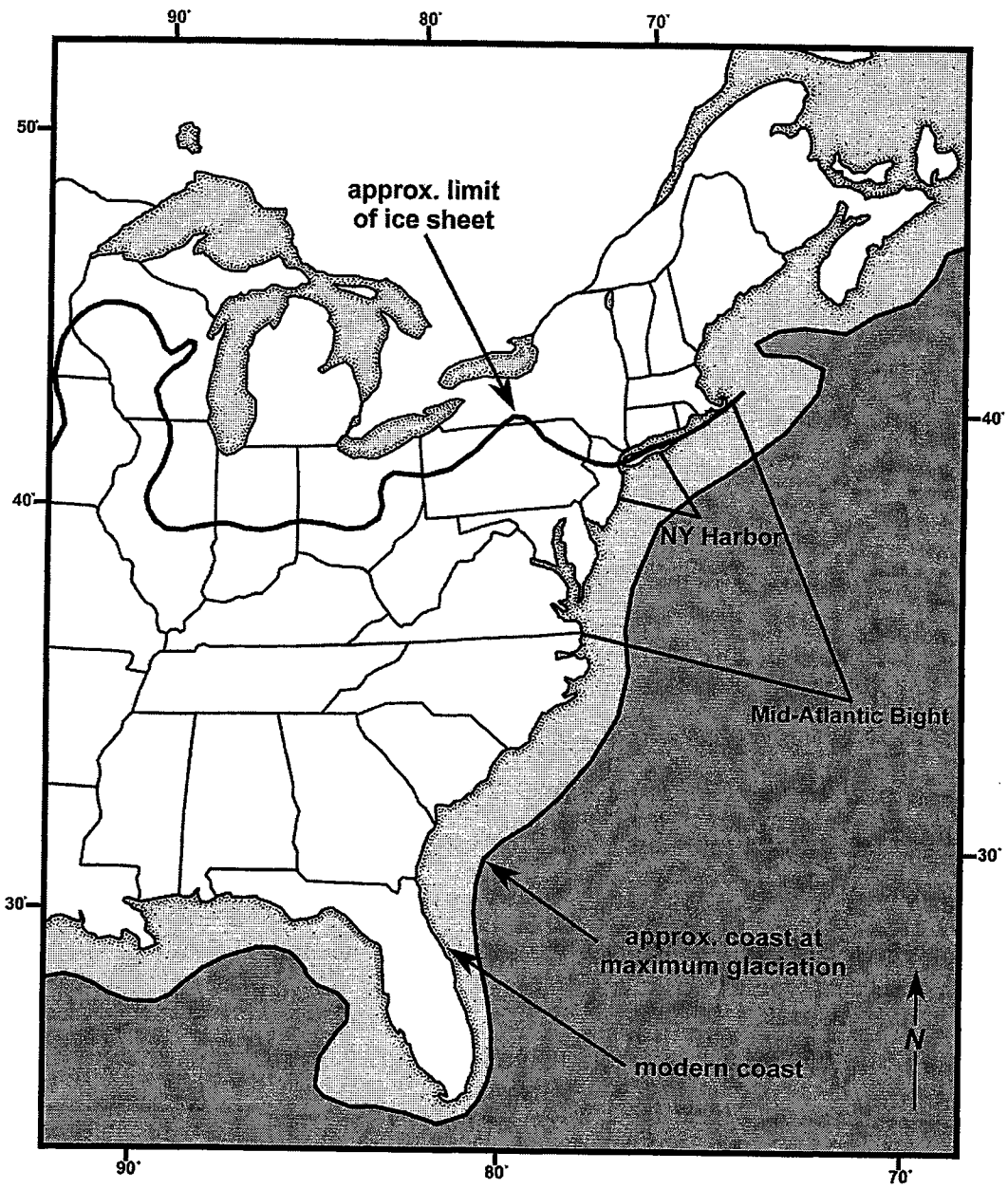

Figure 1. Location of the New York Harbor study area within the Mid-Atlantic Bight.

subsistence and settlement patterns. Compared with their dry-land counterparts, underwater prehistoric sites typically present more challenges in terms of discovery, excavation, and interpretation, mainly as the result of natural and cultural post-depositional processes. This project uses Geographic Information Systems (GIS) computer technology to predict the most likely locations for submerged prehistoric sites in the New York Harbor region.

