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PRIMARY PRODUCTION OFF SOUTHERN CALIFORNIA RELATIVE TO SURFACE LAYER CARBON BUDGETS. A COMPONENT OF THE CALIFORNIA BASINS STUDY, CaBS

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FINAL REPORT

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Table of Contents

ABSTRACT.....	1
INTRODUCTION.....	1
BACKGROUND.....	2
Optical Measurements for Assessing Primary Production.....	3
METHODS.....	4
Study Area.....	4
Methods for Continuing Shipboard Observations.....	4
Optical Measurements.....	4
Fluorometer.....	5
RESULTS.....	6
Moored INF Data.....	6
Bio-Optical Profiles.....	7
Pigments.....	8
Ancillary Measurements.....	8
REFERENCES.....	8

Tables

Table 1	Station dates, times, locations and Secchi depths for CaBS cruises	10
Table 2	Percent light levels of the on-deck simulated <i>in situ</i> incubator as measured by a Biospherical Instruments, Inc., QSL-100 Scalar Quantum Meter.....	11

Figures

Fig. 1	Primary productivity time series for the Southern California Bight.....	12
Fig. 2	Geographic locations of stations occupied during California Basins Study (CaBS).....	13
Fig. 3	Plots of Natural Fluorescence (NF) and total photosynthetically available radiation (PAR) recorded at a depth of 10 meters on the surface mooring	14
Fig. 4	Plots of Natural Fluorescence (NF) and total photosynthetically available radiation (PAR) recorded at a depth of 10 meters on the surface mooring during the second deployment.....	15
Fig. 5	Plot of the time series of PAR from the Mooring Refurbishment Cruise on 20 April until it was snagged by the Navy Submarine Tender on 25 June	16
Fig. 6	Comparison between HPLC and fluorometrically measured chlorophyll <i>a</i> for CaBS cruises, Santa Monica Basin.....	17

Table of Contents (cont'd)

Appendices

APPENDIX A	Primary Productivity Calculations
APPENDIX B	MER-1032, MER-1015 and 4-Channel Deck Cell Calibration Factors
APPENDIX C	Integral Method for Analyzing Irradiance and Radiance Attenuation Profiles
APPENDIX D	Measured Optical Profiles: CaBS Cruise 11, 23 January-3 February 1990
APPENDIX E	Measured Optical Profiles: Mooring Cruise, 17-21 April 1990
APPENDIX F	Measured Optical Profiles: CaBS Cruise 12, 7-14 July 1990
APPENDIX G	Fluorometrically Determined Pigments
APPENDIX H	HPLC Determined Pigments
APPENDIX I	Particulate Carbon, Hydrogen and Nitrogen Data
APPENDIX J	Primary Productivity

SUBJECT: Final Report on Department of Energy Grant DE-FG05-89ER60887
"Primary Production off Southern California Subject to Surface Layer
Carbon Budgets. A component of the California Basins Study, CaBS".

ABSTRACT

The grant was originally planned as a joint effort by myself and Dr. Richard W. Eppley (IMR, Scripps Institution of Oceanography). With my departure from SIO to San Diego State University, Center for Hydro-Optics and Remote Sensing (CHORS) and Dr. Eppley's subsequent retirement, the grant was mostly administered from SDSU. It was envisioned that this grant would be the start of a longer program to apply new, continuous methods of measuring primary production using moored optical sensors in assessing production off Southern California. Unfortunately, the program lasted only 2 1/2 years and funds were only available to support cruises in the first 6 months of 1992 to collect bio-optical ground truth data. This limited our ability to address many of the objectives listed in the proposal.

INTRODUCTION

This grant "Primary Production off Southern California Relative to Surface Layer Carbon budgets. A Component of the California Basins Study, CaBS", started on 1 June 1989 and ended 14 November 1991 with a total dollar support amount of \$233,109. During the first 6 months, we purchased two moored *in situ* natural fluorometers (INF-300) from Biospherical Instruments for deployment on Dr. Barbara Hickey's (University of Washington) surface mooring. Plans were to deploy the mooring in January 1990 and collect bio-optical data for one year, making ground truth measurements around the mooring during 4 cruises. This one year time series would allow us to begin investigating how the short-term physical forcing aliases the long-term primary production record such that the apparent, larger interannual variability in the record is in reality "noise" due to short-term fluctuations in the rate of nutrient input to the euphotic zone. These continuous measurements from moored bio-optical instruments would also allow better estimates of the mean and variance in primary production in these waters than has previously been available from shipboard measurements, as well as, phytoplankton response to short-term physical events. Ancillary measurements that were made were: (1) characterization of the apparent and inherent optical properties, (2) photosynthetic pigment distributions using both HPLC and standard fluorometric methods, (3) carbon, hydrogen and nitrogen content of suspended particulate matter, (4) primary production using conventional ¹⁴C methods from simulated *in situ* experiments.

The goal of this work was to apply new, continuous methods of assessing primary production, using optical sensors, to the surface waters of the ocean off Southern California. The major objectives were:

1. To acquire the optical instrumentation necessary to make the measurements on moorings.

2. To characterize optical properties in the water column by measuring downwelling and upwelling irradiances [$E_d(\lambda)$, $E_u(\lambda)$, respectively], upwelling radiances [$L_u(\lambda)$], scalar irradiances of photosynthetically available radiation [$E(\text{PAR})$], and transmission, and derive diffuse attenuation coefficients [$K(\lambda)$ and $K(\text{PAR})$], radiance reflectances [$R(\lambda)$], water-leaving radiances [$L_w\lambda$], and beam attenuation coefficients, $c(660)$.
3. To develop in-water algorithms for estimating primary production from moored and shipboard optical measurements of natural fluorescence [$L_u(683)$].
4. To devise means of validating the rate of primary production measured by the optical methods in terms of conventional ^{14}C measurements of primary production measurements.
5. To estimate the mean and variance of production using the continuous moored data for comparison with existing time series based on shipboard observations.
6. To determine the distribution and concentration of various phytoplankton pigments using HPLC methods and from this infer taxonomic and physiological differences between phytoplankton communities.
7. To continue to measure concentrations of particulate, suspended chlorophyll, organic carbon and nitrogen in order to calculate residence time biogenic particles in surface waters.
8. To use the measured biomass, primary production, and particle residence time information in carbon budgets for the euphotic zone, in cooperation with others in the CaBS programs.

BACKGROUND

Members of the food chain research group have studied primary production and phytoplankton growth, metabolism and physiological ecology in Southern California waters for about 20 years. In recent years it has become obvious that ships undersample the ocean with respect to primary production. The discontinuance records obtained from occasional cruises are inadequate even for estimating the mean and variance of biomass and production. We have sought to apply new methods, such as remotely sensing ocean color using the Coastal Zone Color Scanner (CZCS) and have developed algorithms for calculating water column primary production from ocean color (Eppley *et al.*, 1985). Ocean color measurements by satellite sensors seem to hold a great promise for assessing ocean primary productivity, especially on ocean basin scales.

Since 1974 primary production has been measured on cruises as a component of the DOE Regional Marine Program, it's successor the California Basin Study, and in recent work supported by NSF. The California Cooperative Oceanic Fisheries Investigation (CalCOFI) program has also measured primary production since 1984. Summary of those results are shown in Figure 1. The line in the figure is simply a least-squares fit to the data points designated "S" in a

multiple linear regression equation (Smith and Eppley, 1982); whereas the "C" values sketched in are the CalCOFI data. The model that generated this plot includes two environmental variables, day length (a proxy for seasonal and solar illumination) and sea surface temperature anomaly at the Scripps Pier (to represent interannual and episodic event scale processes and nitrocline depth). Temporal variability is evident in the cruise data as well as in the continuous line derived from the model. The interannual differences in calculated production are also quite large as is obvious from the differences in height of the annual pigments shown in Figure 1.

Inspection of Figure 1 suggests that sampling infrequently with ships will result in a data set that underestimates annual production in the Southern California Bight. It is assumed that the model represents reality only poorly. The ocean is to far too undersampled by occasional cruises to yield a reliable time series and proxy indicators of physical forcings are very crude. Yet the coincidence of samples at the sharp seasonal peaks in 1975 and 1983 is encouraging. Much of the new production and particle sinking takes place during these bursts of elevated primary production. Meanwhile the prospects for moored optical sensors in measuring chlorophyll and estimating primary production have become increasingly more developed and exciting. These sensors can provide continuous data even during overcast conditions when satellite sensors see only the cloud tops, thus they promise to play an important role along with ships and satellites in future work on ocean productivity.

Optical Measurements for Assessing Primary Production

There are several methods or approaches for measuring primary productivity and modeling it. The approach used here is based on the fluorescence of chlorophyll *a* induced by natural sunlight as opposed to an artificial light pulse such as measured under stimulated fluorescence. Natural fluorescence can be determined by an optical measurement of the nadir point of irradiance at 683 nm [$L_n(683)$], the peak fluorescence emission wavelength of *in vivo* chlorophyll *a*. This natural or solar induced fluorescence reflects photosynthetic rate when suitably normalized to the ambient light field that excites this fluorescence (Topless, 1985). An optical instrument built by Biospherical Instruments of San Diego has been used by numerous investigators to measure natural fluorescence in several oceans. Kiefer, Chamberlin, and Booth (1988) have developed equations relating the measured upwelling irradiance at 683 nm to (a) the total fluorescence of the phytoplankton crop, (b) the concentration of chlorophyll *a*, and (c) the rate of growth photosynthesis. Chamberlain *et al.* (1990) measured photosynthetic rate with ^{14}C and compared that with the rate calculated from natural fluorescence of chlorophyll *a* at 683 nm [$L_n(683)$]. They found that "By accounting for changes in the ratio quantum yields of natural fluorescence and photosynthesis, rates of primary production may be estimated with the accuracy of 25%". These results were quite encouraging and because of this we propose to use this method to model primary productivity in the Southern California Basins.

METHODS

Study Area

The study area was west of Los Angeles, California in the Santa Monica–San Pedro Basin. This basin is located in the Southern California Bight and is adjacent to the coast (100 km long, 40 km wide and 900 m deep). Stations were occupied during two major cruises and one minor mooring cruise and are shown in Figure 2 and listed in Table 1.

Methods for Continuing Shipboard Observations

Particulate carbon and nitrogen samples were taken from CTD bottles at several depths within the euphotic zone. The water was filtered through combusted GF/F filters which have an approximate pore size of 0.7 μm . The filters were frozen and returned to the laboratory for analysis using a Perkin–Elmer CHN Analyzer. Chlorophyll samples were also collected on GF/F filters and were extracted in 90% acetone and measured on the ship using a Turner Designs 10 Fluorometer. Additional pigment samples were collected on 0.4 μm Nuclepore polyester filters and extracted in a 40:60% solution of dimethyl sulfoxide (DSMO) and 90% acetone. The advantage of this solvent is that it enhances pigment extraction efficiencies for cyanobacteria and green algae. Using the method of Bidigare, Kennicutt and Brooks (1985) the various pigment compounds, chlorophylls, chlorophyll degradation products and carotenoids were separated on a C^{18} column and as they eluded off their peaks were measured using absorption and fluorescence detectors. The water samples for ^{14}C carbon primary production measurements were placed in acid clean polycarbonate bottles, 500 ml, and incubated 24 hours in on-deck incubators exposed to natural sunlight. These incubators were the same ones used by Dr. Eppley for previous DOE cruises. Neutral density filters surrounding the incubator tubes provided light intensities (Table 2) and sampling depths were matched to the incubator percent light levels using Secchi data (Table 1). Sea surface temperature was maintained within the incubators by flowing near surface water through the tubes. The equations used to calculate primary productivity are shown in Appendix A.

Optical Measurements

Vertical profiles of optical properties were measured using a Biospherical Instruments MER–1032 (January & April 90 cruises) and a MER–1015 (July 90 cruise). The MER–1032 instrument makes measurements of downwelling irradiance (410, 441, 488, 520, 532, 550, 589, 633, 656, 671 and 694 nm), upwelling irradiance (410, 441, 488, 520, 550, 589, 633 and 671 nm) and upwelling radiance (410, 441, 488, 520, 550, 589, 685 and 710 nm). The MER–1015 measures only downwelling irradiance in 12 channels (407, 438, 461, 485, 517, 536, 558, 586, 622, 671, 694 and 760 nm). Both MER's are optical data acquisition systems which also measure water pressure and temperature. They send the data up an armored coaxial cable to a shipboard computer where the data is displayed and recorded on floppy disk. This data is merged with data

from a 4-channel deck cell (410, 441, 550 and 671 nm) to correct for changes in incident spectral irradiance at the surface during profiling. Included on the MER's and interfaced with a data acquisition is a PAR sensor (MER-1032 only), a sensitive enhanced upwelled radiance sensor at 680 nm (MER-1032 only), a Sea Tech Fluorometer (stimulated fluorescence) and a Sea Tech Transmissiometer [beam attenuation coefficient, $c(660)$; 25 cm pathlengths]. The MER's were calibrated before and after each cruise and these calibrations were found not to be statistically different. Calibration factors for the MER's and deck cell are listed in Appendix B.

