MODIS Team Member - Semi-annual Report
Marine Optical Characterizations
December 1998

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NOAA/NESDIS

SUMMARY

The Marine Optical Characterization Experiment (MOCE) Team completed its first year of providing the SeaWiFS Project continuous observations for their initialization and calibration tasks. Additionally, the team conducted two MOBY recovery and replacement cruises (MOBY L-35, MOBY-L38), and four MOBY calibration excursions at the Lanai mooring site (MOBY-L34, L36, L37, L39). Several unexpected MOBY field repair operations were successfully accomplished. Radiometric, biological and atmospheric data were collected during the MOBY-L35 and MOBY- L38 cruises. The team's goal this period has been to complete the MOBY preparation and cruise schedule requirements as soon as possible, allowing us more time to devote to the ever more pressing MOS red/blue overlap problem and other system development issues such as the mooring weather station. Team activities during the reporting period are shown in Figure 1.

FIELD OPERATIONS

MOBY-L35

The MOBY-L35 recovery and replacement cruise took place July 22 - July 27, 1998. The following personnel participated:

NOAA - Dennis Clark, Marilyn Yuen, Edwin Fisher, Ed King, Eric Stengel, Larisa Koval, Yong Sung Kim

MLML - William Broenkow, Mark Yarbrough, Mike Feinholz, Stephanie Flora, Darryl Peters, John Heine

CHORS - Chuck Trees

University of Miami - Bob Evans

University of Hawaii - Mike Ondrusek

The sixth Marine Optical Buoy, MOBY206, was deployed on 24 July 1998 during the MOBY-L35 oceanographic cruise aboard the R/V Moana Wave. On 24 July, MOBY206 and MOBY205 made two sets of concurrent optical measurements at the Lanai mooring site at approximately

21:30 and 22:30 (GMT). Diver calibrations of the new MOBY were performed on July 25.

During the five days of ship time, five oceanographic stations were occupied (Figure 2). Five Marine Optical System (MOS202) profiles were conducted: one concurrent with a SeaWiFS overpass, and two with MOBY profiles. Four CTD profiles (SBE0091 to SBE0094) were executed during the cruise and Secchi disc measurements were made near local noon each day. Fifty pigment samples were collected for processing on shipboard using the fluorometric technique. Out of the 50 samples, 19 were collected from four CTD casts with the rest (31) from near surface depths, during SeaWiFS overpasses and during station transit. These fluorometrically determined pigment data were transferred to the NOAA sponsor immediately after the cruise. In addition to the fluorometric pigment samples, duplicate samples were also collected for HPLC analysis back at the CHORS laboratory. A total of 53 HPLC samples were collected during the cruise. These samples will be processed in 1999.

Optical profiles were conducted using MD5 VIS and NIR systems for comparison with MOBY, MOS/SIS, and SPMR data sets.

Hand Held Contrast Reduction Meter (HHCRM) measurements, to derive the spectral transmittances, specifically bracketed each SeaWiFS overpass. Water vapor column, ozone column and aerosol optical depth during each overpass were measured using MICROTOPS II. Additional atmospheric transmittance measurements were made at the CIMEL site for comparison with CIMEL data.

Our surface -incident and profiling radiometers (SIS 101cfg04 and MOS202cfg05) were calibrated for irradiance and radiance response before and after the MOBY-L35 experiment. MOS204cfg02 was radiance-calibrated in July before its integration with MOBY206. Two complete sets of radiance and irradiance calibrations were performed on MOBY206, with diver lamp scans and an integration time calibration before the new buoy's deployment. Two sets of post-deployment radiometric calibrations of MOBY205 were carried out in August, and MOScfg03 was calibrated for radiance and wavelength and integration time in September after its removal from MOBY205.

The MD5 radiometer was calibrated before and after the cruise for spectral radiance, spectral h-radiance, and wavelength. The HHCRM was calibrated using the OL420M standard source.

MOBY205 was successfully recovered on 25 July. MOBY was missing the top arm. The buoy received preliminary cleaning, was post-calibrated, dismantled, and placed in storage.

MOBY-L38

The MOBY-L38 recovery and replacement cruise took place October 24 - October 30, 1998. The

following personnel participated:

NOAA - Dennis Clark, Ed Fisher, Yong Sung Kim, Ed King, Larisa Koval, Eric Stengel, Marilyn Yuen

MLML- Mike Feinholz, Stephanie Flora, John Heine, Darryl Peters, Mark Yarbrough

CHORS - Chuck Trees

University of Hawaii - Mike Ondrusek

NASA/GFSC - Robert Caffrey, Gene Eplee

Hawaiian Rafting Adventures - Steve Juarez, Rob Wheeler

The sixth Marine Optical Buoy, MOBY206, was retrieved on October 27 1998 and MOBY207 was deployed on October 24 during the MOBY-L38/M211SOBP oceanographic cruise aboard the R/V Moana Wave (Figure 3). On October 25 and 26 MOBY206 and MOBY207 made concurrent optical measurements at the Lanai mooring site at approximately 22:30 (GMT). The MOBY207 was fitted with a new solar powered strobe/RF system and a reprogrammed GPS/MML unit. The new Novatech combination strobe has a “double pulse” flasher, making the usually hard to locate xenon strobe easier to pinpoint at sea. Unlike the old strobe, this unit has an internal RF locator transmitter. The power for the strobe was changed from alkaline batteries to solar powered lead-acid batteries. The new power system will allow the strobe and RF locator to operate indefinitely. The Argos GPS/MML was reprogrammed by Seimac to improve battery life. These units have never performed to specification on deployment duration and require us to change the batteries every 60 days. As turns it out, this reprogramming has not helped extend the battery life and we continue to work on the problem.

During the seven days of ship time, five oceanographic stations were occupied (Figure 4). Three Marine Optical System (MOS202) profiles were conducted: one with a video camera attached and looking downward, one with the camera looking up, and one in shallow waters over Penguin Bank. Three MLML CTD profiles (SBE0096 to SBE0098) were executed during the cruise and Secchi disc measurements were made near local noon each day.

During the cruise, 54 pigment samples for processing on shipboard were collected and analyzed using the fluorometric technique. Out of the 54 samples, 15 were collected from three CTD casts with the rest (39) from near surface depths, during SeaWiFS overpasses and during station transit. These pigment data were transferred to NOAA immediately after the cruise.

During the cruise 53 particulate and detrital absorption samples were collected and analyzed. Two different methods were used to process these data. The first method involves a batch processing software package. The second process requires manual utilization of Excel spreadsheet capabilities. Both methods should yield the same results. The advantage of the batch processing software is that data files for an entire cruise can be processed without requiring

constant interaction with the computer. The second method requires constant interaction, but this allows for scan by scan data quality control. A comparison between the two methods will be performed later.

In addition to the fluorometric pigment samples, duplicate samples were also collected for HPLC analysis at the CHORS laboratory. A total of 54 HPLC samples were collected during the cruise. These samples will be processed in January 1999. The processing of these samples was delayed, in order to use the new HPLC detectors and new software, which runs on Windows NT. Waiting to process these samples on the new system will improve detection limits and decrease the uncertainty in the pigment data for these cruises.

Initial diver calibrations of MOBY207 were performed on October 25 and 26.

HHCRM measurements were performed to derive the spectral transmittances. Water vapor column, ozone column and aerosol optical depth were measured using MICROTOPS II. Additional atmospheric transmittance measurements were made at the CIMEL site.

Radiometric calibrations were conducted before and after the MOBY-L38 cruise. Our profiling radiometer, MOS202cfg06, the MOBY207 radiometer, MOS205cfg04, the MOBY207 collectors, and MD5 radiometer were pre-calibrated in October for radiance response via OL425 standard. These instruments and SIS101cfg04 were also calibrated for irradiance response via the Gamma Scientific GS5000 incorporating FELs F-471 and F-454. Post-deployment radiance calibration on MOBY206 and on its radiometer, MOS204cfg02, were performed in November using the freshly-recalibrated OL420 sphere standard. MOBY206 irradiance sensors were calibrated using the GS5000 with FEL F-471. In December, the MOS202cfg06 radiance sensor was also calibrated after the MOBY-L38 cruise using OL420 and OL425 spheres. MOS202cfg06 and SIS10lcfg04 were irradiance post-calibrated via the GS5000-F471.

Six bottom samples from Penguin Bank were collected to study the bottom reflectance (Figure 5).

MOBY206 was recovered on October 27. It was disassembled and cleaned and is currently in preparation for deployment as MOBY208 in February 1999.

MOBY CALIBRATIONS

During this reporting period, the MOCE team and professional divers conducted three MOBY205 and MOBY 206 calibration excursions via Hawaiian Rafting Adventures (HRA) chartered dive boat to perform the diver calibrations. During the first trip (MOBY-L34, July 2-3), no final dive calibration was possible due to time constraints during the recovery cruise. The flopper stoppers (wire/dacron system) were replaced with a wire/wire, 24 flopper system.

During the second trip (MOBY-L36, August 24-29), the wire/wire, 24 flopper system was replaced with a wire/nylon 24 flopper system. Diver calibrations and optics cleaning were

performed, and water samples for HPLC analysis were collected and filtered, and the GPS antenna and Argos transmitter were replaced. The GPS/MML Argos unit has been returned to Seimac Ltd. for reprogramming. The new operating mode will result in a longer life from the existing battery packs. The new programming will allow for the larger watch circle of our mooring so the unit transmits less often. The new firmware also corrects a multi-path problem with the internal trimble GPS which can also result in excessive Argos transmissions. With these changes, the unit's batteries should last for the full rated 120 day duration, eliminating the need for periodic field replacement of the unit.

The third trip took place September 16-20 (MOBY-L37). The MOBY206 tether, which had a cracked strain-relief, was replaced. Mooring System Inc. and Preformed Marine are trying to fix the tether strain relief problem. Preformed Marine has offered to re-design the system at no additional engineering charge. The re-designed units will not likely be available for the MOBY207 deployment. We will continue to use the temporary system provided by MSI until the new strain-reliefs are delivered. The damaged flopper system was replaced again with a nylon/nylon 12 flopper system. Diver calibrations (dirty and clean Ed and Lu) and optic cleaning were performed.

One MOBY diver calibration and maintenance cruise (MOBY-L39) with HRA was required during December 1998. A fisherman reported that on November 22 the tether was wrapped around the upper portion of the buoy and the buoy was tilting far more than usual, often exposing the upper arm. As a result of the fisherman's report, HRA was asked on 23 November to visit MOBY as soon as weather allowed to check the situation. The weather had been very poor for 2 weeks prior to the fisherman's report and a tangled tether would ultimately result in loss of the buoy. Poor weather conditions delayed scheduled maintenance in November. When conditions finally cleared, HRA divers inspected MOBY on December 7 and noted a wrapped and chaffed mooring tether, but strong currents prohibited attempts to unwrap the buoy. Mark Yarbrough, Yong Sung Kim, and three divers returned on December 8 with a new Mooring Systems Inc. tether which was successfully installed - the old tether was worn through approximately 50%. Figure 6 shows the tether wrapped around the lower clamp of the upper arm. Clearly the chaffing on the tether was caused by the line rubbing on the clamp and exposed bolt ends. Figure 7 shows the tether in air after recovery. The flopper-stoppers were replaced and three sets of "dirty" diver calibrations were performed on December 9, and all optical collectors were cleaned with anti-foulant tubes replaced on December 10.

CIMEL SERVICE

The CIMEL system was serviced on July 2 during the MOBY-L34 diver calibration trip. During this service, re-routing of the cables was attempted as recommended by NASA to solve the asymmetric almucantar problem. The unit required extensive external cleaning and the metal shell connectors were wrapped with electrical tape to help prevent further corrosion. Subsequent reports from NASA indicate that the AM almucantar measurement was still erroneous. The replacement unit is prepared for possible installation during the next MOBY cruise.

The CIMEL system was serviced again on July 23 during the MOBY-L35 cruise. The AM almucantar problem was traced to binding of the robot cable on the main housing preventing free rotation of the instrument. The problem was fixed by attaching small cable tie "bearing" to the cable where it contacts the housing. The instrument has functioned properly since the repair.

The CIMEL system was again cleaned on August 25 during the MOBY-L36 diver calibration trip.

CIMEL #93 was serviced on October 27 during the MOBY-L38 cruise. The system required some cleaning but was in good shape otherwise.

The Honolulu #106 unit was returned to GSFC on October 8 for re-calibration. GSFC returned the unit on 30 November and it was placed in service at the Honolulu site for testing. The unit was deemed functional by Brent Holben's group and shipped to HRA on December 17 for installation at the Lanai site, replacing unit # 93.

DATA PROCESSING

The conversion of MLDBASE MOBY processing programs from Matlab 4.2 to Matlab 5.2 is completed. All daily processing of MOBY data and HTML documents is done in Matlab 5.2. Matlab 5.2 has removed the ability to save figures as GIF images, so future Web site images will be JPEG images. The JPEG files are approximately 4 times larger than GIF images. This may require the removal of old deployments from the Web site to make room for new deployments. MLML personnel have begun reprocessing all MOBY deployments and writing 4 CD-ROMs for each deployment. MOBY201 and MOBY202 reprocessing is almost complete, while work continues on the rest of the deployments. The CD-ROMs will contain raw and processed MOBY data in MLDBASE and Matlab formats, all FORTH LOG files, compiled files of scientific and engineering data, MOBY deployment homepage, and any auxiliary data (such as satellite images and Lanai airport meteorological observations). A batch processing program was written to reprocess each deployment using a configuration file. The configuration file contains processing information for each MOB file in the deployment. The missing MOB files from deployment MOBY203, 04 and 05 have been received and are being checked for problems. MOBY203, 04 and 05 batch processing configuration files will be created and tested.

