USING A GIS TO MONITOR THE NEW YORK BIGHT AND EVALUATE ALTERNATE MUD DUMP SITES

William Hansen, Barbara Tempalski, and Zeming Cheng
Department of Geology and Geography
Hunter College
New York, NY 10021

ABSTRACT A GIS was used to compile a cartographic data base of the New York Bight for work under contract with the U.S. Army Corps of Engineers. The data base will be used by the corps to identify ocean disposal sites for material dredged from New York harbor. Under the Water Resources Development Act of 1986 (Public Law 99-662) the Corps of Engineers is mandated to conduct a feasibility study for a monitoring and information system for the New York Bight and must select a new alternate disposal site at least twenty miles offshore. Using an ERDAS, system over fifty data layers were digitized, containing information on current vectors, sediment composition, bathymetric data, and selected species distribution. The data were registered to a large-scale digital shoreline data set distributed by the National Ocean Service. The second part of the project will consist of developing weighting factors for the data layers and incorporating distance and cost factors.

The U.S. Army Corps of Engineers bears the responsibility of maintaining the waterways within the port of New York-New Jersey. Due to the high accumulation of sediments deposited in the harbor by the Hudson and Raritan rivers, the channels must be dredged to remain navigable. The corps removes approximately 5.3 million cubic yards each year (Maciolek 1988). Currently this material is dumped at a site 5.7 miles off the New Jersey coast. The Corps of Engineers in conjunction with the Environmental Protection Agency (EPA), monitors the five other ocean dump sites located in the New York Bight; cellar dirt, woodburning ash, acid waste, sludge and industrial waste, and issues permits for the use of these sites. Recently, much attention has turned toward studying the effects of ocean dumping on the marine environment. As a result, the Resouces Development Act (Public Law 99-662, Section 728) was enacted in 1986. This law requires the U.S. Army Corps of Enginees and the New York District to conduct a study on the hydro-environmental system within the Bight area. In doing so the corps is in the process of developing a monitoring and information system for the study area. Measures taken for this study will allow scientists and the corps to analyze the impact of human and natural stresses in the Bight will aid the corps in selecting an alterative site for disposal of the dredged habor material.

The Corps of Engineers study is being conducted in cooperation with the U.S. Environmental Protection Agency as well as various state and municipal agencies in both New York and New Jersey. Further assistance is being provided by the U.S. Army Corps of Engineers' Waterways Experiment Station in Vicksburg Mississippi and the Waste Management Institute of the Marine Science Research Center, State University of New York at Stony Brook. A list of monitoring needs was developed from impaired uses of the New York Bight as identified by the New York Bight Restoration Plan. The impaired uses include beach closures, unsafe seafood, adverse impact on commercial/recreational fisheries and navigation, impact on birds, marine mammals and turtles, and loss of aquatic habitat. Sources of contaminants to be monitored and evaluated for adverse effects include construction and modification of coastal structures, coastal wastewater treatment discharges and combined sewerage overflows, petroleum and chemical spills, and the various ocean

disposal sites.

In order to focus on specific goals and identify the most relevant and up-to-date information available, the Corps of Engineers held a series of workshops in the summer of 1989. The first workshop looked at the question of monitoring the Bight. It examined existing sources of data, identifying a number of historical monitoring programs, and developed a set of parameters for future monitoring efforts in terms of both equipment and technology and methods to be employed. The second workshop addressed modeling the Bight, identifying oceanographic processes that could feasibly be modeled as well as current modeling capabilities.

To manage the large volume of existing data effectively, as well as incorporate new data that would be generated, the Corps of Engineers established a Geographic Information System for the New York Bight. The task of compiling the data layers for the GIS was contracted to the Hunter College Remote Sensing and Spatial Analysis Laboratory as part of a joint study with the State University of New York at Stony Brook.

CONSTRUCTING THE GIS

The initial stage of the project was to create the first series of map layers based on available data. These include fisheries distribution, heavy metal contaminants, bottom sediments, and current information on the Bight. The New York Bight is defined as the area between Montauk Point, New York (41 degrees 5 minutes north, 71 degrees 55 minutes west), and Cape May, New Jersey (38 degrees 55 minutes north, 74 degrees 50 minutes west) extending from the Sandy Hook-Rockaway transit to the edge of the continental shelf. Work at the Remote Sensing and Spatial Analysis Lab was done using ERDAS software running on a Compaq 386 and digitized on a Calcomp 9100 digitizer. The ERDAS system is linked to the lab's Sun fileserver via an Ethernet which facilitated digital input to the GIS. The Universal Transverse Mecator coordinate system was used for the project, most of the sheet maps were digitized as latitude and longitude and then converted. Pixel size for the GIS files was chosen to be 500 by 500 meters; at this resolution the entire Bight could be shown on a 512 by 512 display.

