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

Dennis K Clark
NOAA/NESDIS

SUMMARY

During this reporting period the Marine Optical Characterization Experiment (MOCE) team conducted three major field campaigns. During the first expedition (July 8-31), the Marine Optical Buoy (MOBY203) system was successfully deployed. This MOBY was the original prototype system which has been completely revised and is the third fully operational system developed for MODIS and SeaWiFS support. The team conducted an initial calibration/validation experiment (September 16 - October 5), in which radiometric, biological and atmospheric measurements were collected during SeaWiFS overflights. During the beginning of this cruise, the University of Hawaii's R/V Kila went aground on the reef at Lahaina rendering the vessel inoperable. The team then had to reduce the scope of the observations and utilize a 25 ft. dive boat for operations at the mooring site. In spite of this set back, basic optics and pigment data for five out of seven SeaWiFS coincident overpasses were acquired. The MOBY vicarious calibration data was used to adjust the SeaWiFS calibration coefficients and the match-up data base efforts are being continued in an operational mode.

During this MOBY deployment period the tether line attaching MOBY203 to the mooring buoy was apparently cut on October 26 and again on November 30. During the October incident the MOBY GPS unit indicated the buoy had drifted west at a speed of about 1 knot onto Penguin Bank. Argos positions were not available as the batteries failed the day MOBY drifted free. MOBY was confirmed adrift via chartered airplane on October 29. MOBY was recovered from its grounded location at Penguin Bank via a Smith Maritime vessel Uaukewai on October 30, towed back to Lanai mooring site, and reattached to the mooring (MOBY-L23). During the November incident all navigation systems were functioning and the buoy again moored itself on the Penguin Bank. The buoy was successfully recovered during the mooring and buoy refurbishment cruise (December I- 18). The replacement system (MOBY204) and a new deep-sea mooring was deployed from R/V Ka'imikai-O-Kanaloa during the December operation. Calibration/validation data were collected before and after the MOBY exchange.

OCTS - VALIDATION/CALIBRATION

The Marine Optics Team provided MOBY and cruise bio-optical data sets for Japan's Ocean Color Temperature Sensor calibration scientists in early August. These data were collected during the test and evaluation deployments of the MOBY systems during October 1996 through February 1997. A total of six stations and nineteen

MOBY clear day matchups were sent to NASDA and Goddard Space Flight Center.

FIELD OPERATIONS

M205DOBP (MOBY-L20)

Team members conducted MOBY deployment and bio-optical data collection (M205DOBP), MOBY assembly, and MOBY operations site maintenance in Hawaii, July 12 - 31, 1997 (MOBY-L20). The following personnel participated:

NOAA -Dennis Clark, Ed Fisher, Yuntao Ge, Ed King, Larisa Koval, Eric Stengel, Marilyn Yuen, Yi Liu and Yong Sung Kim

MLML -William Broenkow, Mike Feinholz, Stephanie Flora, Daryl Peters, and Mark Yarbrough

CHORS - Dan Sullivan and Chuck Trees

University of Hawaii - Mike Ondrusek

University of Miami - Ken Voss, Joe Ritter, Bob Evans, and Peter Evans

Prior to the MOBY- L20 deployment and characterization cruise (M205DOBP), radiometric calibrations were performed on MOS205 and SIS. MOBY203 sensors (incorporating the MOS205 radiometer) calibrated on July 10-12 included upwelled radiance at the top, mid, and bottom arms using the OL420M and GS5000 standard sources, and downwelled irradiance at the surface, top, mid, and bottom arms using the GS5000 calibration source. Calibrations were performed at optimal multiplexer positions as well as one position above and below optimum in case the problems similar to those during the MOBY202 deployment are encountered.

Wavelength calibration of MOS205 was checked by scanning line source lamps through the MOBY multiplexer/fiber-optics/collector-head optical path. The profiling radiometer, MOS202, was calibrated for irradiance via the GS5000, radiance via the OL420M, integration time and bin factor via the OL420M, and wavelength via HgA, Ne, Kr, and Xe Oriel lamps. The surface-incident radiometer, SIS101, was calibrated for spectral irradiance on via the GS5000 source.

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 GS5000 calibration system was returned to the manufacturer for calibration after the cruise.

The program bug was fixed in the diver calibration routines which prevented usage of CCD parameters contained in the hard disk parameter file. The final electrical testing

of power system and cellular communications was performed. The final mechanical assembly was conducted and anti-foulant paint was applied.

In preparation for the approaching launch of SeaWiFS, the third Marine Optical Buoy, MOBY203, was successfully deployed at the Lanai, Hawaii mooring site on July 20, 1997 from the R/V Moana Wave (Fig.1).

Five oceanographic stations were acquired during the eight day M205DOBP cruise (July 20-27, 1997). The team activities associated with this deployment included; three buoy diver calibrations, five CTD casts, three MOS profiles, two MOS long-track time-series, and 13 TSM/POC/PON transects. The CTD casts and along-track water pumping yielded 52 TSM and 43 POC/PON filters. During this cruise, 85 HPLC pigment samples were collected for analysis, 34 vertical samples were collected from the CTD, primary productivity and VLST casts, and 29 replicate samples were collected at 3 meters depths and analyzed by HPLC. For the summed mono- and divinyl chlorophyll a and total accessory pigment concentrations for these replicate samples, the average coefficient of variation was found to be only 4.8% and 5.3%, respectively. The data collection was completed and the results were delivered to NOAA.

During the cruise, 53 samples were also collected for pigment analysis using the standard fluorometric technique. The old VisLab fluorometer was shipped to Hawaii for the cruise due to a calibration problem that had occurred with the new Turner Designs Fluorometer during the M204 cruise (February 1997). Mike Ondrusek, University of Hawaii, provided the chlorophyll a standard. A new standard was shipped to Hawaii with the concentration being verified by two spectrophotometers. Both fluorometers were calibrated together and all fluorometric samples were analyzed on both. These results indicated that the problem during M204 was indeed associated with the pigment standard provided by University of Hawaii. The difference between the two fluorometers using the new standard was only 9%. Total particulate and dissolved organic material samples were collected and processed during the cruise. The particulate and DOM absorption data have been delivered to NOAA. In addition, we maintained and performed *in-situ* calibrations on the VisLab Spectral Transmissometer during the various survey tows.

Sun photometer measurements, to derive the spectral transmittances, were performed during the cruise.

In addition to the MOBY deployment, the MOCE team also collected atmospheric and in-water data near the Pu'u O'o vent for further examination of volcanic aerosol effects. The Pu'u O'o vent is located on the Big Island of the Hawaiian archipelago, approximately 10 miles east of Kilauea National Park. Lava was flowing through this vent during M205DOBP. Atmospheric optical measurements were conducted using the MD5 (American Holographic) radiometer to measure near zenith sky radiance and total sky irradiance while the ship was close to the volcano (Fig.2). The M205 track line is shown in Fig. 3.

Radiometric data using the Satlantic profiling system were also collected during M205DOBP. 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 (1991, CHORS Tech. Mem. 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 after the successful deployment of MOBY203 (Fig. 4). Personnel from MLML completed the diver calibration programs. The programs calculate ratios to analyze changes in collector throughput and detector response over time. Also a diver calibration Web page has been developed which allows NOAA team members to easily view the results of the latest diver calibrations.

Postcruise radiometric calibrations were performed on MOS202 and SIS. The MD5 radiometer was post-calibrated for spectral radiance, spectral irradiance, and wavelength. The Hand Held Contrast Reduction Meter (HHCRM) was calibrated using the OL420M standard source.

M2060B (MOBY-L22)

Team members conducted the initial calibration/validation experiment (M2060B) in Hawaii, September 18 - October 10, 1997. The following personnel participated:

NOAA -Dennis Clark, Ed King, Eric Stengel

MLML - Mike Feinholz, Mark Yarbrough, Yong Sung Kim

CHORS - Dan Sullivan, Chuck Trees

This was a multi-platform effort, utilizing the University of Hawaii's R/V Kila and Hawaiian Rafting Adventures R/V Manta. The purpose of this trip was to perform radiometric and biological measurements during SeaWiFS overflights and conduct diver calibrations of the MOBY system.

Precruise preparations included calibration of MOS202, SIS101, the HHCRM, MD5 fiber optic radiometer as well as outfitting the R/V Kila for profiling and water sampling operations.

