MODIS Team Member - Quarterly Report
Marine Optical Characterizations
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SUMMARY

The team's emphasis during this reporting period has been in the areas of designing and testing bio-optical instrumentation, evaluating several of the SeaWiFS bio-optical protocols, processing data collected during field experiments, and reprocessing several of the MOCE 2 and 3 bio-optical data sets. The team conducted one trip to the operations site in Honolulu, Hawaii, making necessary preparations for future field experiments. Part of the team also traveled to Salinas, California, to assist with the fabrication of the next generation Marine Optical Buoys. Technical memoranda are being written to address the remote sensing reflectance, instrument self-shading, and the particle absorption protocols. A manuscript was prepared for the NASA/EOS Aerosol Remote Sensing Workshop scheduled for April 15-19, 1996.

MOBY-L12 EXPERIMENT

Members of the MOCE Team conducted field work and routine site maintenance in Hawaii, February 21- March 7, 1996. The tent was power washed, the black top area was resurfaced, drainage pumps were repaired, storage huts were completed and organized, and the tent was organized to facilitate the team's next major effort of completing the assembly of the first operational MOBY (Fig 1).

Work on the fiber optic irradiance collector design was finalized. Development of this optical-mechanical device, which has an angular response that follows the cosine function was extremely difficult. After testing over 20 various configurations, a final design was selected. The new design is three times more efficient over most of the wavelength region, yet maintains a very good cosine response. The immersion factors for the new fiber optic irradiance collectors were measured from 350 nm to 1100 nm (Fig. 2) and the data are being processed.

The prototype MOS radiometer was characterized for its polarization sensitivity. The characterizations were conducted using the Optronic Laboratories OL-420M source of spectral radiance with a combination of Melles Griot polarization and Oriel depolarization filters. An abbreviated wavelength calibration of MOS was performed using Melles Griot HeNe laser and Oriel Ne and HgA line sources. Results from the

MOS polarization characterization indicated a high degree of polarization sensitivity within the blue and red radiometers overlap region (between 600 and 625 nm) (Fig. 3). The red array showed greater overall polarization sensitivity than the blue, but several wavelengths (551, 577, 705 nm) were relatively insensitive and may serve as reference points to be incorporated into future data processing procedures (Fig. 4). The transmission-reflectance properties of the dichroic "water mirror between the red and blue arrays (Fig. 5) produce a relative response shift of 180°. Polarization sensitivity was greatly reduced by addition of the Oriel depolarizer in the optical path (Figs. 3, 4, 5). Utilization of this depolarization filter will result in an approximate 30% loss of transmission. However, polarization sensitivity is so large that the depolarizers will be incorporated into the present MOS optical system.

MARINE OPTICAL BUOY - Hardware Development

MOS

D. Clark, Y. Ge, and M. Yarbrough (Moss Landing Marine Laboratories) visited American Holographic in Boston, Massachusetts, on February 13, 1996, to examine and test the prototype spectrograph. Preliminary tests resulted in the system displaying sub nanometer resolution with extraordinarily small image distortion. This system represents a milestone in the three-year instrument development project with American Holographic. The system development was required for use in the MOBY application to improve dynamic range and signal to noise. As a result of these tests, the prototype systems were accepted and approval was given to begin production of the operational units.

Since the spectrometers in the MOS system are being replaced with a new design, the front end relay optics must be redesigned to match the updated requirements. A new optical train was designed for this purpose. Various configurations were considered and modeled, and an optically optimized, low cost design was achieved. The blueprints for the required optical elements were drawn, suppliers were identified, and procurements were completed.

A great deal of effort was done in the area of designing and constructing MOS parts. The VS-10 mounts were fabricated and delivered. The new design of the CCD mount for the VS-10 was finalized, four prototype units were fabricated, and eleven additional units were ordered. VS-10 telescope to shutter adapters, coolant pump mounts, connector mounts, and connector o-ring modifications were fabricated. Two MOS deck units were assembled. The final design of remaining MOS internal parts (heat sinks, power supply mounts, optical modifications for depolarizer) was determined. The tests of the CCD cooling system mock-up to determine the feasibility of using the Sea-Bird pump motor to drive the CCD coolant pump and to determine the size requirements of the external heat exchanger were conducted.

MOBY-2

The MOBY lab mock-up was finished and is being used for hardware and software testing. The lab has been full-up and operating with solar panels, batteries, cell phone, GPS, and a MOS mock-up since March 1 and with the prototype MOS since March 22.