Since the 1970s, when cultural resource management studies became mandated by law in the United States, several projects have been undertaken to assess the archaeological potential of the continental shelf (e.g., Barber 1979; Coastal Environments 1977). Though these pioneering studies produced predictive models regarding the location of submerged prehistoric sites, application of these models is difficult due to their complexity and high number of parameters. Factors considered by these models include the environmental characteristics and locations of known terrestrial and underwater sites; channels, current and bathymetric features; and potential for undisturbed context following marine transgression. These types of data may now be organized in a GIS framework, facilitating spatial analysis in a far less cumbersome way than was possible in the past.

Site Patterning Hypothesis

The seeming paucity of archaeological sites dating to the Early and Middle Archaic periods (approximately 10,000 to 6,000 B.P.; Table 1) in eastern North America has prompted some researchers to suggest that this time was marked by a decrease in population size and settlement after the end of the Late Pleistocene (e.g., Fitting 1968; Snow 1980). The start of the Late Archaic period (circa 6000 to 3000 B.P.; Table 1) is marked by apparent population growth, reflected by an increase in the number of known archaeological sites and an increase in site size and variety. The Late Archaic period is roughly coincident with slowing rates of sea level rise and the establishment of the modern coastline. Late Archaic period lifeways in the southern New England/northern Middle Atlantic region have a significant coastal component, characterized by the

Table 1. Prehistoric chronology for the New York Harbor region.

Period	*Dates*	*Common Projectile Points*
Late Woodland	1000 - 500 B.P. Late Holocene	triangular (Clarke, Levanna, Madison, Potomac, Roanoke)
Middle Woodland	2000 - 1000 B.P. Late Holocene	Jack's Reef, Selby Bay/Fox Creek
Early Woodland	2700 - 2000 B.P. Late Holocene	Adena, Calvert, Rossville
Transitional	3000 - 2700 B.P. Late Holocene	small stemmed; fishtail (Orient)
Late Archaic	6000 - 3000 B.P. Mid-Holocene	side-notched (Brewerton, Halifax, Otter Creek); stemmed (Bare Island/Lackawaxen, Holmes, Lamoka); broad (Koens-Crispin, Perkiomen, Savannah River, Susquehanna); triangular (Squibnocket)
Middle Archaic	8000 - 6000 B.P. Mid-Holocene	stemmed (Guilford, Merrimack, Morrow Mountain, Neville, Stanley, Stark); side-notched (Brewerton, Halifax, Otter Creek)
Early Archaic	10,000 - 8000 B.P. Early Holocene	corner-notched (Kirk, Palmer); side-notched (Hardaway, Kessel); bifurcate base (Kanawha, LeCroy, St. Albans); stemmed (Kirk)
Paleoindian	12,500 - 10,000 B.P. Late Pleistocene	fluted (Clovis, Cumberland, Dalton, Hardaway)

presence of shell middens, especially towards the latter part of the period when sea levels were closest to current positions (Braun 1974).

The hiatus model for the Early and Middle Archaic periods, followed by population growth during the Late Archaic, is based upon the terrestrial archaeological record. However, archaeological sites dating to the Early and Middle Holocene are now submerged on the formerly exposed portions of the continental shelf. Our hypothesis is that the coastal plain of the Middle Atlantic region was attractive to prehistoric hunter-gatherers, and that early subsistence and settlement patterns likely had significant coastal components that have been obscured by sea level rise. As archaeological sites dating to this period are documented for the coastal plain, the hiatus model becomes less tenable. Identification of Early and Middle Archaic sites in formerly unsurveyed areas such as the

continental shelf will allow us to fill substantial gaps in our knowledge, and explore issues such as the origins of coastal adaptations, settlement and mobility strategies at the coast versus inland, and possibly variation in human subsistence patterns.

