

A GIS Assessment of Barrier Island Impacts

By Samuel Patterson and Richard Dawson

Coastal landforms are the interface between aquatic and terrestrial ecosystems; as such, they tend to be dynamic in terms of geomorphological change. Changes in coastal and barrier island landforms range from the impacts of storms and tidal action to human-induced changes brought on by dredging and other coastal engineering projects.

For the most part, national parks located on barrier islands or coastal lands have been managed with little definitive knowledge of the regions outside of park boundaries, or of the impacts development of adjacent areas have had on the ecological integrity of the parks. It is becoming increasingly apparent that national parks, whether they are located on barrier islands or coastal lands, are not discrete, isolated landscapes unaffected by development of the surrounding regions. Although they often are perceived as undisturbed refuges, national parks are being impacted negatively by adjacent private development and government sponsored projects.

Particularly damaging to coastal and barrier island NPS areas have been large-scale dredging and spoil disposal, coastal engineering projects (Dean 1988) and oil spills. In many cases, accurate and quantifiable assessment of these impacts to coastal and barrier island geomorphology, hydrology, shoreline erosion, aquatic and terrestrial ecosystems has been inadequate or incomplete.

The proximity of NPS barrier islands to major dredge and disposal operations, oil drilling, and oil transport, has necessitated the involvement of the Service's Southeast Regional Office (SERO) in long-term inventory, monitoring, prediction, and evaluation of impacts. Examples of national seashores impacted by such projects are Cumberland Island (St. Marys Inlet/Kings Bay Naval Submarine Base), Cape Hatteras (Oregon Inlet), and Gulf Islands National Seashore (Pensacola, Pascaguola, and Gulfport channels). Pre-project evaluation of and response to the short- and long-term impacts associated with these projects and with oil transport is critical for the continued viability of coastal and barrier island national parks.

SERO has recognized the need for a comprehensive system that can incorporate both regional and park monitoring data, scientific research, hard copy maps, digital information, aerial photography, digital imagery, databases, predictive models, and decision tree responses under one, integrated, turn-key approach. The SERO and the University of Virginia Department of Environmental Sciences are developing a coastal barrier island remote sensing, monitoring, and GIS program to function in concert with existing scientific research and resource management databases. The program also is fine tuning several sediment transport models and developing a decision tree response model for oil spills to function with the GIS.

Global Positioning Systems

National parks in these coastal areas pose several problems for researchers conducting field work and for GIS specialists creating an accurate park geographic information system. Scale related phenomena become very important on coastal lands and barrier islands as evidenced by vegetation communities, which tend to occur along narrow, linear bands that can be as little as 3 to 5 meters wide. To create a GIS with multiple themes, development of data bases within the following areas are required to provide robust themes



Problems facing barrier island managers can be seen at Pensacola Channel (Gulf Islands N.S.). Need for increased navigational access, Naval Air Station (top center); protection of significant historical resources, Fort Pickens (right); and, preservation of natural features threatened by increased erosion due to channel dredging, Perdido Key (left).

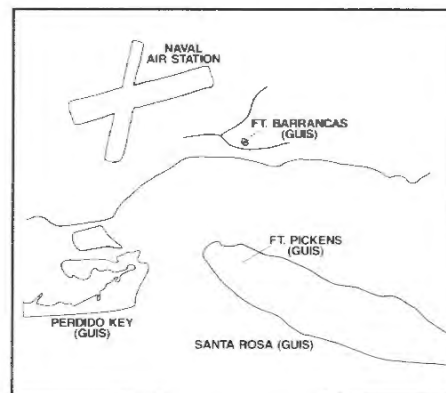
and analytical models.

Before the aerial photography could be flown, another significant problem had to be addressed. Because barrier islands tend to be isolated and due to their dynamic geomorphology, they possess few identifiable ground control points. In some areas, georectification of barrier island aerial photography can be very difficult due to the paucity of permanent structures, roads, and other identifiable land features.

A comprehensive network of mapped and registered ground control targets and permanent monuments whose accuracy exceeded USGS National Map Accuracy Standards was installed, to provide ground control points for rectification of the aerial photography. Precise registration of the ground control points was effected by a Trimble Surveyor global positioning system (GPS). When present, permanent structures also were registered by the GPS for later use in the georectification process.

Remote Sensing

The SERO remote sensing missions are being flown by NASA from 1990 to 1993 and consist of several high performance cameras, three film types (black and white, color infrared, and color), and a Daedalus 10 band digital scanner. The cameras employed on these missions (HR-732 and RC-10) and Daedalus digital scanner have a ground resolution of approximately 1 meter, 3 meters, and 20 meters, respectively.



Unlike smaller remote sensing platforms, the ER-2 aircraft carries all 4 imaging devices simultaneously. The variances of altitude, sun angle, time of day, time of year, and different flight dates thus are eliminated in this multi-platform vehicle. Simultaneous platform imaging removes some very critical problems and biases that usually plague development of accurate spectral classification ranges in image processing of scanned aerial photography. Photographic ecological atlases of each barrier island park are being developed from the 3-meter resolution aerial photography.

The NPS areas incorporated into this remote sensing, mapping, and GIS program, include Assateague, Cape Lookout, Cape Hatteras, Cumberland Island, Canaveral, Biscayne, Timucuan, Virgin Islands and Gulf Islands. The NASA flight missions will be repeated over the next 2 years to monitor impacts from dredging, and to assess changes in island vegetation and migration (accretion and prograding) of the islands.