The tests and evaluation of the ZyXEL modems as replacements for the Supra modems were performed. The ZyXEL modems "hold" the cellular connection much better than the Supra modems and they do not bum up at 45° C. The ZyXEL modems required a hardware modification which will allow the TT7 to perform a processor reset of the modem as may be required. An initial heat testing of one controller unit to 70°C for eight hours was performed. This unit will be run in the lab under high temperature conditions until it is deployed on the mooring float as the field test unit.

Work is continuing on the MOBY software operating system. Most of the problems in the application programs have been solved. The Forth Core has been stable for about six weeks, although more core changes are being planned which will result in better handling of system crashes. The MOS acquisition, GPS, and the modem applications have been running for six weeks without any problems.

DATA REDUCTION

MOCE-3

The along-track particulate absorbance, along-track and profile detrital absorbance, solar atmospheric transmission, and daily flow meter data sets collected during MOCE-3 underwent preliminary quality control procedures. These data files were formatted according to SeaBASS (SeaWiFS Bio-optical Archive and Storage System) requirements and submitted to NASA. It was determined that an incorrect factor was used to process absorption data collected during the MOCE-2 and MOCE-3 research cruises. These data will be reprocessed and resubmitted to NASA.

The total suspended matter (TSM), pigment, and the along-track VLST (Visibility Lab Spectral Transmissometer) data sets collected during MOCE-3 have also undergone preliminary quality control procedures; however, some inconsistencies between recorded and observed depths were noticed. These inconsistencies are in the process of being resolved.

Work is continuing with calibrating the HPLC system. Pigment standards for monovinyl and divinyl chlorophylls *a* and *b* were obtained from Dr. Robert Bidigare,

University of Hawaii. Monovinyl and divinyl chlorophylls co-elute on the Spherisorb ODS-2 column, making quantification impossible. Fortunately, they do have different absorption spectra and by monitoring these chromatographic peaks at two wavelengths (436 nm and 450 nm) monovinyl and divinyl compounds can be quantified. The equations and calibration curves for a dual-wavelength detection scheme are shown in Fig. 6, 7, and 8. This correction to chlorophyll *a* and *b* concentrations will be applied to MOCE-3 cruise data.

MILL CREEK TURBID WATER EXPERIMENT

Pigment samples collected during the Mill Creek experiments were analyzed by HPLC and fluorometric methods. To verify the extraction efficiency of 90% acetone, 1.75 mls of DMSO (dimethylsulfoxide), a strong organic solvent, was added to the pigment sample and then an aliquot was reanalyzed on the HPLC system. Because DMSO changes the acid ratio, these samples were not run again on the fluorometer.

DOCUMENTATION

Clark, D., Gordon, H., Voss, K., Ge, Y., Broenkow, W., and Trees, C. (1996) Validation of Atmospheric Correction over the Oceans, presented at the Aerosol Remote Sensing Workshop, April 15-19, 1996, Washington, D.C.

MLML personnel have prepared a technical memorandum which details CTD profiling and water sampling results from the MOBY-L11 cruise at the Lanai mooring site during November 1995:

Feinholz, M.E. (1996) Oceanographic Profiling Observation From the MOBY-L11 Cruise: 3 to 7 November 1995. Moss Landing Marine Laboratories Technical Memorandum 96-1.21 pp.

Photographs taken during MOCE field deployments and experiments since last July were archived. These photos are used for documentation purposes in presentations, progress reports, project reviews, and meetings.

SeaWiFS PROTOCOL WORKSHOP & MEETING

D. Clark and C. Trees, Center for Hydro-Optics and Remote Sensing, attended the Sixth SeaWiFS Bio-optical Algorithm and Optical Protocols Meeting and the Case 2 Water Measurement Protocols Workshops held at the National Institute of Standards and Technology in Gaithersburg, March 18-22, 1996. D. Clark presented the status of the MOBY program and presented preliminary results of comparisons of the remote

sensing reflectance functions and the effects of instrument self-shading during data collection. C. Trees presented a comparison of the techniques for computing the beta correction for absorption data. He also made a presentation on the differences found in chlorophyll *a* concentrations determined by HPLC and the fluorometric methods.

SUPPORTING GRANTS AND INTERAGENCY ACTIONS

The San Diego State University Foundation grant was awarded.

