PRELIMINARY ANALYSIS OF OCEAN COLOR SCANNER DATA FROM SUPERFLUX III

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SUMMARY

The Ocean Color Scanner collected data on October 15, 20, and 22, 1980, during Superflux III. Single channel gray scale data products generated 5 minutes after the scanner data were collected showed details of the Chesapeake Plume structure, suggesting that this quick-look capability could have potential use to experimenters in real time. The Chesapeake Bay Plume extended offshore about 5 nautical miles on October 15 and 7 nautical miles on October 20. The scanner data also show many other water features within the lower bay itself.

INTRODUCTION

In order to assess the possibility of relating high altitude remotely sensed spectral signatures to Chesapeake Bay plume features, an Ocean Color Scanner (OCS) was flown at an altitude of 12.5 kilometers (41 000 feet) during the Superflux III experiment on October 15, 20, and 22, 1980.

The OCS is a ten-band instrument covering the spectral range of 418 to 804 nanometers. Each channel has a bandwidth of 20 nanometers. The instantaneous field of view at nadir is 60 meters at the 12.5-kilometer altitude. The center wavelengths for the ten bands are listed on table I. An integral part of the OCS system is a set of instruments that allows for real time transmission of a single channel of scanner data. The image can be generated 5 minutes after the data is collected, giving investigators a real time look at the data. A film recorder is used to create the single-channel image. The recorded image is a gray scale film product with the shades of gray corresponding to the backscattered light intensity levels recorded in a particular channel. The single-channel images can be used to qualitatively indicate the location and distribution of suspended particulate matter.

EXPERIMENT

The OCS was flown on October 15, 20, and 22, 1980. There were six flight lines flown on October 15 (see fig. 1). Flight line 4 was flown twice, once in a southeast direction (line 4) and later, in a northwest direction (line 6). The arrows on the flight lines in figure 1 indicate the direction in which aircraft flew while the times listed are the start times

of each flight line. The tide times shown in figure 1 are for the Chesapeake entrance for October 15. A comparison of the flight times with the tide schedule indicates that the overflights bracketed slack after ebb tide which met one objective of the experiment (i.e., to view maximum plume expansion). The beginning and ending flight line coordinates, the starting times, aircraft heading, Sun azimuth, and Sun elevation are listed in table II.

On the 15th, five boats participated in sea truth collection; 18 data sets were collected. Five stations were sampled at the time of the first and third flight lines. Four stations were sampled during flight line 5. One station was sampled during flight line 6 and three stations were sampled about a half hour after the last flight ended. The positions of the 18 stations are shown in figure 2. Only 17 stations are shown since Station J was sampled at two different times. The time of each station collection and the boat position coordinates are listed in table III. On this day, the winds were out of the southwest at 10 knots.

On October 20, 1980, the OCS flew three flight lines, as shown in figure 3. The arrows indicate the direction the aircraft flew while the times represent the start time for each line. The October 20 tide times at the Chesapeake entrance are also shown on figure 3. The flight line times bracket the maximum ebb tide time. The beginning and ending flight line coordinates, the start time, aircraft heading, Sun azimuth, and Sun elevation are listed in table IV. Strong winds from the northwest of about 18 knots kept all the sea-truth collecting boats inshore, except the Kelez which collected seven sea-truth data points under flight line 1. The stations are located as shown on figure 4. The times and location coordinates of the stations are given in table V.

The OCS flew a third mission on October 22. The purpose of this mission was to fly at the same time as the Multichannel Ocean Color Sensor being flown on a P-3 aircraft at a lower altitude. Two parallel flight lines were flown (fig. 5). The first covered an area from the mouth of the Chesapeake Bay to as far west as $74^{o}40'$ west longitude. The second flight was flown 180^{o} to and about 3 nautical miles north of the first line. (See table VI).

SUMMARY AND DISCUSSION

The single-channel gray scale data products generated did show details of the Chesapeake Bay plume structure. Complete analysis of the multispectral scanner data requires three steps: (1) preprocessing of the digital data, (2) correlation of digital data with sea truth data, and (3) use of correlation to produce quantitative maps. At the time of this Symposium, the digital data were still being preprocessed. One of the preprocess steps that has been completed is a scan angle correction. The OCS has a scan angle of $\pm 45^{o}$. As the angle increases, the distance from the scanner to the water surface element being viewed increases and increasingly greater amounts of Sun and sky radiation scattered by the atmosphere reach the scanner and contribute to the total radiation sensed. At the same time, the longer path

length results in increased atmospheric attenuation of the radiation originating from the water. The scan angle correction normalizes the radiance at non-zero scan angles to that at nadir. For this work, the correction is made empirically. Figure 6 shows the shape of a typical algorithm used to correct the digitized data. The correction differs from channel to channel and can also differ in the same channel from flight line to flight line.