Sun photometer HHCRM calibrations were performed on October 1 through a Langley calibration procedure. The validity of using these measurements as

calibration of a sun photometer hinges strongly on the assumption that aerosols are uniformly distributed and do not vary throughout the day. Therefore, an area of atmospheric stability with low aerosol loading was chosen to perform the calibration, It was at an altitude of 10000 feet on Haleakala mountain on Maui (Fig. 5). The Langley plots derived from these measurements are shown in Fig. 6.

During this cruise, 26 HPLC pigment samples were collected using a large volume (>6 liter) positive filtration system. For the samples collected on the R/V Manta, we rigged up a positive pressure system using a gas regulator and a dive tank. The samples were shipped under LN2 to CHORS for HPLC analysis starting on October 27. The analysis has been completed and Table 1 lists the pigment concentrations. Similar relationships were found for this cruise as compared to other MOBY mooring cruises for MDVA (monovinyl plus divinyl chlorophyll a) versus fluorometrically determined chlorophyll a (Fig. 7A) and total accessory pigment concentrations (Fig. 7B). Because of limited space on both vessels, samples were not collected for total particulate or dissolved organic material analyses. Only two Satlantic profiles were made on September 26, because the R/V Kila ran aground after that date and had to be towed to Honolulu for repairs.

M207SOBP (MOBY-L25)

The following personnel participated:

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

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

CHORS - Chuck Trees

University of Hawaii - Mike Ondrusek

Mooring Systems Inc. - Peter Clay and Doug Dooner

Precruise preparations included two complete radiometric calibrations of MOBY204 upwelled radiance and downwelled irradiance collectors (Lu & Ed - Surface, Top, Mid, Bot). The SIS101 radiometer was calibrated for irradiance while MOS202 and MOS 204 were calibrated for integration time, wavelength, radiance, and irradiance. MOS 202 was used for profiling measurements while MOS204 was installed on MOBY204. MOS stability was monitored via scans of the internal incandescent lamp and blue/red LED’s during all calibration runs. SCAMPS (412 and 870 nm) scans of radiance and irradiance sources were performed at the beginning and at the end of each calibration run to monitor lamp stability and ambient light conditions. In addition, time-series SCAMPS background scans were made to monitor internal SCAMPS stability. Radiance scans were made with the HHCRM while the MD-5 VIS system was

calibrated for wavelength and irradiance and the MD-5 VIS/NIR systems were calibrated for wavelength, radiance, and irradiance. The WV Ka'imikai-O-Kanaloa was outfitted for MOBY mount and at-sea operations.

The MOBY203 was again cut adrift on November 30. The buoy was tracked via GPS and Argos until it anchored itself by the flopper stoppers on Penguin Bank. The buoy was taken in tow on December 7 to the lee of Molokai for recovery during the first leg of the MOBY-L25 cruise as originally planned. The deep-sea mooring was also replaced on December 8 - 9 (Fig 8). MOBY deployment activities began December 11 and ended December 12 (Fig. 9). Rough seas interfered with tethering MOBY to the mooring buoy. Hawaiian Rafting Adventures personnel participated in the initial diver calibrations on December 14.

A major ship-wide power surge occurred before departure on 7 December. All four of the UPSes in the power hut were blown out. Loss of clean power was not discovered until 12:30 local time (all equipment were turned off at this time). One of the UPSes, which supplied clean power to the data acquisition hut, was repaired and DAQ resumed around the start of the second leg of the cruise.

During this trip we had to adapt the water collection system to the R/V Ka'imikai-O-Kanaloa. The filtration van was placed on the ship's 03 level. Clean surface water was pumped from the ship's moon hole to the filtration van for continuous alongtrack *in vivo* fluorescence. In addition, a Chelsea fluorometer was mounted in the moon hole measuring alongtrack *in vivo* fluorescence. Twenty seven fluorometric samples were collected and analyzed on the ship. Large volume HPLC samples (30) were collected and stored under LN2 for analysis at CHORS. Total particulate (22) and dissolved organic material (23) absorption samples were collected and analyzed during the cruise. Another Chelsea fluorometer was also placed on the MLML CTD system to improve near surface estimates of *in vivo* fluorescence.

Four oceanographic stations were occupied during the eight days of ship time. Three CTD casts, two MOS profiles, and TSM/POC/DOM transects were performed.

To improve our HPLC system, a new photodiode array detector, PDA (ThermoQuest UV6000LP), was purchased by NOAA, This detector utilizes light pipe technology and scans from 190 to 800 nm at 20 Hz with 20 bit analog-to-digital conversion. The real advantage of the UV6000LP is the increased sensitivity (factor of five over other detectors) by using a 50 mm flow cell and reducing the flow cell volume (2 ml per 10 mm of pathlength). This means that the large HPLC volumes filtered previously (4 to 6 liters) can be reduced to improve filtration time and enhance detection of some of the minor pigment compounds.

The Spectrex Laser particle counter was tested during the cruise and the data looked good. This machine will be used for the SeaWiFS initialization cruise in January 1998. The Galai laser particle counter still has not been fixed and is currently at Brookhaven Instruments in New York.

The Satlantic freefall radiometer malfunctioned during the cruise and has since been fixed. The problem was solved by replacing a bad connector on the sensor.

A hand-held multi-band sun photometer (MICROTOPS II) was used to measure atmospheric transmittance, total ozone column (the equivalent thickness of pure ozone layer at standard pressure and temperature), and precipitable water column.

MOCE/MOBY Team activities for 1997 are shown in Figure 10.

SOFTWAREDEVELOPMENT

The at-sea acquisition system software and hardware updates have been completed. The system consists of 11 computers that controls various instruments. The GPS (Global Positioning System) data (latitude, longitude, speed over ground, heading, and universal time) from two tracking systems are logged by a PowerMac 7300/200 simultaneously., One system is controlled by GPIB (IEEE 488.2 standard) interface, the other by serial connection (RS422). The GPS information is also broadcast through a serial repeater to the other instruments. An electronic flux gate compass controlled with an RS232 serial interface also resides on this computer. The compass provides ship heading direction data so that other data can be corrected accordingly, such as wind speed and direction. This computer also serves as a time server. All other computers synchronize their internal clock by pulling time from this computer through ethernet connection.

The barometer data (air pressure) are logged on a PowerBook 1400cs. A simple RS422 interface is used for this purpose.

Wind speed and direction (two sensors), air humidity and temperature, as well as flow rate measured by two in-line flow meters are all recorded on a PowerMac 7300/180. The original setup for the wind speed measurements was not accurate. The speed sensor measures wind speed from about 1 m/s to 60 m/s. This range is mapped to 0-1 V DC, that is 17 mV for every 1 m/s wind speed change. The two sensors are mounted in front of the ship, cables about 150 ft long were used to connect the sensor to the A/D card. Over this length of cable, the detected noise is around 50 mV, creating an error of about 2 m/s, that is 3 to 4 knots. Also it was found that the A/D (analog to digital conversion) card was set to take differential measurements (voltage difference between two wires), but the physical wire connection was done for the single-ended measurements (voltage between signal and fixed ground). Thus all the data measured to that point were wrong and had to be discarded. To fix these problems, a pulse signal was pulled out. The pulse train is generated by three pairs of magnets in the wind sensor. The frequency varies with wind speed. If we measure the frequency, then it is basically noise immune, since frequency counting is similar to digital signals. The software was also rewritten to accommodate this change. A new calibration procedure was advised to take advantage of the new scheme. Wind direction is measured directly with ND conversion. Temperature and humidity are measured with two channels on the A/D card. Flow rate is taken through HP frequency counters controlled by GPIB.

The temperature and salinity data are recorded on a PowerBook 1400cs.

A utility called master log runs on a PowerBook 1400cs. Users input their activities into the program. This information is combined with time and location obtained automatically and recorded in a file. For routine activities such as alongtrack fluorometric and VLST measurements, profile case, information can be logged in with just a button push in the program. At the end of each cruise, a master log file that recorded all activities is generated.