DIGITAL SHORELINE DATA

The National Ocean Services Digital Shoreline Data was used as a base map for registering all other data layers in this project. Large scale data sets distributed by the National Ocean Service are collected from National Ocean Service nautical charts and represent Mean High Water. The continental United States is divided into eighteen data sets ranging in size from 100,000 to 300,000 data points. Two sets were needed to provide complete coverage of the New York Bight. C3, Long Island, covers the area from the Rhode Island-Connecticut border to Long Branch, New Jersey. C4, Delaware Bay, runs from Asbury Park, New Jersey, to the Delaware-Maryland border.

The data are distributed on 2400-foot 9-track magnetic tapes recorded at 1600 bytes per inch. This represents a series of strings or line segments, which in turn are made up of data points. Each point, called a record by NOS, consists of twenty-five fields made up of eighty characters. The fields consist of information such as scale, source document number, various datum codes, latitude, longitude, and endpoint flags. Endpoint flags signify the end or beginning of a line segment. The line segments are nontopological with latitude and longitude given in degrees, minutes, seconds, and hundredths of seconds.

The first step in preparing this data for input to the GIS was extracting longitude, latitude, and endpoint codes from the original files. A program to extract this information was written at the Hunter Remote Sensing and Spatial Analysis Lab and was run on a Sun work station. The output from this file was then converted to a string format file using a modified version of an existing program. The string format consists of an integer denoting the number of points in the string followed by that many x,y coordinate pairs that make up the string. The strings file for the Long Island data set was combined with the Delaware Bay data set and then subsampled to extract only the Bight area. The combined file was then converted from vector to raster format. It was then written out in ERDAS format using the Spatial Analysis Lab's Terrain Analysis (Terrapin) software. Once in ERDAS GIS format, the file was converted to Universal Transverse Mercator coordinates.

FISHERIES DATA

Fisheries data were available primarily as sheet maps from a number of federal and state technical publications. The source chosen for the GIS was New Jersey's Recreational and Commercial Ocean Fishing Grounds by Long and Figley (1981), published by the New Jersey Department of Environmental Protection. Data for this report were gathered from a number of sources: Northeast Regional Fisheries Cruises, recreational fishing landings gathered by the Department of Commerce, U.S commercial catch and value collected by the National Marine Fisheries Service, and Japanese Longline catch recorded by U.S. Fisheries Observers.

Fisheries data comprised twenty-seven data layers, ranging from surf clams to yellowfin tuna. Eleven sport fisheries layers and fifteen commercial fisheries layers, each consisting of twenty-one species, were created. An additional map showing preferred recreational and commercial fishing grounds was digitized. These data layers were digitized, converted to GIS files, and then registered to the digital shoreline data. Registration was accomplished by identifying twenty shoreline control points. A root mean square error tolerance of 1.5 was used to calculate the coefficient matrix. Nearest neighbor resampling was used to create the rectified GIS file.

Contaminant data was taken from National Oceanagraphic Atmospheric Administration (NOAA) Technical Memorandum NMFS-F/NEC-16, Contaminants in New York Bight and Long Island Sound, Sediments and Demersal Species and Contaminant Effects on Benthos, Summer 1980. Bottom sediment samples were taken from fourty-four sampling stations located throughout the Bight, with the greatest density of locations located near the New York Bight Apex. Testing was done to determine sediment grain size, as well as the amount of organic carbon and Kjeldahl nitrogen. Samples at each station were also tested for the following metals: cadmium, chromium, copper, mercury, nickel, lead, and zinc. An ERDAS digitized point file was created using a sheet map of the reporting stations. The file was copied over for each of the criteria tested, and the values were entered manually. The point files were interpolated to cover the entire Bight, using the ERDAS Surface function, an inverse distance weighting algorithm for point interpolation.

CURRENT DATA

Data on current velocity was provided by Norm Scheffner from the Corps of Engineers Waterways Experiment Station. Current velocities are given in centimeters per second, with the Bight divided into ten-minute-by-ten-minute grid cells. These data were

manually entered as point data using the coordinates of the center of each grid cell. The velocity values were then interpolated using the TERRAPIN, Terrain Mapping package developed at the Hunter College Remote Sensing and Spatial Analysis Lab by Keith Clarke. A ERDAS file was written out using TERRAPIN which can create either an Image or GIS file in ERDAS format.

