MODIS Team Member - Semi-annual Report
Marine Optical Characterizations
June 1997

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NOAA/NESDIS

SUMMARY

During this reporting period, the Marine Optical Characterization Experiment (MOCE) team conducted one major field campaign in which the second Marine Optical Buoy (MOBY) system was successfully recovered, and additional calibration/validation data for OCTS were collected. The team provided these data for the initial OCTS calibration tests, the results were presented at the Second ADEOS Workshop. The completion of the operational testing of the second MOBY system, and the completion of the conversion of the prototype MOBY to an operational version represented major team accomplishments for this period. The team also prepared for the deployment of the third MOBY scheduled for July. This system will be operated in support of the impending SeaWiFS launched scheduled for 18 July.

VALIDATION/CALIBRATION

Bio-optical data collected concurrently with an ADEOS/OCTS overpass on November 18, 1996 by the MOCE team were preprocessed and analyzed. The results (Appendix 1) were transmitted to Chuck McClain who, along with Watson Gregg, presented preliminary OCTS initialization results obtained from OCTS calibration adjustments, which were based upon the November 18th *in situ* data, at the Second ADEOS Workshop.

Additional OCTS calibration/validation data were collected by the MOCE team during the MOBY recovery cruise (M204ROBP), February 23- March 2, 1997. Bio-optical data were collected coincident with four ADEOS/OCTS overpasses. These data represent approximately 75% of concurrent at-sea observations available for calibration/validation of OCTS data.

INTERCALIBRATION

During the November 1996 MOBY deployment cruise (M203DOBP), fluorometrically derived chlorophyll *a* concentrations appeared to be unreasonably high. These concentrations were obtained with a new Turner fluorometer (Model 10-AU-005). In January 1997, a pigment intercalibration exercise was performed at CHORS to verify if there were differences in fluorometrically derived chlorophyll *a* concentrations between the old Turner fluorometer (Model 10-00R) and the newer fluorometer (Model 10-AU-005). Calibration of both fluorometer was performed using the same Sigma chlorophyll *a* standard. Analysis of 70 samples from the November 1996 cruise and from the Gulf of California showed that the newer fluorometer (Model 10-AU-005) overestimated chlorophyll *a* concentrations by 5% when compared to the older instrument (Fig. 1).

FIELD OPERATIONS

Members of the MOCE team participated in a single field deployment during this period. Team members conducted MOBY retrieval and bio-optical data collection (M204ROBP), MOBY assembly, and MOBY operations site maintenance in Hawaii, February 12- March 10, 1997 (MOBY-L16). The following personnel participated:

NOAA - Dennis Clark, Ed Fisher, Phil Hovey, Ed King, Larisa Koval, Eric Stengel, Marilyn Yuen

MLML - Mike Feinholz, Stephanie Flora, Yong Sung Kim, Yi Liu, Daryl Peters, Mark Yarbrough

CHORS - Dan Sullivan, Chuck Trees

University of Hawaii - Mike Ondrusek

University of Miami -Al Chapin, Ken Voss

University of Florida - Zhong Ping Lee

NASA - David Herring

Prior to the MOBY retrieval cruise (M204ROBP), radiometric calibrations were performed on MOS202 and SIS. A system calibration was performed on the fiber optic spectrometer system, where both the radiance and irradiance sensors were calibrated. The fiber optic irradiance sensor was calibrated using the new standard lamp F-453 (NIST calibrated) and the radiance sensor was calibrated using the integrating sphere OL420M. The Turner fluorometer, model 10-AU-005, was calibrated with a chlorophyll a standard provided by Mike Ondrusek, University of Hawaii.

During M204ROBP (February 23- March 2, 1997), CTD casts and radiometric casts were performed while SIS irradiance scans were acquired every 10 minutes during daylight hours (SIS collected data at one minute intervals during all radiometric casts). TSM (Fig. 2a), POC/PON, salinity, dissolved oxygen, and pigment (both fluorometric and HPLC) samples were collected during CTD casts and from the alongtrack water pumping system during four surveys toward and away from the buoy mooring as well as during a 9 km^2 grid survey around the mooring. Most of these data were collected concomitant with four ADEOS/OCTS overpasses. Sun photometer measurements, to derive the spectral transmittances, specifically bracketed each overpass.

Remote sensing reflectance measurements were collected during the retrieval cruise using the fiber optic spectrograph MD-5 (Fig. 2b). These data were processed and analyzed to compare with Kendall Cardre's measurements. The remote sensing reflectance is measured above water surface, which we think is prone to sun glint and water surface effects. A series of measurements were performed to validate this procedure. Dennis Clark presented this results in the MODIS science team meeting.

Radiometric data using the Satlantic profiling system were also collected during M204ROBP (Fig. 3). Efforts were made to develop software to process the irradiance and radiance data into smoothed K profiles for all channels, and a comparison of several different smoothing techniques

was completed. A review of NASA's TM 104566, "Results of the SeaWiFS Data Analysis Round-Robin, July 1997 (DARR-94)," showed that smoothed K values for relatively clear, near-surface waters without cloud contamination contained little vertical structure and were better than 5% for all smoothing programs which were compared. Mueller's integral method for analyzing irradiance and radiance profiles (199 1, CHORS Tech. Mere. 007-91) has been adapted at CHORS so that data collected by the Satlantic free-fall radiometer will be processed with its associated 0.30 m in-water irradiance reference cell.

Diver calibrations were obtained prior to the successful recovery of MOBY202 on March 1, 1997 (Fig. 4). During this MOBY deployment, the multiplexer stepper motor had a shifting problem. Home position tests on four occasions were performed to correct this problem, and positioning parameters were reset via modem. Efforts to determine the amount of data lost due to these multiplexer shifts are now in progress.

The original pumping cable for the Paravane system failed. Previous damage to the cable had resulted in a rupture of the inner hose, and as a result, water was pumping into the exposed internal wiring, causing the pump and the sensor power supplies to short (Fig. 5). The fluorometer power supply was damaged by the high voltage and required replacement.

MOBY202 was returned to Honolulu for postcalibration and refurbishment. The optics were removed and cleaned, and the buoy was pressure washed to remove any remaining biological growth and antifoulant paint. The fiberglass stiffener in the tether was found broken at the MOBY attachment fitting. The multiplexer motor housing was badly corroded with the end cap lifted from the seat, perhaps exacerbating the home position/multiplexer shift problem.

Postcruise radiometric calibrations were performed on MOS202 and SIS as well as on MOBY202 and MOS204. Additional MOBY postcalibrations were performed at fiber optic multiplexer positions two steps below and above optimal in an attempt to salvage scans collected when the multiplexer home position had changed during the deployment. Upon completion of all radiometric postcalibrations, the Optronic OL420M radiance calibration source was shipped to Optronic Laboratories for re-lamp and re-calibration.

MOBY201 was reassembled and repainted in preparation for the next deployments. New controller boxes were mounted and the solar panels were replaced. Fiber optic collectors were cleaned and fiber collector head antifoulant tube changes were specified to fix a glass port clearance problem, which was causing breakage of the port windows.

NOAA group and MLML personnel conducted three short trips to NOAA Sand Island facility in Hawaii (2 to 17 April, 9 to 23 May, and 9 to 23 June) to work on the assembly of MOBY systems and to perform routine site maintenance. All three MOBY systems are completed and ready for future deployments. The radiometer used in the third MOBY, MOS205, was calibrated (wavelength, upwelled radiance, bin factor, integration time) using pen lamps, the GS5000, and the OL420M before being installed in MOBY. The OL420M was delivered on to Sand Island on 12 June after being re-lamped and re-calibrated by the manufacturer on 12 May and 11 June 1997. The SCAMPS radiometers were used to verify standard lamp stability during calibration experiments. MOBY203 irradiance and radiance sensors were calibrated on 14 to 17 June at nominal multiplexer positions and at one step above and below nominal. Several days later, after final buoy assembly, these calibrations were repeated to check response stability. The buoy's radiometric calibration will be determined again before it's deployment scheduled for 19 to 28 July 1997.

SOFTWARE DEVELOPMENT

The entire at-sea data acquisition system has been updated. The system consists of 11 computers that controls various instruments, including global position system data, temperature and salinity graph, flux gate compass, barometer, humidity and air temperature, wind direction and speed, flow rate of water pumping system, fluorescence (and thus concentration) of chlorophyll, and other parameters. The acquisition was built on Macintosh computers running LabVIEW, all data acquisition software were developed with LabVIEW and converted into standard alone applications. The whole system has been upgraded to PowerMac compatible, which means upgrading each application software as well as the necessary hardware that supports it. The software part has been finished, LabVIEW was upgraded to version 4.1. The hardware has been procured and shipped to the operation site in Hawaii to be installed.

Personnel from Moss Landing Marine Laboratories (MLML) nearly completed to fine-tune MLML/NOAA MOBY data processing programs. The reading time for a MOBY raw data file was reduced from five minutes to 30 seconds and another program calculates weighted water-leaving radiances for SeaWiFS, OCTS, and MODIS. NDERIVE_ was changed so that the attenuation coefficient is now calculated with a spectral surface irradiance ratio and weighted water leaving radiances are now calculated as the mean flux not the total flux through each band. READMOB_ corrects the MOBY files for time differences between TT7 and GPS and compass directions are stored as true not magnetic. NOVRLAP_ was created to correct the blue-red overlap. Additional programming changes are required, however, to allow more flexible control of the MOS CCD measurements.

