MODIS Team Member - Semi-annual Report
Marine Optical Characterizations
June 1999

Dennis K Clark
NOAA/NESDIS

SUMMARY

During this reporting period significant progress was made on the enhancements to MOBY. These enhancements included: the completion of the meteorological station modifications to the mooring buoy, completion of a wide-angle radiance distribution video-camera, and construction of the cos collector bezels out of copper to decrease biological fouling. These systems have been deployed and are presently being tested with the initial problems identified and being corrected. The Marine Optical Characterization Experiment (MOCE) Team is approaching the completion of a two year time-series (7/20/97) and twenty two months of providing the SeaWiFS Project continuous observations for their initialization and calibration tasks. The team conducted two MOBY recovery and replacement cruises (MOBY- L43, MOBY-L45), and six MOBY calibration excursions at the Lanai mooring site (MOBY-L40, L41, L42, L44, L46, L47) with several unexpected MOBY field repairs successfully accomplished.. Radiometric, biological and atmospheric data were collected during the MOBY-L43 and MOBY- L45 cruises. Team field activities during the reporting period are shown in Figure 1.

Additional major activities included: the initial MODIS case one bio-optical products were completed and provided to Robert Evans, MODIS initialization planning and logistics implementation, and continued effort to isolate the stray light problem with the VS-10 spectrographs used in MOBY.

FIELD OPERATIONS

MOBY-L43

The MOBY-L43/M212SOBP recovery and replacement cruise took place February 6 - 11, 1999. The following personnel participated:

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

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

CHORS - Chuck Trees

MSI - Peter Clay, Doug Dooner

NIST - Carol Johnson, Howard Yoon

NASA/GSFC - Robert Caffrey

HRA - Dave Christiansen, Steve Juarez, Randy Miller, Rob Wheeler

During the two weeks before the cruise, Mike Feinholz collaborated with Dr. Carol Johnson and Dr. Howard Yoon from the National Institute of Standards and Technology, NIST, to compare several radiance standards and radiometers. The NIST NIPPR radiance source and the VXR radiometer were brought to Snug Harbor, Hawaii, to compare with the NOAA/MLML OL420 and OL425 radiance sources and SCAMPS radiometers (Figure 2). The purpose of this comparison was to validate both the SCAMPS recalibration by NIST in June/July 1998, and the Optronic Laboratories calibrations of the OL420 in October 1998, and OL425 in July 1997. The VXR and SCAMPS were interchanged to measure each radiance standard. The NIPPR was run twice, with 5 different lamp configurations, the OL420 6 times with 2 configurations, and the OL425 twice with 2 configurations. Run-time hours used on the OL420 totaled 6.9 and on the OL425, 2.0. After NIST personnel had left, the SCAMPS scans were performed to analyze the uniformity of radiance distribution across the exit port of the OL420. Conclusions are pending final data analysis and the recalibration of the NIPPR after it was returned to NIST.

MOBY207 was retrieved and the deep-sea mooring replaced on February 7 during the first leg of the MOBY-L43/M212SOBP oceanographic cruise aboard the RN Moana Wave. The deep-sea mooring was upgraded to incorporate our new meteorological station (Figure 3). Power is supplied by three on-board gel-cell batteries which are recharged by three solar panels and one wind-driven generator. Sensors deployed in this initial configuration include air temperature, barometric pressure, humidity, wind speed and direction, and compass heading. The controller incorporates a cellular modem for system monitoring and configuration as well as data transmission.

MOBY208 was deployed on February 9 and tethered to the meteorological mooring buoy on February 10 during the second leg of the cruise (Figure 4). Diver calibrations of the new MOBY were performed on February 11 with the assistance of Hawaiian Rafting Adventures. During the six days of ship time, three oceanographic stations were occupied (Figure 5). Three Marine Optical System (MOS202) profiles and three CTD profiles (SBEO099 to SBE0101) were performed during the cruise, and Secchi disc measurements were made near local noon each day. Eighteen TSM/POC/PON samples were collected from three stations. Twenty-three pigment samples were collected for shipboard processing using the fluorometric technique. Out of 23 samples, 15 were collected from three CTD casts with the rest (8) from near surface depths, during SeaWiFS overpasses. The calibration curve for the Turner Fluorometer is shown in Figure 6 and the fluorometrically determined pigment data are tabulated in Table 1. Twenty- five samples were also collected for HPLC analysis back at the CHORS laboratory.

Twenty-three particulate and detrital absorption samples were collected and analyzed during the cruise.

Hand Held Contrast Reduction Meter (HHCRM) measurements, to derive the atmospheric spectral transmittances, specifically bracketed each SeaWiFS overpass. Water vapor column, ozone column and aerosol optical depth during each overpass were measured using MICROTOPS II.

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

MOBY207 was disassembled, cleaned, and calibrated after the cruise. New copper irradiance bezels were added to fight the bio fouling problem. Some provisions were added to support new Wide Angle Radiance System (WARS) components in preparation for deployment as MOBY209 in May 1999.

MOBY-L45

The MOBY-L45/M213SOBP recovery and replacement cruise took place May 1 - 6, 1999. The following personnel participated:

NOAA - Dennis Clark, Ed Fisher, Yong Sung Rim, Mike Ondrusek, Larisa Koval, Eric Stengel, Marilyn Yuen

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

CHORS - Chuck Trees, Chris Kinkade

Hawaiian Rafting Adventures - Steve Juarez, Rob Wheeler

The ninth Marine Optical Buoy, MOBY209, was successfully deployed at the Lanai mooring site on May 1, 1999 during the MOBY-L45/M213SOBP oceanographic cruise aboard the RN Moana Wave. MOBY208 and MOBY209 made two sets of side-by-side cross-over measurements on May 2 (Figure 7) before MOBY208 was recovered on May 3 (Figure 8). Diver calibrations of MOBY209 were performed on May 4 and the new WARS controller box and camera head were installed on MOBY to conduct the first field test.

Four hydrographic stations were conducted during the cruise. Bio-optical data sets were collected coincident with SeaStar/SeaWiFS overpasses. The best overpass (30 nm) for this cruise occurred during Station 3 on May 5. Two Marine Optical System (MOS202) profiles, and 4 CTD profiles (SBE102 to SBE 105) were conducted. Twenty-five TSM/POC/PON samples were collected from 4 stations. Thirty-eight pigment samples were collected for shipboard processing using the fluorometric technique. Out of 38 samples, 13 were collected from three CTD casts with the

remaining 25 from near surface depths. The calibration curve for the Turner Fluorometer is shown in Figure 9. The coefficient for this calibration was significantly different from the previous cruise calibration for MOBY-L43. Because of this difference, the NOAA Turner-10 Fluorometer was shipped to CHORS for an intercalibration exercise with our existing fluorometer. The results from this intercalibration showed that the coefficient determined in Hawaii was not statistically different from that measured at CHORS laboratories. Now that the calibration has been verified, the chlorophyll concentrations will be calculated from these shipboard fluorometric measurements. Thirty-nine samples were collected for HPLC pigment analysis back at CHORS. Samples were collected for analysis on the Capillary Electrophoresis instrument. Eighteen samples were taken from near the chlorophyll maximum in the water column, and filtered through Nuclepore filters. Six samples were prefiltered using a larger GF/F filter to reduce filtration time by removing the larger phytoplankton cells that do not contain any phycobiliproteins. These samples will be used in cyanobacterial pigment separation and quantification method development on the Capillary Electrophoresis system.
Thirty particulate and detrital absorption samples were collected and analyzed during the cruise.

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

Repairs and maintenance to the meteorological mooring buoy station were performed during the cruise, including reinstalling the Sutron controller box and replacing a shattered solar panel.

MOBY208 was disassembled and cleaned and is currently in preparation for deployment as MOBY210 in August 1999.

After the cruise, the science vans were separated, cleaned and painted for their upcoming shipment to San Diego.

INSTRUMENT CALIBRATIONS

MOBY

During this reporting period, the MOCE team and professional divers conducted six calibration excursions via Hawaiian Rafting Adventures (HRA) chartered dive boat to perform the diver calibrations. During the first trip (MOBY-LAO, January 5), a routine systems checkup was performed and the ARGOS battery was replaced. It was noted that the flopper stoppers were gone but the tether was in good condition. During MOBY-L41 (January 10- 12) the missing flopper stoppers were replaced with an anchor (approximate depth of 60 m), diver calibrations and water sampling/filtration were performed, and the instrument was cleaned at the South Lanai CIMEL site. MOBY optical collectors were cleaned and two sets of “clean” diver calibrations were completed. HRA returned to the buoy site during MOBY-L42 on January 21 under very rough sea conditions to unwrap the tether from MOBY and take underwater photographs of the tether and of MOBY.

