THE ROLE OF THE USFWS GEOGRAPHIC INFORMATION SYSTEM IN COASTAL DECISIONMAKING

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ABSTRACT

Unprecedented demand on coastal resources in the 1980's has generated a need for valid information and analyses to support wise management of the coastal zone. The National Coastal Ecosystems Team of the U.S. Fish and Wildlife Service recently implemented a geographic information system to enhance its ability to analyze and display environmental information about the coastal zone. Outputs from this system have been presented to the State of Louisiana Senate and House Committees on Natural Resources and to the Congressional House of Representatives Committee on Merchant Marine and Fisheries. The purpose of this paper is to describe the use of the Map Overlay Statistical System for addressing selected coastal issues and to discuss its utility for coastal decisionmaking.

INTRODUCTION

In 1975 the U.S. Fish and Wildlife Service (USFWS) initiated a coal project primarily aimed at developing information and technology to manage western coal development in an environmentally sound fashion. Early in this project it became obvious that most of the information needed for Federal coal-leasing decisions existed in map form, primarily within the Bureau of Land Management's District Offices and the Service's Western Energy and Land Use Team in Fort Collins, Colorado. The sheer volume, variety, and geographic coverage of map information needed to make these decisions were staggering and required a system for efficient management and analysis.

The development of a geographic information system for the Service was managed by the Western Energy and Land Use Team. Their first task was to review existing systems nationwide and determine if a system or part of a system existed that would fulfill management and analysis needs. A number of systems, particularly those in the U.S. Forest Service, Bureau of Land Management, and U.S. Geological Survey, as well as a number of States, had components that were powerful and transportable. No system was found that would meet all needs, therefore, the Service decided to construct a geographic information system beginning with subsystems selected from existing software. A geographic information system focusing on analysis called the Map Overlay Statistical System (MOSS) was developed.

At the same time MOSS was under development, another system, aimed at providing operational support to the Service's National Wetland Inventory, was also under development. So that these two efforts would complement one another, the Service decided to focus the Wetland Inventory effort on data entry. A system consisting of both software and hardware was developed that could digitize information from a number of map scales and projections. The system was designed to be capable of meeting or exceeding national map accuracy standards, and to store information in latitude and longitude to accurately represent geographic positions on the earth's surface. The system that was developed and tested was called the Wetlands Analytical Mapping System (WAMS). More recently, this system has utilized an APPS IV stereoplotter to digitize directly from stereo-paired aerial photography.

The National Coastal Ecosystems Team (NCET) recognized the need for geoprocessing capabilities and initiated steps towards acquiring these capabilities in the fall of 1979. Several criteria were used to select a combination of systems that were already available within the USFWS. These systems were installed and brought to operational status in late April of 1981. They included (1) the Wetland Analytical Mapping System for data entry, (2) the Map Overlay Statistical System for data analysis, and (3) the Cartographic Output System (COS) for data display.

THE SYSTEMS

Data Entry System

Data entry at NCET is performed with the Wetland Analytical Mapping System (WAMS). WAMS is an interactive, menu-driven, digitizing, and map-editing system which allows various types of data to be captured in digital format from maps or aerial photography. Aerial photography may be used if the vertical and horizontal positions of features are required; however, horizontal positions usually provide sufficient accuracy for most geographic analyses (Niedzwiadek and Greve 1979). Data entry operators at NCET, therefore, digitize the horizontal locations from map sheets, and the WAMS software checks to insure that national map accuracy standards are met. Digitizing from map sheets with WAMS requires a minimum of six known geographic coordinates to accommodate georeferencing algorithms to allow for the accurate georeferencing (USFWS 1980). Digitizing, editing, and verifying digital map products are conducted in an arc/node format and are data-based only after verification and polygon formation procedures have been passed without error. WAMS is scale and projection independent, capturing map coordinates in a latitude-longitude format. The edges of adjacent maps are also checked and verified during the digitizing process so that adjacent maps can be properly aligned.

