MODIS Team Member - Semi-Annual Report
Marine Optical Characterizations
December 1996

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NOAA/NESDIS

SUMMARY

The major emphasis during this reporting period has been focused on completion of the operational versions of the MOBYs. The team conducted three field experiments. The first, MOBY-L13, field expedition was to the operations site in Honolulu, Hawaii, from July 24 to August 15, making necessary preparations for future field experiments. The first operational version of MOBY was completed, and shore based calibration and testing were initiated. Further work was accomplished on mechanical and electrical assemblies on the second MOBY system. The results of the initial spectrometer test were excellent. The systems have sub-nanometer spectral resolution, while the sensitivity of the system is 1.5 to 2.0 times better than the old one.

During September 14-21, the team conducted the MOBY-L14 deployment and process cruise at the Lanai mooring site. The MOBY was successfully deployed on September 15. A series of tests and diver calibrations were performed. A complete set of bio-optical measurements were obtained at the site, including atmospheric transmittance observations at the MOBY and CIMEL sites. A high resolution pigment grid at the MOBY site was conducted for spatial variability.

The MOBY-L15 deployment and process cruise in the vicinity of Lanai Island was conducted from October 28 to November 25. During the first leg cruise, November 2-4, the first operational version of MOBY was recovered from the Lanai site along with the deep ocean mooring and a new deep ocean mooring deployed. MOBY was then returned to Honolulu for a recalibration and refurbishment. During the second leg of the cruise, November 14-22, the second MOBY system was deployed at the Lanai mooring site on November 16. During the rest of the cruise, a series of bio-optical stations were acquired at the Lanai site and in the vicinity of Lanai in support of the Japanese OCTS. On November 18 a complete bio-optical data set was acquired during an OCTS overpass under ideal conditions.

During this period, the completion of the MOBY systems and their operational testing represented a major accomplishment. During this same period SeaWiFS conducted their end-to-end operational test. Near real-time MOBY data was provided to the SeaWiFS project as part of their systems test.

MOBY-L13 EXPERIMENT

Members of the MOCE Team conducted field work and site maintenance in Hawaii, July 24- August 15, 1996. The following personnel participated:

NOAA - Dennis Clark, Ed Fisher, Yuntao Ge, Phil Hovey, Ed King, Larisa Koval, Eric Stengel, Marilyn Yuen
MLML - Bill Broenkow, Mike Feinholz, Mike Hearne, Yi Liu, Mark Yarbrough
CHORS - Dan Sullivan, Chuck Trees
NASA - Stan Hooker
University of Miami - Jim Brown, Bob Evans
University of Hawaii - Mike Ondrusek
Peoples' Republic of China - Junwu Tang

The components of the operational version of MOBY2 were delivered to the operations site. The first MOBY2 system was completed. Further work was accomplished on mechanical and electrical assemblies on the second system (Figure 1). Three new MOS2 instruments (SN: 002, 004, 005) were assembled and delivered to Hawaii. The MOS2 VAX station data acquisition program for the new MOS2 CCD spectroradiometer was completed and tested. This program was used to calibrate three new MOS2 instruments and the completed MOBY2 system, incorporating MOS2 (SN: 005) (Figure 2).

The MOBY communications test modules were installed on the mooring buoy. The noisy Hawaii cellular phone system caused some problems in the software. Serial buffer overflows would overwrite program memory space because the system accepted noise as valid information. To solve this problem, two fixes were implemented. Cell phones were run in the error corrected mode only, with no fall back to the less secure modes. Limits checking on all the input buffers were added to prevent the overwrite problem from any other source as well. With this buffer fix, the unit operated without problem for four weeks until recovery on September 15.

The new spectrometers were installed in the new MOS systems. Systems calibration procedures were performed on all sensors (4 upwelling radiance ports, 4 downwelling irradiance ports) including wavelength calibrations The system demonstrated superior optical capability with minimal errors.

The angular response for the new irradiance collectors was measured. Development of this optical-mechanical device was a time consuming iterative process since all modeling efforts failed to provide reasonable first approximations. After two iterations, the final design resulted in an outstanding fiber optic collector with high throughput and low angular response deviation. The throughput is about 1.5 to 2 times better than the old design.

The immersion factors for the new fiber optic irradiance collectors were measured at wavelength ranges from 350 nm to 1100 nm. The immersion factors for UV, VIS, and NIR wavelength range were calculated and incorporated into the spectroradiometer data processing software.

Work on the new Pigment and Absorption Filtration (PAF) van continued. Special cabinets were designed and built to hold two five gallon waste flasks, as well as vacuum pumps. The PAF van has two sets of manifolds enabling up to 24 simultaneous filtrations of particulate absorption and fluorometric chlorophyll samples. A large volume positive pressure filtration system (12 manifolds) was installed in the PAF van to increase the volumes filtered (up to 4.2 liters) for each HPLC analysis of oligotrophic waters.

Reinitialization of the CIMEL atmospheric measurement system was conducted at the NASA Aeronet site on Lanai.

Junwu Tang, Director for Remote Sensing at the Institute of Ocean Technology, State Oceanic Administration in the People's Republic of China, worked on Rainbow software development and implementation.

MOBY-L14 EXPERIMENT

The following personnel were involved:

NOAA - Dennis Clark, Ed Fisher, Yuntao Ge, Phil Hovey, Ed King, Larisa Koval, Eric Stengel, Marilyn Yuen
MLML - Mike Feinholz, Drew Gashler, John Heine, Yi Liu, Mark Yarbrough
SATLANTIC - Scott McLean
CHORS - Chuck Trees, Dan Sullivan
University of Miami - Joe Ritter
University of Hawaii - Mike Ondrusek
NIST - Carol Johnson

Prior to the cruise, the final MOBY tests, calibrations, and preparations for the deployment were performed.

Carol Johnson, NIST, participated in the calibration of the optical instruments associated with the MOBY project. Two Single Channel Multipurpose Sensors (SCAMPS) were used for monitoring the stability of our calibration standards of spectral radiance, irradiance, and field reference lamps. The components of the two calibrated radiometers consist of a filtered, temperature controlled, silicon photodiode with required amplifier electronics, power supplies and precision apertures (Figure. 3). The final calibration of MOBY was performed using the SeaWiFS transfer radiometer

(SXR) and SCAMPS (Figure 4). Initial results indicate that the Team's calibration systems are within 1% of the NIST transfer radiometer.

During the calibration, a problem was found with the coupling gel used inside the fiber optics connectors. The problem seems to be caused by a reaction between the gel and the methanol used to clean the optical interface prior to mating the connectors. As a precaution, all of the other fiber optics connections were cleaned and re-mated using different chemicals.

After the initial calibration of the MOBY it became apparent that more control over the operation of the MOS CCDs via the MOBY operational parameters is needed. Now it seems that more control is also needed over the CCD binning factors as well.

MOBY2 was deployed at the Lanai site on September 15 (Figure 5). After four days of experimentation, a good set of operational parameters (integration time and binning factors) were determined, considering our desire to keep the bright days on scale and below the CCD saturation problem area. A series of diver calibrations were performed during the period September 16-21. The mid irradiance port and the upper radiance port have an obvious problem which looks similar to the coupling gel failure on the same collectors discovered during calibration.

On September 20, the humidity sensor indicated a leak in the surface control unit. The unit was recovered from the buoy, repaired, and successfully installed in time for the noon observations the next day (Figure 6). The source of the leak was determined to be bad welds. The MOBY collected data at noon and transmitted the data to MLML VAX 4000 once a day. The data are read into a file format used by the MLML data processing programs. The row CCD spectral radiances are adjusted by dividing by the integration times and subtracting the dark scans from the light. When sensor and fiber optics calibrations have been verified, the adjusted spectral upwelled radiance (Lu) scans will be converted into absolute radiometric units. For the present time, we are presenting only adjusted data in counts/see (Figure 7). The surface irradiance (Es) data sets taken before and after each sub-surface radiance scan are averaged, and are shown in adjusted units of counts/see. Water-leaving radiances (Lw) are computed from Lu using attenuation coefficients calculated from the adjusted radiance values. These attenuation coefficients may have large errors because the sensor response for individual fiber optic collectors are not included. The spectral Es and Lw are weighted with the SeaWiFS responses, and the integrated Es and Lw over the SeaWiFS bands are computed for bands 1-6 (41 2,443, 490, 510, 555, 670 rim).

The data acquisition system for the cruise consisted of 11 computers networked together with ethernet. Two GPS systems provided time and location information to synchronize all data collection system. They broadcasted through the RS232 interface to all other systems, A flux-date electronic compass gave heading and direction information. A notebook computer logged air pressure through a serial port connected to a digital pressure transducer. A relative humidity and temperature

sensor monitored these two parameters and the data were recorded through an A/D converter. Two wind sensors mounted on each side of the boat provided wind speed and direction. A Quadra 650 computer controlled the VLST system, which provided sea water transmittance at 5 different channels, a fluorometer for the detection of chlorophyll concentration, and a pressure transducer which indicates the layer of water column where these data were taken. The fluorometer and pressure transducer plus a water pump were mounted on a V-fin (for towing speeds of about 5-8 knots). Seawater was pumped through the VLST system and flow rate was also measured. Discrete samples at specific times and location were collected for particle size distribution, pigment concentration, and total suspended matter analysis. Information including fluorescence, depth, transmittance, GPS time and location were all relayed to another lab through a serial port. Another computer takes in these information and displays it to the workers in the lab. After a sample was taken, they can log in the data on this computer. A thermosalinograph was controlled by a notebook computer. All activities were recorded by a master log which resides on a separate power book. A PowerPC 7100 backs up all experimental data, In the process of setting up this system, a new compass had to be installed and tested. The relative humidity and temperature sensor had to be adjusted and calibrated. Since many new LabVIEW software programs had to be rewritten, a serial port tester program was written to debug problems encountered.