From the downwelling and upwelling irradiances, and upwelling radiance, the following optical properties were derived as a function of depth and wavelength; diffuse attenuation coefficient, irradiance and remote sensing reflectances. The procedure used for smoothing the optical data is described by Mueller (1991) and is briefly reviewed in Appendix C. The Sea Tech Transmissiometer measures the transmission of red light at 660 nm over a 25 cm pathlength. The percent transmission is then converted to beam attenuation coefficient as $c(660) = \ln (\% \text{ Transmission})$ where percent transmittance is computed as described below. The apparent transmissiometer output voltage as recorded by the MER-1032 is first corrected for the A-D range dependent bias of that board in the MER. Voltage output from the Sea Tech Transmissiometer itself is then corrected for photo diode decay as

$$V = (A/B) \cdot (X-Z),$$

where V is the corrected output voltage, A is the factory air calibration voltage, B is the air calibration voltage measured during the cruise, X is the measured (true) voltage output and Z is the dark voltage measured when the light path is blocked. Transmittance over 25 cm pathlength is calculated as $T = 20 \times V$ and the total beam attenuation coefficient is calculated as

$$c_T \text{ at } 660 = -4 \times \log \left(\frac{T}{100} \right).$$

Finally the attenuation coefficient due to suspended particles, $c_p(660)$, is calculated as $c_p(660) = c_T(660) - c_w(660)$ where $c_w(660)$ is the attenuation of pure water which is 0.364 m^{-1} .

Fluorometer

The output of the fluorometer is in voltages and is relative. This data was not corrected for differences in the A-D range bias.

RESULTS

During the first part of 1990, we participated on two major CaBS cruises (CaBS 11, 23 January-3 February 90 and CaBS 12, 7-14 July 90) where bio-optical properties were measured,

water samples collected for CHN and pigment (HPLC and standard fluorometric) analyses and primary productivity experiments performed. Dr. Barbara Hickey, University of Washington, deployed her surface mooring (33° 44.94'N, 118° 48.26'W) during the first cruise on 24 January 90. Two *in situ* natural fluorometers (prototype INF-300's) were placed on this mooring at 10 and 17 meters depth. They were attached to the outside of the current meter cages for easy removal by divers during the Mooring and Sediment Trap Refurbishment Cruise in April 1990.

Moored INF Data

To obtain continuous natural fluorescence and PAR records for the proposed six month period (January–July 90), an intermediate cruise (17–21 April) was scheduled to refurbish the INF fluorometers, as well as Dr. Mike Landry's floating sediment traps. The optical surfaces of the natural fluorometers were coated with a clear anti-fouling paint, which would retard the growth of organisms on these surfaces for several months. Since the INF-300's were prototypes, Biospherical Instruments sent an electrical engineer on the April cruise to assist in dumping the data to a PC, evaluating instrument performance and inspecting their physical condition during this 3 deployment period. Divers retrieved the instruments and brought them to the ship for inspection. Both instruments had organisms attached to the casings [the 10 m instrument was fouled by mussels, whereas the deeper one at 17 m was covered with long (3 cm) filamentous macroalgae]. The optical windows at the ends of the natural fluorometers, which were coated with the anti-fouling paint, were clean. The data was dumped to the computer and then the fluorometers were cleaned, the casings painted with Epoxy paint, the optical windows coated with anti-fouling paint, and then they were redeployed on the mooring by the divers.

Originally, the plan was to retrieve the natural fluorometers and bring them back to the CHORS Laboratory for cleaning and recalibration. The data would be QC and instrument performance reviewed. Once satisfied, a second mooring cruise was to be scheduled to redeploy the instruments. Unfortunately, because of the shortage of cruise funds, only one mooring cruise was supported and the instruments had to be placed back on the mooring without a thorough evaluation of the data and instrument performance.

A later review of the INF data showed that the near surface mooring at 10 m had stopped collecting data after five days, whereas the deeper one logged data continuously throughout the deployment, but from only two channels. An attempt was made by the Biospherical Engineer to correct these problems during the Mooring Cruise. Time did not permit, before redeploying the natural fluorometer, testing to see if the corrections had fixed the instruments.

Figure 3 shows a plot of natural fluorescence (NF) and total photosynthetically available radiation (PAR) at 10 m depth for the four days that the instrument collected data. The ratio of these parameters, which indicate changes in biomass/productivity is also plotted on the right axis. Throughout the time series, the ratio showed a peak before or near noon. In addition, there was also a gradual decline in this ratio indicating a response of the phytoplankton to changing environmental conditions (*e.g.* physical forcing).

For the second deployment of the INF-300's in April-July, partial data sets were recorded on both instruments. During CaBS 12 in July, Dr. Hickey's surface float on her mooring could not be found. This apparent loss of the mooring was relayed to her group at the University of Washington, who then checked the Argos satellite data. An Argos transmitter was installed on the surface float for just such an occasion. These records showed that the mooring had been removed from its original location on 29 June and transported to Port Hueneme, California. Further investigation revealed that a civilian Naval Engineering Group had snagged the mooring on 25 June with a towed vehicle. For a few days, they tried in vain to unhook it, but finally had to cut the mooring from its anchor. The mooring instruments sat on a dock in Port Hueneme for 2-3 weeks and then we picked them up at the end of CaBS 12. This handling by the Navy group damaged both instruments and the optical windows had to be replaced.

Fortunately, we were able to dump the data from these instruments even in their damaged condition. The near surface (10 m) instrument operated for 26 days (17 April-12 May 90) collecting NF and PAR data. This time series is shown in Figure 4 where NF and PAR are plotted on the left log axis and the ratio NF/PAR on the right. NF/PAR in this figure decreases towards mid day and it can be speculated that this is caused by photoinhibition at this depth at these elevated spring time solar intensities. Figure 3 showed an opposite trend because of the low incident fluxes for the winter period in January (~55% less radiation at the top of the atmosphere). Episodic events can also be seen in this record with one occurring around 26 April and a smaller one on the 8th of May. This instrument quit collecting data after 12 May.

Figure 5 is a plot of PAR for the natural fluorometer placed at 17 m. Only the PAR channel operated continuously from its redeployment on 20 April until it was snagged by the Navy Submarine Tender on 25 June (see Figure 5). Figure 5 shows quite a lot of variability in PAR at this depth during the deployment.

Bio-Optical Profiles

The smoothed profiles for the upcast and downcast of each station are illustrated in Appendices D, E and F (CaBS 11, Mooring Cruise and CaBS 12, respectively). The display for each cast begins with a summary figure showing the smoothed profiles of $E_d(z,488)$ and $E_d(z,488)$, compared with profiles of particle beam attenuation, $c_p(660)$, and stimulated fluorescence. Also shown on the cast summary page is the profile of incident surface irradiance $E_s(550)$ at 550 nm. The lines illustrating the smoothed profiles of $E_d(z,488)$ and $E_s(z,550)$ are compared with the 1 meter binned averages of the actual measurements, plotted as dots and "+", respectively.

Following the summary figure for each good profile is 11 figures showing smoothed profiles of $K_d(z,\lambda)$ and $E_d(z,\lambda)$, 8 showing $K_u(z,\lambda)$ and $E_u(z,\lambda)$ [only for CaBS 11 and Mooring Cruise] and 8 showing $K_l(z,\lambda)$ and $L_u(z,\lambda)$ [only for CaBS 11 and Mooring Cruise]. K's are plotted as solid lines, while E_d , E_u and L_u are all shown as dashed lines.

During the cruises there was spatial heterogeneity in the bio-optical properties. In general the near surface K(488) values ranged from 0.042 to 0.118 m⁻¹ with the highest values found during CaBS 11 and then decreasing towards the last cruise (CaBS 12). The depth of the particle maximum changed from the near surface maxima for most of the stations during the first cruise to deeper subsurface maxima (20–40 m) in July.

Pigments

Standard fluorometric and HPLC methods were used to analyze the pigment concentration and composition during these cruises. A comparison was made between HPLC derived chlorophyll *a* and those determined by the standard fluorometer. A plot of this comparison is shown in Figure 6, and good agreement was found even though these were replicate samples where different pore size filters were used (GF/F, 0.7 µm and Nuclepore 0.4 µm). Based on these results, previous chlorophyll *a* concentrations from past DOE cruises should accurately represent true values. HPLC is the method of choice for pigment analysis, because the standard fluorometric method, which measures the sum of the fluorescence of the individual pigment compound (chls *b* and *c* and phaeopigments), introduces errors in the estimate of chlorophyll *a*.

Fluorometrically measured chlorophyll and phaeopigments are listed in Appendix G, whereas the HPLC derived pigment concentrations for 15 compounds are listed in Appendix H. The HPLC data indicates that Chlorophytes and Prymnesiophytes were in relative high concentrations during these cruises, because the average ratios for the water column for chl *b*/chl *a* and Hex/chl *a* were 0.213 (± 0.159) and 0.397 (± 0.141). Chl *b*/Chl *a* values increased in depth, whereas the Hex/chl *a* showed no apparent vertically trend.

Ancillary Measurements

Appendices I and J summarize the analysis of particulate CHN and primary productivity.

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Table 1. Station dates, times, locations and Secchi depths for CaBS cruises.

Date	Time	Cruise #	CTD #	Latitude	Longitude	Secchi Depth (m)
26 Jan 90	–	CaBS-11	5	33°44.79N	118°47.72W	14
27 Jan 90	1235	CaBS-11	14	33°49.42N	119°02.11W	–
28 Jan 90	1330	CaBS-11	16	33°44.67N	118°49.19W	20
29 Jan 90	1407	CaBS-11	19	33°45.83N	118°48.48W	18
30 Jan 90	1115	CaBS-11	20	33°44.84N	118°50.20W	23
31 Jan 90	1330	CaBS-11	24	33°46.18N	118°49.63W	19
1 Feb 90	1600	CaBS-11	33	33°46.15N	118°48.55W	–
2 Feb 90	–	CaBS-11	34	33°46.01N	118°48.40W	–
17 Apr 90	1125	Mooring	1	33°44.05N	118°48.38W	24
18 Apr 90	1133	Mooring	2	33°42.10N	119°05.99W	17
19 Apr 90	1214	Mooring	3	33°44.52N	118°48.03W	27
20 Apr 90	1225	Mooring	4	33°33.12N	118°47.17W	24
21 Apr 90	1015	Mooring	5	33°40.66N	118°40.46W	20
8 Jul 90	1330	CaBS-12	1	33°45.50N	118°47.60W	17
9 Jul 90	1330	CaBS-12	2	33°45.50N	118°47.60W	18
10 Jul 90	1345	CaBS-12	3	33°50.20N	119°01.59W	22
11 Jul 90	1400	CaBS-12	4	33°45.50N	118°47.60W	24
12 Jul 90	1200	CaBS-12	5	33°45.50N	118°47.60W	19
13 Jul 90	–	CaBS-12	6	33°45.39N	118°47.34W	15

Table 2. Percent light levels of the on-deck simulated *in situ* incubator as measured by a Biospherical Instruments, Inc., QSL-100 Scalar Quantum Meter.

Incubator Tube #	Percent
1	93.9%
2	22.5%
3	13.4%
4	7.1%
5	2.4%

Figure 1. Primary productivity time series for the Southern California Bight. The continuous line is derived from a multiple regression equation fit to the data. The letter "S" data points represent measurements made by Dr. Eppley's laboratory, and are the areally integrated averages of several stations. The letter "C" represents areal values calculated from sampling at one or at most two stations in the grid, courtesy of CalCOFI personnel.

Figure 2. Geographic locations of stations occupied during California Basins Study (CABS) cruises (● January-February 1990, CABS 11; ○ July 90, CABS 12; □ April 90, Mooring Refurbishment).

Figure 3. Plots of Natural Fluorescence (NF) and total photosynthetically available radiation (PAR) (both plotted on the left log axis) recorded at a depth of 10 meters on the surface mooning. The ratio of these parameters (right axis) shows a gradual decline during this short deployment. Points were recorded on one minute intervals and each point is the average of 15 measurements sampled once per second.

Figure 4. Plots of Natural Fluorescence (NF) and total photosynthetically available radiation (PAR) (both plotted on a log axis) recorded at a depth of 10 meters on the surface mooring during the second deployment (17 April–12 May 1990).

Figure 5. Plot of the time series of PAR from the Mooring Refurbishment Cruise on 20 April until it was snagged by the Navy Submarine Tender on 25 June.

Figure 6. Comparison between HPLC and fluorometrically measured chlorophyll *a* for CaBS Cruises, Santa Monica Basin.

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APPENDIX A

PRIMARY PRODUCTIVITY CALCULATIONS

Appendix A

Primary Productivity Calculations

$$\mu\text{g Carbon / liter} = \frac{\text{dpm Sample}}{\text{dpm Added}} * 2.4 \times 10^4 \mu\text{g CL}^{-1} * 1.05$$

where

$$1. \text{ dpm Sample} = \frac{\text{cpm Sample} - \text{cpm Blank}}{E}$$

$$2. \text{ dpm Added} = \mu\text{Ci added} * 2.22 \times 10^6 \frac{\text{dpm}}{\mu\text{Ci}}$$

$$3. 2.4 \times 10^4 \mu\text{g CL}^{-1} \text{ is the average oceanic CO}_2 - \text{C}$$

$$4. 1.05 \text{ is the isotopic discrimination factor}$$

E is the counting efficiency of the Beckman Scintillation Counter as determined by the H number. The quench curve (5/4/90) is of the form

$$E = 0.97334 - 5.2224 \times 10^{-4}(\text{H\#}) + 2.6080 \times 10^{-6}(\text{H\#})^2 - 1.2151 \times 10^{-8}(\text{H\#})^3 \quad r^2 = 0.996$$

cpm = counts per minute

dpm = disintegration per minute

The logo for CHORS (Center for Hydro-Optics & Remote Sensing) features the word "CHORS" in a large, bold, serif font. To the right of the text is a stylized graphic consisting of three overlapping, rounded peaks, resembling a wave or a spectral line.