Research Potential of Submerged Site Archaeology in New York Harbor

Despite the problems of site identification and the technological issues associated with conducting research under water, the potential to recover significant archaeological data is high. Preservation of organic materials such as bone, wood, leather, textiles, and basketry can be much better in waterlogged deposits than typical for the acidic, sandy soils that characterize much of the Northeast. Another potential benefit of submerged prehistoric material, especially artifact scatters lacking temporally diagnostic tools or dateable materials, is that the site can be assigned a relative date based on water depth and local sea level curves.

To date, submerged prehistoric sites have been found most frequently through accidental discovery, usually by fishermen or during construction. However, it is possible to systematically search the sea floor for prehistoric remains with positive results (e.g., Faught and Latvis 1999). Virtually all archaeological survey work is based on the assumption that sites are not randomly distributed around the landscape (Jochim 1981). Instead, prehistoric hunter-gatherer site patterning is related to environmental characteristics such as slope, aspect, drainage, and other terrain features (Bettinger 1980). Moreover, site patterning is also connected with the location of resources, including fresh water, food, and lithic raw material (for making tools). These resources, in turn, are expected to occur in a manner related to the paleogeography of the submerged coastal plain. Identification of favorable landscape features such as stream channels and lithic sources, where large sites are most likely to occur, will focus the search for submerged prehistoric archaeological deposits.

In the New York Harbor region, favorable environmental features used to predict the location of submerged prehistoric sites include former river channels (most notably the Hudson Canyon), embayments, and bedrock outcrops or other sources of raw

material. Models to predict the location of underwater prehistoric sites based on the location of known terrestrial sites can be refined using the spatial analysis capabilities of GIS. In addition, GIS can be used to organize georeferenced images such as bathymetric charts and remote sensing data, as well as tabular and graphic information from cores and other sampling methods. GIS-based predictive models have been shown to be useful for predicting the location of archaeological sites on land (e.g., Wescott and Brandon 2000).

That submerged prehistoric sites do exist in the New York Harbor region is suggested by two factors: the density and diversity of known archaeological resources on land adjacent to this section of the Hudson Estuary, and the recent accidental discovery of a submerged prehistoric deposit during a dredging project east of Sandy Hook, New Jersey (Figure 2). This deposit, known as the Corcione collection, consists of more than two hundred stone artifacts, including 24 Early, Middle, and Late Archaic period projectile points (dating between 10,000 and 3,000 years B.P.), 74 bifacially-worked tools, and 109 unmodified flakes (produced during stone tool manufacture). The Corcione collection is the largest prehistoric assemblage recovered to date from the submerged coastal plain in eastern North America north of Florida (cf. Stright 1990).

