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OCTS and SeaWIFS Bio-Optical Algorithm and Product Validation and Intercomparison in U.S. Coastal Waters

Year End Draft Technical Memorandum

For Period of Performance: July 21, 1997 - July 20, 1998

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Submitted: July 6, 1998

SCOPE

This year end draft technical memorandum reviews the work performed by Principal Investigators Christopher W. Brown and John C. Brock for the Sensor Intercomparison and Merger for Biological and Interdisciplinary Oceanic Studies (SIMBIOS) Project entitled "OCTS and SeaWIFS Bio-Optical Algorithm and Product Validation and Intercomparison in U.S. Coastal Waters" during the period extending from July 21, 1997 to July 20, 1998 in accordance with Article 8 (Reporting Requirements) described in the Statement of Work of Order #S-97879-F.

INTRODUCTION

The successful launch of the National Space Development Agency of Japan (NASDA) Ocean Color and Temperature Sensor (OCTS) in August 1996, and the launch of Orbital Science Corporation's (OSC) Sea-viewing Wide-Field-of-view Sensor (SeaWiFS) in August 1997 signaled the beginning of a new era for ocean color research and application. These data may be used to remotely evaluate 1) water quality, 2) transport of sediments and adhered pollutants, 3) primary production, upon which commercial •

shellfish and finfish populations depend for food, and 4) harmful algal blooms which pose a threat to public health and economies of affected areas. Several US government agencies have recently expressed interest in monitoring U.S. coastal waters using optical remote sensing. This renewed interest is broadly driven by 1) resource management concerns over the impact of coastward shifts in population and land use on the ecosystems of estuaries, wetlands, nearshore benthic environments and fisheries, 2) recognition of the need to understand short time scale global change due to urbanization of sensitive land-margin ecosystems, and 3) national security issues. Satellite ocean color sensors have the potential to furnish data at the appropriate time and space scales to evaluate and resolve these concerns and problems.

In this draft technical memorandum, we outline our progress during the first year of our SIMBIOS project to evaluate ocean color bio-optical algorithms and products generated using OCTS and SeaWiFS data in coastal US waters.

PROPOSAL REVIEW

The objectives of this investigation were to validate and compare bio-optical algorithms and ocean color products using Ocean Color and Temperature Sensor (OCTS) and Sea-viewing Wide-Field-of-View Sensor (SeaWiFS) data in coastal US waters. The specific objectives of the funded NOAA SIMBIOS project were to:

- 1. Collect and compile high quality, *in-situ* bio-optical observations in US coastal waters. This includes rescuing, reformatting, and compiling existing historical biological, optical, and water quality data;
- 2. Evaluate and compare the performance of NASDA/OCTS and NASA/SeaWiFS standard bio-optical <u>algorithms</u> for the diverse Case I and Case II waters of the coastal US and,
- 3. Validate and compare ocean color <u>products</u> generated using OCTS and SeaWiFS data and NASDA and NASA standard bio-optical and atmospheric correction techniques in coastal US waters.

With the failure of ADEOS on June 30, 1997, and consequent lack of OCTS data after this date, we were unable to perform Objectives #2 and #3 activities with OCTS data.

In support of Objective #1, *in-situ* bio-optical data were collected during five cruises in diverse U.S. Case 2 and Case 1 coastal waters of the eastern US (Table 1). Two of these cruises -- Mar97OCC and May97OB -- were conducted before initiation of our SIMBIOS Project (July 21, 1997). The following bio-optical measurements were collected using a Biospherical Instrument's spectroradiometer PRR600s (S/N# 9643) and surface (PRR610, S/N #9644) on all FY97 cruises: above surface spectral downwelling irradiance, in-water spectral downwelling irradiance and upwelling radiance, and colored dissolved organic matter and particulate absorption. Accompanying geophysical measurements included total suspended solids concentration, and chlorophyll and pigment concentrations from fluorometric and High Pressure Liquid Chromatography (HPLC) techniques. Radiometric and HPLC data from four of these five cruises have been submitted to the SIMBIOS Project for inclusion in the SeaWiFS Bio-optical Archive and Storage System (SeaBASS). Data reports for cruises Mar97OCC and May97OB have also been submitted (Appendix A and B), with the reports of the remaining Sep97SAB and Nov97SAB in preparation (Table 1). The Jul98NAN cruise will be conducted during July 6 - 10, 1998.

In support of bio-optical algorithm validation (Objective #2), SeaWiFS chlorophyll and pigment concentrations were estimated by applying the standard SeaWiFS algorithms, i.e. OC2, to remote sensing reflectances computed from in-water optical profiles and above water, downwelling irradiance measurements. These values were compared against *in-situ* measurements of chlorophyll and pigment concentration at 23 stations (Table 2).

Differences ranged from 6% to 639% for OC2 chlorophyll concentration and from 3% to 369% for CZCS pigment concentration during cruises May97OB, Sep97SAB, and Nov97SAR. Preliminary results indicate that the OC2 algorithm overestimates chlorophyll concentration in coastal waters, but performs relatively well in mid-shelf and open ocean waters. This analysis will also be performed for data from cruise Jul98NAN.

Verification of SeaWiFS products was performed in support of Objective #3. High resolution (1 km) HRPT SeaWiFS data acquired at Goddard Space Flight Center (GSFC) or the Coastal Services Center were received and processed to Level-2 products using near-real time meteorological and ozone ancillary data and standard atmospheric correction and product algorithms implemented in the SeaWiFS Data Analysis System (SeaDAS). SeaWiFS-derived chlorophyll-a, CZCS pigment, and K490 of contemporaneous, cloud-free imagery were extracted at ship sampling locations of cruises Sep97SAB and Nov97SAR. The *in-situ* measurements and satellite-derived estimates of chlorophyll-a and CZCS pigment were compared (Table 3). Preliminary examination indicates that satellite-derived estimates of these two geophysical parameters are from 30% to 300% greater than *in-situ* measurements. This analysis will also be performed for contemporaneous, cloud-free data collected during the Jul98NAN cruise.

In addition to conducting activities in support of the above Objectives, personnel associated with this SIMBIOS project participated in the first SIMBIOS Science Team Meeting held August 6-8, 1997 in Solomons, MD. Also, two World Wide Web accessible homepages reporting on activities associated with the project were developed, one at NOAA/CSC (http://www.csc.noaa.gov/crs/cruises/) and one at NOAA/ORA (http://orbit17i.nesdis.noaa.gov/~chrisb/docs/SIMBIOS.html).

The following scientific presentations resulted from data collected from this SIMBIOS Project:

- Geesey, M. Culver, A. Subramaniam, G. DiTullio, and J. Brock. 1998. Optical and Biological variability in the South Atlantic Bight. Presented at a conference for Collaborative Research Activities in the South Atlantic Bight, April 1998.
- Waters, K.J., M. E. Culver, and A. Subramaniam. 1988. Optical closure models applied to coastal and open ocean waters. Abstract submitted to Ocean Optics XIV, Society for Photo-Optical Instrumentation Engineers (SPIE). Conference scheduled for November 1998.

CAMPAIGN SUMMARIES

A summary of station date, time, and location for each the four cruises conducted to date for this SIMBIOS project are presented in Table 4. Vertical profiles of *in-situ* spectral downwelling irradiance and upwelling radiance, and above surface spectral downwelling irradiance at seven channels were collected using a Biospherical Instrument, Inc.'s spectroradiometer PRR600s (S/N# 9643) and surface unit (PRR610, S/N #9644), respectively, on all FY97 cruises. The PRR600s irradiance and radiance sensors were mounted such that the collectors were on the same horizontal plane. PRR data was processed using the Bermuda Bio-Optics Project (BBOP) processing software (Siegel *et al.*, 1995). Accompanying geophysical measurements that were collected included temperature, total suspended solids concentration (TSS), and chlorophyll-a and pigment concentrations. Chlorophyll-a and pigment concentrations were estimated using fluorometric and High Pressure Liquid Chromatography (HPLC) techniques. TSS concentration was measured as described by Parsons *et al.* (1984).

Radiometric and HPLC data from four of these five cruises have been submitted to the SIMBIOS Project for inclusion in the SeaWiFS Bio-optical Archive and Storage System (SeaBASS) (Table 1). Reports for cruises Mar97OCC and May97OB, detailing all activities and comments of these cruises, are attached in Appendix A and B, respectively. Cruise reports are also available on-line at

"http://www.csc.noaa.gov/crs/cruises/SCROL.html". Similar cruise reports for Sep97SAB, Nov97SAR, and Jul98NAN, that will include a log or record of each cruise, are forthcoming.

Biospherical Instruments, Inc. PRR-600s (S/N#9643) and PRR-610 (S/N#9644) were factory calibrated two times in the last year, i.e. February 10, 1997 and January 7, 1998. Calibration certificates for these instruments since January 23, 1996 are attached in Appendix C.

DELIVERABLE REVIEW

The primary deliverables resulting from our SIMBIOS project, as stated in the funded NOAA proposal, are:

- 1. A World Wide Web accessible Coastal Bio-optical data Analysis and Storage System (CoBASS), containing both historical B/O/WQ data and newly acquired *in-situ* bio-optical measurements from disparate U.S. coastal provinces;
- 2. Quantitative evaluation and comparison of the NAŠDA and NASA standard in-water algorithms for the seasonally and regionally varying Case 1 and Case 2 waters of the US coastal ocean and large embayments; and
- 3. Quantitative evaluation of ocean color products generated using NASDA/OCTS and NASA/SeaWiFS standard bio-optical and atmospheric correction techniques in coastal US waters.

In support of Deliverable #1, radiometric and geophysical data from four of the five FY97 cruises have been submitted to the SIMBIOS Project for inclusion in the SeaWiFS Bio-optical Archive and Storage System (SeaBASS). During the teleconferenced review of our SIMBIOS project on June 3, 1998, SIMBIOS Project representatives agreed this submission to SeaBASS fulfills the stated requirement.

In lieu of extensive in-water radiative transfer modeling to validate algorithm performance, standard SeaWiFS algorithms for chlorophyll and CZCS pigment concentrations were evaluated by generating estimates of these parameters using remote sensing reflectances computed from in-water optical profiles and above water, downwelling irradiance measurements and comparing them with *in-situ* measurements. This analysis was not performed for the SeaWiFS diffuse attenuation coefficient (K 490) algorithm. A compilation of results from data collected during our FY97 cruises is presented in Table 2. The failure of ADEOS, and consequent lack of OCTS imagery after this date, prevent us from performing this analysis and intersensor algorithm comparison for data collected after on June 30, 1997.

