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National Aeronautics and Space Administration Operations - Remote Sensing Experiments in the New York Bight, April 7-17, 1975

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16. Abstract

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The purpose of this report is to document the operations performed by NASA in carrying out the six remote sensing experiments. Brief descriptions of the test site, aircraft platforms, experiments, and supporting sensors are presented. The operations of each aircraft are discussed and aircraft flight lines, flight parameters, and data identification parameters are presented in figures and tables. Operations performed by the helicopters and surface platforms to obtain in situ sea truth data will be presented by NOAA in a separate document.

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National Aeronautics and Space Administration

Operations - Remote Sensing Experiments in the New York Bight, April 7-17, 1975

J. W. Usry and J. B. Hall, Jr.

SUMMARY

Six remote sensing experiments were conducted by the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) in the New York Bight between April 7-17, 1975, to evaluate the role of NASA remote sensing technology in monitoring ocean dumping. Twenty-two remote sensors were flown on the C-54, U-2, and C-130 NASA aircraft, while NOAA obtained concurrent in situ sea truth data using helicopters and surface platforms. The primary sensors included a radiometer/scatterometer (RADSCAT), Ocean Color Scanner (OCS), Multichannel Ocean Color Sensor (MOCS), four Hasselblad cameras, two Zeiss cameras, an airborne multispectral photographic system (AMPS) containing four cameras, an Ebert spectrometer, a Reconofax IV infrared (IR) scanner, and a Precision Radiation Thermometer (PRT-5).

The purpose of this report is to document the operations performed by NASA in carrying out the six remote sensing experiments. Brief descriptions of the test site, aircraft platforms, experiments, and supporting sensors are presented. The operations of each aircraft are discussed and aircraft flight lines, flight parameters, and data identification parameters are presented in figures and tables. Operations performed by the helicopters and surface platforms to obtain in situ sea truth data will be presented by NOAA in a separate document.

INTRODUCTION

The New York Bight ocean area is adjacent to one of the most densely populated and industrialized regions in the world and serves as a playground, fishery, dump, sewer, and transportation route. As a repository of man's wastes, it is one of the most abused bodies of water. Waste solids, barged and dumped into the Bight, exceed the combined sediment discharge of all rivers emptying into the Atlantic Ocean between the U.S.-Canadian border and the Chesapeake Bay. Wastes also enter the Bight via the inflowing Hudson, Raritan, and East Rivers, diffusely through land runoff and air fallout, and directly by way of sewage outfalls. In years ahead, the environment may be further compromised by new developments such as offshore nuclear power plants, superports, deep water oil terminals, and artificial islands. These activities, both present and planned, have caused increased concern to the public, the scientific community, and those who depend upon the Bight to make their living. Conflicts between these groups concerning economic development and environmental protection will have to be reconciled. Therefore, a pressing need exists to obtain environmental information about the Bight and relate this information to the needs of the agencies charged with the management of the Bight's resources.

Accordingly, NOAA in 1974 initiated a 7-year New York Bight Marine Ecosystem Analysis Program to obtain environmental information. This program is the first of several Marine Ecosystems Analysis (MESA) programs that are being planned by NOAA. The program represents a wide array of techniques and disciplines that reside within the laboratories of NOAA. The program is focused on providing information to better understand and minimize man's impact on the coastal zone.

A more efficient utilization of the New York Bight resources requires techniques for rapid and accurate assessment of the effects of man's activities on the Bight ecology. This requirement, coupled with the dynamic nature of the marine environment, accents the need for the spatial and temporal advantages of remote sensing systems. Accordingly, as a cooperative effort in the MESA program NOAA requested that NASA investigate the role of their remote sensing technology in defining circulation in the New York Bight and the application of this technology to monitoring and managing ocean dumping. The first step of this cooperative effort was accomplished in the Bight during April 7-17, 1975. Six remote sensing experiments were conducted (five by NASA and one by NOAA) using 22 remote sensors flown onboard aircraft platforms to obtain sea surface information while NOAA obtained concurrent in situ "sea truth" information with a combination of helicopters and surface platforms.

The purpose of this report is to summarize the NASA operations during the New York Bight mission of April 7-17, 1975. This report includes brief descriptions of the remote sensing experiments and sensors, descriptions of the aircraft flight lines correlated with the operation of the remote sensing experiments. Details on the NOAA operations will be published in a separate NOAA report.

TEST SITE

The area selected by NOAA for the joint NOAA-NASA experiments was primarily the Apex of the New York Bight as shown in figure 1. The New York Bight extends from Cape May, New Jersey, to Montauk Point, New York, and seaward to the edge of the continental shelf (200 m depth). The Apex is bound on the north by Long Island, on the south by latitude meridian 40°10'N and on the east by longitude meridian 73°30'W. Presently, within the Apex, sewage sludge is dumped at a location about 18 km (9.7 n mi) south of Long Island. Acid wastes are dumped at a location about 10 km (5.4 n mi) southeast of this sewage sludge dump site. All of the remote sensing experiments of April 7-17, 1975, were conducted within the Apex boundaries except one which also included the northern part of the Bight.

DESCRIPTION OF PLATFORMS, EXPERIMENTS, AND SUPPORTING SENSORS

Three NASA aircraft platforms with a total of 22 remote sensors on-board were used to conduct six remote sensing experiments. Five of these experiments were conducted by NASA and one by NOAA. Descriptions of the platforms, experiments, and the sensors used to obtain supporting information for these experiments follow.

Platforms

C-54 (NASA 438).- The C-54 is a four engine, medium weight, personnel transport, cargo carrier based at Wallops Flight Center, Wallops Island, Virginia. The aircraft has been modified to carry electronic equipment for regional remote sensing research programs. A photograph of the aircraft is shown in figure 2. Specific parameters pertinent to the aircraft capabilities are listed in table 1.

U-2 (NASA 709).- The U-2 is a single-place aircraft designed for high altitude, long-range operations, and is based at NASA's Ames Research Center, Moffett Field, California. The aircraft is characterized by its long wings, tandem landing gear along the fuselage, and droppable auxiliary gear located outboard on each wing. A photograph of the aircraft is shown in figure 3. Specific details pertinent to the U-2 capabilities are given in table 2.

C-130 (NASA 929).- The C-130 is a high-wing, medium altitude, long-range aircraft based at NASA's Johnson Space Center, Houston, Texas. The aircraft is used for multidisciplinary research activities but primarily for overland flights oriented toward multispectral scanner research and development. The aircraft is equipped with four camera windows, a television system, and an on-board photographic darkroom. A photograph of the aircraft is shown in figure 4. Specific details pertinent to the aircraft capabilities are listed in table 3.

Experiments and Supporting Sensors

A summary of the six experiments and supporting sensors are given in table 4. The experiments are listed with the quantity of sensors for each experiment, the platforms on which they were flown, the experiment and sensor purpose, and the NASA-NOAA investigator team responsible for each experiment. The experiments and corresponding sensors are described as follows.

Experiment No. 1 - Radiometer/Scatterometer (RADSCAT).- This experiment was flown on the C-130 aircraft at an altitude of 3.05 km (10,000 ft). In addition to the RADSCAT instrument, two Zeiss cameras, a Reconofax IV IR scanner, and a Precision Radiation Thermometer (PRT-5) were also flown, as requested by NOAA. Data obtained by these instruments will be used by NOAA to aid in correlating RADSCAT data with water circulation parameters. Instruments similar to the Reconofax IV IR scanner and PRT-5 were also flown on the C-54 to support Experiment No. 3; therefore, these two instruments are discussed under that experiment.

RADSCAT is a composite, dual-frequency microwave sensor consisting of a radiometer which detects thermal radiation at microwave frequencies and a scatterometer which measures radar cross section. A photograph of the system installed in the C-130 aircraft is shown in figure 5. RADSCAT and antenna characteristics are listed in table 5. A conceptual description of the composite sensor is presented in reference 1; antenna characteristics in reference 2; and results of measurements showing that the instrument produces high quality data are given in reference 3. A description of the basic RADSCAT design, antenna, mechanical subsystems, and a brief discussion of the associated digital controller are presented in reference 4. The objectives of this experiment were: (1) to evaluate an aircraft radar technique for obtaining ocean surface wind vector/wind stress in a quasi-operational measurement mode; and (2) to evaluate the use of large scale surface area wind distribution, obtained from RADSCAT, for estimating the distribution of near surface ocean currents.

Two Zeiss cameras were used onboard the C-130 to obtain photographic data to aid in correlating RADSCAT data with surface water circulation and surface wind direction. These data were obtained by photographing dye and smoke releases at selected locations. These cameras are normally used for aerial surveys to provide high resolution ground truth data of the target area. Specific camera details pertinent to this experiment are listed in table 6.

Experiment No. 2 - Ocean Color Scanner (OCS).- The Ocean Color Scanner (figure 6) was flown on the U-2 aircraft at an altitude of 19.8 km (65,000 ft) and was supported by four 70-mm Mitchell-Vinten cameras. The OCS was also supported by the Ebert spectrometer, Reconofax IV, and PRT-5 instruments flown on the C-54 at low, 0.46-km (1500 ft), and intermediate, 5.33-km (17,500 ft), altitudes. Data from these instruments are used to develop algorithms and procedures to interpret the OCS data. The objectives of this experiment were to: (1) evaluate the capability of high altitude remote sensing to detect and quantify pollutants in ocean water; (2) determine the optimum spectral bands for future scanners devoted to water pollution detection and measurement; (3) evaluate the ability of the spectral bands planned for the NIMBUS-G Coastal Zone Color Scanner (CZCS) to detect and quantify chlorophyll and sediment in ocean water; and (4) assist NOAA in determining the motion of pollutants dumped into the New York Bight. OCS is a ten-channel multispectral scanner ranging from 433 to 772 nanometer center wavelength with a 90° total scan angle and spatial resolution of 3.5 milliradians. Spectral bands and saturation radiance values are listed in table 7.

The radiance for saturation shown in table 7 is for a gain of one for each channel. Gain may be increased separately for each channel in steps of 1.5, 2, and 3 to allow for changing sun angle due to seasonal changes or time of flight. All channels, except 9, are optimized for water scenes, including atmospheric backscatter as seen for 19.8 km. Channel 9 has the same level of gain as the LANDSAT band 6 that covers 700 to 800 nanometers.

Four 70-mm Mitchell-Vinten cameras were flown with the OCS to provide high resolution photography to aid in locating the U-2 position. Three of these cameras contained black and white film, and one contained color film. A photograph of this system is shown in figure 7. Specific camera details pertinent to this experiment are shown in table 8.

The OCS was also supported by the Ebert spectrometer, Reconofax IV, and PRT-5 instruments flown on the C-54 at low, 0.46 km (1500 ft), and intermediate, 5.33 km (17,500 ft), altitudes. Data from these instruments are used to develop algorithms and procedures to interpret the OCS data.

The Ebert spectrometer flown on the C-54 measures high spectral resolution (5 nm) ocean color spectra at the lower altitudes at or near the time that the OCS experiment is being conducted. Surface temperature data are obtained by the Reconofax IV and PRT-5 instruments.

The ocean color spectra measured by the Ebert spectrometer will be analysed to meet the following objectives: (1) compute the characteristic vectors of the sample of ocean color spectra obtained from the New York Bight area for comparison with those of similar samples previously collected elsewhere in the world; (2) analyze, especially, the color spectra of the acid waste dump using a characteristic vector analysis approach which will allow determination of the extent to which the acid waste "signature" is unique, as compared to the "signatures" of other sources of discoloration in sea water; (3) estimate the spectral transmission of the atmosphere over the New York Bight by comparing color spectra measured along the same track-line at altitudes of 0.46 km (1500 ft) and 5.33 km (17,500 ft). The third objective was the principal objective (in support of OCS) as originally conceived. The intent was to use the high-vs.-low altitude comparative data to calibrate the U-2 imagery. Unfortunately, only one such set of data was obtained on a day when the U-2 was aloft, and then only after low and medium clouds had moved into the New York Bight Apex area. It is doubtful, therefore, whether the data will yield any substantial achievement of this objective.

An Ebert spectrometer uses a grating to project a diffracted light spectrum onto a surface containing a narrow slit. A photomultiplier converts the radiation passing through the slit into a voltage, which in this case was recorded both on a strip chart recorder, and in digital form, on magnetic tape. The position of the slit in the diffracted spectrum determines the wavelength of the measured radiation. In the Goddard Space Flight Center (GSFC) Ebert spectrometer, the diffraction grating is rotated to move the projected spectrum across the slit, thus producing a time-varying output which is a known function of wavelength. In other Ebert designs, the slit is mechanically scanned to produce the spectral output.

As configured for this experiment, the GSFC spectrometer scanned a complete spectrum from 400 to 700 nm in about 1.5 seconds with a spectral resolution of less than 5 nm. The spatial resolution of the nadir-looking instrument is approximately 250 m (with the objective lens removed) at an altitude of 0.46 km (1500 ft), and approximately 200 m (with the objective lens in place) at an altitude of 5.18 km (17,000 ft). Aircraft motion moved the center of the spectrometer view a distance of approximately 120 m during the 1.5 sec. required to observe a single spectrum. No photographs or further specifications were available at this time.

The Reconofax IV infrared mapper is a single channel radiometer that optically/mechanically scans successive contiguous lines across the aircraft flight path. The instrument measures relative temperature of the ocean surface to an accuracy equivalent to $\pm 0.3^{\circ}K$. These data are converted to absolute temperature measurements using the PRT-5 data. A photograph of this instrument is shown in figure 8, and instrument characteristics are listed in Table 9.

The PRT-5 is a lightweight, portable, battery-powered thermal infrared radiometer that detects radiance values equivalent to $\pm 0.5^{\circ}K$. A photograph of this instrument is shown as figure 9, and instrument characteristics are listed in table 10.

<u>Experiment No. 3 - Multichannel Ocean Color Sensor (MOCS)</u>.- The MOCS instrument was flown on the C-54 at an altitude of 5.33 km (17,500 ft). A photograph of the instrument is shown in figure 10 and a schematic of the optical arrangement and list of specifications are shown as figure 11. A description of the instrument with developmental and flight test data are presented in reference 5. The feasibility of remotely detecting water pollutants with MOCS has been demonstrated and is reported in references 5, 6, and 7. The purpose of this experiment was to collect spectral signatures of the various water masses in the New York Bight and correlate these data with sea truth measurements, and to correlate ocean color with thermal data obtained by a Reconofax IV infrared mapper and a Precision Radiation Thermometer (PRT-5).

<u>Experiment No. 4 - Photography</u>.- A photograph of the cluster of four Hasselblad cameras on the C-54 is shown in figure 12. These cameras were flown at an altitude of 5.33 km (17,500 ft). The objectives of this experiment were to demonstrate and calibrate the broad-band optical filtering system for remote sensing of phytoplankton and suspended sediment in water by measuring the spectral radiance of the sea surface. Film-filter combinations were selected to enhance chlorophyll <u>a</u>, suspended sediment, and other measures of water quality. Reference 8 describes the experimental process by which these film-filter combinations were selected to quantify remotely sensed data. Additional experimental data and analysis using this technique are presented in reference 9. The four bands used, camera settings, filters used on each camera, film format, and film type are listed in table 11.

<u>Experiment No. 5 - Multispectral Scanner Data Analysis</u>.- This experiment will use digital multispectral scanner data from the Ocean Color Scanner (OCS) and Multichannel Ocean Color Sensor (MOCS) (see experiment 2 and 3) to evaluate developed techniques (see ref. 10 and 11) for quantitatively determining suspended sediment and chlorophyll concentrations in water. The capability to quantitize other water parameters will be investigated. Data results will include quantitative contour plots of these water parameters. Interpretations of the contours will locate and quantitize the suspended sediment and nutrient concentrations and dispersions in the Hudson River

plume. In addition, quantitative particle information (taken in situ) from ocean dump plumes will locate the associated dump areas and provide information relative to their dispersal characteristics and environmental effects (e.g. changes in chlorophyll a concentrations).