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APPENDIX B

MER-1032, MER-1015 AND 4-CHANNEL DECK CELL
CALIBRATION FACTORS

Appendix B

MER-1032, MER-1015 and 4-Channel Deck Cell Calibration Factors

CaBS 11 and Mooring Cruise			CaBS 12 Cruise		
MER 1032		4/12/90	MER 1015		7/19/91
1	Ed(410)	48.2449	1	Ed(407)	174.47
2	Ed(441)	41.6959	2	Ed(438)	114.17
3	Ed(488)	35.4124	3	Ed(461)	107.24
4	Ed(520)	41.272	4	Ed(485)	150.73
5	Ed(532)	40.1731	5	Ed(517)	103.52
6	Ed(550)	39.7874	6	Ed(536)	118.22
7	Ed(589)	40.5224	7	Ed(558)	105.46
8	Ed(633)	38.4169	8	Ed(586)	87.89
9	Ed(656)	44.3966	9	Ed(622)	89.01
10	Ed(671)	30.9435	10	Ed(671)	90.57
11	Ed(694)	34.427	11	Ed(694)	70.54
12	(PAR)	***	12	Ed(760)	***
13	(%T)		13	(%T)	
14	(Rel. Fluor.)		14	(pressure)	
15	(angle1)		15	(temperature)	
16	(angle2)		16	(Rel. Fluor.)	
17	Lu(410)	1.1034	Deck Cell		
18	Lu(441)	1.3004			
19	Lu(488)	1.0456			
20	Lu(520)	1.0601			
21	Lu(550)	0.6668	1	Es(410)	396.63
22	Lu(589)	0.267	2	Es(441)	115.92
23	Lu(710)	0.9592	3	Es(550)	112.76
24	Lu(685)	***	4	Es(671)	44.70
25	Eu(410)	14.5312			
26	Eu(441)	10.5184			
27	Eu(488)	9.9423			
28	Eu(520)	9.1576			
29	Eu(550)	8.1775			
30	Eu(589)	7.1533			
31	Eu(633)	2.535			
32	Eu(671)	2.8069			
33	(temperature)				
34	(pressure)				
Deck Cell					
1	Es(410)	407.547			
2	Es(441)	116.129			
3	Es(550)	113.387			
4	Es(671)	44.944			

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APPENDIX C

INTEGRAL METHOD FOR ANALYZING IRRADIANCE AND RADIANCE ATTENUATION PROFILES

22 April 1994

By

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INTEGRAL METHOD FOR ANALYZING IRRADIANCE AND RADIANCE ATTENUATION PROFILES

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INTRODUCTION

Vertical profiles of downwelling irradiance $E_d(\lambda, z)$, are related to $E_d(\lambda, 0^-)$, incident irradiance just below the sea surface, by the equation

$$E_d(\lambda, z) = E_d(\lambda, 0^-) e^{-\int_0^z K_d(\lambda, z') dz'}$$

The function $K_d(\lambda, z)$ is the profile of irradiance attenuation coefficients throughout the water column. This same equation relates upwelling irradiance $E_u(\lambda, z)$ to $E_u(\lambda, 0^-)$ and $K_u(\lambda, z)$, and relates upwelling radiance $L_u(\lambda, z)$ to $L_u(\lambda, 0^-)$ and $K_L(\lambda, z)$.

It has become relatively common practice to measure vertical profiles $E_d(\lambda, z)$, $E_u(\lambda, z)$ and $L_u(\lambda, z)$ using underwater radiometers, with the usual objective being to determine $K_d(\lambda, z)$, $K_u(\lambda, z)$ and $K_L(\lambda, z)$. The classical approach to determining $K(\lambda, z)$ from $E(\lambda, z)$ is described in detail by Smith and Baker (1984, 1986). It is necessary to first normalize the $E(\lambda, z)$ profile to surface irradiance $E_s(\lambda, z)$ profiles, measured on the deck of the ship during a cast. $K(\lambda, z)$ is then determined by estimating the slope of $\ln[E(\lambda, z)]$ at depth z ; this is accomplished by least-squares fitting a straight line through a data "window" extending several meters above and below depth z . The window is then slid down a meter or so and least-squares K is determined again, and so on over the entire profile.

A typical window size ranges from 8 m (Smith and Baker, 1984, 1986) to 20 m (used in the present work for preliminary K estimates). This precludes the fitted K profile from following rapid variations through sharply defined layers of suspended particles, which are commonly observed in beam attenuation profiles in coastal and frontal water masses. Even with a 20 m window, moreover, the local slope-fitting procedure is sensitive to high frequency fluctuations in incident irradiance which are not in phase at the on-deck and underwater radiometers.

We present a new method for determining K profiles by minimizing the departure of the estimated optical depth profile

$$\hat{\tau}(\lambda, z) = \int_0^z K(\lambda, z') dz'$$

from the measured optical depth profile

$$\tau(\lambda, z) = \ln \left[\frac{E(\lambda, 0^-)}{E(\lambda, z)} \right]$$

The new approach has the advantage of being able to more closely follow variations in K through very turbid layers (as indicated independently by beam attenuation). At the same time, the integral approach is more successful at smoothing through surface irradiance fluctuations than is the local slope-fitting method.

METHODS

Deck Cell Smoothing

The first step in this procedure is to fit the deck cell irradiance profiles $E_s(z, \lambda)$ directly to Hermitian cubic basic functions,

$$\begin{aligned}\gamma_{01}(\xi) &= \frac{1}{4}(\xi-1)^2(\xi+2) \\ \gamma_{02}(\xi) &= \frac{-1}{4}(\xi+1)^2(\xi-2) \\ \gamma_{11}(\xi) &= \frac{L_i}{8}(\xi+1)(\xi-1)^2 \\ \gamma_{12}(\xi) &= \frac{L_i}{8}(\xi+1)^2(\xi-1) .\end{aligned}\tag{1}$$

For z in the i^{th} depth element $z_{i-1} \leq z < z_i$, ξ is a local coordinate ranging from -1 at node z_{i-1} (the shallow end point of the element) to +1 at node z_i , *i.e.*

$$\xi = \frac{2z - (z_i + z_{i-1})}{L_i} ,\tag{2}$$

with differential

$$d\xi = \frac{2}{L_i} dz ,$$

where L_i is the length of i^{th} finite element, *i.e.*

$$L_i = z_i - z_{i-1} .$$

At any depth z corresponding to location ξ in element i , the smoothed estimate of deck cell irradiance $\hat{E}_s(\lambda, z)$ will be given by

$$\begin{aligned}\hat{E}_s(\lambda, z) &= \gamma_{01}(\xi)\bar{E}_{s,i-1}(\lambda) + \gamma_{02}(\xi)\bar{E}_{s,i}(\lambda) \\ &+ \gamma_{11}(\xi)\partial_z \bar{E}_{s,i}(\lambda) + \gamma_{12}(\xi)\partial_z \bar{E}_{s,i}(\lambda) ,\end{aligned}\tag{3}$$

where $\bar{E}_{s,i}(\lambda)$ is the value of $E_s(\lambda, z)$ and $\partial_z \bar{E}_{s,i}(\lambda)$ is its derivative with respect to z , at node depth z_i . Both the function $\hat{E}_s(\lambda, z)$ and its first derivative are continuous at nodes joining adjacent finite depth elements.

The profile of measured $E_s(\lambda, z)$ is displayed on the computer's screen. Nodes are placed at N depths z_n ($n = 0, \dots, N-1$) selected to allow the cubic functions of Eq. (3) to closely follow major excursions of incident irradiance, while smoothing high frequency "wiggles" which are unlikely to be well matched to incident irradiance fluctuations observed by the underwater radiometer. The selection of which E_s fluctuations to follow closely is one subjective element in this procedure. Our recommended practice is to pick nodes which allow the fitted curve to closely follow fluctuations with wavelengths ≥ 10 m, and to smooth out shorter scale fluctuations. (In the time domain, 10 m corresponds to approximately 20 s at a typical

winch speed of 30 m min⁻¹.) The smoothed $E_s(\lambda, z)$ and normalized $E_d(\lambda, z)$ profiles should, in any event, be examined jointly before proceeding further. If features in the fitted E_s curve are reflected by opposing features in the E_d curve, indicating overcompensation by the deck cell normalization, then the data from that segment of both profiles should be eliminated from the fitting procedure.

Once node depths z_n are selected, the vector of $E_s(z_m, \lambda)$, measured at $m = 1, \dots, M$ depths z_m , may be expressed in matrix form as

$$\tilde{E}_s(\lambda) = \underline{H} \bar{\tilde{E}}_s(\lambda), \quad (4)$$

where $\tilde{E}_s(\lambda)$ is the measured irradiance vector of length M

$$\tilde{E}_s(\lambda) = \begin{bmatrix} E_s(z_1, \lambda) \\ E_s(z_2, \lambda) \\ \vdots \\ E_s(z_m, \lambda) \\ \vdots \\ E_s(z_M, \lambda) \end{bmatrix}, \quad (5)$$

$\bar{\tilde{E}}_s(\lambda)$ is the unknown vector, of length $2N$ of irradiances and vertical gradients of irradiance at the N node depths z_n ,

$$\bar{\tilde{E}}_s(\lambda) = \begin{bmatrix} \bar{E}_{s,0}(\lambda) \\ \bar{E}_{s,1}(\lambda) \\ \vdots \\ \bar{E}_{s,n}(\lambda) \\ \vdots \\ \bar{E}_{s,N-1}(\lambda) \\ \text{-----} \\ \overline{\partial_z E_{s,0}}(\lambda) \\ \overline{\partial_z E_{s,1}}(\lambda) \\ \vdots \\ \overline{\partial_z E_{s,n}}(\lambda) \\ \vdots \\ \overline{\partial_z E_{s,N-1}}(\lambda) \end{bmatrix},$$

and $\underline{H}$ is a matrix with $2N$ columns and M rows

$$H = [h_{mj}],$$

with elements

$$h_{mj} = \begin{cases} \gamma_{01}, z_m \text{ in element } n \text{ and } j = n - 1; \\ \gamma_{11}, z_m \text{ in element } n \text{ and } j = n - 1 + N; \\ \gamma_{02}, z_m \text{ in element } n \text{ and } j = n; \\ \gamma_{12}, z_m \text{ in element } n \text{ and } j = n + N; \\ 0, \text{ otherwise.} \end{cases}$$

To reduce Eq. (4) to normal form for least-squares determination of the vector $\vec{\bar{E}}_s$, multiply both sides by $\underline{H}^T$ the transpose of $\underline{H}$, and rearrange to obtain

$$\vec{\bar{E}}_s(\lambda) = [\underline{H}^T \underline{H}]^{-1} \underline{H}^T \vec{E}_s(\lambda), \quad (7)$$

where $[\underline{H}^T \underline{H}]^{-1}$ is the inverse of matrix $[\underline{H}^T \underline{H}]$.

The resulting components of $\vec{\bar{E}}_{s,n}(\lambda)$ are the coefficients needed, together with the array of node depths z_n , to compute smoothed deck cell irradiance $\hat{E}_s(z, \lambda)$ at any depth z using either Eq. (3), or its matrix equivalent Eq. (4).

The smoothed E_s profiles are now ready for use in obtaining smoothed fits to measured profiles of downwelling irradiance $E_d(z, \lambda)$, upwelled irradiance $E_u(z, \lambda)$ and/or upwelled radiance $L_u(z, \lambda)$. To provide guidance for node placement in a least-squares fit to cubic Hermitian finite elements, the profiles are first binned to 1 m intervals, and preliminary attenuation coefficients K are estimated using the classic practice of fitting a least-squares slope over a window extending a few meters (in this case ± 10 m) on each side of each depth point (see *e.g.* Smith and Baker, 1984, 1986).

Preliminary Bin-Average K and E_d Profile

Profiles of $E_d(\lambda, z)$, $E_u(\lambda, z)$, and $L_u(\lambda, z)$, were averaged into 1-meter depth bins in preparation for preliminary least-squares smoothing to obtain the vertical attenuation coefficients of each quantity. The preliminary smoothing algorithm outlined below is similar to that described by Smith and Baker (1984),

$$\begin{aligned} K_d'(\lambda, z) &= \frac{-1}{E_d(\lambda, z)} \frac{dE_d(\lambda, z)}{dz}, \\ K_u'(\lambda, z) &= \frac{-1}{E_u(\lambda, z)} \frac{dE_u(\lambda, z)}{dz}, \quad \text{and} \\ K_L'(\lambda, z) &= \frac{-1}{L_u(\lambda, z)} \frac{dL_u(\lambda, z)}{dz} \end{aligned} \quad (8)$$

were determined by least-squares fits to the equations

$$\begin{aligned} \ln \left\{ \frac{E_d(\lambda, z) \bar{E}_s(550)}{E_s(550, z)} \right\} &= A_d(\lambda, \bar{z}) - K'_d(\lambda, \bar{z}) [z - \bar{z}], \\ \ln \left\{ \frac{E_u(\lambda, z) \bar{E}_s(550)}{E_s(550, z)} \right\} &= A_u(\lambda, \bar{z}) - K'_u(\lambda, \bar{z}) [z - \bar{z}], \text{ and} \\ \ln \left\{ \frac{L_u(\lambda, z) \bar{E}_s(550)}{E_s(550, z)} \right\} &= A_l(\lambda, \bar{z}) - K'_l(\lambda, \bar{z}) [z - \bar{z}], \end{aligned} \quad (9)$$

where $\bar{z}$ is the mid-depth of a 20 m window, $\bar{E}_s(550)$ is the smoothed 550 nm deck cell irradiance at depth $\bar{z}$, $E_s(550, z)$ is the 550 nm deck cell irradiance coincident with measurements at depth z , and the intercepts A correspond to the natural logarithm of smoothed irradiance/radiance at depth $\bar{z}$, *i.e.*

$$\begin{aligned} A_d(\lambda, \bar{z}) &= \ln [E'_d(\lambda, \bar{z})], \\ A_u(\lambda, \bar{z}) &= \ln [E'_u(\lambda, \bar{z})], \text{ and} \\ A_l(\lambda, \bar{z}) &= \ln [L'_u(\lambda, \bar{z})]. \end{aligned} \quad (10)$$

The values of $E'_d(\lambda, \bar{z})$, $E'_u(\lambda, \bar{z})$, and $L'_u(\lambda, \bar{z})$ [as obtained from $A_d(\lambda, \bar{z})$, $A_u(\lambda, \bar{z})$ and $A_l(\lambda, \bar{z})$ by the above least-squares smoothing algorithm] were then each normalized to the surface by the ratio of deck cell irradiance $E_s(550, 0):E_s(550, \bar{z})$ calculated using Eq. (6).