After the scan angle correction was applied, false color images were generated from Band 7 (664-684 nanometers) of the October 15 and 20 digitized data. Black and white copies of the color originals are shown in figures 7, 8, and 9. Figure 7 is a mosaic of flight lines 2, 3, and 4 collected on October 15. On this day, the winds were from the southwest at 10 knots and the scanner data was collected around slack after ebb tide. The radiance color code is shown under the 9:34 EST flight line. The shade of gray on the left represents the lowest radiance levels while those on the right represent the highest radiance levels. So within the bay, the chalk color represents a body of water with a lower radiance level than the surrounding dark gray color water. Areas with lighter shades of gray within the dark gray body of water represent radiance levels that are higher than the surrounding dark gray. A variety of features can be pointed out. There is a lower radiance level body of water that extends from the mouth of the York River to a line roughly parallel with the mouth of the Hampton Roads. From the Hampton Roads mouth to the mouth of the Chesapeake Bay, the water radiance level is higher, as indicated by the dark shade of gray color. Still higher radiance levels are seen hugging the coast around both Cape Henry and Cape Charles. Off of Virginia Beach, the water has a high radiance level. If it is assumed that the dark gray color water mass extending out of the bay mouth represents the Chesapeake plume, then the plume extended about 5 nautical miles offshore.

On the 15th, flight lines 1, 3, and 5 covered the mouth of the bay. Figure 8 shows the three lines. This figure gives a short time history of the water movement around the Bay mouth. The gray scale is the same as in figure 7. If the three flight lines are viewed in their time sequence, then the chalk colored water mass is seen to move south. The dark gray water mass also seems to move southeast out of the bay. These flight lines have not been normalized for Sun angle differences so the apparent movement of the dark gray water mass out of the Bay may be due, in part, to an increase in water radiance caused by an increase in Sun elevation.

Figure 9 presents a mosaic of flight lines 1 and 3 that was taken on October 20. On this day, the winds were out of the northwest at about 18 knots. The scanner data was collected around ebb tide. The gray scale color code is shown under the 12:10 EST flight line. A definite plume is seen coming out around Cape Henry flowing south. It extends farther south than the October 15 plume. There is a second outflow coming out the middle of the Bay mouth. There also seems to be a third outflow around Cape Charles. Water in both the Thimble Shoal Channel and the Chesapeake Channel has a lower radiance than the surrounding water. The Chesapeake plume seems to extend about 7 nautical miles offshore which is farther than it was on October 15.

FUTURE WORK

Correlation of the digital data with chlorophyll and suspended solids will be attempted. OCS and MOCS data will also be compared.

TABLE I. - OCEAN COLOR SCANNER INFORMATION

Flight Altitude 12.5 km (41000 feet)

Bands	Center Wavelength
1	428 nm
2	466
3	508
4	549
5	592
6	632
7	674
8	714
9	756
10	794

Bandwidth 20 nm Ground Resolution 60 m, (300 feet)

TABLE II. - OCTOBER 15, 1980 FLIGHT DATA

Flight Line	Coordinates Begin	Coordinates End	Start Time EST	Aircraft Heading	Sun Azimuth	Sun Elevation
1	36°45.1'N x 75°51.3'W	37°21.2'N x 76°21.9'W	9:19	328.9°	132°	30°
2	37°18.5'N x 76°29.2'	36°47.0' x 76°03.3'	9:34	146.5°	135°	32°
3	36°36.2' x 75°39.5'	37°23.6' x 76°21.1'	9:50	325.5°	140°	35°
4	37°14.8' x 75°57.3'	36°37.3' x 75°24.8'	10:06	145.2°	143°	36°
5	36°35.6' x 75°35.5'	37°17.2' x 76°11.6'	10:25	325.3°	149°	39°
6	(4 over again) 36°40.9' x 75°28.0'	37°15.0' x 75°57.5'	10:51	322.1°	155°	41°