Several programs were created and modified to generate the MOBY homepage. MOS2 and MOBY2 ancillary sensor calibrations were updated, compiled, and added to the MOBY calibration files, and data for both MOBY201 and MOBY202 deployments were batch processed with the new sensor calibrations. Batch processing also created new GIF images and HTML text of these updated files for the MOBY homepage. The MOBY202 homepage is currently being cleaned up. New images have been created (polar plot of MOBY arm directions and solar zenith and azimuth angles) and old images and HTML documents have been fine tuned. The MOBY201 homepage will be undergoing the same process soon. All MOBY202 files have gone through a second major reprocessing which included correcting the blue-red overlap. A MLML technical publication is being written that describes the algorithms used to process MOBY data.

Quality control flags and algorithms were developed for derived products such as pigment concentration and dissolved organic matter for SeaWiFS and MODIS. Two flags are used to indicate the quality of the water-leaving radiance at various bands. One flag describes the quality of the derived product and the other assesses the overall quality of the computation. A mathematical combination of these flags was developed to simplify the coding cycle.

Development of the MOCE data processing utility program has been completed. The program provides a uniform user-friendly Macintosh interface, and processes all of the data types collected at sea, including chlorophyll *a* concentration, attenuation coefficient, scattering coefficient, wind speed and direction, atmospheric pressure, air temperature and relative humidity, and seawater temperature and salinity. It includes system calibration and conversion, calculates derived products, averages, merges files, wraps files for printing, and produces spreadsheet ready data files for plotting.

The software is being developed to analyze total particulate, detrital, pigment, and DOM absorption data. The application program is being written to selectively sub-sample discrete wavelengths from (multiple) standard spectral absorption input files and generate tables of this data. We are also improving on the user interface to reduce processing time, user-effort and program support.

DATA REDUCTION

The solar normalization scheme used to standardize measured water-leaving radiance to values that would be measured for zenith sun angle at mean earth-sun distance with atmospheric effects removed was reinvestigated. The Rayleigh optical thickness calculation suggested by Gregg and Carder (1990, Limnol. & Oceanog., 35:1657-1675), which incorporates an atmospheric path length corrected for nonstandard atmospheric pressure and for the sphericity of the earth-atmosphere system, will be used for data reduction. Ozone optical thickness will be derived according to Gregg and Carder (1990), with scale height selectable (nominally set at 350 DU) and absorption coefficient taken from Inn and Tanaka (1953, J. Opt. Sot. Am., 43:870-887), between 350-700 nm and exponentially extrapolated from values between 690-700 nm out to 1000 nm. The SIS calibrations and time series data from the September and November 1996 and February 1997 cruises were processed. The surface incident photosynthetically available radiation (PAR) was calculated for use in productivity models.

MLML personnel completed processing of radiometric calibration and completed system responses for four radiometers (MOS202, MOS204, MOS205, SIS 101) and two buoys (MOBY201 and MOBY202). This work is described in a MLML Technical Publication, “Radiometric Calibrations: Procedures and Results”, which is near completion. A history of recent instrument calibrations is shown in Table 1.

The historical oceanic data base consisting of 73 stations established from the 1970-80’s was reexamined. Water-leaving radiances at SeaWiFS and MODIS bands were calculated and related to chlorophyll *a* concentrations. A bio-optical algorithm is being established based upon this data set. The accuracy of the data set, water-leaving radiance normalization method, incident irradiance effect, and instrument self-shading effect are being assessed. A preliminary review shows that it is possible to correct the self-shading effect to some degree. New data recently obtained are being added to the data base.

SPMR (SeaWiFS Profiling Multichannel Radiometer) data collected during MOBY-L16 experiment were processed, a total of 8 stations, 16 profiles. Water leaving radiance, normalized water leaving radiance, and remote sensing reflectance were calculated based on available data set.

DOCUMENTATION

The first draft of a paper on the design of fiber optic radiance and irradiance collectors has been completed. The paper discusses the optics and the engineering design of these accurate and high efficiency collectors. As has been mentioned in previous reports, the new collectors improved the overall performance of MOBY by at least three-fold.

The web site for Marine Optical Team is being developed. The home page is hosted on a SGI impact 2 machine. Interested persons can look at it at (URL: http://orbit22I.nesdis.noaa.gov). It introduces the MOBY program and has a picture archive. It also includes downloadable documents such as the MODIS Algorithm Theoretical Basis Document and other historical publications. It will present ocean color algorithms and data samples as well. Links will point visitors to the other interesting sites.

SUPPORTING COOPERATIVE AGREEMENTS

A three-year cooperative agreement has been awarded to SDSU/CHORS for the proposal entitled *"In Situ* Bio-optical Measurements for Algorithm Development and Validation in Support of the EOS MODIS Execution Phase."

A three-year cooperative agreement has been awarded to Moss Landidng Marine Laboratories/SJSU for the proposal entitled "EOS Bio-optical Algorithm Development".

The following support contracts were awarded:
Research and Data Systems, Corp. (RDC) -4 tasks
QSS Group, Inc. -1 task

MEETINGS

Dennis Clark attended the MODIS Ocean Team meeting, January 6-8, 1997, in Miami, FL.

Dennis Clark attended the MODIS Team meeting, May 6-9, 1997, in Goddard, MD.

Dennis Clark presented a MOBY Status Report to SeaWiFS Project Office, June 6, 1997, in Goddard, MD,

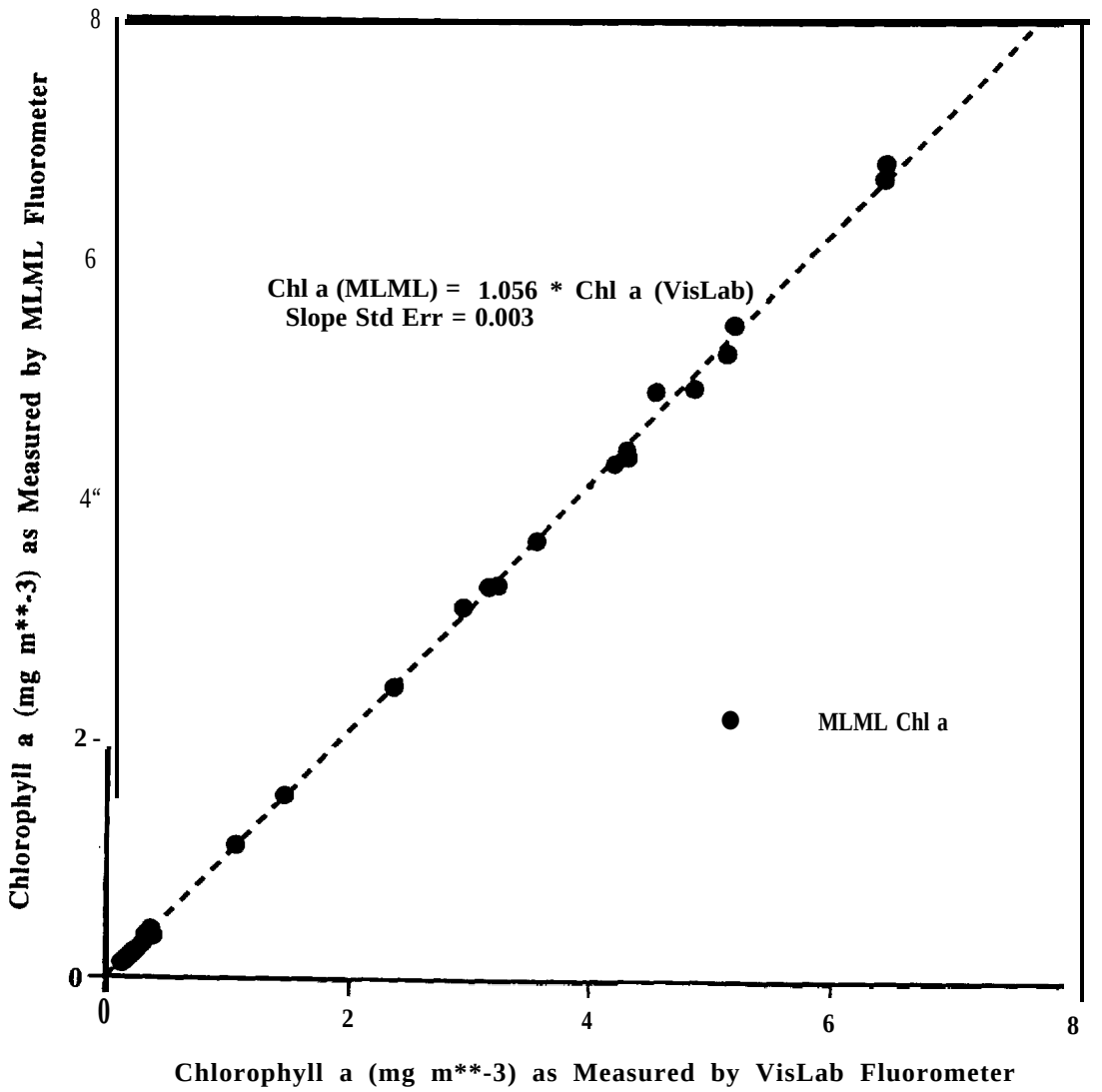


Figure 1. Comparison of fluorometrically determined chlorophyll a using the VisLab Turner Fluorometer (10-00R) and the MLML Turner Fluorometer (10-AU-005). Calibration of the fluormeters was performed with the same chlorophyll a standard. Samples were analyzed from a MOBY Nov 96 cruise and a Gulf of California cruise (Mueller, Nov 96).

Figure 2a. TSM filtration setup used during the MOBY retrieval cruise, M204ROBP.