The Research and Data Systems (RDC) Corporation science support contract has been renewed.

Another Research and Data Systems Corporation science support contract has been initiated.

The Moss Landing Marine Laboratories, San Jose State University grant was awarded.

Funds were transferred to NSF UNOLS for University of Hawaii ship time support for MOBY.

Funds were transferred to NIST for calibration support of MOBY.

FIGURE 1.

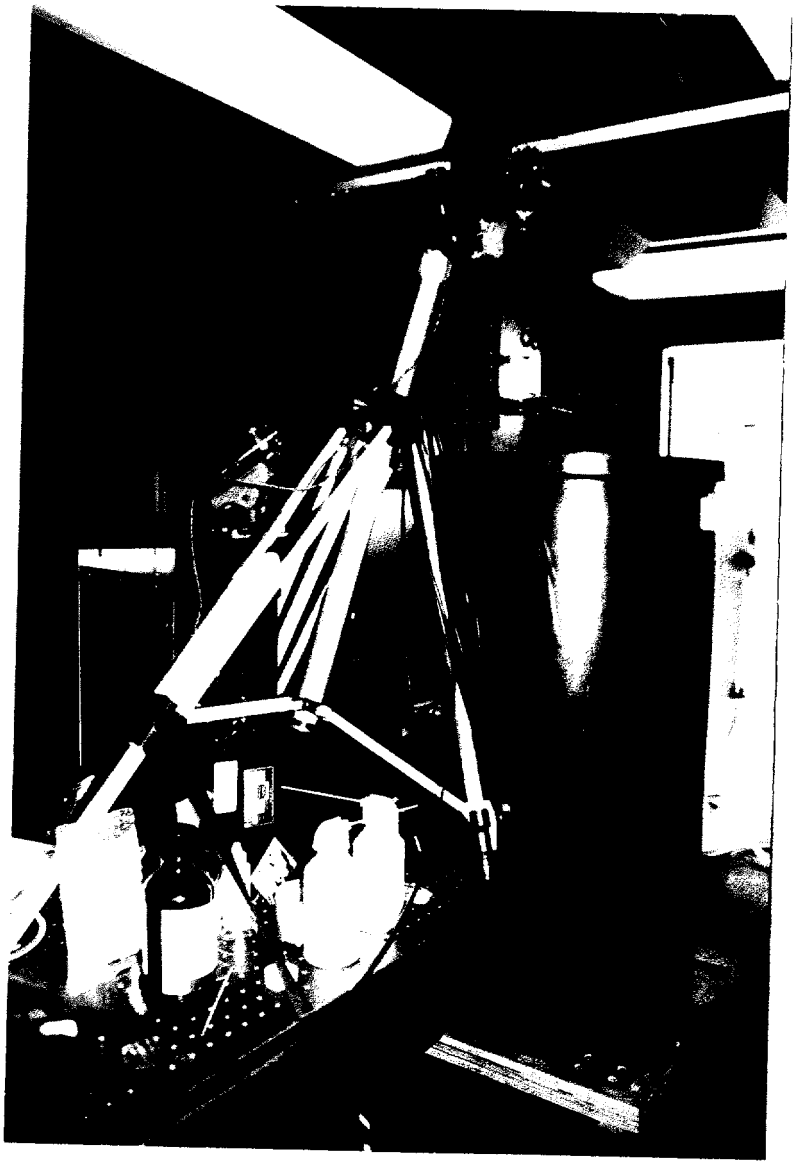


FIGURE 2.