The fluorometric and VLST system is rather complicated. Three computers are involved. Signals that include fluorescence voltage, depth, GPS time and position, transmittance, filter, mode and temperature are all recorded on a PowerMac 7300/200 computer. These data are packaged and sent to through a serial communication line to another computer called VLST Relay. The relay computer takes the packaged data, unpacks and displays it, and relays the data to yet another computer located in the wet lab. This computer is used for display and data logging. Personnel in this lab use the information to decide when to take a water sample for analysis. They record their calibration data in the program called pigment log, which writes all the chlorophyll calibration information into a file.

All of the above computer systems are networked via ethernet.

The MOCE data processing software was updated. A few changes accommodating the data format have been added. Now the software should make the data processing almost near real- time at sea.

The data acquisition software for the fiber optic measurement system was also upgraded. New functions have been added to generate file names according to measurement time automatically. Users have the option to input the file name or take the default. It makes it faster to do the measurements. Also added was the ability to change the headers recorded to the files.

The SGI Challenge computer was upgraded with 10 hard disks and FIDI link. The 10 hard disks have the capacity of 9 GB each disk, for a total of over 90 GB. Together with the original 2 GB system disk and 4 GB second disk, the total now is brought up to about 100 GB. We are ready to process SeaWiFS image data. MODIS processing is being set up too. The new disks are partitioned into several sub-systems. The 2 GB disk is reserved for system software. The 4 GB disk is reserved for MOBY data, four 9GB-disks are set up as one logical volume (they appear as one disk) for SeaWiFS data, another 4 disk cluster was made for MODIS data. A 9 GB disk is used for application software and user home directories, while the last 9GB disk is partitioned into two sections, one specifically for anonymous ftp and one for additional swap space. Anonymous ftp is set up on this computer to allow data loading over the network. Two DLT drivers are being added to the computer system to read satellite images with tapes. A 4.3 GB magnito-optical disk is also being put on line for quick back up.

Personnel from Moss Landing Marine Laboratories (MLML) completed three solar ephemeris algorithms at various levels of precision to compute solar zenith angles, air mass, sunrise, local noon, etc. These and about ninety other programs have been recently annotated and debugged for general use by the team.

INSTRUMENT DEVELOPMENT

A design of an optical system to allow multiple fiber input into the new VS10 spectrometer system is being developed. The goal is to funnel more than 5 channels into the system at the same time. It we succeed in doing this, a better optical system for under water measurements can be developed. A new mechanism has to be developed to achieve better throughput and image quality.

DATA REDUCTION

A set of data collected by different instruments on MOCE platforms, including MOBY, MOS, MD5, and Satlantic profiling system has been compiled. This data set has been analyzed and compared. It was found that all instruments agree well in the blue part of the spectrum, but disagree over 100% in the red (Fig. 11)

The work on developing an algorithm relating *in vito* fluorescence from Moss Landing's CTD system to chlorophyll *a* concentrations is continuing. Data from all MOCE cruises were used in this analysis. The comparison also assisted in identifying outlyners in the pigment data base. Upon inspection of the processed fluorescence data, it was found that the output from the logged amplified instrument had been averaged prior to being delogged. This generated errors of up to 15% when the fluorescence values were low, such as in near-surface waters off Hawaii. All CTD profiles will have to be processed again. The output from the fluorometer was also found to be very noisy in surface waters (O-30 meters) and at depth (150-200 meters) when fluorescence is low. This noise was evaluated, and it seems to be caused by the instrument itself.

The VLST data and chlorophyll *a* concentrations have been processed for the M204 cruise. Construction of M205 calibration files is underway and as they are completed, M205 data will be processed. Particle size, transmittance, and chlorophyll *a* data sets will be available soon.

Atmospheric transmittance data collected during our cruises were corrected for earth-sun distance. Total optical depths were calculated.

DOCUMENTATION

The web site for Marine Optical Team is being developed. The home page is hosted on a SGI Origin machine. Interested persons can look at it at (URL: http://orbit29i.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.

MEETINGS

D. Clark attended the SeaWiFS Data Evaluation and Acceptance Workshop which was held November 18, 1997 at NASA/GSFC. The workshop included discussions on evaluating and accepting SeaWiFS data, and planning for SeaWiFS initialization expeditions. Clark presented the Marine Optical Team's plans for the SeaWiFS initialization cruise that will take place in January near the Hawaiian archipelago.

CONSOLIDATION OF TEAM RESOURCES

The Marine Optical Buoy (MOBY) facility located at Moss Landing Marine Laboratories (MLML) in Salinas, California was shut down at the end of August. Operational functions previously based at MLML have been transferred to the MOBY operational site in Honolulu, Hawaii. Marine Optical Characterization Experiment team members Mark Yarbrough, Mike Feinholz, and Yong Sung Kim have relocated from California to Hawaii, and Yi Liu has moved to Camp Springs, MD and joined the Marine Optics Team at NOAA as a contractor.

