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APPLICATION OF ECOLOGICAL, GEOLOGICAL AND OCEANOGRAPHIC ERTS-1 IMAGERY TO DELAWARE'S COASTAL RESOURCES PLANNING

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UN 362 SR 9654

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GREENBELT, MD. 20771

A. Problems

ERTS-1 satellite imagery is too slow in reaching our team. A faster, more reliable method must be found to deliver ERTS-1 imagery to investigators.

B. Accomplishments

1). During the summer and fall, ground truth for vegetation mapping, land use studies, and coastal processes was collected and organized into an impressive set of maps covering the entire coastal zone of Delaware. (Publication No. 1 in Section D of this report). Multispectral analysis of high altitude RB-57 and U-2 photographs indicated that five vegetation species could be clearly discriminated from 60,000 feet altitude, including, 1) salt marsh cord grass (Spartina alterniflora), 2) salt marsh hay and spike grass (Spartina patens and Distichlis spicata), 3) reed grass (Phragmites communis), 4) high tide bush and sea myrtle (Iva species and Baccharus halimifolia), and 5) a group of fresh water species found in impounded areas built to attract water fowl. All of these species are shown in fifteen overlay maps, covering all of Delaware's wetlands prepared to match the USGS topographic map scale of 1:24,000.

2). Suspended sediment patterns and frontal systems appearing in images of the Delaware Coast obtained during ERTS-1 orbit D-333, on August 16, 1972, have been correlated with aircraft photographs, Secci depth measurements and water sample analyses. Three distinct boundaries were identified, across which Secci disk visibility depths varied from 0.6 - 1.2 meters on the more turbid side to 1.4 - 2.2 meters on the clearer side. Divers operating at a depth of 5 meters observed an improvement in visibility from 0.5 to 2 meters as one of the boundaries moved past them. The water samples contained sand particles in shallow areas while silt was predominently present in deeper waters, usually on the less turbid side of the boundaries. Multispectral scanner band 5 (0.6 - 0.7 microns) gave the sharpest definition of interfaces between waters of differing turbidity. Band 4 (0.5 - 0.6 microns), due to its deeper water penetration, was more sensitive to patterns having lower turbidity yet was veiled by a uniform blanket of atmospheric scattering making identification of sediment patterns more difficult. Band 6 (0.7 - 0.8 microns) and band 7 (0.8 - 1.1 microns) clearly delineated the shoreline and discriminated water from land in the marshes. the results show that ERTS-1 imagery can be of value to investigations of coastal processes occurring over large areas if the spectral bands are properly combined to extract features of interest. (Publication No. 2 in Section D of this report).

3). Coastal vegetation species appearing in the ERTS-1 image taken of the Southern Coast of Delaware, during orbit 333 on August 16, 1972, have been correlated with ground truth vegetation maps, and imagery obtained from high altitude RB-57 and U-2 overflights. The vegetation maps of the entire Delaware Coast were prepared during the month of August, including the day of the satellite overpass, using data collected on foot, in small boats, and from low altitude aircraft. (Publication No. 3 in Section D of this report).

4). Three papers have been prepared for publication and are listed in Section D of this report.

5). The ground truth teams have been expanded to include specialists in more scientific disciplines and more boats and aircraft. (See attached organization chart).

C. Significant Results

1). Overlay maps have been prepared showing vegetation species in the entire coastal zone of the State of Delaware. The overlays are at a scale of 1:24,000 and show six major vegetation species plus impoundments and drainage ditches. RB-57 imagery and multispectral analysis was used. The maps are of considerable value to state planning and environmental control agencies, in addition to serving as ground truth for ERTS-1 data interpretation.

2). Suspended sediment patterns and frontal systems appearing in images of the Delaware Coast obtained during ERTS-1 orbit D-333 on August 16, 1972, have been correlated with aircraft photographs, Secci depth measurements and water sample analyses. Three distinct boundaries were identified, across which Secci disk visibility depths varied from 0.6 - 1.2 meters on the more turbid side to 1.4 - 2.2 meters on the clearer side. Multispectral scanner band 5 (0.6 - 0.7 microns) gave the sharpest definition of interfaces between waters of differing turbidity. Band 4 (0.5 - 0.6 microns), due to its deeper water penetration, was more sensitive to patterns having lower turbidity, yet was veiled by a uniform blanket of atmospheric scattering making identification of sediment patterns more difficult. Band 6 (0.7 - 0.8 microns) and band 7 (0.8 - 1.1 microns) clearly delineated the shoreline and discriminated water from land in the marshes. The results show that ERTS-1 imagery can be of value to investigations of coastal processes occurring over large areas if the spectral bands are properly combined to extract features of interest. (Publication No. 2 in Section D of this report).