The MOBY-L44 cruise was carried out between March 9-l 1, 1999. Broken wind generator blades on the meteorological mooring buoy station were repaired and data retrieved from the controller on March 9 before servicing the sun photometer instrument at the CIMEL site. On March 10 the Sutron controller box was retrieved from meteorological station, the tether was unwrapped from MOBY, and two sets of "dirty" Lu calibrations and one set of "dirty" Ed calibration were completed. MOBY optical collectors were cleaned and recalibrated on March 11.

The MOBY-L46 service cruise was a two day operation conducted in June 1999. Rough weather conditions on June 2 did not allow repairs to the meteorological station wind generator. However, the personnel managed to unwrap the MOBY tether, download Meteorological data, secure loose meteorological station bolts and cables, and service the CIMEL site. The wrapped tether and the new copper irradiance bezels were photographed (Figures 10, 11). The copper bezels had lost all of the black surface finish, leaving a bright reddish copper surface. There was no visible fouling of the copper bezel or the white Teflon collector surfaces. Barnacles were growing just beneath the copper bezel apparently on the plastic of the top and middle collector heads.

RADIOMETRIC STANDARDS & RADIOMETERS

MLML personnel continue to maintain our NIST-tracable radiometric standards at the Sand Island, Hawaii operations facility and perform calibrations of our radiometers. Appendix 1 documents the history of use of MLML/NOAA irradiance and radiance standards. After 40 hours of use, the OL420 radiance source and OL450 controller have been returned to Optronic Laboratories for post-calibration, re-lamping and any necessary maintenance, and recalibration. Approximately 17 hours of lamp time remain on the 5th calibration of the OL420 before it will require service. The latest NIST calibrations of two primary n-radiance standards, FELs F454 and F471, have each been used about one half their useful life of 50 hours, while two other FELs, F453 and GS132, have zero hours use.

Radiometers calibrated during this reporting period included: 3 MOBYs, 3 MOSs, SIS 101, MD5, HHCRM, and University of Hawaii's airplane instrument.

CIMEL SERVICE

The Lanai CIMEL site was serviced at approximately 2-weeks intervals, as time permitted during regular HRA charters to the area. CIMEL received a more thorough service during the scheduled diver calibration trips. At the request of GFSC, CIMEL #93 was removed from Lanai on June 2 1999 and replaced with the calibrated unit #106. CIMEL #93 was returned to GFSC on June 16 for recalibration.

DATA PROCESSING

MOBY began transmitting 2 files a day, March 9, 1999, in preparation for the MODIS launch in August. Both files are processed the next day. The first file begins taking measurements from 20:46 and stops at 21: 18 GMT. The second file begins taking measurements at 22:38 and stops at 22:56 GMT. Both files are weighted to MODIS, SeaWiFS and OCI bands. Currently only SeaWiFS weighted data are available on the ftp site. The MODIS data will be made available after the satellite is launched on the same anonymous ftp site.

MLML personnel completed the CZCS Validation Experiment Data CD-ROM. The CD-ROM contains the original data, reprocessed data, Matlab programs and HTML files. Data are saved in the Moss Landing Database format (MLDBASE) and as comma delimited ASCII files. HTML home pages were also created to make it easy to browse the CD. The HTML include images and links to the ASCII data files.

MLML personnel began working on a comprehensive database which includes pigment, total suspended material and radiometric data from CZCS Era to present. This ocean color database is being used for the MODIS algorithm development. The data are saved in a binary Matlab file. The final output files are ASCII files which can be imported into Excel or Sigma Plot. This data set was compiled using Matlab.

The work is continuing on processing MOS radiometric profiles and SIS incident ii-radiance acquired during MOCE and MOBY cruises. MODIS band responses are being applied to the algorithm development database. The historical MOS data are being incorporated with the MOBY database in MLDBASE format. This procedure has yielded improvement in the method for applying in-band satellite responses, and is expected to improve flexibility of database structure to handle "N''-depth optical profiles.

In May 1999, the HPLC pigment samples from MOBY-L38 and MOBY-I43 cruises were processed. During the calibration of the HPLC system, it was noticed that the pigment standards were not separating from each other as found for the previous analyses. Contamination of the solvents and chemicals was first suspected, so new solvents and chemicals were purchased. Because this did not improve the separation, a new ODS-2 column was purchased. This also did not improve the separation, so the pump flow and valve gradient stepping accuracy were tested. Figure 12 shows a gradient test at 20% steps from 100% to 0% for B and C, using methanol and acetone, and monitoring the absorbance at 330 nm. All valves performed within a 1% error. Because no problem with the HPLC was found, the samples were processed at this increased uncertainty. This problem with pick separation affected only the carotenoid pigment compounds.

The MOCE-4 particle distribution data report is near completion. It has had some proof reading and after this, needs to go through the formal NOAA publishing process.

SOFTWARE DEVELOPMENT

Bob Caffrey at GFSC and engineers at Forth Inc. performed initial work to incorporate a number of operational improvements into the MOBY operating system and to identify the issues involved with moving the current Forth development system from VAX to PC. Bob Cafrey worked to enhance control of the MOBY to MLML VAX file transfer scheme. Currently, for files to be transferred from MOBY to VAX, the name must be stored to a file name buffer stored on disk. The existing system only allows one name to be in the buffer at a time. For a file to be transmitted to the VAX, it must be transferred before another file is acquired. This system of operation then requires a 30-minute transmission window between MOBY file acquisitions, placing potentially restrictive limitations on operations during daylight hours. This limitation could be a problem when the time comes to service two or more satellite passes during the day. Bob completed adding the data structure and Forth words to the MOBY system allowing a buffer of up to eight file names. The data can then be transmitted to the VAX as desired. These changes have received initial testing but require additional long term testing before the deployment. Initial attempts at porting the MLML development system over to a PC were unsuccessful due to the differences in the MLML Forth and the Forth Inc. operating systems. Problems were identified with the insertion of the Forth core into the TT7 controller. The TT7 computers can be programmed using the Forth Inc. Swift-X development system. The MLML operating system will require porting before the PC development system is of use.

Y2K CONCERNS

The MOBY and MOS software systems were designed with Y2K in mind. The RTC chip used in the controllers is designed to function properly until the year 2048. The tests of the MOBY system were performed to identify possible problems associated with Y2K. So far, the MOBY and MOS systems perform normally when operated with the date set after 3 1 December 1999. The system also operates normally across year-end from December 1999 to January 2000.

Some problems may occur with the MOBY GPS units, as we use real time provided by GPS as a check on MOBY time. It is not possible to test for these problems as they are due to the GPS's interpretation of information received by the GPS satellite. The manufacturer suggests to turn the power off and reset the GPS as a method of fixing any known problems. The GPS is powered down as a normal procedure in MOBY, so any resettable GPS errors should pose no problem. The MOBY system is well protected from functional errors in the GPS.

The Trimble instrumentation system is used to collect navigation data during the cruises. There are two time-related concerns regarding this system. The first is called the week number roll over (WNRO) problem which occurs August 21, 1999, and is unique to GPS technology. U.S. government GPS satellites broadcast time in terms of a "GPS week number", which ranges from 0 to 1023. Week 1023 ends on August 21st. The solution to this problem is relatively simple. Updated information will be sent to the satellites and individual GPS systems will in turn download the updated information.

The Y2K problem for the Trimble system (Transpak II) is more complicated. Trimble offers a firmware upgrade, but the upgrade contains a bug that will not be fixed by Trimble. For our purposes, the bug will not be a problem; however, Trimble is no longer manufacturing Transpak II systems and technical support for this system will continue to decrease with time. As a result, we are looking into other navigation companies and instrument systems for integration into our data acquisition suite.

The Trak instrumentation system operates as our time source during cruises. Both the present and the back-up systems have been sent to TRAK Microwave Corporation in Tampa, Florida for firmware upgrades.

INSTRUMENT DEVELOPMENT

The experiments are continuing to find the sources of stray light within the blue and red VS-10 spectrographs. So far, experiments indicate the following:

1. There is no electronic or signal processing source for the blue/red mismatch.

2. The blue/red overlap error is due to stray light within the spectrographs. The problem is compounded by the differences between the calibration and ***in situ*** light fields.

3. The stray light has spectral quality to a large degree mirroring the input spectra.

4. Attempts to reduce the stray light hitting the detector by adding baffles only reduce the stray light in amounts proportional to the reduction of actual image light. The stray light seems to be a component of the image producing light and cannot be eliminated with baffles or filters. However, eliminating energy by filtering wavelengths of no interest, does help reduce stray light in adjacent wavelengths. This method improves signal quality in the long wavelengths (red spectrograph). The Infra Red filter also reduces signal harmonics observed beyond 700 nm in this spectrograph.

5. Limiting bandwidth in the red spectrograph by adding low pass filters only reduces stray light on the long wavelength end of the array. Therefore light from the “red” end of the spectra does not contribute much to the stray light hitting them “blue” end of the detector. This would also indicate the stray light is not from a general “glow” of stray light from within the spectrograph, but from a source much closer to the optical axis.