Product validation of SeaWiFS-derived chlorophyll-a and CZCS pigment was performed for appropriate station data collected during cruises Sep97SAB and Nov97SAR (Table 3). Validation for normalized water-leaving radiances was not performed because of oversight. Validation for diffuse attenuation coefficient (K 490) was also not performed because a method of estimate a comparable value from in-situ radiometer measurements was not agreed upon. Both of these deficiencies will be remedied retrospectively over the next year. Unavailability of adequately processed, high resolution OCTS imagery coincident with the Mar97OCC and May97OB cruises prevented validation for similar

OCTS products. If and when appropriate OCTS imagery becomes available, these analyses will be performed.

PLANS FOR NEXT YEAR

We plan to continue fulfilling the stated objectives of our funded proposal in FY98. Tentative dates and locations of cruises planned for the next year are listed in Table 5.

Table 5. Tentative dates and locations of cruises planned for NOAA SIMBIOS Project in FY1998.

Date	Location	Affiliation/Ship Name
September/October 1998	Gulf of Mexico	ECOHAB
November 1998	Mid-Atlantic Bight	Cape Hatteras
March 1999	Mid-Atlantic Bight	Cape Hatteras

At the request of Dr. Charles McClain, personnel from our SIMBIOS Project will assist Dave Eslinger with his SIMBIOS project entitled "High-latitude Intercomparison and Validation Experiment (HIVE)".

The WWW accessible homepages (mentioned above) on activities associated with the Project will likely be expanded.

ISSUES AND CONCERNS

Insufficient funds were provided to perform standard algorithm evaluation as described in our original proposal. We request that the method of evaluating the standard SeaWiFS algorithms in our contract be changed from analysis by radiative transfer modeling to our present method of applying the standard SeaWiFS algorithms to remote sensing reflectances computed from in-water optical profiles and comparing them with *insitu* measurements.

REFERENCES

Parsons, T.R., Y. Maita, and C.M. Lalli (1984). A Manual for Chemical and Biological Methods for Seawater Analysis, Pergamon Press.

Siegel, D.A., M.C. O'Brien, J.C. Sorensen, D.A. Konnoff, and E. Fields (1995). BBOP Data Processing and Sampling Procedures. Vol. 19, Institute for Computational Earth System Science, UC Santa Barbara, Santa Barbara, CA, 23 pp.

Table 1. Sumr Liquid Liquid	nary of cruise. Chromatograp	s conducted and da hhy.	ttes of relevant data	submission to the SIM	BIOS Project Office.	HPLC = High Pressure
Cruise Name	Date	Location	Vessel	Month of Radiometric Data Submission	Month of HPLC Data Submission	Month of Cruise Report Submission
Mar970CC	3/13/97	Onslow Bay	R/V Onslow Bay	5/97	5/97	2/97
May97OB	5/5-8/97	Onslow Bay, Pamlico Sound	R/V Onslow Bay	5/98	5/98	86/9
Sep97SAB	9/6-24/97	South Atlantic Bight	Cape Hatteras	5/98*	86/9	In Preparation
Nov97SAR	11/4-6/97	Sargasso Sea	R/V Palmetto	2/98	2/98	In Preparation
Jul98NAN	7/6-10/98	Nantucket Shoals	Gulf Challenger	10/98**	**66/10	TBD

* Match up data only** Projected Submission Date

Latitude and lonpitude are given in decimal	
. Chlorophyll and CZCS-pigment concentration algorithm evaluation.	\therefore Diff. = difference (%).
Table 2.	degrees.

Cruise Name	Date	Station	Latitude	Longitude	<i>In-situ</i> Chl-a	OC2 Chl-a	Diff. (%)	In-situ Pigment	OC2 CZCS Pigment	Diff. (%)
May97OB	5/5/97 5/5/97 5/5/97 5/5/97 5/8/97 5/8/97 5/8/97	SC 25 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	34.278 34.305 34.378 34.446 34.446 34.552 35.247 35.197 35.166 35.083	-76.068 -76.280 -76.280 -76.622 -76.650 -76.009 -76.084 -76.168	$\begin{array}{c} 0.14\\ 0.15\\ 0.15\\ 0.15\\ 0.15\\ 0.15\\ 0.15\\ 1.99\\ 1.80\\ 2.12\\ 2.12\end{array}$	$\begin{array}{c} 0.22\\ 0.26\\ 0.26\\ 0.29\\ 0.60\\ 13.7\\ 13.3\\ 9.42\end{array}$	57 73 158 93 140 202 588 588 588 539	0.23 0.26 0.26 0.27 0.27 0.43 3.67 4.54 4.54 4.30	$\begin{array}{c} 0.30\\ 0.36\\ 0.36\\ 0.39\\ 0.39\\ 0.39\\ 0.32\\ 10.1\\ 17.4\\ 16.9\\ 12.1\end{array}$	$30 \\ 38 \\ 38 \\ 38 \\ 374 \\ 374 \\ 369 \\ 369 \\ 369 \\ 380 \\ 38$
Sep97SAB	9/6/97 9/6/97 9/13/97 9/13/97 9/13/97 9/19/97 9/23/97	6A 6B 113 114 123 123 124 23 23 23 23 23 23 23 23 23 23 23 23 23	34.652 34.652 30.906 30.422 29.916 30.837 31.868 31.868	-76.657 -76.538 -81.305 -81.305 -81.305 -81.200 -81.200 -81.200 -81.200 -79.290 -79.046	2.75 2.75 3.77 1.97 0.33 0.33 0.45	3.01 1.37 1.22 6.30 2.76 0.31 0.19	9 224 6 120 58 120	2.75 0.69 5.20 1.97 0.33 0.45	3.95 1.83 8.12 8.12 0.42 0.27	44 165 314 56 84 189 40
Nov97SAR	11/4/97 11/4/97 11/4/97 11/5/97 11/5/97 11/5/97	7 8 11 14 16	32.545 32.401 32.239 31.092 31.018	-79.625 -79.484 -79.339 -78.193 -78.203 -78.203	$\begin{array}{c} 0.20\\ 0.14\\ 0.10\\ 0.03\\ 0.04\\ 0.04 \end{array}$	$\begin{array}{c} 0.79\\ 0.35\\ 0.34\\ 0.17\\ 0.15\\ 0.15\\ 0.16\end{array}$	295 150 170 17 17 250	0.34 0.23 0.22 0.16 0.19	$\begin{array}{c} 1.07\\ 0.48\\ 0.24\\ 0.22\\ 0.20\\ 0.20\end{array}$	215 109 114 25 5

Table 3. Chlorophyll and CZCS-pigment concentration product validation. A comparable value of diffuse attenuation coefficient (K 490) was not estimated from *in-situ* radiometric measurements. Latitude and longitude are given in decimal degrees. Diff. = difference (%).

Cruise Name	Date	Station	Latitude	Longitude	In-situ Chl-a	SeaWiFS Chl-a	Diff. (%)	In-situ Pigment	SeaWiFS CZCS Pigment	Diff. (%)	SeaWiFS K 490
Sep97SAB	9/19/97 9/23/97	19 23	30.83 32.92	-80.76 -79.28	0.33 1.233	0.45 2.05	36 66	0.33 1.23	0.62 2.29	85 85	0.056 0
Nov97SAR	11/3/97 11/3/97 11/3/97 11/3/97 11/4/97 11/4/97 11/4/97 11/4/97 11/4/97	UW1 0W1 0W1 0W1	31.75 31.94 32.06 32.17 32.23 32.54 32.23 32.23 32.23 32.23 32.60	-79.07 -79.04 -79.04 -79.29 -79.47 -79.48 -79.29 -79.29 -79.21	$\begin{array}{c} 0.051\\ 0.083\\ 0.086\\ 0.086\\ 0.092\\ 0.146\\ 0.146\\ 0.135\\ 0.143\\ 0.133\\ 0.033\\ 0.033\end{array}$	$\begin{array}{c} 0.15\\ 0.12\\ 0.32\\ 0.33\\ 0.33\\ 0.33\\ 0.30\\ 0.20\\ 0.14\end{array}$	194 39 265 265 265 211 226 495 326 326	0.34 0.23 0.22	$\begin{array}{c} 0.21\\ 0.16\\ 0.43\\ 0.46\\ 0.45\\ 0.45\\ 0.41\\ 0.27\\ 0.27\\ 0.27\end{array}$	197 78 278	$\begin{array}{c} 0.039\\ 0.036\\ 0.054\\ 0.060\\ 0.088\\ 0.088\\ 0.052\\ 0.036\\ 0.088\\ 0.039\\ 0.036\\ 0.006\\ 0.$

Cruise Name	Station	Date	Time (GMT)	Latitude	Longitude
Mar97OCC	1	3/13/97	11:05	34.433	-76.652
May97OB	5C 5D 5E 5F 5G 8A 8C 8E 8G	5/5/97 5/5/97 5/5/97 5/5/97 5/5/97 5/8/97 5/8/97 5/8/97 5/8/97	14:00 15:20 16:20 17:15 18:40 12:40 13:20 13:40 14:10	$\begin{array}{r} 34.278\\ 34.305\\ 34.378\\ 34.446\\ 34.552\\ 35.247\\ 35.197\\ 35.166\\ 35.083\end{array}$	-76.068 -76.280 -76.462 -76.622 -76.650 -76.009 -76.084 -76.168 -76.251
Sep97SAB	6A 6B 13 14 17 19 23 24	9/6/97 9/6/97 9/13/97 9/14/97 9/17/97 9/19/97 9/23/97 9/24/97	15:01 20:15 15:15 16:15 15:05 15:05 15:51 16:15	34.652 34.439 30.906 30.422 29.916 30.837 32.928 31.868	-76.657 -76.538 -81.305 -81.372 -81.200 -80.764 -79.290 -79.046
Nov97SAR	1 2 3 4 5 6 7 8 9 UW1 UW2 UW3 UW4 UW5 10 11 12 13 14 15 16	1 1/3/97 1 1/3/97 1 1/3/97 1 1/3/97 1 1/3/97 1 1/3/97 1 1/4/97 1 1/4/97 1 1/4/97 1 1/4/97 1 1/4/97 1 1/4/97 1 1/5/97 1 1/5/97	07:00 09:50 11:40 13:10 14:45 16:30 12:15 14:15 16:15 18:00 20:00 22:00 00:00 02:00 02:00 04:00 06:00 08:00 10:00 12:00 16:00	31.753 31.943 32.066 32.172 32.230 32.310 32.545 32.401 32.239 32.097 31.862 31.620 31.423 31.184 31.130 31.125 31.110 31.092 31.065 31.018	-79.070 -79.001 -79.049 -79.172 -79.299 -79.476 -79.625 -79.484 -79.339 -79.213 -79.002 -78.800 -78.501 -78.277 -78.223 -78.207 -78.192 -78.193 -78.203 -78.237

Table 4. Station date, time, and location of FY97 SIMBIOS cruises.

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Appendix A. Report for Cruise MAR97OCC: Onslow Bay.