3). Coastal vegetation species appearing in the ERTS-1 image taken of the Southern Coast of Delaware, during orbit 333 on August 16, 1972, have been correlated with ground truth vegetation maps, and imagery obtained from high altitude RB-57 and U-2 overflights. Major Spartina alterniflora and Spartina patens communities within the tidal marshes can be identified in the ERTS-1 imagery. Phragmites, and other species however, occur in smaller, more dispersed groupings and are difficult to discriminate within the resolution capability of the ERTS-1 scanner. Similarly, major impounded areas, built to attract water fowl can be detected; however, mosquito drainage ditches, covering many of Delaware's marshes, are too narrow and not long enough to be resolved by ERTS-1 sensors. High-marsh and dune communities dominated by high tide bush (Iva frutescens) and sea myrtle (Baccharus halimifolia) can be distinguished from adjacent maritime forest and beach grass communities. (Publication No. 3 in Section D of this report.

D. List of Publications

1. "Application of Automated Multispectral Analysis to Delaware's Coastal Vegetation Mapping" American Society of Photogrammetry, 1973 Convention, Washington, March 11-16, 1973.

2. "Investigation of Coastal Processes Using ERTS-1 Satellite Imagery " American Geophysical Union Annual Fall Meeting, San Francisco, Dec. 4-7, 1972.

3. "Identification of Coastal Vegetation Species in ERTS-1 Imagery" (To be presented at national meeting in Spring, 1973)

E. Conformance to Schedule

Measured from the date of ERTS-1 imagery delivery, we are well ahead of schedule.

F. Work Progress Evaluation

As described in Sections B, C, and D of this report, the massive ground truth collection effort conducted during the summer and fall paid off handsomely, enabling our team to interpret and correlate any ERTS - imagery of this region that we can get our hands on. Federal and State agencies are quite impressed by our results.

G. Adequacy of Funds

If NASA supplies all the funding specified in our contract, all work will be completed on schedule with results exceeding our original expectations. ERTS-1 imagery is better than I expected, but delivery to investigators must be speeded up.

H. Personnel Changes

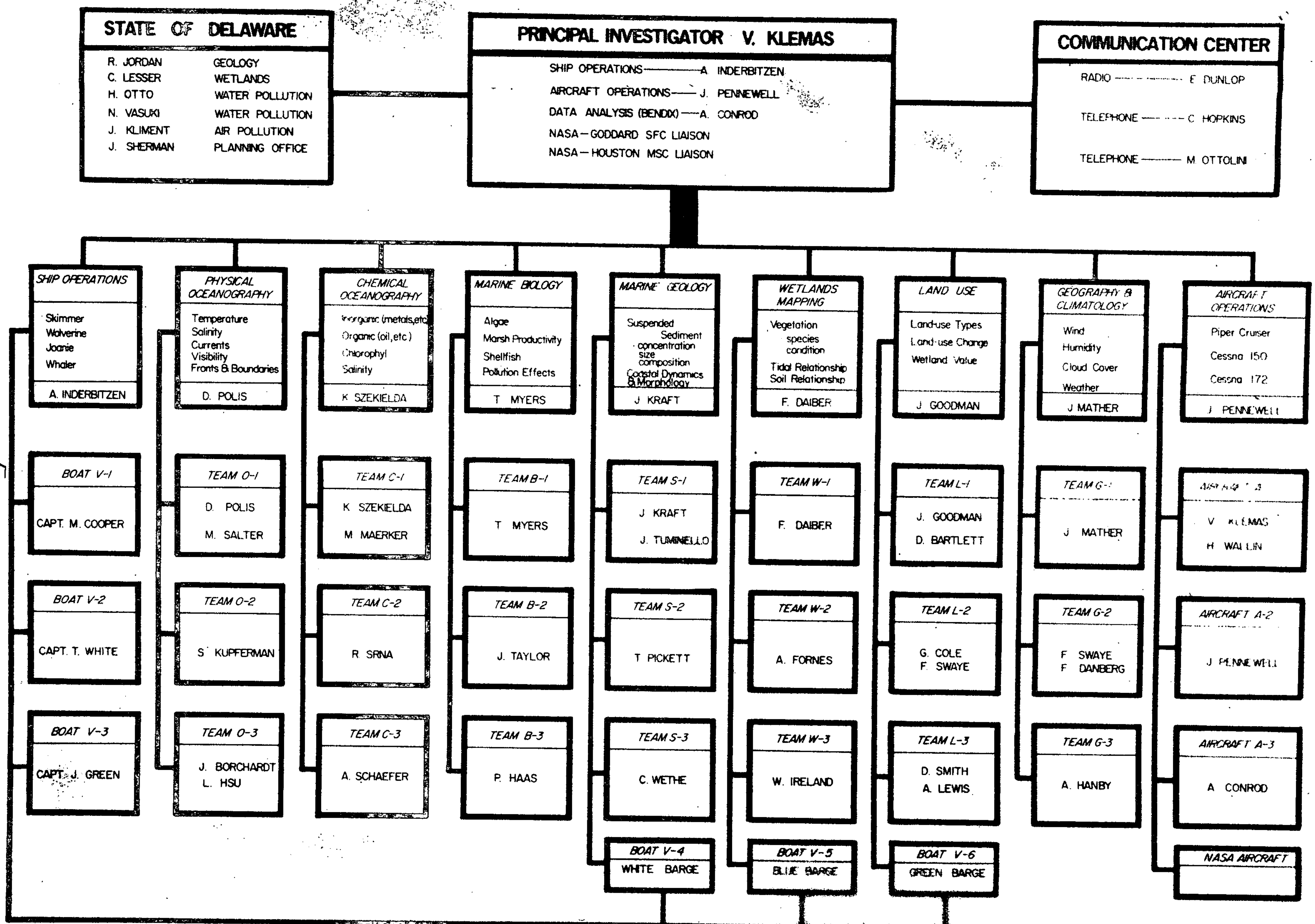
As shown in the attached organizational chart the ground truth teams have been expanded to include specialists from additional disciplines, who will participate in the program at no added cost, with the stipulation that they gain free access to ERTS-1 and NASA aircraft imagery available in my office.