MLML personnel have begun to recast the CZCS era radiometric, long-track and vertical profiling data MLDBASE files into files compatible with the MOBY auxiliary "vaux" parameters. From the 5 nm resolution files, they will recompute water-leaving radiances and other derived products using the current Matlab data reduction programs. The newly-calculated diffuse attenuation coefficients and water-leaving radiances are identical (within the limits of the split-precision values used in the original database) to those calculated in 1980. The normalized water-leaving radiances will be recalculated with the MOBY algorithms. The CZCS era data files will be copied to CD ROMS as the binary MLDBASE files, as ASCII text and JPEG images

of the data plots. The Matlab routines to read the binary files will be included on that CD. An HTML browse file will be produced so that all of the text data can be viewed interactively.

For the MOCE 4 HPLC pigment samples, it was decided that the analysis would be performed using the existing scanning detector (SpectraFOCUS 32-channel detector) because of the problems in getting the newly acquired UV600LP Photodiode Detector working properly. This delayed the delivery of the MOCE 4 pigment data until July. Figure 8 shows a comparison between fluorometrically determined chlorophyll a measured on the ship (NOAA's fluorometer) with replicate samples processed back in the laboratory using the CHORS fluorometer. From a previous MOBY cruise, it was found that the NOAA fluorometer was consistently higher than the CHORS fluorometer by about 6% when analyzing the same pigment extracts. The departure from a 1 to 1 relationship found in Figure 8 is caused by filtration volume differences between the fluorometric and HPLC samples. The volumes from the HPLC are around 4 liters and it is these samples which are processed at CHORS. For the fluorometric samples, processed on the ship with the NOAA fluorometer, only 1.12 liters are filtered. As filtration volumes increase, the particles retained on the filter fill in the voids between the glass fiber matrix, thus improving retention efficiencies. This increase in chlorophyll *a* concentration as filtration volumes increase has been observed on all MOBY and MOCE cruises.

Figure 9 shows the comparison between fluorometrically measured chlorophyll a on the CHORS fluorometer and HPLC determined monovinyl plus divinyl chlorophyll a. The fluorometric estimate of chlorophyll a is 178% higher than that determined by HPLC. This is the largest uncertainty for the fluorometric method which we have observed in the waters around Hawaii. The variance in this plot is larger than previous comparisons, because during the HPLC analysis there were problems in separating the internal standard, canthaxanthin, from the photoprotectant carotenoid, zeaxanthin. Thus, the uncertainty for HPLC determined pigment concentrations during this cruise were somewhat higher than that found for other Hawaii cruises. The relationship between chlorophyll a and total accessory pigments is linear and very close to the global average of 1.465 (Figure 10).

The MOBY, MOS, MD5 and SPMR data from the MOBY-L35 cruise were processed and compared. The four instruments show overall good agreement (Figure 11). The SPMR is higher at 518 nm than other instruments. MOBY, MOS and MD5 agree really well from 400 nm up to 610 nm. MOBY, MOS and MD5 instruments were calibrated with the same standard. The SPMR instrument was independently calibrated by its manufacturer. The agreement of the four instruments demonstrates the go& quality of the data sets.

In September, a laboratory experiment was conducted to investigate changes in absorption properties of phytoplankton as a function of pigment concentration under varying growth light intensities. This was a collaborative effort between CHORS and Dr. Roberto Millan of the Universidad Autonoma de Baja California (UABC), Ensenada, Mexico. Five cultures (diatom, dinoflagellate, chlorophyte, prasinophyte and cryptophyte) were grown under five different light intensities. Absorption and pigment (HPLC) samples were collected at the beginning of the experiment and then every 2 days for 7 days. In addition, absorption and pigment samples were also collected for the other thirteen cultures maintained by the Culture Collection Center at

UABC. Duplicate samples were analyzed to evaluate sampling, filtration and analysis variability. The premise being tested was that varying pigment ratios can be created through different light conditions and that these differences will cause a change in the shape of the phytoplankton absorption spectra. Using a Least Squares Matrix Solution (LSMS), we were hoping to individually separate the *in vivo* absorption spectrum for each pigment compound in the various cultures. For diatom and dinoflagellate cultures, we found that the rate of change for several pigment compounds (fucoxanthin, diadinoxanthin, peridinin and carotene) as a function of chlorophyll a was different. The requirement for a robust solution with the LSMS method is that pigment ratios have to change independently of each other and that the more random the change, the better the solution. We then compared ratios (fucoxanthin:chlorophyll a, diadinoxanthin + diatoxanthin: chlorophyll a and carotene:chlorophyll a) at the beginning of the experiment for all ten diatom cultures. A random pattern was found as shown on Figure 12. This indicates that pigment ratios are species specific and that improvements can be made in estimates of pigment specific *in vivo* absorption by increasing the number of species in each experiment. We are currently planning another laboratory experiment in February using higher growth intensities on many cultures.

INSTRUMENT DEVELOPMENT

CHORS personnel received a newly purchased Thermo Quest's FL3000 Scanning Fluorometer for the HPLC system, which replaces the older Linear 205 Fluorometer. The FL3000 has many improvements over the older Linear instrument, such as an enhanced red-sensitive PMT, improved signal-to-noise, smaller volume flow cell and improved optics. This detector will assist in improving the detection limits for the various chlorophyll degradation products (chlorophyllides, phaeophorbides and phaeophytins) that are found on phytoplankton samples. They also received new HPLC software, which runs on a different operating system than the previous one. The UV6000LP Photodiode Array Detector, which was purchased in February 1998, was sent back to the manufacturer for replacement of the HPLC system. The UV6000LP has replaced the older SpectraFOCUS scanning absorption detector. The newly purchased Thermo Quest FL3000 Scanning Fluorometer and UV6000LP were integrated into the existing HPLC system. Two Thermo Quest engineers traveled to San Diego and spent two days setting up and testing the new detectors and software. Unfortunately, the FL3000 had difficulties communicating with the computer and we are still investigating this problem. The Thermo Quest Crystal Capillary Electrophoresis (CE) system was setup and tested. This CE system will be used to separate. And quantify phycobiliproteins, which are found in cyanobacteria and cryptophytes. Phycobiliproteins can contribute up to 50% of the total pigment content in tropical and subtropical areas. The CE system will use the SpectraFOCUS scanning absorption detector to identify and quantify the various phycobiliproteins (phycoerythrin, phycocyanin and allophycocyanin).

The work on the MOS spectrographs during this period included the final preparation of MOS4 for the MOBY206 deployment and preparation of MOS5 for the MOBY207 deployment. MOS5 received normal periodic vacuum pumping of the CCD heads, cooler circulation pump service and shutter replacement. Housing maintenance was limited to the repair of a few minor spots of

corrosion. The unit required more extensive than usual disassembly to allow spectrograph modifications addressing the blue/red overlap problem. The red spectrograph was modified to reduce internal scattering. The gold reflective coating on a portion of the final mirror was stripped to allow absorption of the first order light within the glass of the mirror instead of reflecting it into the relatively inefficient light trap area. The pre-filter was changed from a 470 nm cut-on filter to a 580 nm cut-on filter to help reduce the effect of these changes on the MOS2 shipboard problem. We hope to make additional and more drastic changes to the MOS2 shipboard instrument. We continue to evaluate the results of stripping the mirrors and changing the blue spectrograph high pass filter in the profiling and MOBY MOS systems. So far we can see no dramatic improvements to attribute to these modifications. Mark Yarbrough is working with the new spectrograph apertures to determine if we can reduce stray light in both spectrographs.

We continue to work with Mooring Systems Inc. to finalize design details of the Mooring Meteorological Station as the buoy and tower construction begins. The operation of the Sutron test system is continuing at the Honolulu site. Data recovery over the cellular/landline link is operating but the cellular/cellular method is unusable. The phone support provided by Sutron for troubleshooting this problem has been dismal. We will likely need to ship one unit back to Sutron for integration. We are in the process of wiring the deployment unit for the February 1999 cruise.

The Single Multipurpose Sensors (SCAMPS) were returned by the National Institute of Standards and Technology (NIST) after re-calibration. Mike Feinholz has been working with Howard Yoon (NIST) to finalize the SCAMPS calibration report and compile a comparison of our standard lamp calibrations versus SCAMPS measurements in order to track our long-term traceability to NIST. The final report was received on November 27. Our historical SCAMPS data are now being converted to radiometric units using these calibration coefficients, which will then be compared with calibrations of our radiance and irradiance standards. John Thomas Riley (NASA/GSFC) and our personnel worked at the Sand Island, HI operations site as part of the SeaWiFS Intercalibration Round Robin Experiment (SIRREX-6). Satlantic radiance heads were used to scan our Optronic OL420 and OL425 spheres for comparison with sources used by others in the bio-optics community. Three of our Spectral Irradiance Standards (FEL:F-453, F-454, GS-132) were re-calibrated by Charles Gibson (NIST) in July. These lamps, which were shipped in April and June, were returned in September, all in good condition. Our Optronic Laboratories OL420 Spectral Radiance Standard was returned to the manufacturer for re-lamp/re-calibration on September 4 having logged 61.7 hours of use since its last calibration on June 11 1997. On October 23 OL420 radiance sphere was returned from Optronic Laboratories with a post-calibration dated October 19 and re-calibration dated October 22.

SITE MAINTENANCE

The wiring of the “utility power” portion of the power van is complete. This allowed usage of the power van to distribute properly grounded power to the instrumentation vans as usual, except for the lack of conditioned power. Lack of conditioned power required the use of small UPS

units to power individual systems during the MOBY-L35 cruise. The modifications to the UPS units were completed after MOBY-L35 cruise and one unit was installed prior to the MOBY-L38 cruise. The remaining units will be installed as time permits. Additional space has been cleared and made available by the University of Hawaii Marine Center. The two new containers are spotted, leveled and powered. We are using the electrical van for assembly of the weather station components and MOS electrical work. The additional yard space was cleared just in time for the arrival of the new mooring buoy and provides a much needed work area for this rather large buoy.

MEETINGS

Dennis Clark attended the SIMBIOS meeting, September 21-25, 1998 in La Jolla, California.

Mike Feinholz attended the Ocean Optics XIV conference hosted by the Office of Naval Research and the National Aeronautic and Space Administration from November 9 to 13 in Kailua-Kona Hawaii.

Dennis Clark attended the MODIS meeting, December 15-17, 1998 at NASA/GSFC.

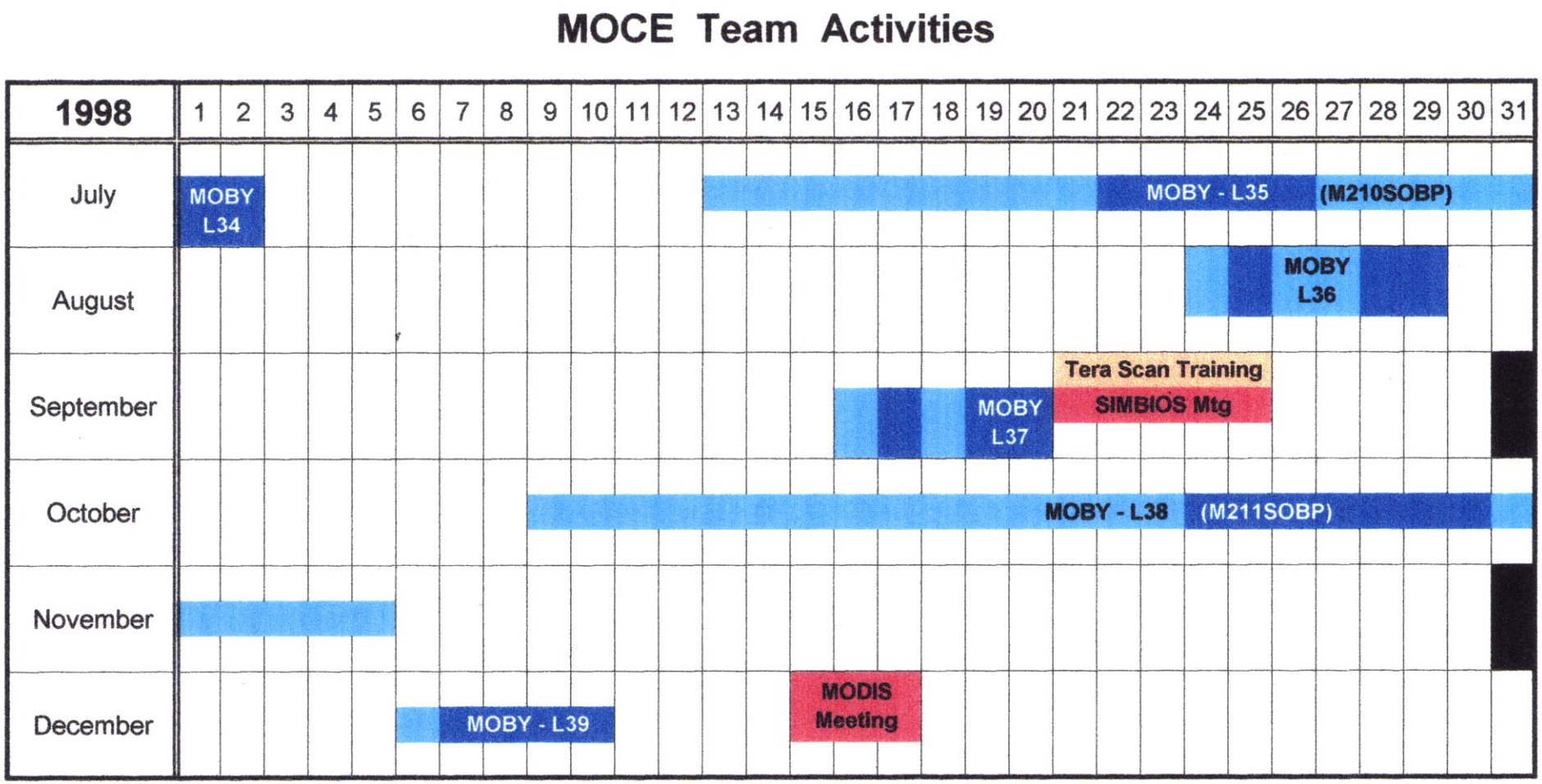

MOCE Team Activities
1998
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
July
August
September
October
November
December
MOBY L34
MOBY - L35
(M210SOBP)
MOBY L36
Tera Scan Training
SIMBIOS Mtg
MOBY L37
MOBY - L38
(M211SOBP)
MODIS Meeting
MOBY - L39

FIGURE 1.