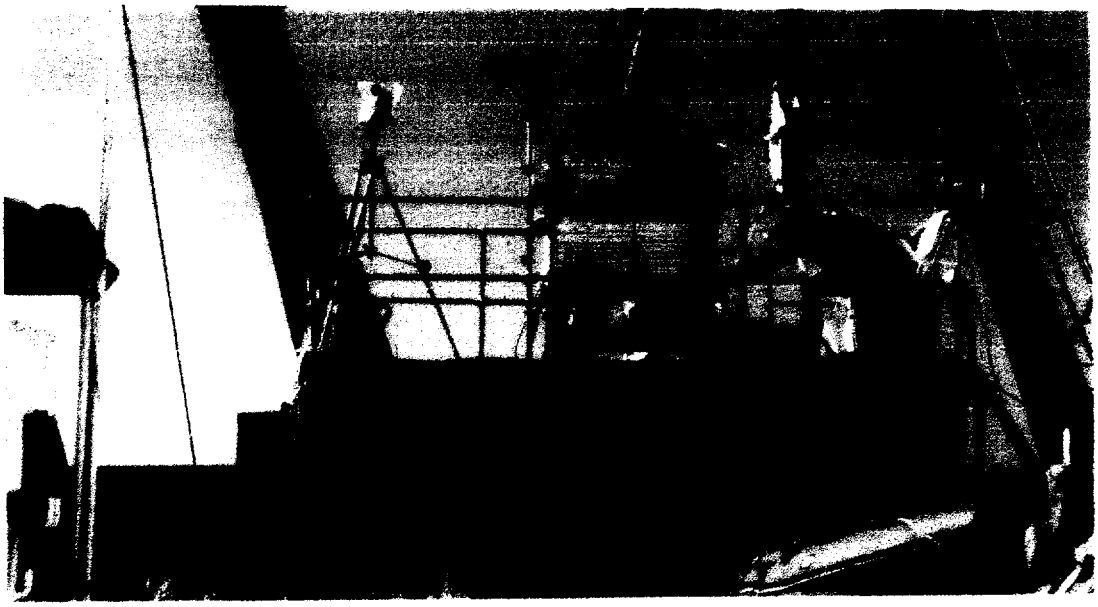


Figure 2b, Remote sensing reflectance fiber optic spectrograph data acquisition setup during M204ROBP.

Figure 3. Deployed Satlantic radiometric profiling system during M204ROBP. The surface irradiance reference sensor is in the foreground and the profiler is in the upper portion of the photograph.

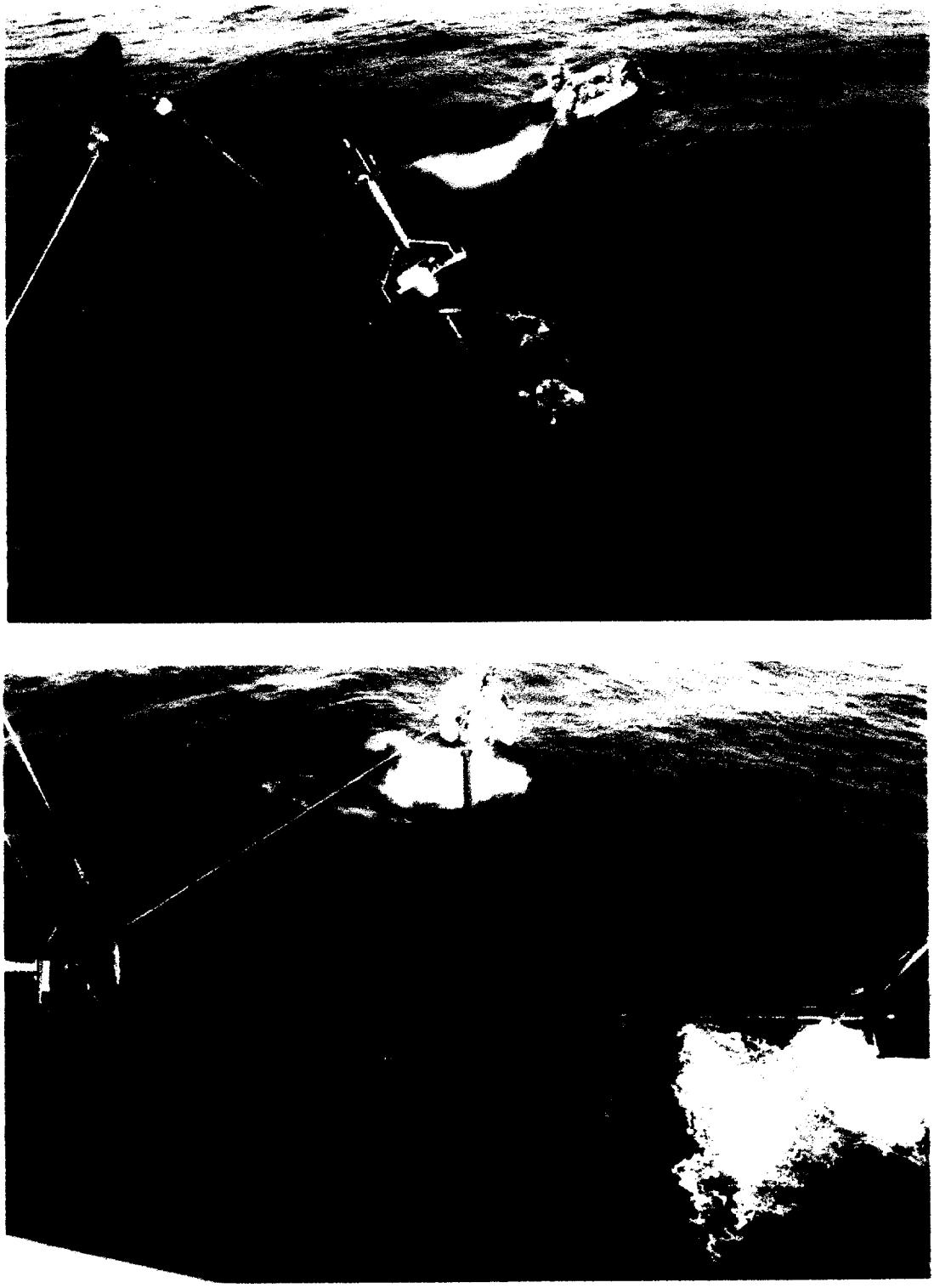


Figure 4. Recovery of MOBY202 on March 1, 1997.

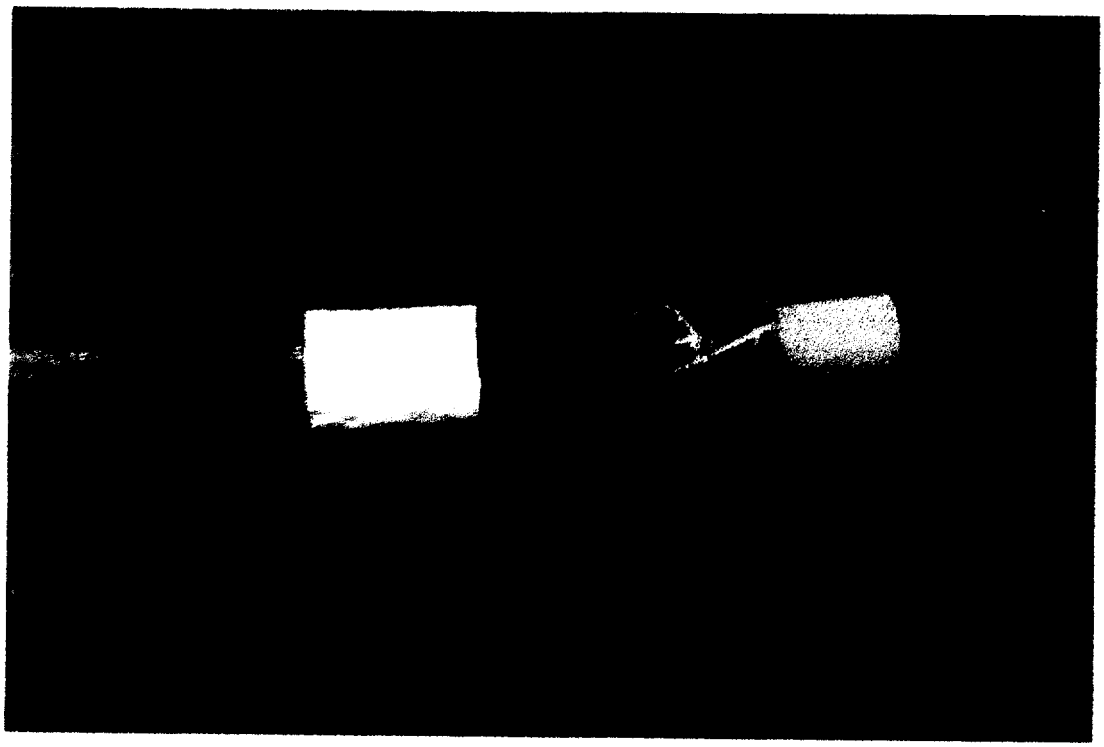


Figure 5. Failed Paravane system water pumping cable.

APPENDIX 1

Preliminary Results for Bio-optical Data Collected November 18, 1996

While conducting MOBY operations during October-November, 1996 the MODIS Marine Optical Characterization Experiment team (MOCE) occupied a station off the coast of Lanai during an ADEOS overpass on November 18. The participants on this cruise are Listed in Figure 1 and the type of instrument/system deployment and its associated sequence times during this station are depicted on Figure 2. The observations which were acquired directly or derived from these operations are listed in Figure 3. The team has completed reducing most of the data from the l8th and we are enclosing some of these data which, are pertinent to evaluating the OCTS data and for your discussions with the Japanese science team.