TABLE III. - SEA TRUTH DATA COLLECTED UNDER OCS OCTOBER 15, 1980 FLIGHTS

	Kelez	John Smith	Judith Ann	RV Langley	Holton
FL-1					
Station	808	805	J	LY1	69
Time EST	9:14	9:19	9:30	9:20	9:19
Location	36°45.7'N	36°51.5'	36°59.3'	36°57.1'	36°55.0'
	75°54.67'W	75°55.4'	75°58.5'	76°02.2'	75°58.0'
FL-3					
Station	809	70	J-1	LY2	802
Time EST	9:50	9:58	9:48	9:58	9:50
Location	36°46.36'N	36°52.1'	36°59.5'	36°58.6'	36°56.0'
	75°48.77'W	75°52.6'	75°58.5'	76°00'	75°55.3'
FL-5					
Station	821	806		LY3	803
Time EST	10:28	10:32		10:40	10:33
Location	36°47.42'N	36°52.5'		37°01.5'	36°58.0'
	75°42.62'W	75°49.5'		75°56.2'	75°51.5'
FL-6					
Station	810				
Time EST	10:48				
Location	36°47.67'N				
	75°41.12'W				

TABLE III. - SEA TRUTH DATA COLLECTED UNDER OCS OCTOBER 15, 1980 FLIGHTS

(continued)

	Kelez	John Smith	Judith Ann	RV Langley	Holton
Station	811	807			804
Time EST	11:44	11:27			11:25
Location	36°48.73'N	36°54.2'			37°01.02'
	75°32.26'W	75°40.6'			75°44.2'

TABLE IV. - OCTOBER 20, 1980

Flight Line	Coordinates Begin	End	Start Time EST	Aircraft Heading	Sun Azimuth	Sun Elevation
1	36°46.4'N x 75°51.1'W	37°25.7'N x 75°57.4'W	11:31	352.8°	168°	43°
2	36°43.2' x 75°37.7'	37°19.5' x 75°42.4'	11:58	355.1°	178°	44°
3	37°19.9' x 76°10.9'	36°49.9' x 76°06.2'	12:10	172.7°	184°	43°

TABLE V. - SEA TRUTH DATA COLLECTED UNDER OCS OCTOBER 20, 1980 FLIGHTS

Station	Time EST	Location
KZ 1	11:30	$36^{o}56.03'N \times 75^{o}53.00'W$
KZ 2	11:35	$36^{o}56.58' \times 75^{o}52.95'$
KZ 3	11:40	$36^{o}57.16' \times 75^{o}52.90'$
KZ 4	11:45	$36^{o}57.72' \times 75^{o}52.81'$
KZ 5	11:50	$36^{o}58.41' \times 75^{o}52.94'$
KZ 6	11:55	$36^{o}59.07' \times 75^{o}53.01'$
KZ 7	12:00	$36^{o}59.72' \times 75^{o}53.12'$

TABLE VI. - OCTOBER 22, 1980

Flight Line	Coordinates Begin	End	Aircraft Heading
1	$36^{o}59.5'N \times 76^{o}20'$	$36^{o}59.5'N \times 74^{o}40'W$	90^{o}
2	$37^{o}02' \times 74^{o}40'$	$37^{o}02' \times 70^{o}10'$	270^{o}