6. Stray light correction may be possible (if not desirable) by measurement and later subtraction of the stray light component from the signal in post processing. Preliminary tests of stray light corrections have yielded the most promising results so far. Whereas all stray light baffling methods combined may produce 2-5% reduction in stay light and usually degrade the image: stray correction by measurement and subtraction reduces the error by 50% or more without impacting signal levels. Indeed, in this case reducing

the stray component of the signal only results in making it more difficult to quantify and correct.

The Wide Angle Radiance System (WARS) was developed to measure the angular distribution of upwelled light off the MOBY mooring (Figure 13). The primary components of this system are a KP-Ml black and white CCD camera manufactured by Hitachi Denshi, Ltd., an EZ-COMPASS-3 tilt/temperature compensated compass magnetometer manufactured by Advanced Orientation Systems, Inc., and a CX100 video frame grabber manufactured by Imagination Corp. All systems are controlled by a Microspace PC/104 MSMP5 low-power Pentium computer. The frame grabber and computer are housed in a sealed PVC box that sits on the main MOBY body (Figure 14). The camera and compass are mounted in a water tight housing equipped with a dome portal for capturing images (Figure 15). The fish-eye lens mounted on the camera provides 138" FOV imagery of the radiance distribution for digitization by the frame grabber. The camera housing can be mounted on the top arm of the MOBY mooring system for remote operation or can be operated interactively. A single serial cable connects the camera housing to the control box. Also connected to the control box is a 12- volt power supply connection and a serial port used for communications to the WARS system via the Laplink program. The first working model of the WARS system was completed in April 1999 and tested during the MOCE-L45 field experiment. WARS was run interactively off the stem of the R/V Moana Wave then deployed for 3 days to run remotely off the top arm of MOBY. Figure 16 shows a sample image collected of MOBY208 at 10:20 A.M. on April 3, 1999. The WARS system was recovered by divers at the end of the cruise and shipped to the University of Miami for calibration.

MEETINGS

A team data meeting was held on May 10 in Honolulu, Hawaii.

SUPPORTING CONTRACTS AND COOPERATIVE AGREEMENTS

The following contracts and cooperative agreements were completed:

San Diego State University - Center for Hydro-Optics and Remote Sensing
San Jose State University - Moss Landing Marine Laboratories
University of Hawaii - Marine Operations Facility
Hawaii Rafting Adventures Inc.
QSS Inc.
RDC, Inc.

MOCE Team Activities

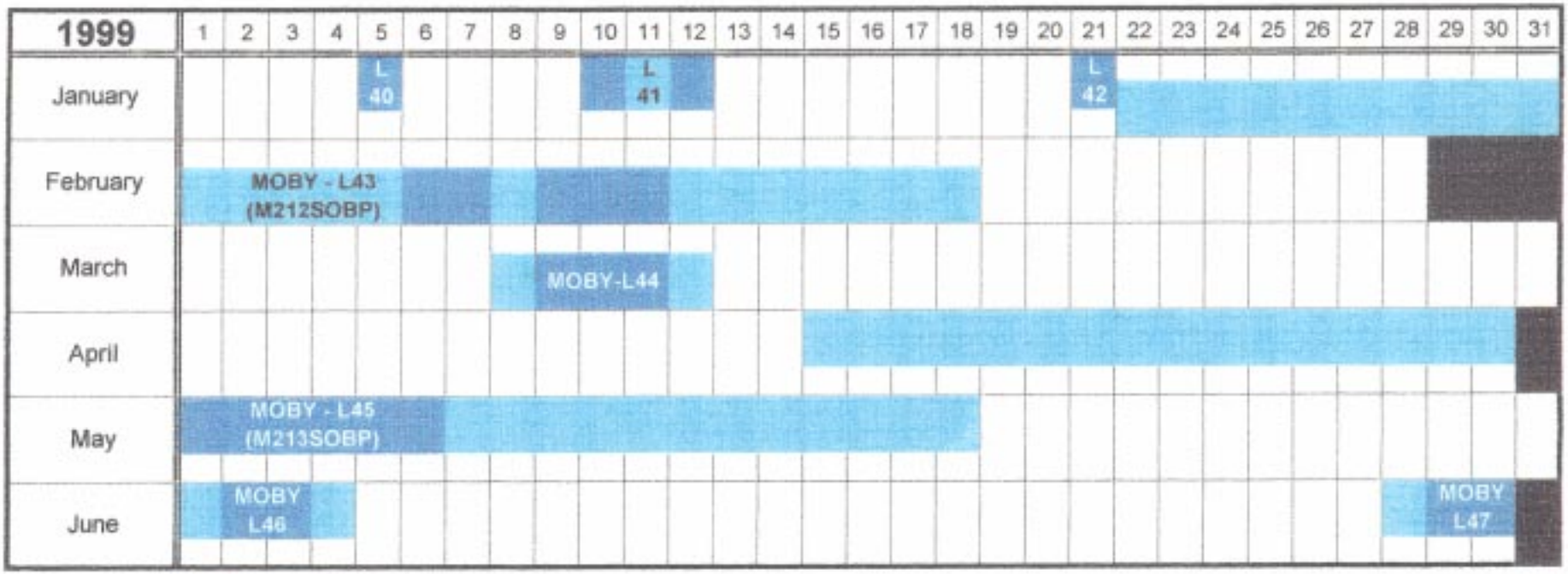


FIGURE 1.

FIGURE 2.

FIGURE 3.

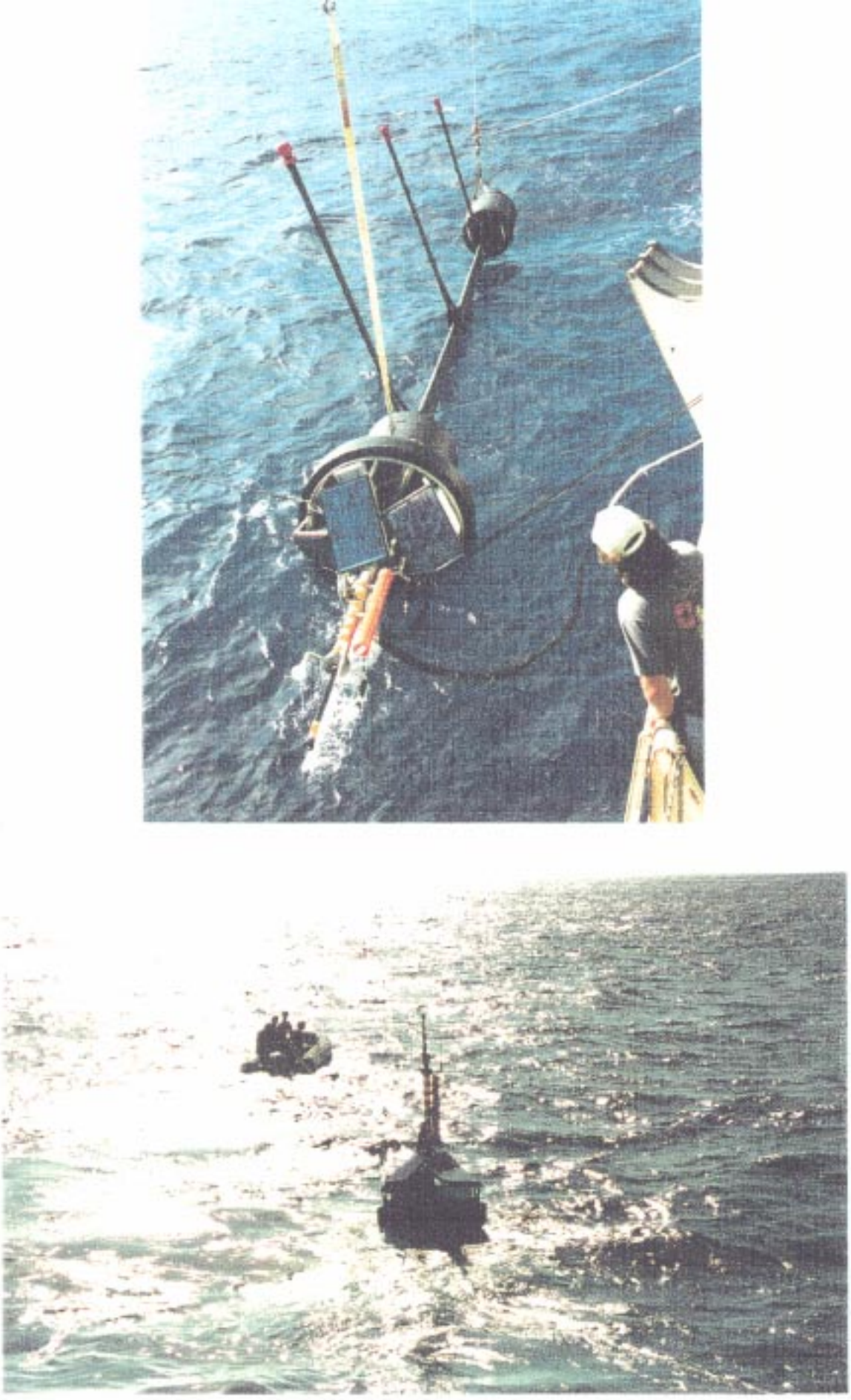


FIGURE 4.