The resulting smoothed profiles of K' and E' are used as a guide in selecting node depths for fitting improved K and E profiles to the measured irradiance.

Optical Depth Profile Fit

Measured optical depth $\tau(z)$ at depth z is calculated as

$$\tau(z) = \ln \left[\frac{E(0^-)}{E(z)} \right], \quad (11)$$

where E may be E_d , E_u or L_u , and $E(0^-)$ is irradiance (or radiance) just beneath the sea surface. A first guess estimate of $E(0^-)$ is obtained from the preliminary bin-averaged, window-fit K' and E' profiles as

$$E(0^-) = E'(10) e^{10K'(10)} \quad (12)$$

(Because of the 20 m fitting window, $K'(10)$ and $E'(10)$ at 10 m are the shallowest estimates in that profile.)

Optical depth is related to the irradiance (or radiance) attenuation coefficient $K(z)$ profile by the

$$\tau(z) = \int_0^z K(z') dz'. \quad (13)$$

If we again divide the water column into $N-1$ finite elements, separated by N nodes at depths z_n ($n = 0, 1, \dots, N-1$), we may estimate $K(z)$ in the depth element $z_{n-1} \leq z < z_n$ as

$$\hat{K}(z) = \gamma_{01}(\xi) \overline{K}_{n-1} + \gamma_{02}(\xi) \overline{K}_n + \gamma_{11}(\xi) \overline{\partial_z K}_{n-1} + \gamma_{12}(\xi) \overline{\partial_z K}_n, \quad (14)$$

where $\gamma_{ij}(\xi)$ and ξ are defined in Eq's. (1) and (2) respectively. The same form of cubic Hermitian polynomial expansion is used in Eq's. (3) and (14) to represent the variables $E_s(z)$ and $K(z)$ respectively.

If we substitute Eq. 14 into Eq. (13), we obtain for $z_{n-1} \leq z < z_n$.

$$\begin{aligned} \tau(z) = \sum_{i=1}^{i \leq n} & \left[\overline{K}_{i-1} \int_{z_{i-1}}^{z_i} \gamma_{01}(\xi) dz' + \overline{K}_{i-1} \int_{z_{i-1}}^{z_i} \gamma_{02}(\xi) dz' \right. \\ & \left. + \partial_z \overline{K}_{i-1} \int_{z_{i-1}}^{z_i} \gamma_{11}(\xi) dz' + \partial_z \overline{K}_{i-1} \int_{z_{i-1}}^{z_i} \gamma_{12}(\xi) dz' \right] \\ & + \overline{K}_{n-1} \int_{z_{n-1}}^z \gamma_{01}(\xi) dz' + \overline{K}_n \int_{z_{n-1}}^z \gamma_{02}(\xi) dz' \\ & + \partial_z \overline{K}_{n-1} \int_{z_{n-1}}^z \gamma_{11}(\xi) dz' + \partial_z \overline{K}_n \int_{z_{n-1}}^z \gamma_{12}(\xi) dz'. \end{aligned} \quad (15)$$

By the definition of ξ and its differential in Eq. (2), we may change variables to express the integral terms in Eq. (15) in the form

$$\int_{z_{n-1}}^z \gamma(\xi) dz' = \frac{L_i}{2} \int_{-1}^{\xi} \gamma(\xi') d\xi'. \quad (16)$$

We may thus formally integrate Eq. (15) from $\xi = -1$ to ξ , once and for all to obtain new coefficients

$$\begin{aligned} g_{01}(\xi) &= \frac{1}{4} \left[\frac{\xi^4 - 1}{4} - \frac{3(\xi^2 - 1)}{2} + 2(\xi + 1) \right], \\ g_{02}(\xi) &= \frac{-1}{4} \left[\frac{\xi^4 - 1}{4} - \frac{3(\xi^2 - 1)}{2} - 2(\xi + 1) \right], \\ g_{11}(\xi, L_i) &= \frac{L_i}{8} \left[\frac{\xi^4 - 1}{4} - \frac{(\xi^3 + 1)}{3} - \frac{(\xi^2 - 1)}{2} + (\xi + 1) \right], \text{ and} \\ g_{12}(\xi, L_i) &= \frac{L_i}{8} \left[\frac{\xi^4 - 1}{4} + \frac{(\xi^3 + 1)}{3} - \frac{(\xi^2 - 1)}{2} - (\xi + 1) \right], \end{aligned} \quad (17)$$

with special values at $\xi = 1$ (i.e. the integrals over a complete finite element from -1 to 1)

$$\begin{aligned} g_{01}(1) &= 1, \\ g_{02}(1) &= 1, \\ g_{11}(1, L_i) &= \frac{L_i}{6}, \text{ and} \\ g_{12}(1, L_i) &= \frac{-L_i}{6}. \end{aligned} \quad (18)$$

With substitutions from (16) through (18) and some rearrangement, we may express Eq. (15) for $z = z_m, z_{n-1} \leq z_m < z_n$, as

$$w_m \tau(z_m) = w_m \sum_{i=0}^n \left[h_{mi} \overline{K_i} + h_{m,i+N} \overline{\partial_z K_i} \right] \quad (19)$$

where

$$h_{mi} = \begin{cases} \frac{L_1}{2} g_{01}(\xi), & n=1, i=0 \\ \frac{L_1}{2}, & n>1, i=0 \\ \frac{L_{i+1} + L_i}{2}, & n>1, 0 < i < n-1 \\ \frac{L_{n-1}}{2} + \frac{L_n}{2} g_{01}(\xi), & n>1, i=n-1 \\ \frac{L_n}{2} g_{02}(\xi), & i=n \end{cases}, \quad \text{and} \quad (20)$$

$$h_{m,i+N} = \begin{cases} \frac{L_1}{2} g_{11}(\xi, L_1), & n=1, i=0 \\ \frac{L_1^2}{12}, & n>1, i=0 \\ \frac{L_{i+1}^2 - L_i^2}{12}, & n>1, 0 < i < n-1 \\ \frac{L_{n-1}^2}{12} + \frac{L_n}{2} g_{11}(\xi, L_n), & n>1, i=n-1 \\ \frac{L_n}{2} g_{12}(\xi, L_n), & i=n \end{cases}. \quad (21)$$

The coefficients w_m in Eq. (19) weight the relative importance of each m^{th} measurement in the τ profile. A relatively simple weighting prescription is used at the time of this writing. The weighting coefficient at each depth z_m is first computed as

$$w_m = \frac{1}{s_o(z_m)},$$

where $s_o(z_m)$ is the standard deviation of measured deck cell irradiance $E_s(\lambda, z)$ relative to the smoothed profile $\hat{E}_s(\lambda, z)$ [computed using Eqs. (3)–(8)] over the 10 m depth interval centered at z_m . This weighting gives reduced importance to irradiance measurements made when surface irradiance fluctuates rapidly (*e.g.* due to variable cloud cover), and increased importance to measurements made when incident irradiance was relatively steady. In depth intervals where both the surface and normalized subsurface irradiance profiles exhibit relatively large amplitude fluctuations, w_m are further multiplied by 10^{-6} to completely discount observations where incident irradiance variations viewed by the deck and underwater radiometers are obviously not in phase.

Ship shadow contamination can be visually recognized in many irradiance profiles measured under overcast conditions. The characteristic shape of this phenomenon is illustrated in Voss, *et al.* (1986). In profiles where ship shadow is present, the resulting curvature in the upper layer can distort the K and irradiance profile fits over the upper 100 m. In principle, a ship shadow model could be used to correct the profile explicitly, but research to develop and test the implementation of such a method is beyond the scope of the present report. As an interim substitute, we simply multiply the weighting coefficients w_m by 10^{-4} at depths where ship shadow curvature is visually apparent. With the surface layer boundary conditions used at present (see below), this has the effect of passing a straight line to represent $E(\lambda, z)$ from the surface intercept to the depth of the first node selected by the operator, without regard to any curvature that may be apparent in the measured data.

In matrix form, Eqs. (19) for $m = 1, 2, \dots, M$ profile observations at depths z_m are combined as

$$\bar{\tau} = \underline{H} \bar{\underline{K}} \quad (22)$$

The M elements of the vector $\bar{\tau}$ are $\tau_m = w_m \ln$, calculated from the data with Eq. (11). The elements of the $M \times 2N$ matrix $\underline{H}$ are $w_m h_{mi}$, where h_{mi} are defined in Eq. (20) for $i \leq n$, in Eq. (21) for $N \leq i \leq n + N$, and $h_{mi} = 0$ for $n < i < N$ and $i > n + N$. Finally the vector $\bar{\underline{K}}$ is defined, similarly to Eq. (6), as

$$\bar{\underline{K}} = \begin{bmatrix} \bar{K}_0 \\ \bar{K}_1 \\ \vdots \\ \bar{K}_n \\ \vdots \\ \bar{K}_{N-1} \\ \text{---} \\ \overline{\partial_z K_0} \\ \overline{\partial_z K_1} \\ \vdots \\ \overline{\partial_z K_n} \\ \vdots \\ \overline{\partial_z K_N} \end{bmatrix} \quad (23)$$

i.e. the unknown vector of attenuation coefficients and their gradients at the N nodes.

As with $\hat{E}_s$, $\hat{K}$ is determined by the least-squares solution to Eq. (22) as

$$\hat{K} = [H^T H]^{-1} H^T \hat{\tau} . \quad (24)$$

Eq. (24) can be solved using any standard matrix inversion program. In our implementation, we have used the singular value decomposition method and computer codes given by Press, *et al.* (1988).

To constrain the solution at the surface node, which depends on the entire data profiles below it, we require that

$$\bar{K}_0 \equiv \bar{K}_1 ,$$

which implies further that

$$\partial_z \bar{K}_0 \equiv \partial_z \bar{K}_1 \equiv 0 .$$

In other words, we impose a layer of constant K between the surface and the depth of the first node selected by the operator.

The bottom boundary values are not constrained, and frequently take on unreasonable values. The solution at the bottom node is determined only by the data in the deepest finite element, where the data values are near the minimum detectable level of the instrument and the profile is consequently noisy. To minimize the influence of the bottom node on the overall profile, a thin (< 10 m) bottom element is selected by picking the second deepest node (node index N-2) very close to the deepest one (index N-1). We then ignore the fitted curve in this bottom boundary layer simply by dropping node N-1 when the fitted K and E curves are calculated using Eqs. (15) and (22).

This completes the mathematical description of the fitting procedure. In use, the first estimate bin-averaged $E'(z)$ profile is overlaid on the measured $E(z)$ profile on the computer screen. To aid the operator in selecting node depths, profiles of bin-averaged $K'(z)$ and smoothed deck cell irradiance $E_s(z)$ are displayed also. If data from a beam transmissometer and/or fluorometer are available, the profiles of beam attenuation coefficient $c_p(z)$ and chlorophyll *a* fluorescence $F(z)$ are displayed as a further guide to selecting node depths. The operator then interactively selects an array of node depths, observes the resulting fit obtained using Eqs. (11-24), and iteratively adjusts node depths and refined estimates of $E(0^-)$ until a best fit is obtained.

After this procedure has been applied to all radiometer channels, each profile of $K_d(\lambda, z)$, $K_u(\lambda, z)$ and $K_L(\lambda, z)$ is represented by a vector of node depths $\bar{z}_n$ and the associated vector $\bar{K}$ [Eq. (23)]. The fitted curve for each $K(\lambda, z)$ can then be calculated using Eq. (15). To calculate the fitted $E_d(\lambda, z)$ profile, Eq. (22) is first used to calculate the $\tau_d(\lambda, z)$ profile and then

$$E_d(\lambda, z) = E_d(\lambda, 0^-) e^{-\tau_d(\lambda, z)} . \quad (25)$$

The same procedure is used to retrieve $E_u(\lambda, z)$ and $L_u(\lambda, z)$ profiles from the Hermitian finite element representation.

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CHORS TECHNICAL MEMORANDUM 003-94

APPENDIX D

**MEASURED OPTICAL PROFILES:
CaBS CRUISE 11, 23 JANUARY-3 FEBRUARY 1990**

CRUISE: CaBS 11

STATION 1

DOWNCAST

26 Jan 1990, 193100 GMT

Lat 33.744, Lon -118.791

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 1, downcast. 26 Jan 1990, 193100 GMT.
 Lat 33.744, Lon -118.791

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 1, downcast. 26 Jan 1990, 193100 GMT.
 Lat 33.744, Lon -118.791

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 1, downcast. 26 Jan 1990, 193100 GMT.
 Lat 33.744, Lon -118.791

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 1, downcast, 26 Jan 1990, 193100 GMT.
 Lat 33.744, Lon -118.791

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 1, downcast. 26 Jan 1990, 193100 GMT.
 Lat 33.744, Lon -118.791

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 1, downcast. 26 Jan 1990, 193100 GMT.