Data analysis technique development has demonstrated quantitative determinations of suspended sediment from LANDSAT (ref. 10) and aircraft (ref. 11) multispectral scanner data. Chlorophyll a has been quantitatively related to aircraft platform multispectral scanner responses (ref. 11).

Experiment No. 6 - Dye Marker/Photography.- The purpose of this experiment was to obtain quantitative water circulation data at the surface and at 10 meters below the surface. Cylindrical cannisters containing fluorescein (green) and rhodamine (red) dye were implanted during two separate missions by NOAA contracted helicopters. The fluorescein dye cannisters floated on the surface from where a line ran to a bottom anchor position. The rhodamine dye cannisters also floated on the surface, but in these cases the line ran to a drogue set at 10-meters depth. The dye dissolved over a period of 6-8 hours with the fluorescein dye yielding surface circulation tracking data, whereas the rhodamine dye yielded circulation tracking data for the 10-meter depth. A C-130 aircraft flying at 3.05 km (10,000 ft) tracked the dyes with photographic sensors consisting of two Zeiss Cameras and an airborne multispectral photographic system (AMPS). Characteristics of these photographic systems are given in table 12.

OPERATIONS AND DISCUSSIONS

The field operations involved six major data-collecting elements as shown in figure 13 and included three NASA aircraft flying the remote sensors and three elements (NOAA and Coast Guard) collecting sea truth data. A day-by-day chronology for each of these elements is shown in table 13. Remote sensors carried onboard the NASA aircraft are listed under each platform in figure 13, and in situ oceanographic sea truth data provided by the ground truth elements are listed under each of those elements. The NOAA ship, George B. Kelez, was the primary ground truth data-collection platform. A Coast Guard helicopter was used to collect water samples for sediment and chlorophyll analysis, and helicopters contracted by NOAA were used to deploy the dye cannisters. Ambrose Light Tower, operated by the Coast Guard, provided meteorological data throughout the mission. Dye markers and smoke bomb releases were also deployed from Ambrose to aid in defining surface currents and wind conditions.

Operations concerning the five NASA remote sensing experiments (see experiments 1 to 5 in table 4) and NASA support for the NOAA experiment (Experiment 6 in table 4) are discussed in this section. Details on the NOAA operations will be published in a separate NOAA report.

C-54

The C-54 flew two missions during the 11-day window. Flight lines, flight parameters, and data identification parameters are shown in figure 14. Both missions (April 10 and April 13) were flown between the hours of 0800-1300 EDT in slightly cloudy weather with some overcast. On April 10, three radial lines (1, 2, and 3) were flown from Kennedy Airport (see figure 14a) and one long line, C1 (including C), extending 157 km (85 n.mi.) out over the ocean were flown in support of Experiment No. 2. In addition, the long line C1 (including C) was flown back at 5.33 km (17,500 ft). The other lines A, B, C, D, and E were flown at 5.33 km (17,500 ft) as required by Experiments 3 and 4. On April 13, no radial lines were flown at the low altitude, 0.46 km (1500 ft), however, the long line C1 (see figure 14d) was flown (out and back). Lines A, B, C, D, and E were again flown at 5.33 km (17,500 ft). The air temperature at 5.33 km (17,500 ft) was -17°C on April 10 and -28°C on April 13. On each mission, two of the Hasselblad cameras malfunctioned probably due to the low operating temperatures, therefore, no images were obtained by these two cameras. Data sets were obtained for the MOCS, Ebert spectrometer and PRT-5.

U-2

The U-2 based at Wallops Flight Center for these experiments, flew three missions during the 11-day window on April 9, 13, and 14. Flight lines for each of these missions and data identification parameters for the OCS and Mitchell-Vinten cameras are shown in figure 15. The first mission (April 9, 1975) was flown during the morning hours from 1029-1200 EDT and during the afternoon hours from 1337-1503 EDT. Light to moderate cirrus and cumulus clouds were encountered over most of the test area. During the second mission (April 13, 1975), which was flown in the morning between the hours from 1030-1201 EDT, light to moderate cirrus and cumulus clouds were encountered over most of the test area. The third mission (April 14, 1975), was flown in the morning between the hours from 1038-1209 EDT, and the weather was clear over the New York Bight. Mitchell-Vinten camera imagery was of good to excellent quality on all three days. On all three missions, a shutter problem on camera 4 resulted in a soft focus around the edge of the film. Also, camera 1 was inadvertently filtered with a Wratten 12 filter rather than Wratten 21+Wratten 57 filter producing panchromatic minus blue imagery rather than yellow band imagery as desired.

C-130 (RADSCAT)

The C-130 flew the RADSCAT mission on Thursday, April 17, between the hours of 1006-1316 EDT. The aircraft flew lines consisting of four 360° standard-rate turns (20 band angle) at each of 10 stations at a nominal altitude of 3.05 km (10,000 ft). RADSCAT measurements were obtained at station 1 (Ambrose Tower) at the start and end of each mission. Also one upwind flight line and two crosswind flight lines were flown near station 1 at the start of the mission. Two Zeiss cameras provided photographic coverage of a smoke release at Ambrose Tower and dye releases at Ambrose and near stations 5 and 7 (corresponds to NOAA buoys 33 and 15). The stations about which these flight lines were flown and data identification parameters for the RADSCAT and Zeiss cameras are shown in figure 16.

C-130 (Dye Markers/Photography)

The C-130 flew two missions at a nominal altitude of 3.05 km (10,000 ft) to support the Dye Markers/Photography Experiment No. 6 conducted by NOAA (see table 4). The first mission was flown on April 10 and the second mission was flown on April 13. The C-130 flight lines are shown in figure 17a. Locations of the dye marker implants are shown in figure 17b. Flight parameters and data identification parameters are shown in figures 17(c-e).

CONCLUDING REMARKS

The NASA aircraft operations involved in conducting six remote sensing experiments over the New York Bight between April 7-17, 1975, have been presented. The test site and aircraft platforms are discussed using figures 1-4 and tables 1-3. Each experiment is discussed and objectives reviewed. Primary and supporting remote sensors used in conducting each experiment are discussed and instrument characteristics presented using figures 5-12 and tables 5-12. Finally, the operations of each aircraft are discussed. Flight line and data identification from the aircraft flight summary reports and flight logs are presented in figures 14-17.

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TABLE 1.- C-54 AIRCRAFT

Serial Designation	NASA 438
Location	Wallops Flight Center, Wallops Island, Virginia
Staging	Wallops Flight Center, Wallops Island, Virginia
Engines	14 cylinder, twin row, air cooled Pratt and Whitney R-2000
Cruise	To 6.1 km (20,000 ft)
Speed	315 km/hr (170 knots) true air speed
Range	5000 km (2700 n.mi.)
Weight	Maximum - 324,704 Nt. (73,000 lb)
	Basic - 204,608 Nt. (46,000 lb)
Fuel	13,400 liters (3,540 gal.)
Crew	Pilot, Co-pilot, Flight Mechanic

TABLE 2.- U-2 AIRCRAFT

Serial Designation	NASA 709
Location	Ames Research Center, Moffett Field, California
Staging	Wallops Flight Center, Wallops Island, Virginia
Range	4630 km (2500 n.mi.)
Cruise	6.5 hr at Mach 0.69
Altitude	19.8 km (65,000 ft)
Speed	Normal at 19.8 km (65,00 ft) - 726 km/hr (392 knots) true air speed
	Long range profile - 741 km/hr (400 knots) true air speed
Weight	Maximum - 100,266 Nt. (22,542 lb)
	Basic - 59,590 Nt. (13, 397 lb)
Payload	2046 Nt. (460 lb)
Fuel	4997 liters (1,320 gal)
Dimensions	Length - 15.2 m (49.75 ft)
	Wing span - 24.4 m (80.17 ft)
	Height - 4.6 m (15.17 ft)
Crew	Pilot

TABLE 3.- C-130 AIRCRAFT

Serial Designation	NASA 929
Location	Johnson Space Center, Houston, Texas
Staging	Langley Research Center, Hampton, Virginia
Range	4630 km (2500 n.mi.)
Cruise	8 hr at 9144 m (30,000 ft)
Altitude	9144 m (30, 000 ft) operational ceiling
Speed	278 to 611 km/hr (150 to 330 knots) true air speed
Weight	Maximum - 600,480 Nt, (135,000 lb)
	Basic - 376,866 Nt. (84,727 lb)
Payload	Included in basic weight
Fuel	26,346 liters (6960 gal)
Dimensions	Length - 29.8 m (97.75 ft)
	Wing span - 40.4 m (132.58 ft)
	Height - 11.7 m (38.50 ft)
Crew	Three man flight crew
	Eight man systems crew (depending on sensors required)

TABLE 4. - SUMMARY OF EXPERIMENTS AND SENSORS

No.	Experiment and Supporting Sensors	Quantity of Sensors	Aircraft Platforms	Experiment and Sensor Purpose	Investigator Teams
1	Radiometer/Scatterometer (RADSCAT) Zeiss Cameras	1 2	C-130 C-130	Obtain surface wind velocity and direction Aid in correlating RADSCAT data with water circulation	Dr. W. L. Jones (NASA) Dr. R. L. Charnell (NOAA)
2	Ocean Color Scanner (OCS) Mitchell-Vinten Cameras Ebert Spectrometer	1 4 1	U-2 U-2 C-54	Ocean color with emphasis on sediment and chlorophyll Location information for OCS Surface spectral information from low altitudes to calibrate OCS	Dr. W. H. Hovis (NASA) Dr. J. L. Muller (NASA) Mr. T. K. Clark (NOAA)
3	Multichannel Ocean Color Scanner (MOCS) *Reconofax IV *PRT-54	1 1 1	C-54 C-54 C-54	Evaluate technique for chlorophyll and sediment detection To obtain thermal information for MOCS data analysis To calibrate Reconofax IV	Mr. G. W. Grew (NASA) Mr. C. A. Hardesty (NASA) Dr. A. Strong (NOAA) Mr. D. K. Clark (NOAA)
4	Photography (Hasselblad Cameras)	4	C-54	Evaluate technique for sediment and chlorophyll detection	Mr. W. E. Bressette (NASA) Mr. L. Strees (NOAA)
5	Multispectral Scanner Data Analysis (MSDA)	Same as Experiment No. 2		Evaluate Interpretative techniques for obtaining sediment distribution from experiment No. 2 and 3 data	Dr. R. W. Johnson (NASA) Mr. T. A. Nelson (NOAA)
6	Dye markers/Photography Zeiss Cameras Airborne Multispectral Photographic System (AMPS)	--- 2 4	Helicopter C-130 C-130	Obtain circulation patterns Track dye markers Track dye markers	Mr. D. K. Clark (NOAA)

*Also supports Experiment No. 2, OCS

TABLE 6.- ZEISS RMK 15/23 CAMERAS

Camera Number	Lens Focal Length, cm(in)	Format, cm(in)	Film Number[a]	Film Emulsion[a] No.	Shutter Speed, Sec	Filter[b]/Serial Number	Spectral Range, microns	F Stop	Forward Overlap, percent	Spacial Resolution, m(ft)	Field of View, deg
1	15.24 (6)	22.86 X22.86 (9 X 9)	S0397	55-1	1/250	KL-36 039	0.4 to 0.7	AEC[c]	60	0.46 (1.5)	37 X 37
2	15.24 (6)	22.86 X22.75 (9 X 9)	2424	41-4	1/150	C-60	0.52 to 0.85	AEC[c]	60	0.46 (1.5)	37 X 37

[a]Eastman Kodak number

[b]ZEISS number

[c]Automatic exposure control

TABLE 7.- OCEAN COLOR SCANNER

Channel	Center Wavelength (nm)	Bandwidth (nm)	Radiance for Saturation (Gain X 1) mw/cm^2
1	433	22.5	40.10
2	471	21.5	26.00
3	509	27.0	23.60
4	547	24.5	14.70
5	583	25.0	11.80
6	620	26.0	10.00
7	662	22.0	7.55
8	698	20.5	5.00
9	733	22.5	11.90
10	772	23.0	3.47

TABLE 8.- MITCHELL-VINTEN CAMERAS

Camera Number	Lens Focal Length, cm(in)	Film		Shutter Speed, sec	Filter Number	Spactral Range Nanometer	F Stop	Spatial Resolution m (ft)
		Format, cm(in)	Number					
1	4.43 (1.75)	5.72 X 5.56 $\left(2\frac{1}{4} \times 2\frac{3}{16}\right)$	Panatomic X, 3400	1/250	Wratten 12	510-700	9.6	9.1 to 15.2 (30 to 50)
2	4.43 (1.75)	5.72 X 5.56 $\left(2\frac{1}{4} \times 2\frac{3}{16}\right)$	Panatomic X, 3400	1/250	Schott GG 475 + Schott BG 18	475-575	5.6	9.1 to 15.2 (30 to 50)
3	4.43 (1.75)	5.72 X 5.56 $\left(2\frac{1}{4} \times 2\frac{3}{16}\right)$	Panatomic X, 3400	1/250	Schott OG 570 + Schott BG 38	580-680	5.6	9.1 to 15.2 (30 to 50)
4	4.43 (1.75)	5.72 X 5.58 $\left(2\frac{1}{4} \times 2\frac{3}{16}\right)$	Aerial Color SO-242	1/250	None	400-700	3.5	9.1 to 15.2 (30 to 50)

TABLE 9.- RECONOFAX IV INFRARED SCANNER

Description

- Single-channel radiometer that optically/mechanically scans successive contiguous lines across the flight path
- Records infrared emissions or reflections from Earth features
- Accuracy equivalent to ± 0.3°K

Spatial characteristics

- 120° scan (± 60° from nadir)
- 3 mrad instantaneous field of view
- Resolution

  0.91m (3 ft) with 351m (1150 ft) swath from 305m (1000 ft)

  9.1m (30 ft) with 3505m (11,500 ft) swath from 3048m (10,000 ft)

Spectral characteristics

- 8 to 14 μm single channel

Data characteristics

- Image recorded on 70-mm film

TABLE 5.- RADIOMETER/SCATTEROMETER (RADSCAT) AND ANTENNA CHARACTERISTICS

Radiometer	
Bandwidth	200 MHz
Dicke modulation frequency	1000 Hz
Integration time	128 msec
Temperature resolution	1°K
Dynamic range	50° to 350° K
Linearity	$\leq$1%
Scatterometer	
Transmitter output power	1 watt
Transmitted pulse lengths	16, 32, and 64 μsec
Receiver gate width	2 μsec
Receiver bandwidth	8 KHz
Doppler range	+2 KHz to -6 KHz
Receiver duty cycle	0.025
Measurement dwell time per surface cell	580 to 920 msec
Resolution	$\leq$1 db
Dynamic range	>65 db
Linearity	$\leq$1 db
Channel Separation	18$\pm$0.5 db
Antenna	
Reflector diameter	121.9 cm (48 in)
Feed	Modified Catler
Operating frequencies	9.3 $\pm$0.1 GHz and 13.9 $\pm$ 0.1 GHz
3 db beamwidth	2.2 and 1.5 degrees
Gain	37.9 and 41.5 db
Beam efficiency	90 and 88.5%
Polorization	Vertical and horizontal
Weight	111 Nt (25 pounds)

TABLE 10.- PRECISION RADIATION THERMOMETER (PRT-5)

Description

- Lightweight, portable, battery-powered thermal-infrared radiometer
- Records thermal-infrared radiations emitted from Earth features (detects radiance down to equivalent of ± 0.5° K)

Spectral Characteristics

- Single bandpass filter (8 to 14 μm)

Spatial Characteristics

- 2° field of view
- 10.7m (35 ft) at 305m (1000 ft) altitude
- 107m (350 ft) at 3048m (10,000 ft) altitude