After the maps have passed verification procedures without error, they are transferred to MOSS. During this transfer, data formats are changed and maps can be transferred to any one of 22 map projections (usually Universal Transverse Mercator Projection, UTM).

Map Analysis System

The analysis of geographic data is conducted with the Map Overlay Statistical System (MOSS). MOSS is an interactive or batch mode geoanalysis system designed for the analysis of natural resource information. Functionally, MOSS is utilized by responding to prompts from the system with an English language command and a map identifier (Reed 1980). The system executes the initiated command resulting in the generation of map or database summaries, tabular measurement information, statistical summaries, text files, interactive measurements of area, distance or location, graphs, plots, interpolated surfaces, and entirely new mapped information derived from user-specified criteria. Over 70 commands are available to perform these functions and can be utilized with a variety of georeferenced data types including text, point, line, polygon, raster, elevation point, and elevation grid (Reed 1980). Multiple attributes can be assigned to point, line, polygon, and raster data types. The functions of MOSS commands can be generally classified into five categories: (1) general purpose, (2) database management, (3) spatial retrieval, (4) data analysis and measurement, and (5) data display (USFWS 1982).

Data Display System

Although MOSS has display functions capable of plotting to a CRT, line printer, and a variety of plotters, the Cartographic Output System (COS) is most often used to generate final map products. COS is operated from a combination of interactive commands and menus and is based on the concept of generating and positioning data components inside of a graphic profile. Data components consist of entries or groups of entries recognized by the operator as being separate entities in a cartographically sound graphic product such as a legend, scale, or map overlay. The positions of these components are determined in the graphic profile according to operator-specified coordinates.

WAMS, MOSS, and COS are all operational on a Data General Eclipse Minicomputer S/250 at the National Coastal Ecosystems Team in Slidell, Louisiana. These systems have been used to address a number of coastal issues in the Gulf of Mexico and on the Atlantic seaboard. Products from these systems have been successfully used to influence funding to address national resource issues as well as to assist in site-specific locational decisions.

APPLICATIONS AND USE OF PRODUCTS

These geographic information systems are currently being used by a number of Federal and State agencies throughout the United States to highlight and analyze resource-related issues. Applications at the Coastal Team have addressed numerous environmental issues. Some of the major types of analyses include (1) habitat trend and change analysis, (2) dredged disposal and port development, (3) permitting and accumulative impacts, (4) modeling habitat impacts from energy development, (5) environmental impact statements for

OCS oil and gas leasing program, (6) modeling oil spill vulnerability of coastal areas, and (7) wildlife distribution and vegetation analysis. The following section discusses selected projects that have been completed or are ongoing at NCET.

Habitat Trend Analysis

Habitat trend analyses are being conducted in selected areas of every State bordering the Gulf of Mexico. The single most effective project analyzing habitat trends was conducted for the active delta region of the Mississippi River.

This project, entitled "The Mississippi River Active Delta Project," was the first project initiated and completed at NCET. In April of 1971, the New Orleans Disctrict U.S. Army Corps of Engineers (USACE) and USFWS's Field Office in Lafayette, Louisiana, requested assistance from NCET to measure wetland changes in natural subdeltas of the Mississippi River active delta to allow USACE and USFWS to more effectively manage activities according to natural hydrologic units. This request was made in reply to the mandate to dredge and maintain the Mississippi River channel at 55 feet as opposed to 35 feet. The additional dredge material produced from the maintenance of a 55-foot channel involves millions of cubic feet of sediment each year that had to be disposed of in the delta region. The USFWS proposed that the USACE use a portion of the dredge material to mitigate wetlands lost from leveeing the river.