During the 7 day cruise, samples were collected for fluorometric analysis in a near-realtime mode. Samples were also collected and frozen in liquid nitrogen for HPLC analysis at CHORS, San Diego. Software modifications were made to the HP Diode Array and Integrating Sphere system to improve processing speed and plotting capabilities. Three CTD casts (SBE0034-42) were performed during the cruise. Seawater for 53 TSM and 53 POC/PON (analyses were sampled and filtered samples were collected). Deep “particle-free” water was collected for future irradiance collector immersion experiments.

An 8 km^2 survey grid was performed around MOBY, measuring near surface *in vivo* fluorescence, temperature and beam attenuation using the towed system. Duplicate fluorometric chlorophyll samples were collected and analyzed onboard ship, and HPLC samples were collected for analysis at CHORS. Using one minute averaged chlorophyll corrected *in* vivo fluorescence, a surface contour map was generated. This survey showed that the chlorophyll field was heterogeneous with concentrations ranging from 0.042 to 0.110 mg m^-3. A contour map with sample spacing is shown in Figure 8.

A Satlantic Free-Fall Profiling Radiometer was deployed off the stern of the R/V Moana Wave to depths of up to 250 m (Figure 9). Four sets of three profiles each were made around the mooring with the data analyzed using software provided by the manufacturer.

Atmospheric transmittance observations were performed at the MOBY and CIMEL sites. Experiments of instrument self-shading effects on upwelling radiance measurements were carried out (Figure 10). These data are also being analyzed.

After the cruise, laboratory experiments were performed using MOS2 (SN: 002) to characterize the instruments' "linear" response to varying light levels, integration time, and CCD binning parameters. Calibrations for MOS2 002 included:

1) Up and down Lu port wavelength calibration via Ne and HgA lamps
2) Response linearity experiment (Figure 11)
3) Integration time linearity experiment (Figure 12)
4) CCD bin factor linearity experiment (Figure 13)
5) Irradiance response via F-453 standard lamp (Figure 14)
6) Radiance response via OL420 integrating sphere (Figure 14)

The SIS irradiance response via the F-453 standard lamp was processed, and tungsten-halogen lamp spectra were interpolated to MOS and SIS calibrated wavelengths via a NIST lamp fit program provided by Charles Gibson (NIST). CTD profiling data obtained during MOBY-L14 cruise were processed using SeaBird's SeaSoft software (Figure 15)

MOBY-L15 EXPERIMENT

The following personnel were involved:

NOAA - Dennis Clark, Ed Fisher, Yuntao Ge, Phil Hovey, Ed King, Larisa Koval, Eric Stengel, Marilyn Yuen
MLML - Bill Broenkow, Mike Feinholz, Stephanie Flora, Drew Gashler, John Heine, Yong Sung Kim, Yi Liu, Brian Schlining, Mark Yarbrough
University of Miami - Ken Voss, Albert Chapin
University of Hawaii - Mike Ondrusek
MSI - Peter Clay, Doug Dooner
CHORS - Chuck Trees, Dan Sullivan
NASA - Charles McClain

Prior to the MOBY L-15 field experiment, diver calibrations were performed in October. No gross changes in the collector responses were indicated. Upper arm data were more noisy, presumably from movement of the light source due to wave action. More replicates are needed to obtain meaningful data.

The second operational version of MOBY was completed. The old leaky MOBY controller and upper power junction boxes were replaced with the new NOAA units. The electrical system was installed and tested. The alignment of the MOS unit was checked and optimized and the unit, fiber optics, and collectors were installed, Tests

were performed on three types of optical coupling gels because of the clouding problems we experienced during the last deployment. Dow Corning Q2-3067 Optical compliant was determined to be the most resistant to water, seawater, methanol and Lectra-Clean. System responses on all fiber optic collectors of the second version of MOBY are significantly lower than the first version, presumably due to mux differences.

Shore-based calibration and testing were performed. The following radiometric calibrations were conducted:

1) Pre-L15 MOS2 unit #4 Calibrations:
   Wavelength calibration of up Lu port via Ne and HgA lamps,
   Up Lu port radiance calibration via OL420M S3W4D100
   Up Lu port Integration time via 0L420M
   Down Lu port delta counts from multiple Iite scans, multiple background (lamp off) scans
   Fiber coupling stability with the 138”1 mm fiber and #8 irradiance head and MUX #2
      a) recoupled with and without fiber and ferule cleaning and gel
      b) MUX port 1,3-10 relative sensibility
   Check affect of copper anti-foulant attachment for MOS Up Lu port

2) Pre-L15 SIS Calibration:
   Irradiance calibration with GS5000 FEL F-453 reference lamp

3) Pre-Deployment MOBY-2 calibrations with MOS2 #4 and MUX #3:
   Irradiance Sfc, Top, Mid, Bot response via GS5000 FEL F-453
   Radiance Top, Mid, Bot response via OL 420M S3W5D100

The first at-sea expedition was from November 2-4, 1996. MOBY was recovered from the Lanai site and returned to Honolulu for post-calibration and refurbishment. Biofouling was minimal to the superstructure of the buoy, limited to a few gooseneck barnacles in protected areas of the buoy. Some small barnacles were found on the outside surface of the mid irradiance bezels, one small barnacle on the inside of the surface irradiance bezel. The teflon collectors were clean. Light bryozoan growth were accumulated primarily in the unpainted areas near the end of the arms. Some bryozoan fouling penetrated to the radiance collector ports through the air vent holes in the anti-foulant tube mounts. Moderate bryozoan fouling was found on about half the MOS Lu port. Moderate bryozoan and small clam fouling were observed in the inner instrument bay and MOS.

MOS nearly leaked due to electrolysis of the stainless closure nuts. Nylon covers were made to protect the parts from exposure during the next deployment. More corrosion resistant titanium nuts will be made to replace the stainless ones. The protective mux cover had leaked through a bad o-ring groove in the PVC cover. The

leakage and resulting exposure to sea water caused light surface corrosion to the fiber optic SMA connectors. The rest of the fiber optic connector cover components worked well and the fiber/connectors were intact.

The surface float had been refurbished and reassembled. The marine lantern battery required replacement. The new tether assemblies were delivered by Mooring Systems, Inc. Personnel from MSI helped with the float reassembly and mooring preparation.

The new version of the MOBY was deployed at the Lanai mooring site on November 16 during the second at-sea expedition (Figure 16).' There was a problem with the mux after deployment. The home position had changed since the calibration. It took two days of experiments to find the new home position and reconfigure the MOBY for the changes, Pre-calibrations should hold if the problem is only with the home encoder. (The home position has been stable ever since.) This MOBY was deployed without antifoulant tubes on the fiber optic collectors, but a copper antifoulant tube was added to the MOS Lu port.

During the cruise, nine SBE-911 + CTD casts were performed: 8 to approximately 200 m; 1 to 1000 m. Water was sampled and processed for 50 Total Suspended Material (TSM), 68 Particulate Organic Carbon and Nitrogen (POC, PON), 44 dissolved oxygen, and 48 salinity analyses.

Upwelling radiance was measured during the cruise using the same fiber optic system. This setup was used to measure instrument self-shading effect. The system includes a two channel spectrometer, an irradiance sensor, and a fiber radiance sensor (Figure 17). Upwelling radiance is measured with the fiber sensor, which has a diameter of only 6 mm, minimizing the self-shading effect. An attempt was made to measure the self-shading effects using disks again, however, this failed due to strong winds and rough sea conditions.

Atmospheric transmittance observations were performed using a Hand Held Contrast Reduction Meter (HHCRM) to obtain optical thickness of the atmosphere. The data have been reduced and analyzed for the extraterrestrial flux with the Langley technique. Tables and plots have been obtained and the best fit spectral intercept has been determined.

The data acquisition system **was** updated for the cruise. The Macintosh computers were swapped out for several of the instruments, Necessary hardware such as A/D, GPIB control, or serial port expansion cards were installed. Five new monitors replaced the ones that belonged to NASA (which were shipped back at the end of the trip as requested). This arrangement made the data acquisition more reliable. LabView 4.0 was installed to both a PowerMac system and a Mac IIfx system to see whether the upgrade is better. Al systems may be upgraded to the PowerMac PCI bus

structure, which requires all acquisition software to be upgraded and plug-in cards switched.

After the MOBY-L15 cruise, the following radiometric calibrations were performed:

1) Post-deployment MOBY with MOS2 unit #5 and MUX #3 calibrations:
   Irradiance Sfc, Top, Mid, Bot response via GS5000 FEL F-453
   Radiance Top, Mid, Bot response via OL420M

2) Post-L15 MOS2 #5 calibrations (after removal from MOBY):
   Wavelength calibration of up Lu port via Ne and HgA lamps
   Up Lu port radiance calibration via 0L420M

3) Post-L15 MOS2 #2 calibrations:
   Up port Lu, and down port Ed wavelength calibration via Ne and HgA lamps
   Up port Lu bin factor linearity via OL420M with different intensity settings
   Irradiance response via GS5000 FEL F-453
   Radiance response via OL420M

4) Post-L15 SIS Calibration:
   Irradiance response via GS5000 FEL F-453

System calibration was performed again on the fiber optic spectrometer system. Both radiance and irradiance sensors were calibrated. The radiance sensor was calibrated using the integrating sphere OL420M. The irradiance sensor was calibrated using the new standard lamp F-453 (NIST calibrated).