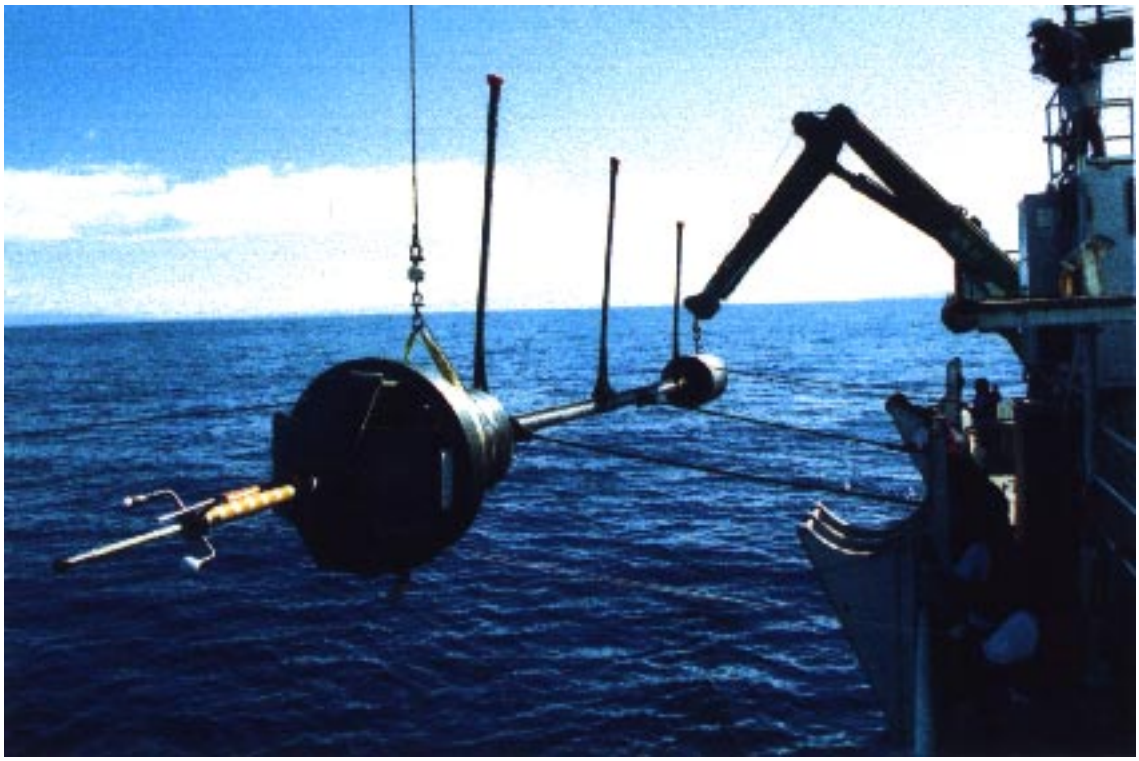


Fig.1 Deployment of MOBY203 on July 20, 1997

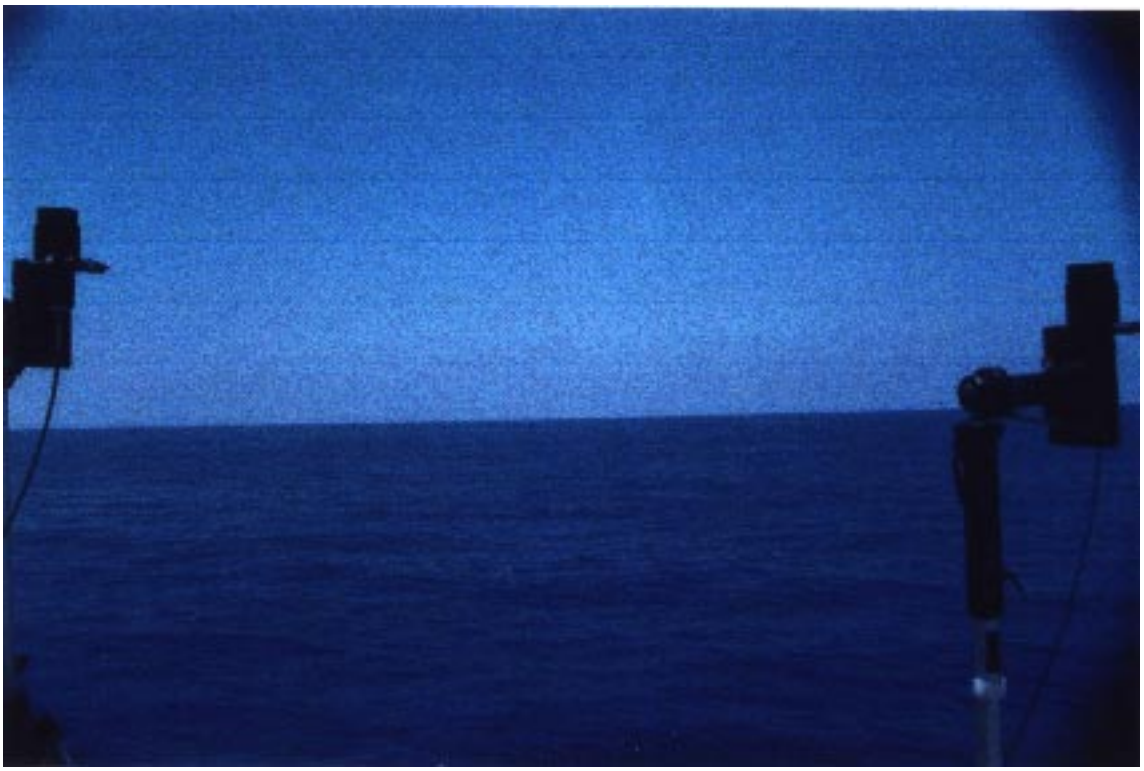


Figure 2. Fiber optic spectrograph data acquisition setup during M205DOBP

M205 Track Line
July 25 - 27 1997

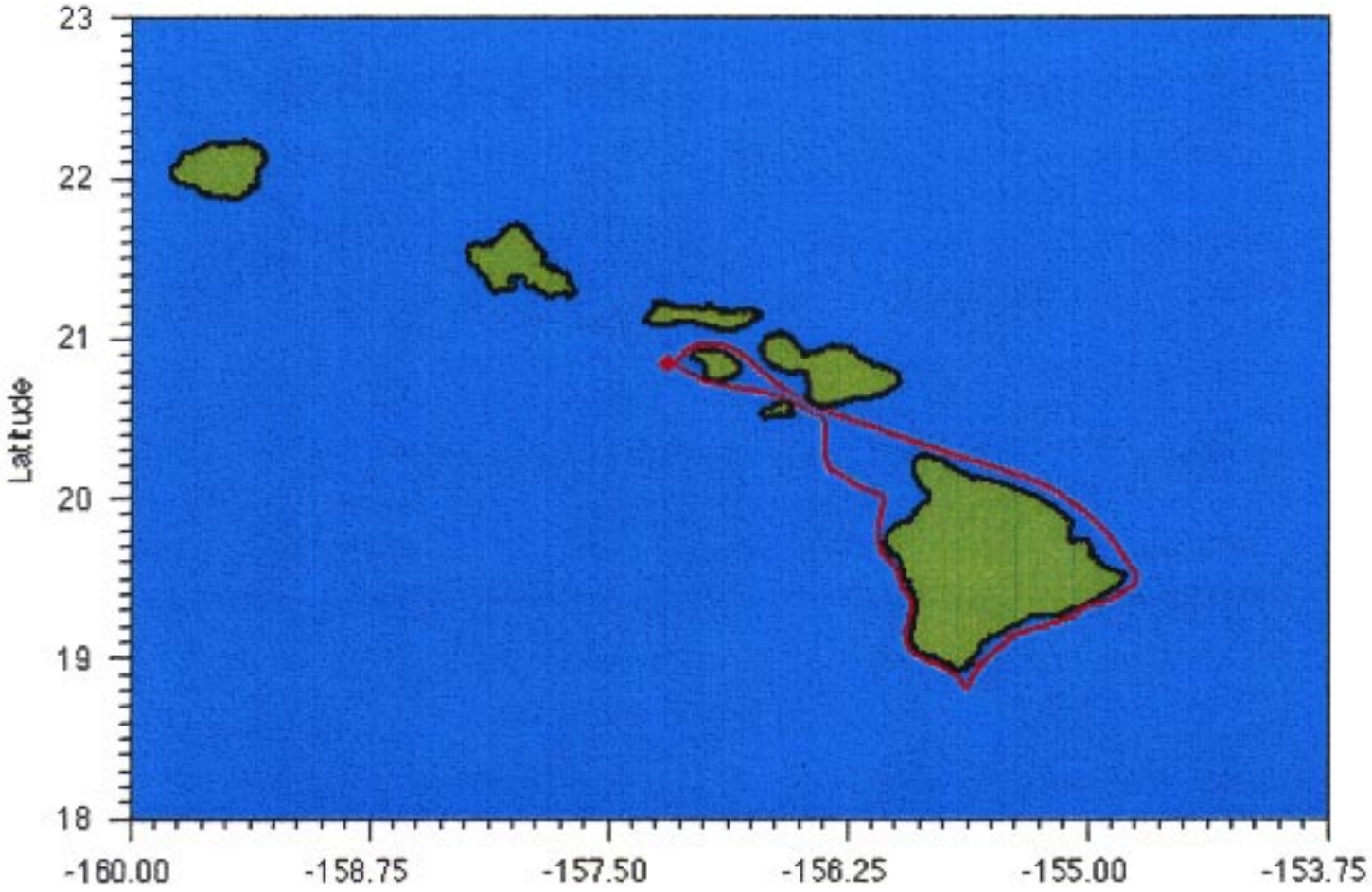


FIGURE 3.

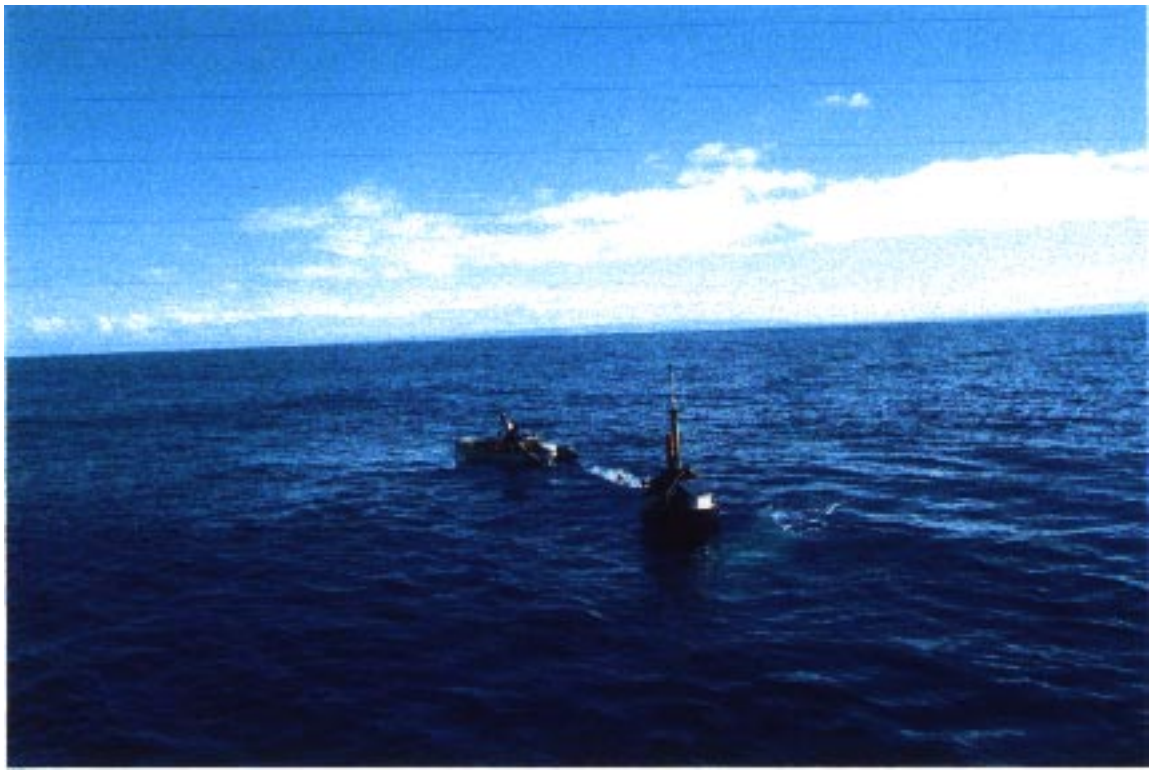


Figure 4. Diver calibration operation during M205DOBP.