Data Characteristics

- 0- to 5-V analog multiplexed on PBW and recorded on magnetic tape

Applications

- Provides a target temperature reference

TABLE 11.- PHOTOGRAPH SENSOR COMPLEMENT AND CAMERA SETTINGS

Camera	Focal length mm (in)	Filter	Film Format mm (in)	Film Type[c]	Speed (sec)	f Number
1. Hasselblad	40 (1.57)	5543 (green)[a]	70 (2.76)	2402 Black & White	1/250	4
2. Hasselblad	40 (1.57)	5250 (blue green)[a]	70 (2.76)	2402 Black & White	1/250	4
3. Hasselblad	40 (1.57)	12 (yellow)[b]	70 (2.76)	2402 Black & White	1/250	11
4. Hasselblad	40 (1.57)	89B (N1R)[b]	70 (2.76)	2424 Black & White	1/250	5.6

[a]Baird-atomic B-3 optical filter with central wavelength of 5540 and 5250 anstroms

[b]Kodak Wratten optical filter number

[c]Kodak film number

TABLE 12.- ZEISS RMK 15/23 CAMERAS AND

AIRBORNE MULTISPECTRAL PHOTOGRAPHIC SYSTEM (AMPS)

Camera Number	Lens Focal Length, cm(in)	Film			Shutter Speed, sec	Filters		F Stop	Forward Overlap, percent	Spatial Resolution, m(ft)	Field of View, deg
		Format cm(in)	Number[a]	Emulsion[a] No.		Spectral Range, µm	Transmission percent				
ZEISS 1	15.24 (6)	22.86 X 22.86 (9 X 9)	S0397	51-1	1/250	0.4 to 0.7	36	AEC[b]	60	0.46 (1.5)	37X37
ZEISS 2	15.24 (6)	22.86 X 22.86 (9 X 9)	2402	173-3	1/250	0.52 to 0.85	60	AEC[b]	60	0.46 (1.5)	37X37
AMPS 1	15.24 (6)	5.72 X 5.72 (2.25 X 2.25)	2424	56-12	1/200	0.7 to 0.8	-	13	20	-	21
AMPS 2	15.24 (6)	5.72 X 5.72 (2.25 X 2.25)	S0022	2-1	1/200	0.4 to 0.5 plus 0.35 to 0.60	-	4	20	-	21
AMPS 3	15.24 (6)	5.72 X 5.72 (2.25 X 2.25)	S0022	2-1	1/200	0.6 to 0.7	-	4	20	-	21
AMPS 4	15.24 (6)	5.72 X 5.72 (2.25 X 2.25)	S0022	2-1	1/200	0.5 to 0.6	-	4	20	-	21

[a]Eastman Kodak number

[b]Automatic exposure control

TABLE 13.- NASA/NOAA OPERATIONS - NEW YORK BIGHT SPRING ACTIVITIES

Date	OPERATIONS ELEMENTS						
	C-54	U-2	C-130	Helicopters: Coast Guard	Helicopters: Contract	Kelez	Ambrose Tower
Mon. April 7	No Flights		Support LACIE Program	No Flight	No Flights	Instrs. Not Ready	No Mission Requirements
Tues. 8							
Wed. 9	No Flight	X AM PM		X 6 Samples			
Thurs. 10	X	No Flight	X	No Flight	X	X	Weather Data
Fri. 11	No Flights Due to Weather					Buoy (33) Main.	No Mission Requirements
Sat. 12						X	Weather Data
Sun. 13	X	X AM	X	X 31 Samples	X	X	Weather Data Dye Implants
Mon. 14	No Flight	X AM PM	No Flight Weather	X 25 Samples	No Flights	X	Weather Data
Tues. 15	No Flights Due to Weather					Rudder Problems	No Mission Requirements
Wed. 16						X	Weather Data
Thurs. 17	Mission Ended		X RADSCAT	Mission Ended	X	Mission Ended	Weather Dye and Smoke
Fri. 18	No Further Mission Scheduled						

X = Operations Implemented.

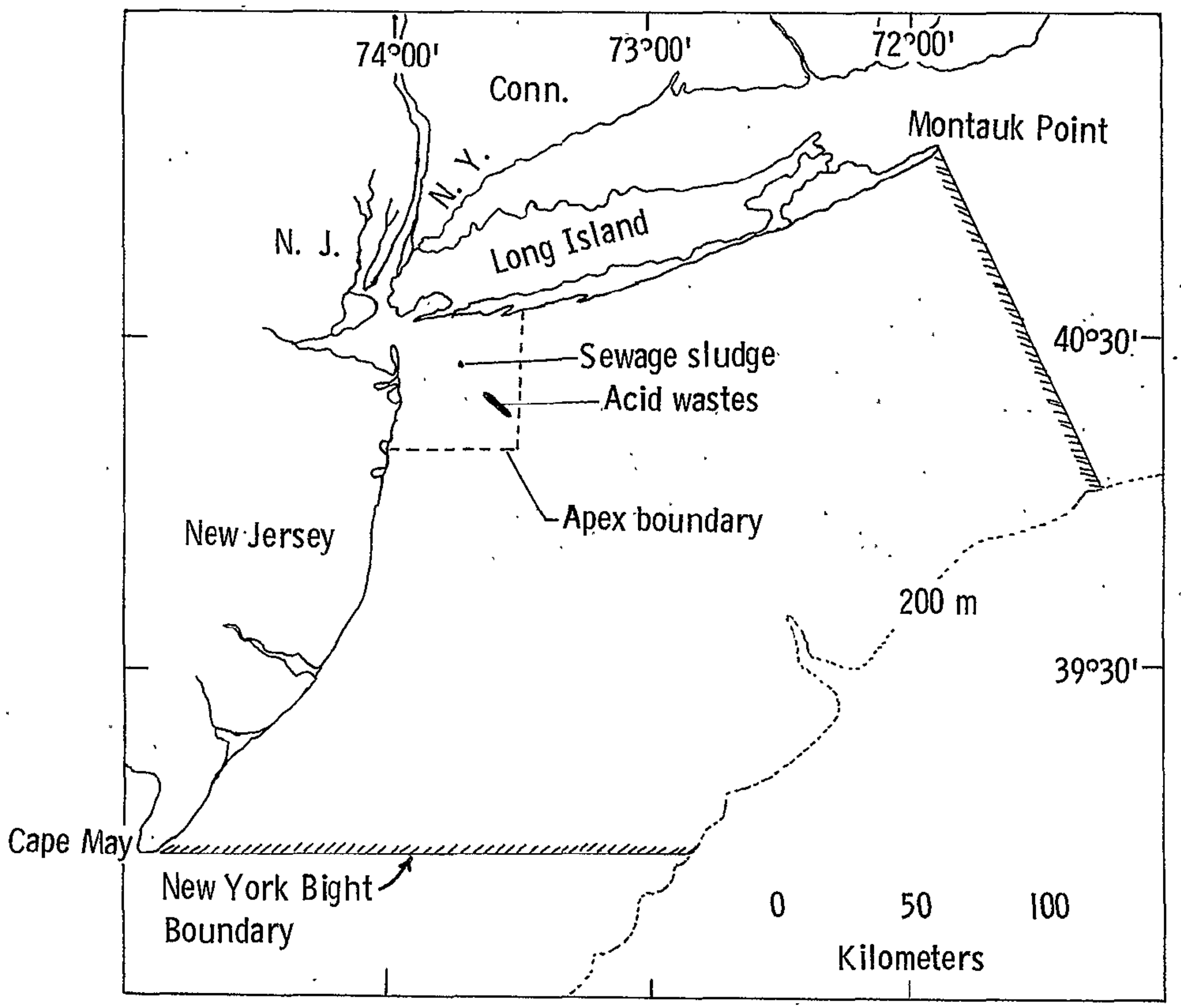


Figure I. - MESA Defined New York Bight and Apex.

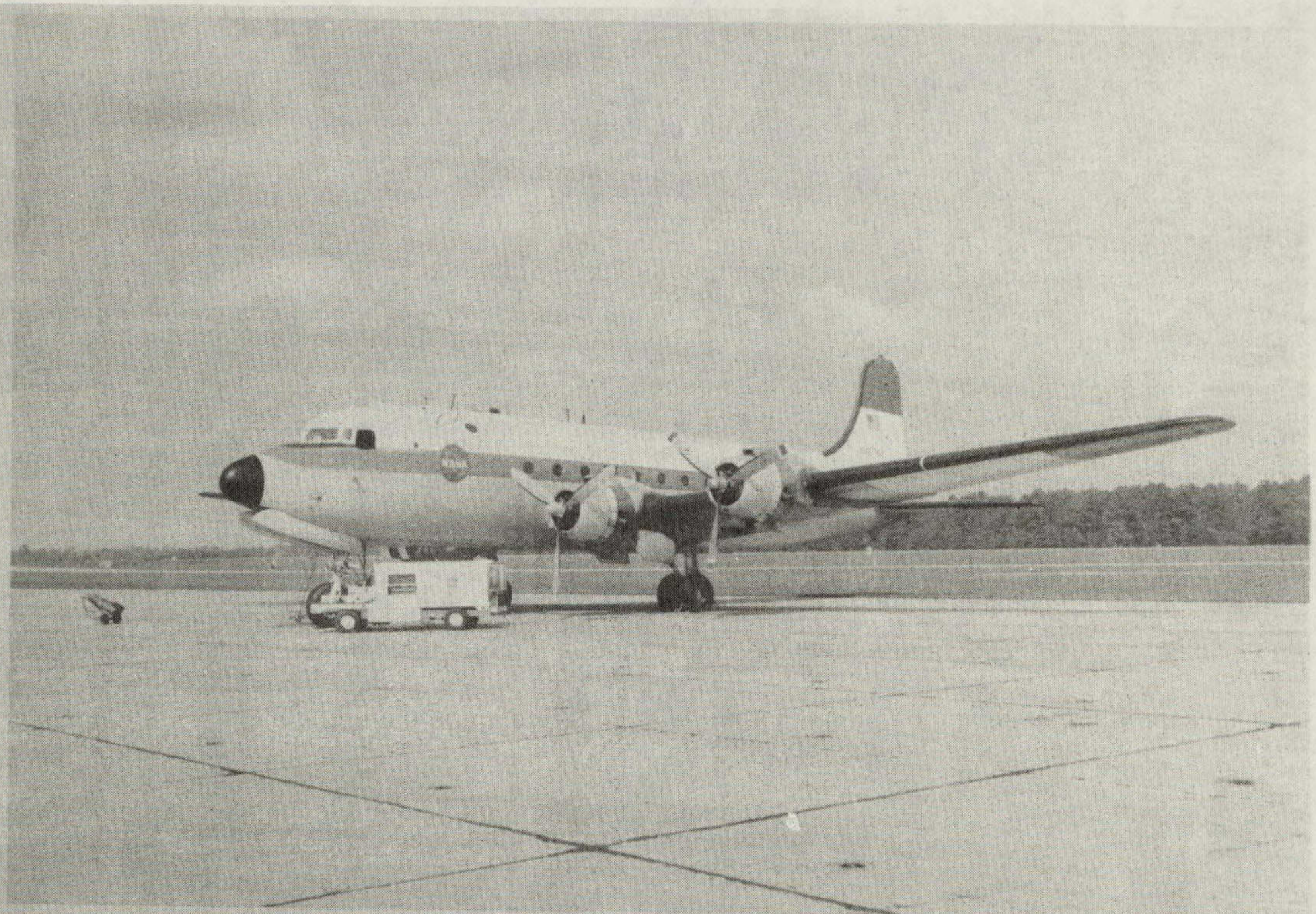


Figure 2. - C-54 aircraft (NASA 438).

Figure 3. - U-2 aircraft (NASA 709).

Figure 4. - C-130 Aircraft (NASA 929).

Figure 5. - Radiometer/Scatterometer (RADSCAT) on C-130.

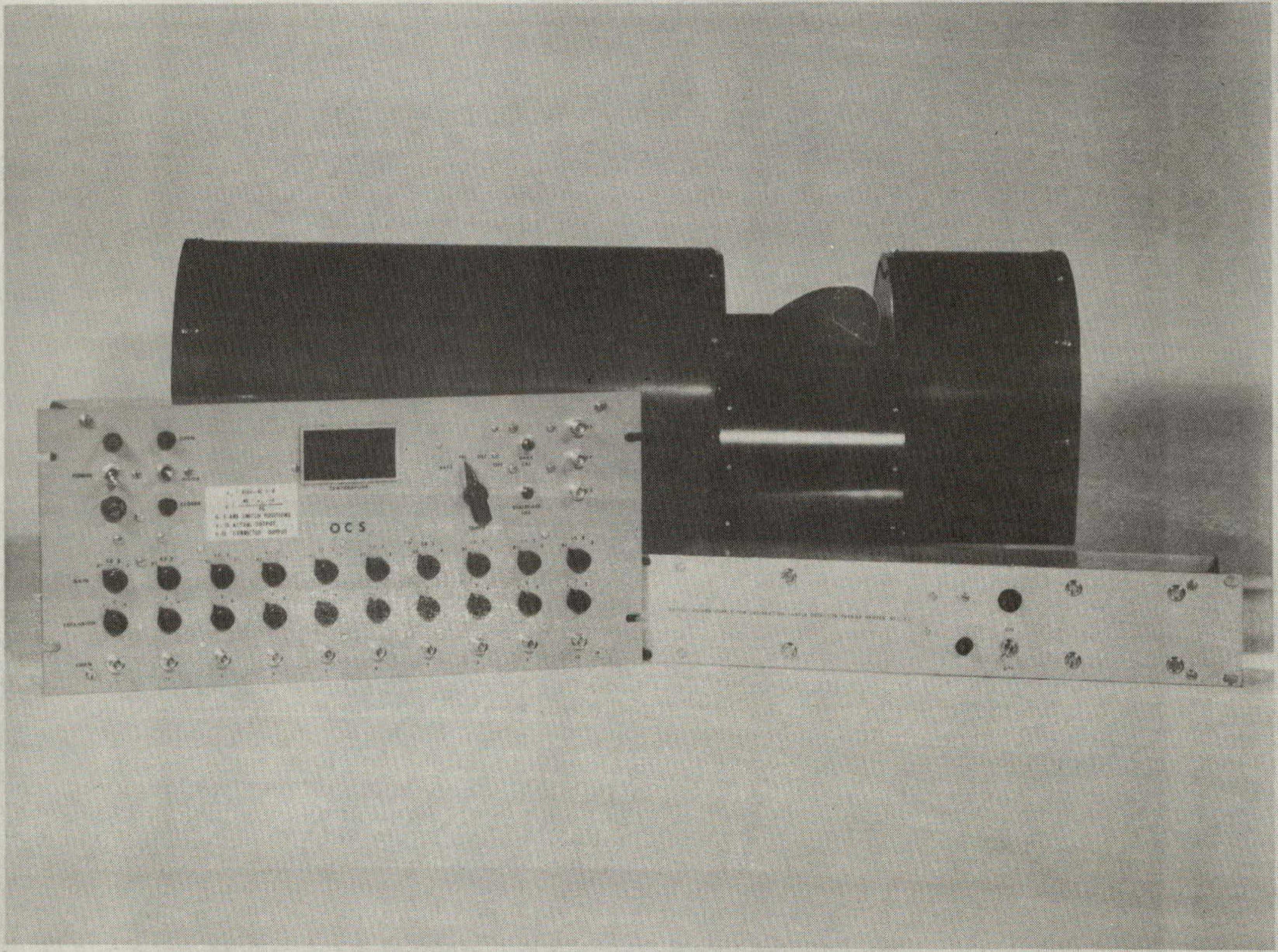


Figure 6. - Ocean Color Scanner (OCS).