CSC Technical Report CSC/5-97/001

NOAA CSC/CRS Cruise MAR97OCC: OCTS Calibration Cruise

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May 1997



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This is a NOAA Coastal Services Center Technical Report. The NOAA CSC Coastal Remote Sensing Program intends to publish forthcoming reports as official NOAA Technical Reports.

Abstract

The calibration of the Ocean Color and Temperature Sensor (OCTS) on board the Advanced Earth Observing Satellite (ADEOS) needs to be verified. This requires precise measurements of radiance just below the sea surface in reasonably clear waters from which water leaving radiance can be calculated. Scientists from the Coastal Remote Sensing Program at the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center and the Southeast Fisheries Science Center at NOAA/National Marine Fisheries Service undertook a cruise out of Beaufort, North Carolina. One station, located at 34° 25.98'N, 76° 39.14'W, was occupied at 11:05 a.m., March 13, 1997, contemporaneous with an ADEOS overpass. *In-situ* measurements of temperature, spectral downwelling irradiance, and spectral upwelling radiance to a depth of 15 meters were made along with above surface spectral downwelling irradiance. Surface chlorophyll concentration was also measured.

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Acknowledgments

We thank Captain Doug Willis and the crew of the *R/V Onslow Bay* for assistance provided. The chlorophyll sample analysis was performed by Elin Haugin, Southeast Fisheries Science Center, Beaufort, North Carolina. This cruise was made possible by a NOAA Coastal Ocean Program Grant to Dr. Tester.

I. Introduction

The Ocean Color and Temperature Sensor (OCTS) on the Japanese Advanced Earth Observing Satellite (ADEOS) requires sea-truth data for post-launch characterization. Accurate measurements of water-leaving radiance in relatively clear waters are required to verify the calibration on this sensor after launch. To support this activity, the Coastal Remote Sensing (CRS) Program at the National Oceanic and Atmospheric Administration (NOAA)/Coastal Services Center (CSC) undertook a cruise out of Beaufort, North Carolina, on 13 March 1997.

II. Objectives

The objectives of this cruise were to obtain sub-surface upwelling radiance in relatively clear, deep waters. The water-leaving radiance calculated from these measurements can be compared to those derived from the OCTS sensor, in order to assess the sensor's calibration.

III. Methods

A. Sampling Location

One station (Station 1) was occupied on 13 March, 1997, to make optical profile measurements in the water column. Surface samples were also acquired at this location for chlorophyll analysis by fluorometric and High-Pressure Liquid Chromatography (HPLC) techniques. The station was located at 34° 25.975'N, 76°39.137'W, and is shown in Figure 1.

B. Sampling Platform

The *R/V Onslow Bay*, belonging to the NOAA/National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center, was used for this cruise. The Onslow Bay is a 15-meter (m) fisheries survey vessel.

C. Sample Collection Methods Summary

A PRR600s was deployed off the starboard side of the vessel, using a davit and a 4-m long pole with a pulley at the end (Figure 2). The instrument was lowered to a depth of 15 m and brought back to the surface between 11:00 a.m. and 11:15 a.m. The PRR600s measured *in-situ* spectral downwelling irradiance, spectral upwelling radiance, and temperature. Surface bucket samples were obtained for chlorophyll analysis.





D. Sampling Gear

The PRR600s (Serial No. 9643) is a spectroradiometer manufactured by Biospherical Instruments, Inc., that measures seven channels of downwelling irradiance, seven channels of upwelling radiance (Table 1), depth, tilt, roll, and temperature. A surface unit (PRR610 - Serial No. 9644) is used to measure seven matched channels of surface downwelling irradiance on deck. Channels 1 to 6 on all sensors and channel 7 on the radiance sensor are narrow band (10 nanometer [nm] Full Width at Half Maximum [FWHM]) centered at the indicated wavelengths, while channel 7 on the irradiance sensor is a broadband detector that measures Photosynthetically Available Radiation (PAR) between 400 and 700 nm (Table 1).

The irradiance and radiance sensors of the PRR600s are separate units, mounted such that the collectors are on the same horizontal plane. The instrument mount was attached to a tension release on a kevlar reinforced electrical cable. The PRR610 surface unit was strapped onto a radio antenna on the starboard side of the vessel, close to the davit used to lower the PRR600s (Figure 2).

Channel	PRR600s Downwelling	PRR600s Upwelling	PRR610
No.	Light Sensor	Light Sensor	
1	380 nm	380 nm	380 nm
2	412 nm	412 nm	412 nm
3	443 nm	443 nm	443 nm
4	490 nm	490 nm	490 nm
5	510 nm	510 nm	510 nm
6	555 nm	555 nm	555 nm
7	PAR	683 nm	PAR

Table 1. Center Wavelengths for the PRR System

E. Bottle Samples

The chlorophyll biomass was determined using a Turner Designs fluorometer (Parsons *et al.* 1984). Discrete surface water samples were obtained for chlorophyll analysis using a bucket, at the same time as the PRR cast. In the lab, 1 liter (1) of sea water was filtered through glass fiber GF/F filters which were then stored in 90 percent acetone in a freezer for about 24 hours. Then the filters were ground and the chlorophyll *a* and phaeopigment concentrations were determined using the formula given in Smith *et al.* 1981.

F. Optical Data Processing

The PRR data was processed using the Bermuda Bio-Optics Project (BBOP) processing software (Siegel *et al.* 1995). A least common denominator (LCD) file was created from the binary data files, the cast card files, the calibration files, and cruise notes. The LCD file header contains the metadata for the cast and includes information on the parameters sampled, parameters derived, filters used, and the statistical results of the regression used

to extrapolate to the sub-surface. An example header is presented in Appendix A. The pressure channel data was recalculated using an offset to adjust for the distance of the pressure sensor from the cosine collector. The tops and bottoms of the individual profiles were marked using an interactive Matlab[®] script and the corresponding record numbers were inserted into the LCD header section. Data less than the dark threshold was replaced by -9.9×10^{35} . Then the data was quality controlled using flags for data with tilt and roll angles greater than 10° , and records in which the surface incident irradiance was not uniform. The temperature channel was despiked, in two passes with a difference threshold. A moving average was calculated for the temperature channel. The data were separated into upcast and downcast profiles and then binned to 0.5-m bins. Subsurface downwelling irradiance and upwelling radiance were extrapolated to just below the surface, and spectral attenuation coefficients were calculated for the optical channels over a 5 point moving window.

IV. Results

Although initial weather forecasts had called for clear skies in the morning with Northeast winds at 15 knots, there were cloud banks to the east, presumably over the Gulf Stream. Also, winds were considerably stronger at 20 to 25 knots and wave heights were 3 to 4 feet (ft), with swells up to 8 ft. We did not occupy a Gulf Stream station as originally planned, because it was obviously under clouds. The water depth at station was 24 m and surface water temperature was 16.6° Celcius (C). The temperature profile showed that the water column was very well mixed from surface to 15 m (16.6°C from surface to 15 m).

A. Pigment Analyses

The average chlorophyll *a* concentration at the surface at Station 1 was 0.539 μ g Chlorophyll *a* /liter (Chl *a*/l) (0.539, 0.552, 0.526).

B. Optical data

Because the boat rolled as much as it did, the instrument was quickly lowered to about 2 m below the surface during the downcast and no data was collected near the surface during the downcast (Figure 3). The water column was optically clear with measurable light at all wavelengths to 14 m. Data was obtained all the way to the surface during the upcast (Figure 4). The rough sea state also caused the instrument to jerk around a lot and much of the data is flagged for tilt and/or roll greater than 10°. The effect of the rough sea state could be seen as kinks in the optical profiles (Figures 3 and 4), as well as in the tilt and roll data (Figure 5). The rolling motion of the boat can also be seen in the changes in surface irradiance data (Figure 5). While there were no dense clouds overhead during the cast, the surface irradiance changed by an average of 18 percent during the downcast and upcast respectively. Overall, there was a 11 percent change in incident irradiance at the surface from the beginning of the downcast to the end of the upcast. The

sub-surface irradiance and radiance were calculated using BBOP processing software and the results for the upcast and downcast are shown in Tables 5 and 6, respectively. The min and max depth refer to the minimum and maximum depths of data used to calculate the sub-surface light, and n points is the number of data points used in the calculation. b0 is the intercept and b1 is the slope of the regression, min, max, and mean refer to the minimum, maximum, and mean of the data used in the regression.









channel	min	max	n	b0	b1	min	max	mean	std	var	un-	abdev
	depth	depth	points						dev		certainty	
Down	cast											
ed380	0.5	6	10	53.22	0.69	5.33	26.07	12.36	1.75	1.36	1.11	0.03
ed412	0.5	6	10	87.93	0.76	16.14	51.50	29.39	1.51	1.19	1.12	0.04
ed443	0.5	6	10	104.13	0.81	28.07	68.87	44.25	1.38	1.11	1.12	0.04
ed490	0.5	6	10	115.58	0.85	42.21	83.62	59.21	1.29	1.07	1.13	0.04
ed510	0.5	6	10	114.27	0.85	42.05	84.70	59.36	1.30	1.07	1.14	0.04
ed555	0.5	6	10	112.52	0.84	38.35	80.11	55.16	1.31	1.08	1.13	0.04
lu380	0.5	6	10	0.29	0.73	0.03	0.15	0.08	1.66	1.30	1.26	0.07
lu412	0.5	6	10	0.60	0.81	0.13	0.39	0.25	1.43	1.14	1.21	0.05
lu443	0.5	6	10	0.88	0.85	0.27	0.64	0.46	1.32	1.08	1.18	0.05
lu490	0.5	6	10	1.40	0.89	0.60	1.11	0.87	1.21	1.04	1.12	0.04
lu510	0.5	6	10	1.35	0.88	0.58	1.06	0.84	1.21	1.04	1.12	0.04
lu555	0.5	6	10	1.08	0.88	0.45	0.84	0.65	1.23	1.04	1.12	0.04
lu683	0.5	6	10	0.10	0.71	0.01	0.05	0.02	1.68	1.31	1.06	0.02
Upcast												
ed380	0.5	6	10	59.46	0.67	4.06	38.78	13.09	2.19	1.85	1.33	0.09
ed412	0.5	6	9	102.62	0.73	14.57	72.66	35.00	1.68	1.31	1.27	0.08
ed443	0.5	6	9	126.22	0.78	26.22	94.10	52.28	1.50	1.18	1.22	0.07
ed490	0.5	6	9	142.85	0.81	40.81	111.67	69.30	1.37	1.11	1.20	0.06
ed510	0.5	6	9	147.29	0.81	41.04	111.39	69.70	1.37	1.11	1.21	0.06
ed555	0.5	6	9	142.24	0.80	37.18	107.42	65.27	1.40	1.12	1.21	0.06
lu380	0.5	6	9	0.36	0.70	0.03	0.19	0.10	1.84	1.45	1.29	0.09
lu412	0.5	6	9	0.76	0.77	0.15	0.49	0.31	1.52	1.19	1.17	0.06
lu443	0.5	6	9	1.23	0.80	0.33	0.81	0.58	1.38	1.11	1.16	0.04
lu490	0.5	6	9	1.87	0.86	0.76	1.37	1.09	1.24	1.05	1.15	0.04
lu510	0.5	6	9	1.80	0.86	0.75	1.32	1.06	1.24	1.05	1.15	0.04
lu555	0.5	6	9	1.45	0.85	0.58	1.05	0.83	1.25	1.05	1.15	0.04
lu683	0.5	6	9	0.12	0.68	0.01	0.06	0.03	1.78	1.39	1.14	0.04