MARINE OPTICAL BUOY - Software development

Personnel from Moss Landing Marine Laboratories have nearly finished the process, begun in February, of converting the VAX-based MLDBASE programs from the FORTRAN and C language to the Matlab language. All major MLDBASE low level, menu driven, oceanographic and time/data functions have been completed. The required NOAA processing programs have also been defined. Although most of the programs operate the same as their VAX counterparts, there are exceptions where Matlab offers a more efficient way of manipulating data. The help files written to accompany each Matlab MLDBASE file will show the inputs, outputs and examples of the use of each program. New programs have been written to create home pages accessible on the world-wide-web, These home pages are password protected and provide access to images of raw MOBY radiometric and engineering data. Four programs were written to view the raw MOBY data during diver calibrations. Monthly files of the data from the FORTH log files and auxiliary MOBY data were created to keep track of the MOBY's daily operation; two programs were written to do this.

MARINE OPTICAL BUOY - Hardware development

Final assembly of MOS unit #1 is continuing. MOS CCD systems were tested to investigate the source of the sub-fullscale saturation problem. It was found that the saturation at less than full scale is due to uneven illumination of the CCD. Additional spectrograph alignments to center the maximum intensity to the center of the slit and CCD array may improve the performance of some units.

Additional work is required to optimize the MOS/CCD system in the following areas:

1) Investigate optical improvements to more evenly illuminate the CCD in the vertical dimension.
2) Investigate the tradeoffs involved with reducing the Region of Interest (ROI) to use only the area of best image quality. Reducing the (ROI) in the vertical (along slit) dimension reduces the saturation problem and increases usable full scale range, but results in increased measurement noise due to the loss of usable image area for binning and averaging.
3) Optimize secondary lens focusing to maximize throughput.

DATA REDUCTION

MOCE-3

All VLST data collected during the MOCE-3 cruise were preprocessed due to an error in the processing program. The algorithm used in converting the fluorescence to chlorophyll concentration was corrected. There was also an error detected in the average processing program and as a result of this finding, all MOCE-3 data must be reaneraged using the new utility,

MOCE-2

As a result of the consistent errors found in the previous series of processing utilities, it has been determined that MOCE-2 data will also be double checked for errors that were made apparent during the MOCE-3 processing. This involve retracting data from NASA archive and reprocessing it to ensure its correctness.

DOCUMENTATION

A revised version of the ATDB was completed.

A new naming convention has been developed for our field experiments. Keeping in mind that DOS has an eight character filename limitation, the following definitions are in place:

Filename 12345678. xxx where

1 = M for MOBY
2 = Current MOBY version number
3 = First digit of sequential order for cruise
4 = Second digit of sequential order for cruise
5 = D for MOBY deployment
R for MOBY recovery
S for MOBY swap out
6-8 = O for optical data collected
B for biological data collected
P for Physical data collected

For example, filename M202RO indicates that the second cruise involving the second version of MOBY was a recovery cruise and only optical data were collected during that cruise.

The previous naming convention , MOBY-L##, will be maintained for trips where no ship time occurs. Thus, the last four trips should be referred to as follows:

24 Jul -15 Aug 96	MOBY-L13
14-21 Sep 96	M201DOBP
2-4 Nov 96	M202RO
14-22 Nov 96	M203DOBP

MEETINGS

September - SeaWiFS Protocol and Workshop -C. Trees and P. Hovey traveled to Booth Bay, Maine, September 29- October 3, to participate in Beta Inter calibration exercises with colleagues at Bigelow Laboratory for Ocean Sciences. The HP Diode Array and Integrating Sphere system were compared to four other spectrophotometer using 10 phytoplankton cultures. These cultures were selected to cover several phytoplankton groups with a variety of cell sizes. Several turbid water samples from Booth Bay and nearby rivers were collected.

October - D. Clark attended MODIS Team Meeting.

December - D. Clark participated in his ATDB review at NASA HQ.

December - D. Clark and K. LeFevre participated in a budget review with NASA personnel.

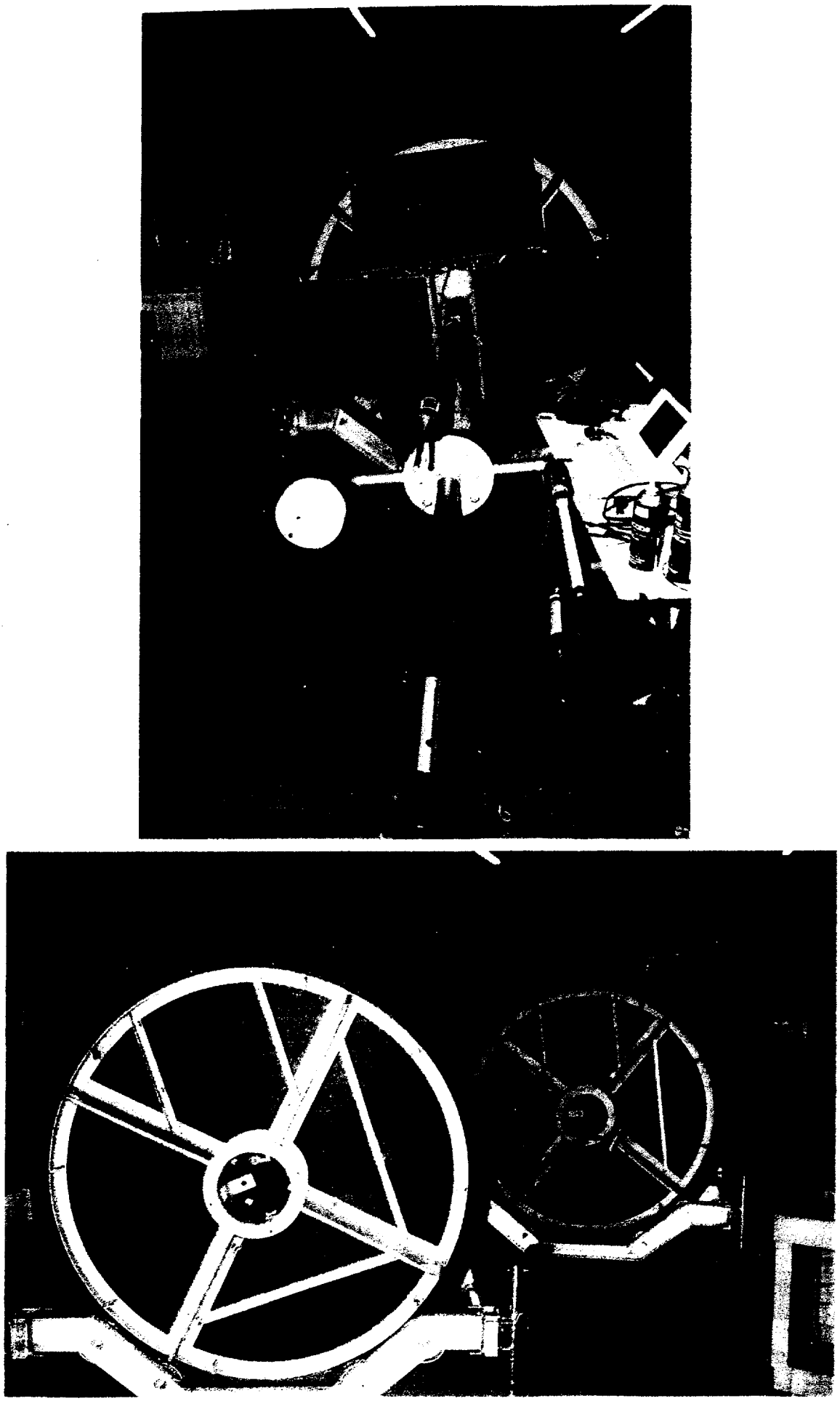

FIGURE 1.