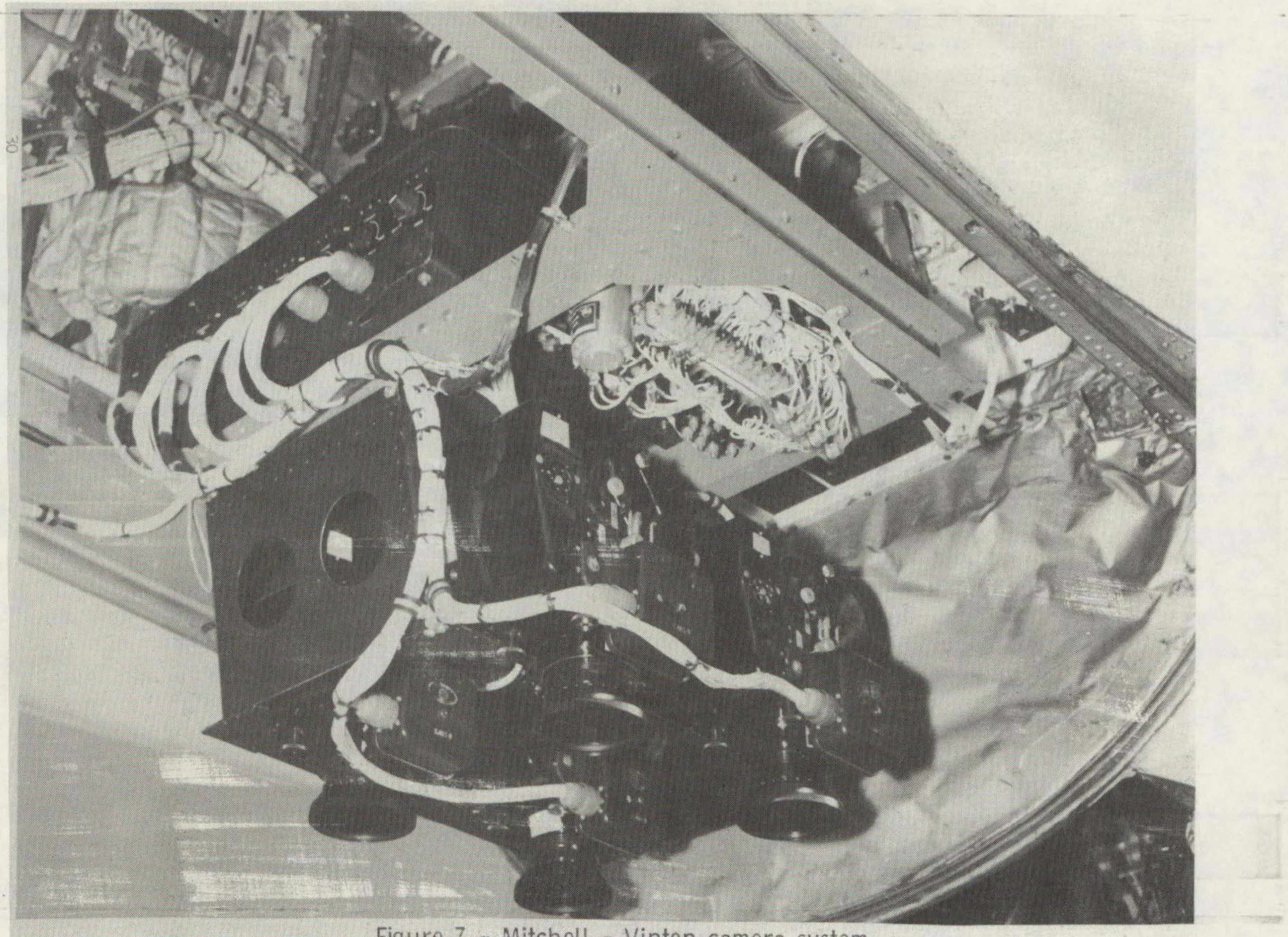


Figure 7. - Mitchell - Vinten camera system.

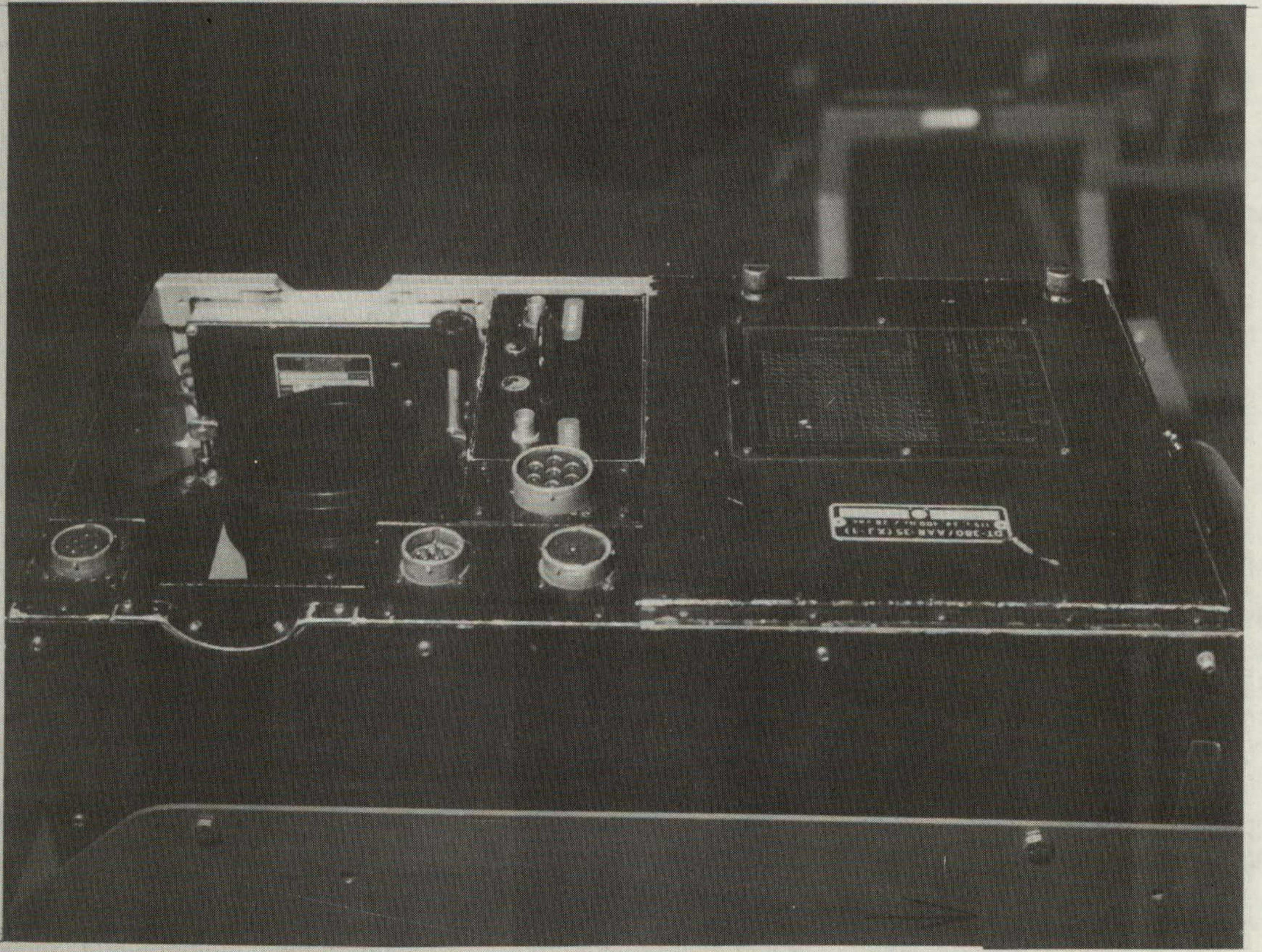


Figure 8. - Reconofax IV Infrared Scanner

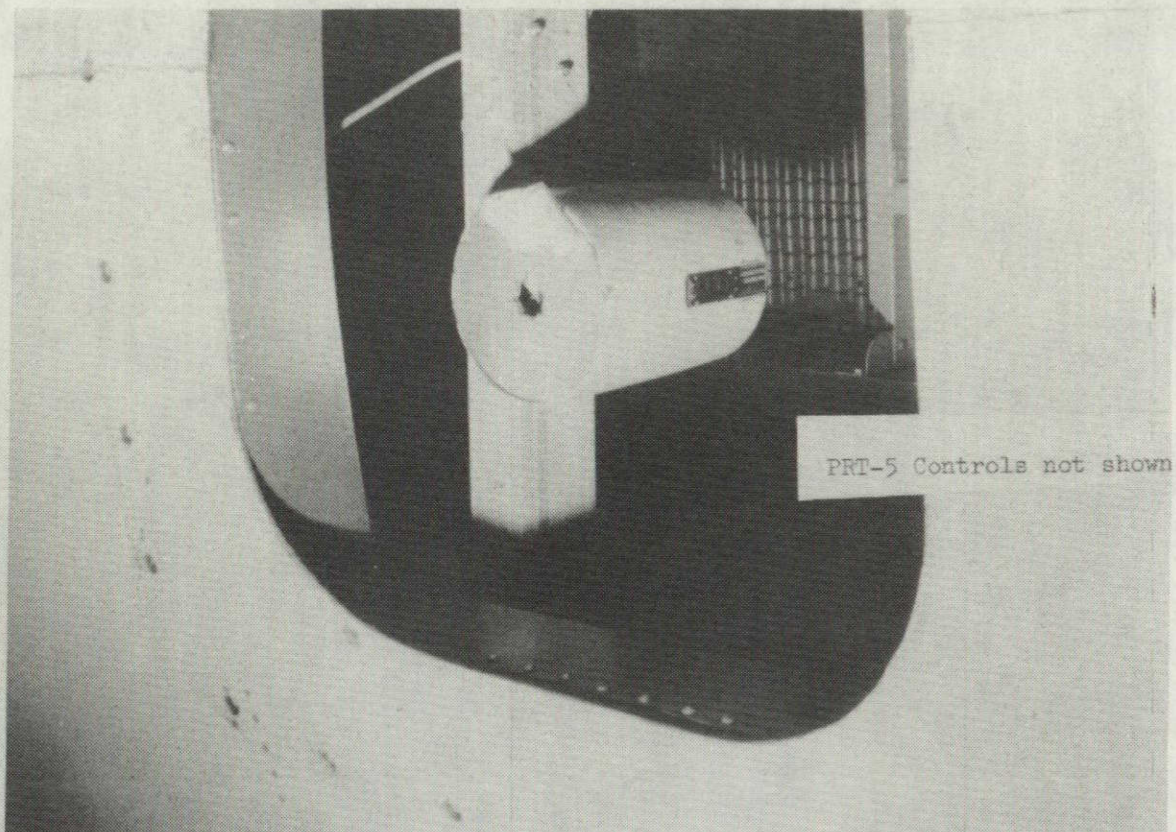


Figure 9.- PRT-5.

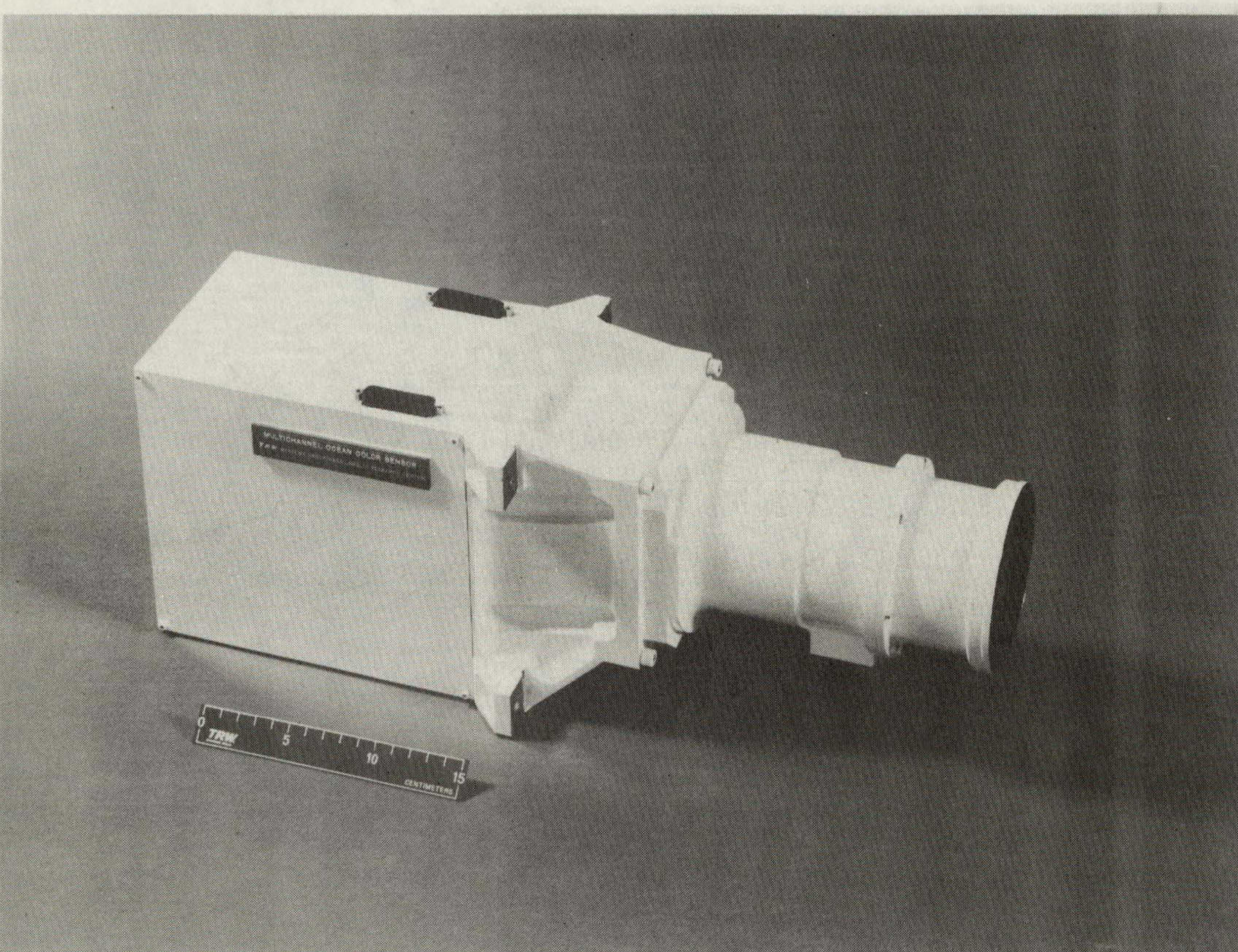
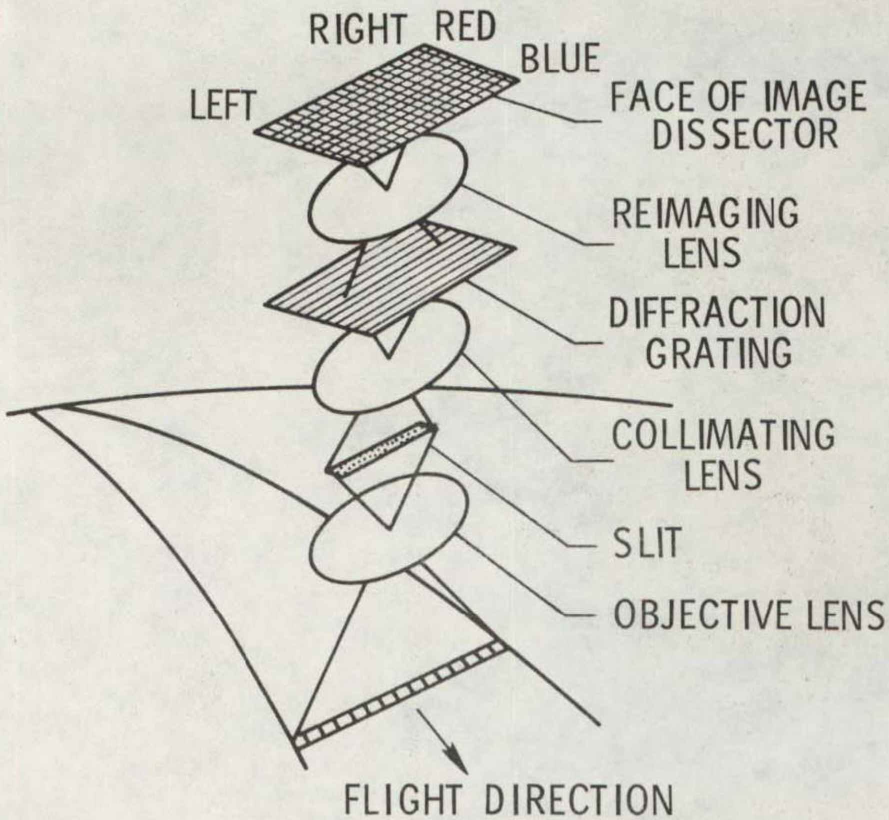


Figure 10. - Multichannel Ocean Color Sensor (MOCS).