Lat 33.744, Lon -118.791

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 1, downcast. 26 Jan 1990, 193100 GMT.

Lat 33.744, Lon -118.791

CRUISE: CaBS 11

STATION 1

UPCAST

26 Jan 1990, 194700 GMT

Lat 33.744, Lon -118.791

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 1, upcast, 26 Jan 1990, 194700 GMT.

Lat 33.744, Lon -118.791

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 1, upcast, 26 Jan 1990, 194700 GMT.

Lat 33.744, Lon -118.791

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 1, upcast, 26 Jan 1990, 194700 GMT.

Lat 33.744, Lon -118.791

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 1, upcast, 26 Jan 1990, 194700 GMT.
 Lat 33.744, Lon -118.791

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 1, upcast, 26 Jan 1990, 194700 GMT.

Lat 33.744, Lon -118.791

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 1, upcast, 26 Jan 1990, 194700 GMT.
 Lat 33.744, Lon -118.791

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 1, upcast, 26 Jan 1990, 194700 GMT.
 Lat 33.744, Lon -118.791

CRUISE: CaBS 11

STATION 2

DOWNCAST

27 Jan 1990, 193600 GMT

Lat 33.819, Lon -119.015

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 2, downcast. 27 Jan 1990, 193600 GMT.

Lat 33.819, Lon -119.015

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 2, downcast. 27 Jan 1990, 193600 GMT.

Lat 33.819, Lon -119.015

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 2, downcast. 27 Jan 1990, 193600 GMT.
 Lat 33.819, Lon -119.015

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 2, downcast. 27 Jan 1990, 193600 GMT.
 Lat 33.819, Lon -119.015

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 2, downcast, 27 Jan 1990, 193600 GMT.
 Lat 33.819, Lon -119.015

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 2, downcast. 27 Jan 1990, 193600 GMT.

Lat 33.819, Lon -119.015

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 2, downcast. 27 Jan 1990, 193600 GMT.

Lat 33.819, Lon -119.015

CRUISE: CaBS 11

STATION 2

UPCAST

27 Jan 1990, 195300 GMT

Lat 33.819, Lon -119.015

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 2, upcast. 27 Jan 1990, 195300 GMT.

Lat 33.819, Lon -119.015

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 2, upcast, 27 Jan 1990, 195300 GMT.

Lat 33.819, Lon -119.015

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 2, upcast, 27 Jan 1990, 195300 GMT.
 Lat 33.819, Lon -119.015

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 2, upcast, 27 Jan 1990, 195300 GMT.

Lat 33.819, Lon -119.015

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 2, upcast, 27 Jan 1990, 195300 GMT.

Lat 33.819, Lon -119.015

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 2, upcast, 27 Jan 1990, 195300 GMT.

Lat 33.819, Lon -119.015

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 2, upcast, 27 Jan 1990, 195300 GMT.
 Lat 33.819, Lon -119.015

CRUISE: CaBS 11

STATION 3

DOWNCAST

28 Jan 1990, 201500 GMT

Lat 33.734, Lon -118.818

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 3, downcast. 28 Jan 1990, 201500 GMT.
 Lat 33.734, Lon -118.818

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 3, downcast. 28 Jan 1990, 201500 GMT.
 Lat 33.734, Lon -118.818

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 3, downcast. 28 Jan 1990, 201500 GMT.
 Lat 33.734, Lon -118.818

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 3, downcast, 28 Jan 1990, 201500 GMT.
 Lat 33.734, Lon -118.818

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 3, downcast. 28 Jan 1990, 201500 GMT.
 Lat 33.734, Lon -118.818

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 3, downcast. 28 Jan 1990, 201500 GMT.
 Lat 33.734, Lon -118.818

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 3, downcast, 28 Jan 1990, 201500 GMT.

Lat 33.734, Lon -118.818

CRUISE: CaBS 11

STATION 3

UPCAST

28 Jan 1990, 203200 GMT

Lat 33.745, Lon -118.813

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 3, upcast, 28 Jan 1990, 203200 GMT.

Lat 33.745, Lon -118.813

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 3, upcast, 28 Jan 1990, 203200 GMT.

Lat 33.745, Lon -118.813

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 3, upcast, 28 Jan 1990, 203200 GMT.
 Lat 33.745, Lon -118.813

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 3, upcast, 28 Jan 1990, 203200 GMT.

Lat 33.745, Lon -118.813

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 3, upcast, 28 Jan 1990, 203200 GMT.

Lat 33.745, Lon -118.813

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 3, upcast, 28 Jan 1990, 203200 GMT.
 Lat 33.745, Lon -118.813

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 3, upcast, 28 Jan 1990, 203200 GMT.

Lat 33.745, Lon -118.813

CRUISE: CaBS 11

STATION 4

DOWNCAST

29 Jan 1990, 202700 GMT

Lat 33.770, Lon -118.802

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 4, downcast. 29 Jan 1990, 202700 GMT.
 Lat 33.770, Lon -118.802

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 4, downcast. 29 Jan 1990, 202700 GMT.
 Lat 33.770, Lon -118.802

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 4, downcast, 29 Jan 1990, 202700 GMT.
 Lat 33.770, Lon -118.802

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 4, downcast. 29 Jan 1990, 202700 GMT.
 Lat 33.770, Lon -118.802

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 4, downcast. 29 Jan 1990, 202700 GMT.
 Lat 33.770, Lon -118.802

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 4, downcast. 29 Jan 1990, 202700 GMT.
 Lat 33.770, Lon -118.802

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 4, downcast. 29 Jan 1990, 202700 GMT.
 Lat 33.770, Lon -118.802

CRUISE: CaBS 11

STATION 4

UPCAST

29 Jan 1990, 204400 GMT

Lat 33.777, Lon -118.793

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 4, upcast, 29 Jan 1990, 204400 GMT.

Lat 33.777, Lon -118.793

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 4, upcast, 29 Jan 1990, 204400 GMT.

Lat 33.777, Lon -118.793

AIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202

Centimeter

Inches

MANUFACTURED TO AIM STANDARDS
BY APPLIED IMAGE, INC.

2 of 3

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 4, upcast, 29 Jan 1990, 204400 GMT.
 Lat 33.777, Lon -118.793

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 4, upcast, 29 Jan 1990, 204400 GMT.

Lat 33.777, Lon -118.793

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 4, upcast, 29 Jan 1990, 204400 GMT.
 Lat 33.777, Lon -118.793

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 4, upcast, 29 Jan 1990, 204400 GMT.
 Lat 33.777, Lon -118.793

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 4, upcast, 29 Jan 1990, 204400 GMT.
 Lat 33.777, Lon -118.793

CRUISE: CaBS 11

STATION 5

DOWNCAST

30 Jan 1990, 181500 GMT

Lat 33.741, Lon -118.830

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 5, downcast. 30 Jan 1990, 181500 GMT.
 Lat 33.741, Lon -118.830

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 5, downcast. 30 Jan 1990, 181500 GMT.
 Lat 33.741, Lon -118.830

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 5, downcast. 30 Jan 1990, 181500 GMT.
 Lat 33.741, Lon -118.830

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 5, downcast. 30 Jan 1990, 181500 GMT.
 Lat 33.741, Lon -118.830

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 5, downcast. 30 Jan 1990, 181500 GMT.
 Lat 33.741, Lon -118.830

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 5, downcast. 30 Jan 1990, 181500 GMT.

Lat 33.741, Lon -118.830

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 5, downcast. 30 Jan 1990, 181500 GMT.

Lat 33.741, Lon -118.830

CRUISE: CaBS 11

STATION 5

UPCAST

30 Jan 1990, 183100 GMT

Lat 33.747, Lon -118.836

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 5, upcast, 30 Jan 1990, 183100 GMT.

Lat 33.747, Lon -118.836

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 5, upcast, 30 Jan 1990, 183100 GMT.

Lat 33.747, Lon -118.836

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 5, upcast, 30 Jan 1990, 183100 GMT.

Lat 33.747, Lon -118.836

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 5, upcast, 30 Jan 1990, 183100 GMT.
 Lat 33.747, Lon -118.836

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 5, upcast, 30 Jan 1990, 183100 GMT.

Lat 33.747, Lon -118.836

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 5, upcast, 30 Jan 1990, 183100 GMT.

Lat 33.747, Lon -118.836

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 5, upcast, 30 Jan 1990, 183100 GMT.
 Lat 33.747, Lon -118.836

CRUISE: CaBS 11

STATION 6

DOWNCAST

31 Jan 1990, 185500 GMT

Lat 33.769, Lon -118.805

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 6, downcast. 31 Jan 1990, 185500 GMT.
 Lat 33.769, Lon -118.805

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 6, downcast. 31 Jan 1990, 185500 GMT.

Lat 33.769, Lon -118.805

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 6, downcast. 31 Jan 1990, 185500 GMT.

Lat 33.769, Lon -118.805

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 6, downcast. 31 Jan 1990, 185500 GMT.
 Lat 33.769, Lon -118.805

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 6, downcast. 31 Jan 1990, 185500 GMT.
 Lat 33.769, Lon -118.805

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 6, downcast. 31 Jan 1990, 185500 GMT.

Lat 33.769, Lon -118.805

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 6, downcast. 31 Jan 1990, 185500 GMT.

Lat 33.769, Lon -118.805

CRUISE: CaBS 11

STATION 6

UPCAST

31 Jan 1990, 191100 GMT

Lat 33.776, Lon -118.802

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 6, upcast, 31 Jan 1990, 191100 GMT.

Lat 33.776, Lon -118.802

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 6, upcast, 31 Jan 1990, 191100 GMT.

Lat 33.776, Lon -118.802

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 6, upcast, 31 Jan 1990, 191100 GMT.

Lat 33.776, Lon -118.802

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 6, upcast, 31 Jan 1990, 191100 GMT.

Lat 33.776, Lon -118.802

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 6, upcast, 31 Jan 1990, 191100 GMT.

Lat 33.776, Lon -118.802

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 6, upcast, 31 Jan 1990, 191100 GMT.
 Lat 33.776, Lon -118.802

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 6, upcast, 31 Jan 1990, 191100 GMT.
 Lat 33.776, Lon -118.802

CRUISE: CaBS 11

STATION 7

UPCAST

2 Feb 1990, 212700 GMT

Lat 33.763, Lon -118.800

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 7, upcast, 2 Feb 1990, 212700 GMT.

Lat 33.763, Lon -118.800

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 7, upcast, 2 Feb 1990, 212700 GMT.

Lat 33.763, Lon -118.800

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 7, upcast, 2 Feb 1990, 212700 GMT.
 Lat 33.763, Lon -118.800

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 7, upcast, 2 Feb 1990, 212700 GMT.

Lat 33.763, Lon -118.800

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 7, upcast, 2 Feb 1990, 212700 GMT.

Lat 33.763, Lon -118.800

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 11, Station 7, upcast, 2 Feb 1990, 212700 GMT.

Lat 33.763, Lon -118.800

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 11, Station 7, upcast, 2 Feb 1990, 212700 GMT.
 Lat 33.763, Lon -118.800

CHORS

Center for Hydro-Optics & Remote Sensing

San Diego State University 6505 Alvarado Road, Suite 206 San Diego, CA 92120-5005 619/594-2272 or 594-2230

CHORS TECHNICAL MEMORANDUM 003-94

APPENDIX E

**MEASURED OPTICAL PROFILES:
MOORING CRUISE, 17-21 APRIL 1990**

CRUISE: mooring (CaBS 11a)

STATION 1

UPCAST

19 Apr 1990, 194300 GMT

Lat 33.742, Lon -118.805

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS (mooring), Station 1, upcast, 19 Apr 1990, 194300 GMT.
 Lat 33.742, Lon -118.805

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS (mooring), Station 1, upcast, 19 Apr 1990, 194300 GMT.
 Lat 33.742, Lon -118.805

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS (mooring), Station 1, upcast, 19 Apr 1990, 194300 GMT.
 Lat 33.742, Lon -118.805

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS (mooring), Station 1, upcast, 19 Apr 1990, 194300 GMT.

Lat 33.742, Lon -118.805

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS (mooring), Station 1, upcast, 19 Apr 1990, 194300 GMT.

Lat 33.742, Lon -118.805

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS (mooring), Station 1, upcast, 19 Apr 1990, 194300 GMT.

Lat 33.742, Lon -118.805

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS (mooring), Station 1, upcast, 19 Apr 1990, 194300 GMT.

Lat 33.742, Lon -118.805

CRUISE: mooring (CaBS 11a)

STATION 2

DOWNCAST

20 Apr 1990, 152200 GMT

Lat 33.701, Lon -119.099

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS (mooring), Station 2, downcast. 20 Apr 1990, 152200 GMT.

Lat 33.701, Lon -119.099

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS (mooring), Station 2, downcast. 20 Apr 1990, 152200 GMT.
 Lat 33.701, Lon -119.099

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS (mooring), Station 2, downcast. 20 Apr 1990, 152200 GMT.

Lat 33.701, Lon -119.099

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS (mooring), Station 2, downcast. 20 Apr 1990, 152200 GMT.

Lat 33.701, Lon -119.099

UPWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS (mooring), Station 2, downcast. 20 Apr 1990, 152200 GMT.

Lat 33.701, Lon -119.099

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS (mooring), Station 2, downcast. 20 Apr 1990, 152200 GMT.

Lat 33.701, Lon -119.099

UPWELLING RADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS (mooring), Station 2, downcast. 20 Apr 1990, 152200 GMT.