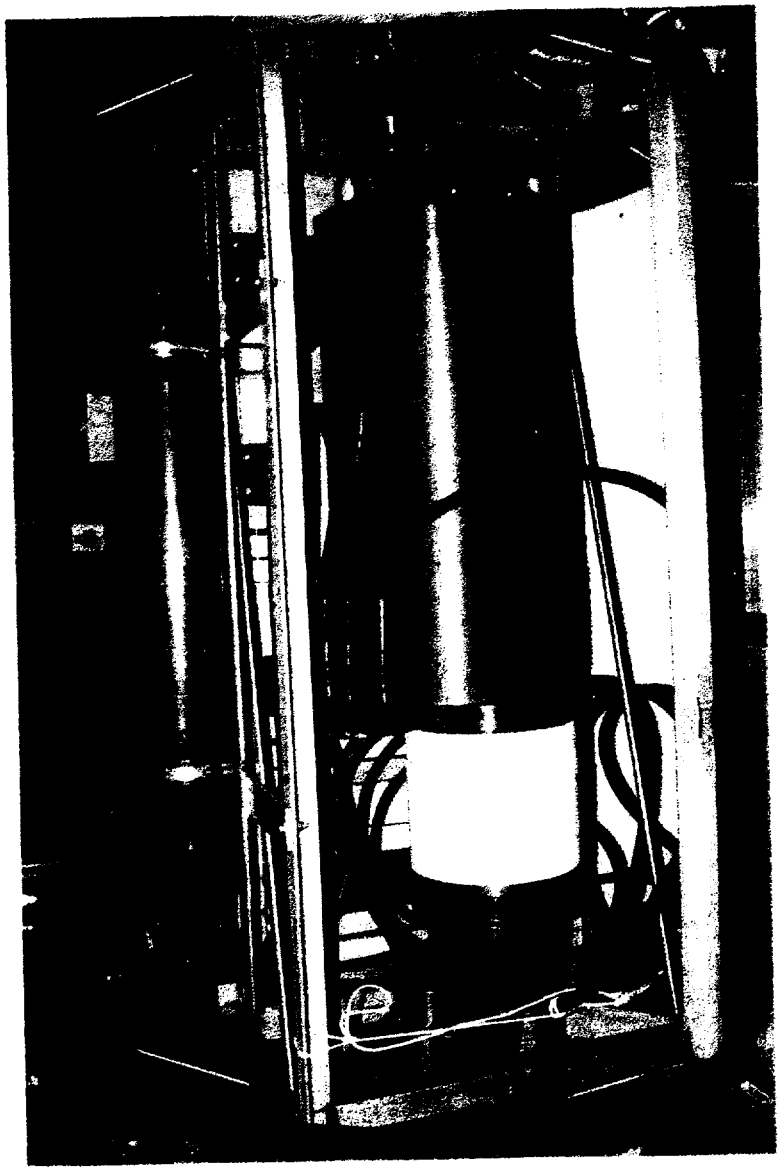

FIGURE 2.

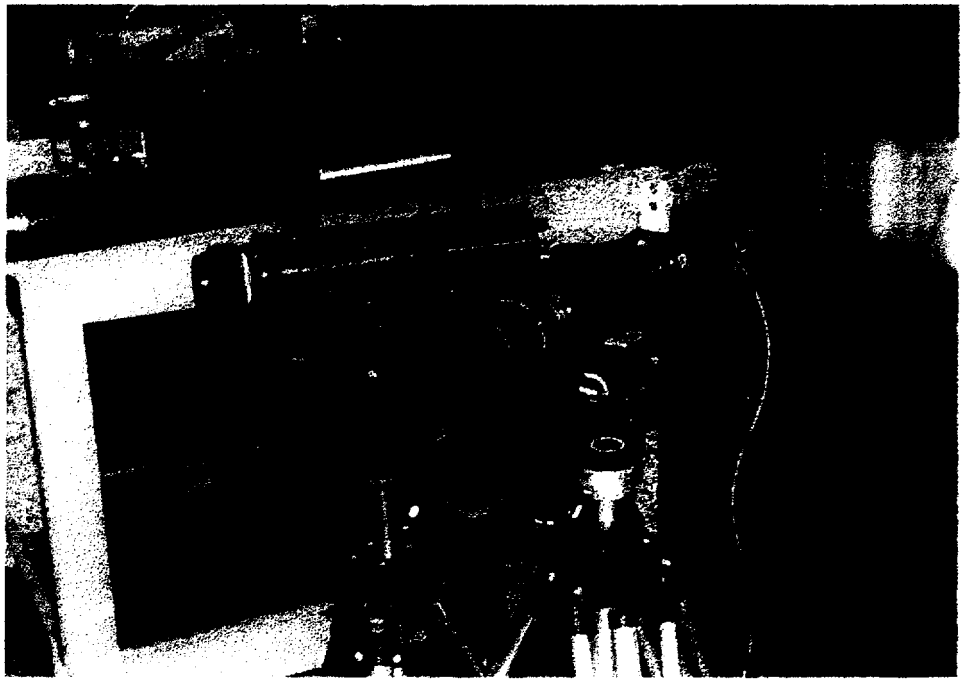

FIGURE 3.

FIGURE 4.

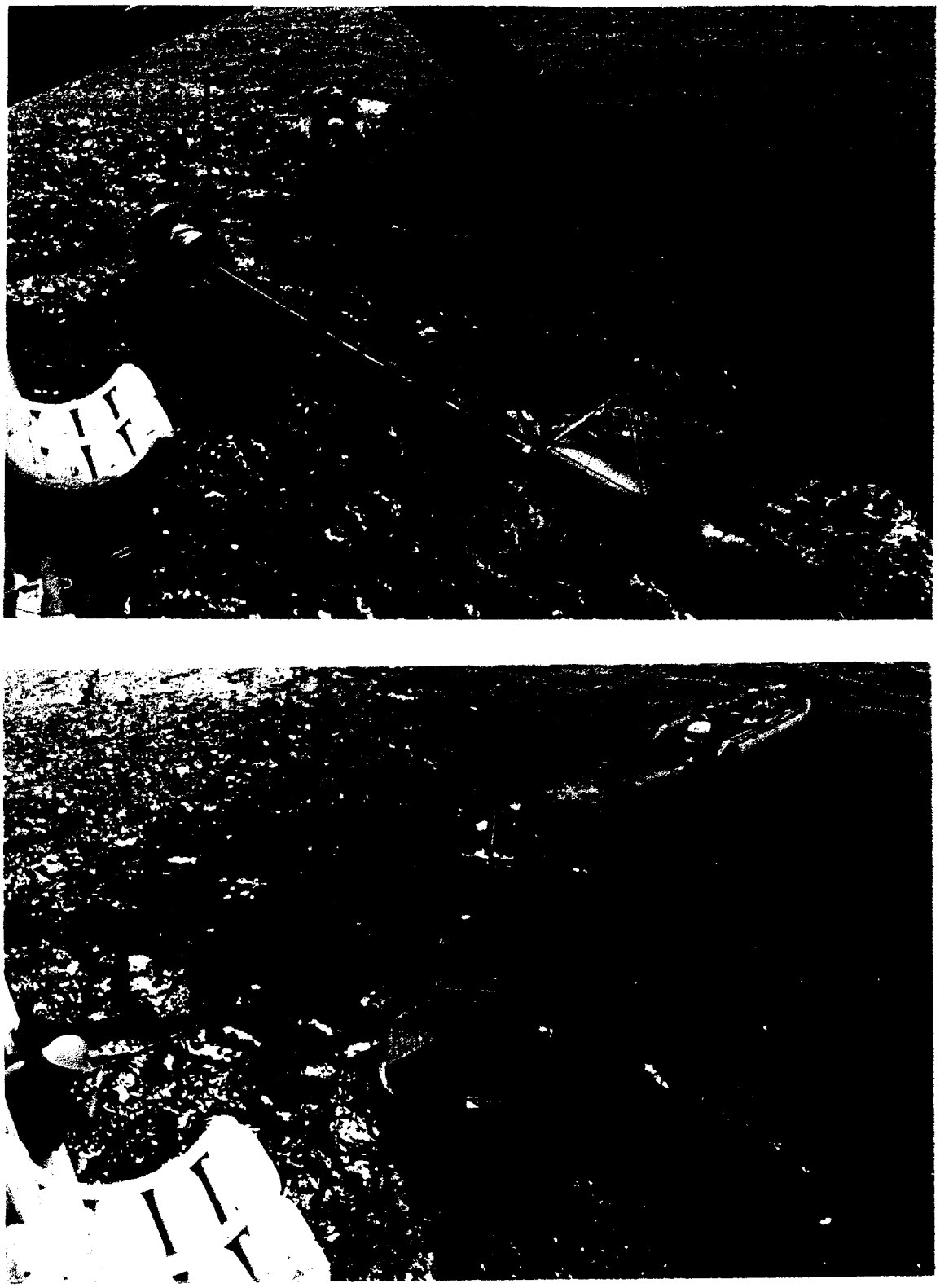

FIGURE 5.

FIGURE 6.

File: DAILYMBY.TXT

FhdS 1: NOAA Marine Optical BuoY
FhdS 2: Position: 20*49.33′ N 157*11.46′ W

DscS 1: Julian Day
DscS 2: GMT Time (HH.MM)
DscS 3: Observation Date (YY.MMDD)
DscS 5: Water-Leaving Radiance SeaWiFS Band 1 (Adjusted Counts/Sec)
DscS 6: Water-Leaving Radiance SeaWiFS Band 2 (Adjusted Counts/Sec)
DscS 7: Water-Leaving Radiance SeaWiFS Band 3 (Adjusted Counts/Sec)
DscS 8: Water-Leaving Radiance SeaWiFS Band 4 (Adjusted Counts/Sec)
DscS 9: Water-Leaving Radiance SeaWiFS Band 5 (Adjusted Counts/Sec)
DscS 10: Water-Leaving Radiance SeaWiFS Band 6 (Adjusted Counts/Sec)
DscS 13: Surface Irradiance SeaWiFS Band 1 (Adjusted Counts/Sec)
DscS 14: Surface Irradiance SeaWiFS Band 2 (Adjusted Counts/Sec)
DscS 15: Surface Irradiance SeaWiFS Band 3 (Adjusted Counts/Sec)
DscS 16: Surface Irradiance SeaWiFS Band 4 (Adjusted Counts/Sec)
DscS 17: Surface Irradiance SeaWiFS Band 5 (Adjusted Counts/Sec)
DscS 18: Surface Irradiance SeaWiFS Band 6 (Adjusted Counts/Sec)

Xdat :