MOBY - L43 (M212SOBP) Station Summary

Date (local)	Julian Day	Station #	Station Name	Start Time (local)	Start Position (deg N)	(deg W)	End Time (local)	End Position (deg N)	(deg W)	Overpass Time & Distance (local)	(nm)	(orbit #)	(local)	(nm)	(orbit #)
09 Feb 99	040	1	Lee of Lanai	10:33	20.601	156.985	14:48	20.656	156.893	12:54	153	8160.53			
10 Feb 99	041	2	MOBY Site 1	10:37	20.811	157.180	16:14	20.799	157.150	12:01	594	8174.54	13:38	756	8175.53
11 Feb 99	042	3	MOBY Site 2	10:28	20.808	157.199	14:32	20.848	157.225	12:45	21	8189.54			

FIGURE 5.

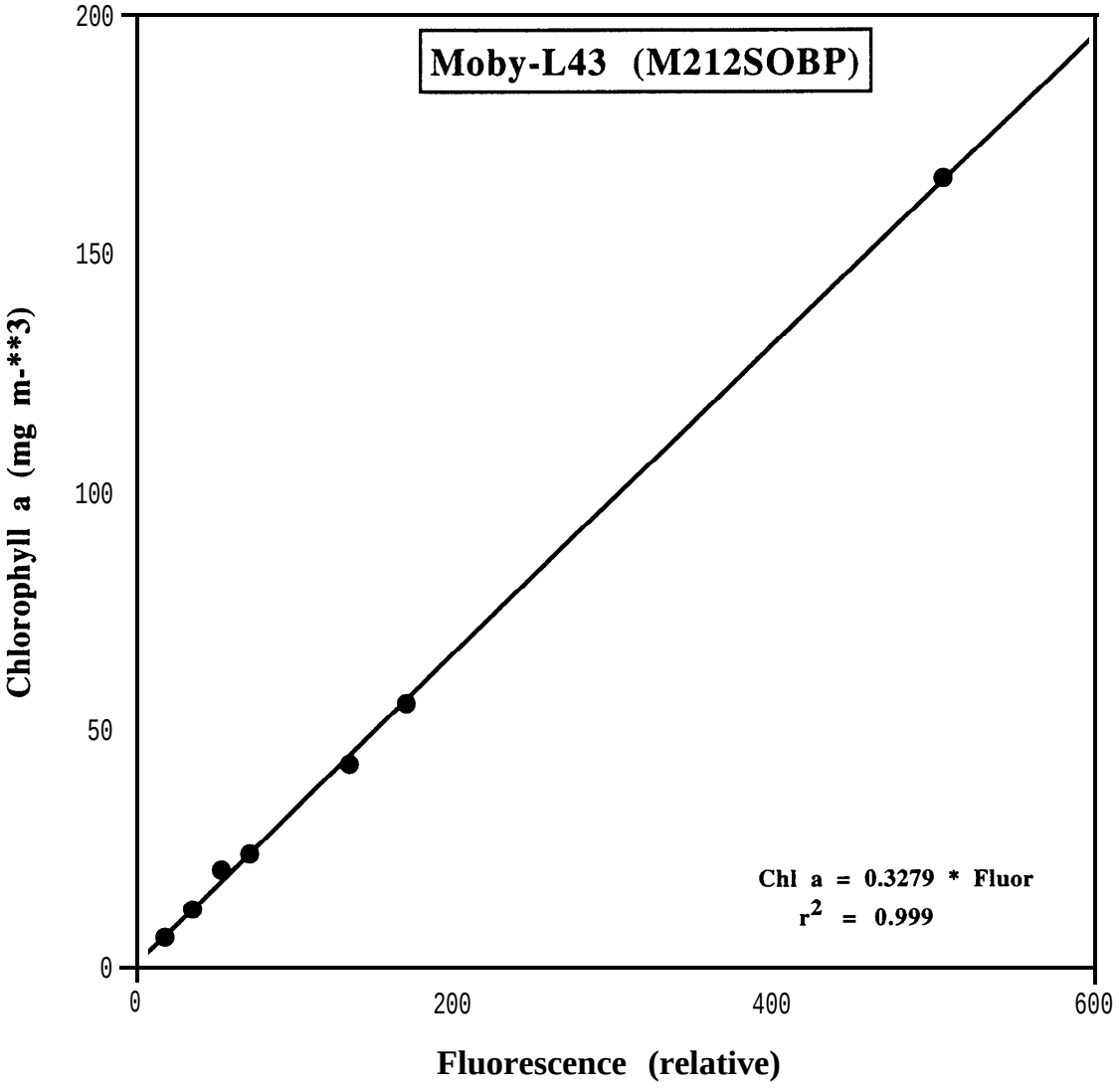

Moby-L43 (M212SOBP)
Chlorophyll a (mg m-**3)
Fluorescence (relative)
Chl a = 0.3279 * Fluor
r2 = 0.999
0
50
100
150
200
0
200
400
600

FIGURE **6.**

FIGURE 7.

FIGURE 8.

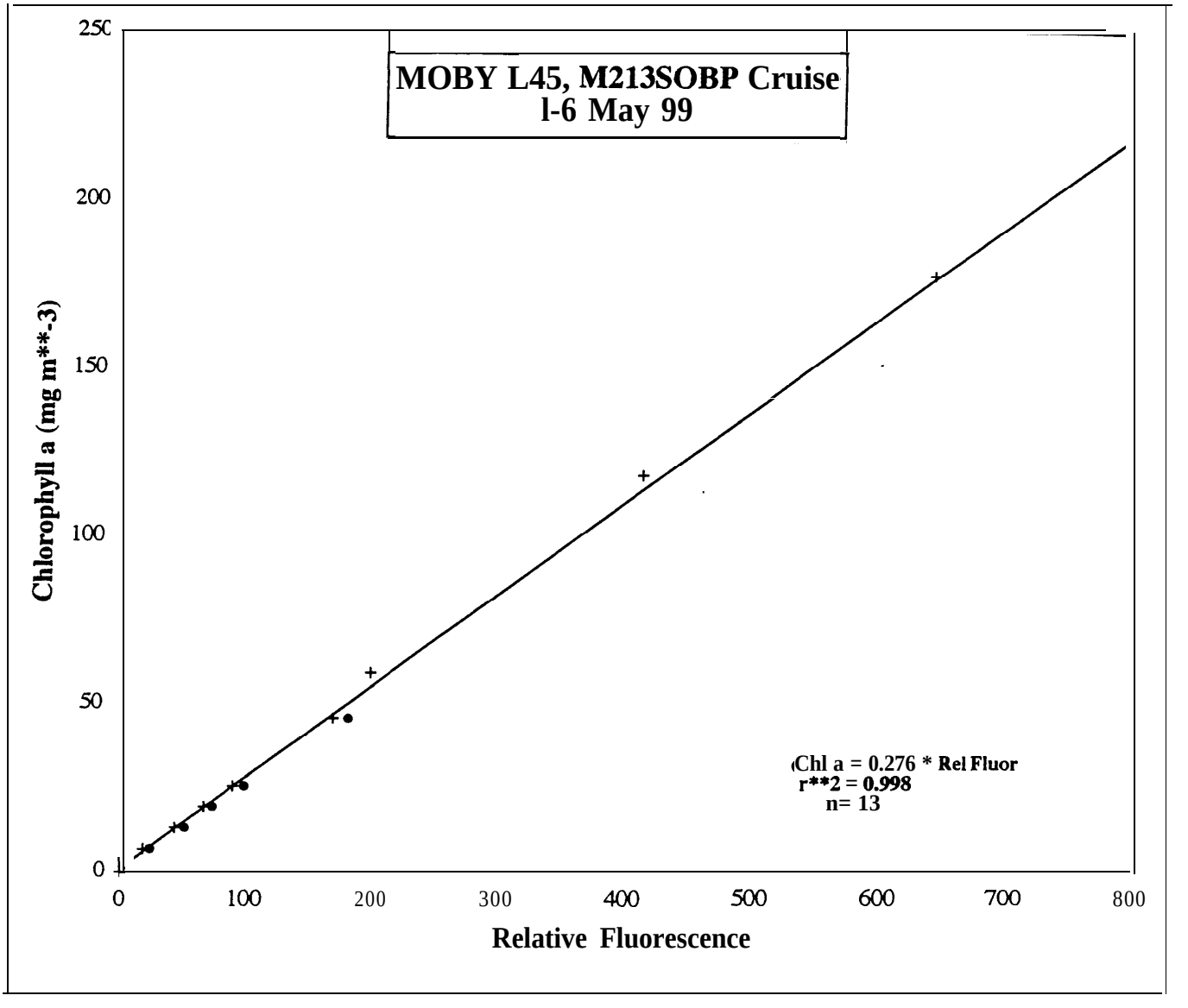


FIGURE 9. Calibration curve for NOAA Turner-10 Fluorometer during MOBY L45 Cruise.