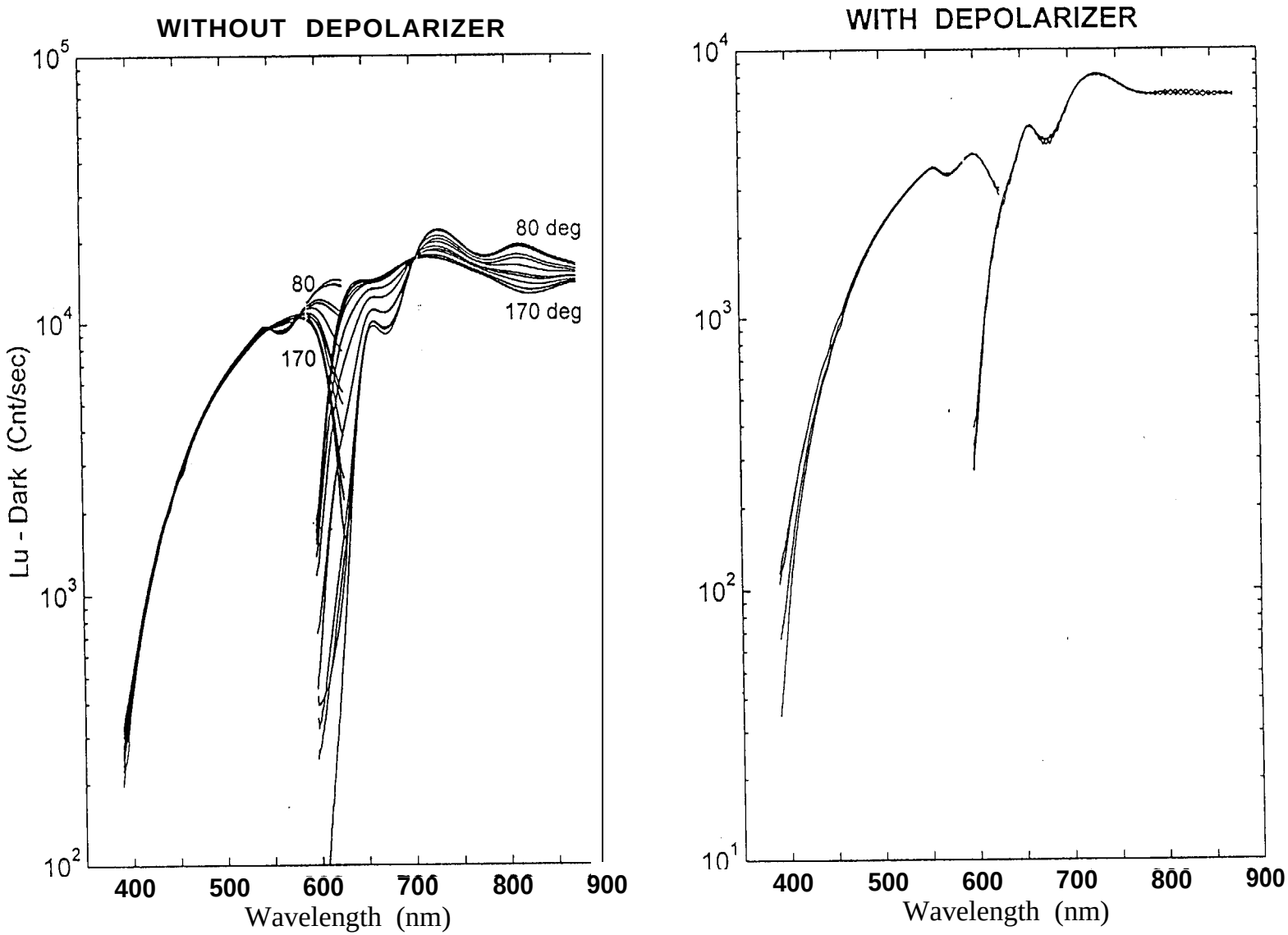


FIGURE 3. Dark corrected ADU (Counts/Second) MOS Radiance (Lu) measurements with Melles Griot polarization filter between 0 and 180°, without and with the Oriel depolarization filter,

