Dr. F. J. Wobber*
Dr. R. R. Anderson†
Earth Satellite Corp.
Washington, D.C. 20006

Simulated ERTS Data for Coastal Management

Simulated information was used to demonstrate an approach for analyzing coastal processes and coastal environment.

Abstract: *Increasing attention is being given the preservation and protection of the coastal zone as a unique ecological system and largely ill-appreciated natural resource. Of particular concern are coastal wetlands and nearshore marine environments. Large quantities of aircraft imagery for coastal studies have been collected to date. Imagery which can potentially contribute to coastal resources management is becoming available in large quantities from the ERTS-A satellite.*

In the anticipation of small-scale synoptic and repetitive ERTS-A image data, earth orbital imagery has been analyzed with emphasis on testing the products that have value to coastal problem-solving. Simulated ERTS-A information-products have been applied to problems of coastal zone management. Simulated earth resources survey imagery, with supporting aerial photographs were used to demonstrate how relatively raw "data slices" can be used in combination to generate otherwise obscure information for practical decision-making in coastal areas.

Introduction

Increasing international attention is being given the preservation and protection of the coastal zone as a unique ecological system and largely ill-appreciated natural resource. Of particular concern are coastal wetlands and nearshore marine environments. Dredging, draining, and filling of wetlands, coastal erosion, or offshore dumping of pollutants can either totally destroy or permanently alter these unique areas.

The potential contributions of aerial and orbital remote sensing techniques to resources problems have been widely discussed, and large quantities of aircraft imagery have been collected to date. Operational applications of small scale images had, however, not been widely tested at this writing‡, although this is necessary to focus ERTS technology on practical problems for management action. Imagery which can potentially contribute to coastal resources management will soon be available in large quantities from the ERTS-A satellite and complementary aircraft underflights. In anticipation of small-scale synoptic and repetitive ERTS-A image data, Apollo-9 imagery has been analyzed with emphasis on demonstrating products which have value to coastal problem-solving.

Possible utilization of ERTS data for coastal zone management and coastal ecology includes: (1) delineation and mapping of wetlands plant communities and boundaries of the wetlands eco-system; (2) monitoring wetlands on a regular basis for protection from manmade and natural reductions in wetlands

* This article was received in 1971—before ERTS-A Satellite was launched.

† Dr. Anderson is Professor in the Dept. of Biology, American University, Washington, D.C., and EarthSat Principal Associate.

‡ This article was submitted for publication in November 1971—*Editor.*

productivity; i.e., preservation of areas which contribute to the food chain; (3) monitoring of tidal and offshore marine currents for placement of erosion-control structures such as groins, bulkheads and jetties; and (4) dredge site planning.

Relatively few attempts have been made to document remote-sensing applications for these purposes using what is perhaps the most sophisticated and least tested part of a total earth resources surveys system—acquisition and analysis of small-scale imagery. Data which can be applied to coastal protection are often published as relatively raw image records. Interpretation procedures and results obtained may be poorly documented. *Data* derived from Apollo-9 imagery has been used to develop ERTS *information-products* which were judged to have significant value for coastal zone management.

Objective of the Survey

The objective of this study is to apply simulated ERTS-A information-products to problems of coastal zone management. Simulated earth resources survey imagery, i.e., Gemini and Apollo photography, with supporting aerial photographs were used to demonstrate how relatively raw *data slices* can in combination be used to generate otherwise obscure *information* for practical decision-making in coastal areas.

Approach

To test the hypothesis that data from an earth resources survey satellite can contribute to coastal management, selected images over the Gulf Coast of the United States have been used to simulate and conceptualize a coastal zone information system based on small scale image data. The area chosen was one within which the authors' *lacked* ground truth; judgements are therefore based on imagery data alone.

A set of selected Apollo-9 and supporting Gemini and aerial color imagery has been gathered which, the senior author's experience indicates, is reasonably representative of the scales anticipated from an operational aerial-orbital earth resources survey system. Color aerial photographs were used to simulate the sampling capability of aerial underflights. The photographs selected contained evidence of coastal current systems, dredging, dredge spoil disposal in wetlands, and potentially adverse shoreline erosion and sedimentation.

Development of Information Products

Introduction

Data analysis and development of useful information-products cannot proceed without attention to coastal management goals—goals which may vary internationally. The principal steps (as interpreted by the authors) in coastal management can be very broadly described as:

- Define coastal management goals.
- Define coastal resources problems.
- Identify the information needs for resolving problems.
- Collect required data.
- Analyze resources.
- Implement a coastal management program (management action).