OPTICAL SCHEMATIC



SPECIFICATIONS

400-700 NM SPECTRAL RANGE

15 NM SPECTRAL RESOLUTION

150 SPECTRA/SWATH WIDTH

17.1° FIELD OF VIEW

100 NT. (22.5 POUNDS), WEIGHT

7.5 WATTS, POWER

0.01 M^3 (.35 CUBIC FEET), VOLUME

Figure 11. - Optical Schematic and Specifications of MOCS.

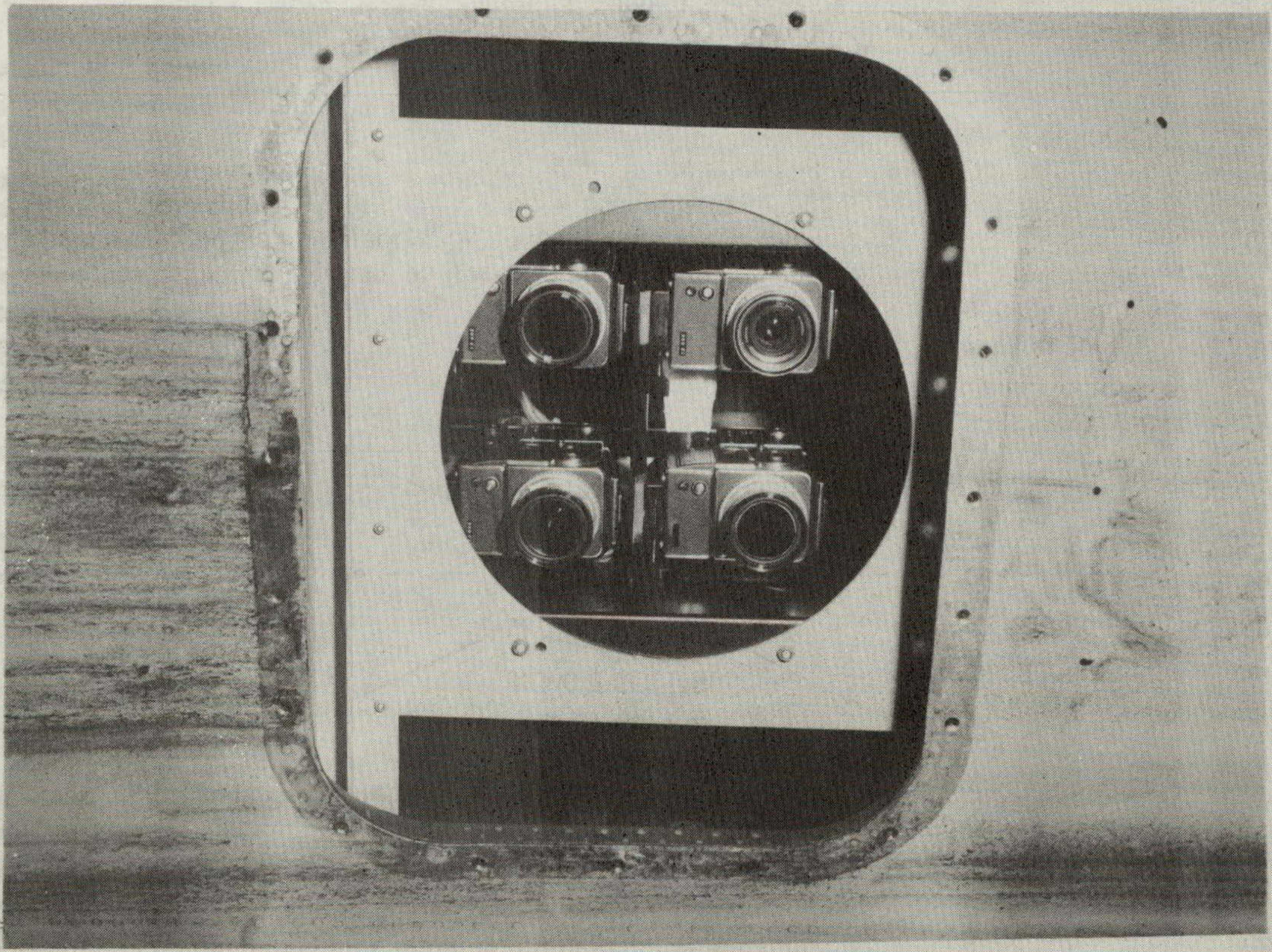


Figure 12. - Hasselblad cameras.

NASA / NOAA N.Y. BIGHT 1975 SPRING ACTIVITY Apr 7-17

REMOTE SENSING

NASA (Wallops) C-54

- Multichannel Ocean Color Sensor (MOCS)
- Hasselblad cameras (4)
- Ebert Spectrometer
- Precision Radiation Thermometer (PRT-5)
- Reconofax IV IR Mapper

NASA (JSC) C-130

- Radiometer/Scatterometer (RADSCAT)
- Reconofax IV IR Mapper
- PRT - 5
- Zeiss RMK 15/ 23 (2 metric cameras)
- AMPS cameras

NASA (AMES) U-2

- Ocean Color Scanner (OCS)
- 70 mm Mitchell-Vinten cameras

SEA TRUTH

NOAA SHIP KELEZ

- STD cast (on station)
- Sediment (3 depths, on sta.)
- Chlorophyll (3 depths, on sta., on track)
- Surface temp (on sta., on track)
- Fluorescence (chlorophyll-a)
- Optical measurements
- PRT -5
- Secchi disk (transparency)
- Sounding data

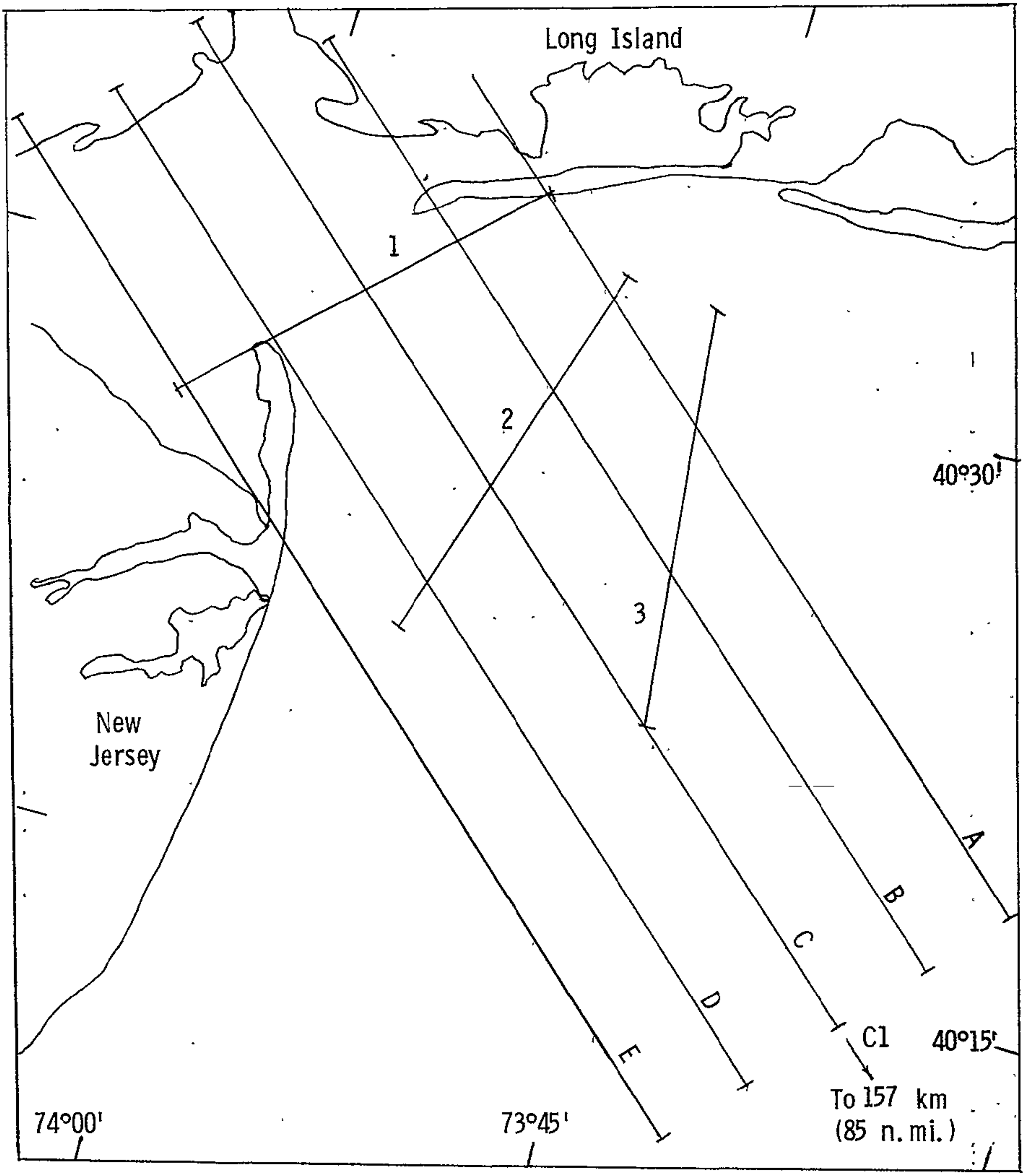
HELICOPTERS

- Coast Guard
  - Sediment
  - Chlorophyll
- Contracted helicopters
  - Dye implants

AMBROSE TOWER

- Weather data
- Dye
- Smoke release

Figure 13. - Data collection platforms and sensors.



(a) Flight lines April 10, 1975.

Figure 14. - C-54 flight lines, flight parameter and data identification parameters.

Line	Alt Km	(ft)	Time, EDT	Latitude, deg. Beginning	Ending	Longitude, deg Beginning	Ending
1	0.46	(1500)	0801	40° 34'	40° 26.5'	73° 57'	74° 03'
2	0.46	(1500)	0813	40° 32.5'	40° 22'	73° 44'	73° 53.5'
3	0.46	(1500)	0823	40° 32'	40° 21'	73° 45.5'	73° 44.5'
C1	0.46	(1500)	0834	40° 36'	To 157 Km	74° 05.5'	To 157 Km
C	5.33	(17500)	0944	40° 36'	40° 14.5'	74° 05.5'	73° 36'
E	5.33	(17500)	1024	40° 32.5'	40° 11'	74° 10.5'	73° 41'
B	5.33	(17500)	1042	40° 36.5'	40°16.5'	74° 01'	73° 33.5'
D	5.33	(17500)	1059	40° 33'	40° 12.5'	74° 07.5'	73° 38.5'
A	5.33	(17500)	1114	40° 36.5'	40° 18.5'	73° 55.5'	73° 31.5'

(b) Flight Parameters, April 10, 1975

Figure 14. - continued.

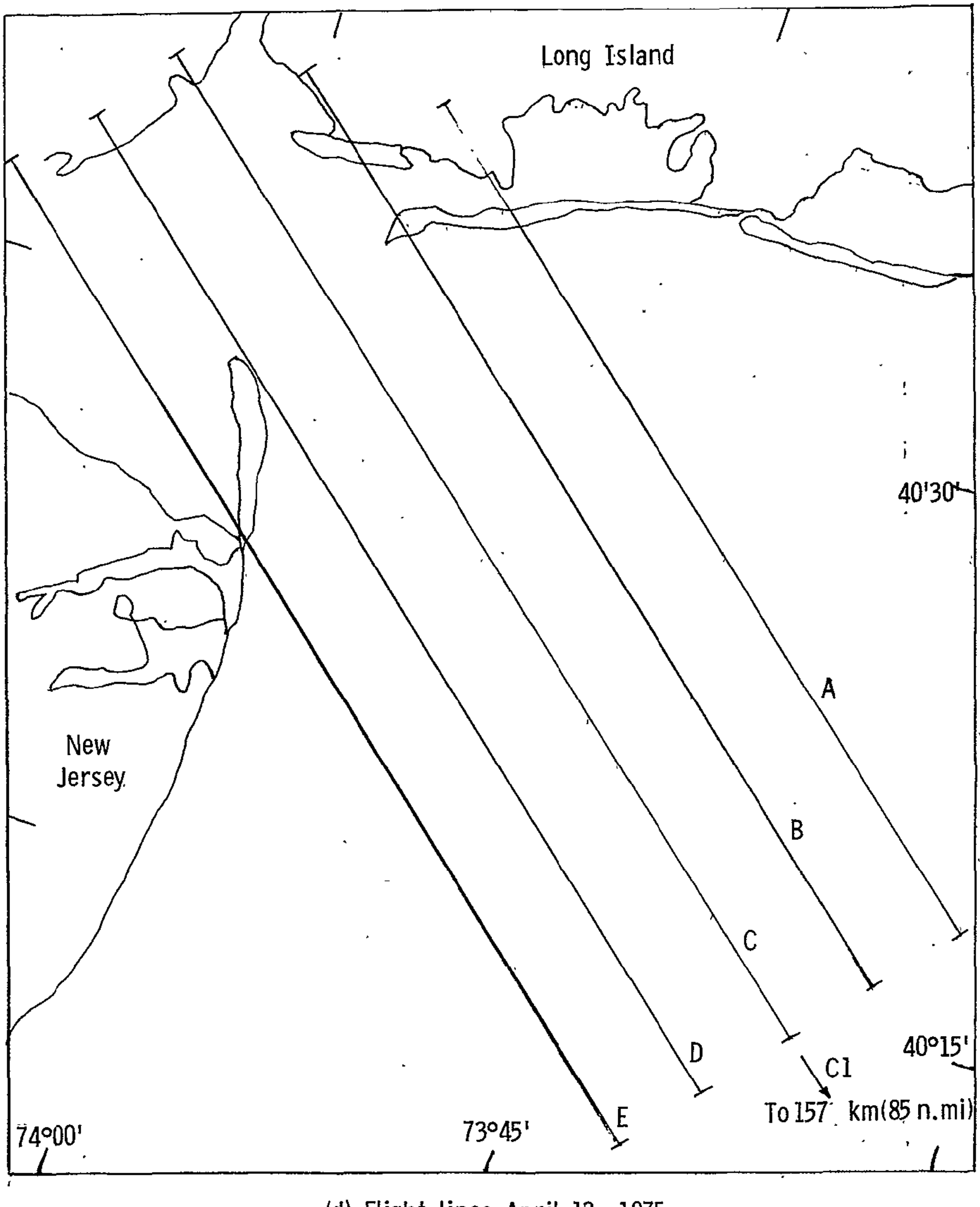
Line	Sensor/No.	Roll	Number of Frames
1	–	–	–
2	–	–	–
3	–	–	–
C1	–	–	–
C	Hass/01	W3200101*	14
E	↓	↓	13
B	↓	↓	15
D	↓	↓	12
A	↓	↓	19
C	Hass/04	W3200104*	14
E	↓	↓	13
B	↓	↓	15
D	↓	↓	12
A	↓	↓	19

* Flight log identification numbers

1. Lines 1, 2, 3 and C1 were flown at 0.46 km (1500 ft). The Ebert spectrometer, Reconafax IV and PRT-5 recorded data continuously on magnetic tape, 70 mm file (Roll No. W3200105*) and/or strip chart.
2. Line C1 (includes C) was flown at 0.46 km (1500 ft) and 5.33 km (17,500 ft) and data were recorded as in (1).
3. Along lines A-E the MOCS, Reconofax IV, and PRT-5 ran continuously and data were recorded as in (1).