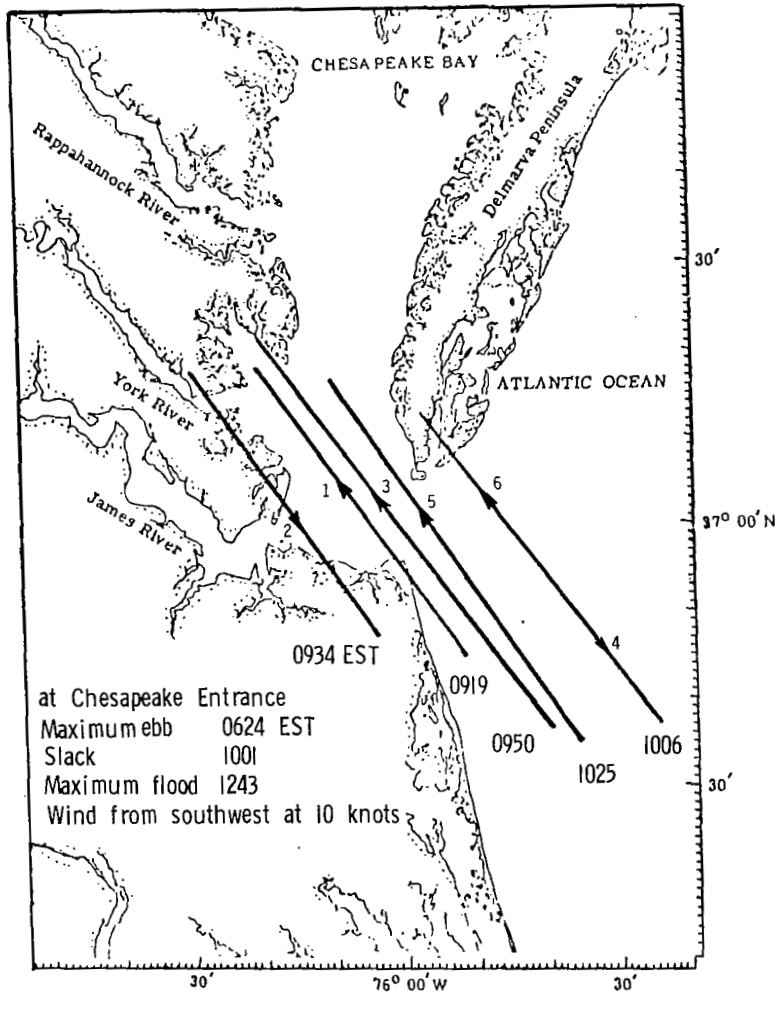

Figure 1.- Flight track of Lear Jet/OCS mapping mission on October 15, 1980.

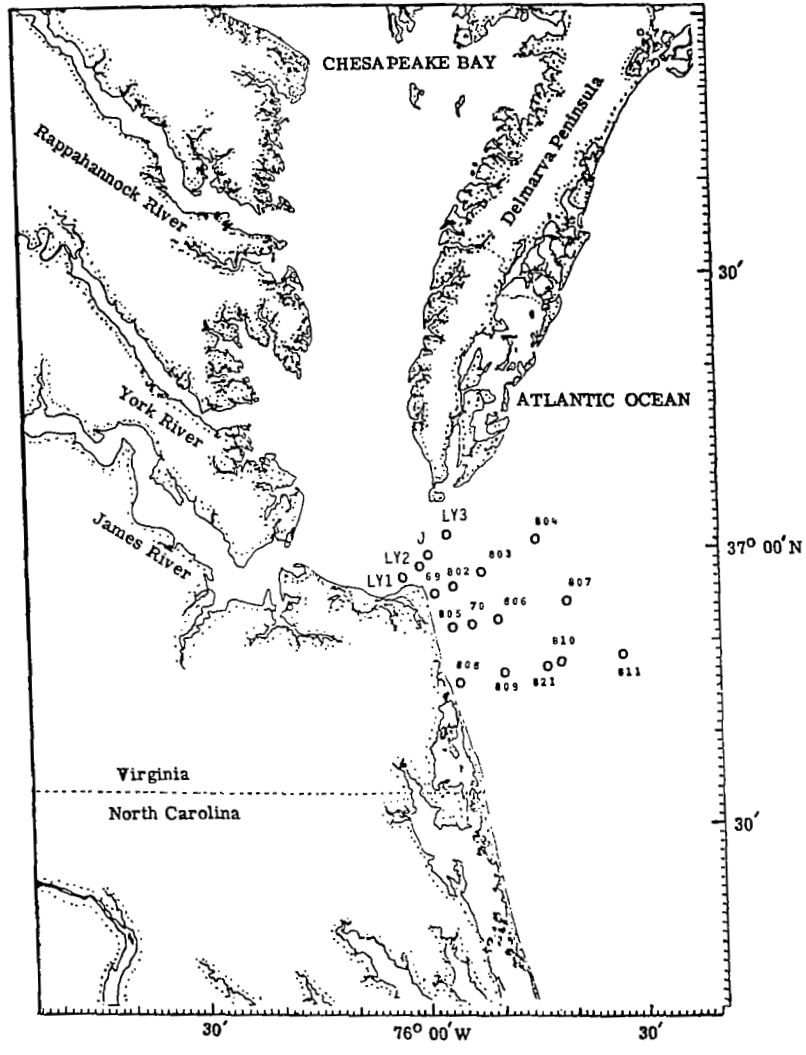

Figure 2.- Location of sea-truth stations on October 15, 1980.