Satisfactory implementation assumes the necessary regulatory authority is available or can be obtained.

Successful development of information products for application to practical problems is the most effective means of demonstrating utility of aerial-orbital earth resources survey the utility of aerial-orbital earth resources survey data for solving ecologically and economically significant coastal protection problems. Moreover, it is useful to show that even exceptionally complex coastal management goals of state or local governments may be solved by utilizing relatively simple orbital analysis techniques.

This was well illustrated during a preliminary analysis within state government (Figure 1) where aerial and orbital remote sensing data were found to have potentially greatest value to coastal management when related to allocation of budgeted state resources and responsive to municipal shoreline modification and protection requests. Based on preliminary studies, it was projected that the real ERTS-A information products will prove most immediately applicable to basic economic objectives, i.e., to the optimal allocation of state funds for protection of shore and wetlands environments, including placement and maintenance of groins, jetties, sea walls and bulkheads, placement of fill to protect, restore and improve the coastal environment, and location and maintenance of dredged channels for inland waterway traffic.

Image Analysis

A general flow diagram illustrating the manual and enhancement techniques leading to information products is shown in Figure 2. The analysis required to develop the various information products assumes applications-

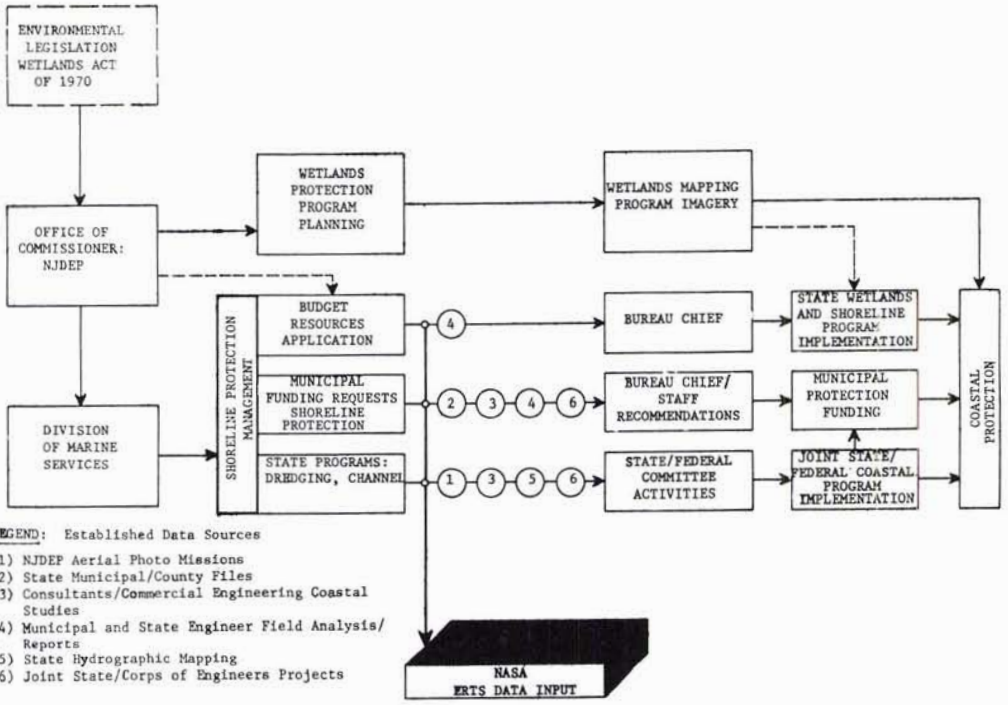

FIG. 1. Generalized decision flow for protection of New Jersey's coastal environment.