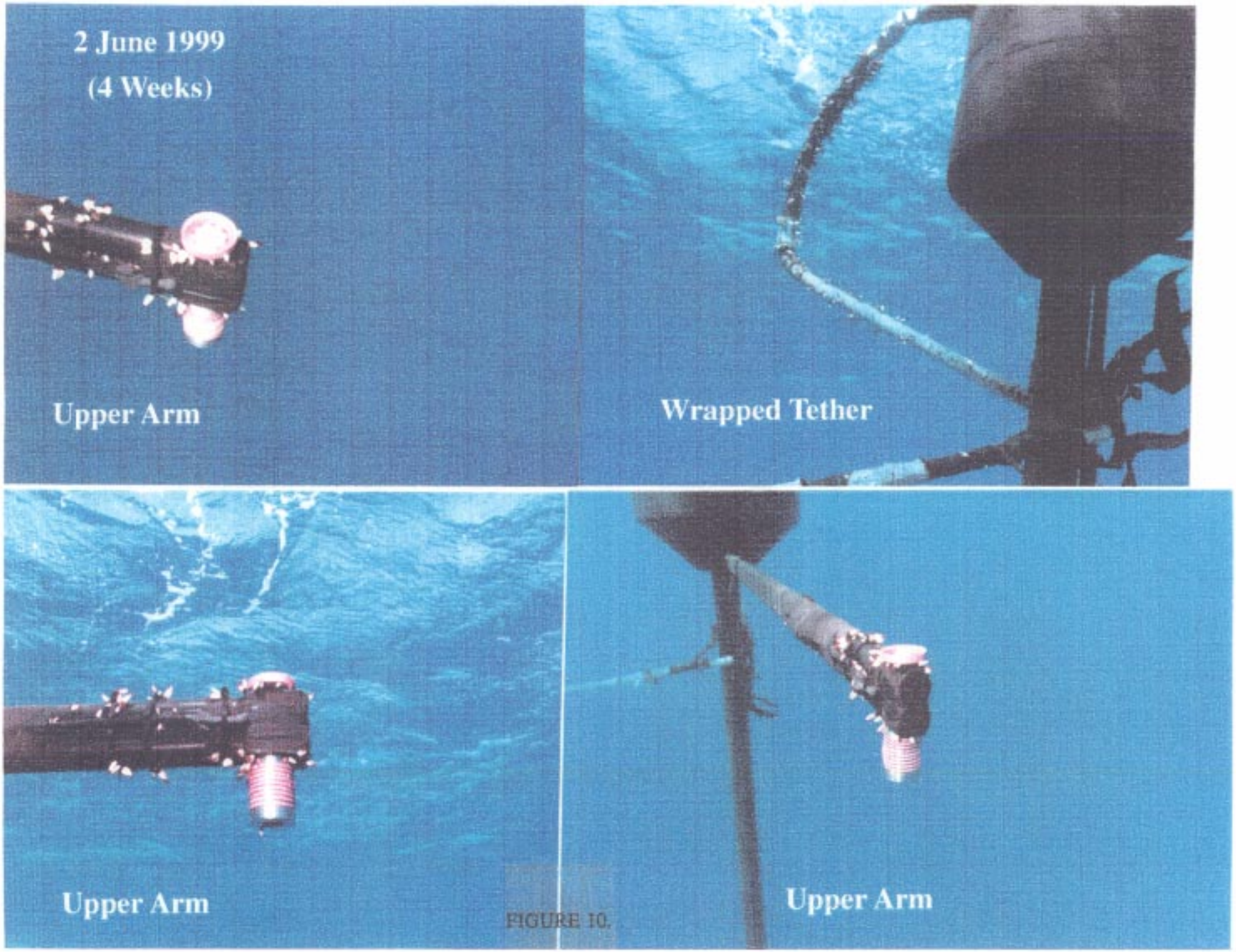

2 June 1999
(4 Weeks)
Upper Arm
Wrapped Tether
Upper Arm
Upper Arm

FIGURE 10.

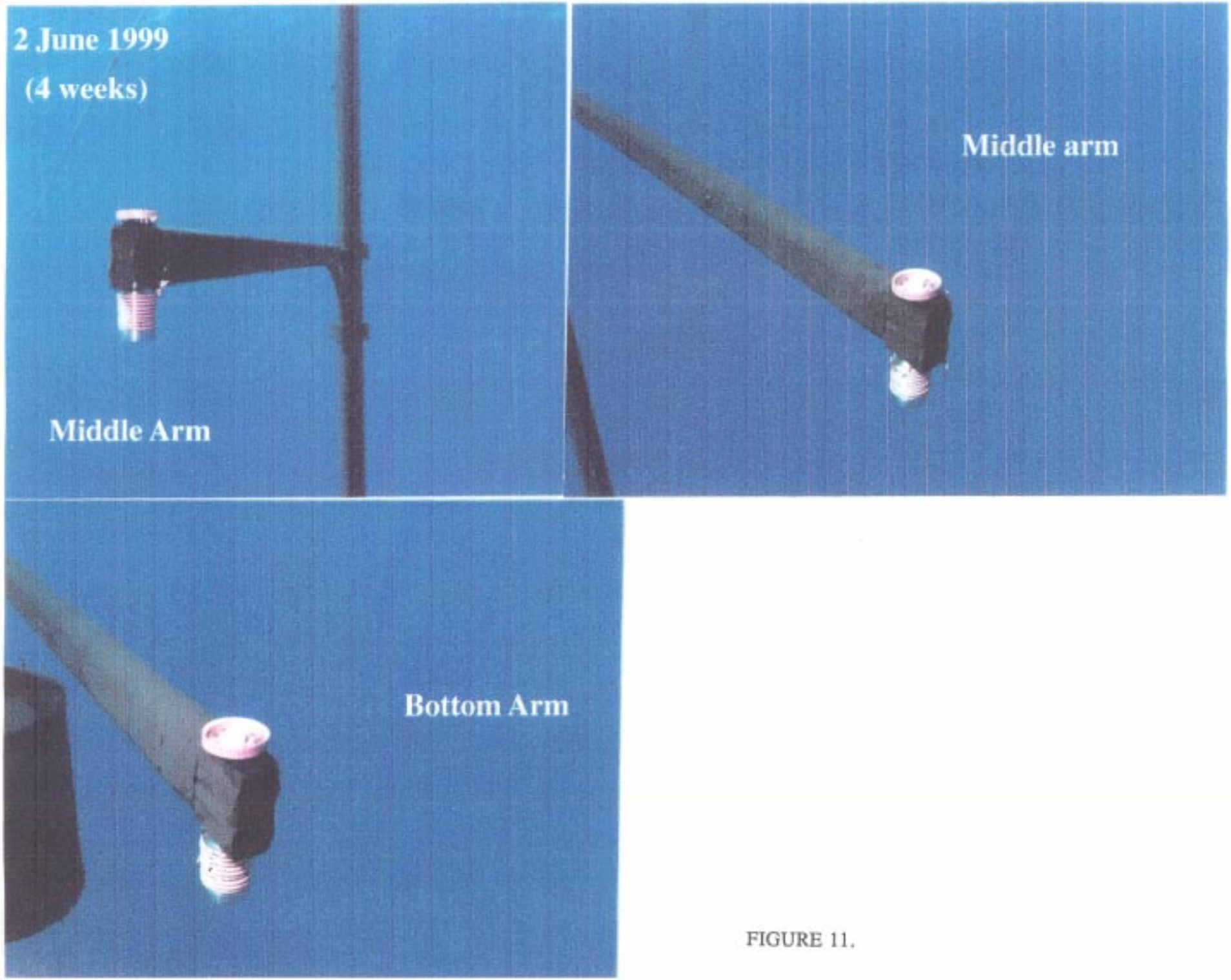


FIGURE 11.

