N73-28344

Paper M 4

CORRELATION OF ERTS MULTISPECTRAL IMAGERY WITH SUSPENDED MATTER AND CHLOROPHYLL IN LOWER CHESAPEAKE BAY

D. E. Bowker, *NASA-Langley Research Center, Hampton, Virginia,* P. Fleischer, T. A. Gosink, W. J. Hanna and J. Ludwick, *Old Dominion University, Norfolk, Virginia*

ABSTRACT

The feasibility of using multispectral satellite imagery to monitor the characteristics of estuarine waters is being investigated in this study. Preliminary comparisons of MSS imagery with suspended matter concentrations, particle counts, chlorophyll, transmittance and bathymetry have been made. Some visual correlation of radiance with particulates and chlorophyll has been established. Effects of bathymetry are present, and their relation to transmittance and radiance is being investigated. Greatest detail in suspended matter is revealed by MSS band 5. Near-surface suspended sediment load and chlorophyll can be observed in bands 6 and 7.

Images received to data have partially defined extent and location of high suspensate concentrations. Turbid water of the James River enters Chesapeake Bay as a plume that can be traced along the southern shore and extends seaward of Cape Henry. An area of highly variable turbidity exists in the lower Bay between Hampton and Cape Charles, and may be related to strong tidal currents and large-scale bedforms found here. Net quantity of suspended matter in the lower Bay has been decreasing since the inception of the study, and represents the diminution of turbid flood waters carried into the Bay in late September, 1972. The results so far point to the utility of MSS imagery in monitoring estuarine water character for the assessment of siltation, productivity, and water types.

1. INTRODUCTION

The single most useful body of data that one could assemble concerning an estuarine system would be information from which a realistic model of water movement could be developed for the system is generally recognized. Almost all else that occurs in the system is controlled by circulation or is strongly related to it. The causes of water movement, such as tides, wind, and density gradients due to variations in salinity, sediment load and temperature have been delineated. The integration and correlation of the causes of water movement in an estuarine system are complex problems which have been adequately solved for only a very few simple situations.

The lower Chesapeake Bay is a complex estuarine system. It, like many other similar systems, is undergoing continuous change. The factors influencing water circulation are not stable. Physical models of parts of this system have been constructed by the U. S. Army Corps of Engineers. These models have yielded useful results in several experiments, but the changing patterns of water circulation in the actual system cannot be duplicated in these physical models. The water circulation patterns in the lower Chesapeake Bay system remain largely unknown.

Direct measurements of water movement may bot as fully explain the dispersal of pollutants, the mixing of fresh and salt water, or the dynamics of sediment movement as measurement of the item of interest. While these and other phenomena are the results of, and are related to, water movement, their relationships to water circulation patterns are not exactly similar. Thus some measurements in addition to that of water movement may be necessary to describe the phenomena of concern. Remote sensing of suspended sediment load, bottom topography, and other parameters related to water circulation would contribute to more understanding and better management of the resources of our estuarine environments. From our measurements of chlorophyll, plankton, sediments, and bottom topography, some estimates of productivity and sediment dynamics can hopefully be derived for the test area, and by correlations with ERTS data be extended to similar interpretations for other coastal zone areas.

Suspended sediments in estuarine water play important roles in estuarine ecology, and at the same time are involved in certain key physical processes of the tidal environment. Physical processes revealed by the pattern of suspended sediment concentration in water include the elements of circulation, mixing, turbulence and dilution as well as scour or erosion of the bottom and shoreline. The importance to ecology is linked to the capacity of clay-sized sediments to absorb, and later to release, both organic and inorganic substances. Living organisms are a part of the suspended matter in estuarine waters. The chlorophyll in such waters is contained principally in these living organisms. To be assessed these have to be distingusihed from the non-living particulates.

In bay, river and near-coastal waters the suspended sediment load is several orders of magnitude higher than that found in the open ocean. Thus the determination of chlorophyll levels in coastal zone waters by remote sensing is more difficult than in the open sea.[3] Since these waters are shallower than the open sea, there is the probability that the bottom will contribute to the remotely sensed image. Separation of the contribution of the various factors to the satellite imagery is a major part of our objectives.

