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TO RELATE CHLOROPHYLL AND SUSPENDED SEDIMENT CONTENT IN THE LOWER CHESAPEAKE BAY TO ERTS-1 IMAGERY (TASK 2)

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16. Abstract The use of multispectral imagery from ERTS-1 to quantitatively monitor turbidity, suspended matter, and chlorophyll is being evaluated in this study. Synoptic measurements of surface-water characteristics are being made on three baselines and twenty stations in lower Chesapeake Bay in synchrony with satellite overpasses. Turbidity is measured as transmittance by a continuously recording transmissometer, and suspended matter is collected by filtration. Preliminary correlations to ERTS multispectral imagery have been made by microdensitometric methods. Final correlations will be made from the bulk tape format.

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SEMI-ANNUAL REPORT

(February through July 1973)

Principal Investigator: Peter Fleischer
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Title: To relate chlorophyll and suspended sediment content in the lower Chesapeake Bay to ERTS-1 imagery.

Objectives:

Correlate ERTS-1 imagery with surface measurements of suspended sediments, salinity, plankton content, bottom topography, and other properties of lower Chesapeake Bay waters.

Describe the estuarine environment of portion of the lower Chesapeake Bay in terms of phytoplankton productivity and of sediment transport.

Develop ground-truth measurement techniques applicable to the interpretation for coastal zones of remote sensor data to be obtained from future earth observation satellites.

Test Sites:

The primary site is lower Chesapeake Bay and the Bay entrance. Two comparison areas also investigated are the Hampton Roads-lower James River, and the inner continental shelf off the Chesapeake Bay entrance.

Procedures:

In this study of lower Chesapeake Bay we are monitoring three primary parameters for correlation with ERTS imagery. These are: turbidity, measured as percent light transmittance and expressed as the attenuation coefficient, alpha, where

$$\alpha = -\frac{1}{\text{beam path-length}} \ln \text{ (transmittance)};$$

suspended matter concentration and composition; and chlorophyll concentration.

These parameters have been selected because they may be most readily expected to possess a spectral signature. Secondary parameters, which are monitored because they are intimately related to the others, but which do not necessarily have a unique spectral signature, are water temperature, salinity, and depth, and sea state.

Data collection of the above parameters is performed every 18 days, in synchrony with ERTS overpasses. Two platforms are used. The Old Dominion University research vessel LINWOOD HOLTON occupies three baselines in lower Chesapeake Bay (Fig. 1) or adjacent waters, and collects transmissometric, bathymetric, temperature and salinity data, and water samples for suspended sediment and analysis. Additional water samples for suspended matter and chlorophyll analysis are collected at about 20 spot samples in lower Chesapeake Bay and the adjacent James River by helicopter.

Light transmission is measured with a continuously recording transmissometer system. This consists of a Bendix/Marine Advisors Transmissometer Probe and a strip chart recorder. The recorder contains an automatic balancing circuit that replaces the conventional manual readout of this transmissometer, and a crystal-controlled drive that makes the recorder suitable for small-boat use (Bryant, 1973). The beam path-length of the instrument has been reduced from 1 meter to 0.43 meters to make it operable in the turbid waters characteristic of this estuary (Melchor, 1972). The transmissometer has a bandpass of about 500 A, centered at 5250 A, which corresponds approximately to channel 4 of the ERTS multispectral scanner (Fig. 2). In order to permit rapid, continuous profiling of the Bay so that an ERTS overpass can be bracketed within several hours by the ship's date, the transmissometer probe is keel-mounted on the

LINWOOD HOLTON at a location 4 feet below the water surface. Mounting and removal are accomplished in about 20 minutes each by two Scuba divers. This transmissometer mounting allows vessel speeds of 6 to 8 knots, and makes it possible to occupy most baselines within 3 hours of a satellite overpass.

Suspended matter is determined by filtration of ship- and helicopter-obtained water samples, and is analyzed for concentration on a dry-weight basis, for particle size and number by an automated particle counter, and for organic matter by low-temperature oxygen ashing, and for mineralogic content by X-ray diffraction analysis.

Samples collected by helicopter are analyzed for chlorophyll and particulate count. Chlorophyll analysis is performed by acetone extraction-spectrophotometry. Particle counts are made with a π MC particle counter at NASA-Langley Research Center.