I. Future Planned Work

1. The coastal vegetation studies will be expanded to include other types of land use, i.e., industrial, commercial, recreational, etc..

2. An in-depth study of coastal processes will be conducted correlating ERTS-1 imagery with more detailed measurements, including salinity, sediment concentration, turbidity, chlorophyll, phytoplankton, etc.. In addition to employing boats and fixed-wing aircraft, the use of high speed sampling from helicopters is being considered.

3. Dye studies will be conducted during the next ERTS-1 overpass, to determine dye visibility and also to test the environmental impact of an off-shore oil terminal just outside the Delaware Bay.



STATE OF DELAWARE
R. JORDAN GEOLOGY
C. LESSER WETLANDS
H. OTTO WATER POLLUTION
N. VASUKI WATER POLLUTION
J. KLIMENT AIR POLLUTION
J. SHERMAN PLANNING OFFICE
PRINCIPAL INVESTIGATOR V. KLEMAS
SHIP OPERATIONS—A. INDERBITZEN
AIRCRAFT OPERATIONS—J. PENNEWELL
DATA ANALYSIS (BENDIX)—A. CONROD
NASA—GODDARD SFC LIAISON
NASA—HOUSTON MSC LIAISON
COMMUNICATION CENTER
RADIO — E. DUNLOP
TELEPHONE — C. HOPKINS
TELEPHONE — M. OTTOLINI
SHIP OPERATIONS
Skimmer
Wolverine
Joanie
Whaler
A. INDERBITZEN
BOAT V-1
CAPT. M. COOPER
BOAT V-2
CAPT. T. WHITE
BOAT V-3
CAPT. J. GREEN
PHYSICAL OCEANOGRAPHY
Temperature
Salinity
Currents
Visibility
Fronts & Boundaries
D. POLIS
TEAM O-1
D. POLIS
M. SALTER
TEAM O-2
S. KUPFERMAN
TEAM O-3
J. BORCHARDT
L. HSU
CHEMICAL OCEANOGRAPHY
Inorganic (metals,etc)
Organic (oil,etc)
Chlorophyl
Salinity
K. SZEKIELDA
TEAM C-1
K. SZEKIELDA
M. MAERKER
TEAM C-2
R. SRNA
TEAM C-3
A. SCHAEFER
MARINE BIOLOGY
Algae
Marsh Productivity
Shellfish
Pollution Effects
T. MYERS
TEAM B-1
T. MYERS
TEAM B-2
J. TAYLOR
TEAM B-3
P. HAAS
MARINE GEOLOGY
Suspended Sediment
concentration
size
composition
Coastal Dynamics
& Morphology
J. KRAFT
TEAM S-1
J. KRAFT
J. TUMINELLO
TEAM S-2
T. PICKETT
TEAM S-3
C. WETHE
BOAT V-4
WHITE BARGE
WETLANDS MAPPING
Vegetation
species
condition
Tidal Relationship
Soil Relationship
F. DAIBER
TEAM W-1
F. DAIBER
TEAM W-2
A. FORNES
TEAM W-3
W. IRELAND
BOAT V-5
BLUE BARGE
LAND USE
Land-use Types
Land-use Change
Wetland Value
J. GOODMAN
TEAM L-1
J. GOODMAN
D. BARTLETT
TEAM L-2
G. COLE
F. SWAYE
TEAM L-3
D. SMITH
A. LEWIS
BOAT V-6
GREEN BARGE
GEOGRAPHY & CLIMATOLOGY
Wind
Humidity
Cloud Cover
Weather
J. MATHER
J. MATHER
TEAM G-2
F. SWAYE
F. DANBERG
TEAM G-3
A. HANBY
AIRCRAFT OPERATIONS
Piper Cruiser
Cessna 150
Cessna 172
J. PENNEWELL
AIRCRAFT A-2
J. PENNEWELL
AIRCRAFT A-3
A. CONROD
NASA AIRCRAFT