M210SOBP
Station 1: MOBY I

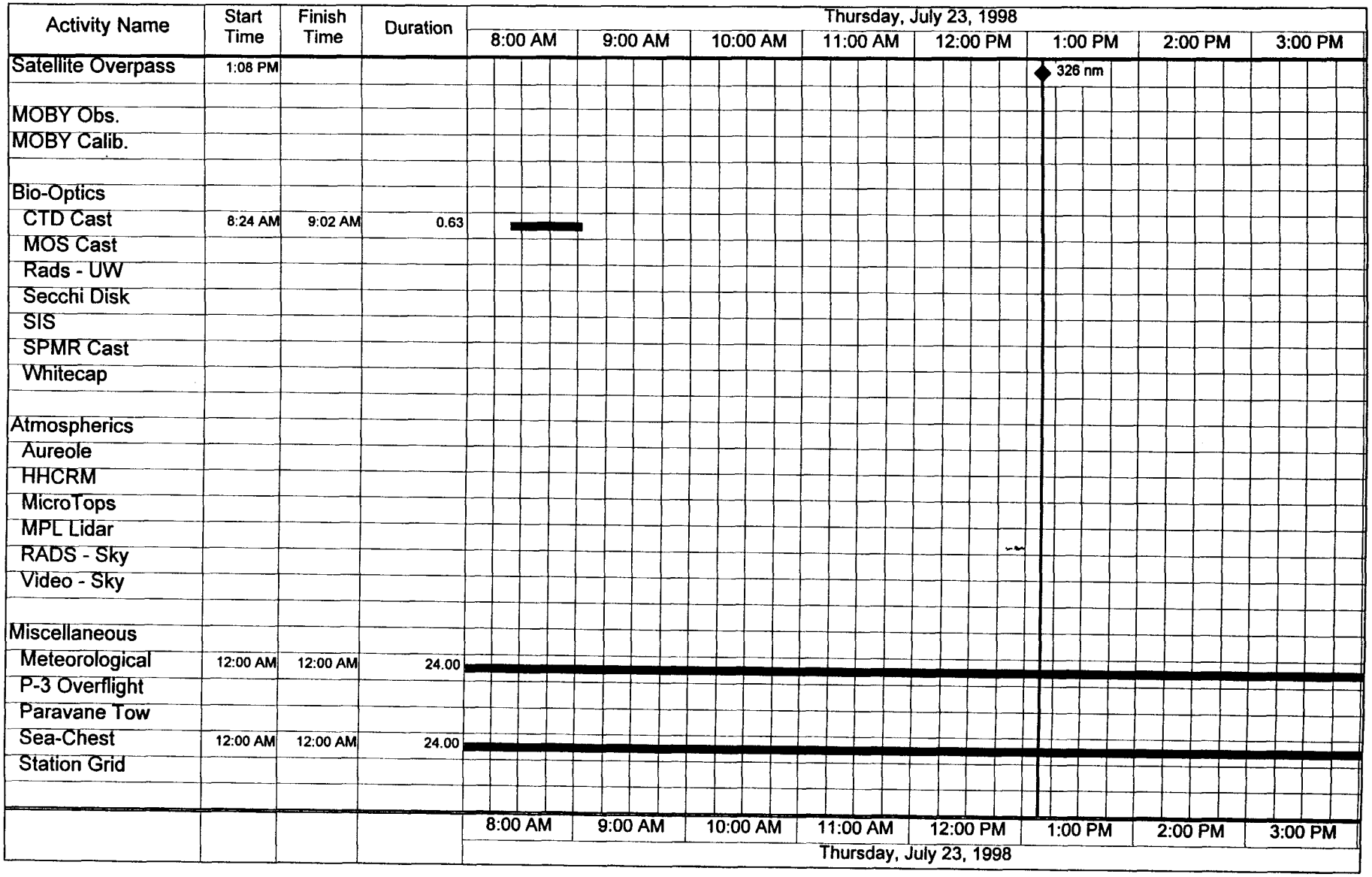
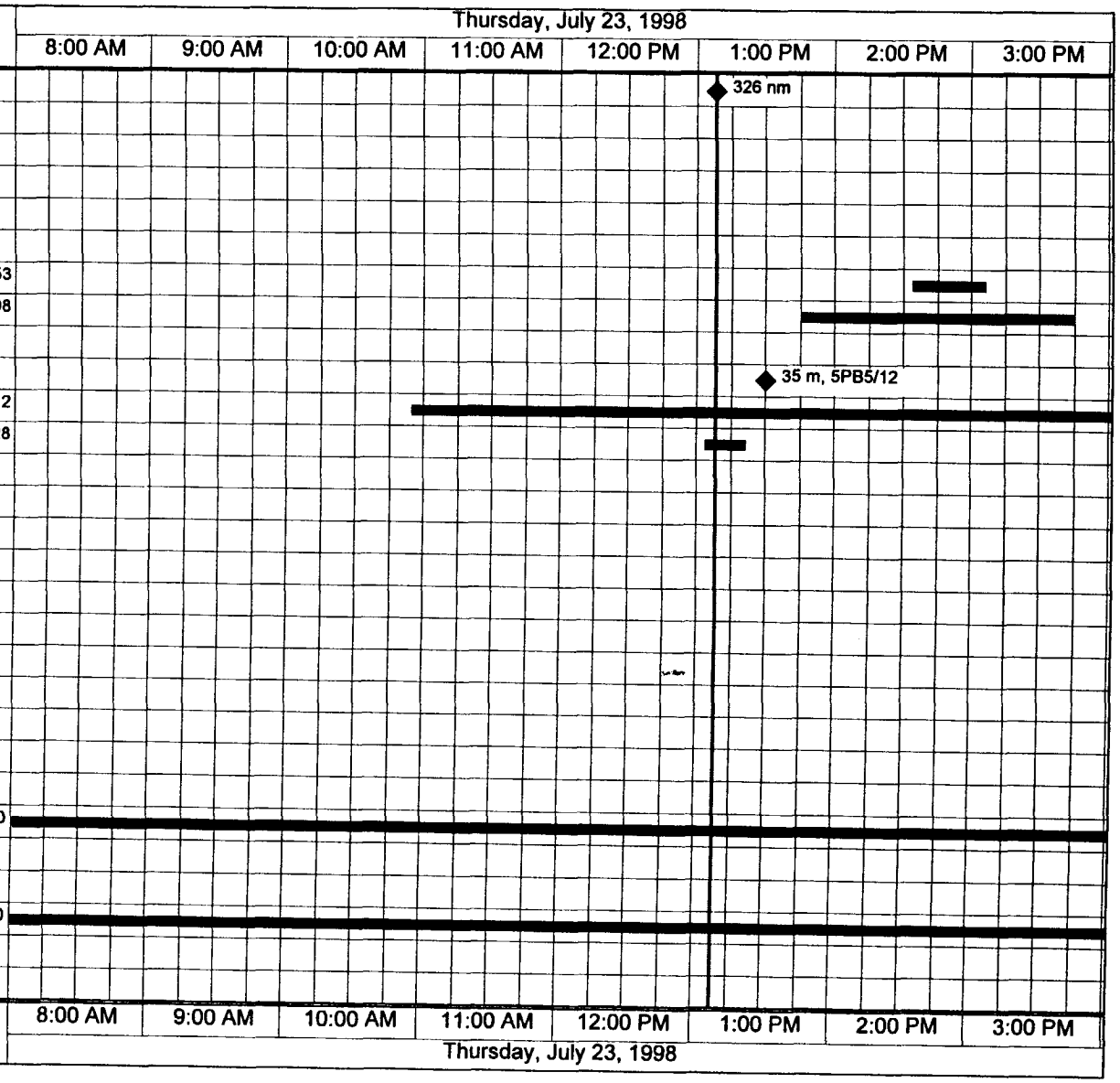


FIGURE 2.

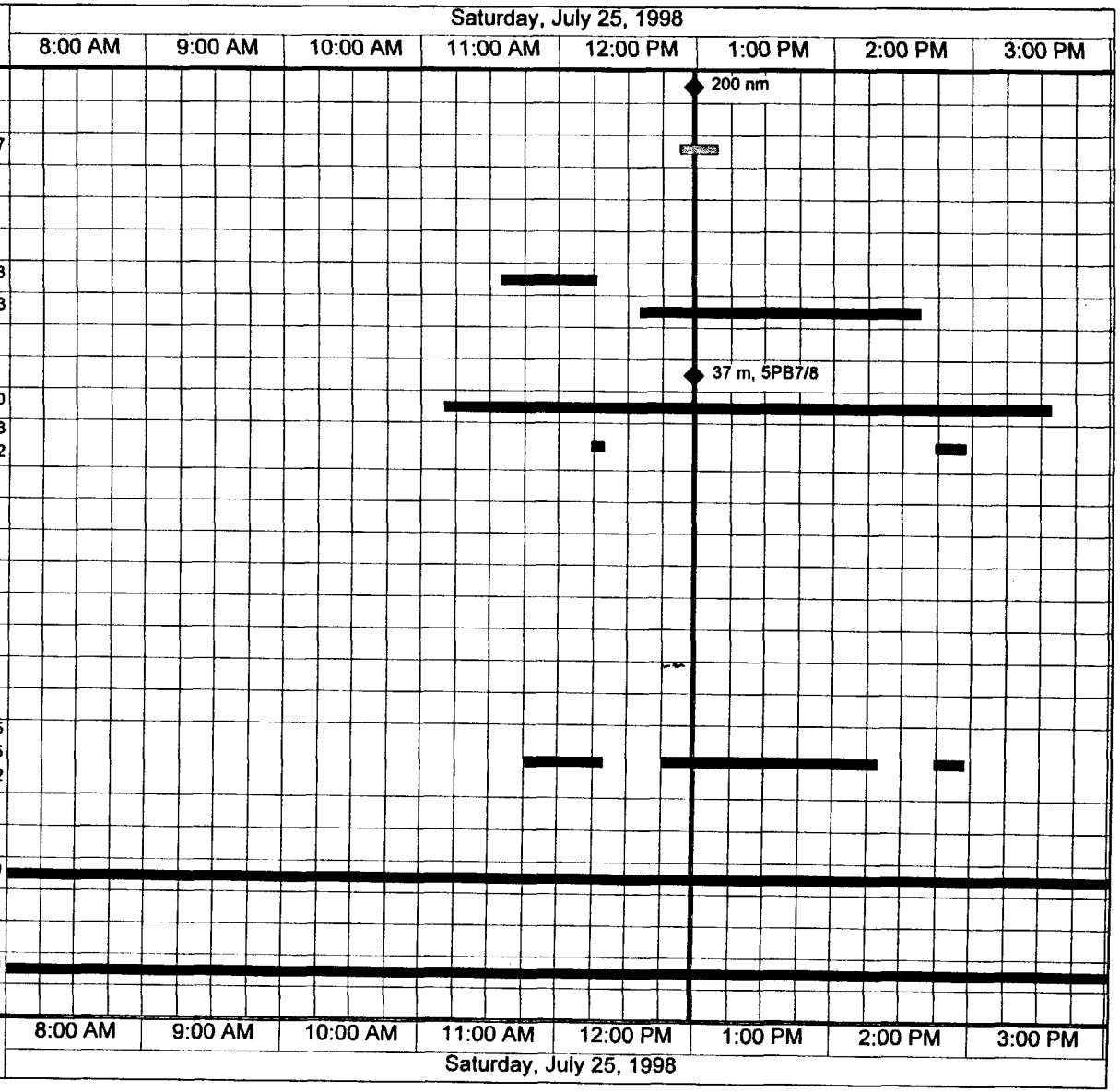
M210SOBP
Station 2: CIMEL Site

Activity Name	Start Time	Finish Time	Duration
Satellite Overpass	1:08 PM		
MOBY Obs.			
MOBY Calib.			
Bio-Optics			
CTD Cast	2:34 PM	3:06 PM	0.53
MOS Cast	1:46 PM	3:45 PM	1.98
Rads - UW			
Secchi Disk	1:30 PM		
SIS	10:55 AM	5:02 PM	6.12
SPMR Cast	1:04 PM	1:21 PM	0.28
Whitecap			
Atmospherics			
Aureole			
HHCRM			
MicroTops			
MPL Lidar			
RADS - Sky			
Video - Sky			
Miscellaneous			
Meteorological	12:00 AM	12:00 AM	24.00
P-3 Overflight			
Paravane Tow			
Sea-Chest	12:00 AM	12:00 AM	24.00
Station Grid			