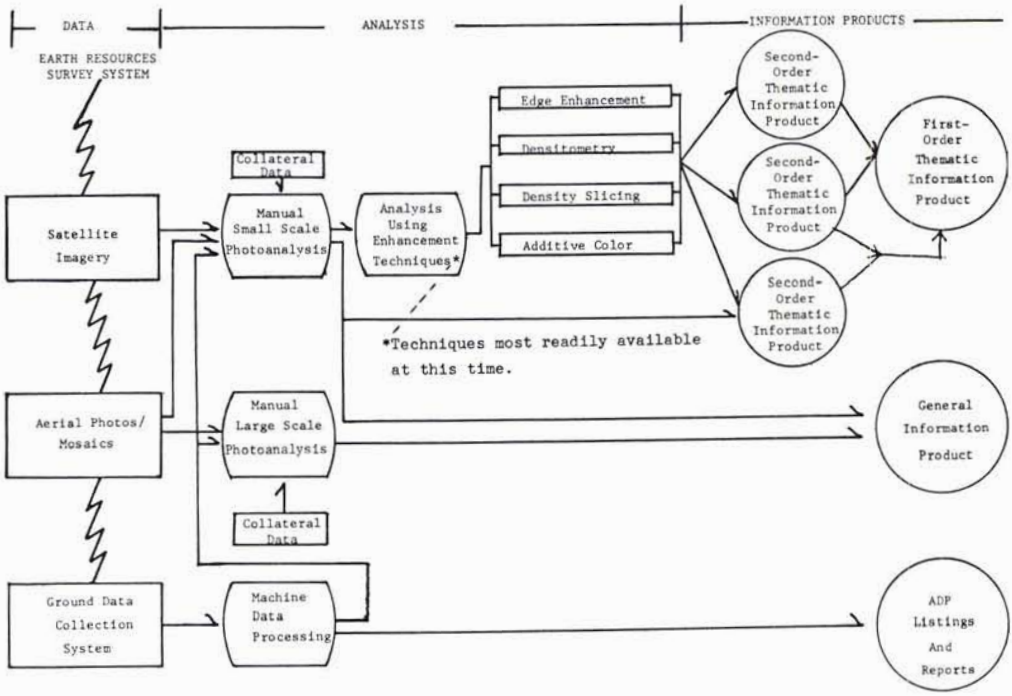

FIG. 2. Resources analysis as discussed in this paper involves development of information products using remote-sensing image analysis techniques. Combining general and second-order thematic information products can yield useful first order thematic information product for coastal management action.

discipline experience in biology, coastal oceanography and sedimentology. Information products included in this paper were developed using manual analysis techniques alone; special enhancement techniques to supplement manual methods will be tested in the future.

INFORMATION PRODUCT CATEGORIES

In order to simulate ERTS information products, Gemini and Apollo-9 orbital photographs with a supporting aerial photograph were analyzed. (Figures 3 and 4). To approximate an operational situation, this included *rapid* image analysis and development of *overlays* judged by EarthSat and state representatives to have general utility in *routine operational situations*. Three distinct varieties of basic information products were developed as a base for making rapid decision in coastal zone management (Figure 5).

These information products have been designated:

General Information Product (GIP). Product is limited to a single applications-discipline. Although requiring special experience and discipline expertise for its preparation, this product contains relatively raw *information*, is generally suitable as a base map, and can be used as a broadly-based decision-making tool. Maps showing the outline of wetlands areas or dredge channel systems are examples of this type of product.

Second-Order Thematic Information Product (SOTIP). Product contains specific data slices (elements) basic to decision-making. By combining two or more second-order thematic products, a first-order thematic information product may result. For example, a second-order overlay product showing zones of offshore sediment plumes (indicative of erosion)