Table 2. Sub-surface Light

Normalized water leaving radiance, as defined by Gordon et al. 1988, was calculated as:

$$(L_{w})_{N} = \left[\frac{(1-\rho)(1-\overline{\rho})F_{0}(\frac{L_{u}}{E_{d}})}{m^{2}(1-rQ\frac{L_{u}}{E_{d}})}\right]$$

where:

- $(L_w)_N$ is the normalized water leaving radiance
- ρ is the Fresnel reflectance of the sea surface for normal incidence, here = 0.021
- $\overline{\rho}$ is the Fresnel reflection albedo of the sea surface for irradiance from the sun and sky, here = 0.043

- F_0 is the mean extraterrestrial solar irradiance, here $F_{0(385)}=94.5$, $F_{0(415)}=170$, $F_{0(445)}=192.8$, $F_{0(490)}=192.2$, $F_{0(515)}=183.1$, $F_{0(555)}=184.1$, $F_{0(675)}=151.6$ (from [Labs and Neckel 1970])
- L_u is the sub-surface upwelling radiance calculated from optical profile
- E_d is the sub-surface downwelling irradiance calculated from optical profile
- m is the refractive index of sea water, here = 1.34
- r is the water-air reflectance for totally diffuse irradiance, here = 0.48
- Q is the ratio of the upwelling radiance to the upwelling irradiance towards the zenith, here = 5.07

The sub-surface irradiance, radiance, and normalized water leaving radiance are shown in Table 3 and the spectra for the downcast and the upcast are shown in Figure 7.



wave-	downcast	upcast	down-	upcast	downcast	upcast	downcast	upcast
length	Ed	Ed	cast L _u	Lu	L _{WN}	L _{WN}	R _{rs}	R _{rs}
380	53.2	22 59.46	0.29	0.36	0.2723	0.303007	0.005449	0.006054
412	87.9	93 102.62	2. 0.6	0.76	0.615508	0.669004	0.006824	0.007406
443	104.	13 126.22	0.88	1.23	0.868041	1.004181	0.008451	0.009745
490	115.5	58 142.85	1.4	1.87	1.251708	1.356086	0.012113	0.013091
510	114.2	27 147.29	1.35	1.8	1.162166	1.203399	0.011814	0.012221
555	112.5	52 142.24	1.08	1.45	0.944097	1.004189	0.009598	0.010194

 Table 3. Normalized Water Leaving Radiance and Remote Sensing Reflectance

V. References

Gordon, H. R., O. B. Brown, R. H. Evans, J. W. Brown, R. C. Smith, K. S. Baker and D. K. Clark (1988). "A Semianalytic Radiance Model of Ocean Color." *Journal of Geophysical Research* 93(D9): 10909-10924.

Labs, D. and H. Neckel (1970). "Transformation of the Absolute Solar Radiation Data Into The International Practical Temperature Scale Of 1968." *Solar Physics* 15: 79.

Parsons, T. R., Y. Maita and C. M. Lalli (1984). A Manual For Chemical And Biological Methods For Seawater Analysis, Pergamon Press.

Siegel, D. A., M. C. O'Brien, J. C. Sorensen, D. A. Konnoff and E. Fields (1995). BBOP Data Processing and Sampling Procedures. **Vol:** 19, Institute for Computational Earth System Science, UC Santa Barbara, Santa Barbara, CA, 23 pp.

Smith, R. C., K. S. Baker and P. Dustan (1981). Fluorometric Techniques for the Measurement of Oceanic Chlorophyll in the Support of Remote Sensing. *SIO Ref.* 81-17, Visibility Laboratory, Scripps Institution of Oceanography, La Jolla, CA 92093, 14 pp.
VI. Metadata

The metadata, including point of contacts, types of analyses, for the cruise is given below.

A. Core Documentation

Identification_Information Citation Citation_Information Originator: National Oceanic and Atmospheric Administration Coastal Services Center Publication_Date: 1997

Title: NOAA CSC/CRS Cruise MAR97OCC: OCTS Calibration Cruise Online Linkage: http://www.csc.noaa.gov/crs/cruises/mar97occ/index.html

Description

Abstract: See Abstract, page iii

Purpose: See Objectives, page 1

Supplemental_Information: StartDate: 19971303 StopDate: 19971303 Preview: http://www.csc.noaa.gov/crs/cruises/index.html

Time_Period_of_Content Time_Period_Information Single_Date/Time Calendar_Date: 1997 Currentness Reference: Publication Date

Status **Progress:** Complete **Maintenance_and_Update_Frequency:** Unknown

Spatial Domain

Bounding Coordinates: West Bounding Coordinate: -76.652 East Bounding Coordinate: -76.652

- North Bounding Coordinate: 34.433
- South Bounding Coordinate: 34.433

Keywords

Theme Theme_Keyword_Thesaurus: None Theme_Keyword: oceanography Theme_Keyword: bio-optical Theme_Keyword: turbidity Theme_Keyword: blooms Theme_Keyword: resuspension Theme_Keyword: river plumes Theme_Keyword: coastal water optics Theme_Keyword: case II algorithms Theme_Keyword: absorption Theme_Keyword: attenuation Theme_Keyword: in-situ optical profiling Theme_Keyword: ocean color satellites Theme_Keyword: coastal ocean algorithm development Place Place_Keyword_Thesaurus: None Place_Keyword: Onslow Bay Place_Keyword: Beaufort, NC Place_Keyword: South Atlantic Bight Place_Keyword: United States Time Temporal_Keyword: Spring Temporal_Keyword: March, 1997 Parameters measured Parameter_Keyword: spectral downwelling irradiance Parameter_Keyword: spectral upwelling radiance Parameter_Keyword: temperature Point_of_Contact: Contact_Information: Contact_Organization_Primary: Contact_Organization: NOAA Coastal Services Center Contact_Person: Dr. A. Subramaniam Contact Address: Address_Type: mailing and physical 2234 South Hobson Avenue Address: City: Charleston State: South Carolina Postal_Code: 29405-2413 Country: USA Contact_Voice_Telephone: (800)789-2234 Contact_Electronic_Mail_Address: crs@csc.noaa.gov Hours_of_Service: 8 a.m.-5 p.m., M-F

B. Citation Information

Source Citation: Subramaniam, A., E.M. Armstrong, K.J. Waters, J.C. Brock, P.A. Tester, and E. Haugen. 1997. NOAA CSC/CRS Cruise MAR97OCC: OCTS Calibration Cruise. CSC Technical Report CSC/5-97/001. NOAA Coastal Services Center. Charleston, SC. Pp18

Currentness: May 1997

Access Constraints: None

Use Constraints: This data was acquired for scientific research and is applicable for algorithm validation purposes only.

C. Data Quality

Process Description: See Methods, page 2

Spectroradiom	eter measurements: Spectral downwelling irradiance,
-	spectral upwelling radiance, temperature
Instrument:	PRR600s, PRR610
Operator:	Ajit Subramaniam
Address:	see point of contact
Manufacturer:	Biospherical Instruments, Inc.
Address:	5340 Riley Street
	San Diego, CA 92110-2621
Phone:	(619) 686.1888

Chlorophyll measurements:

Methods reference: Parsons, T. R., Y. Maita and C. M. Lalli (1984). A manual for chemical and biological methods for seawater analysis, Pergamon Press. Pp107-110. Smith, R. C., K. S. Baker and P. Dustan (1981). Variations: Fluorometric Techniques for the Measurement of Oceanic Chlorophyll in the Support of Remote Sensing. SIO Ref. 81-17, Visibility Laboratory, Scripps Institution of Oceanography, La Jolla, CA 92093, 14 pp. Analyst: Elin Haugen Address: National Marine Fisheries Service Southeast Fisheries Science Center - Beaufort Laboratory 101 Pivers Island Road Beaufort, NC 28516-9722 (919) 728.2747 Telephone:

Attribute Accuracy: See Appendix B

Spectroradiometer Calibration:

1 st Calibration:	1/24/96
2 nd Calibration:	3/26/96
3 rd Calibration:	2/10/97

Horizontal Positional Accuracy: 400 m

Entity and Attribute Overview Description: See Methods, page 2

D. Metadata Reference Information

Metadata Date:

Contact Organization: NOAA/Coastal Services Center

Contact Person: Lauren Parker

Full Address: see point of contact

The core documentation section is designed for the purposes of the Coastal Information Directory (CID). The metadata in this section is used in building the CID's database.