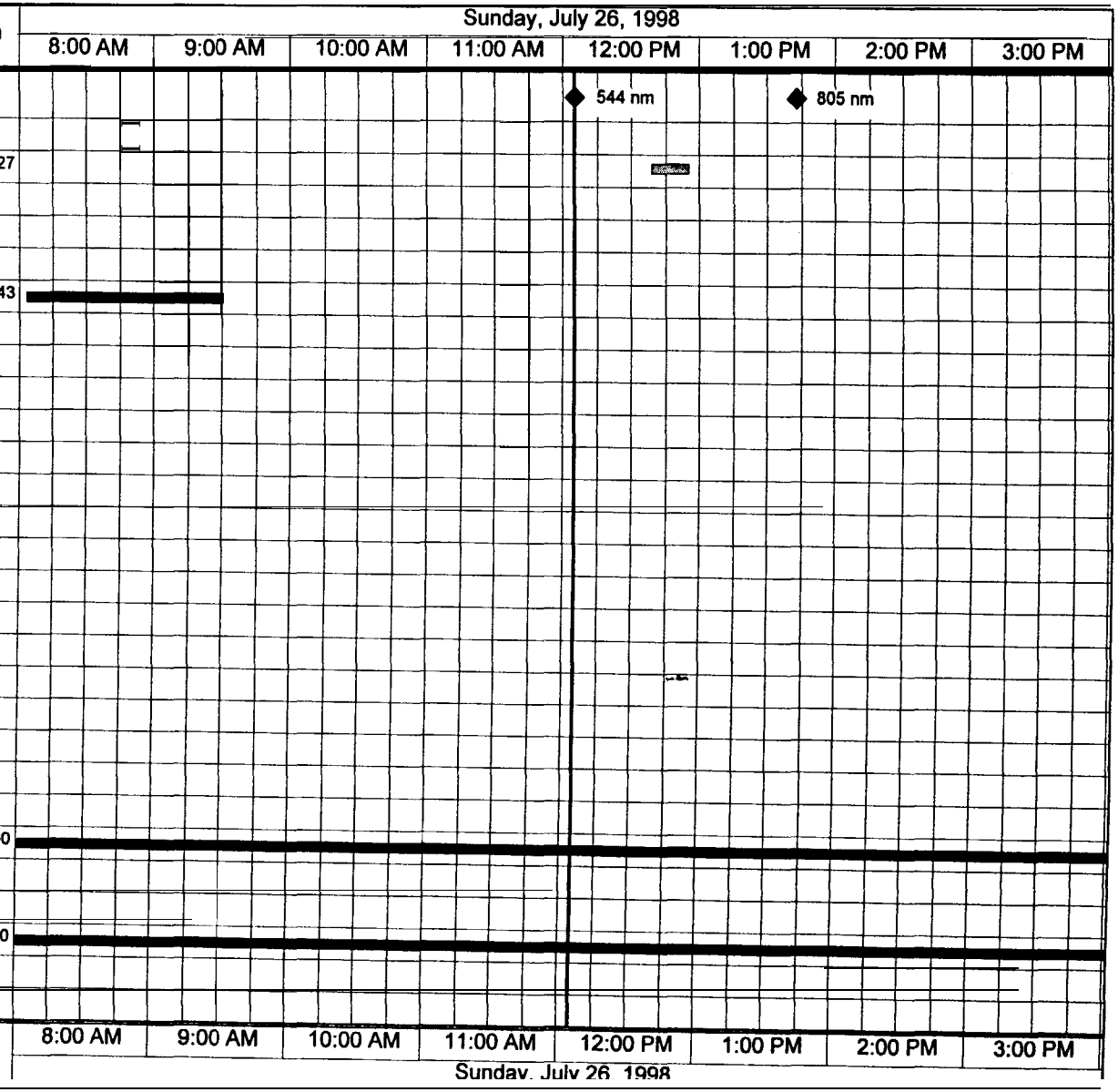
M210SOBP
Station 3: MOBY II

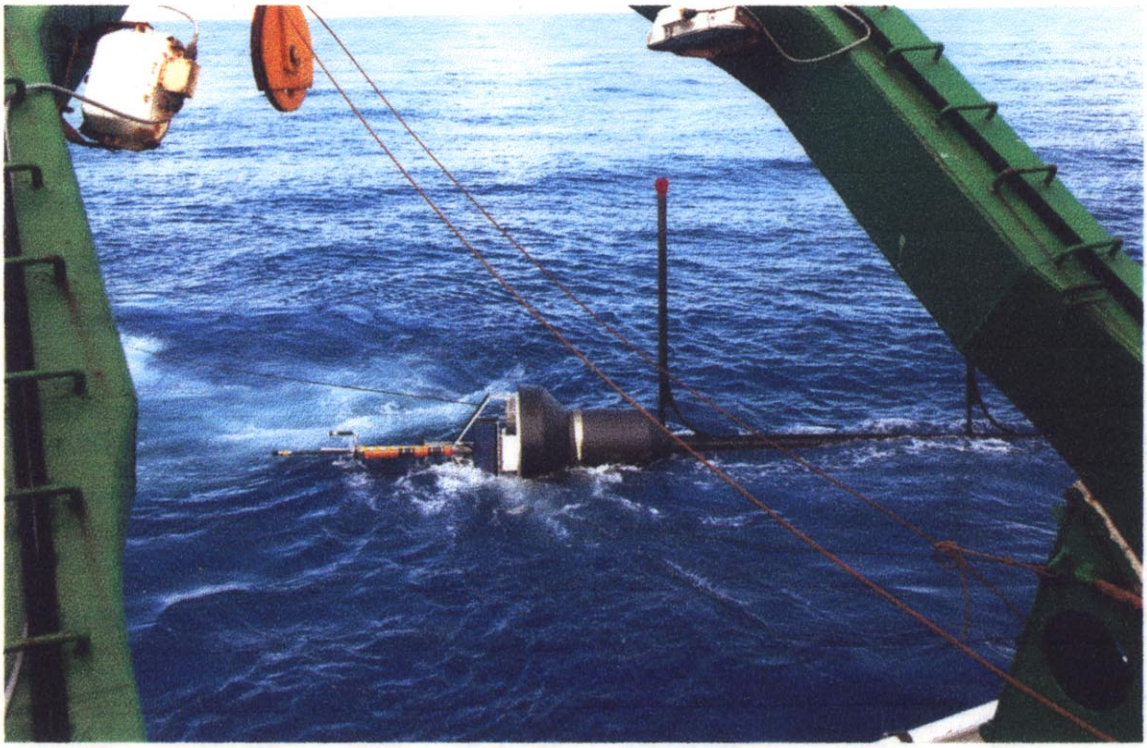
Activity Name	Start Time	Finish Time	Duration
Satellite Overpass	12:59 PM		
MOBY Obs.	12:53 PM	1:09 PM	0.27
MOBY Calib.			
Bio-Optics			
CTD Cast	11:35 AM	12:16 PM	0.68
MOS Cast	12:35 PM	2:37 PM	2.03
Rads - UW			
Secchi Disk	12:59 PM		
SIS	11:10 AM	3:34 PM	4.40
SPMR Cast	12:14 PM	12:19 PM	0.08
	2:44 PM	2:57 PM	0.22
Whitecap			
Atmospherics			
Aureole			
HHCRM			
MicroTops			
MPL Lidar			
RADS - Sky			
Video - Sky	11:46 AM	12:19 PM	0.55
	12:46 PM	2:19 PM	1.55
	2:44 PM	2:57 PM	0.22
Miscellaneous			
Meteorological	12:00 AM	12:00 AM	24.00
P-3 Overflight			
Paravane Tow			
Sea-Chest	12:00 AM	12:00 AM	24.00
Station Grid			



M210SOBP
Station 4: Kalohi Deep

Activity Name	Start Time	Finish Time	Duration
Satellite Overpass	12:05 PM 1:43 PM		
MOBY Obs.	12:39 PM	12:55 PM	0.27
MOBY Calib.			
Bio-Optics			
CTD Cast	8:04 AM	9:30 AM	1.43
MOS Cast			
Rads - UW			
Secchi Disk			
SIS			
SPMR Cast			
Whitecap			
Atmospherics			
Aureole			
HHCRM			
MicroTops			
MPL Lidar			
RADS - Sky			
Video - Sky			
Miscellaneous			
Meteorological	12:00 AM	7:00 PM	19.00
P-3 Overflight			
Paravane Tow			
Sea-Chest	12:00 AM	7:00 PM	19.00
Station Grid			





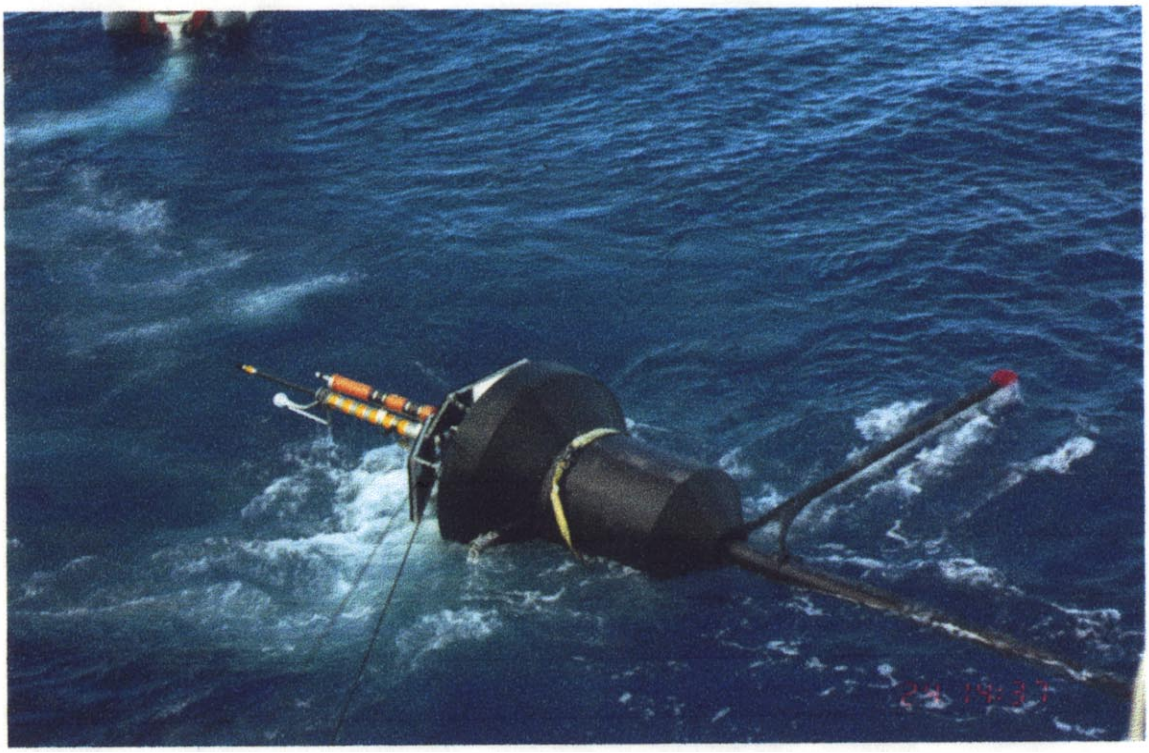


FIGURE 3.

MOBY - L38 / M211SOBP
Station 1: MOBY Site I

Activity Name	Start Time	Finish Time	Duration
SeaWiFS Overpass	12:23 PM		
MOBY Calibrations	8:37 AM	11:21 AM	2.73
MOBY Observations			
MOBY206	12:40 PM	12:56 PM	0.27
MOBY207	11:32 AM	12:04 PM	0.53
	12:39 PM	12:57 PM	0.30
Bio-Optics			
CTD Cast			
MOS Cast			
Secchi Disk			
SIS	8:20 AM	5:19 PM	8.98
SPMR Cast	11:56 AM	12:03 PM	0.12
	12:42 PM	12:50 PM	0.13
Atmospherics			
HHCRM	11:00 AM	12:00 PM	1.00
Micro Tops	11:00 AM	12:00 PM	1.00
MD5			
Video - Sky	11:12 AM	1:32 PM	2.33
Miscellaneous			
CIMEL Site			
Meteorological	10:13 AM	11:59 PM	13.77
P-3 Overflight			
Sea-Chest	10:13 AM	11:59 PM	13.77
Station Grid/Track			
Van Veen Grab			