(c) Data Identification Parameters, April 10, 1975

Figure 14. - continued.



(d) Flight lines April 13, 1975.

Figure 14. - Continued.

	Alt			Latitude		Longitude	
Line	Km	(ft)	Time, EDT	Beginning	Ending	Beginning	Ending
C	5.33	(17500)	0952	40° 36'	40° 14.5'	74° 05.5'	73° 36'
A	5.33	(17500)	1005	40° 36.5'	40° 18.5'	73° 55.5'	73° 31.5'
D	5.33	(17500)	1021	40° 33'	40° 12.5'	74° 07.5'	73° 38.5'
B	5.33	(17500)	1036	40° 36.5'	40° 16.5'	74° 01'	73° 33.5'
E	5.33	(17500)	1054	40° 32.5'	40° 11'	74° 10.5'	73° 41'
C1	0.46	(1500)	1306	40° 36'	To 157 Km	74° 05.5'	To 157 Km

(e) Flight Parameters, April 13, 1975

Figure 14. - continued.

Line	Sensor/No.	Roll	Number of Frames
C	Hass/02	W3210102*	12
A	↓	↓	13
D			17
B			2
E			13
C	Hass/04	W3210104*	12
A	↓	↓	13
D			12
B			15
E			13

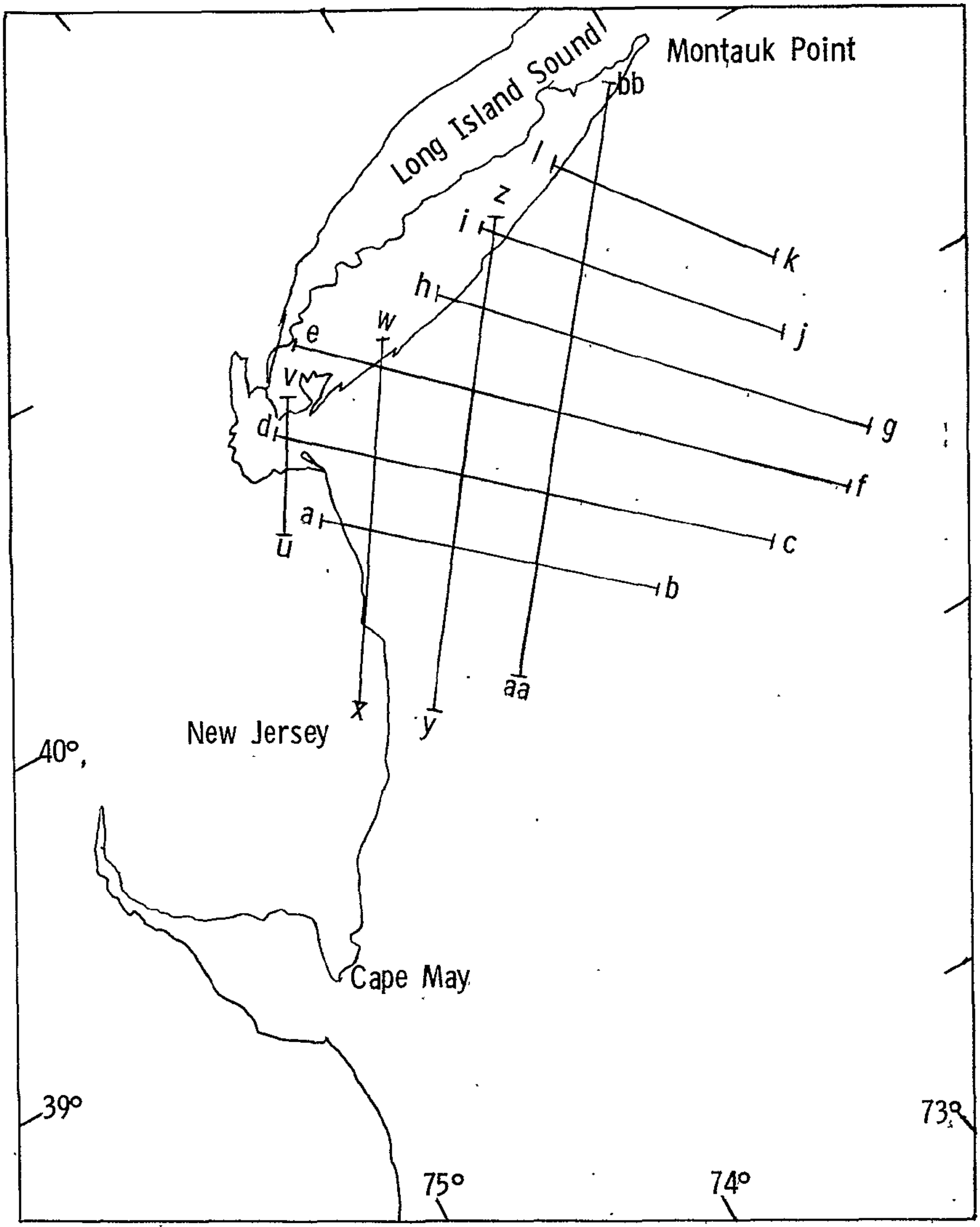
* Flight log identification numbers.

1. The Ebert spectrometer, Reconofax IV and PRT-5 data were recorded continuously along line C2 (see figure 14 d) on magnetic tape, 70 mm film (Roll No. W3210105*) and/or strip chart.

2. MOCS ran continuously along the lines A-E and data were recorded on magnetic tape.

(f) Data Identification Parameters, April 13, 1975

Figure 14. - concluded.



(a) Flight lines April 9, 1975.

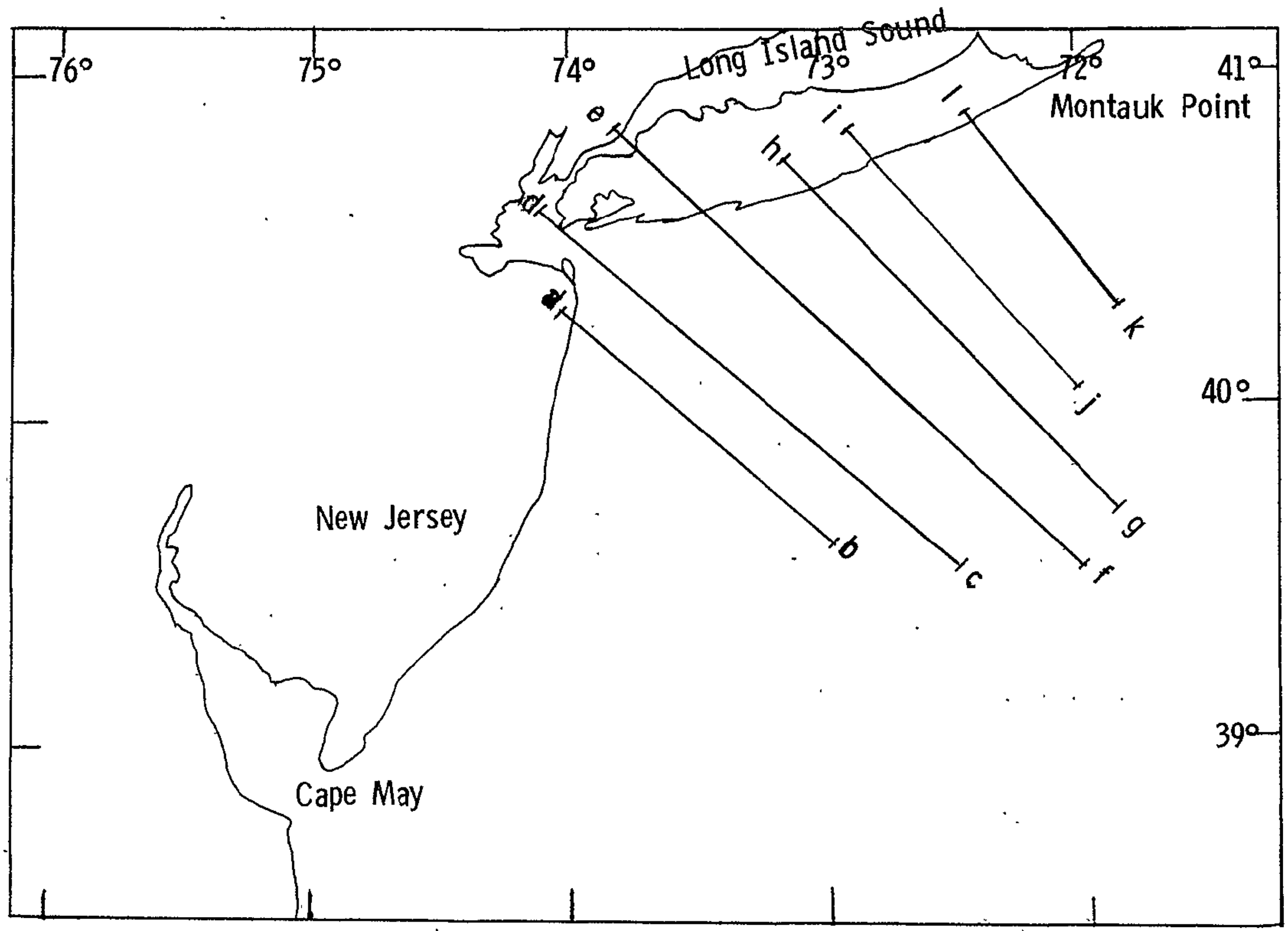
Figure 15. - U-2 flight lines and data identification parameters.

Check Points	Frame Numbers	Mitchell-Vinten Cameras* Time (GMT-hr.min.sec) START	END	OCS** Time (GMT-hr.min.sec) START	END	Cloud Cover/Remards
a-b	0001-0013	14:30:33	14:39:54	14:29:30	14:39:00	Light scattered cumulus, frames 0011-0013
c-d	0014-0032	14:46:05	14:01:03	14:45:00	15:00:00	10-60% scattered cumulus, frames 0014-0018
e-f	0033-0050	15:06:49	15:20:23	15:06:00	15:19:30	10-60% scattered cumulus, frames 0043-0050
g-h	0051-0066	12:24:26	15:36:37	15:23:30	15:35:30	10-20% scattered cumulus, frames 0051-0056
i-j	0067-0077	15:41:26	15:49:38	15:40:30	15:48:30	10-30% scattered cumulus
k-l	0078-0086	15:55:25	16:00:52	15:54:30	16:00:00	10-40% scattered cumulus, frames 0078-0081
u-v	0135-0137	18:01:19	18:02:52	18:00:30	18:02:00	Clear
w-x	0138-0149	18:10:10	18:18:50	18:09:30	18:18:00	Light scattered cumulus, frames 0138-0140
y-z	0150-0167	18:23:34	18:37:10	18:22:30	18:36:00	10% cirrus, frames 0154-0156, 10% cumulus, 0165-0167
aa-bb	0168-0189	18:46:54	19:03:55	18:46:00	19:03:00	10-30% cumulus, frames 0187-0189

* Information shown is the same for all four cameras.
** Data numbers not available at this time.

(b) Data Identification Parameters April 9, 1975

Figure 15.- continued.



(c) Flight lines April 13, 1975.

Figure 15. - Continued.

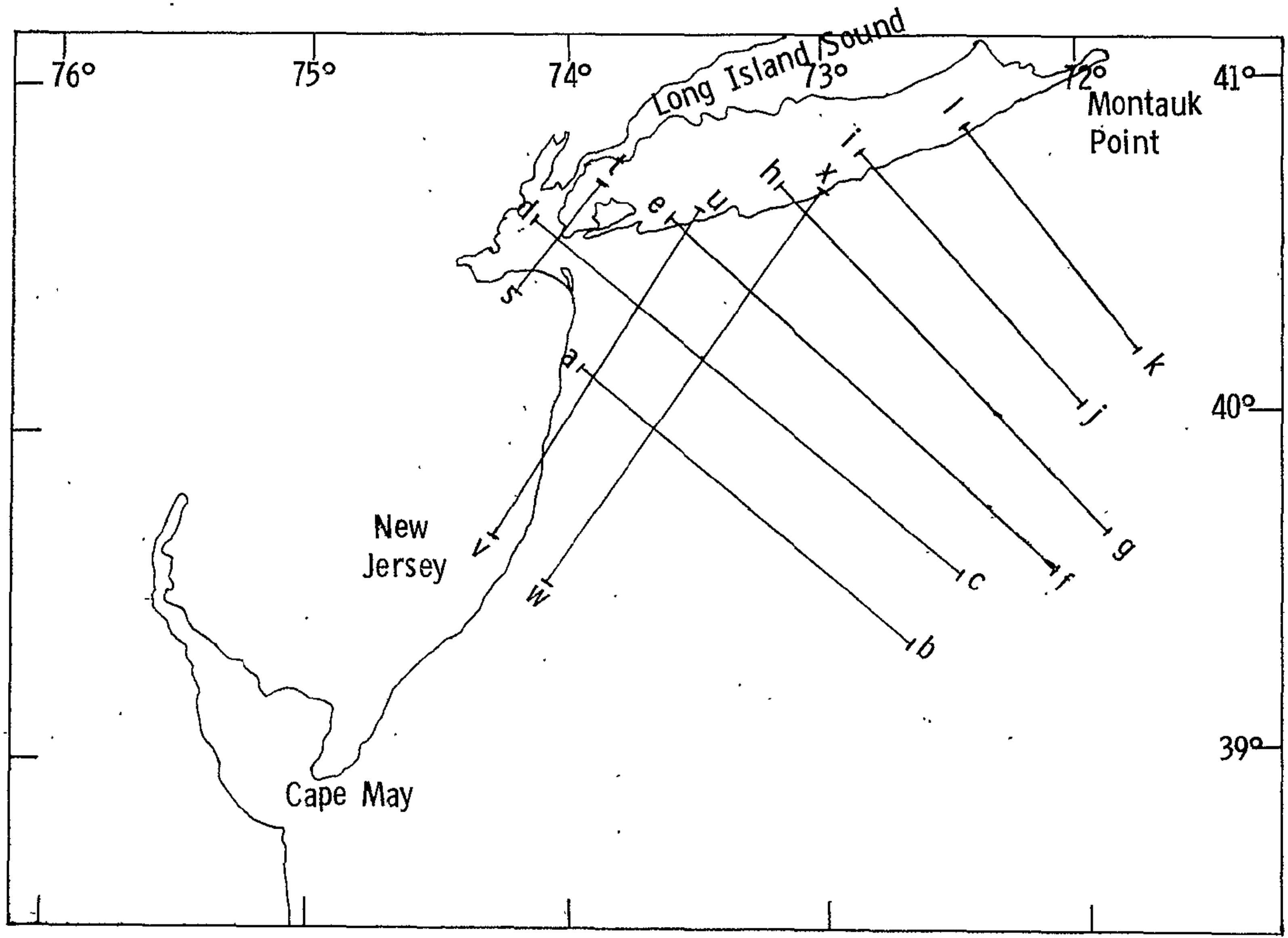
Check Points	Frame Numbers	Mitchell-Vinten Cameras* Time(GMT-hr.min.sec) START	END	OCS** Time(GMT-hr.min.sec) START	END	Cloud Cover/Remarks
a-b	0001-0013	14:29:54	14:39:04	14:29:54	14:39:04	10% scattered cumulus, frames 0001-0002
c-d	0014-0032	14:45:35	15:00:25	14:45:35	15:00:25	10-20% scattered cumulus, frames 0014-26, 0028-32
e-f	0033-0051	15:06:34	15:20:40	15:06:34	15:20:40	10-20% scattered cumulus
g-h	0052-0067	15:25:02	15:36:47	15:25:02	15:36:47	10-20% scattered cumulus
i-j	0068-0079	15:42:19	15:50:48	15:42:19	15:50:48	10-20% scattered cumulus
k-l	0080-0087	15:56:41	16:01:43	15:56:41	16:01:43	10-20% scattered cumulus

* Information shown is the same for all four cameras.