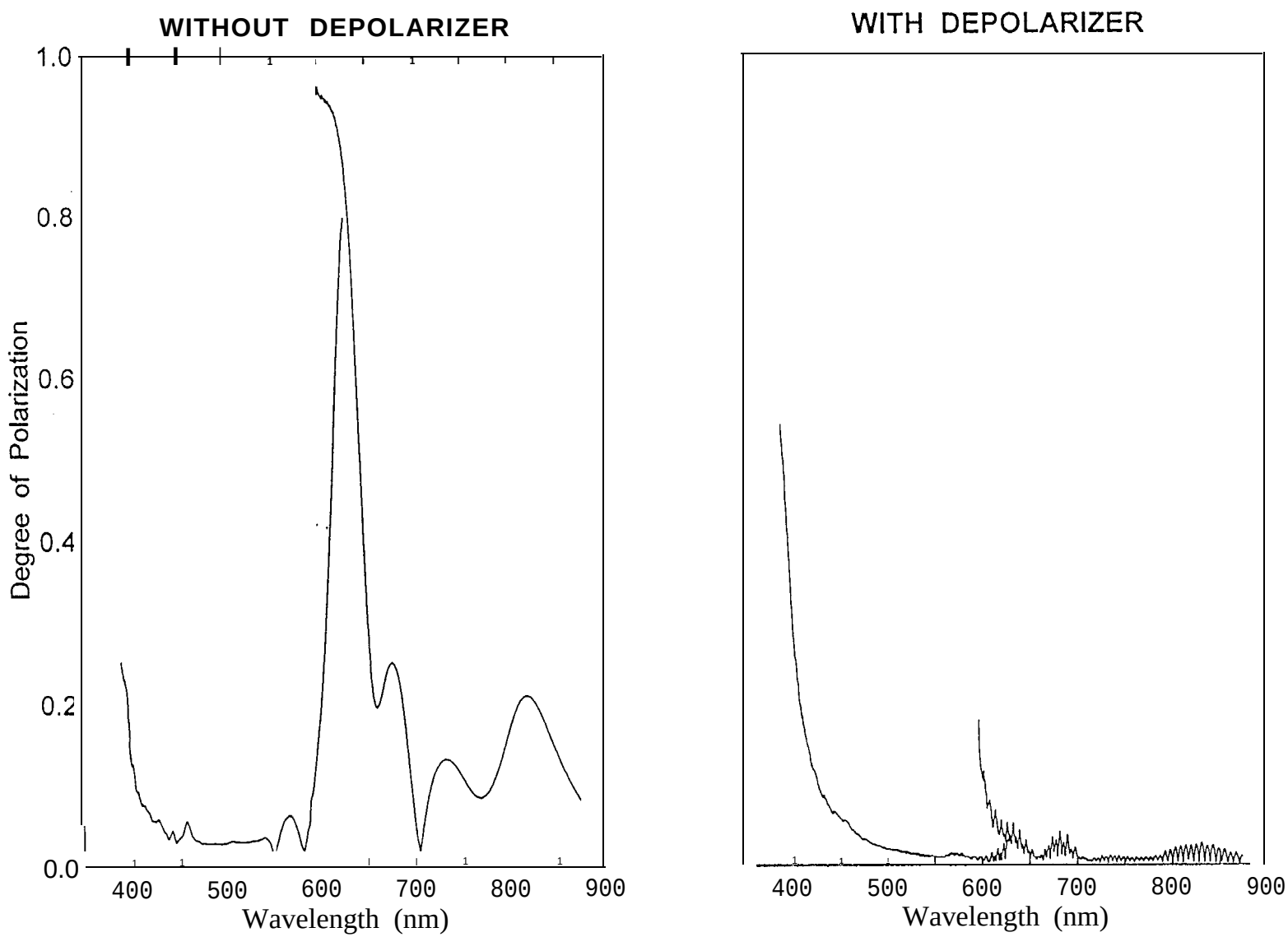


FIGURE 4. Degree of Polarization (Max response - Min / Max + Min) for 0 to 180° polarization filter, without and with depolarization filter,