Lat 33.701, Lon -119.099

CHORS

Center for Hydro-Optics & Remote Sensing

San Diego State University 6505 Alvarado Road, Suite 206 San Diego, CA 92120-5005 619/594-2272 or 594-2230

CHORS TECHNICAL MEMORANDUM 003-94

APPENDIX F

MEASURED OPTICAL PROFILES:
CaBS CRUISE 12, 7-14 JULY 1990

CRUISE: CaBS 12

STATION 1

DOWNCAST

8 Jul 1990, 191000 GMT

Lat 33.762, Lon -118.791

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 1, downcast. 8 Jul 1990, 191000 GMT.

Lat 33.762, Lon -118.791

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 12, Station 1, downcast. 8 Jul 1990, 191000 GMT.
 Lat 33.762, Lon -118.791

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 12, Station 1, downcast. 8 Jul 1990, 191000 GMT.
 Lat 33.762, Lon -118.791

CRUISE: CaBS 12

STATION 1

DOWNCAST

9 Jul 1990, 015000 GMT

Lat 33.762, Lon -118.791

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 1, downcast. 9 Jul 1990, 015000 GMT.

Lat 33.762, Lon -118.791

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 1, downcast. 9 Jul 1990, 015000 GMT.

Lat 33.762, Lon -118.791

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 1, downcast. 9 Jul 1990, 015000 GMT.

Lat 33.762, Lon -118.791

CRUISE: CaBS 12

STATION 2

DOWNCAST

9 Jul 1990, 182800 GMT

Lat 33.759, Lon -118.792

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 2, downcast. 9 Jul 1990, 182800 GMT.

Lat 33.759, Lon -118.792

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 2, downcast. 9 Jul 1990, 182800 GMT.

Lat 33.759, Lon -118.792

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CuBS 12, Station 2, downcast. 9 Jul 1990, 182800 GMT.
 Lat 33.759, Lon -118.792

CRUISE: CaBS 12

STATION 3

DOWNCAST

10 Jul 1990, 182900 GMT

Lat 33.833, Lon -119.023

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 3, downcast. 10 Jul 1990, 182900 GMT.

Lat 33.833, Lon -119.023

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 3, downcast. 10 Jul 1990, 182900 GMT.

Lat 33.833, Lon -119.023

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 3, downcast. 10 Jul 1990, 182900 GMT.

Lat 33.833, Lon -119.023

CRUISE: CaBS 12

STATION 4

DOWNCAST

11 Jul 1990, 182800 GMT

Lat 33.758, Lon -118.792

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_g(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_g(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 4, downcast. 11 Jul 1990, 182800 GMT.

Lat 33.758, Lon -118.792

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 4, downcast. 11 Jul 1990, 182800 GMT.

Lat 33.758, Lon -118.792

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 4, downcast. 11 Jul 1990, 182800 GMT.

Lat 33.758, Lon -118.792

CRUISE: CaBS 12

STATION 4

UPCAST

11 Jul 1990, 184200 GMT

Lat 33.758, Lon -118.792

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 4, upcast, 11 Jul 1990, 184200 GMT.

Lat 33.758, Lon -118.792

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 4, upcast, 11 Jul 1990, 184200 GMT.

Lat 33.758, Lon -118.792

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 12, Station 4, upcast, 11 Jul 1990, 184200 GMT.
 Lat 33.758, Lon -118.792

CRUISE: CaBS 12

STATION 5

DOWNCAST

12 Jul 1990, 190900 GMT

Lat 33.762, Lon -118.791

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 12, Station 5, downcast. 12 Jul 1990, 190900 GMT.
 Lat 33.762, Lon -118.791

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 12, Station 5, downcast. 12 Jul 1990, 190900 GMT.
 Lat 33.762, Lon -118.791

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 12, Station 5, downcast. 12 Jul 1990, 190900 GMT.
 Lat 33.762, Lon -118.791

CRUISE: CaBS 12

STATION 5

UPCAST

12 Jul 1990, 192000 GMT

Lat 33.762, Lon -118.791

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 5, upcast, 12 Jul 1990, 192000 GMT.

Lat 33.762, Lon -118.791

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 5, upcast, 12 Jul 1990, 192000 GMT.

Lat 33.762, Lon -118.791

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 5, upcast, 12 Jul 1990, 192000 GMT.

Lat 33.762, Lon -118.791

AIM

Association for Information and Image Management

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Silver Spring, Maryland 20910

301/587-8202

Centimeter

Inches

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BY APPLIED IMAGE, INC.

3 of 3

CRUISE: CaBS 12

STATION 6

DOWNCAST

13 Jul 1990, 170000 GMT

Lat 33.756, Lon -118.789

PROFILE COMPARISONS: Beam Attenuation Coefficient c_p (660) at 660 nm, Chl Fluorescence, Downwelling Irradiance E_d (488), Irradiance Attenuation Coefficient K_d (488) at 488 nm, and Deck Cell Irradiance E_s (550) at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 6, downcast, 13 Jul 1990, 170000 GMT.

Lat 33.756, Lon -118.789

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 12, Station 6, downcast. 13 Jul 1990, 170000 GMT.
 Lat 33.756, Lon -118.789

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 12, Station 6, downcast. 13 Jul 1990, 170000 GMT.
 Lat 33.756, Lon -118.789

CRUISE: CaBS 12

STATION 6

UPCAST

13 Jul 1990, 171900 GMT

Lat 33.756, Lon -118.789

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 6, upcast, 13 Jul 1990, 171900 GMT.

Lat 33.756, Lon -118.789

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 6, upcast, 13 Jul 1990, 171900 GMT.

Lat 33.756, Lon -118.789

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 6, upcast, 13 Jul 1990, 171900 GMT.

Lat 33.756, Lon -118.789

CRUISE: CaBS 12

STATION 7

DOWNCAST

13 Jul 1990, 212200 GMT

Lat 33.748, Lon -118.818

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_S(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 7, downcast. 13 Jul 1990, 212200 GMT.

Lat 33.748, Lon -118.818

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 12, Station 7, downcast, 13 Jul 1990, 212200 GMT.
 Lat 33.748, Lon -118.818

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 12, Station 7, downcast. 13 Jul 1990, 212200 GMT.
 Lat 33.748, Lon -118.818

CRUISE: CaBS 12

STATION 7

UPCAST

13 Jul 1990, 214100 GMT

Lat 33.748, Lon -118.818

PROFILE COMPARISONS: Beam Attenuation Coefficient $c_p(660)$ at 660 nm, Chl Fluorescence, Downwelling Irradiance $E_d(488)$, Irradiance Attenuation Coefficient $K_d(488)$ at 488 nm, and Deck Cell Irradiance $E_s(550)$ at 550 nm.

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES
 Cruise: CaBS 12, Station 7, upcast, 13 Jul 1990, 214100 GMT.
 Lat 33.748, Lon -118.818

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 7, upcast, 13 Jul 1990, 214100 GMT.

Lat 33.748, Lon -118.818

DOWNWELLING IRRADIANCE and ATTENUATION COEFFICIENT PROFILES

Cruise: CaBS 12, Station 7, upcast, 13 Jul 1990, 214100 GMT.

Lat 33.748, Lon -118.818

CHORS

Center for Hydro-Optics & Remote Sensing

San Diego State University 6505 Alvarado Road, Suite 206 San Diego, CA 92120-5005 619/594-2272 or 594-2230

CHORS TECHNICAL MEMORANDUM 003-94

APPENDIX G

FLUOROMETRICALLY DETERMINED PIGMENTS, CaBS CRUISES 1990

FLUOROMETRICALLY DETERMINED PIGMENTS

DATE	CRUISE	CTD STA	LATITUDE	LONGITUDE	TIME	DEPTH	Chl	Phaeo
	#	#			(LAT)	(m)	(mg m-3)	(mg m-3)
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	10	0.317	0.204
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	20	0.267	0.220
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	30	0.280	0.210
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	40	0.340	0.199
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	50	0.787	0.457
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	60	0.798	0.493
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	70	0.359	0.458
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	80	0.140	0.242
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	100	0.055	0.192
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	150	0.010	0.181
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	0	0.303	0.161
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	8	0.501	0.212
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	16	0.449	0.202
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	30	0.644	0.439
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	30	0.828	0.324
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	50	0.218	0.358
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	60	0.204	0.316
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	70	0.104	0.262
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	85	0.048	0.208
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	0	0.254	0.151
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	8	0.290	0.163
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	15	0.327	0.183
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	20	0.373	0.196
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	26	0.290	0.397
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	37	0.685	0.467
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	50	0.191	0.288
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	60	0.155	0.269
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	70	0.060	0.181
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	85	0.036	0.175
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	0	0.237	0.123
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	14	0.333	0.135
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	19	0.726	0.277
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	25	0.992	0.575
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	33	0.435	0.416

FLUOROMETRICALLY DETERMINED PIGMENTS

DATE	CRUISE	CTD STA	LATITUDE	LONGITUDE	TIME	DEPTH	Chl	Phaeo
	#	#			(LAT)	(m)	(mg m-3)	(mg m-3)
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	45	0.178	0.257
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	75	0.131	0.254
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	85	0.085	0.200
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	100	0.040	0.152
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	0	0.031	0.145
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	8	0.386	0.179
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	15	0.353	0.164
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	20	0.386	0.175
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	26	0.346	0.167
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	32	0.422	0.303
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	39	0.478	0.243
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	55	0.551	0.553
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	70	0.234	0.338
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	85	0.087	0.215
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	100	0.062	0.182
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	0	0.412	0.216
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	10	0.514	0.207
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	20	0.429	0.218
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	30	0.554	0.256
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	40	0.514	0.400
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	50	0.287	0.360
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	60	0.218	0.284
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	70	0.137	0.240
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	80	0.088	0.209
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	90	0.027	0.198
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	100	0.021	0.154
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		0	0.409	0.197
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		10	0.745	0.254
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		20	0.455	0.244
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		30	0.726	0.265
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		40	0.767	0.328
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		50	0.313	0.315
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		60	0.237	0.298
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		70	0.148	0.248

FLUOROMETRICALLY DETERMINED PIGMENTS

DATE	CRUISE	CTD STA	LATITUDE	LONGITUDE	TIME	DEPTH	Chl	Phaeo
	#	#			(LAT)	(m)	(mg m-3)	(mg m-3)
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		80	0.004	0.192
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		90	0.034	0.184
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		101	0.022	0.150
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	0	0.294	0.134
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	7	0.307	0.143
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	14	0.402	0.233
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	19	0.343	0.211
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	24	0.627	0.299
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	34	0.787	0.411
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	65	0.419	0.473
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	90	0.099	0.201
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	100	0.052	0.195
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	0	0.261	0.126
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	7	0.274	0.146
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	15	0.363	0.158
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	20	0.317	0.155
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	26	0.767	0.339
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	32	0.583	0.616
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	37	1.012	0.843
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	50	0.514	0.589
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	65	0.356	0.443
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	85	0.148	0.279
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	100	0.046	0.207
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	0	0.257	0.100
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	9	0.234	0.130
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	18	0.961	0.214
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	24	1.840	0.556
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	32	1.196	0.578
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	45	0.452	0.459
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	55	0.257	0.378
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	65	0.251	0.389
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	75	0.204	0.334
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	90	0.063	0.202
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	100	0.063	0.193

FLUOROMETRICALLY DETERMINED PIGMENTS

DATE	CRUISE	CTD STA	LATITUDE	LONGITUDE	TIME	DEPTH	Chl	Phaeo
	#	#			(LAT)	(m)	(mg m-3)	(mg m-3)
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	0	0.156	0.090
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	10	0.209	0.103
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	20	0.323	0.134
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	26	0.300	0.138
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	34	0.327	0.205
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	41	0.472	0.261
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	65	0.392	0.470
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	75	0.261	0.401
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	87	0.168	0.285
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	100	0.075	0.207
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	0	0.782	0.029
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	7	0.952	0.203
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	15	0.933	0.132
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	21	0.709	0.194
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	27	1.892	0.298
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	31	2.818	0.640
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	39	1.452	0.703
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	50	1.084	0.679
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	65	0.597	0.481
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	80	0.277	0.325
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	100	0.109	0.244
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		6	0.523	0.158
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		8	0.536	0.142
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		16	0.982	0.509
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		22	2.181	1.199
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		40	0.629	0.784
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		50	0.281	0.442
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		80	0.134	0.318
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		100	0.064	0.245

CHORS

Center for Hydro-Optics & Remote Sensing

San Diego State University 6505 Alvarado Road, Suite 206 San Diego, CA 92120-5005 619/594-2272 or 594-2230

CHORS TECHNICAL MEMORANDUM 003-94

APPENDIX H

**HPLC DETERMINED PIGMENTS,
CaBS CRUISES 1990**

HPLC Determined Pigments

Chlid a	Chlorophyllide <i>a</i>
Chl c	Chlorophyll <i>c</i>
Perid	peridinin
But-19'	butanoy/oxyfucoxanthin
Fuco	fucoxanthin
Hex-19'	hexanoyloxy fucoxanthin
Pras	prasincoxanthin
Viol	violaxanthin
Cis-Fuco	<i>cis</i> fucoxanthin
Dia	diadinoxanthin
Allo	alloxanthin
Lut	luthein
Chl b	chlorophyll <i>b</i>
Chl <i>a</i>	chlorophyll <i>a</i>
Carot	B-carotene