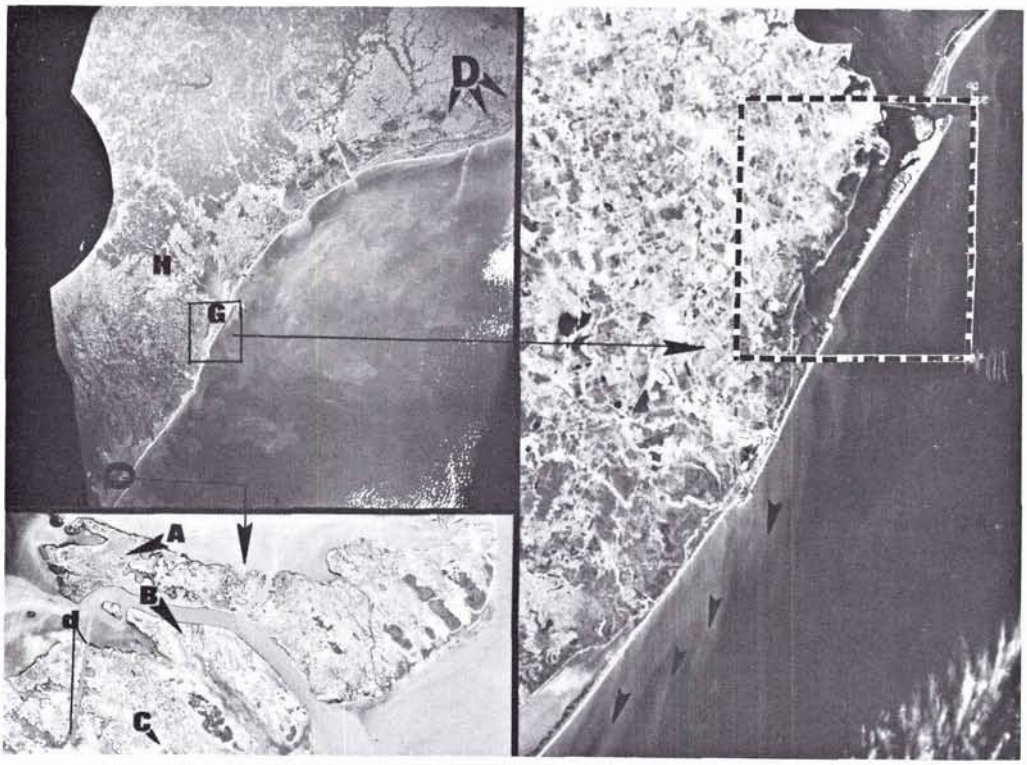

FIG. 3. Gemini XII color photograph (upper left) over the Gulf Coast of Texas showing the cities of Houston (*H*) and Galveston (*G*). Wetlands areas (e.g., *D*) are difficult to discriminate in some places using the orbital color photographs alone. Comparative Apollo-9 color-infrared photographs includes the area within which information products were developed and permits wetlands areas to be more easily analyzed. Directions of sediment drift (arrows) are indicated by light colored plumes. Aerial color imagery at 1:24,000 scale (lower left) provides an effective tool for sampling wetlands ecology including marsh species such as *Spartina alterniflora* (*A*), *Spartina patens* (*B*); and Dredge fill scars (*C*) and a dredge channel (*D*) can also be detected.

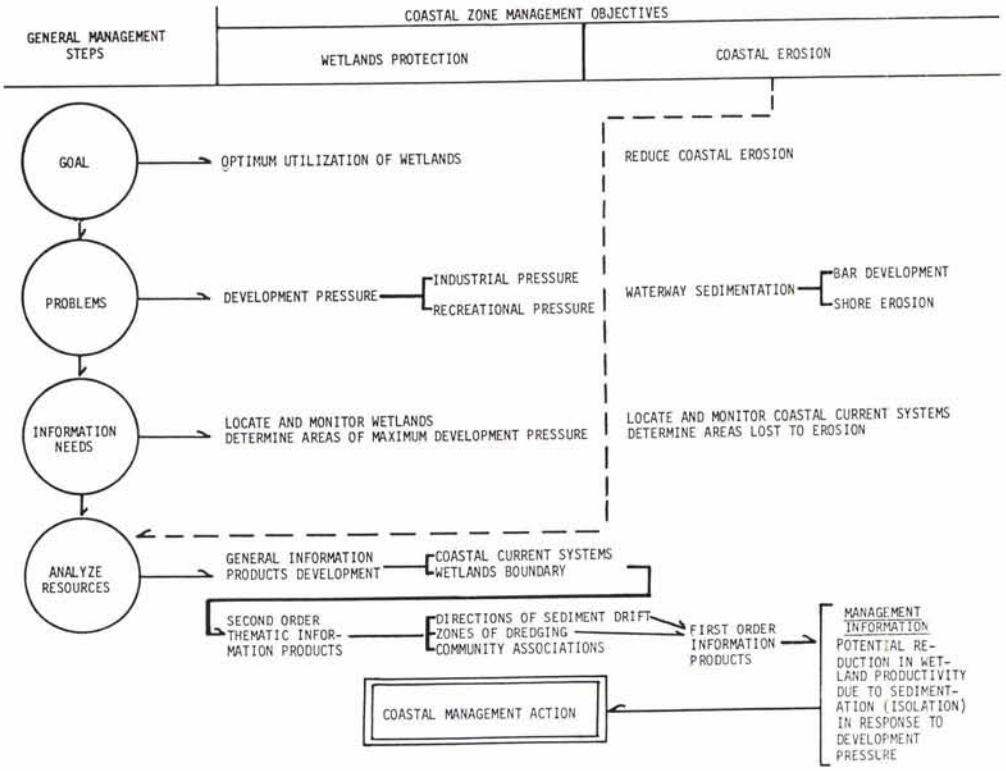

FIG. 4. Resources analysis as conceptualized in this paper involves development of information products using remote-sensing image analysis techniques. The integration of general and second-order thematic information products developed from a related problem area (e.g., coastal erosion combined with wetlands products) yielded useful first-order thematic information product for coastal management action.