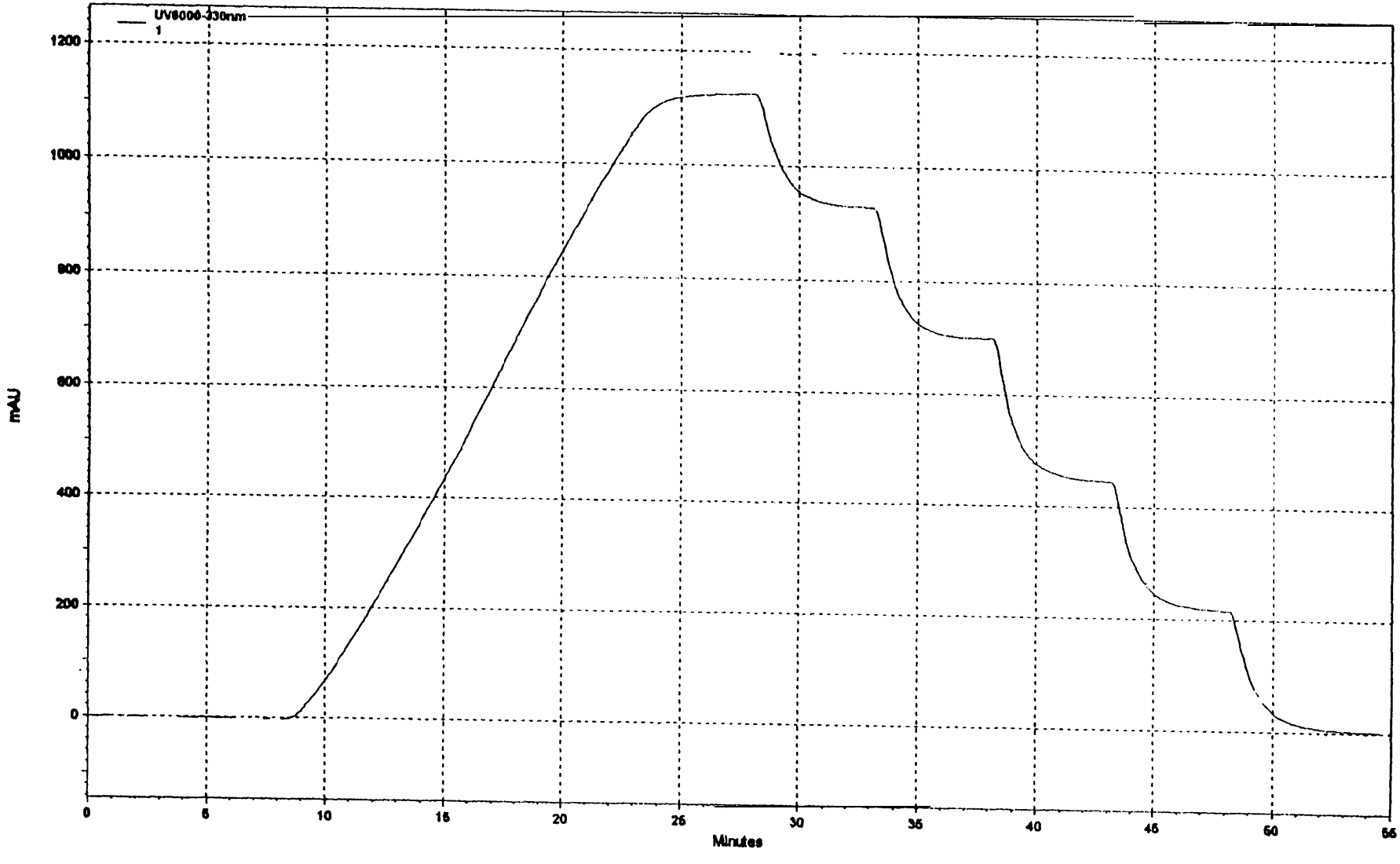
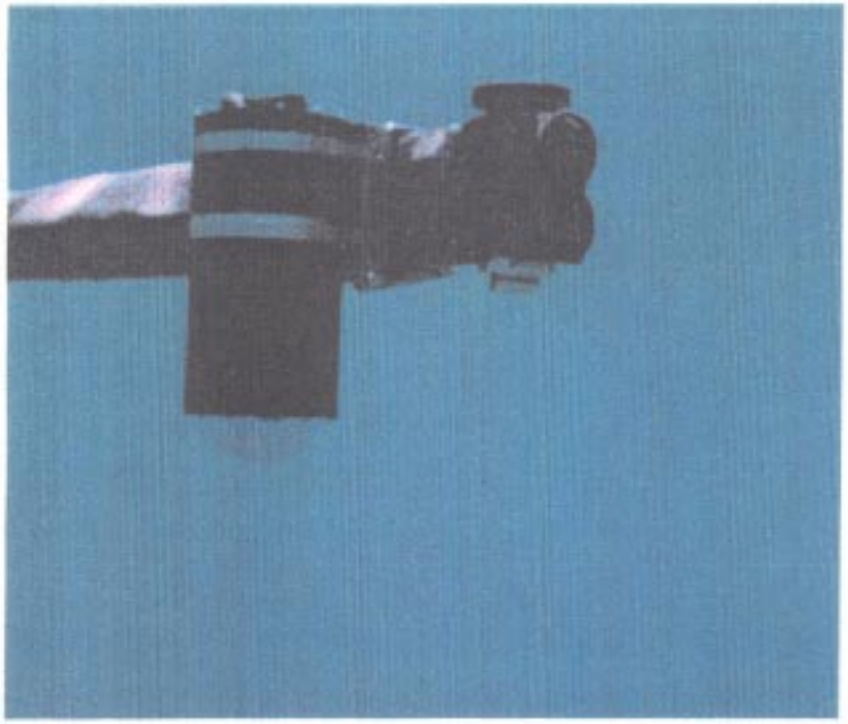


FIGURE 12. Valve gradient testing for valves B & C using methanol and acetone, and measuring the absorbance at 330 nm.

MOBY Radiance Distribution Camera Augmentation



- Observations:
  - Upwelled Radiance
  - Distribution -138 degrees
  - XYZ Tilt & Compass
  - 440 nm
- Features:
  - 8 bit digitization
  - 14 gigabyte storage
  - In-situ Exchangeability
  - Frequency - 30hz

FIGURE 13.

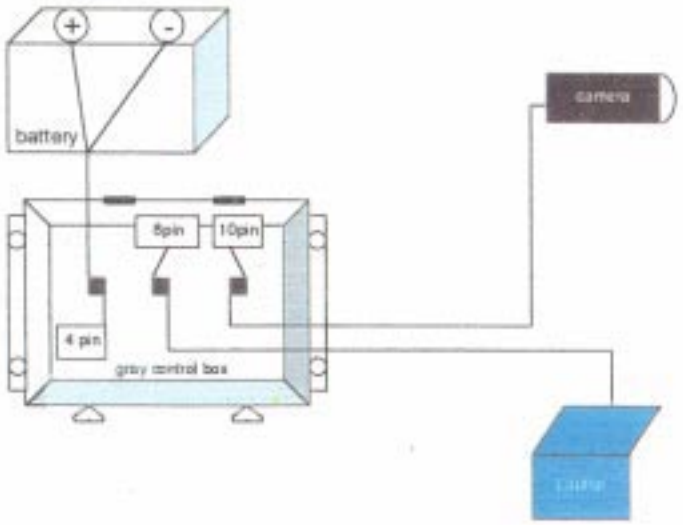


FIGURE 14.

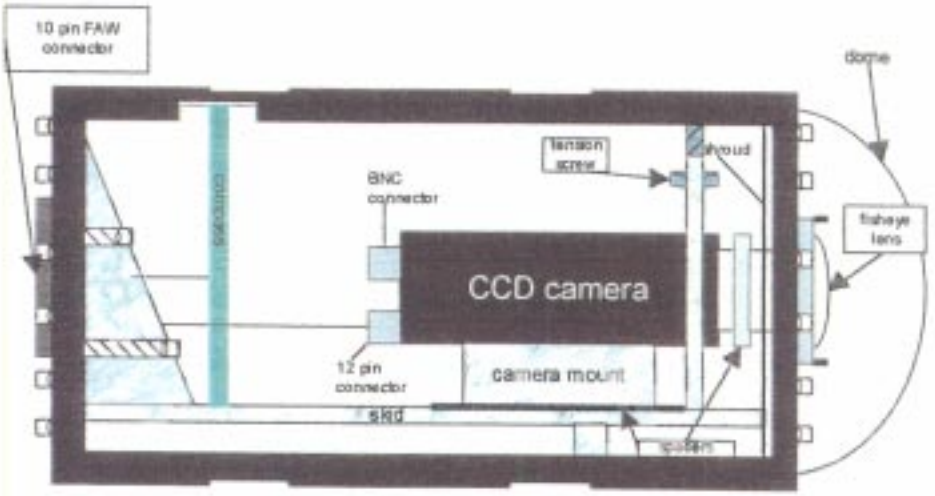

10 pin FAW connector
dome
tension screw
shroud
BNC connector
fisheye lens
CCD camera
12 pin connector
camera mount
skid

FIGURE 15.