The water-leaving radiances (Lw) were measured by three different systems: the Marine Optical System (MOS), Satlantic's SPMR, and a fiber-optic Spectrograph. The MOS data were acquired closest to the overpass time (21:18 GMT) with the Lw's being computed from the 0.7 meter Lu's which were observed at 21:38 (GMT). The K_1's were computed from the 0.7 and 9.1 m Lu measurements. These Lw and K_1 measurements are listed in the following table:

Wavelength	412 nm	443 nm	490 nm	520 nm	565 nm	670 nm
Lw(uw/cm^{2}sr nm)	**0.5577**	**0.6331**	**0.7107**	**0.4081**	**0.2581**	**0.0160**
K_1(m^{-1})	**0.0603**	**0.0546**	**0.0473**	**0.0624**	**0.0801**	**0.2301**

The approximate ship's position for this measurement time period was 20.679 degrees N latitude and 156.930 degrees W longitude. The winds were from the north at sustained speeds in excess of 12 m/sec. The atmosphere was very clear and stable. Two Langley calibration data sets were made in the morning and afternoon and demonstrate excellent agreement. The spectral transmittances derived from the HHCRM (sun photometer) measurements bracketing the overpass time are listed in the following table:

Wavelength	T [410nm]	T (440nm]	T [490nm]	T[520nm]	T[560nm]	T[670nm]
21:00 GMT	0.614	0.682	0.771	0.788	0.819	0.895
22:00 GMT	0.637	0.713	0.798	0.812	0.829	0.914

The tau Rayleigh's were computed from the atmospheric pressures according to the following relationships $t_R = P/P_0 t_{RO}$; where P_o= 1013.25 mb and $t_{R0} = 0.008569\ \lambda^{-4}(1 + 0.0113\ \lambda^{-2} + 0.00013\ \lambda^{-4})$. The calculated tau's for the atmospheric pressures at 21:00 and 22:00 GMT, 1013.11 and 1012.38 mb respectively, are tabulated as follows:

Wavelength	t_R[410nm]	t_R[440nm]	t_R[490nm]	t_R[520nm]	t_R[560nm]	t_R[670nm]
21:00 GMT	0.3250	0.2427	0.1559	0.1223	0.0903	0.0436
22:00 GMT	0.3248	0.2426	0.1558	0.1222	0.0903	0.0436

The phytoplankton pigments for a surface water sample taken at 22:05 were analyzed by Chuck with fluorometric and HPLC measurement techniques. The HPLC analysis also included the separation and quantification of mono- and divinyl chlorophyll *a*, since divinyl chlorophyll *a* is present in significant quantities in these waters. The presence of divinyl causes a significant error in the HPLC chlorophyll *a* determination which normally only accounts for the monovinyl chlorophyll *a* compound. The fluorometric technique yielded a chlorophyll *a* concentration of 0.230 mg/m^3 and phaeopigment concentration of 0.071 mg/m^3 for total pigment concentration of 0.301 mg/m^3. A plot of fluorometrically determined chlorophyll *a* versus mono- plus divinyl chlorophyll a is shown in Figure 4 for surface and vertical samples. The HPLC monovinyl plus divinyl chlorophyll *a* concentration was 0.150 mg/m^3 with no phaeopigments detected. The complete HPLC accessory pigment determinations are tabulated below for the compounds which were present.

Perid.	But.	Puce.	Hex.	Diadino.	Diatox.	Zea/Lut	Chl. *b*	Mv Chl *a*	Dv Chl *a*
0.0065	**0.0075**	**0.0043**	**0.0172**	**0.0130**	**0.0044**	**0.1248**	**0.0163**	**0.060**	**0.090**

After completion of the station, later that evening, a triangular track was run, towing a para-vane with the fluorometer and pumping system, to investigate the bio-optical variability in the near-surface waters to the east of the station. A plot of that track and the along-track concentrations of mono + divinyl chlorophyll *a* with the beam attenuation (530 nm) for a one-meter pathlength are presented in Figure 5.

We are still in the process of completing these data sets and these data should still be considered preliminary. However, they have been reviewed and I do not expect any major deviations. I hope these results will benefit the OCTS processing algorithms evaluation. The Team has just completed the retrieval of MOBY and during this operation managed, in very high wind conditions, to collect comprehensive bio-optical, atmospheric, and physical data sets concurrent with four OCTS overpasses. Station summaries for these overpasses are listed in Figures 6-9. I would recommend that you request these data from the Japanese during your meeting. Good LUCK and call if you have any questions.

MOBY-II DEPLOYMENT PERSONNEL
NOVEMBER 14-22

PERSONNEL	TITLE
NOAA	**Marine Optics Team**
Dennis Clark	Senior Scientist
Marilyn Yuen	Research Associate
Edward King .	Research Technician
Phil Hovey.	Research Technician
Eric Stengel	Research Technician
Yuntao Ge	Research Associate
Larisa Koval	Research Associate
Yi Liu	Research Associate
San Jose State University	**Moss Landing Marine Laboratories**
Mark Yarbrough	Senior Research Associate
Mike Feinholz	Research Associate
Drew Gashler	1Student - Diver
Stephanie Flora	Student
San Diego State University	**Center for Hydro-Optics & Remote Sensing**
Chuck Trees	Research Professor
Dan Sullivan	Research Technician
University of Miami	**Physics Department**
Ken Voss	Professor
Albert Chapin	Research Technician
University of Hawaii	**Biology Department**
Mike Ondrusek	Student - Diver

Figure 1

STATION 2 - LANAI

STATION DEPLOYMENT SEQUENCE	Start Time	Finish Time	Duration
SATELLITE PASS	11:18 AM		
MOBY OBS.	11:00 AM	12:05 PM	1.08
MOBY CALS.			
PARAVANE TOW			
BIO-OPTICS			
CTDO Cast	8:30 AM 2:29 PM	9:30 AM 3:31 PM	1.00 1.03
SIS	8:00 AM	6:00 PM	10.00
SATATLAN Cast	9:30 AM	10:00 AM	0.50
MOS Cast	10:30 AM	12:30 PM	2.00
RADS-UW	10:45 AM	12:45 PM	2.00
VLST Cast			
SATATLAN Cast	12:30 PM	1:00 PM	0.50
SECCHI DISK	8:47 AM 2:30 PM		
PRODUCTIVITY	5:00 AM	6:45 PM	13.75
P vs I	12:05 PM		
MD5-FIBEROPTIC	12:35 PM	1:02 PM	0.45
ATMOSPHERICS			
HHCRM	7:40 AM	5:30 PM	9.83
RADS-SKY	8:00 AM 2:50 PM	10:15 AM 5:00 PM	2.25 2.17
AUREOLE	8:00 AM 2:50 PM	10:15 AM 5:00 PM	2.25 2.17
SKY CONDITIONS			
PARAVANE TOW	6:12 PM	8:10 PM	1.97