Figure 5. Sun photometer HHCRM calibration site.

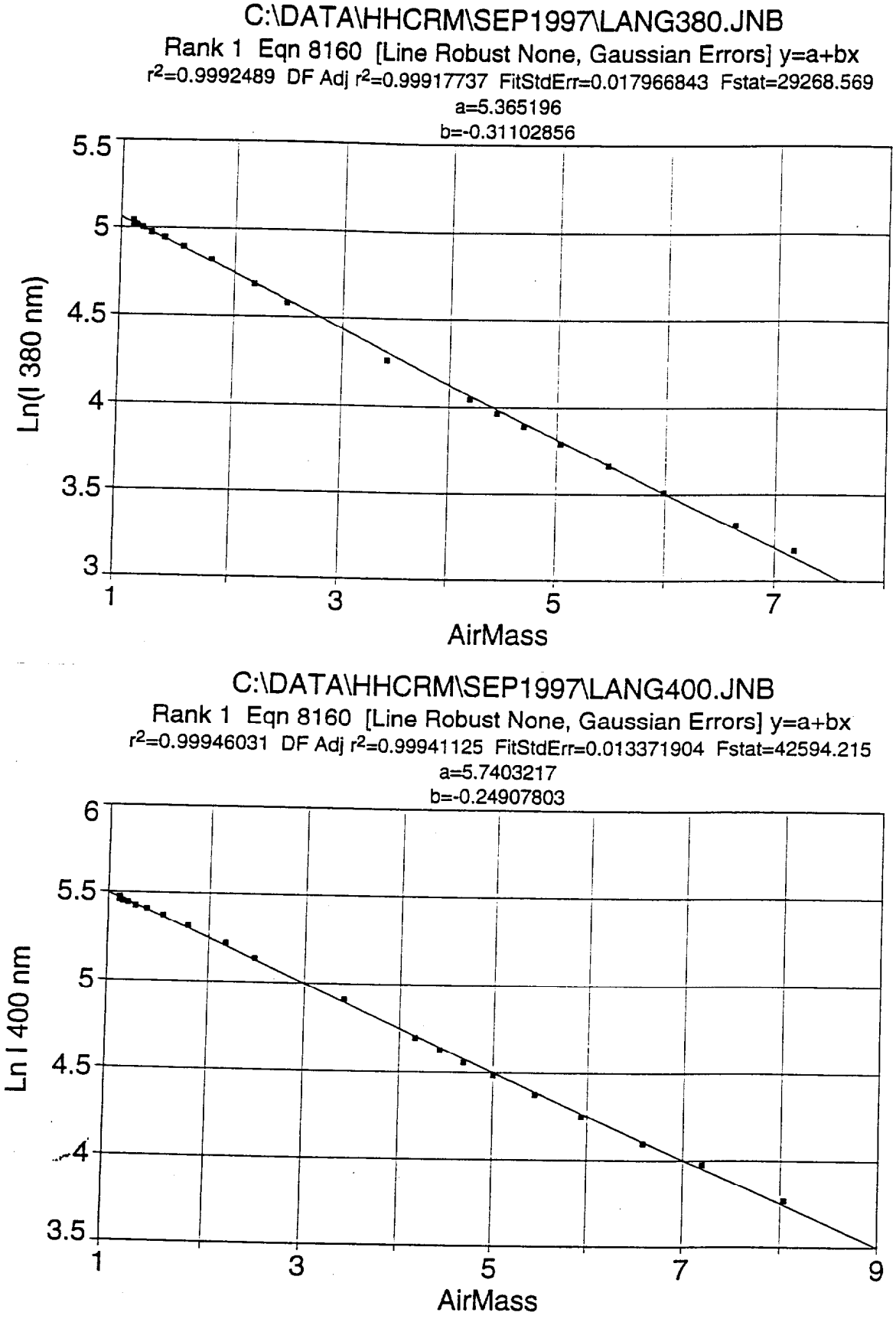
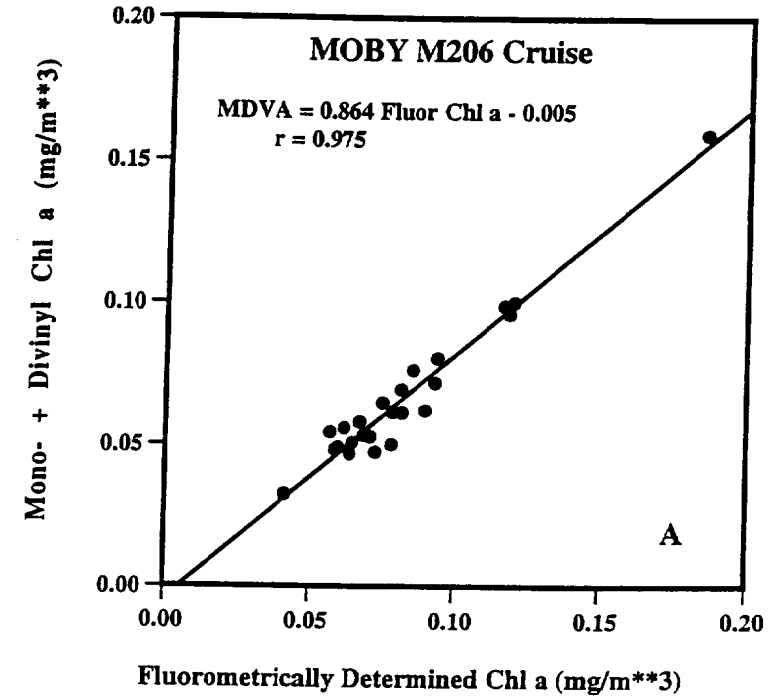


Figure 6. Langley plots obtained during M2060B.



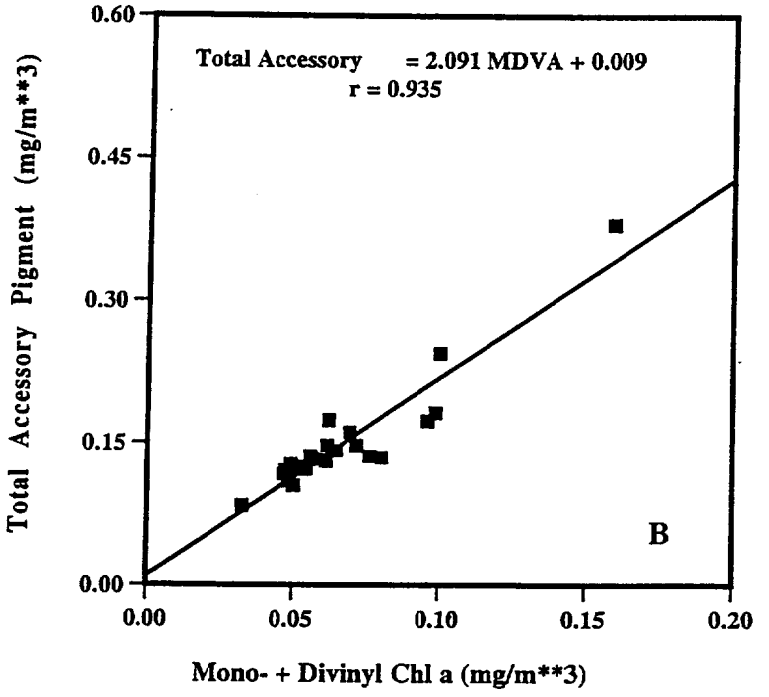


FIGURE 7. Comparison between HPLC determined monovinyl + divinyl chlorophylla and (A) fluormetrically determined chlorophyll a and (B) total accessory pigment cocnetrations.