Results:

During the period February through July 1973, there were 10 ERTS passes over the lower Chesapeake Bay. Cloud cover was a recurrent problem during this period. Two passes resulted in good imagery, and a third pass has partly usable imagery. In the remainder, cloud cover obscures the test sites. R/V LINWOOD HOLTON baseline sampling cruises were carried out during 8 of the 10 passes. Two cruises were cancelled or aborted because of rough seas. Water sampling by helicopter was done on all passes with partial or no cloud cover.

During the last two ERTS passes of this period, 7 and 25 July, ship and helicopter sampling was performed 1) on a continental shelf transect extending eastward from Cape Charles (7 July), and 2) in Hampton Roads and lower James River (25 July), in place of the standard lower Chesapeake Bay sampling area. The purpose of these efforts was to obtain ground and satellite data on the interaction of lower Chesapeake Bay water with adjacent waters. The James

River area was also monitored for chlorophyll in surface waters via a second helicopter with the experimental tunable dye laser being developed at NASA-Langley Research Center.

A continuous plot of transmission and radiance (MSS 4) is shown for each baseline on Jan. 26 and Feb. 13 (Figs. 3 & 4). The radiance data was taken from the 9-inch positive transparency using a microdensitometer. Atmospheric effects have not been considered. In general, when the transmission increases the radiance decreases. Also, it is noticed that the transmission is much lower on Feb. 13 than on Jan. 26, and as a result the radiance is much higher.

Water samples were analyzed at several stations along the baselines for total sediment concentration. This data, along with the attenuation coefficient, alpha, and the radiance, are shown for both Jan. 26 and Feb. 13 (Fig. 5). There is excellent agreement between the suspended sediment and alpha. The correlation between these and the radiance also seems to be very high. It must be remembered that water is subject to rapid change and a time difference between the satellite photography and the sample collection can be very important. Stations 1 and 2 are about an hour apart and fall on opposite sides of the satellite time. It required about 4 to 6 hours to complete the baselines.

Conclusions:

Preliminary correlations by microdensitometer have shown relationships between radiance, alpha, and suspended matter concentrations in surface waters of lower Chesapeake Bay during two ERTS passes. These results indicate that point-sample and continuous baseline data can be successfully correlated to ERTS imagery.

To put these conclusions on a firmer and more quantitative basis, correlations will be made in more detail and with greater precision.

In the future the data will be taken from the magnetic tapes and cross correlations will be made for each of the variables. A regression analysis will be made to relate sediment to radiance.

Additional passes will be required to evaluate the effect of environmental variables on the correlations. Such factors as sediment load, organic versus inorganic suspensates, and atmospheric haze can be evaluated in situ only by repeated observations. Similarly, circulation and its effects on ERTS-observable parameters requires additional observation for elucidation.

References Cited:

Bryant, E.L., 1973, Automatic recorder for a turbidity measurement probe: Langley Working Paper 1097, NASA/Langley Res. Center, 16 p.

Melchor, J.R., 1972, Surface water turbidity in the entrance to Chesapeake Bay, Virginia: Masters Thesis, Old Dominion University, Norfolk, Virginia, 67 p.