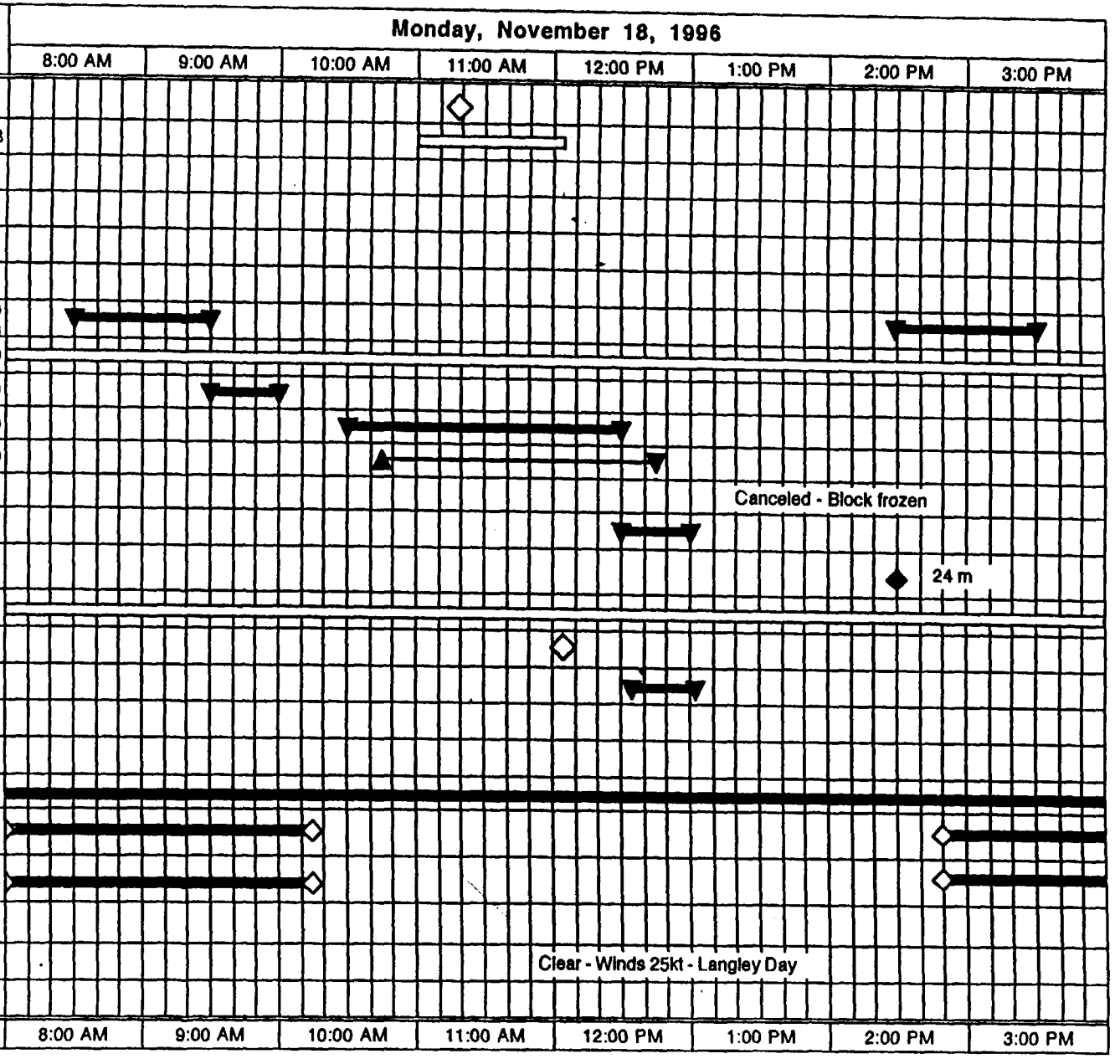


Figure 2

Lanai 15 At-Sea Observations

Marine Optical Characterization Experiment Team

- Incident Spectral Irradiance
- Downwelled Spectral Irradiance
- Upwelled Spectral Irradiance
- Upwelled Spectral Radiance
- Upwelled Spectral Radiance Distribution
- Sky Radiance & Polarization Distribution
- Spectral Solar Atmospheric Transmission
- Water-Leaving Radiance
- Attenuation Coefficients Downwelled irradiance
- Attenuation Coefficients Radiance
- Spectral Reflectance
- Beam Spectral Attenuation Profiles
- Phytoplankton Pigments (HPLC)
- Phytoplankton Pigments (Fluorimetric)
- Fluorescence Profiles
- Chlorophyll a Profiles
- Oxygen & Salinity Profiles
- Atmospheric Pressure
- Relative Humidity

Trackline Salinity
Trackline Temperature
Trackline Beam Attenuation (530 nm)
Trackline Fluorescence
Trackline Chl a
Total Suspended Material
inorganic Suspended Material
Particle Spectral Absorption Coefficients
Detritus Spectral Absorption Coefficients
Pigment Spectral Absorption Coefficients
CDOM Absorption Coefficients
Particle Size Frequency Distribution
Particulate Organic Carbon
Particulate Organic Nitrogen
Primary Productivity
Phytoplankton Speciation Videos
Secchi Disk Depth
Wind Velocity
Sea & Sky State Photographs

Figure 3

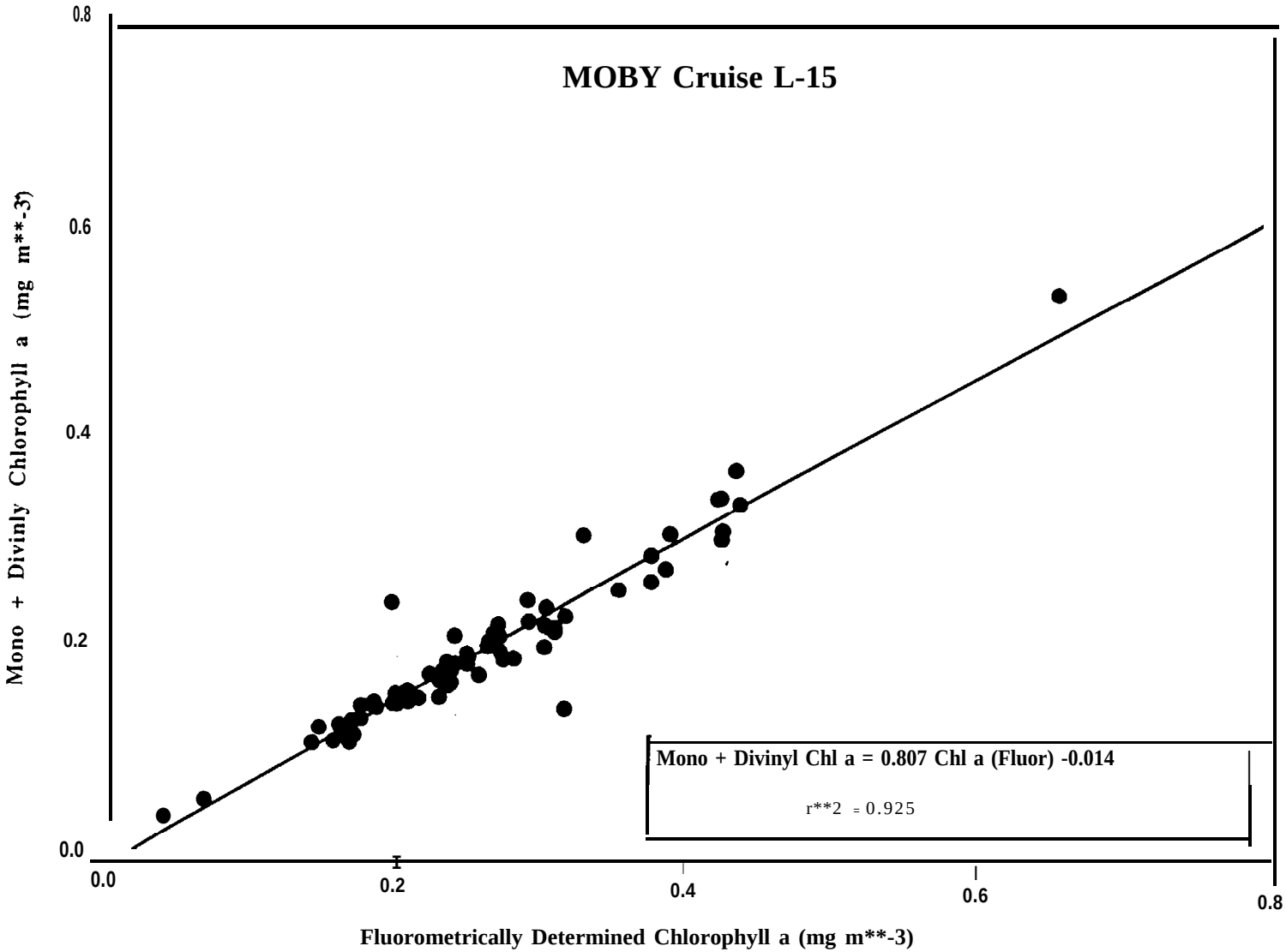
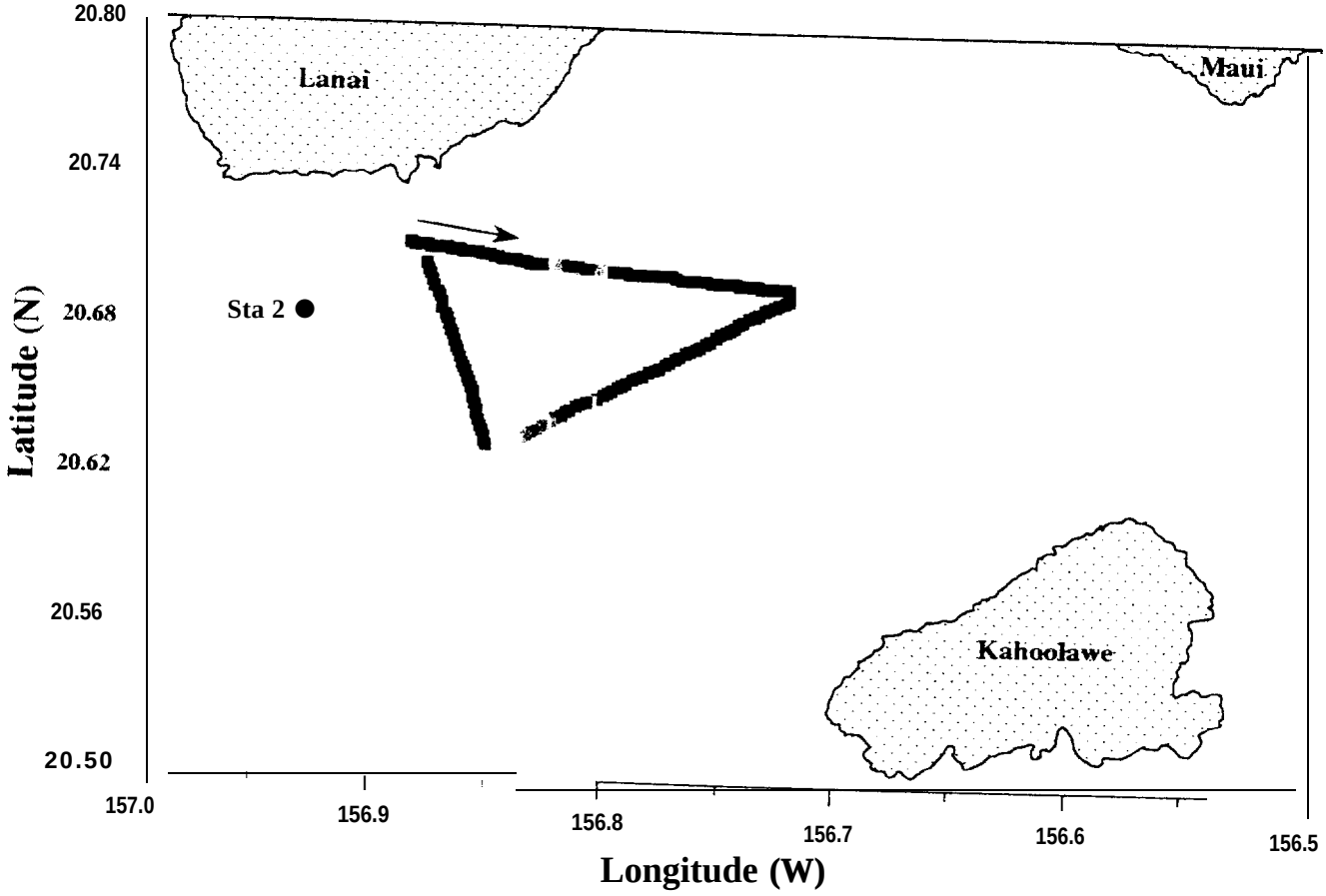