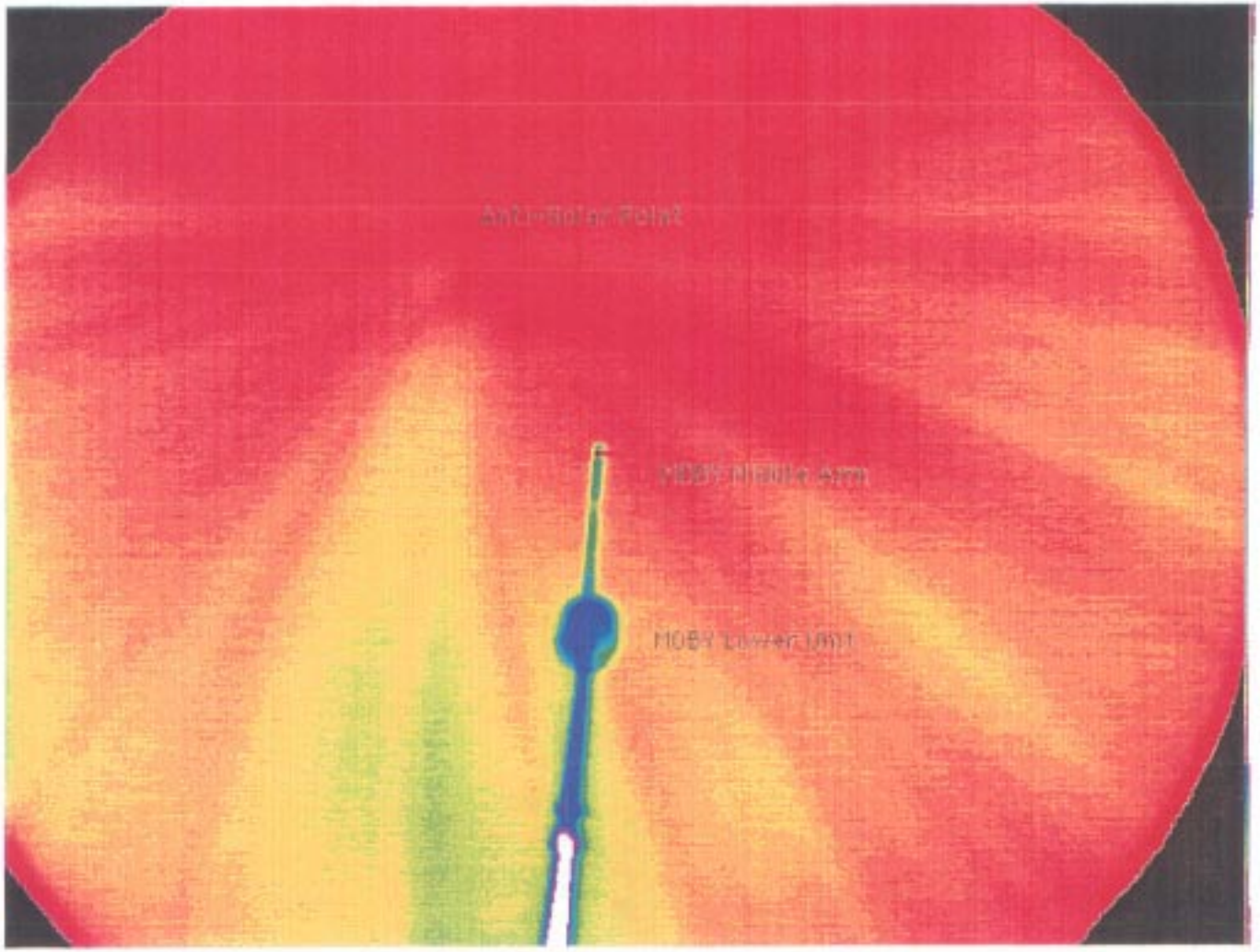


FIGURE 16.

Julian Date	GMT	CTD #	Sta	Latitude	Longitude	z	Chl a (mg/m**3)	Phaeopigment (mg/m**3)
40	2053	S BE0099	1	20.6072	156.9785	205	0.0161	0.0296
40	2053	SBEO099	1	20.6072	156.9785	80	0.3805	0.1548
40	2053	SBEO099	Sta 1	20.6072	156.9785	16	0.0769	0.0255
40	2053	SBE0099	Sta 1	20.6072	156.9785	8	0.0880	
40	2053	SBE0099	Sta 1	20.6072	156.9785	0	0.0896	0.0324
40	1254	SeaWiFS OverFlight	--	--	-.	0	0.0916	0.0334
40	1254	SeaWiFS OverFlight	--	--	-.	0	0.0911	0.0296
41	2201	SeaWiFS OverFlight	--	20.8 1383	157.1815	3	0.1052	0.0405
41	2201	SeaWiFS OverFlight		20.8 1383	157.1815	3	0.1037	0.0383
41	2201	OverFlight		20.8 1383	157.1815	3	0.1042	0.0348
42	139	SBElOO	Sta 2	20.8023	157.167	90	0.4209	0.1753
42	139	SBElOO	2	20.8023	157.167	25	0.2358	0.1142
42	139	SBElOO	Sta 2	20.8023	157.167	16	0.2019	0.0932
42	139	SBE100	Sta 2	20.8023	157.167	8	0.1351	0.0533
42	139	SBElOO	Sta 2	20.8023	157.167	0	0.1032	0.03 15
42	2036		Sta 3	20.80867	157.19833	120	0.3491	0.1813
42	2036	SBElOl	3	20.80867	157.19833	25	0.1644	0.0575
42	2036	SBE101	3	20.80867	157.19833	16	0.1169	0.0325
42	2036	SBElOl	Sta 3	20.80867	157.19833	8	0.1174	0.0350
42	2036		Sta 3	20.80867	157.19833	0	0.1270	0.0376
42	2244	SeaWiFS OverFlight	--	20.80 15	157.1885	3	0.0997	0.0277
42	2244	SeaWiFS OverFlight		20.8015	157.1885	3	0.0916	0.0255
42	2244	OverFlight		20.8015	157.1885	3	0.093 1	0.0288

TABLE 1

Appendix 1: Run time for MLML/NOAA Radiometric Calibration Sources

1. - Irradiance Calibration Sources:

FEL-F452 - Cal # 1 by NIST on 09-May-1996
FEL-F452 - Cal # 2 by Gamma Scientific on 24-Jul- 1996 (at 8.19A)

Date	Instrument	Cruise	Hours
Aug 1996	MOBY201	Pre-Cal	2.9
		(TOTAL	2.9)

FEL-F452 - Cal # 3 by Gamma Scientific on 23-Aug-1996 (at 8.2A)

Date	Instrument	Cruise	Hours
Sep 1996	NIST- DVM	Pre-L14	0.6
Sep 1996	MOBY201	Pre-Cal	3.9
Sep 1996	MOS202 & SXR	Pre-L14	1.5
Sep 1996	<Lamp Broken>	Pre-L14	
		(TOTAL	6.0)

FEL-F453 - Cal # 1 by Gamma Scientific on 30-Oct-1996

Date	Instrument	Cruise	Hours
Sep 1996	MOS202 & SIS	Pos-L14	2.0
Sep 1996	MD5	Pos-L14	0.4
Nov 1996	MD5 & Zeis - J.Porter	Pre-L15	1.7
Nov 1996	MOBY20 1	Pos-Cal	4.9
Nov 1996	MD5	Pos-L15	0.7
Nov 1996	MOS202	Pos-L15	2.4
Feb 1997	MD5	Pre-L16	0.9
Feb 1997	MOS202	Pre-L16	0.6
Feb 1997	SIS	Pre-L16	0.5
Mar 1997	MOBY202	Pos-Cal	7.3
Mar 1997	MD5	Pos-L16	0.6
Mar 1997	MOS202	Pos-L16	0.5
Mar 1997	HHCRM	Pos-L16	0.2
Mar 1997	SIS	Pos-L 16	0.4
Jul 1997	MOBY203	Pre-Cal	18.4
Jul 1997	MD5	Pre-L20	1.3
Jul 1997	MOS202 & SIS	Pre-L20	1 .O
Jul 1997	MOS202 & SIS	Pos-L20	1.4
Jul 1997	MD5	Pos-L20	1.2
		(TOTAL	46.7)

FEL-F453 - Cal # 2 by Gamma Scientific on 13-Oct-1997

Date	Instrument	Cruise	Hours
Oct 1997	SCAMPS	Pos-L22	2.7
Oct 1997	SIS	Pos-L22	0.4
Dec 1997	SCAMPS	Pre-L25	0.7
		(TOTAL	3.8)

FEL-F453 - Cal # 3 by NIST on 29-Jul-1998

FEL-F454 - Cal # 1 by NIST on 09-May- 1996

Date	Instrument	Cruise	Hours
Nov 1997	MOS202 & SIS	Pre-L25	1.4
Dec 1997	MD5	Pre-L25	4.1
Dec 1997	MOBY204	Pre-Cal	7.1
Jan 1998	MOBY203	Pos-Cal	4.6
Jan 1998	MOS & SIS & MD5	Pre-M4	1.7
Jan 1998	RADS- K.Voss	Pre-M4	0.6
Jan 1998	Zeis - J.Porter	Pre-M4	0.7
Mar 1998	MOS202 & SIS	Pos-M4	3.9
Mar 1998	MOBY205	Pre-Cal	5.4
Mar 1998	MD5	Pre-L28	0.8
Apr 1998	MOS202 & SIS	Pre-L29	1.1
Apr 1998	MOBY204	Pos-Cal	2.3
		(TOTAL	33.7)