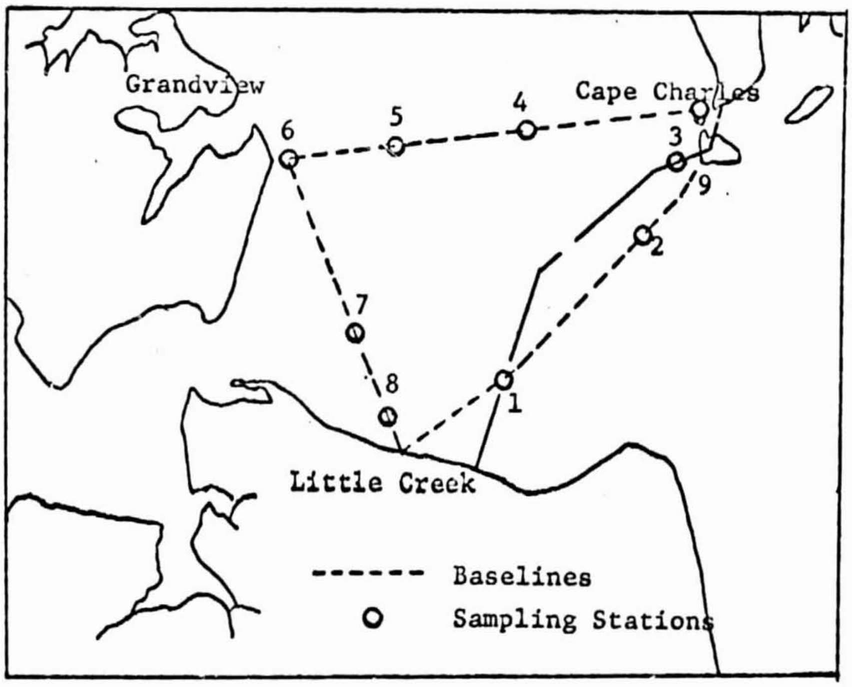

Figure 1. Location map of lower Chesapeake Bay showing baselines and sampling stations occupied during ERTS overpasses.

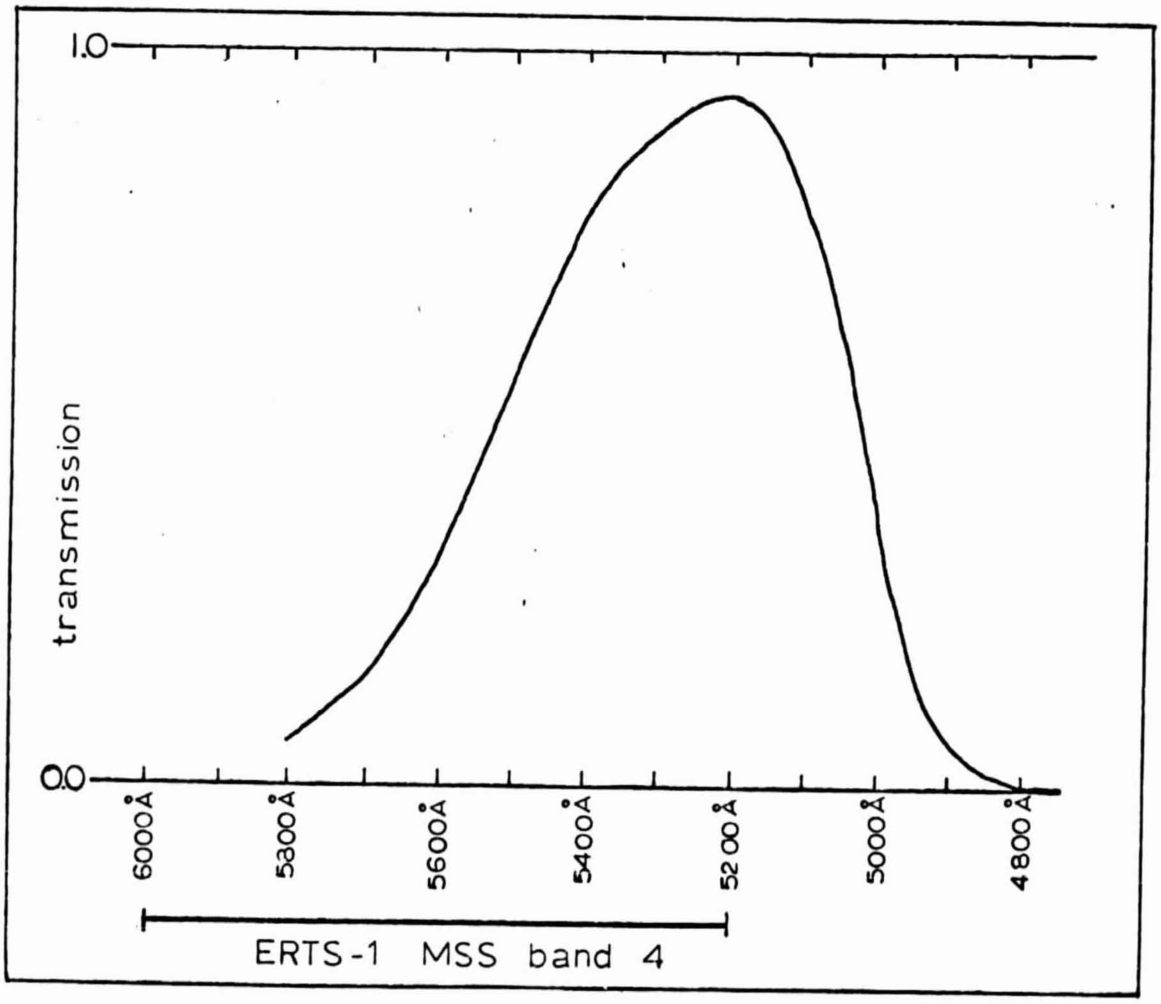

Figure 2. Transmissometer-probe filter characteristics and relation to band 4 of the ERTS-1 multispectral scanner.