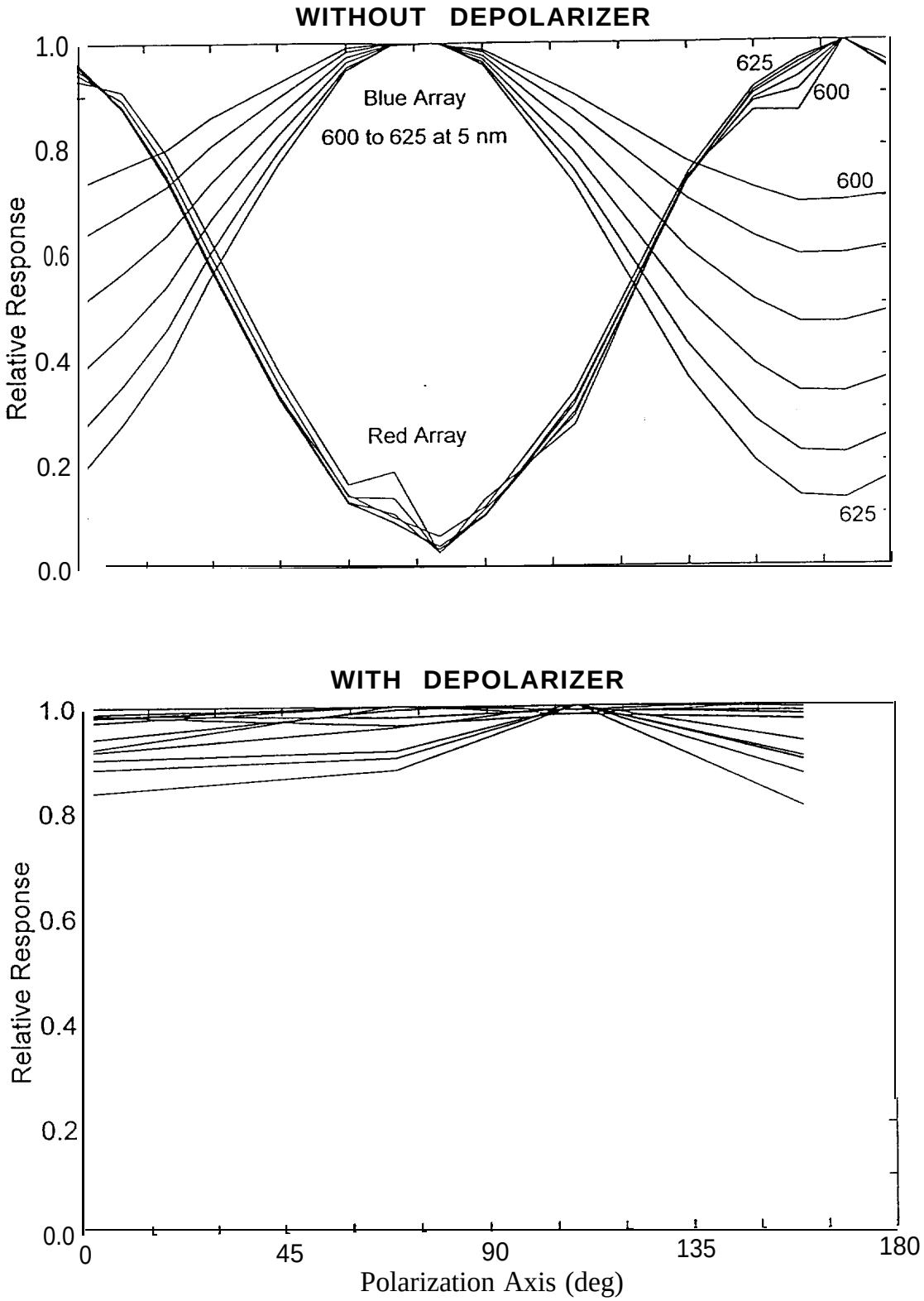


FIGURE 5. Relative Polarization Response of MOS wavelengths within the blue-red radiometer overlap region as a function of polarizer filter axis, without and with depolarization filter.

Monovinyl and Divinyl Chl *a* & *b* Calibrations

To calculate the concentration of DV Chl *a* from MV chl *a*, the following equations are used:

$R_1 = \frac{area}{conc}$ or response factor

A = area of peak

C = cone

M v = monovinyl

DV = Di-vinyl

$\lambda_1 = 436$

$\lambda_2 = 450$

(1) $$A(\lambda_1) = R_{MV}(\lambda_1) C_{MV} + R_{DV}(\lambda_1) C_{DV}$$

(2) $$A(\lambda_2) = R_{MV}(\lambda_2) C_{MV} + R_{DV}(\lambda_2) C_{DV}$$

to solve for C_{MV}, we multiply Eq. (1) by $R_{Dv}(\lambda_2)$ and Eq. (2) by $R_{Dv}(\lambda_1)$ and then substract,

(3) $$R_{DV}(\lambda_2) A(\lambda_1) - R_{DV}(\lambda_1) A(\lambda_2) = C_{MV}[R_{DV}(\lambda_2) R_{MV}(\lambda_1) - R_{DV}(\lambda_1) R_{MV}(\lambda_2)]$$

or

(4) $$C_{MV} = \frac{R_{Dv}(\lambda_2) A(\lambda_1) - R_{DV}(\lambda_1) A(\lambda_2)}{R_{DV}(\lambda_2) R_{MV}(\lambda_1) - R_{DV}(\lambda_1) R_{MV}(\lambda_2)}$$

and

(5) $$C_{DV} = \frac{A(\lambda_1) - R_{MV}(\lambda_1) C_{MV}}{R_{Dv}(\lambda_1)}$$