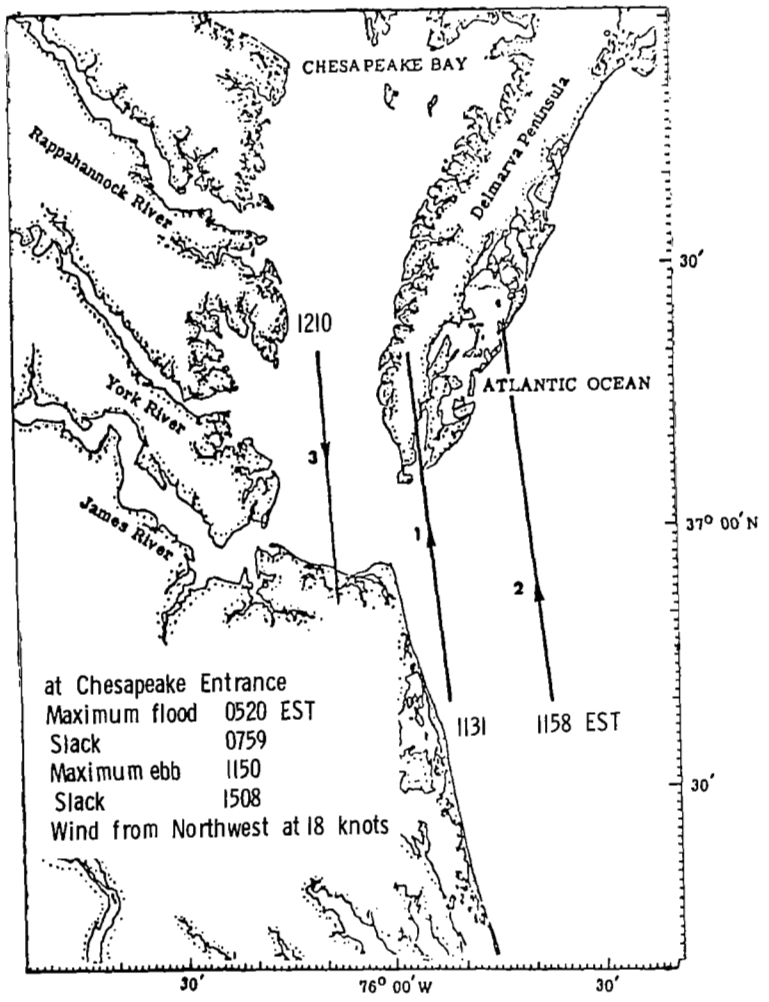

Figure 3.- Flight track of Lear Jet/OCS mapping mission on October 20, 1980.