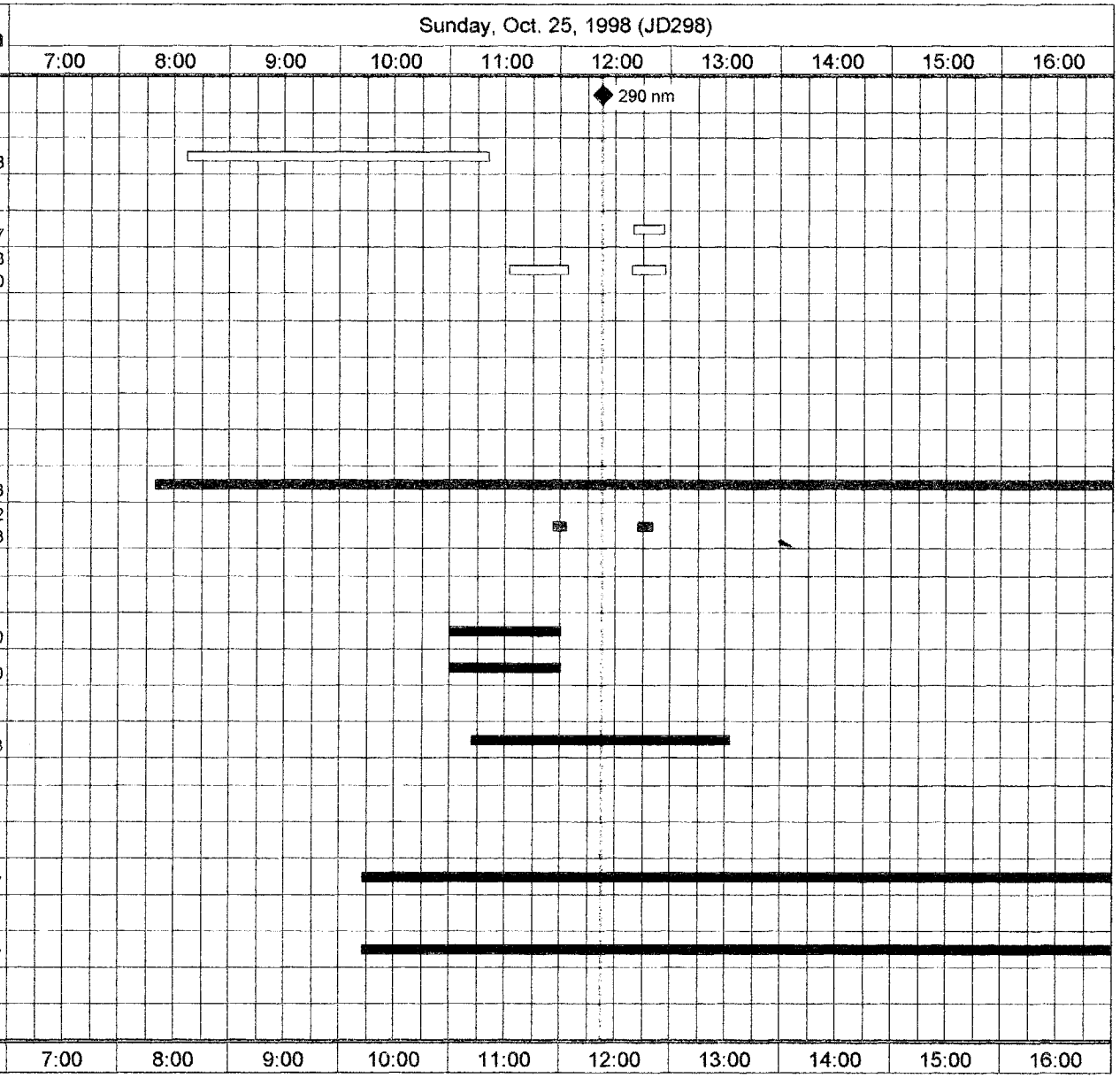
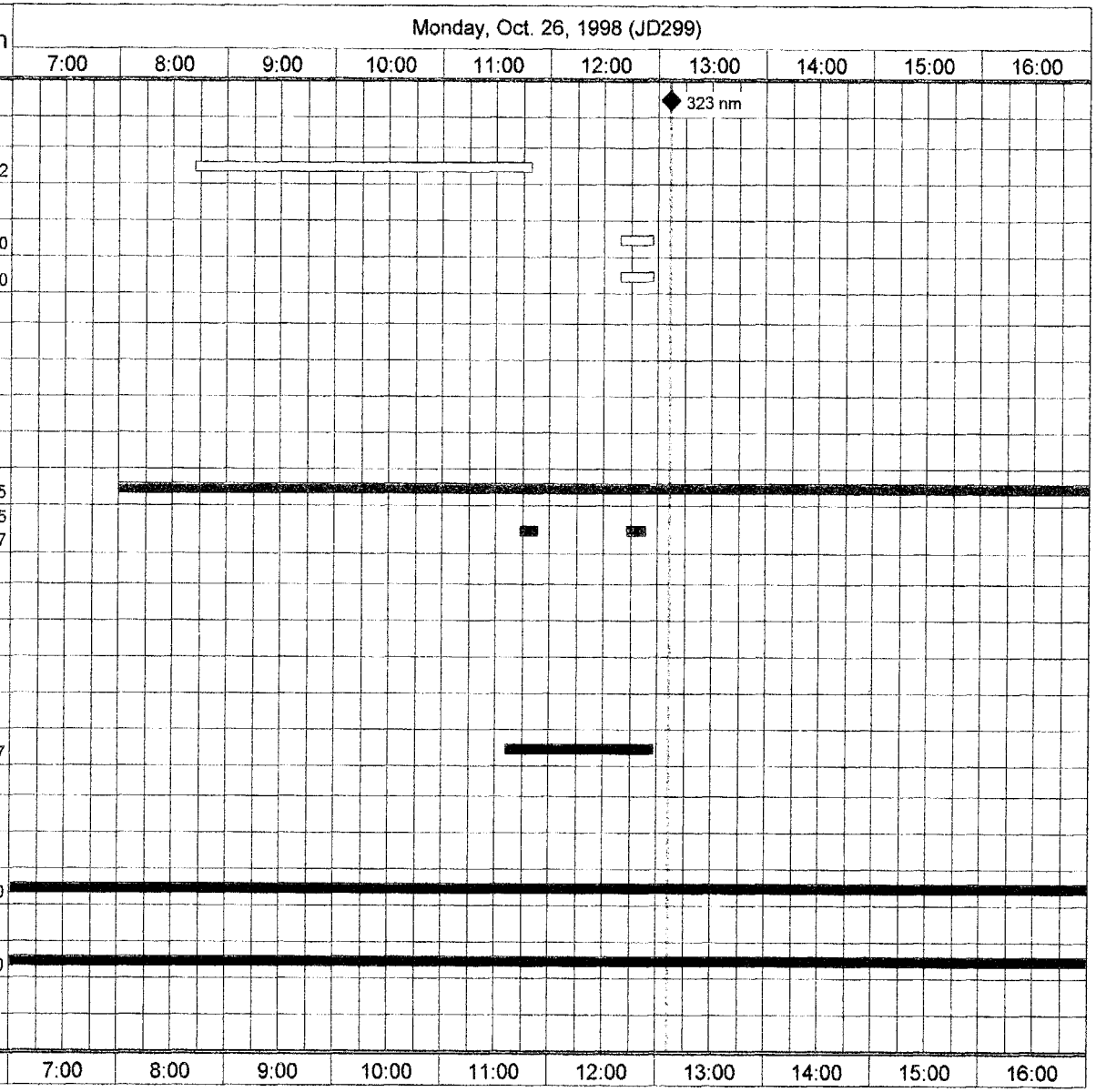


FIGURE 4.

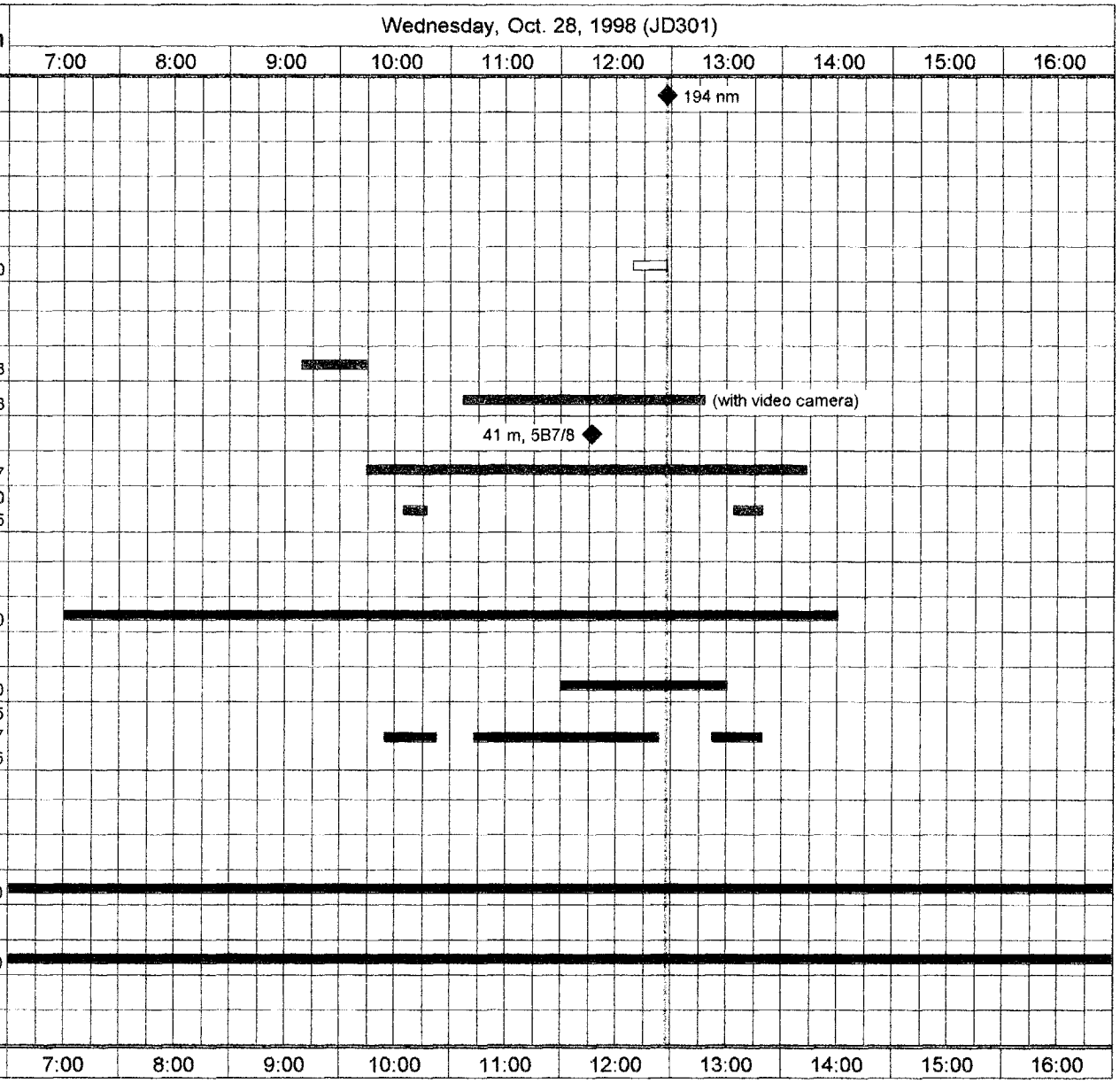
MOBY - L38 / M211SOBP
Station 2: MOBY Site II

Activity Name	Start Time	Finish Time	Duration
SeaWiFS Overpass	1:07 PM		
MOBY Calibrations	8:42 AM	11:49 AM	3.12
MOBY Observations			
MOBY206	12:39 PM	12:57 PM	0.30
MOBY207	12:39 PM	12:57 PM	0.30
Bio-Optics			
CTD Cast			
MOS Cast			
Secchi Disk			
SIS	8:00 AM	6:27 PM	10.45
SPMR Cast	11:44 AM	11:53 AM	0.15
	12:43 PM	12:53 PM	0.17
Atmospherics			
HHCRM			
Micro Tops			
MD5			
Video - Sky	11:36 AM	12:58 PM	1.37
Miscellaneous			
CIMEL Site			
Meteorological	12:00 AM	12:00 AM	24.00
P-3 Overflight			
Sea-Chest	12:00 AM	12:00 AM	24.00
Station Grid/Track			
Van Veen Grab			



MOBY - L38 / M211SOBP
Station 3: MOBY Site III

Activity Name	Start Time	Finish Time	Duration
SeaWiFS Overpass	12:58 PM		
MOBY Calibrations			
MOBY Observations			
MOBY206			
MOBY207	12:39 PM	12:57 PM	0.30
Bio-Optics			
CTD Cast	9:39 AM	10:14 AM	0.58
MOS Cast	11:07 AM	1:18 PM	2.18
Secchi Disk	12:17 PM		
SIS	10:15 AM	2:13 PM	3.97
SPMR Cast	10:35 AM	10:47 AM	0.20
	1:34 PM	1:49 PM	0.25
Atmospherics			
HHCRM	7:30 AM	2:30 PM	7.00
Micro Tops			
MD5	12:00 PM	1:30 PM	1.50
Video - Sky	10:25 AM	10:52 AM	0.45
	11:13 AM	12:53 PM	1.67
	1:22 PM	1:49 PM	0.45
Miscellaneous			
CIMEL Site			
Meteorological	12:00 AM	12:00 AM	24.00
P-3 Overflight			
Sea-Chest	12:00 AM	12:00 AM	24.00
Station Grid/Track			
Van Veen Grab			