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imagery also will be used to create digital GIS change detection maps for temporal and spatial analyses.

Image Processing

NASA aerial photography of the barrier islands from the summer of 1990 is being converted digitally by an Optronix scanner at a resolution of .8 meters (2000 dots per inch). Extensive testing was conducted to determine the optimal spatial resolution for delineation of the narrow barrier island vegetation communities. The NASA photography is of such high resolution that individual trees from the same community can be differentiated. Scans of such high resolution can create problems when performing supervised or unsupervised image classifications, because one community may be broken into several identified classes. A vegetation classification scheme of 20 classes has been adopted for the NPS barrier islands.

The scanned aerial photographs are georectified with coordinates derived from the GPS ground control targets that were laid out prior to the flights. Permanent structures visible on the aerial photographs also were registered by the GPS for use in the georectification process. The georectified scans will be edge-matched and "zipped" together. Following supervised classification of the vegetation communities, all the individual scans will be joined seamlessly to create a georectified vegetation data layer of each barrier island.

Geographic Information Systems

Remote sensing and mapping analysis of island migration and vegetation composition over time can give scientists and resource managers an outlook on barrier island previously not possible. The incorporation of remote sensing imagery with other digitized GIS data layers can provide unique insights into island dynamics and interactions between the hydrology, ecology, geomorphology, and human impacts. GIS data themes can be viewed as a single data layer or as part of a composite overlay format.

The major themes of the GIS are: vegetation (derived from image processed aerial photographic scans, National Wetlands Inventory Maps, and NOAA seagrass maps); geomorphology (from current photographs, shoreline erosion, beach profiles, and digital line graphs); fauna (from USFWS Ecological Inventory

maps), adjacent land use (from Minerals Management Service Ecological Characterization studies); and cultural resources (from NPS Cultural Sites Inventory and List of Classified Structures).

Digital Line Graphs

Digital line graphs (DLG) at the 1:24,000 scale are needed for assessing change in the geomorphology and the location of the barrier islands over time. Most DLGs for coastal areas of the Atlantic and Gulf of Mexico were mapped in the early 1960s. Storms and dredging operations have significantly altered several of these islands. Availability of these maps in a digital format would provide researchers a 1960s window to compare with 1990 data being derived today. Change detection analysis between the two dates could yield useful information about island position and areal extent. Maps not available from USGS in DLG format will be scanned by automated techniques retaining the topological elements of the data theme(s) of interest, which then are imported into the GIS (Fain 1989).

Inlet Dredging Impact Model

Historic aerial photography, shoreline erosion, spoil disposal sites, and geophysical data are being collected from the Corps of Engineers for coastal and barrier island inlets that have been dredged. Extensive information exists on dredging projects conducted adjacent to barrier island national parks (Dean 1988). The model will account for the physical parameters existing at each inlet such as history of dredging at the site, sediment transport rate, volume of sediment available, and direction of transport. Incorporation of these parameters into the model will provide estimates regarding the effect of sediment removal (dredging) or sediment interruption (jetty) on the "downstream" island in terms of area affected. Once this affected area has been identified then data from the various GIS themes will be listed to display the resources that would be impacted.

Oil Spill Decision Model

The SERO and the Department of Environmental Sciences at UVA are developing an oil spill decision support model (Psarrafis and Ziogas 1985) that is based on contingency planning and response (Etkin

1990), and impact prediction and damage assessment (Psarrafis et al. 1986). Detailed information regarding oil types, estimation of flow volume and direction, time of year, climatic variables, sources of abatement/cleanup equipment and personnel, and response protocol (mechanical devices, dispersants, bioremediation, etc.) will be included in the decision support system model.

The Gulf region model will be assessed in terms of response capabilities and limitations, hierarchy of rapid response teams and contacts, environmental sensitivity of the shoreline to oil types transported through the Gulf, and relevant economic factors. The model will be validated by current risk assessment data derived from actual oil spill data and will be tested against low, mid, and worst case scenario spills for oil type and volume, from least to the most susceptible islands.

Conclusion

Remote sensing and GIS technologies, when coupled with other sets of information and field data, represent a powerful tool for quantification of impacts to coastal and barrier island national parks. The future of effective impact forecasting in dynamic areas like barrier islands resides in the use of predictive GIS models that have been updated with monitoring data and tested against historical suites of monitoring data and scientific research.

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References

- Dean, R.G. 1988. Review of Dredging Effects on Adjacent Park Systems. NPS Technical Doc. UFL-COEL-88-015. 115 p.
- Etkin, D.S. ed. 1990. Oil Spill Contingency Planning: A Global Perspective. Oil Spill Intelligence Report. Arlington, MA 120 p.
- Fain, M. 1989. Automated GIS Data Conversion. GIS World. Nov-Dec. pp 50-53.
- Psarrafis, H.N. and B.D. Ziogas. 1985. A Tactical Decision Algorithm for the Optimal Dispatching of Oil Spill Cleanup Equipment. Management Science. Vol. 31, No. 12. Dec. pp 1475-1481.
- Psarrafis, H.N., C.G. Therakan, and A. Ceder. 1986. Optimal Response to Oil Spills: The Strategic Decision Case. Operations Research. Vol. 34, No. 2, Mar-Apr. pp 203-217.
- Stutheit, S. 1989. GPS is Creating a Technological Revolution. GIS World. Nov-Dec. pp 23-31.