MOBY Cruise L-15
Mono + Divinly Chlorophyll a (mg m**-3)
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
Mono + Divinyl Chl a = 0.807 Chl a (Fluor) -0.014
r**2 = 0.925
Fluorometrically Determined Chlorophyll a (mg m**-3)

Figure 4


Lanai
Maui
Kahoolawe
Sta 2
Latitude (N)
20.80
20.74
20.68
20.62
20.56
20.50
157.0
156.9
156.8
156.7
156.6
156.5
Longitude (W)

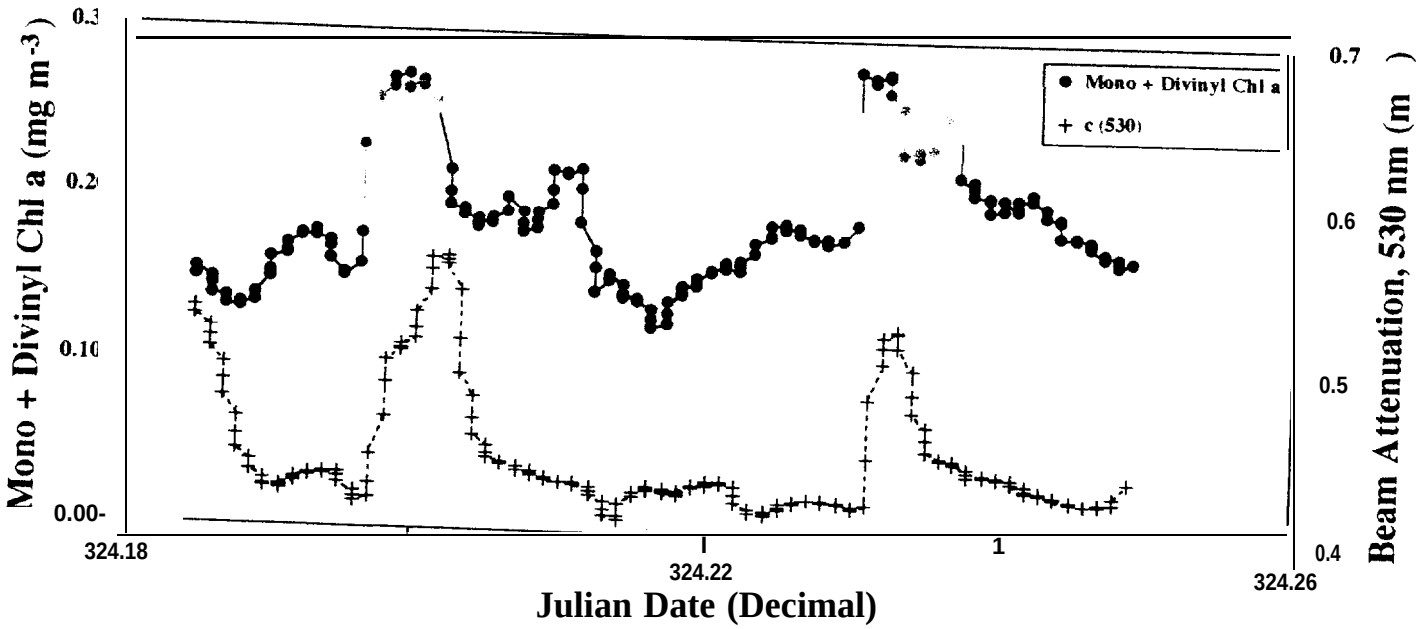

Mono + Divinyl Chl a
c (530)
Mono + Divinyl Chl a (mg m-3)
Beam Attenuation, 530 nm (m)
0.3
0.2
0.10
0.00
0.7
0.6
0.5
0.4
324.18
324.22
1
324.26
Julian Date (Decimal)

Figure 5

STATION 1 - BARBERS PT. OAHU

STATION DEPLOYMENT SEQUENCE	Start Time	Finish Time	Duration
SATELLITE PASS	11:15 AM		
MOBY OBS.	11:00 AM	12:05 PM	1.08
MOBY CALS.			
PARAVANE TOW			
BIO-OPTICS			
CTDO Cast	12:00 PM	12:38 PM	0.63
SIS	11:18 AM	2:54 PM	3.60
SATLAN Cast	11:06 AM	11:23 AM	0.28
MOS Cast	12:18 PM	2:21 PM	2.05
RADS-UW			
VLST Cast			
SATLAN Cast	10:56 AM	11:26 AM	0.50
R S R	11:28 AM 12:57 PM 2:27 PM	11:40 AM 1:05 PM 2:36 PM	0.20 0.13 0.15
WHITECAP RAD	10:00 AM	3:00 PM	5.00
SECCHI DISK	1:15 PM		
PRODUCTIVITY			
P vs I			
ATMOSPHERICS			
HHCRM	11:00 AM	5:25 PM	6.42
RADS-SKY	11:00 AM	4:30 PM	5.50
AUREOLE	11:00 AM	4:30 PM	5.50
MPL LIDAR	8:30 AM	11:59 PM	15.48
SKY CONDITIONS			
PARAVANE TOW	6:45 PM	8:00 PM	1.25