The sketch map (Figure 1) shows the eighteen helicopter sampling stations and the three transects (dotted lines) in the lower Chesapeake Bay test site that have thus far been occupied. The Old Dominion Institute of Oceanography research ship, Linwood Holton, is used for bottom profiling with precision echo depth recorder on the ship and to log the attentuation coefficient, using a Bendix Transmissometer; to log surface salinity, using a Beckman *in situ* salinometer supplemented with periodic collection of water samples; and to log surface water temperature.

Water samples will be collected in real time from a helicopter platform and returned quickly to the laboratory for examination. Water samples are analyzed for salinity, chlorophyll content, sediment content, and optical transparency. Particulate counts and size-distribution analyses are made by means of a Millipore π Mc particle measurement counter. Inorganic sediments will be examined by microscope and x-ray diffraction.

2. SATELLITE DATA OBSERVATIONS

To date we have received only one complete set of data, namely that for the October 10, 1972 pass. We have had four additional satellite pass dates with clear weather, but only partial picture coverage for two of those dates has come to us.

All of the clear weather days on which we have had satellite coverage have been under calm wind conditions and thus a haze has affected all satellite coverage of this test site.

Figure 5 is a MSS band 5 negative print of the test site area at high tide from the October 10, 1972 pass. The enormous sediment load in the James River as well as what is assumed to be sediment structure in the Bay is obvious. The James River at the time of the pass was carrying sediment from recent floods in the Richmond area, but carries more sediment than the neighboring tributaries visible to the north, and it remained so in a picture from the December 3, 1972 pass.

It has been found that film is not a satisfactory method for microscale work due to the relatively poor quality of the prints, densitometer drift problems, and the "venetian blink" effect. Computer readout of the individual lines is superior, but is not without its own set of problems. For example, using the print as a first look tool, it is necessary to ascertain which line(s) of the several thousand in the scene contain the information sought. Another is, that all of the structure visible in the bay (Figure 5) is caused chiefly by only three neighboring shades of gray on the 0-64 shading scale.

High contrast subjects such as the Bay-Bridge (along sample points 1,2,3) as well as the islands, the Hampton Roads Bridge and the James River Bridge (along sample points 13,14) are discernable in this band. The mothballed fleet (above sample site 11) is also quite visible.

Note also that the main channels <u>seem</u> to be evident in the detail. (The channels run close to 50 feet whereas most of the surrounding water is less than 30 feet.)

The scene is somewhat washed out in band 3, but shoal waters do show a pronounced bottom signal. If one looks progressively from band 3 to band 7, the shoal effect can be readily followed.[4,5] The expected sharp delineation between land and water masses is found in band 7, but it can be noted that the heavy sediment load around the outer peninsula (near sample sites 3 and 4) is still visible in band 7.

3. SURFACE SAMPLE DATA

There seems to be a positive correlation between particulate count and chlorophyll concentration data (Figures 3 and 4) and there appears to be a rough correlation between the sediment data and the pictures (Figure 2) but no correlation with the pictures is obvious for the chlorophyll containing portion of the load. Unfortunately, the surface truth data for this pass was collected on October 9, 1972 instead of the 10th because of an early error on our part in computing the satellite pass date.

Chlorophyll values are found to vary by factors of 2 to 3 within short horizontal distances and thus it is suggested that several samples from approximately a 1000 foot square be combined for a composite sample at sampling locations so as to better match the broad footprint of the satellite data. For this pass the chlorophyll concentrations range from about 10 to 40 mg/m^3 with some highs of 150 to 350 mg/m^3 (see Figure 4). Later passes have chlorophyll values all down in the 10-30 (or less) mg/m^3 range. We hope to obtain a continuous record of chlorophyll across the Bay this spring when an improved model of a tunable dye laser becomes available.[6]

The particulate load runs on the order of several hundred thousand particles per liter with the size range maximum occurring between 0.5 and 1.5μ for the October 10 pass. Later passes analyze for an order of magnitude less particles and with the particle size range maximum between 2 and 4μ.