VII. Appendix A - Example Profile Header information

The following information is found as a header on all BBOP processed files. <cruise info> filename p970313a date 03-13-1997 day_of_year 72 day_since_010192 1899 file created 11:03:50 cruise station 1 position 76 39.137 34 25.975 longitude 76 39.137 latitude 34 25.975 sky_state clear operator_name ajit sun position 2 cruise_id cope i sep96cop cruise session_started 11:04:02 session_stopped 11:07:29 depth_offset .32 cal_date_uw9643 021097 cal_date_sfc9644 021097 downcast ended 11:07:25.738 337 upcast_ended 11:07:27.558 340 yoyo no closest_CTD_cast none sun_intensity bright cloud_type 30% clouds on horizon cloud_amt 30% (high clouds) wind_speed_and_dir 20 kts? north-northeast swell 5-6ft collection software_version prrprof_002086c number_units 1 collection_cal_file 96439644.cfl;prr-600 #9643/9644 calibration file 2/10/96 cac lcd calib_file 0 /csc/nep1/coors/bbops/BUILD/calib/unit0_021097.cfl 1 /csc/nep1/coors/bbops/BUILD/calib/unit1_021097.cfl 2 /csc/nep1/coors/bbops/BUILD/calib/unit2_021097.cfl lcdfile created Mar 19 1997 16:59:38 castid index 1prr_record 1depth p970313a.dt1 9.9000000e+01 9.9000000e+01 1.9616880e+00 p970313a.db1 1.7900000e+02 1.7900000e+02 1.4350000e+01 p970313a.ub1 2.2900000e+02 2.2900000e+02 1.4603000e+01 3.2900000e+02 3.2900000e+02 8.3759400e-02 p970313a.ut1

```
<sampled_parameters>
 lprr_record 110
 1ed380 0 -0.008317 0.000146
 1ed412 0 -0.021345 0.000551
 1ed443 0 -0.021874 0.000189
 1ed490 0 -0.02298 0.000282
 led5100-0.0223130.000171
 1ed555 0 -0.022801 0.00048
 1par 0 -9.05594 0.000371
 ledgnd 0 1 0
 1temp 0 0.1421 0.0889
 ldepth
           0. 9.38300e-01 8.31773e+01 2.65899e+01 0.9383 83.1773 26.9099 0 0
 1tilt 0 0.04178 2.68617
 1roll 0 0.041514 2.69727
 2lu380 0 -0.151929 0.000198
 2lu412 0 -0.498479 -0.000103
 2lu443 0 -0.90121 0.000203
 2lu490 0 -0.996381 0.00016
 2lu510 0 -1.24348 0.00033
 2lu555 0 -1.74733 0.000162
 2lu683 0 -1.52118 0.000105
2lugnd 0 1 0
3es380 0 -0.031424 0.00024
3es412 0 -0.03211 -0.000879
3es443 0 -0.033785 -2.1e-05
3es490 0 -0.032938 -0.000256
3es510 0 -0.032641 -0.000241
3es555 0 -0.032326 0.000203
3par 0 - 10.5311 - 6.9e-05
3edgnd 0 1 0
<derived_parameters>
aq-1Tilt-1Roll
d-ltemp
d-d-ltemp
m-d-d-ltemp
bin_0.5_1depth
ptsbin_0.5
kc-1ed380
kc-1ed412
kc-1ed443
kc-1ed490
kc-1ed510
```

<filters_used>

prrrecalz -0 1depth 0.9383 83.1773 26.5899 /csc/nep1/coors/bbops/BUILD/mar97occ/lcd/p970313a.lcd outfile27050 bbopradq -fa 1ed380 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa 1ed412 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa led443 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradg -fa led490 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa led510 2.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa 1ed555 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa 3es380 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradg -fa 3es412 1.000000e-03 p970313a.lcd outqp970313a.lcd bbopradq -fa 3es443 1.000000e-03 p970313a.lcd outqp970313a.lcd bbopradq -fa 3es490 1.000000e-05 p970313a.lcd outqp970313a.lcd bbopradg -fa 3es510 1.000000e-05 p970313a.lcd outqp970313a.lcd bbopradq -fa 3es555 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa 3par 1.000000e-01 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu380 1.000000e-02 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu412 1.000000e-02 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu443 1.000000e-03 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu490 1.000000e-03 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu510 1.000000e-03 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu555 2.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu683 2.000000e-04 p970313a.lcd outqp970313a.lcd bbopangq 1Tilt 1Roll 10 2 inqp970313a.lcd outqp970313a.lcd bbopdespike -d 1temp 0.05 10 indqp970313a.lcd outdqp970313a.lcd bbopdespike -d d-1temp 0.05 10 indqp970313a.lcd outdqp970313a.lcd bbopmovavg -f d-d-1temp 5.0 dqp970313a.lcd mdqp970313a.lcd bbopbin -b 0.5 mdqp970313a.lcd bbopkc -s 1ed380 5 inkbmdqp970313a.lcd.1 outkbmdqp970313a.lcd.1 bbopkc -s led412 5 inkbmdqp970313a.lcd.1 outkbmdqp970313a.lcd.1 bbopkc -s led443 5 inkbmdqp970313a.lcd.1 outkbmdqp970313a.lcd.1 bbopkc -s 1ed490 5 inkbmdqp970313a.lcd.1 outkbmdqp970313a.lcd.1 bbopkc -s led510 5 inkbmdqp970313a.lcd.1 outkbmdqp970313a.lcd.1

VIII. Appendix B - Calibration Certificates

The following pages contain the calibration history of the PRR600 instrument.

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	~										
B	ios	pheric	al Instru	iments In	iC.				Bioch	harical water	TRUT
CA		BRATIO	N CERTIFIC	CATE for PF	RR Spectro	radiometer				AURPA CON	DATA
			Calib	nation Datas	1/22/08		Form	7/11/06	``````````````````````````````````````	ALIDRATION	UAIA
				fation Date.	DDV 6005	-	Fonn.	//11/90			
			Mod	iel Number:	PRV-0005	-					
			Ser		9043	-					
			0 4.5.5	Operator:							
			Stan	dard Lamp:	91/11 (05/	30/95)					
					Calibration	Calibration	Calibration	Calibration			
			Lamp	Immersion	Voltage -	Voltage -	Factor - Dry	Factor - Wet			
Ch	Tag	<u> </u>	Irradiance	Coefficient	Dark"	Light	(V/µW)	(V/µW)	Max E (Dry)		
-		DOWNWI	1 207	DIANCE CHANF	0.000132	United ance Un	0.013074	$n_{\rm E} = 1 rradian$	764.9	<u></u>	
1	0	300 412	1.397	0.677	0.000132	-0.018129	-0.013074	-0.008773	308.9		
3	ő	443	3 701	0.682	0.000113	-0.120950	-0.032714	-0.022313	305.7		
4	0	490	6,159	0.690	0.000302	-0.209334	-0.034039	-0.023491	293.8		
5	0	510	7.302	0.694	0.000168	-0.240489	-0.032957	-0.022859	303.4		
6	0	555	10.041	0.701	0.000465	-0.332822	-0.033194	-0.023279	301.3		
7	0	PAR4)	0.0142	0.686	0.000330	-0.194557	-13.767821	-9.442522	0.726	4)	
8	0	Gnd.3)	0.000291	Volts							
			Ca	libration Factor:	WET = ((Light	- Dark) x Imme	ers. Coeff.)/Lam	ip Output			
					DRY = (Light -	Dark)/Lamp O	utput	Calibratian			
			Lamp		Blanks			Voltage -	Calibration	Calibration Easter Wet	
~ ħ	Tan) (pm)	fil cm	Coefficient	Reflectivity	Radiance ^{®)}	Voltage - Dark	Blocked ³⁾	Vollage -		Max I (We
<u>Cii</u>	Tay		NG RADIANCI	E CHANNELS	Renectivity	Radiance Uni	ts: uW/cm²·nm	sr. L = Radiar		(0) (0)	11147 6 (1116
1	1	380	1.397	1.765	0.985	0.012	0.000221	0.000214	-0.003021	-0.150639	66.4
2	1	412	2.411	1.758	0.985	0.021	-0.000068	-0.000079	-0.018727	-0.505131	19.8
3	1	443	3.701	1.752	0.985	0.032	0.000233	0.000215	-0.050659	-0.900887	11.1
4	1	490	6.159	1.745	0.984	0.054	0.000180	0.000150	-0.092345	-0.988998	10.1
5	1	510	7.302	1.743	0.984	0.064	0.000363	0.000337	-0.136471	-1.235454	8.1
6	1	555	10.041	1.738	0. 9 84	0.087	0.000180	0.000128	-0.263356	-1.734900	5.8
7	1	683	16.897	1.730	0.984	0.147	0.000095	-0.000003	-0.394184	-1.550051	6.5
8	1	Gnd."	0.000190	Volts	()			ata a Eastari		· · · · · · ·	
			l amo Die	Ury Radiance =	(Camp Output : (50 cm) ² /(300 c	k Plaque Kellec			π		
			Cal	ibration Factor:	WET = (Light -	· Dark)/(Drv Ra	diance x Immer	sion Coefficient)		
8	0	TEMPERA	ATURE		Temperature	(°C) = (Voltage	- Offset)/Scal	4	<u>. </u>		
		Scale		[0.1419						
		Offset			0.0801						
10	0	PRESSUR	RE/DEPTH ^{II}		Pressure/Dep	th (dbars or m	eters) = (a x V	oltage ²) + (b x	Voltage) + c		
		Scale Fac	tor "a"	ļ	0.9374						
		Scale Fac	tor "b"	•	83.8842						
		UTSEL "C"	TOACTUAL	VOI TAGE CON	26.9636	CTOPE /Far				Λ	
		NOMINAL	TOACTORE		Rad Array	CTORS (FOR U	PG MILL GYIGLU	al sensors, on	iy, see manua	•)	
		Scale Fact	tor [1.057679	1 074227						
		Offset		0.000205	0.000278						
		Full Scale	Voltage	9,4547	9.3090						
				_							
		FIRMWAR	E VERSIONS	Tag 0	Tag 1						
		Underwate		129 V	20434						
		Notes:									
		1. Annual c	alibration is rec	commended.		••					
		2. Calibratic	ons were perfor	med at approxin	natery 20 to 30	"U.	of the 14 - 4		فيتعاربه والمسارية		
		o) Uanc in	Tagiance and "l	DIOCKOU FACIANO	a the calibrati-	NOCKING	or the calibratio	n source, Thes	e values shouk		
		the loof a	ument will he m	notinų vaiuce kil Rodina		i Hra. Usel (De) (utally Gark Sens		iou al the temp		
		4) PAR im-	diance unite se	e uFinsteine/cm	² .sac.						
		5) Nominal	/Tvoical value/s	⇒µ⊏nieroniero()) I).							
		6) For conv	ersion of area t	o solid angle. a	factor (divisor)	of Plisincomo	rated.				
		7) Water te	mperature sen	BOF.							
				-							

DO NOT DESTROY Biospherical instruments inc. CALIBRATION DATA ----

Biospherical Instruments Inc. CALIBRATION CERTIFICATE for PRR Spectroradiometer

Calibration Date: 1/23/96 Model Number: PRV-600S Serial Number: 9643 Operator: JCE/LFG

Form: _______7/11/96

OPTIONAL CHANNELS

Ch	Tag

٥	Transmissometer ¹⁾		
	II GIIGIINSEVI(15191	Output = (V	oltage - Offset)/Scale
	Scale Factor	1.0	Volts/Volt
	Offset	0.0	Volts
0	Scalar PAR: QSP-200 S/N 4443	quanta/(cm ²	sec) = (Voltage - Offset//Scale
	Scale Factor (Wet)	-1.161E-17	Volts/(guanta/cm ² ·sec)
	Offset	0.0009	Voits
0	AXIS 1 ANGLE SENSOR - "TILT"	Degrees = (\	/oftage - Offset//Scale
	Scale Factor	0.0418	
	Offset	2.6862	
0	AXIS 2 ANGLE SENSOR - "ROLL"	Degrees = (V	/oltage - Offset//Scale
	Scale Factor	0.0416	
	Offset	2.6973	
0	Light Scattering Sensor ¹⁾	Output = (Vo	Itage - Offset//Scale
	Scale Factor	1.0	Volts/Volt
	Offset	0.0	Volts
0	Fluorometer ¹⁾	Output = (Vo	Itage - Offset/Scale
	Scale Factor	1.0	Voltevolt
	Offset	0.0	Volts
	0	0 Scalar PAR: QSP-200 S/N 4443 Scale Factor (Wet) Offset 0 AXIS 1 ANGLE SENSOR - "TILT" Scale Factor Offset 0 AXIS 2 ANGLE SENSOR - "ROLL" Scale Factor Offset 0 Light Scattering Sensor ¹¹ Scale Factor Offset 0 Fluorometer ¹¹ Scale Factor Offset	Offset 0.0 0 Scalar PAR: QSP-200 S/N 4443 quanta/(cm² Scale Factor (Wet) -1.161E-17 Offset 0.0009 0 AXIS 1 ANGLE SENSOR - "TILT" Degrees = (N Scale Factor 0.0418 Offset 2.6862 0 AXIS 2 ANGLE SENSOR - "ROLL" Degrees = (N Scale Factor 0.0416 Offset 2.6973 0 Light Scattering Sensor ¹¹ Output = (Vold Scale Factor 0 Fluorometer ¹¹ Output = (Vold Scale Factor 0 Fluorometer ¹¹ Output = (Vold Scale Factor 0 Fluorometer ¹⁰ Output = (Vold Scale Factor 0 Offset 0.0

Notes:

1) These sensors are not calibrated at BSI. When applicable, see the manufacturers' specifications.