APPLICATION OF AUTOMATED MULTISPECTRAL ANALYSIS TO DELAWARE'S COASTAL VEGETATION MAPPING

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The growing demand for accurate vegetation and land use mapping in the coastal zone has produced considerable interest in aerial photo-interpretation as a means to produce such maps. This study evaluates a mapping technique which combines the unbiased precision of automated photo analysis with the judgement of a human observer having extensive field experience. The result is a high speed, cost-effective method for producing enhanced photo maps showing a number of spectral classes – each enhanced spectral class being representative of a vegetative species or group of species.

The mapping technique described in this paper utilizes the General Electric Multispectral Data Processing System (GEMSDPS). The GEMSDPS is a hybrid, analogue-digital system designed as an analysis tool to be used by an operator whose own judgement and knowledge of ground truth can be incorporated at any time into the analyzing process. The system consists of 1) a modified color television camera which scans a true color or color-infrared photograph, 2) analogue data processing circuitry which operates on the video signal, 3) television monitors which display the image and results of analysis to the operator and 4) a digital computer which can be used to control the analysis, store the results, and reproduce them in a variety of forms on demand. The operator can control the analysis himself, if he wishes, and see immediately the results of any adjustments he makes. He can thus combine his knowledge of the scene gained in the field with electronic analysis and 1) measure the spectral characteristics of any chosen region of any size in the scene, 2) search the scene for regions with similar characteristics and once they are identified, enhance and store them; 3) modify the stored image if necessary to make it compatible with his knowledge of the area, and 4) read out the percentage of the total scene occupied by regions with the specified spectral signature. By repeating the procedure for other regions in the scene, the operator can quickly produce a composite photo map, enhancing all of the spectrally classified objects or regions of interest.

Overlay maps of Delaware's coastal zone were thus prepared, showing the dominant species or group of species of vegetation in any given marsh area. Five such categories of vegetation were used indicating marshes dominated by 1) salt marsh cord grass (Spartina alternaflora), 2) salt marsh hay and spike grass (Spartina patens and Distichlis spicata), 3) reed grass (Phragmites communis), 4) high tide bush and sea myrtle (Iva species and Baccharus halmifolia), and 5) a group of fresh water species found in impounded areas built to attract water fowl. In addition, major secondary species were indicated where appropriate. Small, representative areas of each of the major marsh regions were analyzed and enhanced to show detailed growth patterns not shown on the large scale maps.

The automated hybrid approach described in this paper is fast, easy to operate and flexible as to the types of imagery used, the analysis modes applied to it, and the form of the final result.

APPLICABILITY OF ERTS-1 SATELLITE IMAGERY TO THE STUDY OF COASTAL PROCESSES

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SUMMARY

Images of the Delaware Coast obtained in the four multispectral scanner bands during ERTS-1 Orbit No. 333 on August 16, 1972, have been correlated with aircraft imagery and ground measurements of suspended sediment patterns and frontal systems. The ground truth was gathered from boats, shore installations and low altitude aircraft over the last seven months, including the day of the satellite overpass. Multispectral scanner band 5 (0.6 - 0.7 microns) gave the sharpest definition of interfaces between waters of differing turbidity. Band 4 (0.5 - 0.6 microns), due to its deeper water penetration, was more sensitive to patterns having lower turbidity, yet was veiled by a uniform blanket of atmospheric scattering making identification of sediment patterns more difficult. Band 6 (0.7 - 0.8 microns) clearly delineated the shoreline and discriminated water from land in the marshes.