N	JDay	GMT	ObsDate	Lw_SW1	Lw_SW2	Lw_SW3	Lw_SW4	Lw_SW5	Lw_SW6	Es_SW1	Es_SW2	Es_SW3	Es_SW4	Es_SW5	Es_SW6
1	260	22.28	96.0916	2872	3776	4412	3156	1464	176	404818	635125	943990	1046331	914980	959219
2	261	22.29	96.0917	1627	2175	2594	1858	876	147	248837	379777	547735	600510	516467	530912
3	262	22.28	96.0918	561	744	897	646	308	37	195696	299265	432446	473169	407524	416695
4	263	22.23	96.0919	1375	1808	2144	1533	728	180	404401	631486	934267	1034832	902271	1934525
5	264	-	96.0920												
6	265	-	96.0921												
7	266	22.50	96.0922	612	812	977	703	334	165	195614	306340	454684	503880	439845	1976514
8	267	22.49	96.0923	654	873	1053	769	379	196	191898	300004	444355	491989	429096	1932340
9	268	22.49	96.0924	722	973	1191	875	429	226	172537	268529	395866	437167	380542	1702327
10	269	22.50	96.0925	807	1095	1351	1004	503	280	174977	271863	399854	441342	383234	1708039
11	270	22.49	96.0926	582	771	921	650	298	121	187849	293654	434847	481278	419794	1892962
12	271	22.49	96.0927	788	1099	1397	1020	490	224	234197	369298	551736	612512	536097	2422574
13	272	22.49	96.0928	583	767	913	639	290	113	191734	299187	442131	489335	425996	1915728
14	273	22.49	96.0929	666	891	1093	802	388	197	188528	294423	435625	481988	420273	1889682
15	274	-	96.0930												
16	275	22.49	96.1001	720	961	1169	860	419	222	188674	294877	436498	483137	421247	1900179
17	276	22.49	96.1002	713	941	1143	838	406	204	188047	293919	435084	481618	419960	1891650
18	277	-	96.1003												

FIGURE 7.

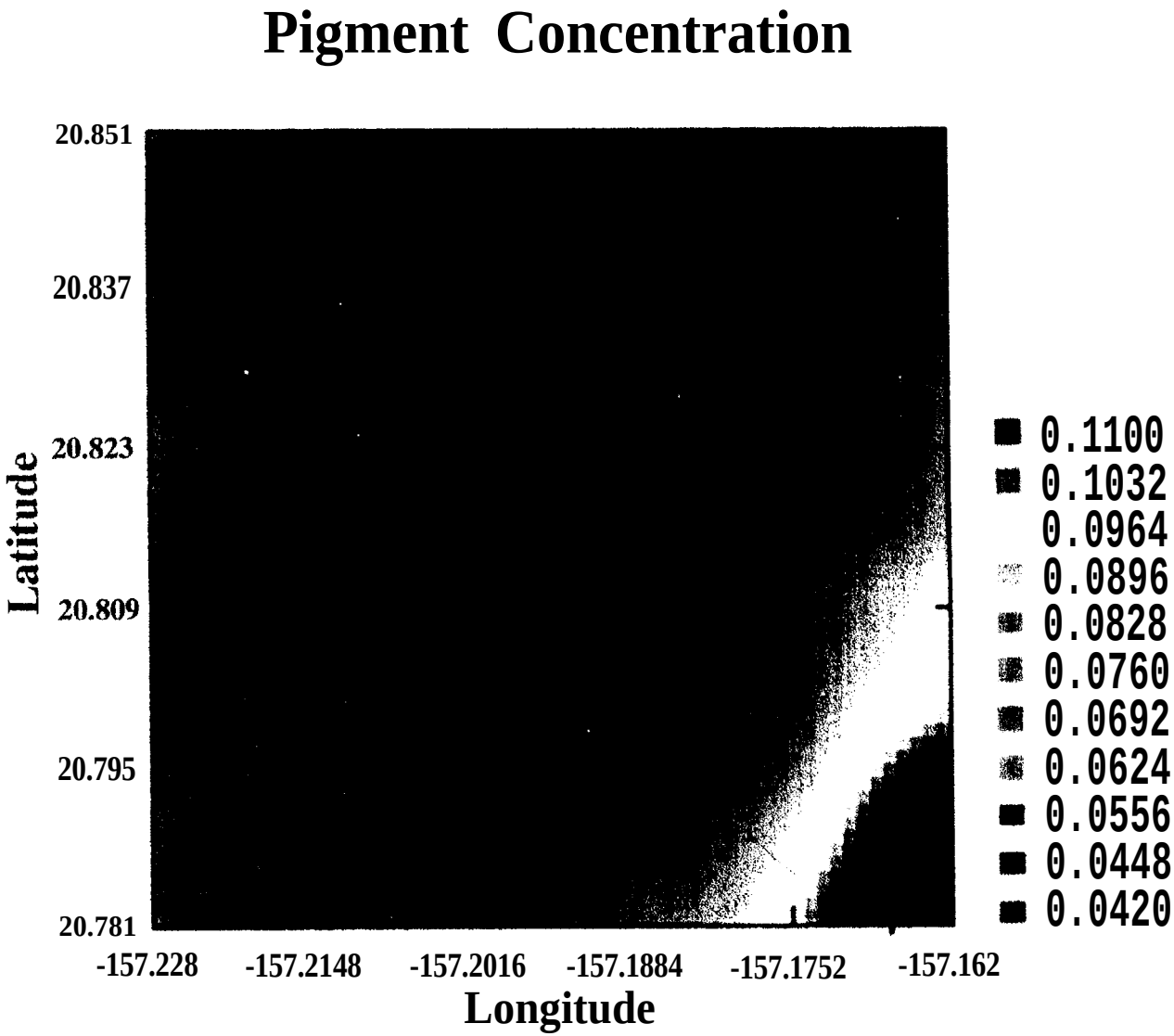
Pigment Concentration
20.851
20.837
20.823
20.809
20.795
20.781
Latitude
-157.228
-157.2148
-157.2016
-157.1884
-157.1752
-157.162
Longitude
0.1100
0.1032
0.0964
0.0896
0.0828
0.0760
0.0692
0.0624
0.0556
0.0448
0.0420

FIGURE 8.

FIGURE 9.

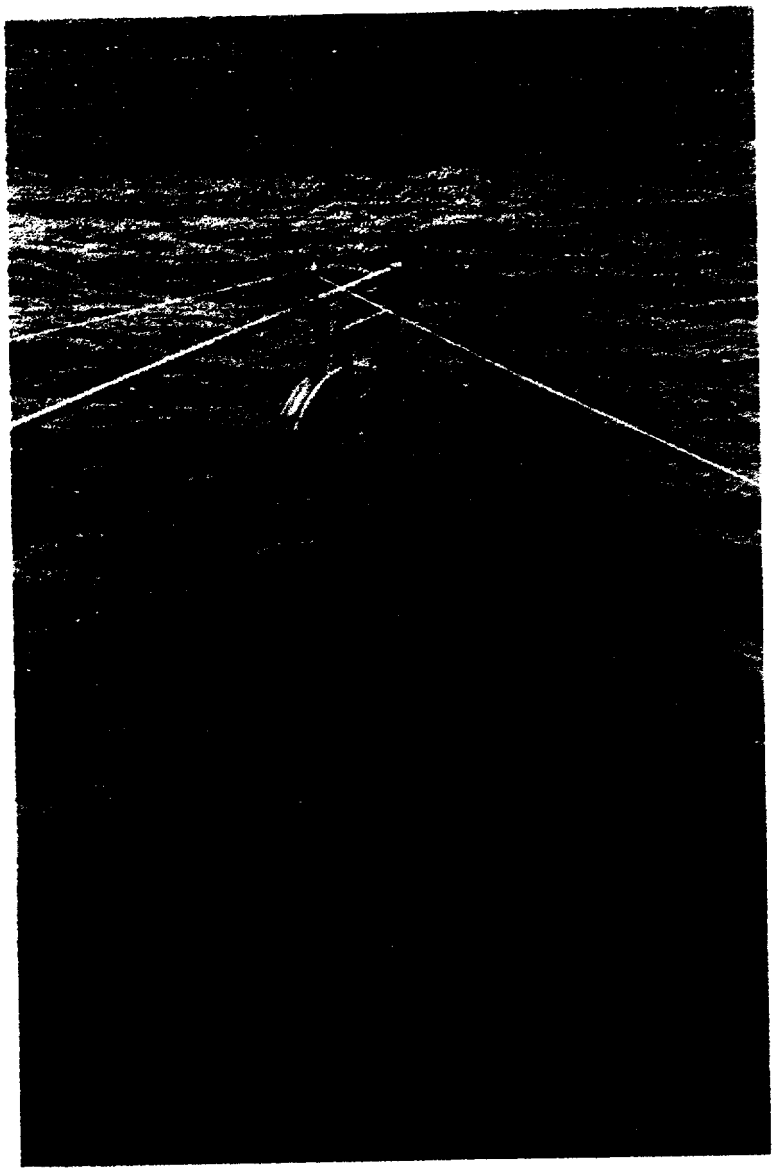

FIGURE 10.