OTHER DATA LAYERS

A map showing the major shipping lanes into New York Harbor was digitized as well as military operating areas in the New York Bight. The Hudson Canyon, as defined by the 50-meter contour, was digitized from a NOS bathymetric chart. For the next stage of the project more detailed bathymetric data will be used, NOS digital hydrographic data, which contains over 3 million data points covering the New York Bight. The existing ocean disposal sites were also digitized: the acid waste site (no longer used), the woodburning site, the industrial waste site, cellar dirt site, and the sewerage sludge sites, the twelve mile site (no longer used), and the 106 mile site.

EVALUATING PROPOSED SITES

The first use of the GIS was to aid in the selection of a disposal site for dredged material. Under P.L. 99-662, section 211, the EPA was directed to provide an alternate site for disposal of dredged material which do not meet the standards set forth for disposal at the existing site due to their pollutant content. The Corps of Engineers, New York District, and the Environmental Protection Agency, New York Office, proposed a number of dredged material disposal sites. The Corps of Engineers proposed four replacement sites designated C1, C2, C3, and C4, and the EPA proposed two alternate sites (for dredged material containing pollutants) designated E1 and E2. Under PL 99-662 the alternate sites must be at least twenty miles offshore. In order to evaluate the proposed sites three composite files were created from the GIS files. The criteria used for evaluating the sites, and in creating the overlay, were selected by the Corps of Engineers. For the first overlay the following five GIS files were used:

1. Percent of gravel in surface sediments from Freeland and Swift (1978)
2. Hudson Canyon 50-meter contour
3. Distribution of lobster and red crab from Long and Figley (1982)
4. Navigation lanes, Corps of Engineers
5. Sport and commercial fishing grounds from Long and Figley (1982)

The files were initially recoded to a value of one, so that the resulting output overlay file contained pixels ranging in value from zero to five depending upon how many of the chosen criteria occurred. The boundaries of proposed sites were superimposed on the overlay file to show how many limiting factors occurred within that site.

Site C1, the northernmost site and the one closest to New York harbor, lies at the confluence of the three shipping lanes. C2, which lies farther to the south, does not contain any of the limiting factors. Sites C3 and C4 both contain areas with two or three of the limiting factors present. The two EPA sites are in areas with one or two limiting factors.

A second overlay was created using seven files, the same five as were used in the first overlay with the following two added:

1. Distribution of biomass, all taxonomic groups in grams per square meter from Wigley and Theroux (1981)
2. Distribution of surf and quahog clams from Long and Figley (1982)

In the resulting file there were no areas with none of the limiting factors, and also no areas with all seven factors. With the two additional criteria the results were similar with Corps site C1 containing the fewest limiting factors.

A third overlay consisted of a more detailed analysis. The same seven GIS files were used as in the second overlay, but the files were not all recoded to a value of one. The resulting file contains fifty-six categories, each a unique combination of the seven data layers. This facilitates more detailed interpretation as to what limiting factor or factors occur in each potential disposal area.

FUTURE WORK

As mentioned earlier, detailed bathymetric data will be added to the GIS. A tape of ungridded depths and bottom features has been purchased from the National Geophysical Data Center. This will be used to create a number of layers such as bottom slope and aspect, as well as combining these factors with other data such as currents. The lab is also looking for other sources of species distribution such as Woods Hole and the Sandy Hook Marine Fisheries Station.

Satellite data will also be incorporated into the GIS. Sediment plumes from the Hudson-Raritan estuary, visible on SPOT images, can be used to determine the dominant current direction. Thermal infrared AVHRR images can be used to map seasurface temperature.

The workshops on monitoring and modeling the New York Bight identified storms as the most important source of energy input to the Bight. Storm data such as wind velocities, direction, storm tracks, and other information would be useful for determining the susceptibility of different sites to large-scale disturbances as a result of increased energy input. A great deal of information on physical oceanographic processes in the bight exist and should be incorporated in the GIS. This would include more detailed analysis of currents and circulation patterns.

CONCLUSION

The use of oceans as a vast dumping ground for human refuse has become a critical societal issue. The question of what permanent effect past actions have had and whether the oceans can recover must be addressed. A great deal of information exists and is being produced. Agencies such as the Environmental Protection Agency and the Corps of Engineers must consolidate this information and focus in on the pressing questions that must be answered.