/ B	ios	pherio	al Instru	iments In	IC.				<u> </u>		
E/			FORM for	PRR Spect	roradiome	er					
							_				
			Calib	ration Date:	3/26/96	-	Form:	7/11/96			
			Mod	lel Number:	PRV-600S	-					
			Ser	ial Number:	9643	-					
				Operator	- JCE/LFG						
			Stan	dard Lamp:	94531 (10/	11/95) for In	radiance, 94	532 (10/11/9	5) for Radi	ance.	•
					Calibration	Calibration	Calibration	Calibration			
			Lamp	Immersion	Voltage -	Voltage -	Factor - Dry	Factor - Wet			
Ch	Tag	<u>λ (nm)</u>	Irradiance	Coefficient	Dark ³⁾	Light	(V/µW)	(V/µW)	Max E (Dry)		
		DOWNW	ELLING IRRAD	DIANCE CHAN	NELS	Irradiance Un	its: µW/cm⁴·nr	n, E = Irradiano	:e		
1	0	380	1.486	0.671	0.000160	-0.019050	-0.012927	-0.008677	773.6		
2	0	412	2,559	0.677	0.000095	-0.081553	-0.031907	-0.021592	313.4		
3	0	490	3.500	0.662	0.000110	-0.126520	-0.032421	-0.022113	206.5		
-	0	510	7 683	0.694	0.000108	-0.210429	-0.000702	-0.023200	306.7		
0 2	л Л	555	10.536	0 701	0.000459	-0.200415	-0.032809	-0.022017	304.8		
7	ň	PAR ⁴⁾	0.0152	0.686	0.000337	-0 200664	-13 196577	-9.050741	0.758	4)	
2	<u> </u>	God ³⁾	0.000309	Volts		0.200004	-10,130077	-3.000747			
<u> </u>			Ca	libration Factor:	WET = ((Light	- Dark) x Imme	rs. Coeff VLam	p Output		<u> </u>	
			-		DRY = (Light -	Dark)/Lamp O	utput	F F			
			Lamp		`		Calibration	Calibration	Calibration	Calibration	
			Irradiance @	Immersion	Plaque		Voltage -	Voltage -	Voltage -	Factor - Wet	
Ch	Tag	λ (nm)	60 cm	Coefficient	Reflectivity	Radiance	Dark	Blocked ³⁾	Light	<u>(V/µW)</u>	Max L (We
		UPWELL	ING RADIANCI	E CHANNELS		Radiance Uni	ts: µW/cm²•nm	•sr, L = Radian	ce		
1	1	380	1.308	1.765	0.985	0.011	0.000133	0.000133	-0.002922	-0.151959	65.8
2	1	412	2.275	1.758	0.985	0.020	0.000209	0.000202	-0.017559	-0.509911	19.6
3	1	443	3.514	1.752	0.965	0.031	0.000192	0.000188	-0.048676	-0.911268	11.0
4	1	490	5.911	1.745	0.964	0.051	0.000122	0.000108	-0.090184	-1.005825	9.9
5		510	7.038	1./43	0.964	0.061	0.000272	0.000261	-0.133038	-1.248987	8.0
9 7	1	683	9.740	1.730	0.304	0.065	0.000124	0.000057	-0.250077	-1,755312	5./ 8.4
/ R	1	God 37	0.000124	Volts	0.504	0.140	0.00027		-0.332210	-1.303109	0.4
<u> </u>	····			Dry Radiance =	(Lamp Output)	x Plaque Reflec	tivity x Lamp Di	stance FactorVa			
			Lamp Dis	stance Factor =	(50 cm) ² /(300 cm)	cm) ²			-		
			Cal	ibration Factor:	WET = (Light -	Dark)/(Dry Ra	diance x Immer	sion Coefficient)			
9	0	TEMPER	ATURE7. 1		Temperature	(*C) = (Voltage	- Offset)/Scal	8	······		
	:	Scale			0.1419						
		Offset			0.0801						
10	0 1	PRESSU	RE/DEPTH "		Pressure/Dep	th (dbars or m	eters) = (a x V	oltage ²) + (b x \	/oltage) + c		
		Scale Fac	tor "a"		0.9374						
		Scale Fac	tor "b"	ļ	83.8842						
		Offset "c"			26.9635						
		NOMINAL	TO ACTUAL		IVERSION FAI	CTORS" (For	use with exteri	nai sensors, on	ily, see manu	al)	
		Seele Eee		IFT. AITAY	Rad. Array						
	ì	Scale Fac	lor	1.00/6/9	1.0/422/						
		JIISEL Sull Soole	Valtara	0.000208	0.000278						
	r	UN SCAR		0.4047	0.3030						
	F	FIRMWAF	VERSIONS								
			-	Tag 0	Tag 1						
	ι	Inderwat	er ROM	2766B	2043A						
	N 1 2 3	Notes: , Annual (2. Calibrati 3) "Dark" in as the "(calibration is rec ons were perfor radiance and "E Offset" when en	commended. med at approximations Blocked" radiance tering values int	nately 20 to 30 se values repres	*C. sent a blocking n file. Use the to	of the calibratio ptally dark sens	n source. These or values obtaine	values shouk	f not be used erature where	
		the instr	ument will be us	ied.							
	4) PAR im	diance units an	e µEinsteins/cm	^{4.} sec.						
	5	i) Nominai	/Typical value(s		factor (d. 2 1						
	7) FOF COM) Water H	rension of area t	o solici angle, a kor	ractor (divisor)	or PI is incorpo	rated.				
	8) A chance	e in depth of 1	meter in seawat	er corresponds	to approximate	lv a 1 dbar char	oe in pressure			
	9) These c	hannels/sensor	s were not evalu	ated during this	s service period	.,				

Biospherical Instruments Inc. CALIBRATION CERTIFICATE for PRR Spectroradiometer

Calibration Date: 3/26/96 Model Number: PRV-600S Serial Number: 9643 Operator: JCE/LFG

Form: 7/11/96

OPTIONAL CHANNELS

Tag		_	
0	Transmissometer ¹⁾	Output = (Vo	Itage - Offset)/Scale
	Scale Factor	1.0	Volts/Volt
	Offset	0.0	Volts
0	Scalar PAR: QSP-200 S/N 4443 ²⁾	quanta/(cm ²	sec) = (Voltage - Offset)/Scale
	Scale Factor (Wet)	-1.161E-17	Volts/(quanta/cm ² ·sec)
	Offset	0.0009	Volts
0	AXIS 1 ANGLE SENSOR - "TILT"	Degrees = (V	oltage - Offset//Scale
	Scale Factor	0.0418	
	Offset	2.6862	
0	AXIS 2 ANGLE SENSOR - "ROLL"2	Degrees = (V	oitage - Offset)/Scale
	Scale Factor	0.0415	
	Offset	2.6973	
0	Light Scattering Sensor ¹⁾	Output = (Vo	tage - Offset)/Scale
	Scale Factor	1.0	Volts/Volt
	Offset	0.0	Volts
0	Fluorometer ¹⁾	Output = (Vo	tage - Offset//Scale
	Scale Factor	1.0	Volts/Volt
	Offset	0.0	Volts
	0 0 0 0	Tag 0 Transmissometer ¹¹ Scale Factor Offset 0 Scalar PAR: QSP-200 S/N 4443 ²⁰ Scale Factor (Wet) Offset 0 AXIS 1 ANGLE SENSOR - "TILT" ²⁰ Scale Factor Offset 0 AXIS 1 ANGLE SENSOR - "TILT" ²⁰ Scale Factor Offset 0 AXIS 2 ANGLE SENSOR - "ROLL" ²⁰ Scale Factor Offset 0 Light Scattering Sensor ¹¹ Scale Factor Offset 0 Fluorometer ¹¹ Scale Factor Offset 0 Fluorometer ¹¹ Scale Factor Offset	TagOutput = (Volume Scale Factor0Transmissometer ¹¹ Output = (Volume 1.00Scale Factor1.00Scalar PAR: QSP-200 S/N 4443 ²¹ quanta/(cm ² .Scale Factor (Wet)-1.181E-17Offset0.00090AXIS 1 ANGLE SENSOR - "TILT" ²¹ Degrees = (VScale Factor0.0418Offset2.68620AXIS 2 ANGLE SENSOR - "ROLL" ²¹ Degrees = (VScale Factor0.0416Offset2.69730Light Scattering Sensor ¹¹ Output = (VolScale Factor1.0Offset0.00Fluorometer ¹¹ Output = (VolScale Factor1.000ffset0.0

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Notes:

1) These sensors are not calibrated at BSI. When applicable, see the manufacturers' specifications.

2) These channels/sensors were not evaluated during this service period.