The question of where to dispose of the dredged material remained an issue for USACE and USFWS. Acreage measurements and graphics depicting habitat trends were requested to locate appropriate sites for dredge disposal, marsh mitigation, and freshwater and sediment diversion. The USFWS also realized that, despite the release of planimetered change measurements by NCET indicating alarming rates of wetland changes in recent decades, a depiction of the change was required to show more effectively the dramatic alteration of wetlands. Two sets of products, therefore, were generated: (1) area measurements and graphics indicating change in each subdelta, and (2) area measurements and graphics indicating change in the entire delta (Figure 1 and Table 1).

Table 1. Comparison of area summaries for the Mississippi River Active Delta in 1956 and 1978.

HABITAT TYPE	1956 ACREAGE	1978 ACREAGE	ACREAGE CHANGE	% CHANGE
MARSH	182,838	89,381	-93,457	- 51%
FORESTED WETLAND	7,894	3,233	- 4,661	- 59%
UPLAND	3,362	6,915	+ 3,553	+ 106%
SPOIL	3,057	11,369	+ 8,313	+ 272%

Figure 1. Mississippi River Active Delta as it appeared in 1956 and 1978.

Graphic products and reports from this project have not only been used by USACE and USFWS for regional and site-specific locational decisions, they have also been presented before Parish, State, and Congressional legislative bodies. Products from this project have been presented to the Louisiana Senate and House Committee on Natural Resources by Senator Samuel B. Nunez, Jr., to highlight and portray the dramatic problem of coastal wetland alterations incurred by man's activities (Nunez and Sour 1981). Senator Nunez's presentation contained the major graphical display of wetland change to the committee. The State of Louisiana later allocated $35 million to various State agencies and organizations in an attempt to address the serious problem of wetland loss. Other uses of these products have influenced similar results, although not as dramatic, at hearings before a subcommittee of the House of Representatives in Washington, D.C. (Johnston 1981). High quality graphics and professional delivery of those products and information, therefore, have significantly affected State and Federal decisions concerning coastal resources. Products are also being used by a number of educational institutions such as the Louisiana Nature Center and Louisiana State University.

Dredge Disposal and Port Development

The Mobile District U.S. Army Corps of Engineers (USACE) required the use of geoprocessing capabilities to effectively analyze the potential impacts of depositing dredge material in coastal areas. The dredge material disposal problem arose from the Corps' mandate to deepen Pascagoula and Mobile Bay ship channels from 35 to 55 feet deep. NCET has constructed a large geographic database consisting of wetland and deep water habitats, benthic assemblages, bottom sediments, salinity, archeological sites, artificial reefs, oyster leases, distribution of 23 species of finfish and shellfish, oyster reefs, bathymetry, and current dredge disposal sites. The geographic analysis of multiple resource overlays are being conducted to select sites for dredge disposal and to measure the impacts of fish and wildlife resources with disposal actions. This continuing program should assist USFWS and USACE in minimizing the impacts of dredge disposal on important marine and estuarine resources. Cartographic modeling of the entire Mississippi Sound and Mobile Bay is currently being negotiated as an additional analysis for delineation of the most sensitive offshore biological communities.

BLM Environmental Impact Statement for Offshore Oil and Gas Leasing

The current administration has opened up vast areas in the Gulf of Mexico to oil and gas exploration. The Bureau of Land Management's Offshore Continental Shelf Office (now Minerals Management Service, MMS) was required to write an environmental impact statement on oil and gas exploration for the entire Gulf of Mexico. NCET was requested by the Assistant Director of the Department of Interior to assist MMS in gathering data and calculating areal and linear measurements of coastal resources in the gulf. Areal and linear measurements had to be conducted for a number of political and planning unit areas, ranging from the county level to extensive offshore planning units. Standard U.S. Geological Survey 1:250,000 scale geounits were used as base maps for a study area which consisted of the entire Gulf of Mexico. Tabular summaries of resource information were generated for each county bordering the coast. These summaries included the distance or length of shoreline features along the coast, including recreational beaches, mangroves, marshes, etc. Area summaries were also calculated for important offshore resources such as seagrass beds, nursery grounds, and shellfish concentration areas. Each geographic unit, i.e., county, was then ranked in terms of resource priority based on these measurements (MMS 1982). Oil and gas leases will be given an environmental ranking according to their proximity to the areas and the probability of an oil spill reaching the most important coastal areas.