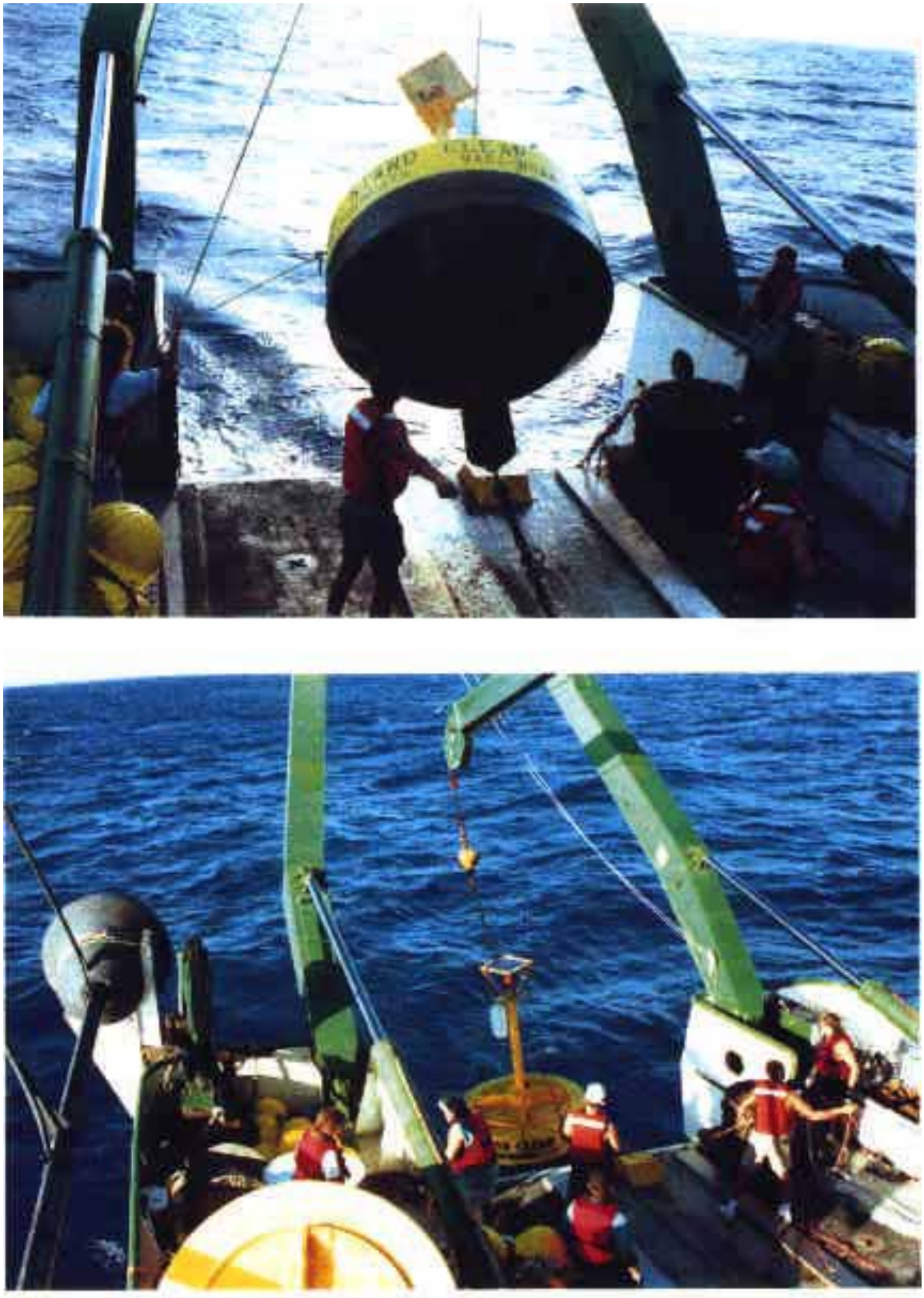


FIGURE 8.

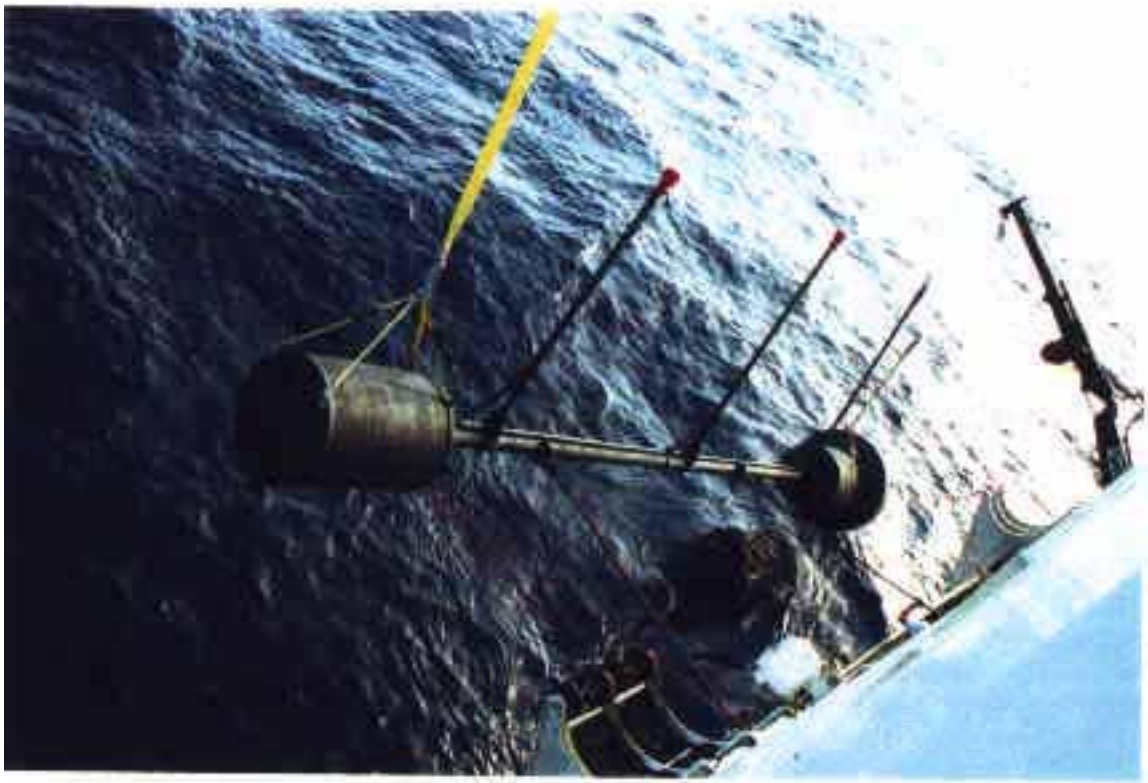


FIGURE 9.