One can also divide both sides of Eq. (4) by $A(\lambda_1)$ to get

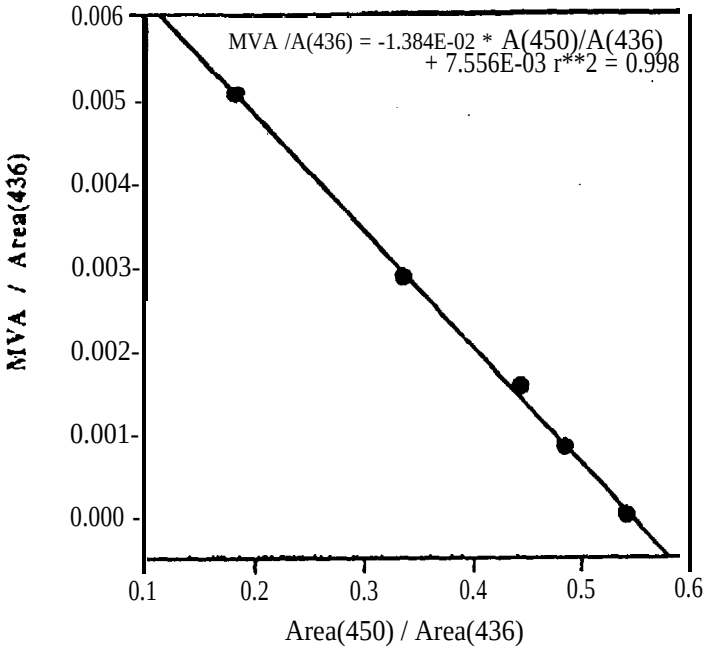
$$\frac{C_{MV}}{A(\lambda_1)} = \frac{R_{DV}(\lambda_2)}{R_{DV}(\lambda_2)R_{MV}(\lambda_1) - R_{DV}(\lambda_1)R_{MV}(\lambda_2)} - \frac{R_{DV}(\lambda_1)}{R_{DV}(\lambda_2)R_{MV}(\lambda_1) - R_{DV}(\lambda_1)R_{MV}(\lambda_2)} * \frac{A(\lambda_2)}{A(\lambda_1)}$$

or

$\frac{C_{MV}}{A(\lambda_1)} = b - m\frac{A(\lambda_2)}{A(\lambda_1)}$, which describes a linear equation as shown in the calibration curves.

Eq. 5 can also be written as $$\frac{C_{DV}}{A(\lambda_1)} = \frac{1}{R_{DV}(\lambda_1)} - \frac{R_{MV}(\lambda_1)}{R_{DV}(\lambda_1)} * \frac{C_{MV}}{A(\lambda_1)}$$

FIGURE 6.


MVA /A(436) = -1.384E-02 * A(450)/A(436)
+ 7.556E-03 r**2 = 0.998
0.006
0.005
0.004
0.003
0.002
0.001
0.000
MVA / Area(436)
0.1
0.2
0.3
0.4
0.5
0.6
Area(450) / Area(436)