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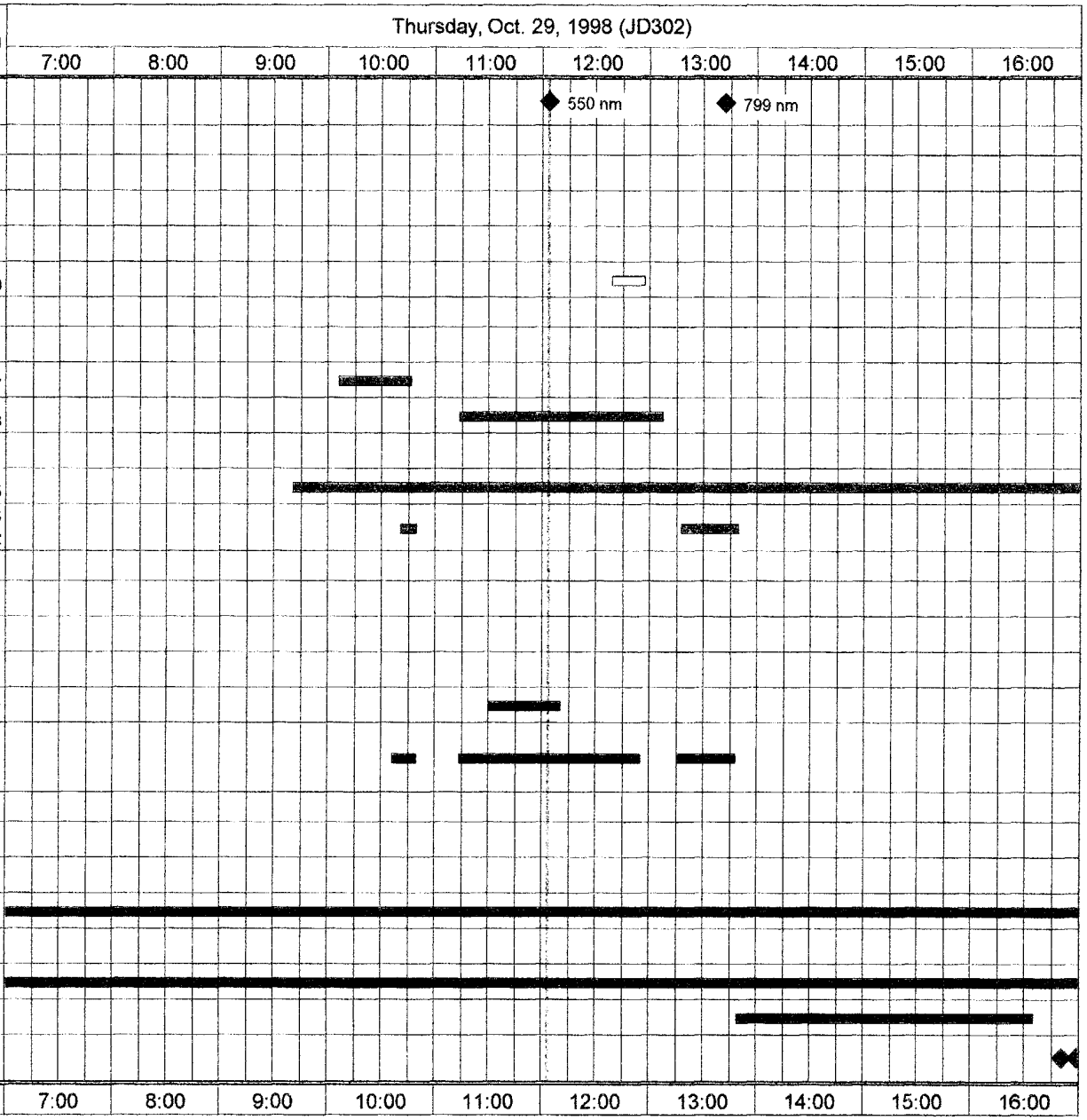
9Dec98

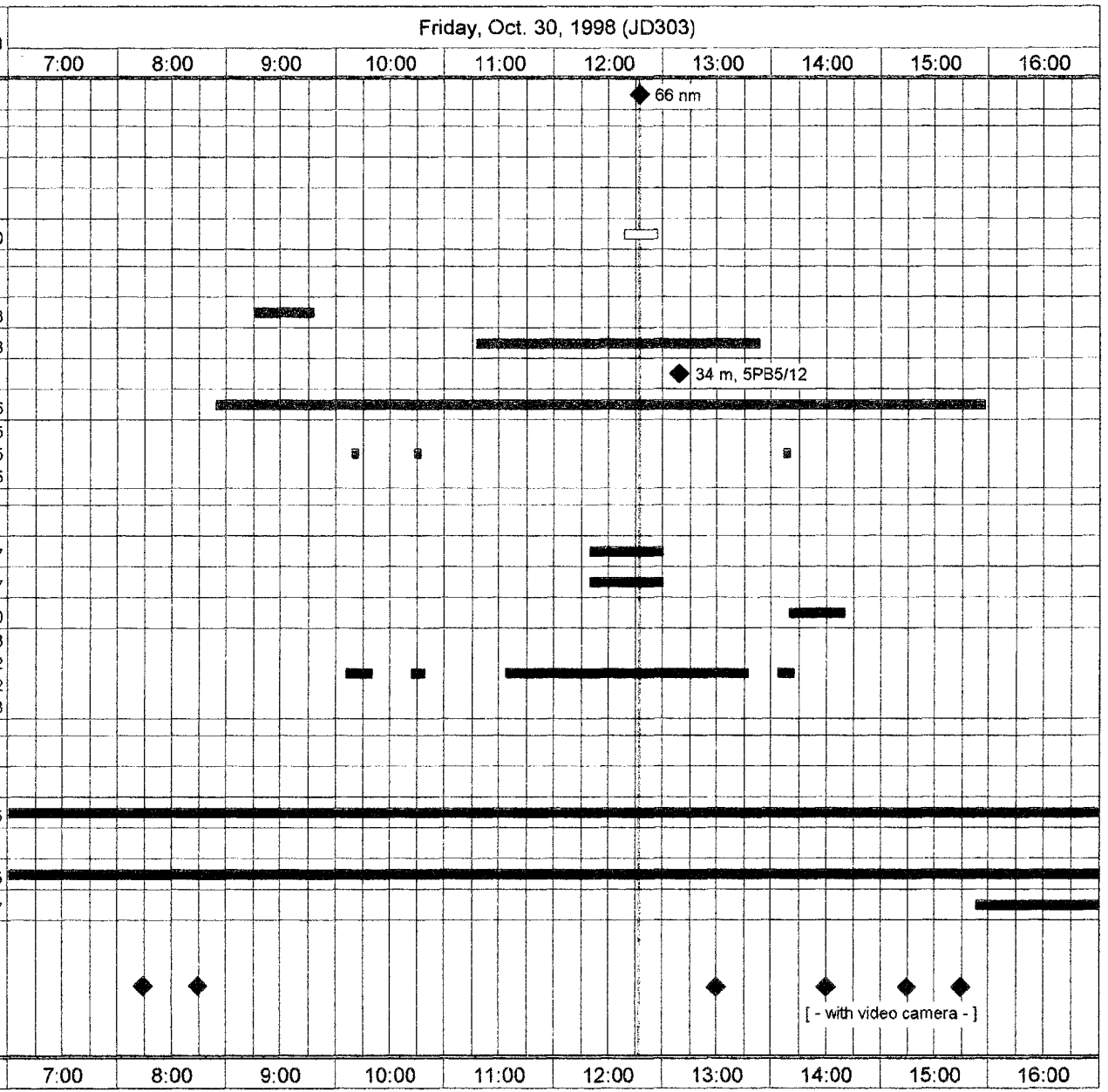
MOBY - L38 / M211SOBP
Station 4: MOBY Site IV

Activity Name	Start Time	Finish Time	Duration
SeaWiFS Overpass	12:04 PM 1:42 PM		
MOBY Calibrations			
MOBY Observations			
MOBY206			
MOBY207	12:39 PM	12:57 PM	0.30
Bio-Optics			
CTD Cast	10:06 AM	10:46 AM	0.67
MOS Cast	11:14 AM	1:07 PM	1.88
Secchi Disk			
SIS	9:41 AM	5:32 PM	7.85
SPMR Cast	10:41 AM 1:18 PM	10:49 AM 1:49 PM	0.13 0.52
Atmospherics			
HHCRM			
Micro Tops			
MD5	11:30 AM	12:10 PM	0.67
Video - Sky	10:36 AM 11:14 AM 1:16 PM	10:49 AM 12:55 PM 1:48 PM	0.22 1.68 0.53
Miscellaneous			
CIMEL Site			
Meteorological	12:00 AM	12:00 AM	24.00
P-3 Overflight			
Sea-Chest	12:00 AM	12:00 AM	24.00
Station Grid/Track	1:49 PM	4:35 PM	2.77
Van Veen Grab	4:51 PM 4:59 PM		



MOBY - L38 / M211SOBP
Station 5: Penguin Banks

Activity Name	Start Time	Finish Time	Duration
SeaWiFS Overpass	12:48 PM		
MOBY Calibrations			
MOBY Observations			
MOBY206			
MOBY207	12:39 PM	12:57 PM	0.30
Bio-Optics			
CTD Cast	9:16 AM	9:48 AM	0.53
MOS Cast	11:18 AM	1:53 PM	2.58
Secchi Disk	1:09 PM		
SIS	8:55 AM	3:58 PM	7.05
SPMR	10:09 AM	10:12 AM	0.05
	10:44 AM	10:47 AM	0.05
	2:07 PM	2:10 PM	0.05
Atmospherics			
HHCRM	12:20 PM	1:00 PM	0.67
Micro Tops	12:20 PM	1:00 PM	0.67
MD5	2:10 PM	2:40 PM	0.50
Video - Sky	10:06 AM	10:20 AM	0.23
	10:42 AM	10:49 AM	0.12
	11:34 AM	1:47 PM	2.22
	2:04 PM	2:12 PM	0.13
Miscellaneous			
CIMEL Site			
Meteorological	12:00 AM	6:21 PM	18.35
P-3 Overflight			
Sea-Chest	12:00 AM	6:21 PM	18.35
Station Grid/Track	3:53 PM	6:21 PM	2.47
Van Veen Grab	8:15 AM		
	8:45 AM		
	1:30 PM		
	2:30 PM		
	3:15 PM		
	3:45 PM		



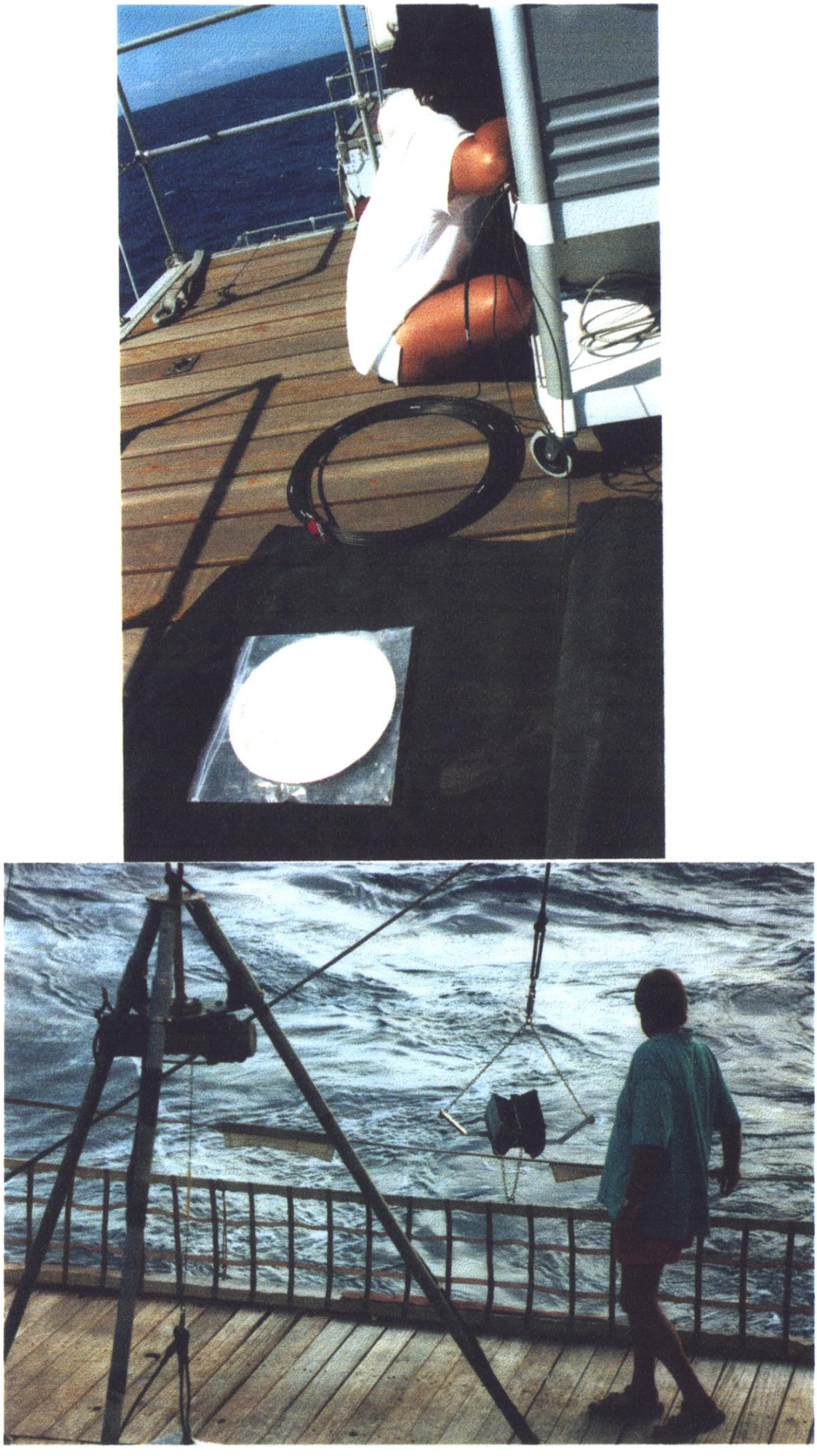


FIGURE 5.