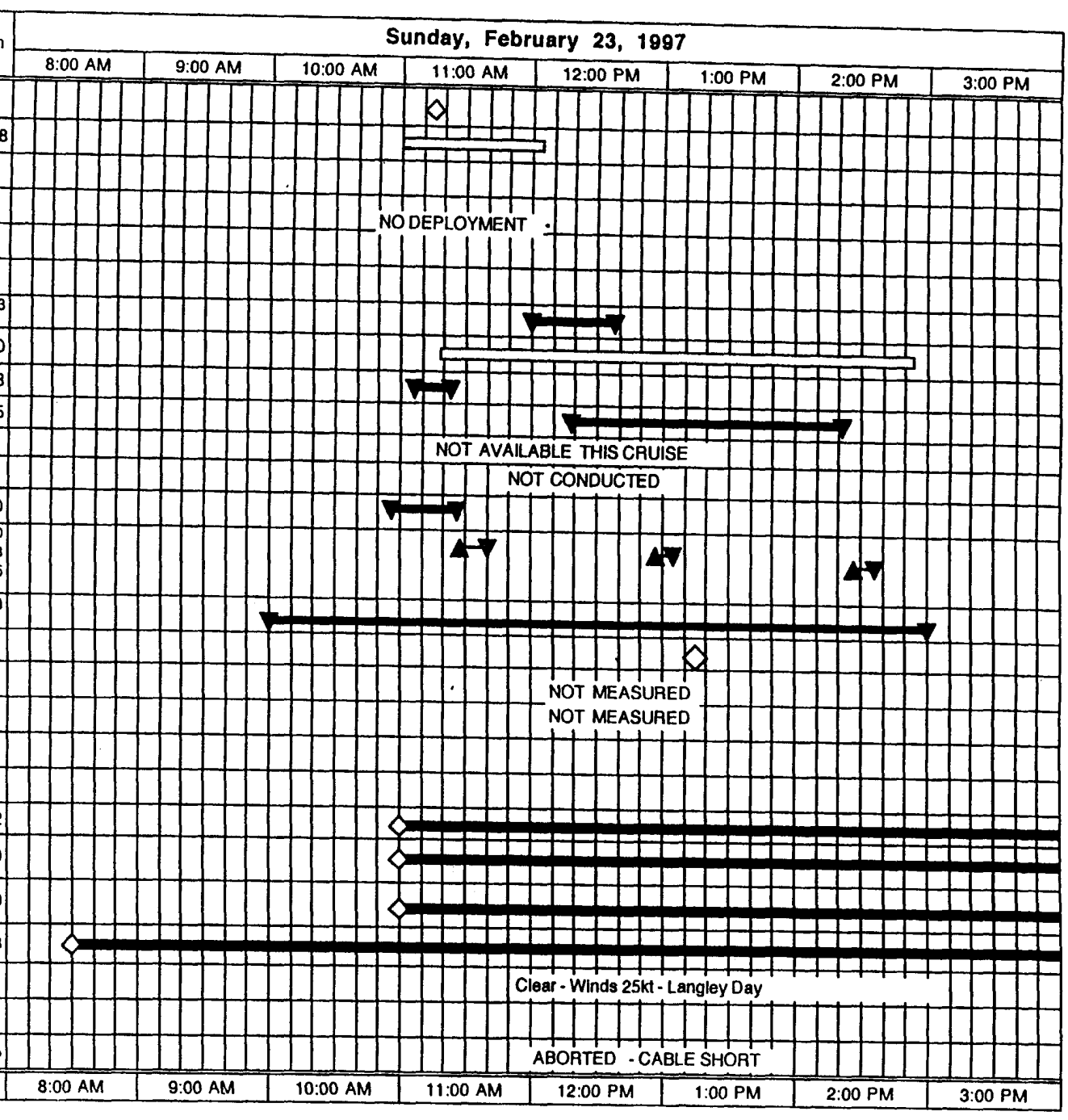


Figure 6

STATION 2 - KAUMALAPAU HARBOR LANAI

STATION DEPLOYMENT SEQUENCE	Start Time	Finish Time	Duration
SATELLITE PASS	11:15 AM		
MOBY OBS.	11:00 AM	12:05 PM	1.08
MOBY CALS.			
PARAVANE TOW			
BIO-OPTICS			
CTDO Cast	12:40 PM	1:18 PM	0.63
SIS	11:18 AM	2:54 PM	3.60
SATLAN Cast	1:02 PM	1:30 PM	0.47
MOS Cast			
RADS-UW			
VLST Cast			
SATLAN Cast	1:02 PM	3:06 PM	2.07
R S R	1:00 PM	1:09 PM	0.15
WHITECAP RAD	10:00 AM	4:30 PM	6.50
SECCHI DISK			
PRODUCTIVITY			
P vs I			
ATMOSPHERICS			
HHCRM	11:00 AM	5:25 PM	6.42
RADS-SKY	8:50 AM	9:30 AM	0.67
AUREOLE	8:50 AM	9:30 AM	0.67
MPL LIDAR	12:00 AM	11:59 PM	23.98
SKY CONDITIONS			
PARAVANE TOW			

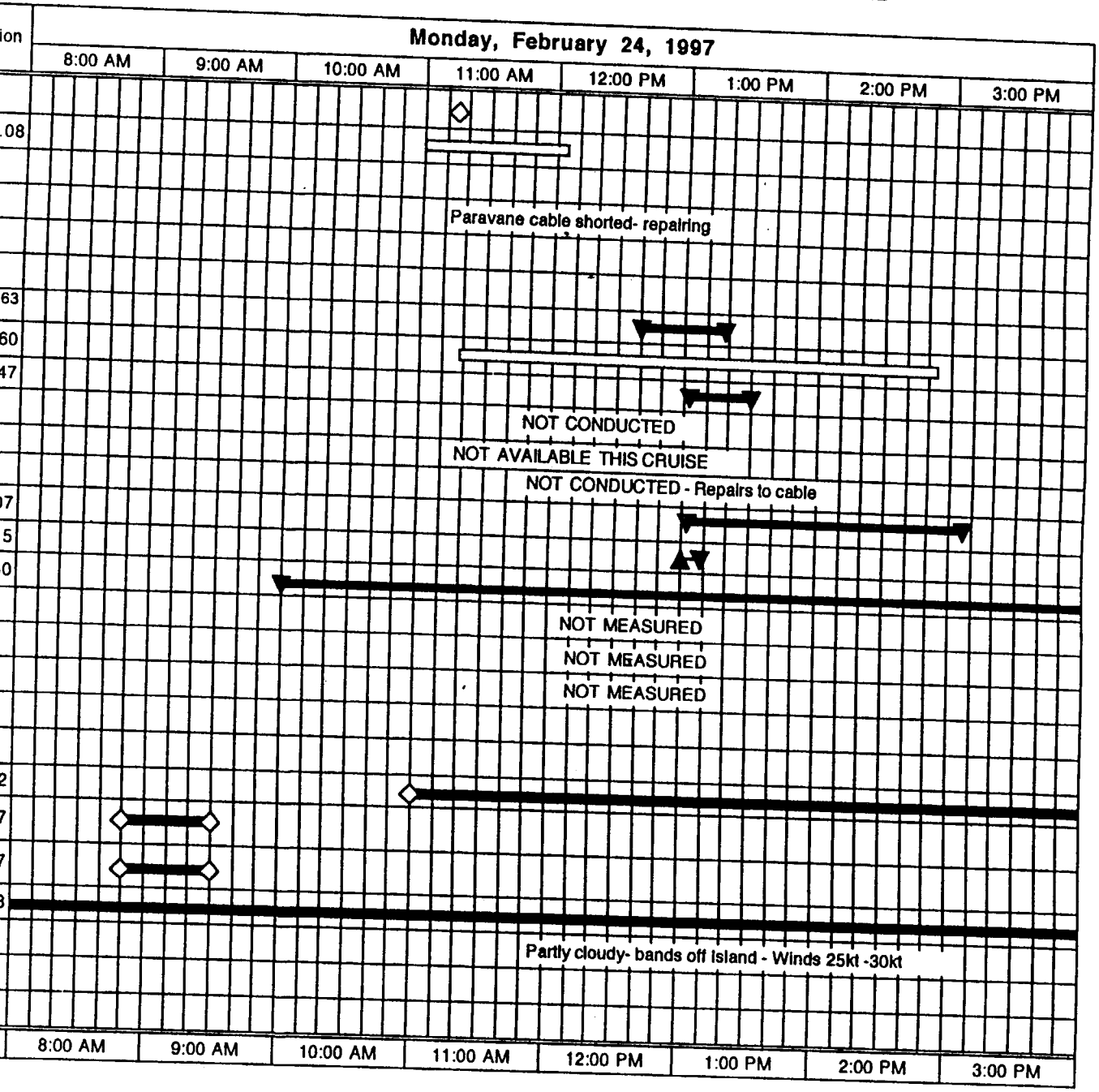


Figure 7

STATION 5 - MOBY SITE

STATION DEPLOYMENT SEQUENCE	Start Time	Finish Time	Duration
SATELLITE PASS	11:08 AM		
MOBY OBS.	11:15 AM	12:15 PM	1.00
MOBY CALS.			
PARAVANE TOW			
SEA CHEST	12:00 AM	11:59 PM	23.98
BIO-OPTICS			
CTDO Cast	9:30 AM 11:30 AM	10:00 AM 11:50 AM	0.50 0.33
SIS	6:15 AM	7:00 PM	12.75
SATLAN Cast	10:51 AM	11:15 AM	0.40
MOS Cast	11:39 AM	2:02 PM	2.38
RADS-UW			
VLST Cast			
SATLAN Cast	2:11 PM	2:29 PM	0.30
R S R	11:22 AM	11:37 AM	0.25
WHITECAP RAD	10:30 AM	3:00 PM	4.50
SECCHI DISK	12:55 PM		
PRODUCTIVITY	5:00 AM		
P vs I	11:55 AM		
ATMOSPHERICS			
HHCRM	12:00 PM	1:55 PM	1.92
RADS-SKY	12:00 PM	1:45 PM	1.75
AUREOLE	12:00 PM	1:55 PM	1.92
MPL LIDAR	12:00 AM	11:55 PM	23.92
SKY CONDITIONS			