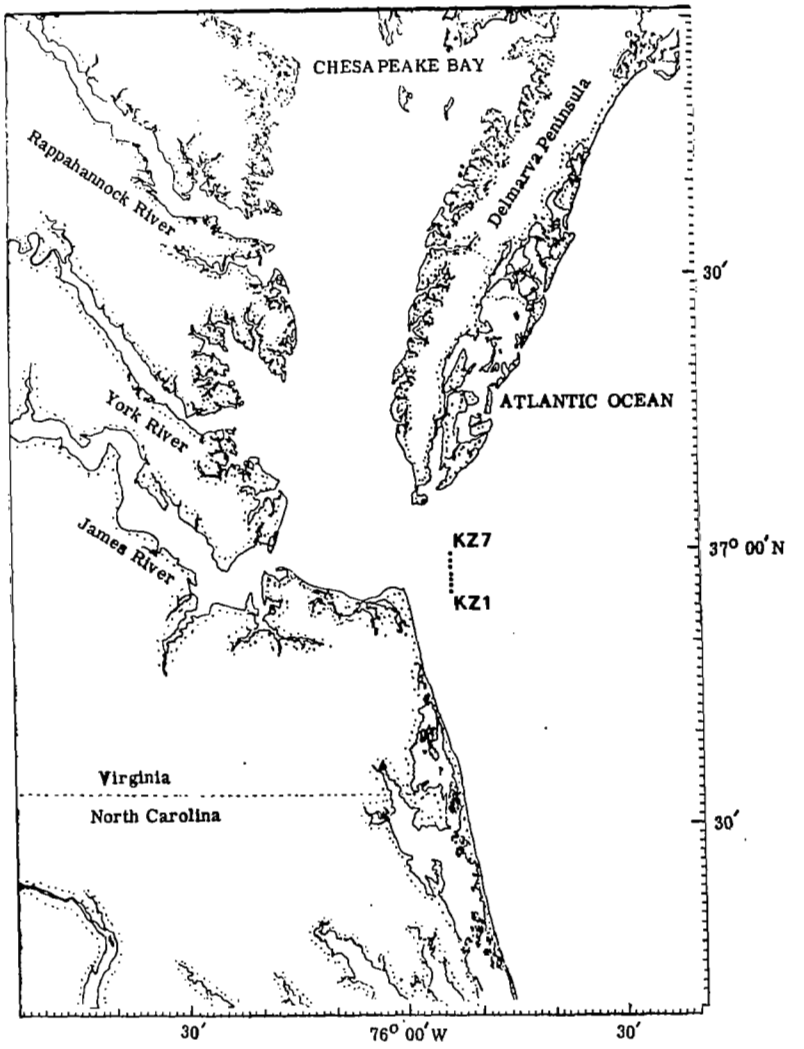

Figure 4.- Location of sea-truth stations on October 20, 1980.

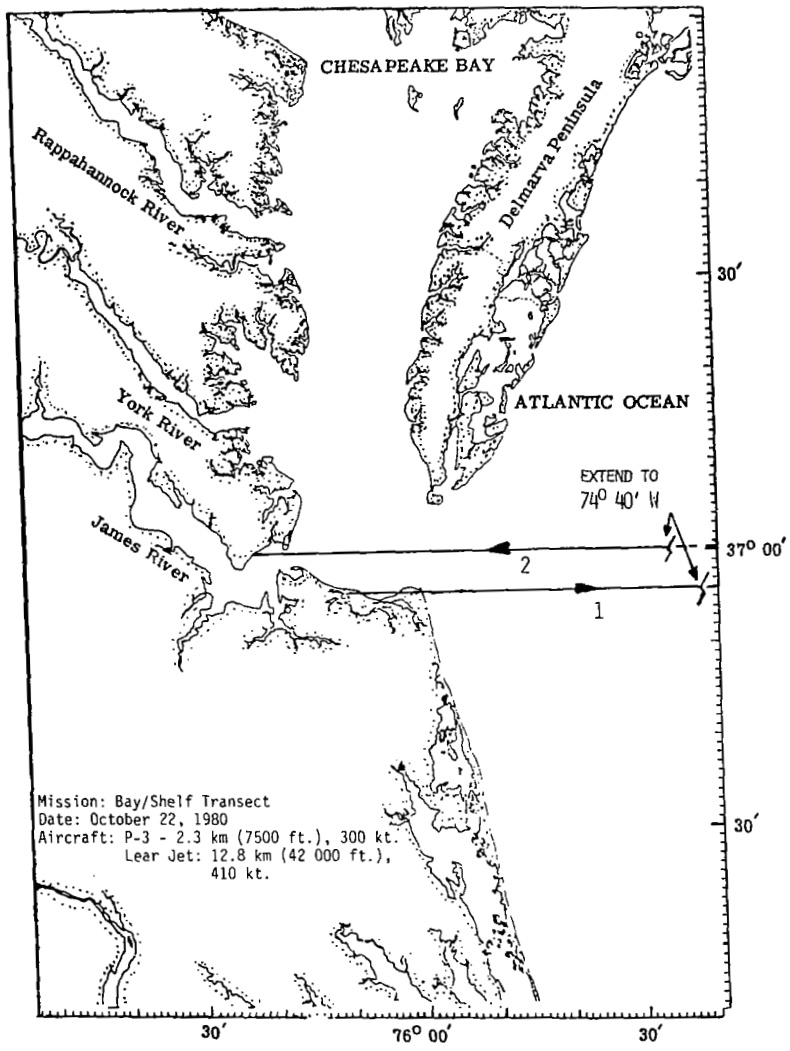

Figure 5.- Flight tracks of P-3/MOCS and Lear Jet/OCS missions on October 22, 1980.