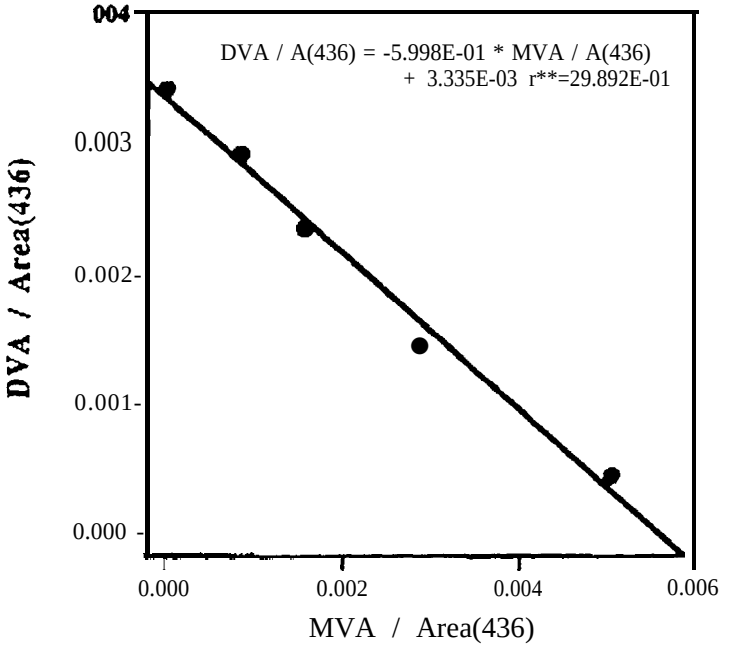
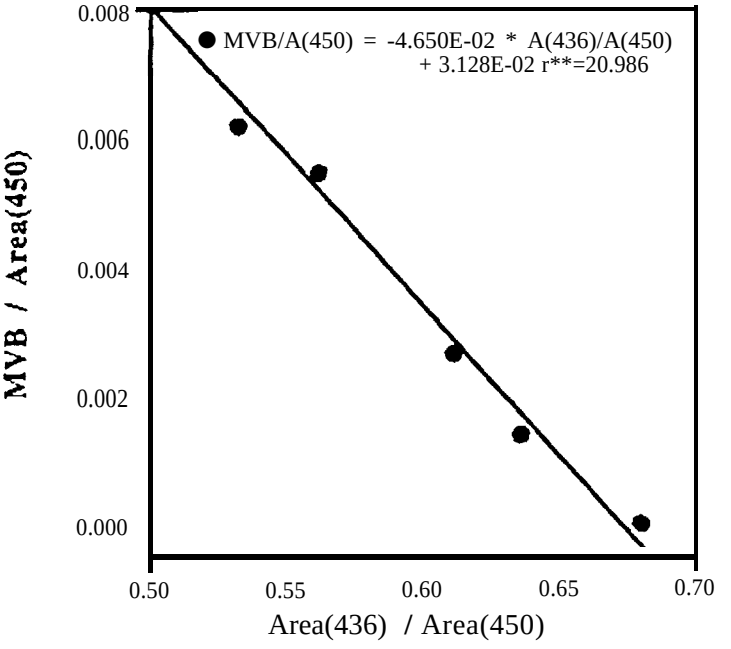

DVA / A(436) = -5.998E-01 * MVA / A(436)
+ 3.335E-03 r**=29.892E-01
004
0.003
0.002
0.001
0.000
DVA / Area(436)
0.000
0.002
0.004
0.006
MVA / Area(436)

FIGURE 7.


MVB/A(450) = -4.650E-02 * A(436)/A(450)
+ 3.128E-02 r**=20.986
MVB / Area(450)
0.008
0.006
0.004
0.002
0.000
0.50
0.55
0.60
0.65
0.70
Area(436) / Area(450)

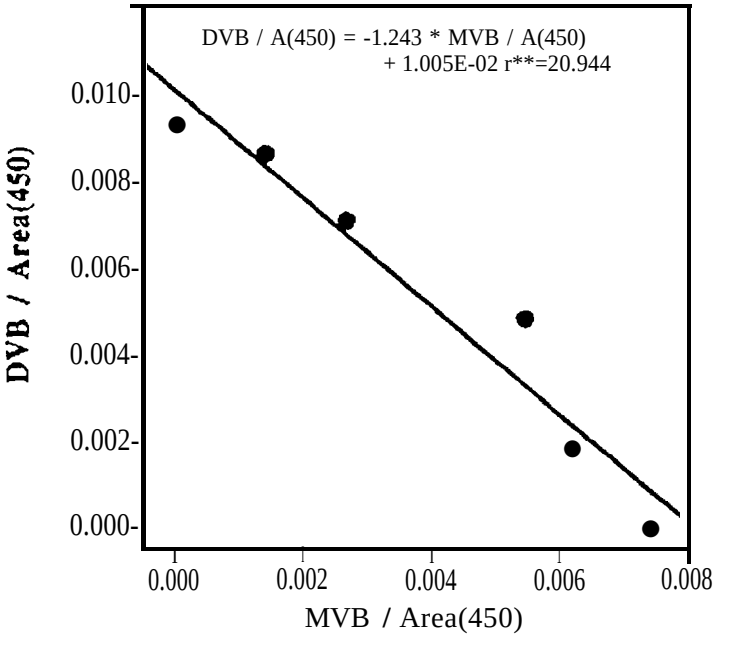

DVB / A(450) = -1.243 * MVB / A(450)
+ 1.005E-02 r**=20.944
DVB / Area(450)
0.010-
0.008-
0.006-
0.004-
0.002-
0.000-
0.000
0.002
0.004
0.006
0.008
MVB / Area(450)

FIGURE 8.