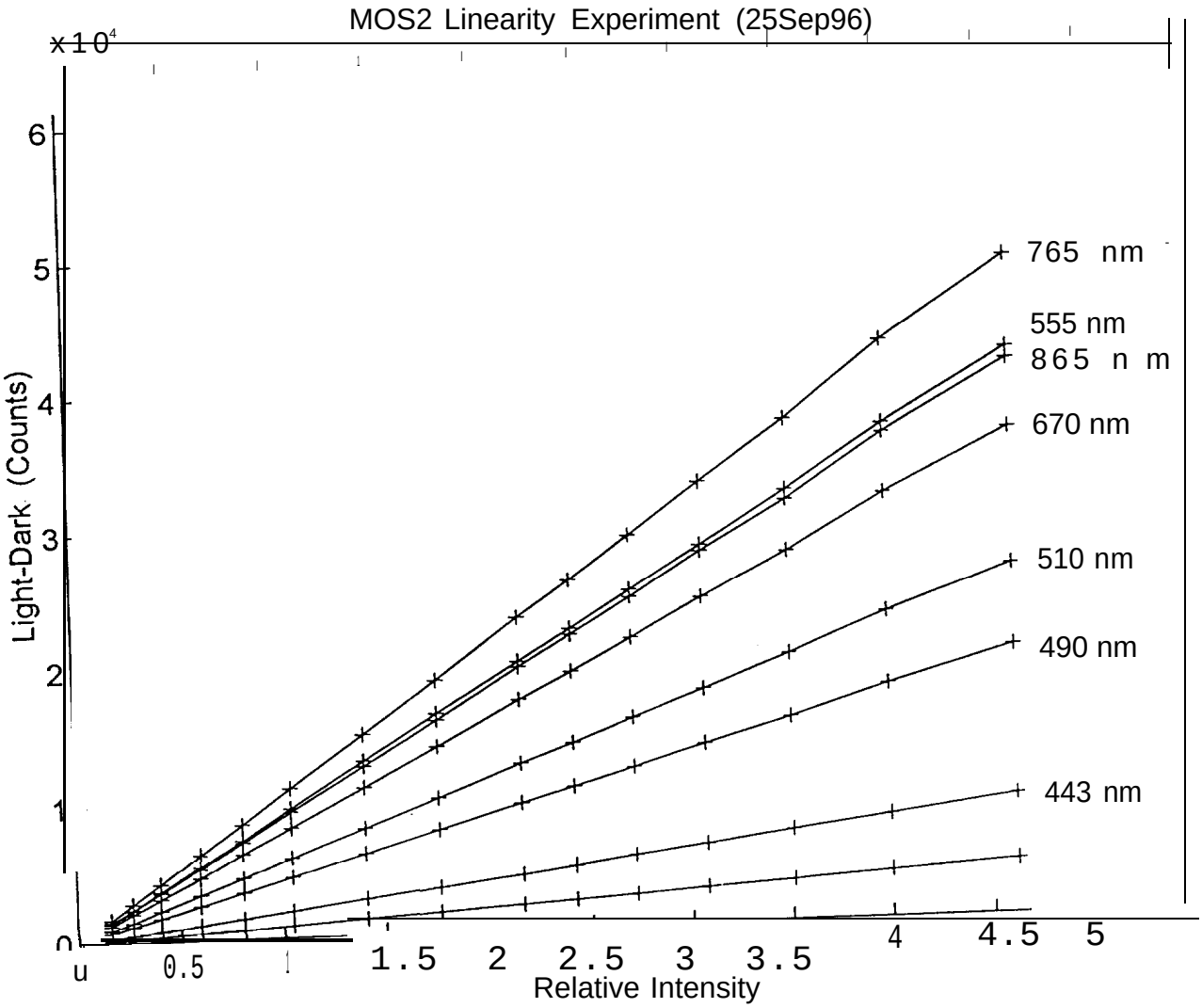

FIGURE 11. MOS2#002 Response Linearity at SeaWiFS Center Wavelengths

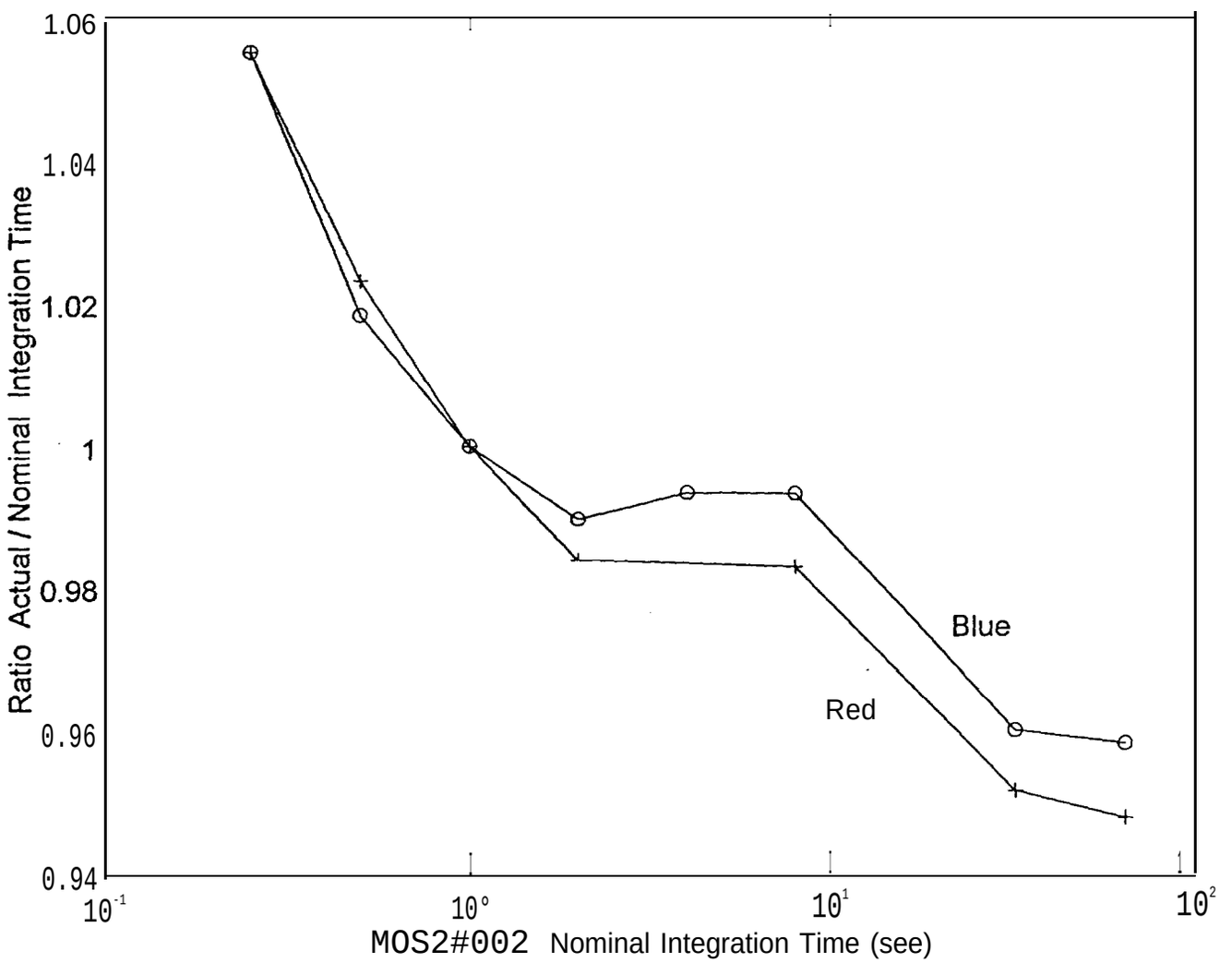

FIGURE 12. MOS2#002 Integration Time Calibration (Relative to 1 Second)