B C/	ios	pherio Bratio	cal Instru	ments In ATE for Pf	IC. RR Spectro	radiometer			D	O NOT DE	STROY
Calibration Date: 2/10/97 Form: 2/18/97						Biosp	herical Inst-	uments I <mark>nc.</mark> L DATA			
			Mod	el Number:	PRV-600S				· NVI		
			Seri	al Number: Operator:	9643	-					
			Stand	dard Lamp:	94531 (01/	02/97) for Ir	radiance 94	4532 (10/11/	95) for Rad	iance.	
					Calibration						· · · · · · · · · · · · · · · · · · ·
			Lamo	Immersion	Voltage -	Calibration	Eactor - Dry	Calibration Factor - Wet			
Ch	Тас	j λ (nm)	Irradiance	Coefficient	Dark ³⁾	Light	(V/µW)	(V/µW)	Max E (Dry)		
		DOWNW	ELLING IRRAD	IANCE CHANI	NELS	Irradiance Un	its: µW/cm²·nr	n, E = Irradian	ce		
1	0	380	1.578	0.671	0.000146	-0.019400	-0.012390	-0.008317	807.1		
2	0	412	2.595	0.677	0.000551	-0.081300	-0.031541	-0.021345	317.0		
3	0	443	4.003	0.682	0.000189	-0.128186	-0.032071	-0.021874	311.8		
	0	490	7 880	0.690	0.000282	-0.221056	-0.033297	-0.022960	310.8		
R	0	555	10,730	0 701	0.000480	-0.348378	-0.032511	-0.022313	307.6		
7	0	PAR ⁴⁾	0.0154	0.686	0.000371	-0.202865	-13.204159	-9.055940	0.757	4)	
8	0	Gnd. ⁵⁾	0.000318	Volts							
			Cali	ibration Factor:	WET = ((Light	- Dark) x Imme	ers. Coeff.)/Lam	p Output			
 					DRY = (Light -	Dark)/Lamp O	utput	Calibration		0	
			Lamp	Immoreion	Plaque		Calibration	Voltage -	Voltage	Calibration Eactor - Wet	
Сћ	Тао	λ (pm)	50 cm	Coefficient	Reflectivity	Radiance ⁶⁾	Dark	Blocked ³⁾	Light		Max L (Wet)
		UPWELL	ING RADIANCE	CHANNELS		Radiance Unit	ts: µW/cm²·nm	-sr, L = Radiar	nce		
1	1	380	1.308	1.765	0.988	0.011	0.000198	0.000206	-0.002858	-0.151929	65.8
2	1	412	2.275	1.758	0.989	0.020	-0.000103	-0.000098	-0.017526	-0.498479	20.1
3	1	443	3.514	1.752	0.990	0.031	0.000203	0.000203	-0.048370	-0.901210	11.1
4	1	490	5.911	1.745	0.990	0.052	0.000160	0.000151	-0.089873	-0.996381	10.0
5	1	510	7.038	1.743	0.990	0.062	0.000330	0.000321	-0.133200	-1.243485	8.0
3	1	555	9.746	1.738	0.991	0.085	0.000162	0.000123	-0.259162	-1.74/331	5.7
	$\frac{1}{1}$	Gnd ⁵⁾	0.000179	1.730 Volts	0.990	0.147	0.000105	0.00025	-0.303500	-1.321104	0.0
F	· ·		0.000170	ry Radiance =	(Lamp Output :	x Plaque Reflec	tivity x Lamp D	istance Factor)/	π		
			Lamp Dis Cali	tance Factor =	$(50 \text{ cm})^2/(300 \text{ cm})^2$	cm) ² - Dark)/(Drv Ra	diance x Immer	sion Coefficient)		
9	0	TEMPER	ATURE		Temperature	(*C) = (Voltage	- Offset)/Scal	e	,		
		Scale			0.1421		·				
		Offset			0.0889					· · · ·	
10	0	PRESSU	RE/DEPTH*	1	Pressure/Dep	th (dbars or m	eters) = (a x V	oltage ²) + (b x	Voltage) + c		
		Scale Fac	ctor "a"		0.9383						
		Offset "c'	and and a second s		26,9099						
		NOMINAL	TO ACTUAL V	OLTAGE CON	VERSION FA	CTORS ⁹⁾ (For	use with exter	nal sensors, o	nly, see manu	ai)	
				Irr. Array	Rad. Array	•					
		Scale Fac	tor	1.057679	1.074227						
		Offset		0.000205	0.000278						
		rull Scale	e voitage	y.4547	8.3090						
		FIRMWAI	RE VERSIONS								
				Tag 0	Tag 1						
		underwat		2/658	2043A						
		Notes:		emmende d							
		1. Annual 2. Calibrat	Galipration is reci ions were perfor	ummended. med at approvi	mately 20 to 30	•C.					
		3) "Dark" i	irradiance and "8	liocked" radian	ce values repre	sent a blocking	of the calibratio	on source. Thes	e values should	i not be used	
		as the "	Offset" when ent	tering values in	to the calibratio	n file. Use the t	otally dark sens	or values obtain	ed at the tempe	erature where	
		the insti 4) PAP im	rument will be us adiance unite are	ed. uFinetaine/ca	1 ² ·sec						
		5) Nomina	I/Typical value(s)	, ^в енасанатон)							
		6) For con	version of area to	, solid angle, a	factor (divisor)	of Pi is incorpo	rated.				
		7) Water to 8) A charac	emperature sens	iof. natar in econom	or correctored	to approvimete	lv a 1 dher ohe	nne in pressure			
		9) These of	channels/sensors	s were not evalu	uated during thi	s service period	ny er iu∪er ulle!].	i Ae ii hicsonie	•		

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Biospherical Instruments Inc. CALIBRATION CERTIFICATE for PRR Spectroradiometer

		Calibration Date Model Number Serial Number Operator	e: 2/10/97 r: PRV-600S r: 9643 r: TMM	Form: <u>2/18/97</u>
		OPTIONAL CHANNELS		
Ch	Ta	g		
11	0	Transmissometer ¹⁾	Output = (Vo	Itage - Offset//Scale
1		Scale Factor	1.0	Volts/Volt
		Offset	0.0	Volts
12	0	Scalar PAR: QSP-200 S/N 4443	quanta/(cm ² ·:	sec) = (Voltage - Offset)/Scale
		Scale Factor (Wet)	-1.020E-17	Volts/(quanta/cm ² ·sec)
		Offset	0.0009	Volts
13	0	AXIS 1 ANGLE SENSOR - "TILT"2)	Degrees = (V	oltage - Offset)/Scale
		Scale Factor	0.0418	
		Offset	2.6862	
14	0	AXIS 2 ANGLE SENSOR - "ROLL" ²⁾	Degrees = (Ve	oltage - Offset//Scale
		Scale Factor	0.0415	
		Offset	2.6973	
15	0	Light Scattering Sensor ¹⁾	Output = (Vol	tage - Offset/Scale
		Scale Factor	1.0	Volts/Volt
		Offset	0.0	Volts
16	0	Fluorometer ¹⁾	Output = (Vol	lage - Offset)/Scale
		Scale Factor	1.0	Volts/Volt
		Offset	0.0	Volts
		Notes: 1) These sensors are not calibrated at B	SI. When applic	able, see the manufacturers' specifications.

2) These channels/sensors were not evaluated during this service period.

Appendix B. Report for Cruise MAY97OB:Onslow Bay and Pamlico Sound.

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CSC Technical Report CSC/2-98/001

NOAA NMFS Cruise MAY970B: Onslow Bay and Pamlico Sound Cruise

Ajit Subramaniam REMSA, Inc. NOAA Science Center Room 711b 4700 Silver Hill Road, Stop 9910 Washington DC 20233-9910

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February 1998



UNITED STATES DEPARTMENT OF COMMERCE National Oceanic and Atmospheric Administration COASTAL SERVICES CENTER 2234 Hobson Avenue, Charleston, SC 29405-2413

Her: (HCML & A v) Creater: Adobe Hustrater((M) 3.0 CreationDate: (7/1/12) (7:41 AM)

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Abstract

The algorithms for the calculation of chlorophyll *a* concentrations in the coastal waters of the U.S. need to be verified for the Ocean Color and Temperature Sensor (OCTS) on board the Advanced Earth Observing Satellite (ADEOS). This requires precise optical measurements below the sea surface in coastal waters from which remote sensing reflectance, downwelling irradiance and upwelling radiance can be calculated. Scientists from the Southeast Fisheries Science Center at NOAA/National Marine Fisheries Service undertook two one-day cruises out of Beaufort, North Carolina. Five stations were occupied on May 5, 1997 in Onslow Bay and four stations were occupied on May 8, 1997 in Pamlico Sound respectively. *In-situ* measurements of temperature, spectral downwelling irradiance, and spectral upwelling radiance were made along with above surface spectral downwelling irradiance. Surface chlorophyll *a* concentration, phytoplankton pigment, and total suspended sediments were also measured.

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Acknowledgments

We thank Captains Doug Willis and the crew of the *R/V Onslow Bay* and the *R/V Chipman* respectively for assistance provided. A NOAA Coastal Ocean Program Grant to Dr. Tester and Dr. Rick Stumpf made this cruise possible.

I. Introduction

Monitoring the health of U.S. coastal waters is an important goal of the National Oceanic and Atmospheric Administration (NOAA). Satellite ocean color sensors are capable of providing regular synoptic water quality data for the U.S. coast. Scientists use various algorithms to derive products such as chlorophyll biomass from satellite data to study short and long term changes in water quality. However, these algorithms need to be evaluated and validated. Towards this purpose, scientists from the National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center undertook two one-day cruises in Onslow Bay and Pamlico Sound.

II. Objectives

The objectives of this cruise were to obtain sub-surface downwelling irradiance, upwelling radiance, chlorophyll pigment concentration and total suspended sediment solids concentration in coastal waters. The remote sensing reflectance calculated from these measurements were used to evaluate and validate the SeaWiFS OC2 algorithm.

III. Methods

A. Sampling Location

Five stations (Stations 5C-5G) were occupied on 5 May 1997, and four stations (Stations 8A-8G) were occupied on 8 May 1997 to make optical profile measurements in the water column (Figure 1). Surface samples were also acquired at this location for total suspended solids (TSS) concentration and for chlorophyll analysis by fluorometric and High-Pressure Liquid Chromatography (HPLC) techniques

B. Sampling Platform

The *R/V Onslow Bay*, belonging to the NOAA/National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center, was used on 5 May 1997. The *R/V Chipman*, also belonging to NOAA/NMFS, was used on 8 May 1997.

C. Sample Collection Methods Summary

A PRR600s was deployed off the starboard side of the vessel using a davit (Figure 2). The PRR600s measured *in-situ* spectral downwelling irradiance, spectral upwelling radiance, and temperature. Surface bucket samples were obtained for chlorophyll analysis.