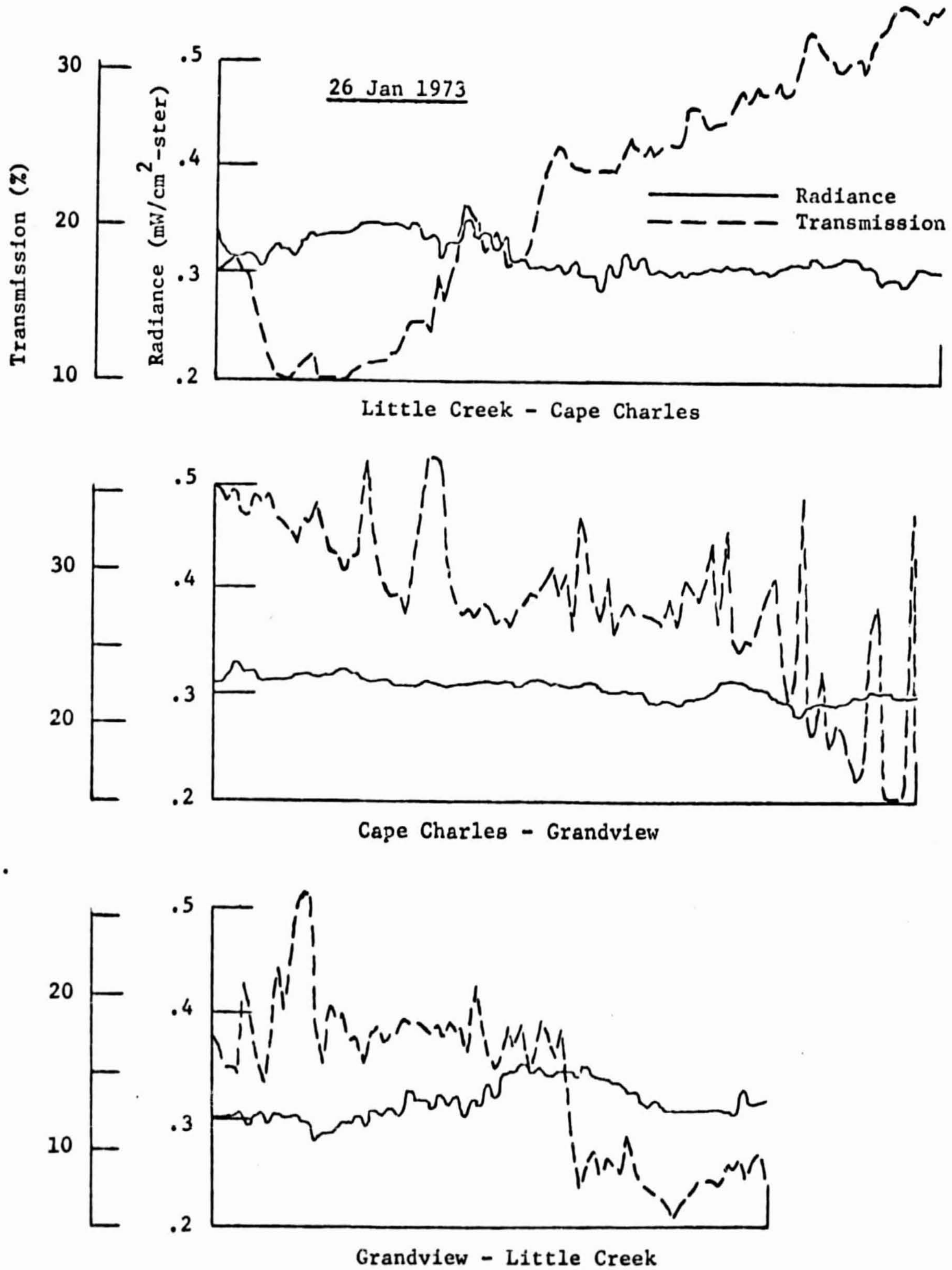

Figure 3. Light transmission profiles (percent transmission per 0.43 m) and radiance profiles of MSS band 4, obtained by microdensitometry of a positive transparency image of the January 26, 1973, overpass.