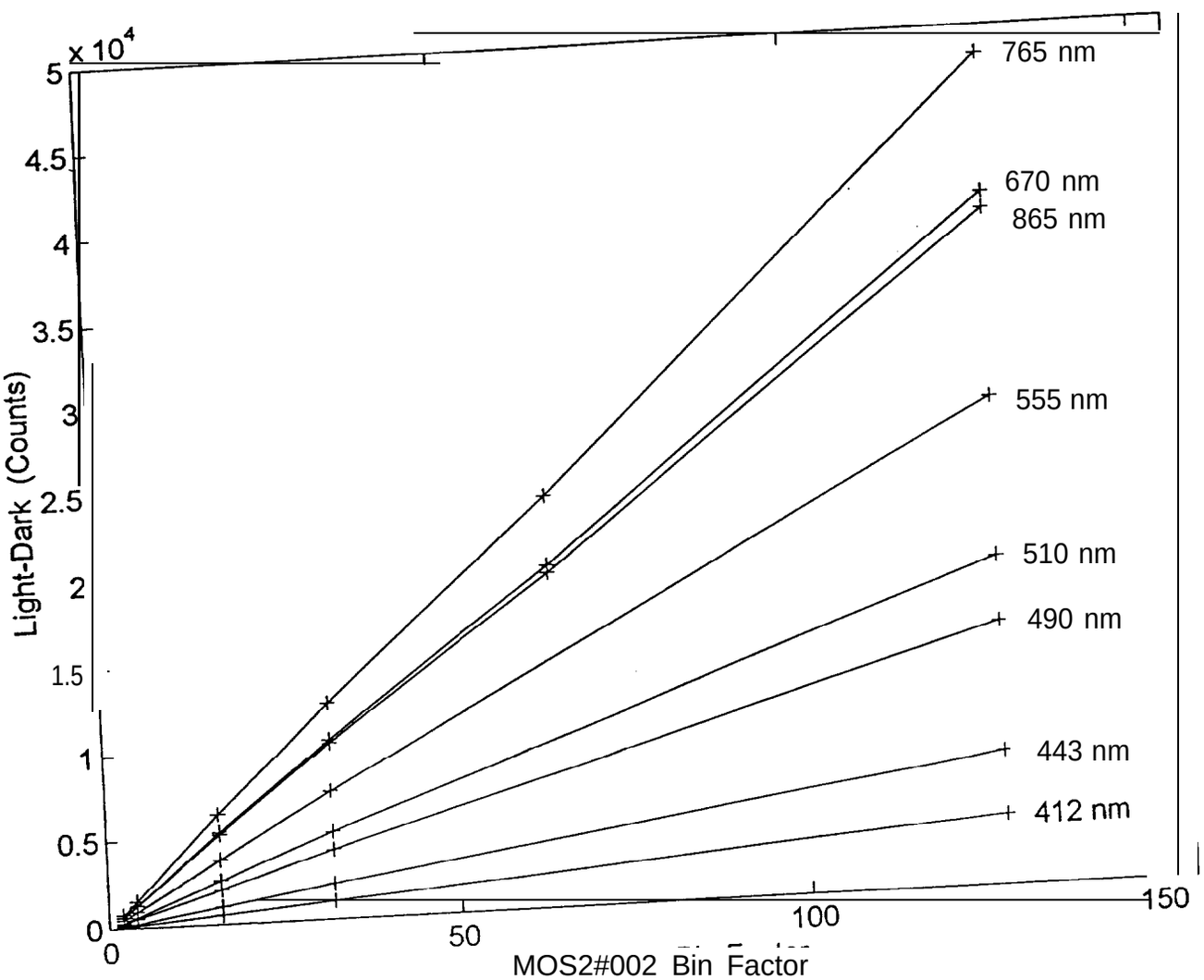

FIGURE 13. MOS2#002 CCD Bin Factor Linearity at SeaWiFS Center Wavelengths

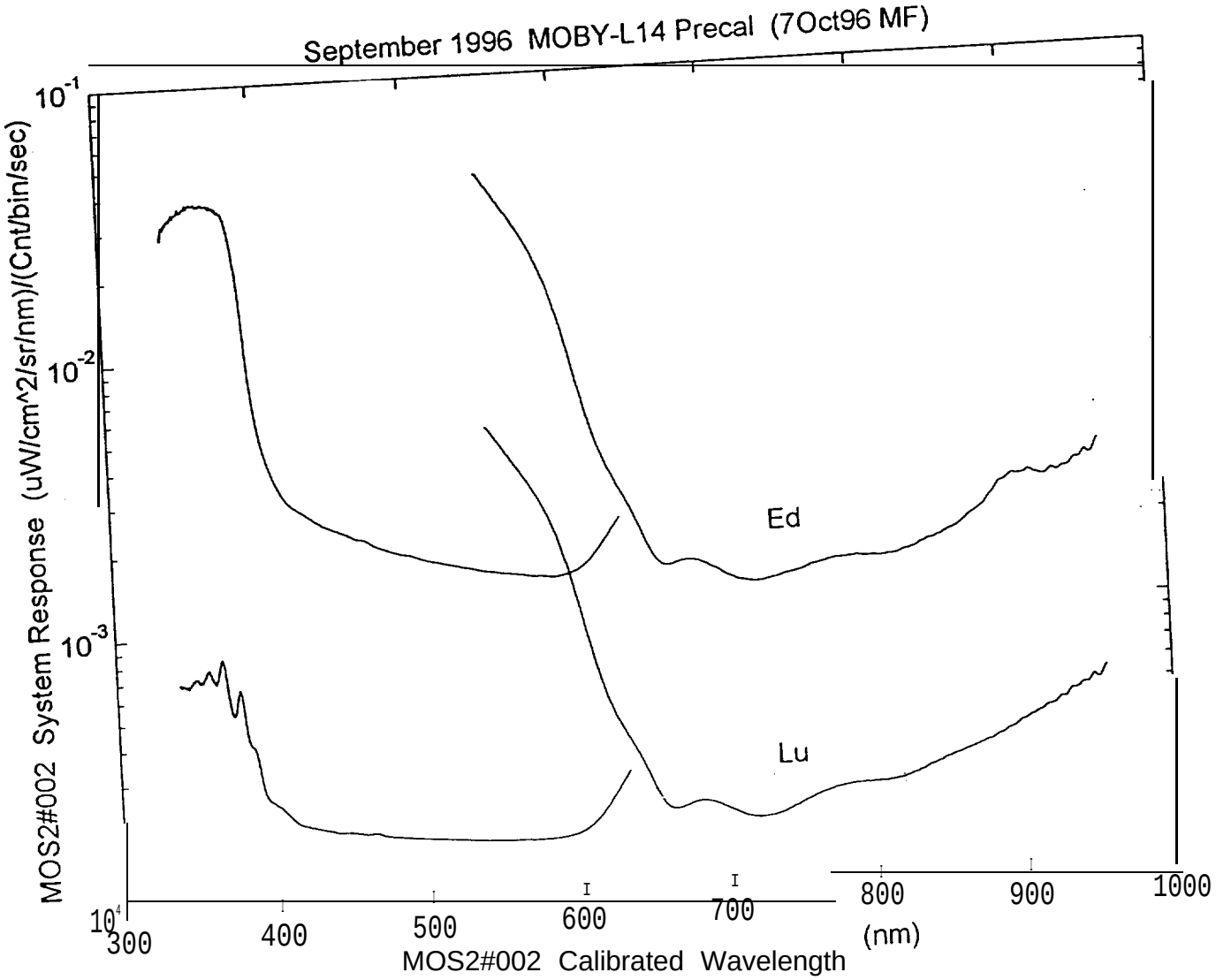

FIGURE 14. MOS2#002 **Radiance and Irradiance System Response**

Cruise: MOBY L-14

Station: 09-- Lanai Mooting

Latitude: 20*48.8' N

Longitude: 157*10.1' W

Ship: R/V Moana Wave

Date: 15:10 (Local) 19 Sept 1996