** Data numbers not available at this time.

(d) Data Identification Parameters

Figure 15.- continued.



(e) Flight lines April 14, 1975

Figure 15. - Continued.

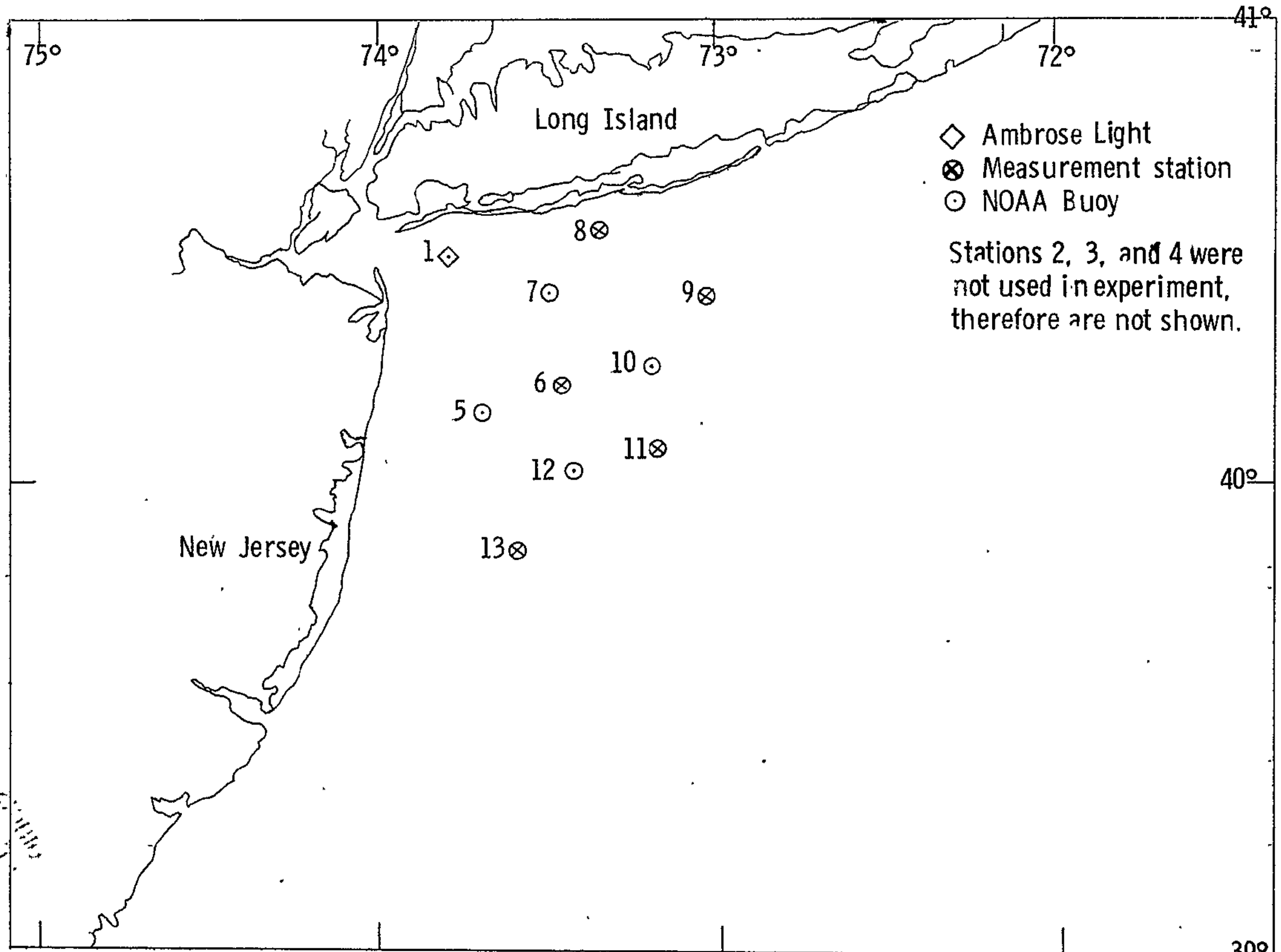
Check Points	Frame Numbers	Mitchell-Vinten Cameras* Time(GMT-hr.min.sec) START	END	OCS** Time(GMT-hr.min.sec) START	END	Cloud Cover/Remarks
a-b	0001-0007	14:38:15	14:44:09	14:38:15	14:44:09	clear
c-d	0008-0026	14:52:18	15:06:00	14:52:18	15:06:00	clear
e-f	0027-0042	15:13:44	15:26:16	15:13:44	15:26:16	clear
g-h	0043-0057	15:30:55	15:42:17	15:30:55	15:42:17	clear
i-j	0058-0066	15:49:52	15:56:33	15:49:52	15:56:33	clear
k-l	0067-0075	16:01:15	16:08:56	16:01:15	16:08:56	clear
s-t	0106-0107	18:04:01	18:04:20	18:04:01	18:04:20	clear
u-v	0108-0116	18:13:45	18:20:06	18:13:45	18:20:06	clear
w-x	0117-0123	18:26:33	18:31:45	18:26:33	18:31:45	clear

* Information shown is the same for all four cameras.

** Data numbers not available at this time.

(f) Data Identification Parameters

Figure 15. - concluded.



(a) Flight measurement stations.

Figure 16.- C-130 (RADSCAT) flight stations, flight parameters and data identification parameters.

Station	Number of Runs	Time, GMT Start Stop	Latitude Start Stop	Longitude Start Stop	ZEISS 1 Start Frame Stop Frame	ZEISS 2 Start Frame Stop Frame	RADSCAT Tape Number*
1	4	14:06:45 14:18:00	40°25.3' 40°25.3'	73°51.8' 73°50.4'	– – Roll 59*	– – Roll 60*	14
7	4	14:23:40 14:45:05	40°25.9' 40°22.0'	73°27.3' 73°31.3'	8 30	8 30	
7 to 6	1	14:46:05 14:47:15	– –	– –	31 38	31 38	
6	4	14:48:05 14:59:01	40°73.1' 40°08.2'	73°28.7' 73°26.7'	– –	– –	
5	4	15:05:00 15:15:30	40°07.9' 40°03.6'	73°32.6' 73°32.9'	39 47	39 47	14 15B
5 to 13	1	15:65:40 15:18:45	– –	– –	50 56	50 56	
13	4	15:19:50 15:30:35	39°51.8' 39°46.3'	73°35.6' 73°33.8'	– –	– –	
13 to 12	1	15:34:05 15:35:05	– –	– –	57 63	57 63	
12	4	15:37:40 15:48:30	40°02.3' 39°58.5'	73°27.2' 73°27.0'	– –	– –	
12 to 11	1	15:52:15 15:53:15	– –	– –	64 70	64 70	15B

* Flight log identification numbers

(b) Flight Parameters and Data Identification Parameters

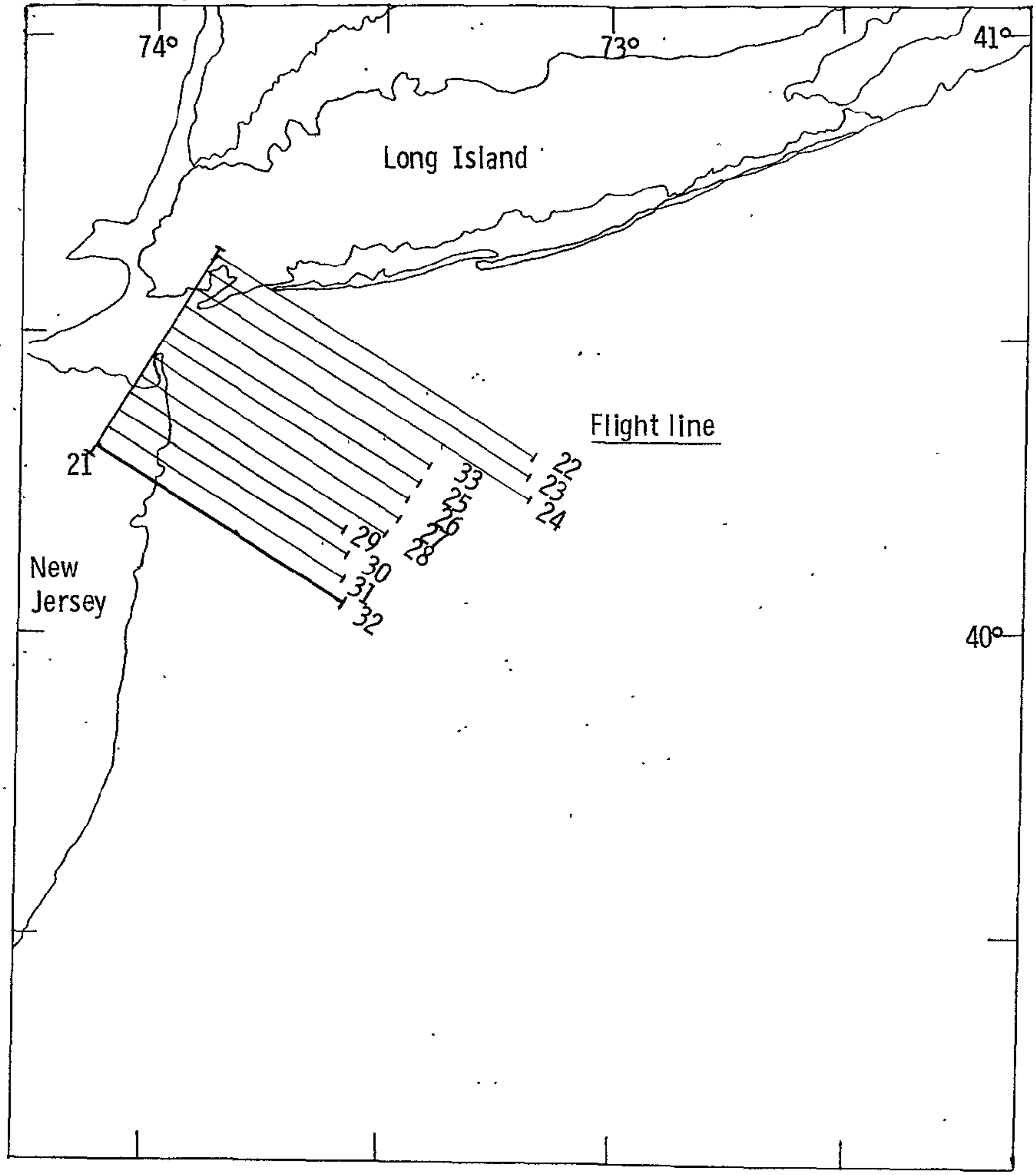
Figure 16. – continued.

Station	Number of Runs	Time, GMT Start Stop	Latitude Start Stop	Longitude Start Stop	ZEISS 1 Start Frame Stop Frame	ZEISS 2 Start Frame Stop Frame	RADSCAT Tape Number*
11 to 10	1	16:10:30 16:11:30	- -	- -	71 78	71 78	15B
10	4	16:11:45 16:22:15	40° 15.4' 40° 10.9'	73° 12.5' 73° 13.6'	- -	- -	
10 to 9	1	16:25:05 16:27:05	- -	- -	79 104	79 104	
9	1	16:24:15 16:28:10	40° 15.0' 40° 23.0'	73° 10.5' 73° 04.6'	- -	- -	16
9	4	16:29:25 16:39:50	40° 25.7' 40° 21.2'	73° 03.6' 73° 05.4'	- -	- -	
9 to 8	1	16:45:25 16:46:40	- -	- -	105 112	105 112	
8	1	16:41:25 16:45:40	40° 23.8' 40° 31.8'	73° 09.4' 73° 18.9'	- -	- -	
8	4	16:46:40 16:57:35	40° 33.5' 40° 28.7'	73° 21.2' 73° 25.2'	- -	- -	
8	1	17:00:10 17:03:30	40° 26.6' 40° 26.4'	73° 34.3' 73° 46.1'	- -	- -	
1	4	17:04:30 17:15:55	40° 27.3' 40° 23.0'	73° 49.5' 73° 54.3'	113 124	113 124	

*Flight log identification numbers.

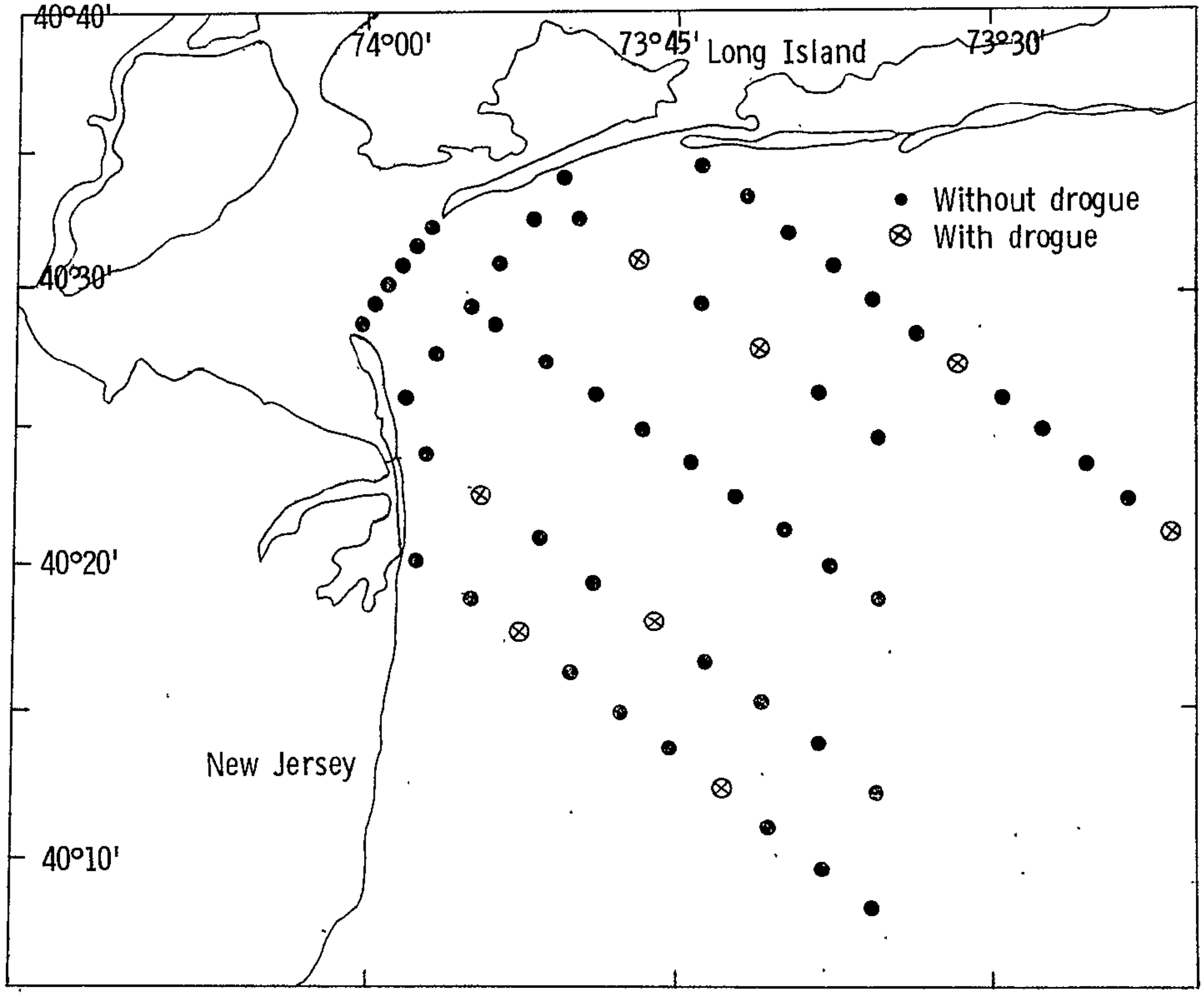
(b) concluded.