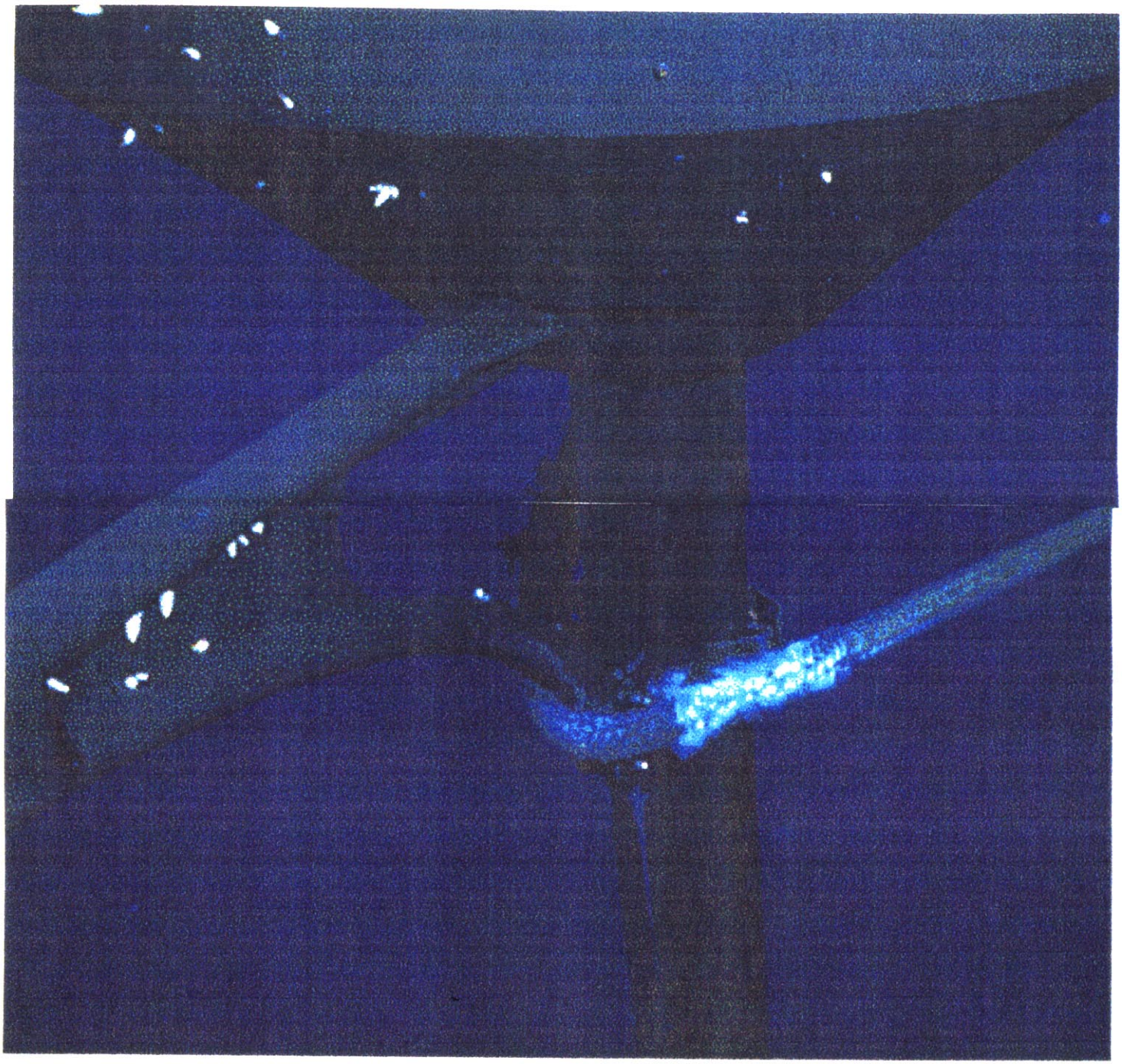


FIGURE 6.

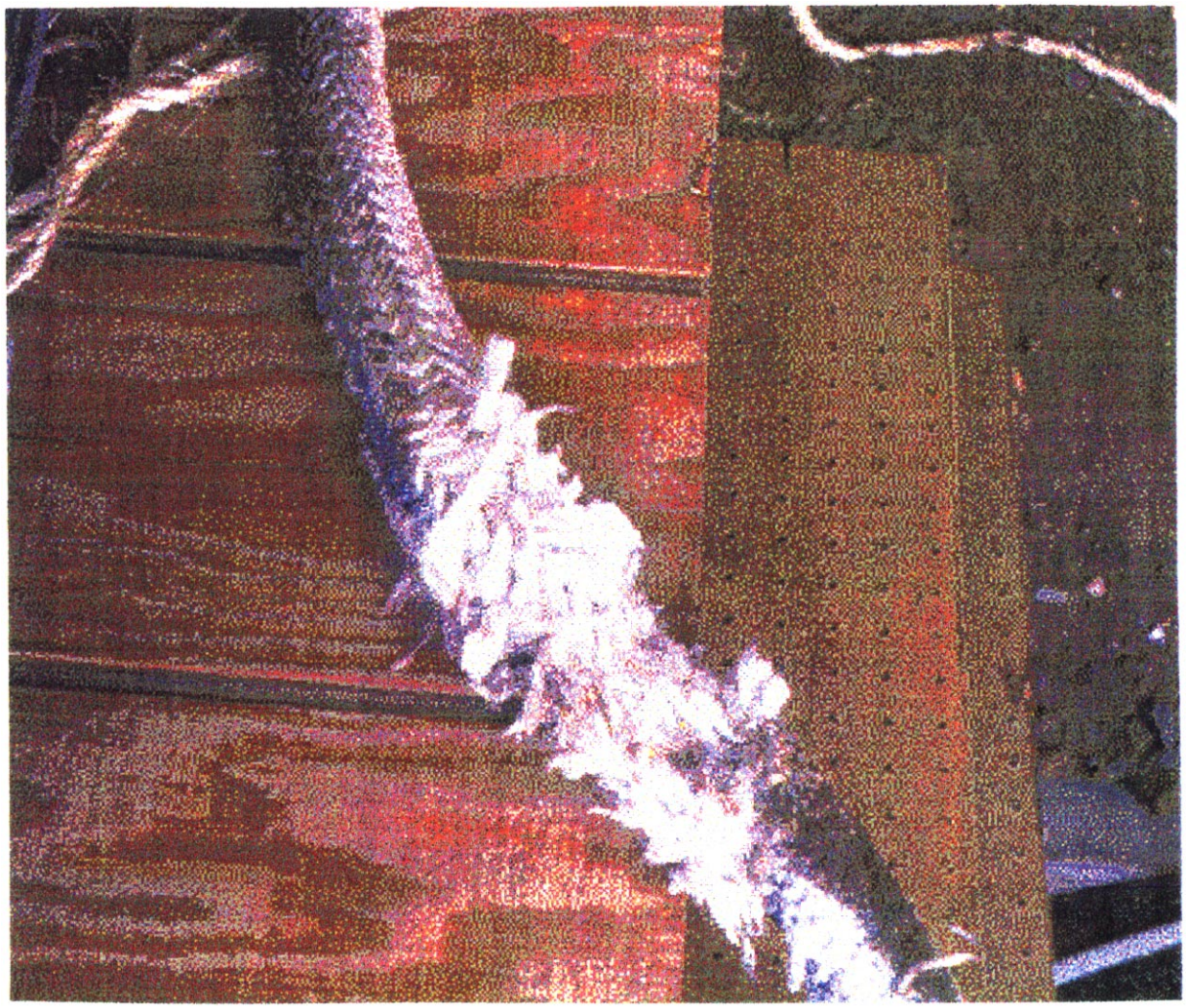


FIGURE 7.

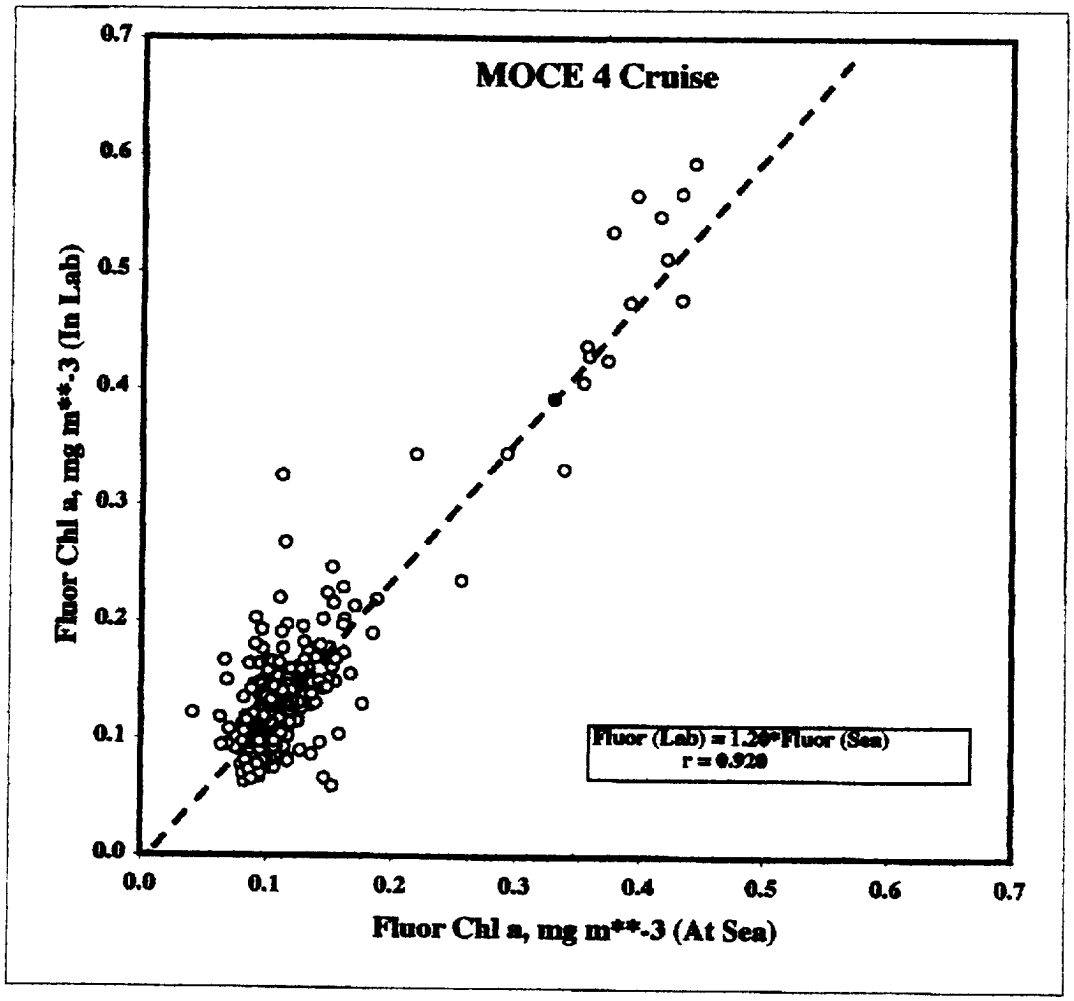


FIGURE 8. Comparison between fluorometrically determined chlorophyll a concentrations measured at sea and replicate samples processed in the laboratory using the same method.

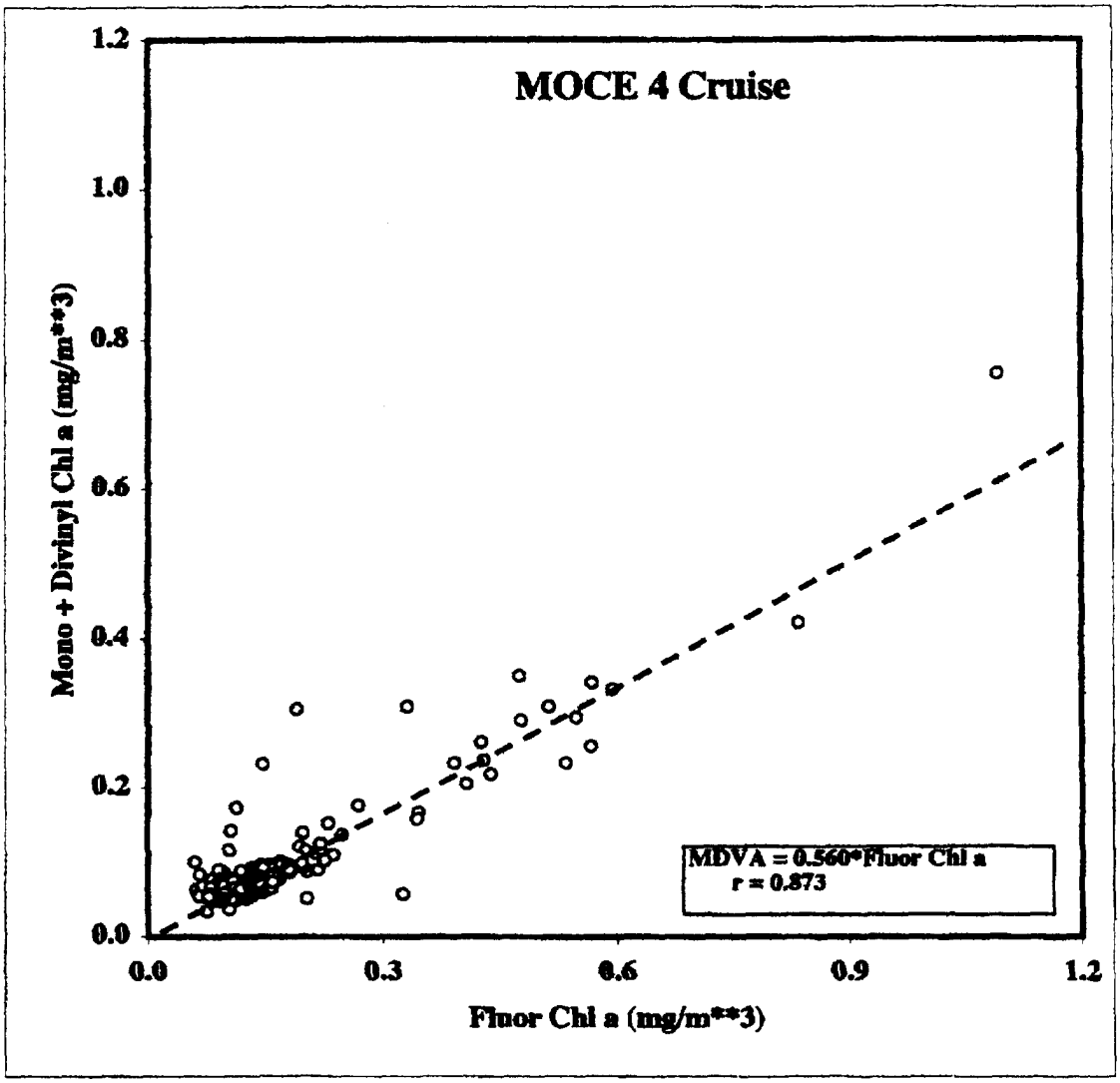


FIGURE 9. Comparison between fluorometrically measured chlorophyll a and HPLC measured monovinyl plus divinyl chlorophyll a.