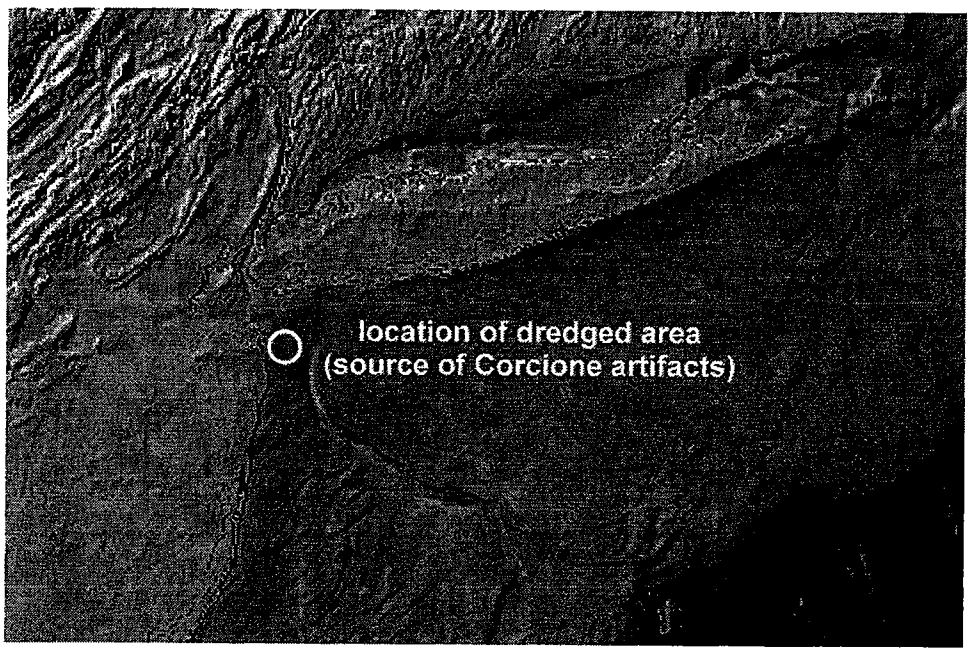

Figure 2. Offshore source of the Corcione artifacts. Note proximity to Hudson Canyon.

METHODS

The spatial analysis capabilities of GIS are well-suited to investigating the locations of submerged prehistoric sites. In order to assess the archaeological potential of the New York Harbor region, several factors must be considered. First, land forms that are most conducive to prehistoric utilization are identified, based on the patterning of known terrestrial archaeological sites. Next, remnants of these optimal land forms are sought underwater, incorporating data pertaining to the geography of the coastal zone, sea level fluctuations, coastal system morphology, and sedimentation. Areas with the highest potential for site preservation are more closely investigated with remote sensing techniques (e.g., side-scan sonar, sub-bottom profiling). Where possible, divers are deployed to ground-truth targets identified by remote sensing. This staged methodology has been effective for locating prehistoric sites in the Gulf of Mexico (Faught and Latvis 1999; Stright 1986).

In this paper, the preliminary results of the first phase of this long-term research project, construction of a GIS-based model of prehistoric land use patterns, are described. This work is ongoing, and is being conducted at the GIS Laboratory housed in the Department of Anthropology, State University of New York at Stony Brook. Software available at the GIS Laboratory includes Erdas Imagine 8.5 (for imagery analysis, image rectification, and georeferencing) and ArcGIS 8.1 (for organizing geographical data, spatial analysis, and developing a predictive model for submerged prehistoric site location).

A total of 53 USGS 7.5 minute series topographic maps (from New York and New Jersey counties surrounding New York Harbor) was digitally scanned, georeferenced, and stitched together to provide a base map for the GIS project. Most of the quadrangles were produced using the North American Datum (NAD) of 1927, so this projection was retained when the maps were georeferenced using United Transverse Mercator (UTM) as the coordinate system.

The archaeological data are housed at the New York State Office of Parks, Recreation, and Historic Preservation in Waterford and at the New Jersey State Museum in Trenton. Although both states are working towards maintaining their archaeological site files using GIS, the information is currently in the form of annotations on paper USGS quad sheets linked to site inventory forms by unique site numbers. In addition to site location, data collected for each archaeological site (where possible) included site age, site type, and contents. These data were organized in a database (attribute table) associated with a GIS point coverage, where each point plotted on the topographic base map represented the location of the site's center.

Several problems inherent in the archaeological site files became apparent at the start of this study. Importantly, many of the documented sites were reported prior to the mid-twentieth century (e.g., Cross 1941; Parker 1920), when radiocarbon dating became available. While exact dates for these sites are unknown, early recorded sites tend to be biased in favor of late prehistoric burials and fortifications and other earthworks, which have little relevance to understanding Archaic period settlement patterns, the goal of this study. Further, the exact location of many early documented sites in New York and New Jersey is unknown, limiting their usefulness in a GIS-based model.

Another problem encountered with many sites regardless of date reported was incomplete site inventory forms; a number of sites are documented solely by name and location, with no information on contents or even a rough age estimate. Dozens of sites were eliminated from the project database because of these problems. Data from a total of 186 archaeological sites from counties in New York and New Jersey were used for this study (Figure 3).

The relative paucity of known archaeological sites in some counties (e.g., Kings [Brooklyn] and Queens in New York) may be at least in part due to bias in terms of site discovery and reporting. For example, several avocational archaeologists were extremely active during the mid-twentieth century on Staten Island, and they routinely published their findings. In contrast, there has been minimal work by avocationals or professionals in Kings County. Thus, while general trends in prehistoric site patterning can be seen