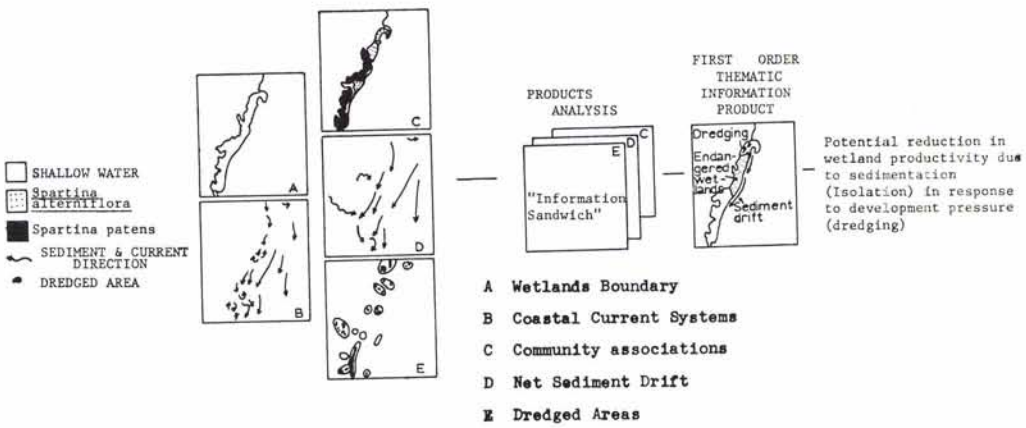

FIG. 5. Information products developed from simulated (manual) ERTS analysis. *A*, *B*—General information products. *C*, *D*, *E*—Second-order thematic information products.

combined with an overlay product showing shore changes indicative of erosion damage, thus providing the basis for planning the allocation of funds for coastal stabilization programs. Repetitive overlay products intended for change detection are also included.

First Order Thematic Information Product (FOTIP). Product development normally requires multi-disciplinary analysis, although it is sufficiently refined and detailed so that very limited experience is required for its use. Product is largely directed towards answering a single question or meeting a single decision-making need. It can generally be used for direct and immediate management action without further refinement. For example, a product which isolates change and is suitable for map updating produced from two or more repetitive overlay products is a first-order thematic information product.

The information products prepared and results obtained from a simulated application to coastal management, are incorporated in Figure 4. The simulated information products cited have value for application to problems outside of the coastal zone. Studies are now underway to develop comparable products for geological exploration, water quality, and urban geographic problems in anticipation of ERTS-A.

The simulated ERTS imagery which was analyzed yielded useful information including (1) delineation of dredged areas and dredge spoil deposits, and (2) nearshore marine current systems. Combining second-order thematic information products served to delineate wetland areas judged to be important for maintaining commercial fin and shell-fish populations which were in potential danger of destruction—information not previously identified.

Summary and Conclusion

Three categories of information products have been experimentally tested for coastal management purposes following small scale photographic analysis under routine (simulated) ERTS operational conditions. The potential contribution of ERTS data to coastal management is well illustrated by the fact that Gemini and Apollo (ERTS-simulated) photography (refined using complementary aerial data) proved useful for identifying the loss of a potentially valuable wetlands area.

Acknowledgements

Thanks are due to the New Jersey Department of Environmental Protection for providing information concerning state coastal needs. Mr. Donald Garofalo of EarthSat drafted the required line drawings. The views expressed in this paper are those of the authors and not necessarily those of the cooperating state agency.

The American Society of Photogrammetry
publishes two Manuals which are pertinent to its discipline:

Manual of Photogrammetry (Third Edition)

	Price to Members	*Price to Nonmembers*
1220 pages in 2 volumes, 878 illustrations, 80 authors. (Sold only in sets of 2 volumes)	$19.00	$22.50

Manual of Color Aerial Photography

550 pages, 50 full-color aerial photographs, 16 pages of Munsell standard color chips, 40 authors	$21.00	$24.50

Send orders, or requests for further information to
ASP, 105 N. Virginia Ave., Falls Church, Va. 22046