MOCE / MOBY Team Activities

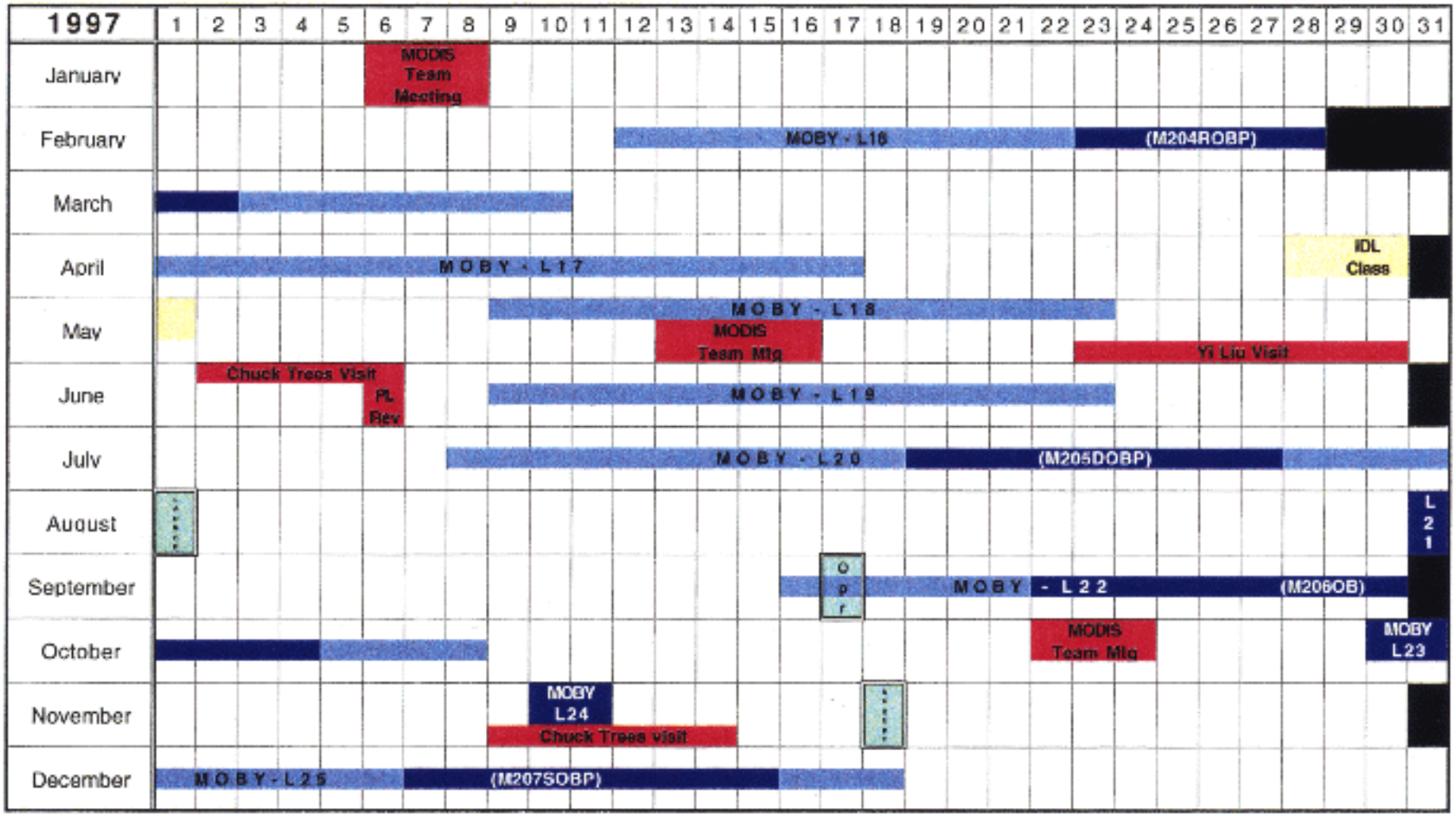


FIGURE 10.

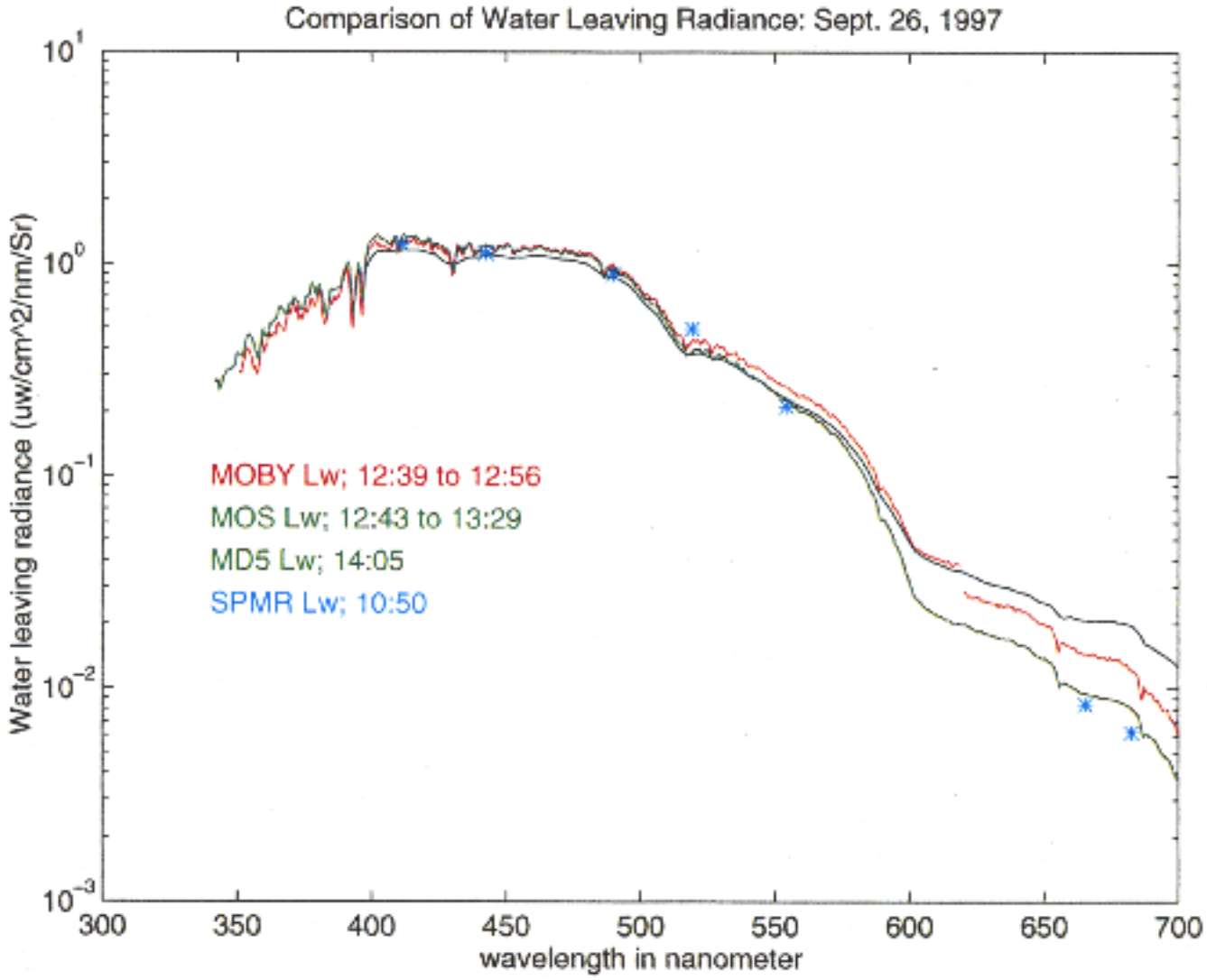

Comparison of Water Leaving Radiance: Sept. 26, 1997
Water leaving radiance (uw/cm^2/nm/Sr)
wavelength in nanometer
MOBY Lw; 12:39 to 12:56
MOS Lw; 12:43 to 13:29
MD5 Lw; 14:05
SPMR Lw; 10:50

FIGURE 11.

Table 1. Pigment data from MOBY M206 Cruise off Lanai, Hawaii (22 September - 4 October 1997)

Sam #	Sta	Date	Time	Area	Lat	Long	Depth	Chl a-Fl	Pha-Fl
1	Dive Boat	22-Sep-97	2121	MOBY	999	999	0	0.0416	0.0155
2	Dive Boat	23-Sep-97	2000	MOBY	999	999	0	0.0673	0.0185
3	Dive Boat	23-Sep-97	2100	MOBY	999	999	0	0.0817	0.0145
4	Dive Boat	23-Sep-97	2215	MOBY	999	999	0	0.0900	0.0227
5	Dive Boat	23-Sep-97	2252	MOBY	999	999	0	0.0647	0.0115
6	RV Kila	26-Sep-97	1307	MOBY	20.7928	157.2072	0	0.1857	0.0494
7	RV Kila	26-Sep-97	2307	MOBY	20.7928	157.2072	0	0.1201	0.0261
8	RV Kila-CTD	26-Sep-97	999	MOBY	999	999	1	0.0787	0.0204
9	RV Kila-CTD	26-Sep-97	999	MOBY	999	999	16	0.0922	0.0322
10	RV Kila-CTD	26-Sep-97	999	MOBY	999	999	31	0.1168	0.0004
11	RV Kila	27-Sep-97	0051	MOBY	20.7928	157.2072	0	0.0751	0.0205
12	Dive Boat	30-Sep-97	1845	999	20.7150	156.9133	0	0.0940	0.0296
13	Dive Boat	30-Sep-97	2011	MOBY	999	999	0	0.0709	0.0219
14	Dive Boat	30-Sep-97	2250	999	20.7053	156.8928	0	0.0727	0.0176
15	Dive Boat	30-Sep-97	2250	999	20.7053	156.8928	0	0.0783	-0.0015
16	Dive Boat	2-Oct-97	1839	999	20.7368	157.0024	0	0.0569	0.0276
17	Dive Boat	2-Oct-97	1931	MOBY	999	999	0	0.0596	0.0246
18	Dive Boat	2-Oct-97	2040	MOBY	999	999	0	0.0619	0.0199
19	Dive Boat	2-Oct-97	2130	MOBY	999	999	0	0.0815	0.0255
20	Dive Boat	2-Oct-97	2240	MOBY	999	999	0	0.0684	0.0187
21	Dive Boat	2-Oct-97	2240	MOBY	999	999	0	0.0639	0.0144
22	Dive Boat	4-Oct-97	1743	Mid Channel	20.8583	156.7467	0	0.0856	0.0271
23	Dive Boat	4-Oct-97	1811	Green Water	20.7637	156.8263	0	0.1187	0.0692
24	Dive Boat	4-Oct-97	2015	MOBY	999	999	0	0.0586	0.0188
25	Dive Boat	4-Oct-97	2230	MOBY	999	999	0	0.0932	0.0213