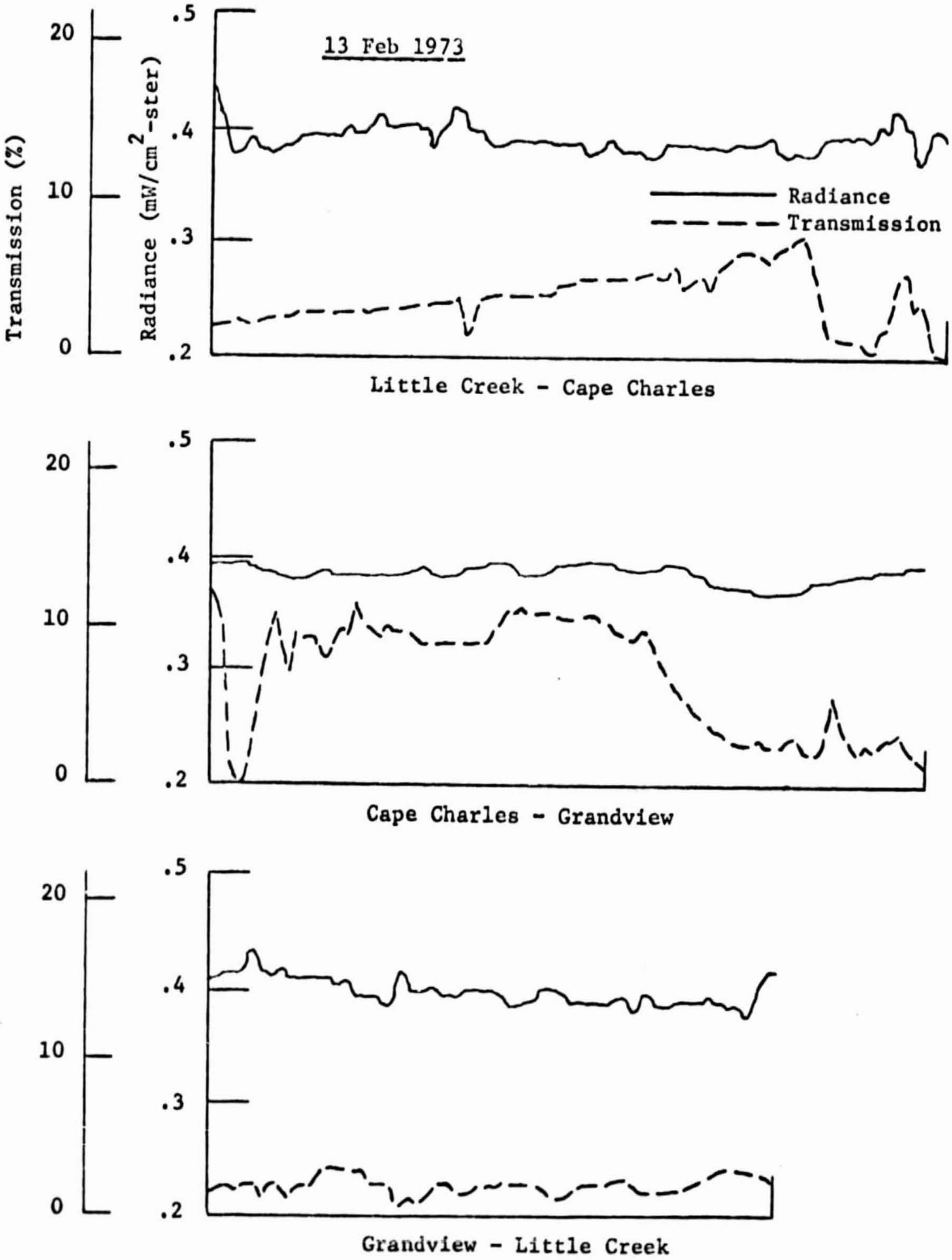

Figure 4. Light transmission profiles (percent transmission per 0.43 m) and radiance profiles of MSS band 4, obtained by microdensitometry of a positive transparency image of the February 13, 1973, overpass.