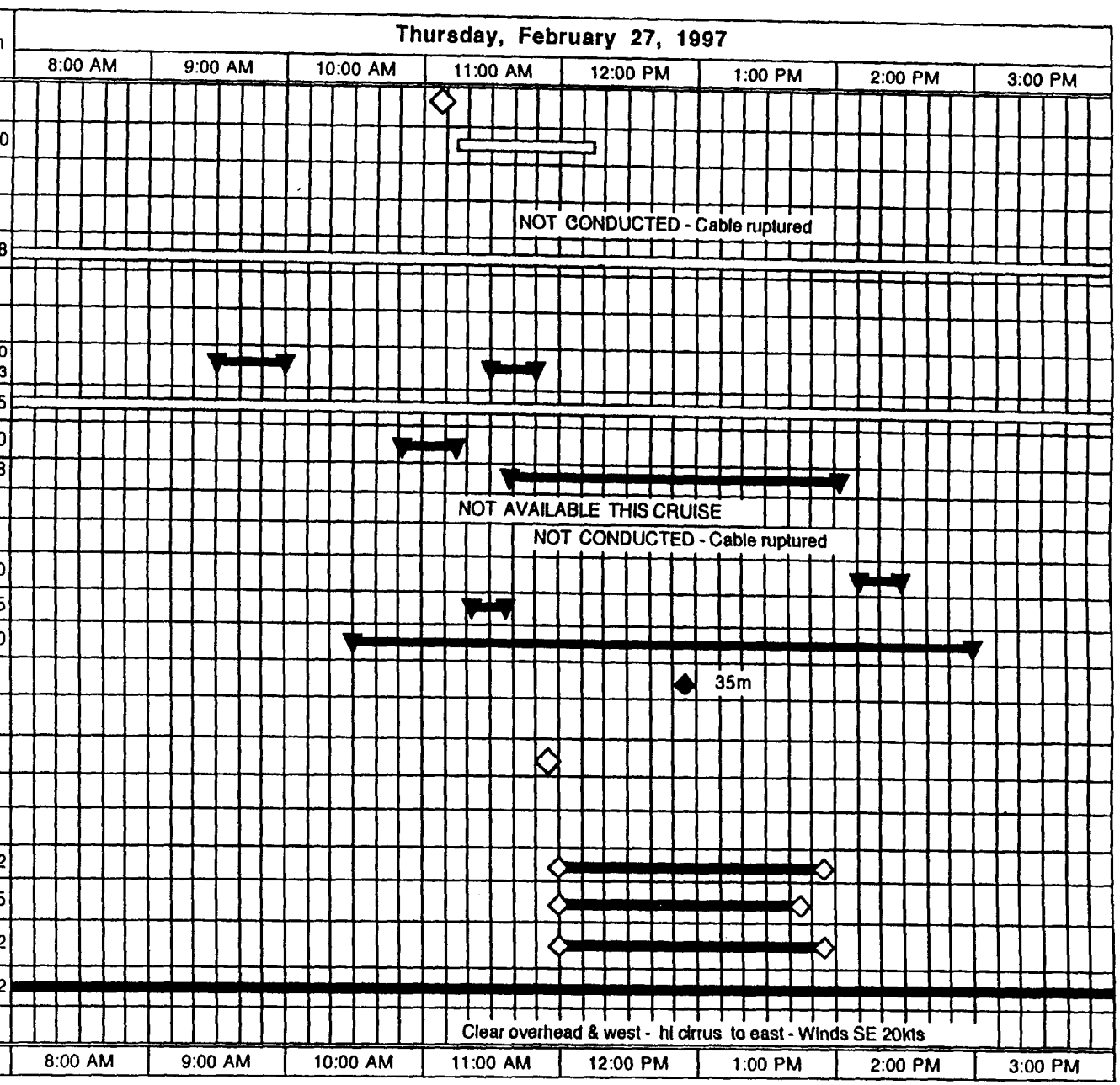


Figure 8

STATION 8 - MOBY SITE

STATION DEPLOYMENT SEQUENCE	Start Time	Finish Time	Duration
SATELLITE PASS	11:28 AM		
MOBY OBS.			
MOBY CALS.			
PARAVANE TOW			
SEA CHEST	12:00 AM	5:44 PM	17.73
STATION GRID	4:58 AM	8:48 AM	3.83
BIO-OPTICS			
CTDO Cast	9:30 AM	10:00 AM	0.50
SIS	6:36 AM	5:58 PM	11.37
SATLAN Cast	10:24 AM	10:41 AM	0.28
MOS Cast	11:07 AM	1:01 PM	1.90
RADS-UW			
VLST Cast			
SATLAN Cast	1:10 PM	1:22 PM	0.20
R S R	1:05 AM	1:20 AM	0.25
WHITECAP RAD	10:00 AM	1:00 PM	3.00
SECCHI DISK	12:00 PM		
PRODUCTIVITY			
P vs I	11:41 AM		
ATMOSPHERICS			
HHCRM	10:50 AM	12:50 PM	2.00
RADS-SKY	9:30 AM	12:51 PM	3.35
AUREOLE			
MPL LIDAR	12:00 AM	5:00 PM	17.00
SKY CONDITIONS			

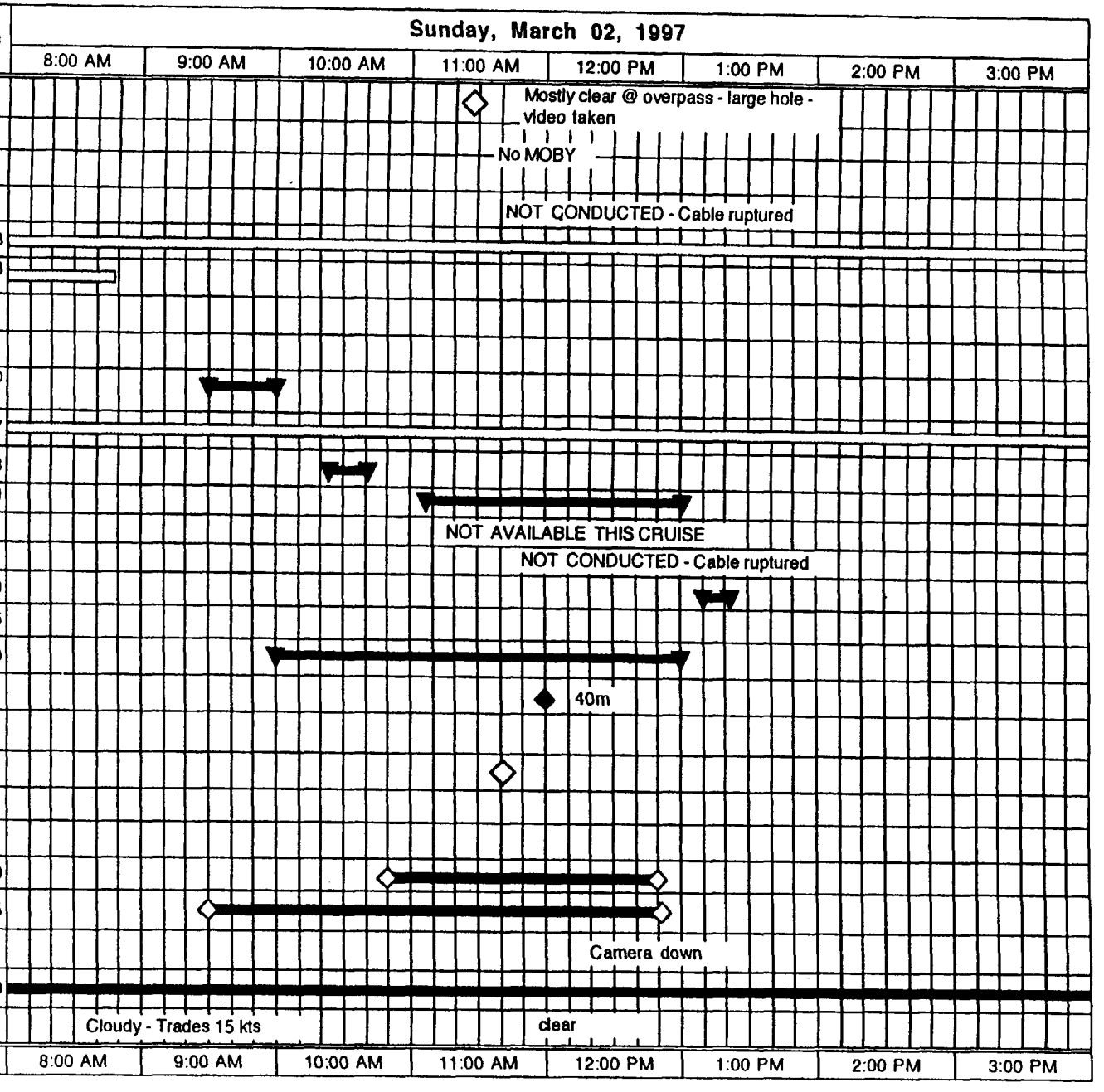


Figure 9

Table 1. Radiometer Calibration History

Instrument	Date	Experiment
MOS202	12-Sep-96	PreL14: Lu-OL420, HgA, Ne; Ed-F452, HgA, Ne
	14:2l-Sep-96	L 14: profiles on 17,18, 19-Sep-96 at/near Lanai
	24-Sep-96	PosL14: Lu-OL42, Bin, Int, HgA, Ne; Ed-F453, Bin, Int, Lin, HgA, Ne; LED
	14:22-Nov-96	L15: profiles on 18,19,21-Nov-96 at/near Lanai
	23-Nov-96	PosI,15: Lu-OL420, Bin, HgA, Ne; Ed-F453, HgA, Ne
	21-Feb-97	PreL16: Lu-OL420; Ed-F453, HgA, Ne, Kr, Xe; LEDs
	23-Feb:02-Mar	L 16: profiles on 23,27,28-Feb, 2-Mar at Barbers Pt and Lanai Mooring
	03:04-Mar-97	PosL16: Lu-OL420, Int; Ed-F453, HgA, Ne
MOS204	05:08-Aug-96	PreL13: UP and DN Lu-OL420, HgA, Ne
	08:09-Nov-96	PreL15 (Before install in MOBY): Lu-OL420, Int; HgA, Ne
	16-Nov:01-Mar	Deployed in MOBY202 at Lanai Mooring
	08-Mar-97	PosL16 (after remove frm MOBY): Lu-OL420, Int, Bin, HgA, Ne; LEDs
MOS205	05:07-Aug-96	PreL13: UP and DN Lu-OL420, HgA, Ne
	15-Sep:03-Nov	Deployed in MOBY201 at Lanai Mooring
	23-Nov-96	PosL15 (after remove frm MOBY): Lu-OL420, HgA, Ne
	11:13-Jun-97	L 17: UP Lu-GS500/F-453 & OL420M, Bin, Int, HgA,Ne,Kr,Xe, LED's
MOBY201	10:12-Aug-96	PreLl3: Lu T, M, B-OL420; Ed S, T,M,B-F452
	10:11-Sep-96	PreL14: Lu T, M,B-OL420; Ed S,T,M,B-F-452
	15-Sep:03-Nov	Deployment at Lanai Mooring
	12-Nov-96	PreL15: Lu T, M,B-OL420; Ed S,T,M,B-F453
MOBY202	11-Nov-96	PreLl5: Lu T,M,B-OL420; Ed S, T,M,B-F453
	16-Nov:01-Mar	Deployment at Lanai Mooring
	5:7-Mar-97	PosL16: Lu T,M,B-OL420; Ed S, T, M, B-F453 (each sensor at 5 MUX pos)
MOBY203	14:17-Jun-97	L17: Lu T, M, B-OL420M; Ed S,T,M,B-F453 (+- 1 MUX pos)
	20,21-Jun-97	L 17: Lu-OL420M & F453/ISA; Ed-F453; Ed B-HgA & Ne
SIS101	14:21-Sep-96	L 14: Scans during cruise
	24-Sep-96	PosL14: Es-F453
	07-Nov-96	PreL15: Es-F453
	14:22-Nov-96	L 15: Scans during cruise
	23-Nov-96	PosL15: Es-F453
	22-Feb-97	PreL16: Es-F453
	23-Feb:02-Mar	L 16: Scans during cruise
	08-Mar-97	PosL16: ES-F453