A second analysis for the impact statement was conducted for scattered areas in the gulf consisting of live bottoms and restricted areas where oil and gas activities are limited. These restricted areas were delineated according to their distance from live bottoms or no activity zones where no oil and gas activities are permitted. Zones range from 1 to 4 miles, with more restrictions enforced in the zones closer to live bottom areas. MMS requested the acreages and percentage of each oil lease block occupied by the live bottom areas and various restricted activity zones. The lease blocks and the restricted activity zones were digitized for 12 areas at a scale of 1:120,000. MOSS was used to generate color graphics and area summaries of the intersections between the lease blocks and zones (Figure 2 and Table 2). MMS used these figures to assign an environmental ranking to each block based on the area and percent of each block within the restriction zones (MMS 1982). Quantifying the effects of Outer Continental Shelf oil and gas development on coastal ecosystems will continue for the next 3 years.

Table 2. Acreage summaries for lease blocks A367 and A368.

SUBJECT		AREA	FREQUENCY	PERCENT
A367	4 MILE/ZONE	3491.85	1	60.78
A367	1 MILE/ZONE	1973.96	1	34.36
A367	NO ACTIVITY	279.48	3	4.86
TOTAL (IN ACRES)		5745.3	5	100.00
A368	3 MILE/ZONE	1205.58	1	21.03
A368	1 MILE/ZONE	1211.77	1	21.13
A368	4 MILE/ZONE	3289.45	1	57.37
A368	NO ACTIVITY	26.93	1	.47
TOTAL (IN ACRES)		5733.7	4	100.00