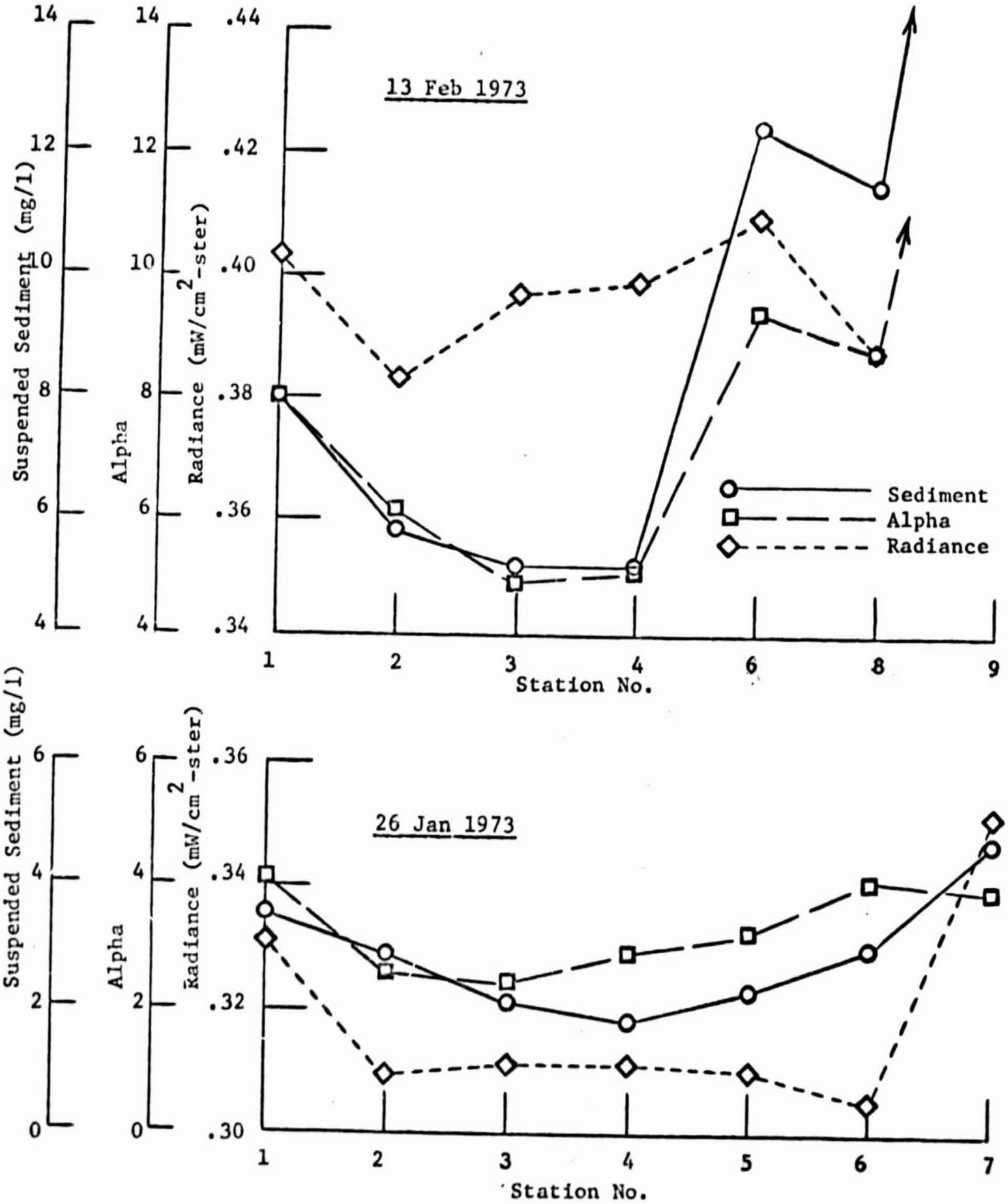

Figure 5. Suspended sediment; attenuation coefficient, alpha; and radiance, MSS band 4, at sampling stations on baselines in lower Chesapeake Bay.