The following patterns and boundaries of suspended sediment are visible in the preferred satellite image of band 5 near the mouth of Delaware Bay:

A). The sharp boundary curving around Cape Henlopen.

B). A long boundary one third the distance from Cape Henlopen, N.J., towards Cape May, Delaware.

C). A boundary extending Southeast from the Coast between Cape Henlopen and Indian River Inlet, Delaware.

D). A considerable number of patches of suspended sediment near the tip of Cape May.

Due to the high turbidity of bay water, none of the boundaries or patterns represent bottom features. Boundary A is generally found in the same location and changes only its shape as a function of tidal cycle. It is closely related to bottom topography, showing heavy sand particles stirred up by breaking waves and tidal currents sweeping over the Hen and Chicken Shoal. During ebb tide, it frequently turns into a multiple plume which also contains silt leaving the bay. In addition, the prevailing littoral drift causes heavier sand particles to move north and deposit on the northwest side of Cape Henlopen, with the result that the Cape is growing rapidly in that direction. Boundary B is less predictable, appearing only during portions of some tidal cycles and changing its positions by several miles along the Cape May - Cape Henlopen axis during a fraction of a tidal cycle. It is similar to boundaries extending for miles along the New Jersey and Delaware Coasts of the bay. These boundaries change their distances from shore in response to river flow and tide stage, but are otherwise remarkably sharp and stable. Boundary C usually moves rapidly inland during flood tide, and several miles southward, till it joins the Indian River Inlet sediment plume. Storms tend to destroy these boundaries and cause strong mixing.

Secci disc measurements across boundaries A and B have generally given Secci depths of about 0.6 to 1.2 meters on the turbid side of the boundary and 1.4 to 2.2 meters on the clearer side. This compares well with a visibility change from about 0.5 to several meters, estimated by divers setting up wave towers 250 feet off the coast, as boundary C moved past the towers. Away from shore, the suspended particles consist primarily of silt coming out of Delaware Bay. Near Cape May where the bay is shallow, bottom sediment gets picked up by the tidal currents and waves breaking over the numerous shoals, resulting in the multitude of smaller sediment plumes designated as region D.

The conclusions in this paper are supported by measurements and a large number of photographs taken from various altitudes and on the ground. The results show, that ERTS-1 imagery can be of value to investigations of coastal processes, particularly synoptic studies of major shoreline changes and suspended sediment patterns over large areas, if one selects the proper band for best discrimination of the features to be analyzed.

IDENTIFICATION OF COASTAL VEGETATION SPECIES IN ERTS-1 IMAGERY

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University of Delaware

SUMMARY

Coastal vegetation species appearing in the ERTS-1 image taken of the Southern Coast of Delaware, during orbit 333 on August 16, 1972, have been correlated with ground truth vegetation maps, and imagery obtained from high altitude RB-57 and U-2 overflights. The vegetation maps of the entire Delaware Coast were prepared during the month of August, including the day of the satellite overpass, using data collected on foot, in small boats, and from low altitude aircraft. Multispectral analysis of high altitude RB-57 and U-2 photographs indicated that five vegetation species could be clearly discriminated from 60,000 feet altitude, including, 1) salt marsh cord grass (Spartina alterniflora), 2) salt marsh hay and spike grass (Spartina patens and Distichlis spicata), 3) reed grass (Phragmites communis), 4) high tide bush and sea myrtle (Iva species and Baccharus halimifolia), and 5) a group of fresh water species found in impounded areas built to attract water fowl. All of these species are shown in fifteen overlay maps, covering all of Delaware's wetlands prepared to match the USGS topographic map scale of 1:24,000.

Major Spartina alterniflora and Spartina patens communities within the tidal marshes can be identified in the ERTS-1 imagery. Phragmites, and other species however, occur in smaller, more dispersed groupings and are difficult to discriminate within the resolution capability of the ERTS-1 scanner. Similarly, major impounded areas, built to attract water fowl can be detected; however, mosquito drainage ditches, covering many of Delaware's marshes, are too narrow and not long enough to be resolved by ERTS-1 sensors. High-marsh and dune communities dominated by high tide bush (Iva frutescens) and sea myrtle (Baccharus halimifolia) can be distinguished from adjacent maritime forest and beach grass communities.