The Geographic Information System being constructed for the New York Bight provides a means for organizing the vast amount of available information and is a powerful tool for making management decisions. A GIS is uniquely qualified to handle this type of information and to provide a framework for answering such questions. The successful application of GIS technology to these issues will both increase the role of such systems and provide the means for addressing important environmental issues.

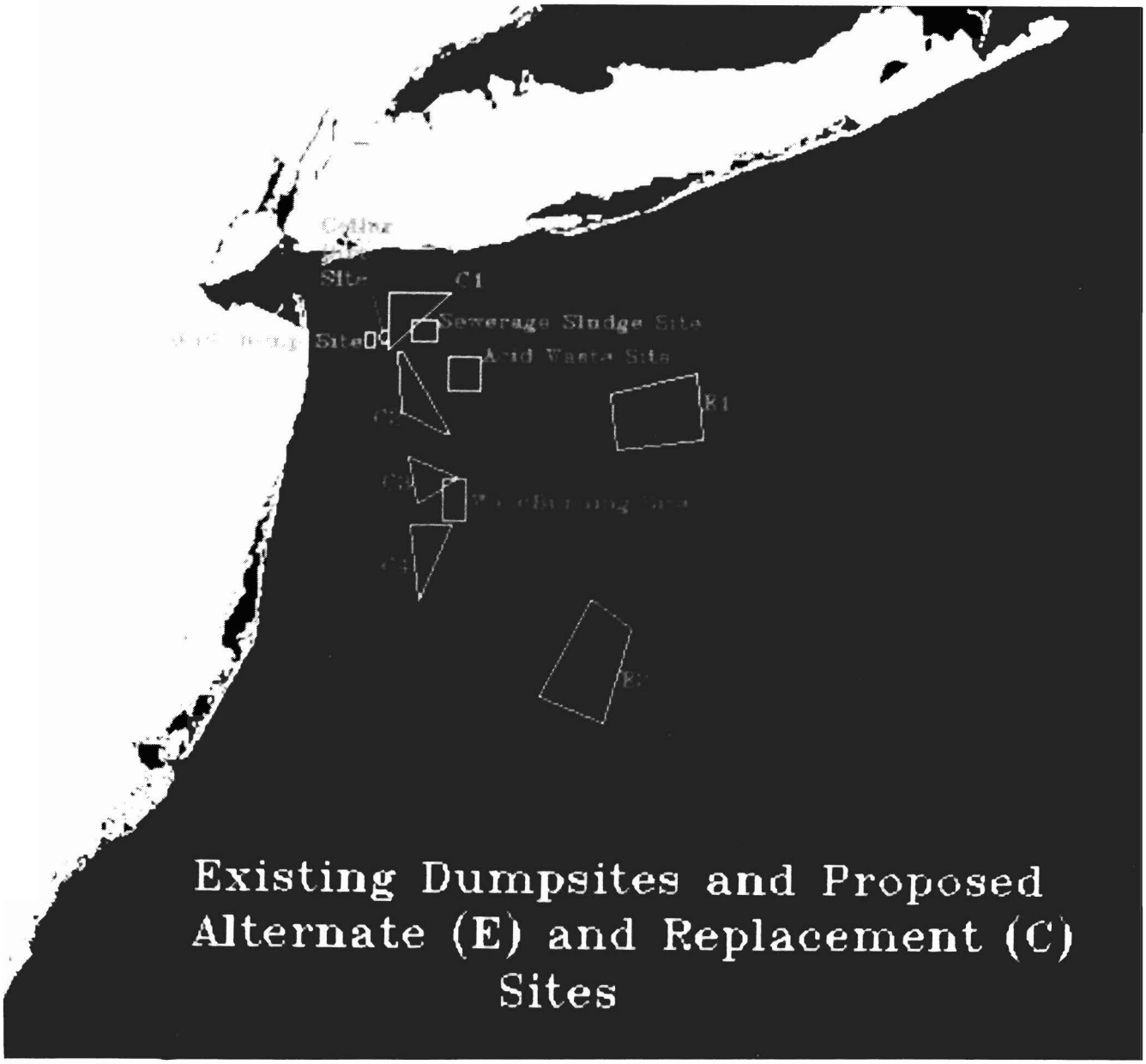

Figure 1 Existing and Proposed Dumpsites in the New York Bight

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