FEL-F454 - Cal # 2 by NIST on 29-Jul-1998

Date	Instrument	Cruise	Hours
Oct 1998	MOBY207	Pre-Cal	6.4
Feb 1999	MOBY208	Pre-Cal	6.3
Apr 1999	MOBY207	Pos-Cal	2.2
Apr 1999	MOBY209	Pre-Cal	4.8
May 1999	MOBY208	Pos-Cal	4.2
		(TOTAL	23.9)

FEL-F471 - Cal # 1 by MST on 19-Jun-1997

Date	Instrument	Cruise	Hours
Jul 1998	MOBY206	Pre-Cal	5.5
Jul 1998	MD5	Pre-L3 5	1.0
Jul 1998	MD5	Pos-L35	0.7
Aug 1998	MOBY205	Pos-Cal	3.6
Sep 1998	MOS & SIS	Pos-L35	1.4
Oct 1998	MOS & SIS	Pre-L3 8	1.0
Oct 1998	MD5	Pre-L3 8	1.6
Nov 1998	MD5	Pos-L38	1.3
Nov 1998	MOBY206	Pos-Cal	3.1
Dec 1998	MOS202 & SIS	Pos-L38	0.8
Jan 1999	MD5	Pre-L43	1.8
Feb 1999	MOS202 & SIS	Pos-L.43	4.8
Apr 1999	MD5	Pre-L45	0.7
May 1999	J.Porter	Pos-L45	1.1
		(TOTAL	28.4)

FEL-GS 132 - Cal # 1? by Gamma Scientific on 12-May-1978
FEL-GS 132 - Cal # 2 by NIST on 28-Jul-1998

FEL-GS09 10 - Cal # 1 by Gamma Scientific on 28-Dec- 1993
FEL-GS0910 - Cal # 2 by Gamma Scientific on 12-Jan-1994 (ISA)

FEL-GS09 10 - Cal # 3 by Gamma Scientific on 17-Jan- 1994 (ISA)

Date	Instrument	Cruise	Hours
Feb 1994	<Lamp Broken>	Pre-L 1	
		(TOTAL	?.?)

FEL-GS922 - Cal # 1 by Gamma Scientific on 15-Aug-1994

Date	Instrument	Cruise	Hours
Sep 1994	Misc.	SIRREX-3	?.?
Oct 1994	MOS & SIS & FASTIE	Pre-M3	6.3
Nov 1994	MOS & SIS & FASTIE	Pos-M3	2.6
Mar 1995	MOS & SIS & MD5	LO9	2.1
Aug 1995	MD5	L10	0.6
Oct 1995	MD5	Pre-L11	1.6
Nov 1995	MD5	Pos-Ll 1	0.8
		(TOTAL	14.0+)

FEL-GS922 - Cal # 2 by Gamma Scientific on 05-Oct-1994 (ISA)
FEL-GS922 - Cal # 3 by Gamma Scientific on 24-Jul-1996

2. - Radiance Calibration Sources:

OL420M - Cal # 1 by Optronic Laboratories on 04-Feb- 1992
OL420M - Cd # 2 by Optronic Laboratories on 10-Jun- 1994

Date	Instrument	Cruise	Hours
Aug 1995	MD5	L10	2.0
Oct 1995	MD5	Pre-Lll	7.2
Nov 1995	MD5	Pos-Lll	4.9
Feb 1996	MOS	L12	2.6
Feb 1996	MD5	L12	0.8

OL420M - Cal # 3 by Optronic Laboratories on 23-May- 1996

Date	Instrument	Cruise	Hours
Aug 1996	MOS204	L13	3.7
Sep 1996	MOBY20 1	Pre-Cal	8.4
Sep 1996	MD5	Pre-L14	1.5
Sep 1996	MOS202 & SXR	Pre-L14	2.1
Sep 1996	NIST - SXR	Pre-L14	2.9
Sep 1996	MD5	Pos-L14	1.8
Sep 1996	MOS202	Pos-L14	8.1
Nov 1996	MD5 & Zeis - J.Porter	Pre-L15	2.8
Nov 1996	MOBY202	Pre-Cal	5.5
Nov 1996	MOBY201	Pos-Cal	1.9
Nov 1996	MD5	Pos-L15	0.5
Nov 1996	MOS202	Pos-L15	2.6
Feb 1997	MD5	Pre-L16	2.4
Feb 1997	MOS202	Pre-L16	0.4
Mar 1997	MD5	Pos-L16	0.8
Mar 1997	MOS202	Pos-L16	2.8
Mar 1997	HHCRM	Pos-L16	0.5
Mar 1997	MOBY202	Pos-Cal	7.7
		(TOTAL	56.4)

OL420M - Cal # 4 by Optronic Laboratories on 1 l-Jun-1997

Date		Instrument	Cruise	Hours
Jul	1997	MOBY203	Pre-Cal	8.9
Jul	1997	MD5	Pre-L20	2.2
Jul	1997	MOS202	Pre-L20	3.2
Jul	1997	MD5	Pos-L20	1.3
Jul	1997	MOS202	Pos-L20	3.1
Sep	1997	SCAMPS	Pre-L22	1.7
Sep	1997	MD5 & HHCRM	Pre-L22	1.7
Sep	1997	MOS202	Pre-L22	1.6
Dec	1997	MD5 & HHCRM	Pre-L25	1.0
Dec	1997	MOBY204	Pre-Cal	1.3
Jan	1998	MOBY203 & MD5	Pos-Cal	4.7
Jan	1998	MOS202 & HHCRM	Pre-M4	1.1
Feb	1998	MOS202	Pos-M4	1.3
Mar	1998	MOBY205	Pre-Cal	7.6
Mar	1998	MD5 & HHCRM	Pre-L28	1.3
Apr	1998	MD5	Pos-L28	1.0
Apr	1998	MOS202	Pre-L29	0.6
Jun	1998	MOBY204	Pos-Cal	3.1
Jul	1998	SIRREX-6	Pre-L3 5	3.1
Jul	1998	MOBY206	Pre-Cal	3.3
Jul	1998	MD5 & HHCRM	Pre-L3 5	2.0
Jul	1998	MD5	Pos-L35	0.8
Aug	1998	MOBY205	Pos-Cal	3.2
Sep	1998	MOS202	Pos-L35	1.9
			(TOTAL	61.6)

OL420M - Cal # 5 by Optronic Laboratories on 22-Oct- 1998

Date	Instrument	Cruise	Hours
Nov 1998	MD5 & HHCRM	Pre-L3 8	1.9
Dec 1998	MOBY206	Pos-Cal	3.6
Dec 1998	MOS202	Pos-L38	1.1
Jan 1999	MST - VXR	Pre-L43	6.9
Jan 1999	MD5 & HHCRM	Pre-L43	1.5
Feb 1999	MOBY208	Pre-Cal	4.8
Mar 1999	MOS202	Pos-L43	3.1
Apr 1999	MOBY207	Pos-Cal	2.8
Apr 1999	MOBY209	Pre-Cal	3.1
Apr 1999	MD5 & HHCRM	Pre-L45	0.9
May 1999	MD5	Pos-L45	0.9
May 1999	MOBY208	Pos-Cal	1.5
May 1999	J.Porter	Pos-L45	0.7
		(TOTAL	32.8)

OL425 - Cal # 1 by Optronic Laboratories on 3 1-Jul- 1997

Date	Instrument	Cruise	Hours
Nov 1997	MOS202	Pre-L25	1.2
Dec 1997	MOBY204	Pre-Cal	8.8
Jan 1998	MOS202	Pre-M4	0.8
Jan 1998	RADS- K.Voss	Pre-M4	0.7
Jan 1998	Zeis - J.Porter	Pre-M4	0.9
Mar 1998	MOBY205	Pre-Cal	0.9
Jun 1998	MOBY204	Pos-Cal	3.9
Jul 1998	MOS204	Pos-L29	2.0
Jul 1998	SIRREX-6	Pre-L35	3.3
Jul 1998	MOBY206	Pre-Cal	1.2
Sep 1998	MOBY205	Pos-Cal	1.3
Oct 1998	MOS202	Pre-L3 8	1.7
Oct 1998	MOBY207	Pre-Cal	6.5
Oct 1998	MD5	Pre-L3 8	2.2
Dec 1998	MOS202	Pos-L38	0.7
Jan 1999	NIST- VXR	Pre-L43	2.0
Apr 1999	MOBY207	Pos-Cal	1.8
		(Total	39.9)