References

3. Confer Report by Karl Heinz Szekielda, University of Delaware and Robert Curran, NASA-Goddard - "Chlorophyll Structure in the Ocean." E-72-10047

4. Confer Report by Robert L. Charnell and George A. Maul of the NOAA-Physical Oceanography Laboratory," Oceanographic Observation of New York Bight From ERTS-1". E72-10156

5. Confer Report by V. Klemas, University of Delaware, "Applicability of ERTS-1 Satellite Imagery to the Study of Coastal Processes." E72-10119

6. P. B. Mumola, NASA-Langley and H. H. Kim, NASA-Wallops. "Remote Sensing of Marine Plankton by Dye Laser Induced Fluorescence." Presented at the 1972 IEEE Conference on Engineering in the Ocean Environment, Newport, Rhode Island, September, 1972.

Figure 1

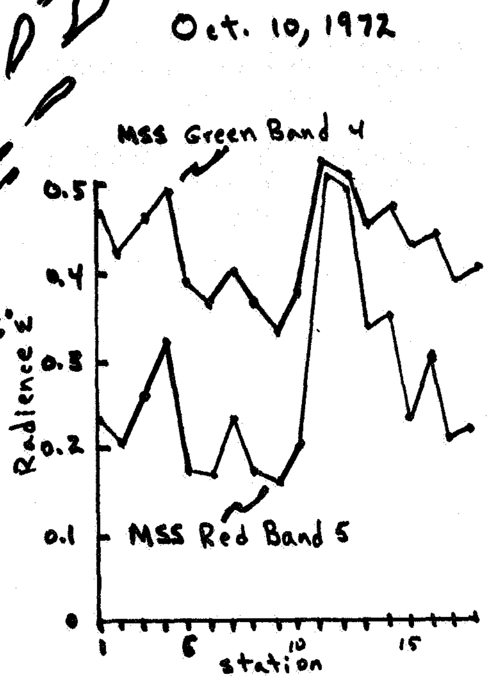

Figure 2

Oct. 9, 1972

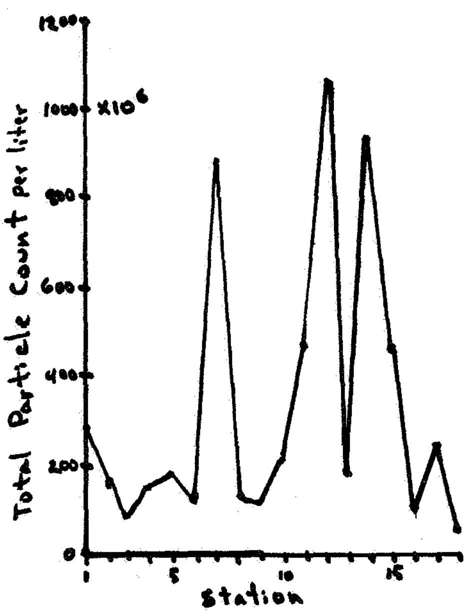

Figure 3

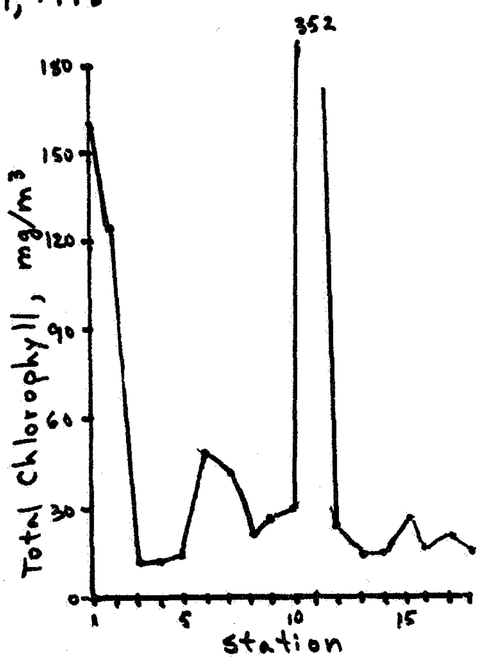

Figure 4

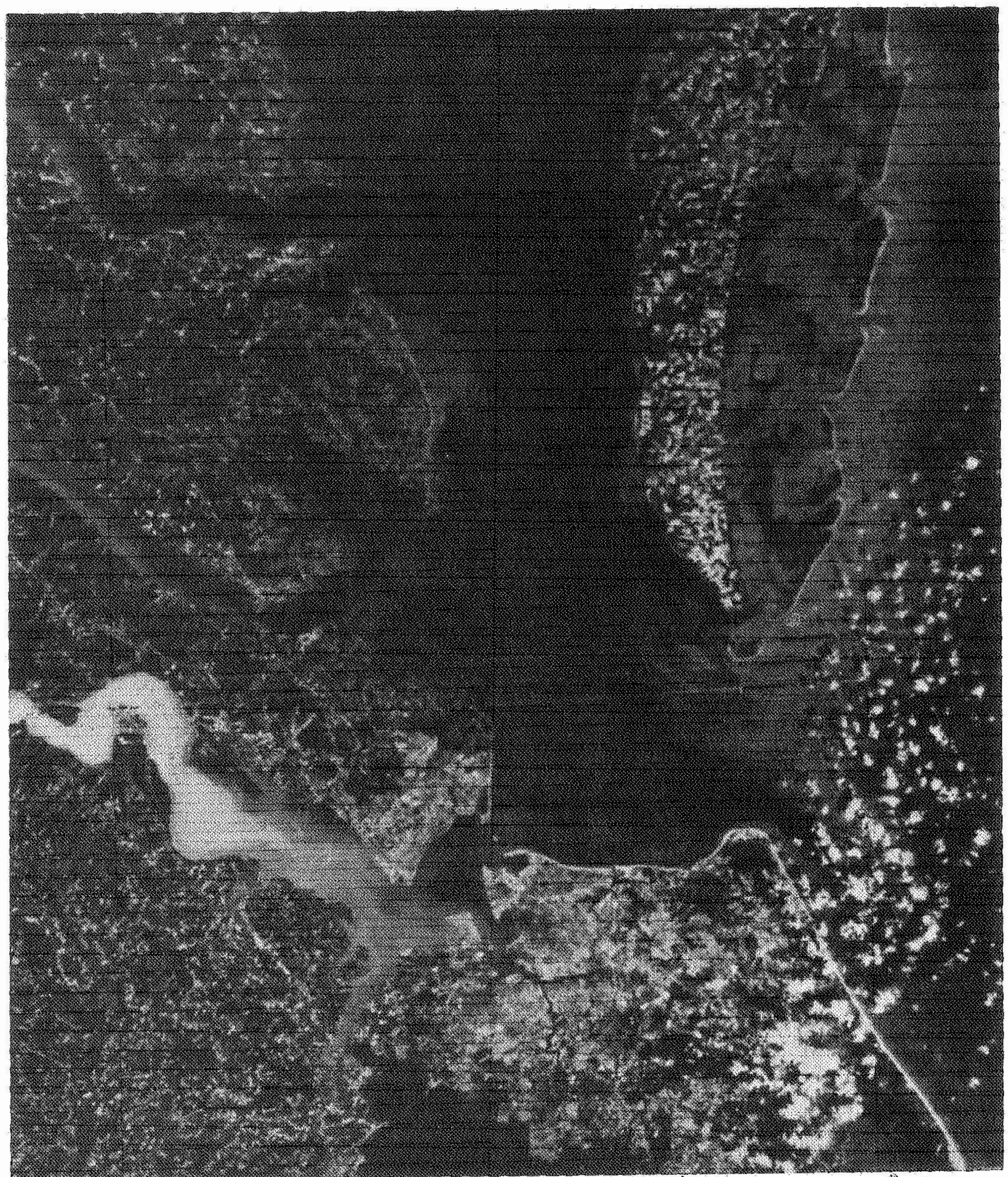

FIGURE 5
MSS Band 5. October 10, 1972. Chesapeake Bay Entrance

B