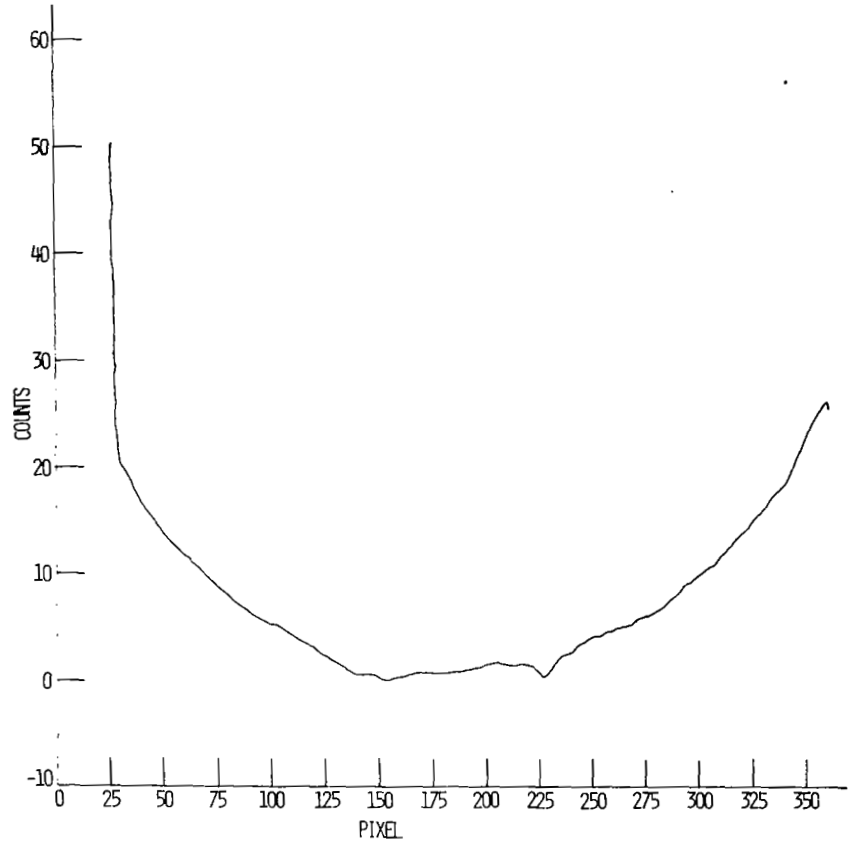

Figure 6.- Scan angle correction curve.

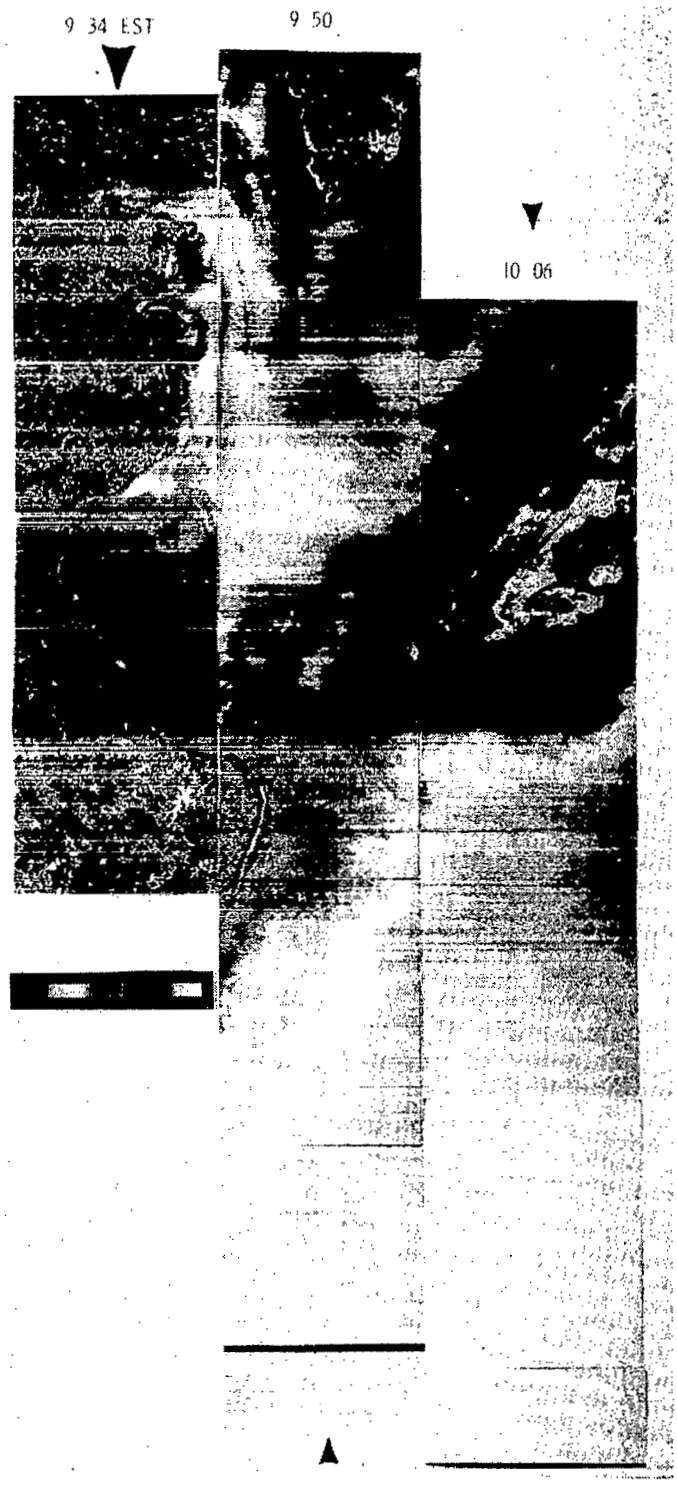

Figure 7.- Mosaic of flight lines 2, 3, and 4 taken on October 15, 1980.