HPLC DETERMINED PIGMENTS

Date	Cruise	CTD	Latitude	LONG	Time	Depth	Chlid	Chl c	Perid	But	Fuco	Hex	Pras	Viol	cis-	Dia	Allo	Lut	Chl b	Chl a	Carot
	#	#				(m)	a								Fuco						
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	0			0.000	0.029	0.029	0.091	0.008			0.019	0.012	0.051	0.014	0.205	
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	10		0.013	0.024	0.039	0.057	0.120	0.007	0.005		0.039	0.021	0.059	0.042	0.316	0.010
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	20			0.016	0.039	0.051	0.118	0.007	0.006		0.037	0.032	0.068	0.020	0.267	0.005
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	30	0.013		0.013	0.033	0.046	0.120	0.007	0.002	0.007	0.026	0.004	0.056	0.033	0.289	
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	40		0.011	0.015	0.039	0.059	0.152	0.009	0.009	0.009	0.030	0.045	0.096	0.048	0.363	0.018
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	50		0.090	0.043	0.110	0.233	0.365	0.020	0.026	0.060	0.038	0.051	0.044	0.127	0.853	
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	60			0.026	0.104	0.371	0.299	0.023	0.046	0.092	0.036	0.058	0.078	0.131	0.802	0.014
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	70	0.017	0.011		0.065	0.139	0.132	0.007	0.009	0.033	0.012	0.008	0.039	0.099	0.374	
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	80				0.050	0.044	0.069				0.004		0.017	0.037	0.141	
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	100				0.019	0.021	0.026				0.003		0.004	0.010	0.048	
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	150															
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	8		0.019	0.027	0.065	0.072	0.211	0.011	0.024	0.051	0.071	0.035	0.092	0.054	0.484	
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	16		0.031	0.030	0.063	0.087	0.212	0.008	0.014	0.015	0.048		0.083	0.073	0.525	0.010
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	22		0.036	0.075	0.072	0.077	0.173	0.010	0.011	0.013	0.046	0.035	0.066	0.062	0.557	0.023
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	30		0.068	0.026	0.038	0.523	0.083		0.032	0.078	0.033	0.016	0.011	0.040	0.814	
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	30		0.042	0.072	0.065	0.235	0.222	0.014	0.027	0.058	0.056	0.032	0.052	0.069	0.710	0.020
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	50	0.014	0.011		0.033	0.117	0.080		0.004	0.007	0.008		0.021	0.051	0.233	
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	60				0.044	0.077	0.075				0.005		0.027	0.081	0.209	
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	70				0.026	0.041	0.035				0.004		0.006	0.033	0.096	
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	85				0.009	0.018								0.008	0.040	
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	100					0.024	0.009								0.023	
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	0				0.013	0.013	0.020							0.014	0.041	
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	8				0.023	0.020	0.028						0.003	0.017	0.067	
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	15				0.051	0.052	0.067				0.005		0.017	0.068	0.159	
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	20				0.053	0.066	0.089			0.042	0.006		0.026	0.074	0.196	
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	26				0.076	0.105	0.153	0.005	0.005	0.034	0.011		0.065	0.070	0.304	
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	37	0.016	0.029	0.031	0.101	0.195	0.386	0.024	0.030	0.099	0.041	0.083	0.146	0.248	0.758	0.009
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	50		0.017	0.011	0.053	0.068	0.156	0.008	0.005	0.008	0.026		0.088	0.044	0.370	0.018
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	60		0.013	0.010	0.037	0.052	0.133	0.006	0.005	0.013	0.029		0.088	0.032	0.309	0.008
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	70		0.006	0.008	0.037	0.048	0.107	0.005	0.005		0.028		0.077	0.027	0.272	0.012
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	85			0.008	0.037	0.043	0.085	0.003	0.006	0.008	0.035	0.023	0.076	0.022	0.246	
										0.029	0.033	0.077		0.005		0.030		0.074	0.014	0.192	
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	8	0.018	0.055	0.014	0.043	0.056	0.131	0.005	0.006		0.046	0.007	0.072	0.026	0.317	
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	15	0.014	0.018	0.017	0.057	0.075	0.172	0.007	0.008	0.009	0.044		0.092	0.038	0.392	0.011
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	20		0.015	0.014	0.056	0.083	0.190	0.014	0.021	0.044	0.044	0.025	0.090	0.037	0.392	0.013
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	26		0.015	0.013	0.045	0.062	0.152	0.002	0.004	0.012	0.025		0.055	0.037	0.342	
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	32	0.034	0.030	0.034	0.112	0.125	0.290	0.012	0.020	0.053	0.041	0.051	0.101	0.069	0.591	0.017
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	39		0.031	0.013	0.101	0.128	0.292	0.012	0.008	0.030	0.025	0.034	0.085	0.110	0.582	0.019
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	55		0.023		0.110	0.210	0.270	0.009	0.009	0.013	0.017	0.007	0.069	0.189	0.596	
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	70	0.005	0.013		0.057	0.067	0.110	0.003	0.017		0.008		0.025	0.112	0.236	
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	85				0.033	0.019	0.046				0.010			0.037	0.092	
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	100				0.017	0.014	0.033				0.002		0.003	0.030	0.062	

HPLC DETERMINED PIGMENTS

Date	Cruise	CTD	Latitude	LONG	Time	Depth	Chlid	Chl c	Perid	But	Fuco	Hex	Pras	Viol	cis- Fuco	Dia	Allo	Lut	Chi b	Chi a	Carot
	#	#				(m)	a														
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		0				0.061				0.018		0.034					
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		10	0.031	0.042	0.037	0.087	0.166	0.299	0.011	0.017	0.013	0.080	0.054	0.072	0.090	0.738	0.018
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		20		0.025	0.008	0.064	0.100	0.222	0.008	0.011	0.027	0.042	0.031	0.041	0.060	0.451	0.011
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		30		0.025	0.032	0.107	0.187	0.376	0.015	0.026	0.057	0.047	0.032	0.065	0.095	0.753	0.01i
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	0	0.021	0.039		0.016	0.053	0.089	0.002	0.005	0.013	0.027		0.051	0.082	0.254	
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	7	0.033	0.054		0.023	0.068	0.104	0.004	0.005	0.017	0.022		0.055	0.025	0.267	
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	14	0.030	0.049		0.041	0.093	0.186	0.011	0.013		0.026	0.030	0.127	0.070	0.474	
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	19	0.027			0.026	0.052	0.136	0.007	0.008	0.017	0.017	0.008	0.025	0.063	0.321	
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	24	0.091	0.148	0.005	0.041	0.108	0.316	0.017	0.022	0.063	0.031	0.030	0.024	0.107	0.579	
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	34	0.216	0.270	0.008	0.097	0.318	0.590	0.012	0.031	0.071	0.032	0.034	0.054	0.084	0.743	
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	45	0.193	0.148	0.008	0.069	0.192	0.317	0.015	0.023	0.035	0.014	0.012	0.045	0.171	0.587	
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	65	0.050	0.080	0.003	0.037	0.104	0.098	0.010	0.006		0.008	0.019	0.057	0.188	0.369	
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	75	0.044	0.042		0.037	0.082	0.082	0.004		0.016	0.005	0.007	0.035	0.118	0.253	
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	90				0.010	0.024	0.033						0.005	0.044	0.075	
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	100				0.012	0.015	0.024						0.003	0.017	0.107	
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	0				0.019	0.066	0.076				0.052		0.080	0.021	0.247	
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	7		0.009		0.026	0.081	0.123	0.005			0.056		0.082	0.029	0.306	0.008
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	15		0.016		0.042	0.063	0.154	0.006			0.034	0.007	0.085	0.039	0.317	
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	20		0.010		0.040	0.099	0.161				0.032	0.029	0.052	0.016	0.309	
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	26	0.010	0.115	0.008	0.116	0.457	0.539	0.006			0.094	0.073	0.045	0.056	0.900	0.026
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	32	0.018	0.066	0.011	0.066	0.366	0.228	0.004			0.039	0.012	0.024	0.044	0.488	0.016
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	37	0.033	0.084	0.011	0.091	0.645	0.276	0.006			0.047	0.017	0.022	0.076	0.840	0.015
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	50	0.011	0.014		0.045	0.207	0.180	0.016			0.015	0.011	0.040	0.184	0.535	0.013
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	65	0.000	0.013		0.040	0.133	0.135	0.009			0.008	0.008	0.044	0.172	0.351	
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	85	0.015			0.032	0.064	0.068	0.004			0.004		0.018	0.082	0.176	
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	100				0.020	0.021	0.057						0.004	0.021	0.063	
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	0			0.013	0.014	0.076	0.062		0.008		0.041	0.012	0.044	0.019	0.206	
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	9		0.042	0.015	0.019	0.076	0.090		0.030		0.044	0.016	0.044	0.016	0.201	
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	18	0.093	0.333	0.303	0.140	0.231	0.180	0.011	0.027	0.040	0.111	0.065	0.053	0.065	0.916	0.032
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	24	0.239	0.673	0.280	0.179	0.875	0.380	0.016	0.146	0.096	0.143	0.118	0.071	0.165	1.683	0.046
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	32	0.176	0.351	0.026	0.074	0.988	0.269	0.006	0.082	0.152	0.051	0.017	0.025	0.059	1.044	0.021
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	45	0.104	0.096	0.010	0.038	0.267	0.120	0.005	0.011	0.041	0.016	0.039	0.037	0.086	0.440	
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	55		0.051	0.020	0.032	0.111	0.059			0.014	0.009	0.012	0.018	0.080	0.249	
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	65	0.025	0.039	0.000	0.022	0.123	0.066			0.005	0.007	0.011	0.015	0.092	0.246	
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	75	0.013	0.021	0.007	0.029	0.085	0.060	0.003	0.013		0.007	0.009	0.014	0.077	0.183	
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	90				0.093	0.044	0.032						0.005	0.022	0.052	
10-Jul-90	CaBS-12	3	33 50.2 N	119 1.59 W	1345	100				0.019	0.034	0.039						0.003	0.021	0.048	
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	0				0.012	0.045	0.043		0.005		0.028		0.043	0.006	0.123	
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	10			0.024	0.022	0.056	0.069		0.004		0.034		0.047	0.014	0.188	
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	20	0.035	0.058		0.036	0.102	0.114	0.002	0.007		0.034	0.014	0.060	0.019	0.254	
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	26		0.051		0.031	0.073	0.129	0.005	0.006		0.027	0.013	0.053	0.028	0.310	0.008

HPLC DETERMINED PIGMENTS

Date	Cruise	CTD	Latitude	LONG	Time	Depth	Chl d	Chl c	Perid	But	Fuco	Hex	Pras	Viol	cis- Fuco	Dia	Allo	Lut	Chl b	Chl a	Carot
	#	#				(m)	a														
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	34	0.023	0.066		0.025	0.061	0.123	0.010	0.011	0.012	0.021	0.020	0.049	0.051	0.308	
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	41	0.045	0.091	0.024	0.060	0.110	0.245	0.013	0.013	0.011	0.031	0.018	0.072	0.078	0.503	0.017
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	49	0.093	0.205	0.033	0.126	0.258	0.510	0.009	0.015	0.049	0.043	0.035	0.036	0.085	0.790	
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	65		0.041	0.006	0.057	0.290	0.191	0.017		0.112	0.020	0.041	0.067	0.058	0.442	
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	75	0.019	0.044		0.039	0.109	0.083	0.005		0.039	0.006	0.007	0.031	0.128	0.258	
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	87		0.025		0.032	0.064	0.055				0.004		0.017	0.078	0.147	
11-Jul-90	CaBS-12	4	33 45.5 N	118 47.6 W	1400	100				0.017	0.031	0.039				0.002		0.006	0.019	0.074	
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	0		0.095	0.181	0.057	0.086	0.074				0.100	0.024	0.048	0.021	0.664	0.036
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	7		0.117	0.239	0.077	0.158	0.111				0.128	0.032	0.064	0.022	0.947	0.049
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	15	0.018	0.067	0.229	0.088	0.195	0.174				0.126	0.028	0.058	0.033	1.008	0.035
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	21	0.014	0.075	0.036	0.038	0.191	0.152	0.005			0.038	0.011	0.060	0.048	0.523	0.014
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	27	0.061	0.183	0.540	0.187	0.406	0.456	0.015			0.194	0.060	0.064	0.134	2.094	0.071
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	31	0.152	0.642	0.679	0.316	0.369	0.568	0.028			0.213	0.128	0.053	0.201	2.488	0.048
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	39	0.074	0.235	0.046	0.106	0.484	0.664	0.030	0.057	0.156	0.050	0.113	0.041	0.161	1.291	0.027
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	50	0.048	0.072	0.045	0.112	0.527	0.545	0.018	0.037	0.068	0.054	0.068	0.033	0.131	1.158	0.037
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	65	0.011	0.067	0.054	0.067	0.144	0.147	0.008	0.007		0.029	0.008	0.042	0.143	0.536	0.009
12-Jul-90	CaBS-12	5	33 45.5 N	118 47.6 W	1200	80	0.009	0.022	0.006	0.036	0.061	0.088				0.010		0.019	0.090	0.232	
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		6		0.064		0.020	0.192	0.098	0.002	0.026		0.057		0.055	0.025	0.402	
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		8	0.052	0.099		0.024	0.225	0.094	0.004	0.026		0.039	0.009	0.046	0.031	0.464	
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		16	0.071	0.132		0.039	0.204	0.243	0.031	0.069		0.048	0.067	0.177	0.317	0.937	0.017
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		30	0.075	0.110	0.029	0.036	0.216	0.213	0.018	0.022		0.025	0.054	0.064	0.217	0.714	
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		40	0.078	0.072		0.018	0.161	0.108	0.023	0.013	0.007	0.014	0.040	0.121	0.265	0.589	
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		50		0.043		0.016	0.092	0.047	0.006	0.021		0.006		0.020	0.106	0.243	
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		80		0.025		0.018	0.045	0.045						0.014	0.060	0.078	
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		100				0.007	0.024	0.024						0.005	0.021	0.042	