Figure 16. - concluded.



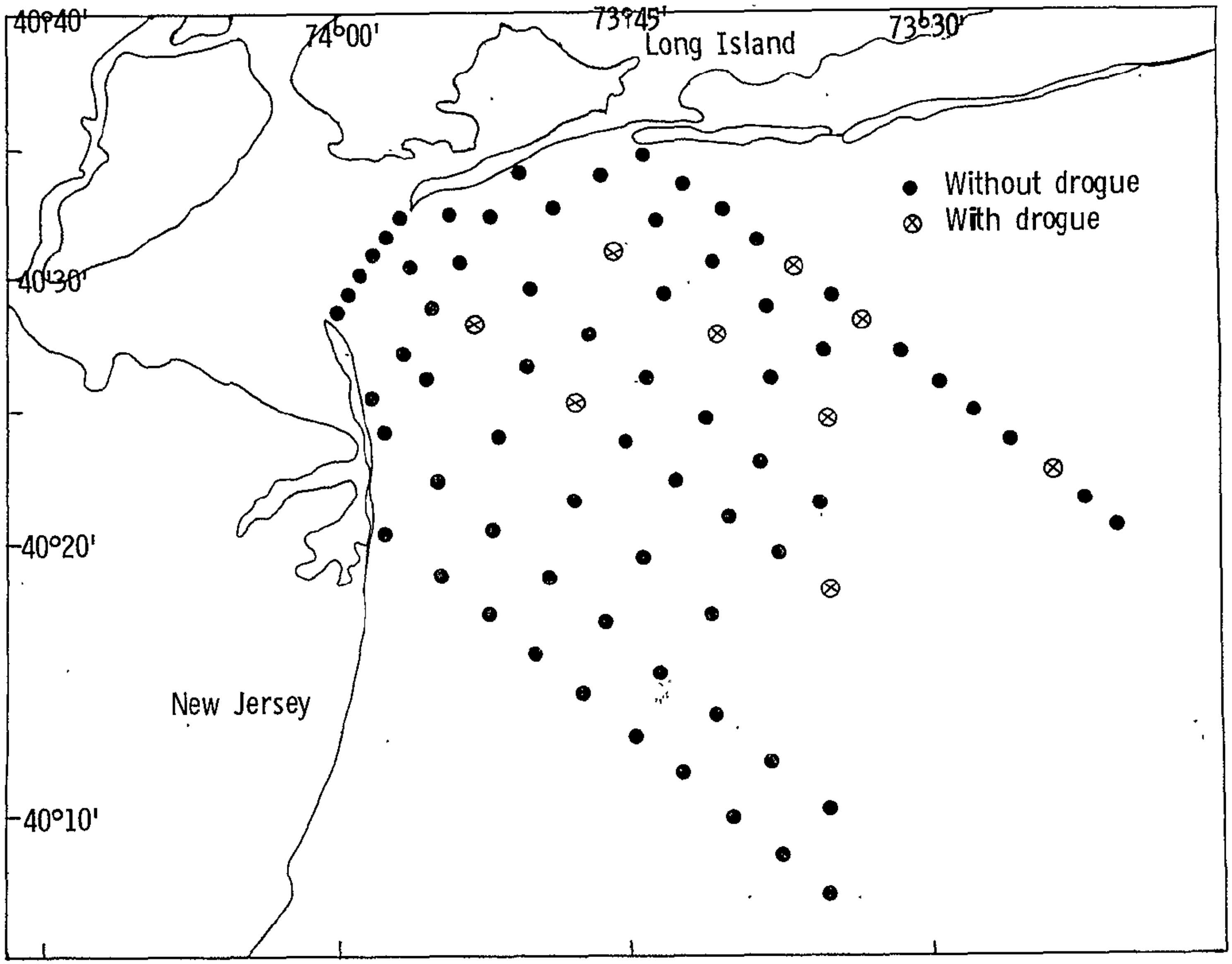
(a) Flight lines April 10 and 13.

Figure 17. - C-130 flight lines (Experiment No. 6), dye implant locations and data identification parameters.



(b) Approximate locations of dye implants, April 10.

Figure 17. - Continued.



(b) Concluded, April 13.

Figure 17. - Continued.

Flight Line	Time, GMT Start Stop	Latitude Start Stop	Longitude Start Stop	ZEISS 1 Start Frame Stop Frame	ZEISS 2 Start Frame Stop Frame	AMPS 1 Start Frame Stop Frame	AMPS 2 Start Frame Stop Frame	AMPS 3 Start Frame Stop Frame	AMPS 4 Start Frame Stop Frame	Reconofax IV Tape Number
				Roll 4	Roll 5	Roll 6	Roll 7	Roll 8	Roll 9	
21	12:41:50 12:47:20	40° 16.8' 40° 39.1'	74° 07.1' 73° 52.6'	01 24	01 24	01 51	01 51	01 51	01 51	6
22	12:51:00 12:58:35	40° 39.0' 40° 18.2'	73° 52.4' 73° 09.6'	26 64	26 64	52 84	52 84	52 84	52 84	
24	13:00:10 13:00:55	40° 13.8' 40° 15.1'	73° 10.2' 73° 13.8'	65 67	65 67					
26	13:05:30 13:15:25	40° 10.4' 40° 32.6'	73° 13.8' 73° 55.9'	68 108	68 108	85 158	85 158	85 158	85 158	
25	13:18:40 13:25:10	40° 35.0' 40° 15.1'	73° 57.2' 73° 24.0'	109 138	109 138	159 170	159 170	159 170	159 170	
23	13:30:35 13:40:15	40° 15.1' 40° 37.3'	73° 11.0' 73° 52.6'	139 180	139 180	171 198	171 198	171 198	171 198	

(c) Flight Data and Data Identification Parameters, April 10, Morning Flight.

Figure 17.- continued.

Flight Line	Time, GMT Start Stop	Latitude Start Stop	Longitude Start Stop	ZEISS 1 Start Frame Stop Frame	ZEISS 2 Start Frame Stop Frame	AMPS 1 Start Frame Stop Frame	AMPS 2 Start Frame Stop Frame	AMPS 3 Start Frame Stop Frame	AMPS 4 Start Frame Stop Frame	Reconofax IV Tape Number
24	13:43:35	40° 06.7'	73° 56.4'	181	181	199	199	199	199	6
	13:51:55	40° 13.9'	73° 10.1'	223	223	212	212	212	212	
33	13:54:00	40° 10.2'	73° 08.9'	224	224	213	213	213	213	
	14:04:10	40° 33.8'	73° 56.5'	268	268	301	301	301	301	7
				Roll 11	Roll 12	Roll 13	Roll 14	Roll 15	Roll 16	
25	14:11:50	40° 01.8'	73° 59.3'	01	01	01	01	01	01	
	14:20:05	40° 10.1'	73° 11.4'	42	42	83	83	83	83	
26	14:22:50	40° 10.1'	73° 16.3'	43	43	84	84	84	84	
	14:31:35	40° 29.3'	73° 59.3'	81	81	159	159	159	159	
27	14:34:15	40° 29.2'	74° 03.8'	82	82	160	160	160	160	
	14:40:30	40° 12.9'	73° 27.4'	113	113	230	230	230	230	
28	14:42:55	40° 09.5'	74° 01.1'	114	114	231	231	231	231	
	14:50:00	40° 25.7'	74° 01.1'	144	144	289	289	289	289	

(c) continued.

Figure 17. - continued.

Flight Line	Time, GMT Start Stop	Latitude Start Stop	Longitude Start Stop	ZEISS 1 Start Frame Stop Frame	ZEISS 2 Start Frame Stop Frame	AMPS 1 Start Frame Stop Frame	AMPS 2 Start Frame Stop Frame	AMPS 3 Start Frame Stop Frame	AMPS 4 Start Frame Stop Frame	Reconofax IV Tape Number
						Roll 17	Roll 18	Roll 19	Roll 20	
29	14:55:20 15:00:50	40° 26.5' 40° 10.9'	74° 05.0' 73° 34.5'	145 172	145 172	01 56	01 56	01 56	01 56	7
30	15:02:40 15:09:15	40° 07.1' 40° 22.1'	73° 31.9' 74° 04.5'	173 201	173 201	57 114	57 114	57 114	57 114	↓
31	15:11:40 15:18:00	40° 22.1' 40° 05.4'	74° 09.6' 73° 33.8'	202 233	202 233	115 178	115 178	115 178	115 178	8
32	15:20:10 15:27:30	40° 02.1' 40° 19.2'	73° 31.1' 74° 07.9'	234 265	234 265	179 240	179 240	179 240	179 240	↓

(c) concluded

Figure 17. - continued.

Flight Line	Time, GMT Start Stop	Latitude Start Stop	Longitude Start Stop	ZEISS 1 Start Frame Stop Frame	ZEISS 2 Start Frame Stop Frame	AMPS 1 Start Frame Stop Frame	AMPS 2 Start Frame Stop Frame	AMPS 3 Start Frame Stop Frame	AMPS 4 Start Frame Stop Frame
				Roll 21	Roll 22	Roll 23	Roll 24	Roll 25	Roll 26
21	17:34:45 17:39:00	40° 18.3' 40° 36.9'	74° 04.8' 73° 51.9'	01 22	01 22	01 17	01 43	01 43	01 43
22	17:41:55 17:49:30	40° 38.3' 40° 18.8'	73° 54.3' 73° 11.0'	23 60	23 60	- -	44 119	44 119	44 119
23	17:51:45 18:00:45	40° 15.6' 40° 37.0'	73° 08.9' 73° 52.7'	61 100	61 100	- -	120 197	120 197	120 197
24	18:03:45 18:12:35	40° 38.1' 40° 13.9'	73° 57.9' 73° 09.6'	101 139	101 139	- -	198 274	198 274	198 274
						Roll 27	Roll 28	Roll 29	Roll 30
33	18:19:40 18:28:50	40° 11.3' 40° 33.5'	73° 11.0' 73° 56.5'	140 179	140 179	01 92	01 92	01 92	01 92
25	18:32:45 18:41:25	40° 32.5' 40° 10.1'	74° 00.4' 73° 11.7'	180 223	180 223	93 179	93 179	93 179	93 179

(d) Flight data and data identification parameters, April 10, afternoon flight (No Reconofax IV data)

Figure 17. - continued.

Flight Line	Time, GMT Start Stop	Latitude Start Stop	Longitude Start Stop	ZEISS 1 Start Frame Stop Frame	ZEISS 2 Start Frame Stop Frame	AMPS 1 Start Frame Stop Frame	AMPS 2 Start Frame Stop Frame	AMPS 3 Start Frame Stop Frame	AMPS 4 Start Frame Stop Frame
26	18:45:10	40° 08.1'	73° 11.8'	224	224	180	180	180	180
	18:54:30	40° 29.2'	73° 59.1'	264	264	260	260	260	260
				Roll 31	Roll 32	Roll 33	Roll 34	Roll 35	Roll 36
27	19:01:15	40° 28.7'	74° 01.9'	01	01	01	01	01	01
	19:07:20	40° 12.9'	73° 27.5'	31	31	68	68	68	68
28	19:09:20	40° 09.3'	73° 24.7'	32	32	69	69	69	69
	19:16:35	40° 25.9'	74° 01.2'	63	63	131	131	131	131
29	19:19:20	40° 25.7'	74° 05.2'	64	64	132	132	132	132
	19:25:10	40° 10.4'	73° 32.6'	93	93	190	190	190	190
30	19:28:35	40° 07.0'	73° 29.8'	94	94	191	191	191	191
	19:35:30	40° 22.3'	74° 05.0'	124	124	248	248	248	248
31	19:39:05	40° 21.3'	74° 07.6'	125	125	249	249	249	249
	19:45:25	40° 04.6'	73° 31.8'	156	156	300	300	200	300
						Roll 37	Roll 28	Roll 39	Roll 40
32	19:50:40	40° 00.4'	73° 24.0'	157	157	01	01	01	01
	19:58:05	40° 15.5'	74° 00.1'	187	187	57	57	57	57

(d) concluded.

Figure 17. - continued.

Flight Line	Time, GMT Start Stop	Latitude Start Stop	Longitude Start Stop	ZEISS 1 Start Frame Stop Frame	ZEISS 2 Start Frame Stop Frame	AMPS 1 Start Frame Stop Frame	AMPS 2 Start Frame Stop Frame	AMPS 3 Start Frame Stop Frame	AMPS 4 Start Frame Stop Frame	Reconofax IV Tape Number
				Roll 41	Roll 43	Roll 44	Roll 45	Roll 46	Roll 47	11
21	13:37:25	40° 19.6'	74° 07.0'	01	01	01	01	01	01	
	13:38:35	40° 39.5'	73° 51.4'	23	23	45	45	45	45	
22	13:42:20	40° 38.7'	73° 51.2'	25	25	46	46	46	46	
	13:50:00	40° 18.0'	73° 09.8'	63	63	122	122	122	122	
23	13:53:10	40° 15.4'	73° 08.1'	64	64	123	123	123	123	
	14:02:45	40° 37.3'	73° 52.9'	106	106	206	206	206	206	
24	14:06:40	40° 35.7'	73° 55.0'	107	107	207	207	207	207	
	14:14:40	40° 14.8'	73° 11.6'	147	147	287	287	287	287	
						Roll 48	Roll 49	Roll 50	Roll 51	
33	14:21:20	40° 31.1'	73° 14.1'	148	148	01	01	01	01	
	14:30:45	40° 34.6'	73° 58.0'	188	188	81	81	81	81	
25	14:34:15	40° 32.6'	74° 01.6'	189	189	82	82	82	82	
	14:40:50	40° 16.2'	73° 25.3'	222	222	149	149	149	149	
26	14:44:20	40° 13.9'	73° 24.0'	223	223	150	150	150	150	12
	14:52:20	40° 31.2'	74° 03.2'	257	257	218	218	218	218	
27	14:56:00	40° 29.5'	74° 04.8'	258	258	219	219	219	219	
	15:02:45	40° 12.4'	73° 27.0'	287	290	283	283	283	283	

(e) Flight data and data identification parameters, April 13.

Figure 17. - continued.

Flight Line	Time, GMT Start Stop	Latitude Start Stop	Longitude Start Stop	ZEISS 1 Start Frame Stop Frame	ZEISS 2 Start Frame Stop Frame	AMPS 1 Start Frame Stop Frame	AMPS 2 Start Frame Stop Frame	AMPS 3 Start Frame Stop Frame	AMPS 4 Start Frame Stop Frame	Reconofax V Tape Number
				Roll 52	Roll 43	Roll153	Roll 54	Roll 55	Roll 56	12
28	15:07:20 15:14:15	40° 10.4' 40° 26.0'	73° 27.9' 74° 00.6'	01 30	291 320	01 60	01 60	01 60	01 60	
29	15:17:45 15:22:30	40° 24.4' 40° 10.9'	74° 00.7' 73° 34.0'	31 54	327 350	61 107	61 107	61 107	61 107	
30	15:25:00 15:31:40	40° 07.0' 40° 20.5'	73° 29.5' 74° 00.7'	55 83	351 379	108 164	108 164	108 164	108 164	
31	15:35:05 15:35:35	40° 18.4' 40° 06.8'	74° 01.8' 73° 36.7'	84 106	380 402	165 211	165 211	165 211	165 211	
32	15:43:00 15:47:40	40° 02.9' 40° 12.9'	73° 33.0' 73° 54.7'	107 126	403 421	212 252	212 252	212 252	212 252	

(e) concluded.

Figure 17. - concluded.