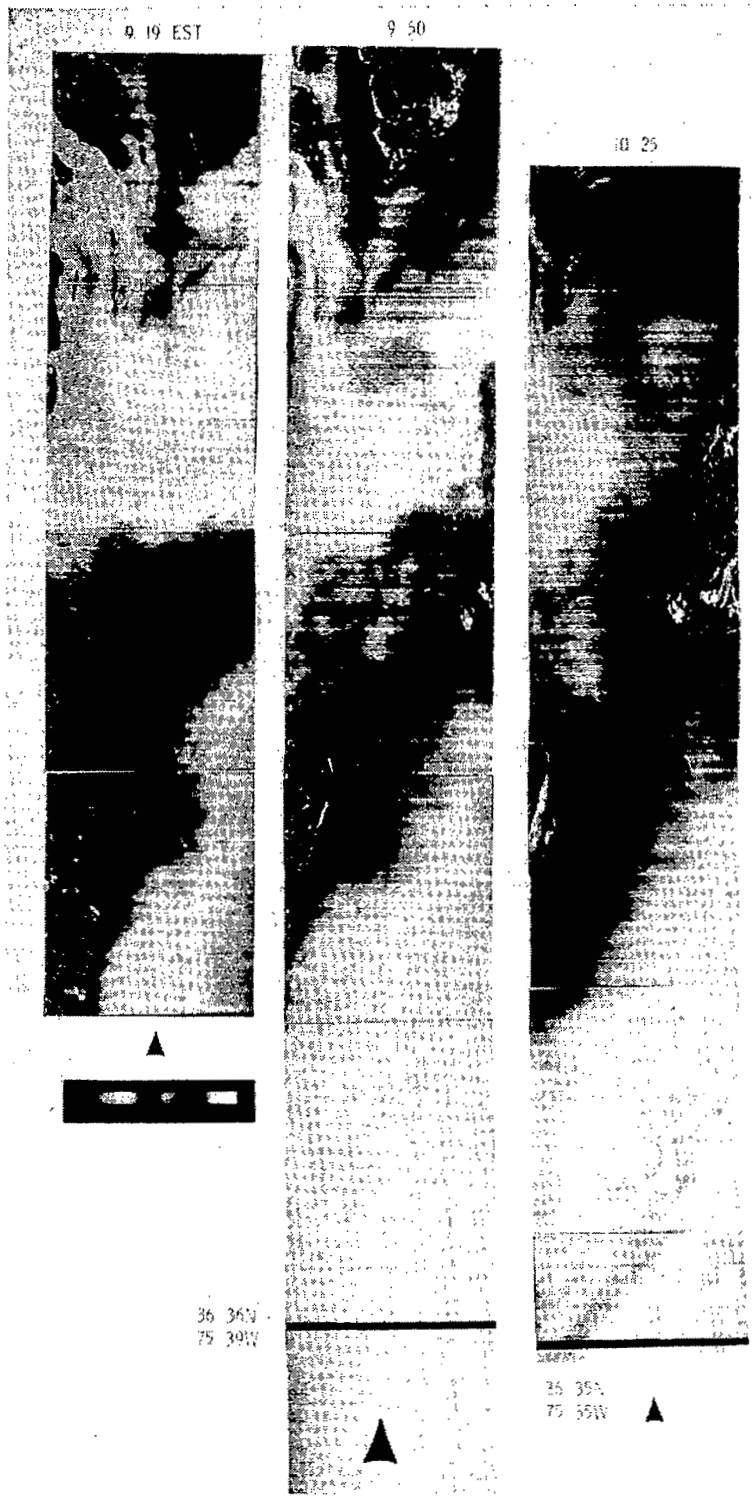

Figure 8.- Composite of flight lines 1, 3, and 5 taken on October 15, 1980.

Figure 9.- Mosaic of flight lines 1 and 3 taken on October 20, 1980.