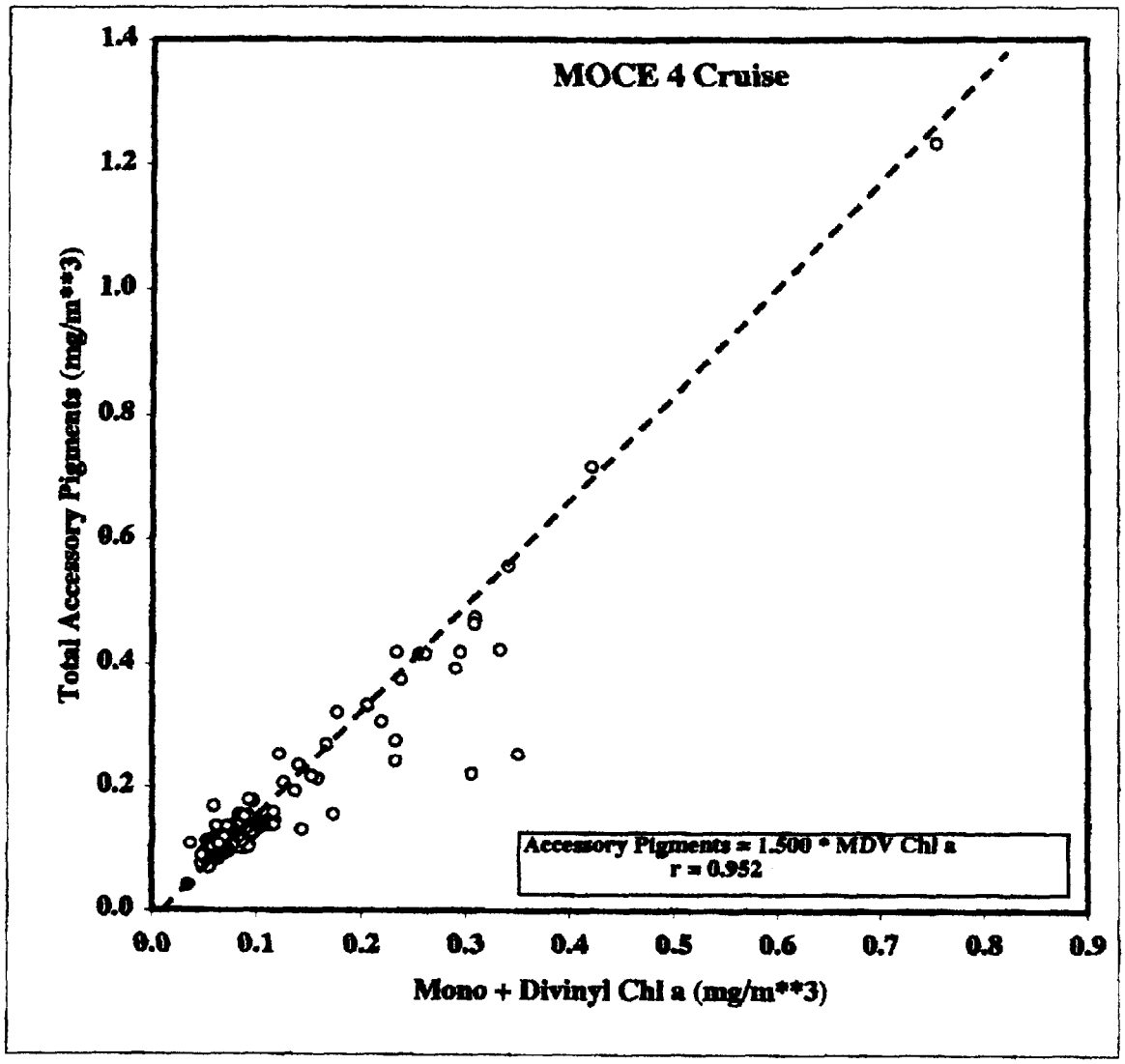


FIGURE 10. Monvinyl plus divinyl chlorophyll a versus total accessory pigment concentration.

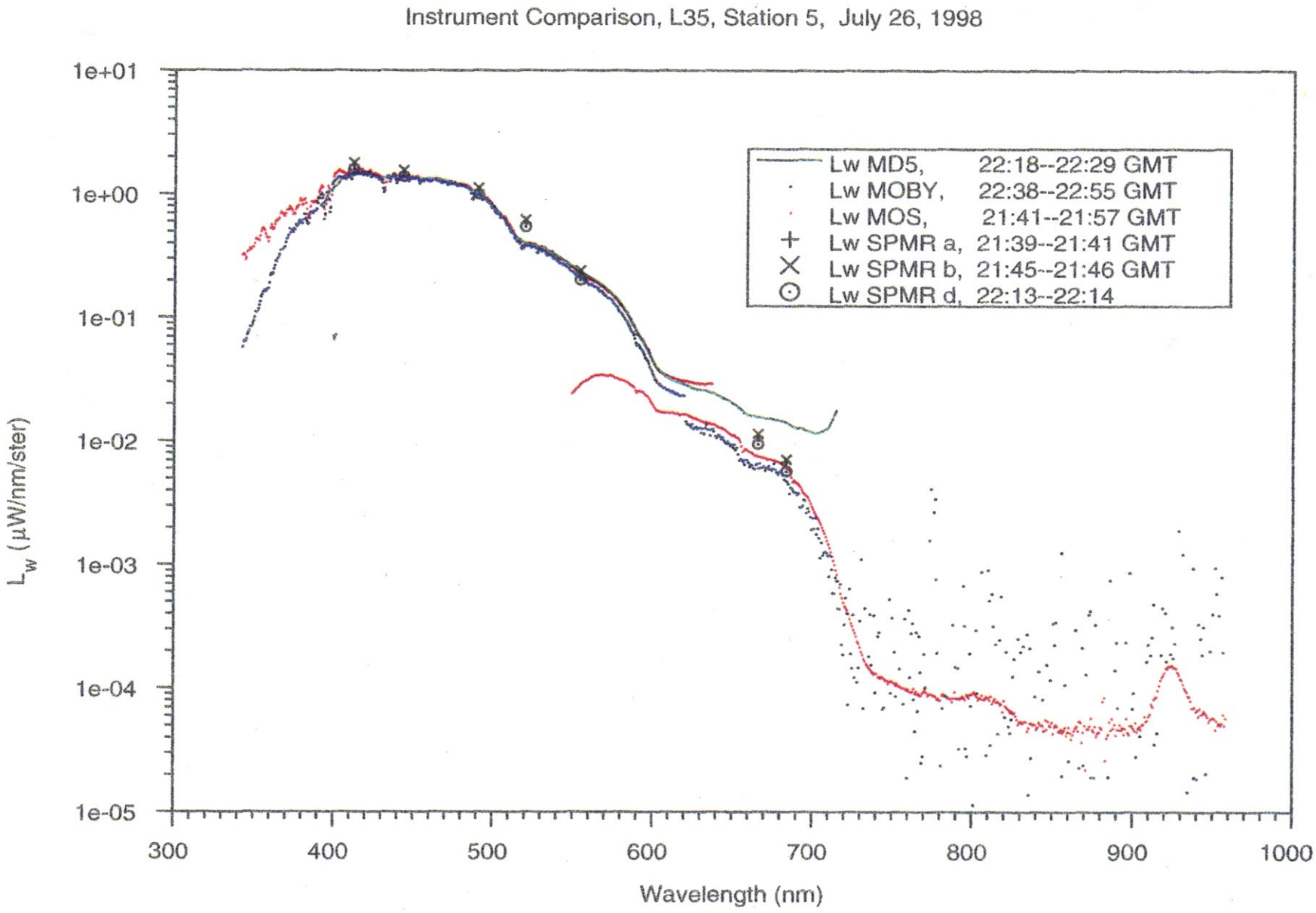

Instrument Comparison, L35, Station 5, July 26, 1998
Lw MD5, 22:18--22:29 GMT
Lw MOBY, 22:38--22:55 GMT
Lw MOS, 21:41--21:57 GMT
Lw SPMR a, 21:39--21:41 GMT
Lw SPMR b, 21:45--21:46 GMT
Lw SPMR d, 22:13--22:14
1e+01
1e+00
1e-01
1e-02
1e-03
1e-04
1e-05
L_w (µW/nm/ster)
300
400
500
600
700
800
900
1000
Wavelength (nm)

FIGURE 11.

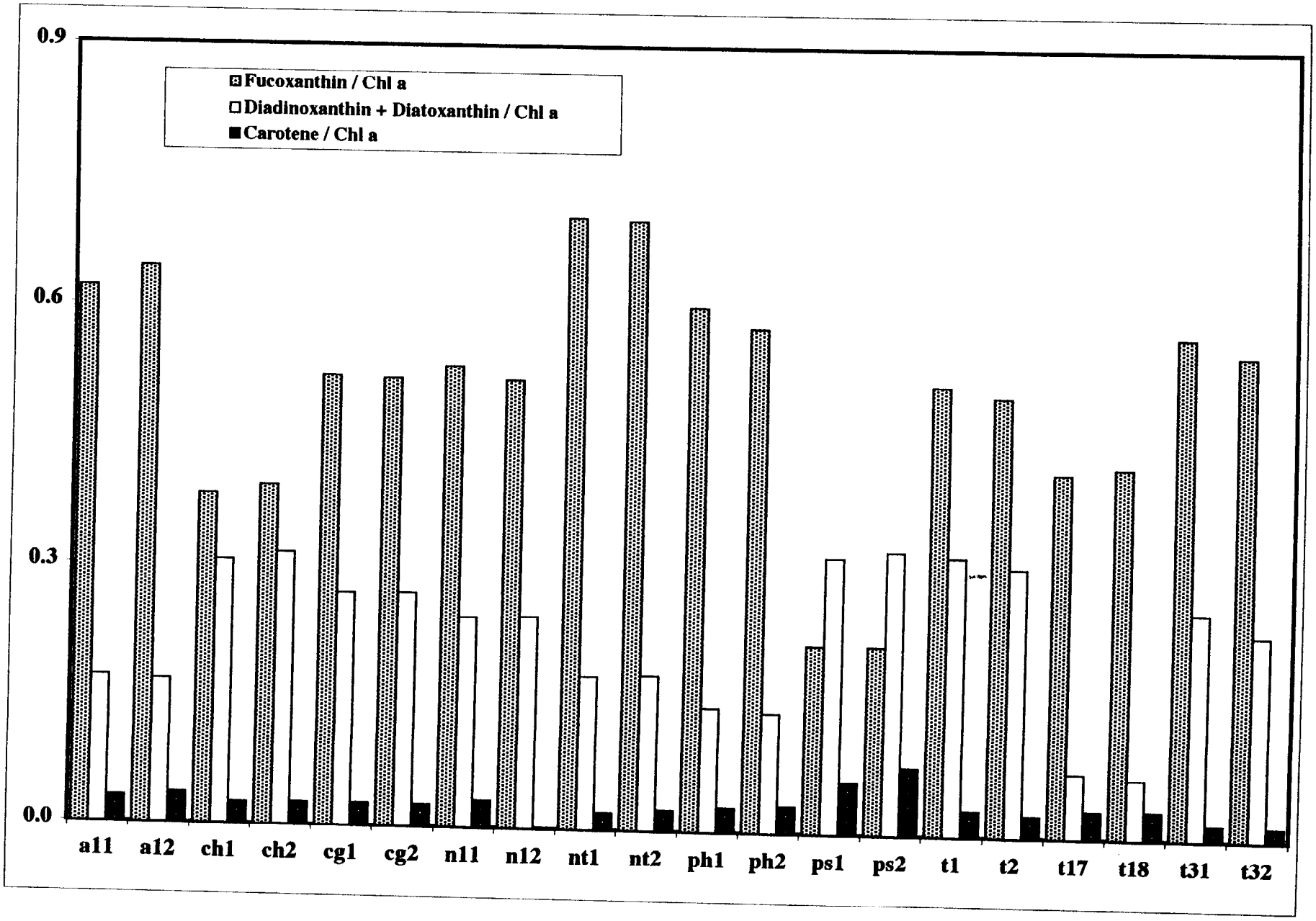

0.9
0.6
0.3
0.0
Fucoxanthin / Chl a
Diadinoxanthin + Diatoxanthin / Chl a
Carotene / Chl a
a11
a12
ch1
ch2
cg1
cg2
n11
n12
nt1
nt2
ph1
ph2
ps1
ps2
t1
t2
t17
t18
t31
t32

FIGURE 12.