Secchi: 36 m

Munsell: 10B 7/8

File: SBEO042P

Wind: 8 kts 010 T

waves: 2 ft 10 sec

Clouds: 10% Cumulus

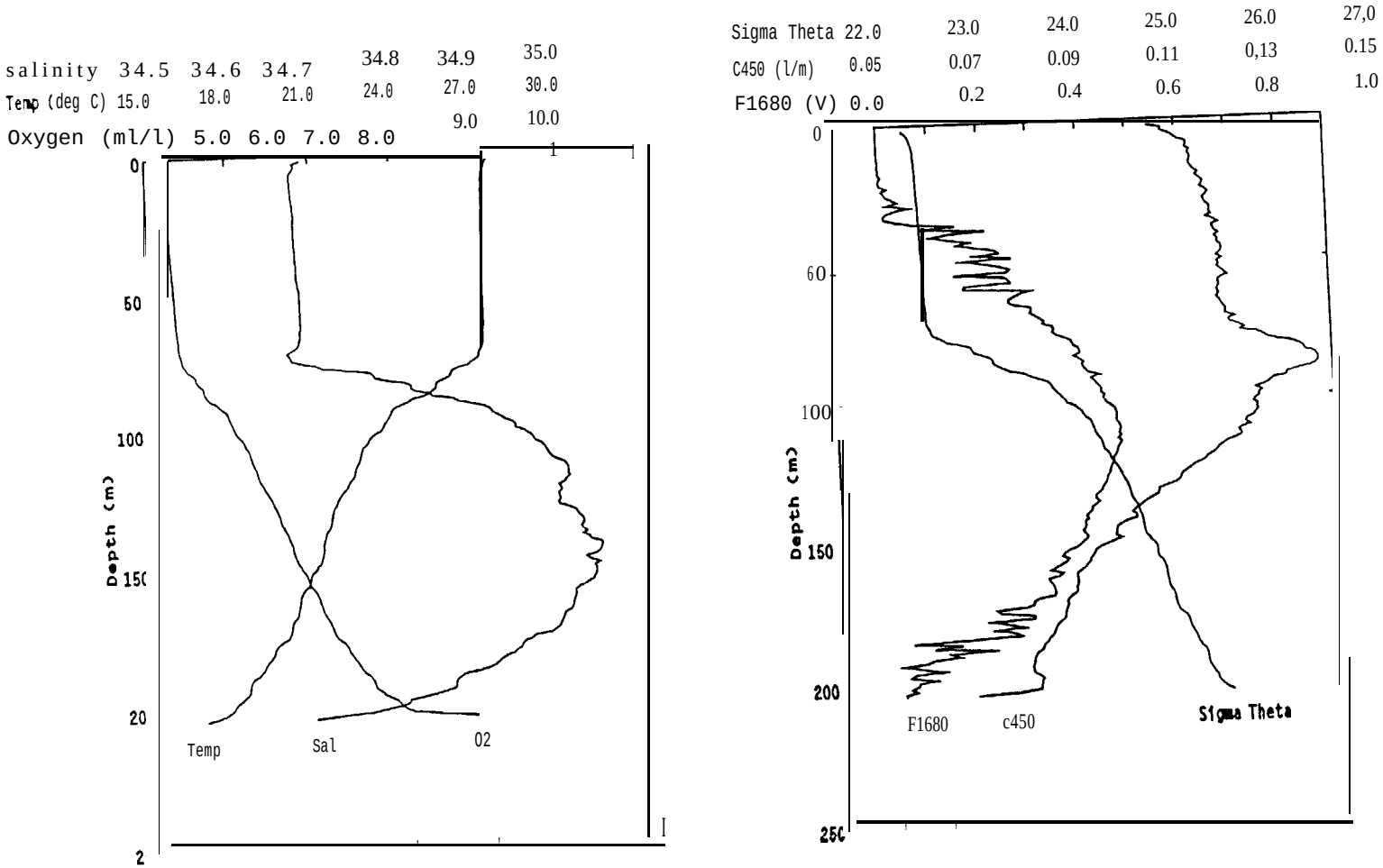

FIGURE 15. Oceanographic Profiles From MLML CTD During MOBY-L14 Cruise

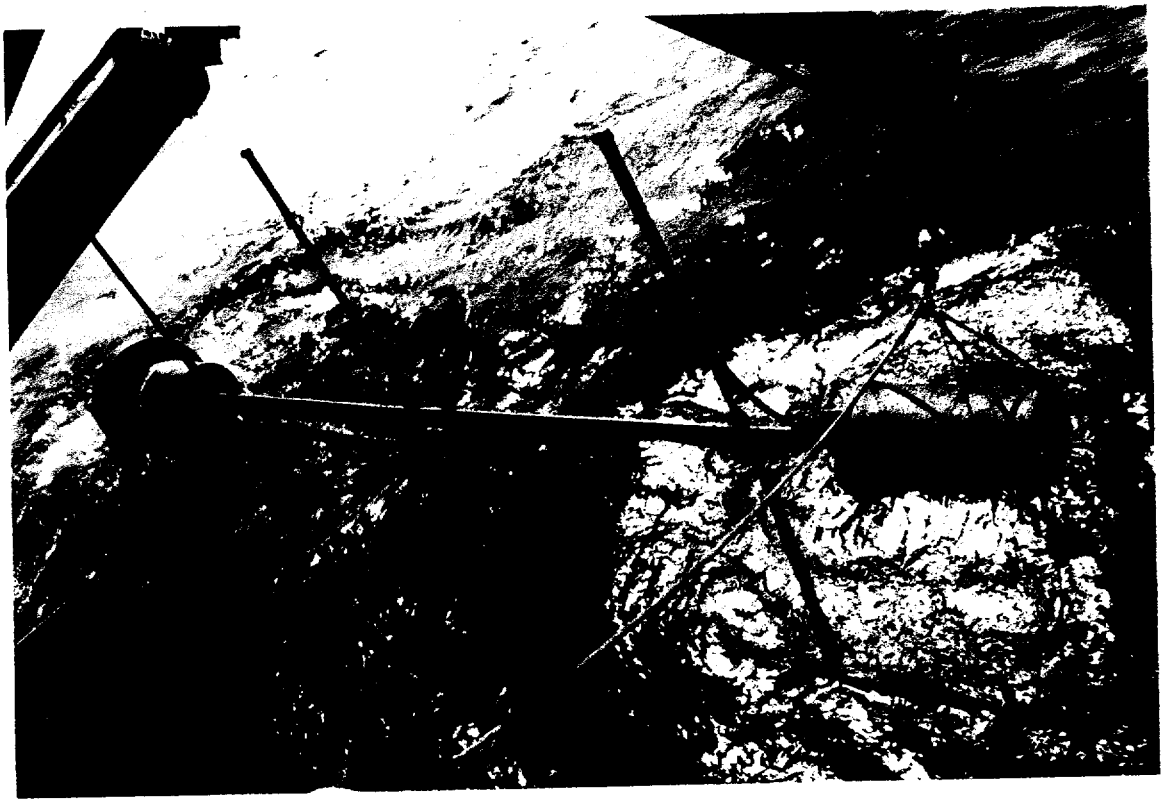

FIGURE 16.

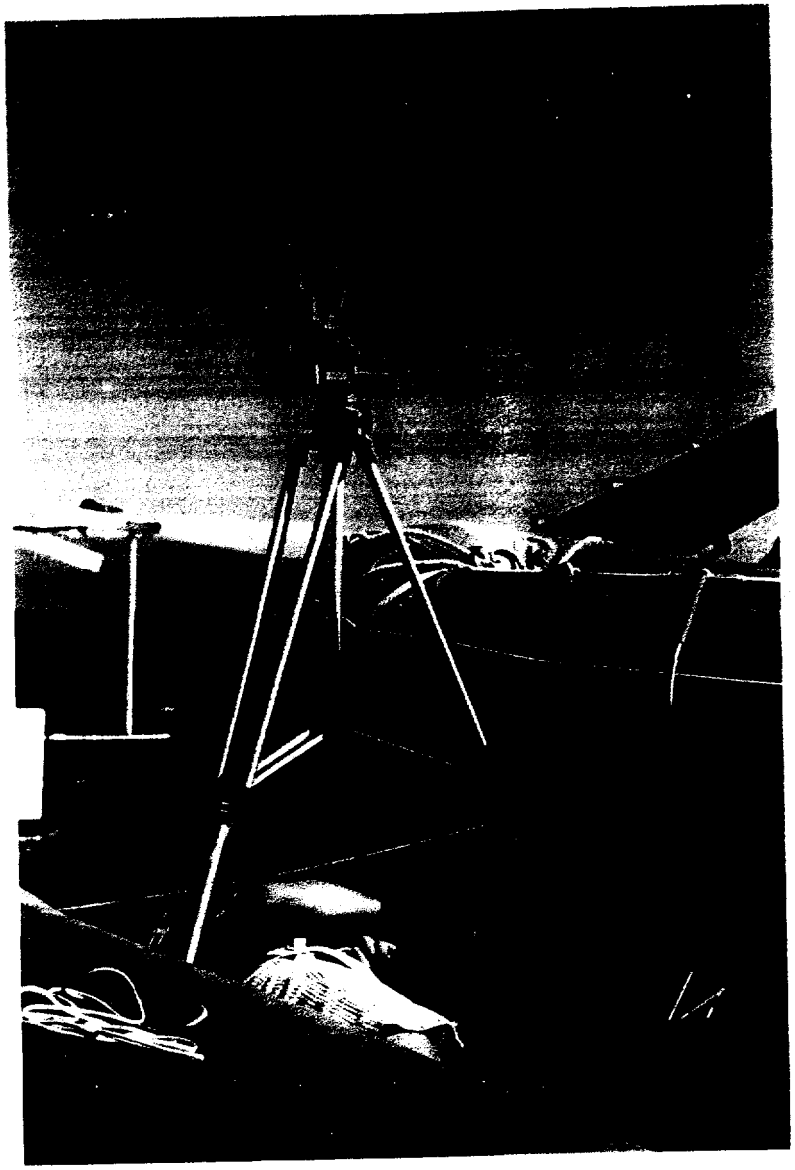

FIGURE 17.

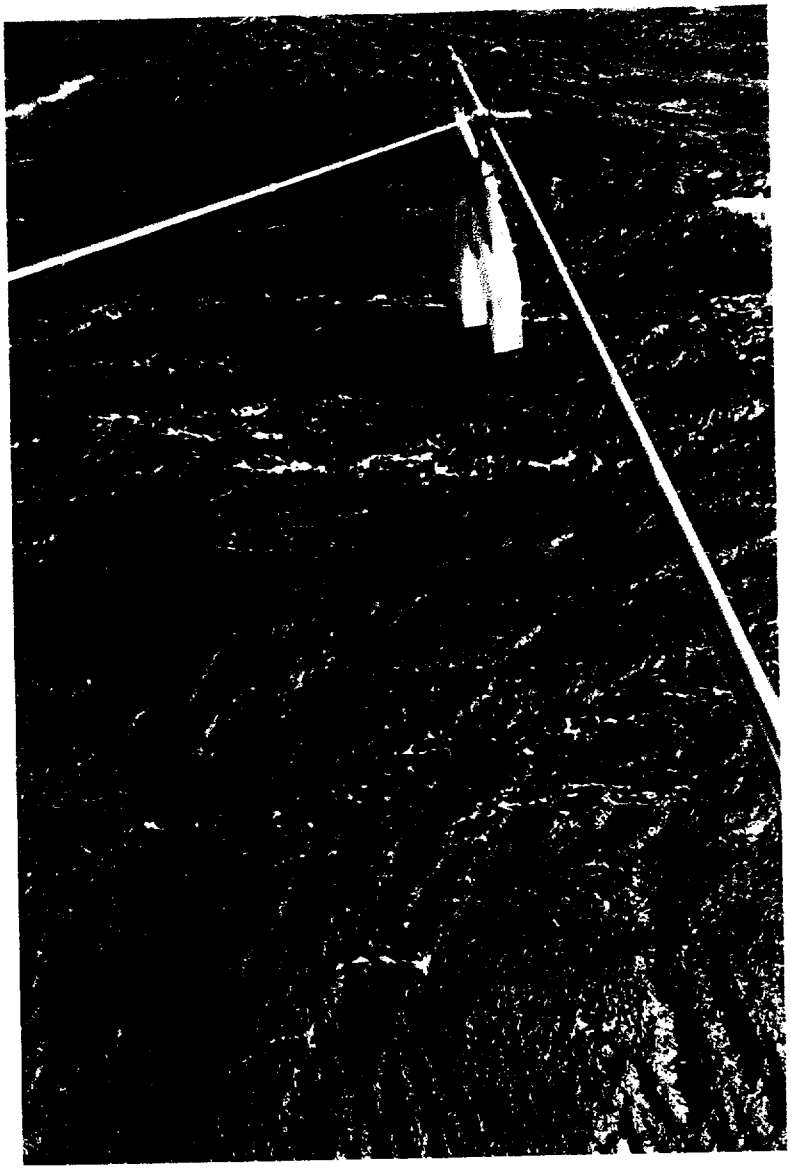

FIGURE 18.