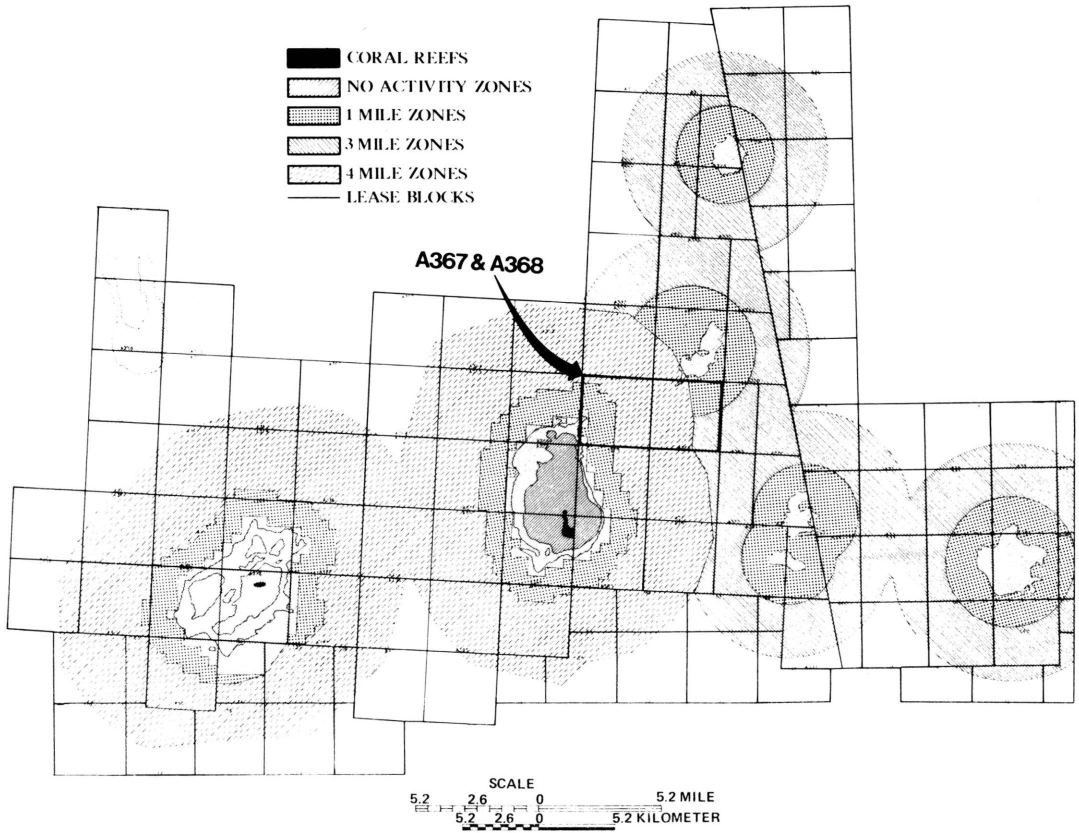

Figure 2. Plot of offshore lease blocks in West and East Flower Gardens.

Oil Spill Vulnerability Modeling

A recent pilot project undertaken by NCET for the Louisiana Offshore Oil Port (LOOP) produced a composite map depicting protection priorities for onshore and nearshore areas in the event of an oil or toxic chemical spill. The project demonstrated the use of MOSS cartographic modeling capabilities to indicate the vulnerability of different geographic areas to oil and toxic chemical spills.

The Barataria Pass quadrangle in coastal Louisiana was selected for the study area. Inputs for the analysis consisted of eight resource variables: wetland habitats, oyster leases, recreational beaches, historical sites, endangered species, bird rookeries, marinas, and water intakes. These resource variables were ranked from low vulnerability (1) to high vulnerability (3). Ranking criteria consisted of a previously developed methodology for ranking biological habitats (Adams et al. 1982), and methods utilized by the New Orleans MMS office. Resource maps were digitized and the all point data were buffered with distance factors to indicate zones of proximity to the resource. Resource overlays were converted to a cell format and recoded to the appropriate value determined by the ranking criteria cited above. The cell maps were arithmetically composited using cartographic modeling methods to produce single map indicating oil spill vulnerability. Vulnerability index values were grouped into logical classes to produce a final map product that depicted three levels of vulnerability: (1) low vulnerability, (2) medium vulnerability, and (3) high vulnerability. Figure 3 depicts the distribution of these values in the Barataria Pass 7½' USGS quadrangle.

Additional work and products will facilitate oil spill cleanup activities and deployment of spill response personnel in order to protect those areas of highest vulnerability. Data will be available on NCET's computer system with an offsite graphics terminal and in atlas form plotted on opaque stable base material. The opaque overlays will be overlayed on USGS quadrangle for visual geographic referencing. This particular application has utility in hazardous waste and oil spill management, environmental impact assessments, effluent discharge assessment, and development contingency plans for the cleanup and deployment of spill response personnel.

SUMMARY

The National Coastal Ecosystems Team is using geoprocessing methodologies to assist agencies who have legislative mandates or responsibilities to manage coastal resources. The above case studies illustrate how NCET's geographic information system was and is being used to address a variety of coastal issues. These studies are not a complete review of applications at NCET; however, they provide a record of the types of analyses that are being applied to resource issues in coastal and offshore areas using GIS technology. Color graphics and tabular summaries produced at NCET have helped

Figure 3. Oil spill protection priority index map.

influence important environmental decisions on a variety of levels.

To have significant impacts, these materials had to be presented by professional witnesses who were well versed in the complexity and problems associated with biological systems and who can effectively present facts and conclusions at local, State, and Federal legislative levels.

In conclusion, if management of coastal ecosystems is to be based on the best available information, it is imperative that this knowledge be transferred to decisionmakers in a form that is readily accessible and understandable. Geoprocessing techniques at NCET have provided the means for accurately analyzing and portraying information for use by scientists, administrators, and lawmakers at many levels. The result has been a successful rapport between various Government officials and a significant impact on coastal decisionmaking.

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