Sam #	Chl c	Perid	But	Fuco	Hex	cis Hex	Pras	Phorb a	Dinox	Diadino	Allo	Diatox	Lut	Zea	Chl b	Chl a''	Chl a	Chl a'	Phaeo b	MVA	DVA
1	0.0016	0.0008	0.0018	0.0015	0.0056	0.0000	0.0000	0.0000	0.0000	0.0061	0.0018	0.0007	0.0022	0.0590	0.0000	0.0022	0.0438	0.0000	0.0000	0.0139	0.0187
2	0.0019	0.0007	0.0028	0.0025	0.0063	0.0000	0.0000	0.0005	0.0007	0.0047	0.0025	0.0017	0.0950	0.0000	0.0086	0.0000	0.0783	0.0045	0.0000	0.0240	0.0340
3	0.0027	0.0024	0.0028	0.0032	0.0072	0.0000	0.0000	0.0002	0.0009	0.0070	0.0026	0.0000	0.0000	0.0931	0.0028	0.0000	0.0790	0.0060	0.0000	0.0315	0.0298
4	0.0026	0.0028	0.0036	0.0046	0.0065	0.0000	0.0000	0.0000	0.0009	0.0103	0.0021	0.0012	0.0039	0.1147	0.0176	0.0025	0.0862	0.0000	0.0000	0.0215	0.0406
5	0.0026	0.0030	0.0024	0.0042	0.0064	0.0000	0.0000	0.0000	0.0010	0.0081	0.0024	0.0000	0.0000	0.0884	0.0036	0.0000	0.0694	0.0000	0.0000	0.0197	0.0312
6	0.0043	0.0055	0.0082	0.0167	0.0211	0.0000	0.0000	0.0000	0.0000	0.0231	0.0133	0.0155	0.0163	0.1829	0.0181	0.0550	0.1917	0.0000	0.0001	0.1050	0.0543
7	0.0089	0.0035	0.0062	0.0094	0.0163	0.0000	0.0021	0.0000	0.0022	0.0166	0.0059	0.0000	0.0095	0.1484	0.0148	0.0000	0.1296	0.0000	0.0001	0.0507	0.0495
8	0.0030	0.0027	0.0036	0.0054	0.0091	0.0000	0.0000	0.0000	0.0004	0.0112	0.0025	0.0027	0.0040	0.0876	0.0084	0.0030	0.0856	0.0034	0.0000	0.0214	0.0402
9	0.0027	0.0000	0.0038	0.0058	0.0099	0.0000	0.0000	0.0001	0.0000	0.0113	0.0000	0.0000	0.0000	0.1044	0.0190	0.0307	0.1820	0.0493	0.0001	0.1386	0.0272
10	0.0045	0.0000	0.0044	0.0096	0.0142	0.0000	0.0014	0.0000	0.0018	0.0126	0.0015	0.0000	0.0086	0.1057	0.0102	0.0070	0.1167	0.0000	0.0000	0.0689	0.0300
11	0.0044	0.0068	0.0032	0.0065	0.0078	0.0000	0.0000	0.0000	0.0000	0.0092	0.0019	0.0015	0.0032	0.0882	0.0075	0.0013	0.0794	0.0000	0.0001	0.0397	0.0249
12	0.0030	0.0011	0.0052	0.0077	0.0152	0.0000	0.0000	0.0000	0.0014	0.0093	0.0020	0.0000	0.0017	0.0680	0.0197	0.0000	0.1016	0.0000	0.0000	0.0449	0.0355
13	0.0029	0.0012	0.0039	0.0054	0.0110	0.0000	0.0000	0.0000	0.0000	0.0073	0.0023	0.0000	0.0000	0.0845	0.0065	0.0000	0.0682	0.0000	0.0000	0.0270	0.0259
14	0.0039	0.0000	0.0024	0.0055	0.0090	0.0000	0.0000	0.0000	0.0000	0.0081	0.0035	0.0013	0.0026	0.0783	0.0059	0.0000	0.0726	0.0000	0.0000	0.0053	0.0422
15	0.0000	0.0000	0.0037	0.0042	0.0079	0.0000	0.0000	0.0000	0.0000	0.0089	0.0024	0.0000	0.0016	0.0723	0.0035	0.0000	0.0662	0.0000	0.0000	0.0234	0.0268
16	0.0023	0.0011	0.0029	0.0027	0.0079	0.0000	0.0000	0.0000	0.0015	0.0074	0.0019	0.0022	0.0036	0.0762	0.0040	0.0071	0.0719	0.0015	0.0000	0.0254	0.0291
17	0.0039	0.0019	0.0034	0.0046	0.0084	0.0000	0.0000	0.0000	0.0000	0.0029	0.0034	0.0000	0.0018	0.0890	0.0061	0.0020	0.0675	0.0000	0.0000	0.0189	0.0304
18	0.0029	0.0019	0.0040	0.0057	0.0092	0.0000	0.0000	0.0000	0.0000	0.0085	0.0037	0.0018	0.0033	0.0841	0.0040	0.0000	0.0704	0.0062	0.0000	0.0317	0.0243
19	0.0044	0.0015	0.0046	0.0075	0.0107	0.0000	0.0008	0.0001	0.0007	0.0126	0.0040	0.0025	0.0052	0.0990	0.0064	0.0000	0.0883	0.0008	0.0000	0.0374	0.0319
20	0.0039	0.0021	0.0044	0.0055	0.0082	0.0000	0.0007	0.0000	0.0010	0.0088	0.0030	0.0000	0.0000	0.0787	0.0048	0.0009	0.0682	0.0000	0.0000	0.0285	0.0249
21	0.0027	0.0018	0.0034	0.0045	0.0081	0.0000	0.0006	0.0000	0.0000	0.0088	0.0035	0.0012	0.0027	0.0748	0.0044	0.0005	0.0625	0.0000	0.0000	0.0204	0.0264
22	0.0029	0.0014	0.0026	0.0041	0.0112	0.0000	0.0010	0.0000	0.0008	0.0061	0.0005	0.0000	0.0000	0.0941	0.0054	0.0019	0.1004	0.0037	0.0000	0.0355	0.0407
23	0.0068	0.0009	0.0066	0.0094	0.0138	0.0000	0.0022	0.0009	0.0018	0.0068	0.0013	0.0013	0.0027	0.0834	0.0307	0.0018	0.1311	0.0021	0.0000	0.0375	0.0587
24	0.0016	0.0010	0.0031	0.0047	0.0085	0.0000	0.0005	0.0001	0.0005	0.0083	0.0020	0.0020	0.0036	0.0671	0.0044	0.0012	0.0647	0.0009	0.0000	0.0210	0.0274
25	0.0052	0.0026	0.0051	0.0064	0.0115	0.0013	0.0013	0.0002	0.0011	0.0104	0.0042	0.0032	0.0000	0.0816	0.0063	0.0027	0.0875	0.0038	0.0000	0.0455	0.0263

TABLE 1