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APPENDIX I

PARTICULATE CARBON, HYDROGEN AND NITROGEN DATA, CaBS CRUISES 1990

PARTICULATE CARBON, HYDROGEN AND NITROGEN DATA

DATE	CRUISE	CTD STA	LATITUDE	LONGITUDE	TIME	DEPTH	Wet	Carbon	Hydrogen	Nitrogen
	#	#			(LAT)	(m)	Samples	(micro gms l-1)	(micro gms l-1)	(micro gms l-1)
26-Jan-90	CaBS-11	5	33 44.79 N	118 47.72W		10		115.6	36.2	6.3
26-Jan-90	CaBS-11	5	33 44.79 N	118 47.72W		30		148.9	41.4	12.3
26-Jan-90	CaBS-11	5	33 44.79 N	118 47.72W		40		130.1	34.9	11.8
26-Jan-90	CaBS-11	5	33 44.79 N	118 47.72W		50		162.2	40.0	10.8
26-Jan-90	CaBS-11	5	33 44.79 N	118 47.72W		60		128.6	57.1	16.3
26-Jan-90	CaBS-11	5	33 44.79 N	118 47.72W		70		203.6	57.8	13.8
26-Jan-90	CaBS-11	5	33 44.79 N	118 47.72W		80		320.2	91.9	66.9
26-Jan-90	CaBS-11	5	33 44.79 N	118 47.72W		100		335.1	63.6	58.7
26-Jan-90	CaBS-11	5	33 44.79 N	118 47.72W		150		359.1	81.4	28.8
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	0		333.2	58.5	16.3
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	20		116.6	34.3	17.2
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	30		213.7	46.4	57.9
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	40		125.2	33.3	10.5
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	50		129.4	31.8	13.6
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	60		99.7	26.7	12.7
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	70		89.2	42.0	6.5
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	80		62.2	21.7	3.5
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	100		67.2	16.9	5.3
27-Jan-90	CaBS-11	14	33 49.42 N	119 2.11 W	1235	150		106.4	21.7	2.9
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	8		184.3	41.6	12.2
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	16		160.2	38.4	10.1
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	22		175.8	47.2	14.7
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	30		209.8	52.2	17.3
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	41		240.3	44.1	15.6
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	50		119.1	31.4	9.0
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	60		252.6	44.0	5.8
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	70		148.8	40.1	13.1
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	1330	85		83.4	26.1	7.5
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	0		148.3	52.4	9.9
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	8		124.1	36.1	9.3
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	15		131.0	55.9	11.7
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	20		197.5	77.2	11.0
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	26		122.7	58.8	37.2
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	37		113.6	53.8	59.5

PARTICULATE CARBON, HYDROGEN AND NITROGEN DATA

DATE	CRUISE #	CTD STA #	LATITUDE	LONGITUDE	TIME (LAT)	DEPTH (m)	Wet Samples	Carbon (micro gms l-1)	Hydrogen (micro gms l-1)	Nitrogen (micro gms l-1)
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	50		85.9	50.3	60.1
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	60		143.1	48.6	3.7
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	70		79.7	34.7	20.2
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	85		115.3	37.2	70.9
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	1407	100		81.4	47.1	24.7
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	0		172.8	37.4	11.4
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	14		117.1	43.1	10.2
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	19		111.6	32.4	18.5
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	25		99.7	29.8	14.0
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	33		124.8	36.6	11.0
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	45		105.3	29.7	14.0
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	75		74.6	22.5	7.7
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	85		109.6	29.0	6.1
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	1115	100		102.0	35.7	3.7
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	0		110.0	34.1	54.7
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	8		92.0	28.6	8.7
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	15		122.1	56.8	13.2
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	20		108.8	43.6	11.0
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	26		137.3	38.6	12.3
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	32		89.2	30.1	12.1
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	39		89.7	27.6	8.0
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	55		80.6	25.0	6.1
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	70		93.9	48.2	2.8
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	85		98.1	50.5	50.4
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	1330	100		75.4	45.3	6.8
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	0		111.1	28.1	12.1
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	10		130.3	64.7	16.0
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	20		104.3	41.4	10.2
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	30		117.4	54.3	16.0
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	40		154.8	64.1	12.3
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	50		72.9	42.2	31.5
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	60		60.5	41.7	31.1
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	70		55.1	24.7	9.3
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	80		53.2	28.3	4.3

PARTICULATE CARBON, HYDROGEN AND NITROGEN DATA

DATE	CRUISE #	CTD STA #	LATITUDE	LONGITUDE	TIME (LAT)	DEPTH (m)	Wet Samples	Carbon (micro gms l-1)	Hydrogen (micro gms l-1)	Nitrogen (micro gms l-1)
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	90		57.4	37.7	4.5
1-Feb-90	CaBS-11	33	33 46.15 N	118 48.55 W	1600	100		127.7	43.6	64.2
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		0		97.1	49.7	6.8
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		10		107.2	48.2	9.9
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		20		103.8	37.3	40.3
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		30		122.8	30.0	196.9
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		40		97.4	41.6	12.1
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		50		43.8	15.9	4.3
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		60		52.0	17.1	3.9
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		70		58.2	19.4	3.1
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		80		111.8	25.3	79.5
2-Feb-90	CaBS-11	34	33 46.01 N	118 48.40 W		90		63.7	23.7	2.8
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	0	**	150.7	981.4	16.5
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	7	**	120.7	748.4	12.8
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	14	**	167.1	41.2	13.2
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	19	**	111.7	26.7	11.8
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	24	**	131.9	44.4	16.8
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	34	**	140.1	27.5	27.6
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	45	**	138.7	33.1	12.0
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	65	**	85.6	962.6	9.2
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	75	**	67.0	523.0	6.5
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	90	**	199.2	975.9	67.3
8-Jul-90	CaBS-12	1	33 45.5 N	118 47.6 W	1330	100	**	81.3	976.0	8.9
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	0	**	105.2	90.8	15.4
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	7	**	167.3	90.8	16.1
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	15	**	147.4	46.8	20.6
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	26	**	148.6	1010.5	17.5
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	32	**	124.1	1007.5	12.5
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	37	**	123.3	995.6	20.2
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	50	**	76.7	983.6	12.2
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	65	**	74.8	682.0	19.8
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	85	**	72.1	996.9	17.7
9-Jul-90	CaBS-12	2	33 45.5 N	118 47.6 W	1330	100	**	85.8	999.8	16.5

4

[illegible]

PARTICULATE CARBON, HYDROGEN AND NITROGEN DATA

DATE	CRUISE	CTD STA	LATITUDE	LONGITUDE	TIME	DEPTH	Wet	Carbon	Hydrogen	Nitrogen
	#	#			(LAT)	(m)	Samples	(micro gms l-1)	(micro gms l-1)	(micro gms l-1)
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		0		213.3	101.9	15.6
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		6		125.5		13.1
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		8		151.9	66.3	18.8
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		22		251.3	80.8	41.6
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		30		148.7	43.7	15.9
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		40		150.7	53.5	10.9
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		50		91.5		
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		65		82.9	37.1	13.6
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		80		114.0	52.3	43.6
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W		100		109.3		

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APPENDIX J

PRIMARY PRODUCTIVITY, CaBS CRUISES 1990

PRIMARY PRODUCTIVITY

DATE	CRUISE	CTD STA	LATITUDE	LONGITUDE	Depth	14C uptake	Mean	Std Dev	Int Prod	Total Int Prod
	#	#			(m)	(mgC m-3 d-1)	(mgC m-3 d-1)	(mgC m-3 d-1)	(mgC m-2 d-1)	(mgC m-2 d-1)
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	0	63.41				
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	0	43.85	51.69	10.34	1,272	
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	0	47.81				
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	16	110.18				
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	16	104.70	107.30	2.75	767	
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	16	107.02				
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	22	144.74				
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	22	153.66	148.34	4.70	786	
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	22	146.63				
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	30	43.20				
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	30	53.01	48.10	6.94	374	
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	41	18.61				
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	41	18.99	19.93	1.96		3,199
28-Jan-90	CaBS-11	16	33 44.67 N	118 49.19 W	41	22.18				
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	0	73.16				
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	0	63.79	69.67	5.12	1,068	
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	0	72.05				
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	15	85.30				
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	15	60.53	72.77	12.39	380	
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	15	72.49				
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	20	73.32				
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	20	79.34	79.09	5.64	293	
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	20	84.60				
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	26	19.19				
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	26	18.24	18.50	0.60	180	
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	26	18.08				
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	37	11.97				
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	37	13.00	14.29	3.17		1,921
29-Jan-90	CaBS-11	19	33 45.83 N	118 48.48 W	37	17.91				
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	0	41.41				
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	0	47.71	46.52	4.63	1,238	
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	0	50.43				
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	19	91.54				
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	19	74.70	83.83	8.51	481	
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	19	85.26				

PRIMARY PRODUCTIVITY

DATE	CRUISE #	STATION NUMBER	LATITUDE	LONGITUDE	Depth (m)	14C uptake (mgC m-3 d-1)	Mean (mgC m-3 d-1)	Std Dev (mgC m-3 d-1)	Int Prod (mgC m-2 d-1)	Total Int Prod (mgC m-2 d-1)
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	25	76.83				
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	25	77.19	76.41	1.06	474	
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	25	75.20				
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	33	43.54				
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	33	37.58	41.97	3.85	315	
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	33	44.80				
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	45	9.81				
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	45	10.78	10.55	0.65		2,508
30-Jan-90	CaBS-11	20	33 44.84 N	118 50.20 W	45	11.05				
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	0	43.94				
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	0	46.94	48.26	5.10	1,083	
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	0	53.89				
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	15	93.97				
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	15	104.04	96.12	7.10	451	
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	15	90.34				
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	20	90.86				
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	20	83.46	84.42	4.13	328	
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	20	88.96				
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	26	26.65				
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	26	23.74	24.78	1.62	238	
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	26	23.95				
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	39	12.40				
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	39	10.83	11.89	0.92		2,100
31-Jan-90	CaBS-11	24	33 46.18 N	118 49.63 W	39	12.45				
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	0	26.81				
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	0	38.20	39.63	13.59	1,117	
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	0	53.88				
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	15	100.14				
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	15	116.72	109.31	8.43	498	
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	15	111.05				
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	20	88.24				
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	20	93.00	89.76	2.81	601	
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	20	88.05				
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	26	109.65				
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	26	129.06	110.71	17.85	849	

PRIMARY PRODUCTIVITY

DATE	CRUISE	STATION	LATITUDE	LONGITUDE	Depth	14C uptake	Mean	Std Dev	Int Prod	Total Int Prod
	#	NUMBER			(m)	(mgC m-3 d-1)	(mgC m-3 d-1)	(mgC m-3 d-1)	(mgC m-2 d-1)	(mgC m-2 d-1)
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	26	93.41				
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	37	47.88				
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	37	43.45	43.67	4.10		3,065
9-Jul-90	CaBS-12	2	33 45.50 N	118 47.60 W	37	39.68				
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	0	58.02				
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	0	52.43	50.91	7.97	3,133	
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	0	42.29				
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	18	330.14				
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	18	218.19	297.24	68.78	4,921	
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	18	343.39				
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	24	1,357.37				
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	24	1,385.33	1,342.99	51.08	5,787	
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	24	1,286.26				
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	32	109.96				
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	32	106.45	103.73	7.94	985	
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	32	94.79				
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	45	54.62				
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	45	48.00	47.81	6.91		14,826
10-Jul-90	CaBS-12	3	33 50.20 N	119 1.59 W	45	40.81				
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	0	56.16				
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	0	60.06	58.73	2.23	2,196	
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	0	59.98				
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	20	157.71				
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	20	172.64	160.83	10.60	900	
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	20	152.15				
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	26	139.99				
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	26	140.16	139.32	1.32	796	
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	26	137.80				
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	34	60.97				
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	34	59.87	59.60	1.52	374	
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	34	57.96				
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	41	45.36				
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	41	43.09	47.22	5.31		4,266
11-Jul-90	CaBS-12	4	33 45.54 N	118 47.50 W	41	53.21				

PRIMARY PRODUCTIVITY

DATE	CRUISE	STATION	LATITUDE	LONGITUDE	Depth	14C uptake	Mean	Std Dev	Int Prod	Total Int Prod
	#	NUMBER			(m)	(mgC m-3 d-1)	(mgC m-3 d-1)	(mgC m-3 d-1)	(mgC m-2 d-1)	(mgC m-2 d-1)
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	0	184.87				
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	0	166.60	176.69	9.28	3,509	
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	0	178.60				
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	15	292.73				
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	15	311.94	291.24	21.49	1,673	
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	15	269.04				
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	21	277.96				
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	21	272.37	266.45	15.36	1,180	
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	21	249.01				
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	27	126.93				
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	27	137.01	126.81	10.27	1,148	
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	27	116.48				
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	39	61.24				
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	39	62.96	64.45	4.17		7,510
12-Jul-90	CaBS-12	5	33 45.75 N	118 47.34 W	39	69.17				
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	0	173.93				
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	0	174.78	175.55	2.12	1,715	
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	0	177.95				
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	8	233.53				
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	8	263.02	253.17	17.01	577	
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	8	262.96				
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	10	329.19				
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	10	318.48	324.21	5.39	3,456	
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	10	324.96				
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	22	231.50				
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	22	262.08	251.78	17.57	1,141	
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	22	261.77				
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	30	32.60				
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	30	34.82	33.37	1.26		6,889
13-Jul-90	CaBS-12	6	33 45.39 N	118 47.34 W	30	32.69				

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