Figure 1. Location of stations



PRR600s

Figure 2. Deployment of the PRR600s

	PRR File	name		P970505C	P970505D	P970505E	P970505F	P970505G	P970508A	P970508C	P970508E	P970508G
	TSS	VolFilt	(Iml)	2000	2000	2000	1500	1500	500	500	500	500
	Ap	VolFilt	(Iml)	1000	750	400	300	200	150	150	150	150
	HPLC	VolFilt	(Iml)	2000	1000	750	1000	1000	200	200	200	200
	ChIF	VolFilt	(ml)	1000	1000	500	300	200	100	100	100	100
	Air	Temperature	<u>(</u> 0)	20	19	19	19		20	20		20
	Total	Depth	í (II)	20	18	12	19		9	13	22	٢
	Time	. 1		14:00	15:20	16:20	17:15	18:40	12:40	13:20	13:40	14:10
	Longitude)		-76.068	-76.280	-76.462	-76.622	-76.650	-76.009	-76.084	-76.168	-76.251
1 locations	Latitude			34.278	34.305	34.378	34.446	34.552	35.247	35.197	35.166	35.083
Station	Station			2C		SE SE	5 H2	55	× 4	 22	8E	8G
Table 1.	Date	2		215/97	215/97	515/97	215/97	515/97	5/8/97	5/8/97	5/8/97	5/8/97

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D. Sampling Gear

The PRR600s (Serial No. 9643) is a spectroradiometer manufactured by Biospherical Instruments, Inc., which measures seven channels of downwelling irradiance, seven channels of upwelling radiance (Table 2), depth, tilt, roll, and temperature. A surface unit (PRR610 - Serial No. 9644) is used to measure seven matched channels of surface downwelling irradiance on deck. Channels 1 to 6 on all sensors and channel 7 on the radiance sensor are narrow band (10 nanometer [nm] Full Width at Half Maximum [FWHM]) centered at the indicated wavelengths, while channel 7 on the irradiance sensor is a broadband detector that measures Photosynthetically Available Radiation (PAR) between 400 and 700 nm (Table 2).

The irradiance and radiance sensors of the PRR600s are separate units, mounted such that the collectors are on the same horizontal plane. The instrument mount was attached to a tension release on a kevlar reinforced electrical cable. The PRR610 surface unit was strapped onto a radio antenna on the starboard side of the vessel, close to the davit used to lower the PRR600s (Figure 2).

Channel	PRR600s Downwelling	PRR600s Unwelling	PRR610
No.	Light Sensor	Light Sensor	110010
1	380 nm	380 nm	380 nm
2	412 nm	412 nm	412 nm
3	443 nm	443 nm	443 nm
4	490 nm	490 nm	490 nm
5	510 nm	510 nm	510 nm
6	555 nm	555 nm	555 nm
7	PAR	683 nm	PAR

Table 2.	Center	Wavelengths	for the	PRR	System
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E. Bottle Samples

The chlorophyll biomass was determined using a Turner Designs fluorométer (Parsons *et al.* 1984). The TSS concentration was measured as described by Parsons *et al.* (1984). Phytoplankton pigment concentrations were determined as described in Tester *et al.* (1995). Discrete surface water samples were obtained for these analyses using a bucket, at the same time as the PRR cast.

F. Optical Data Processing

The PRR data was processed using the Bermuda Bio-Optics Project (BBOP) processing software (Siegel *et al.* 1995). A least common denominator (LCD) file was created from the binary data files, the cast card files, the calibration files, and cruise notes. The LCD file header contains the metadata for the cast and includes information on the parameters sampled, parameters derived, filters used, and the statistical results of the regression used to extrapolate to the sub-surface. An example header is presented in Appendix A. The

pressure channel data was recalculated using an offset to adjust for the distance of the pressure sensor from the cosine collector. The tops and bottoms of the individual profiles were marked using an interactive Matlab[®] script and the corresponding record numbers were inserted into the LCD header section. Data less than the dark threshold was replaced by -9.9x10³⁵. Then the data was quality controlled using flags for data with tilt and roll angles greater than 10°, and records in which the surface incident irradiance was not uniform. The temperature channel was despiked, in two passes with a difference threshold. A moving average was calculated for the temperature channel. The data were separated into upcast and downcast profiles and then binned to 0.5-m bins. Subsurface downwelling irradiance and upwelling radiance were extrapolated to just below the surface, and spectral attenuation coefficients were calculated for the optical channels over a 5 point moving window.

Results IV.

Bottle Samples Α.

The analyses of the bottle samples showed that the total suspended sediment concentrations were very high, especially inside Pamlico Sound. The chlorophyll concentrations were low in contrast, indicating that the optical properties of these waters may be dominated by sediments.

Table 3. Pigment Analyses											
Date	Station	Latitude	Longitude	TSS	Chl	Fuco	19'-hex	Didino	Zea	chl – a	beta-car
Duit	0.0000000		U	mg/L	µg/l	μg/l	µg/l	µg/l	μg/1	µg/l	µg/l
5/5/97	5C	34.278	-76.068	3.75	0.229	0.038	0.013	0.016	0.012	0.138	0.000
5/5/97	5D	34.305	-76.280	5.75	0.256	0.040	0.006	0.036	0.017	0.151	0.0116
5/5/97	5E	34.378	-76.462	6.25	0.499	0.133	0.006	0.053	0.000	0.259	0.000
5/5/97	5F	34.446	-76.622	8.00	0.269	0.051	0.017	0.035	0.020	0.145	0.000
5/5/97	5G	34.552	-76.650	13.67	0.433	0.109	0.000	0.060	0.020	0.249	0.000
5/8/97	8A	35.247	-76.009	18	4.538	0.406	0.000	0.235	0.253	2.612	0.172
5/8/97	8C	35.197	-76.084	18	3.673	0.372	0.000	0.216	0.327	1.990	0.169
5/8/97	8E	35.166	-76.168	14	3.592	0.381	0.000	0.156	0.403	1.803	0.157
5/8/97	8G	35.083	-76.251	9 ·	4.302	0.449	0.000	0.222	0.445	2.115	0.184

Optical data B.

The optical data were collected in rather shallow waters (Table 1) and the profiles themselves never extended below 18m, often shallower than 10 m. The profiles of downwelling irradiance, upwelling radiance, and PAR are shown in Appendix A (Figures A.1.a – A.18.a). Figures \overline{A} .1.b – \overline{A} .18.b show the tilt and roll of the PRR600 and when calculable, the spectral diffuse attenuation. Comments on the quality of the profile and the depth of measurement nearest to the surface are shown in Table 4. The above surface downwelling irradiance (Es) should be constant during a profile if there was no change in the light field due to passing clouds etc. This was tested by calculating the coefficient of variation (standard deviation/mean) for Es and is shown in Table 4. The large change in Es at stations 5D and 5F appear to be due to a shadow on sensor rather than due to clouds. The relatively large Es at station 5G seems to be due to the very low sun angle at 6:40 PM when the measurements were made. Tilt or roll of greater than 10° do not allow for the robust measurement of downwelling irradiance or upwelling radianace. Profiles 5C1, 5D2, 5E1, 5G2, and 8G2 were not used for algorithm evaluation because they were contaminated by factors such as large tilts or rolls, ship shadow contamination, etc.

Table 4. Su	mmary of Opt	ical Profiles	5
Profile	Depth of Firs Measurement	Max. C.V Of Es	Comments
P970505C1	1.65	0.8%	K changes at 4 m, Ed increases with depth
P970505C2	0.92	2.1%	Uniform, good cast
P970505D1	1.24	38.9%	Underwater cast good, shadow over surface sensor
P970505D2	0.74	45.0%	Underwater cast good, shadow over surface sensor
P970505E1	2.83	2.2%	Mostly uniform cast, discard top 3.8 m
P970505E2	0.87	5.8%	Uniform, good cast
P970505F1	2.29	43.0%	Underwater cast good, large change in surface sensor
P970505F2	0.78	2.0%	Uniform, good cast
P970505G1	1.27	8.3%	Uniform, good cast. Low sun angle
P970505G2	0.54	10.0%	Large increase in Ed, Lu near surface. Tilt and Roll > 15°
P970508A1	0.91	1.4%	Uniform cast, shallow
P970508A2	0.64	0.5%	Uniform cast, shallow
P970508C1	0.92	0.9%	Very shallow cast. 0.8-1.7m only
P970508C2	0.81	0.6%	Very shallow cast. 0.8-2.3m only
P970508E1	0.98	0.9%	Uniform cast for wavelengths > 443 nm
P970508E2	0.51	0.1%	Uniform cast for wavelengths > 443 nm
P970508G1	0.80	0.2%	Uniform, good cast
P970508G2	0.58	1.2%	Uniform, good cast large Roll near surface

Algorithm Evaluation

The downwelling irradiance and upwelling radiance were extrapolated to the null depth just below the surface (E_0 -) by the BBOP software. The downwelling irradiance was propagated through the water-air interface using a transmission loss of 4% (SeaBAM

Tech memo). The upwelling radiance was propagated through water-air interface using a factor of 0.544 (SeaBAM Tech memo). The above water (E_0 +) downwelling irradiance and upwelling radiance are shown in Table 5 (Ed+(λ) and Lu+(λ) respectively). The above water downwelling irradiance measured by the reference sensor mounted on the ship are also shown (Es λ) along with the coefficient of variation of this measurement (Es λ Err). The difference between the measured downwelling irradiance (Es) and the calculated downwelling irradiance (Ed+) was calculated and shown in Table 5 (ds λ). The remote sensing reflectance (Rrs λ) was calculated using either Es or Ed+, which ever was more appropriate. The SeaWiFS OC2 algorithm (SeaBAM Tech memo) was then used to calculate the satellite estimates of chlorophyll a and CZCS pigment. The ratios of satellite derived to measured quantities for chlorophyll a and CZCS pigment are also shown in Table 5.

Station	50	5D	5E	5F	5F	5G
Date	5/5/97	5/5/97	5/5/97	5/5/97	5/5/97	5/5/97
Date Time GMT	18.00	19.15	20:15	22:10	22:10	23:40
I atitude	34 278	34,305	34.378	34,446	34.446	34.552
Langitude	-76 068	-76.280	-76.462	-76.622	-76.622	-76.650
TSS mg/L	3.75	5.75	6.25	8.00	8.00	13.67
ChiFug/l	0 229	0.256	0.499	0.269	0.269	0.433
Chia HPI C	0.138	0.151	0.259	0.145	0.145	0.249
	71 2525	57.9345	55.8263	38.6623	32.2810	9.6688
Ed+300	153 0960	89.7019	92.7574	74.6242	55.7885	18.0764
Ed+412 Ed+412	164 0670	104.7570	113.7230	105.5370	67.8250	23.5997
Ed+449	139 4370	128.5790	140.8620	130.8590	76.3379	26.9401
Ed+510	153.6910	169.2120	138.1630	129.8870	76.5869	26.8790
Ed+510	162.0340	122.3720	121.1700	131.8190	77.4048	26.0929
$L_{11} + 380$	0.8738	0.5479	0.2631	0.2785	0.2634	0.0639
L_{n+412}	1.2947	1.0677	0.5910	0.5690	0.5495	0.1576
L_{11+443}	1.4229	1.3529	0.8888	0.7674	0.7504	0.2365
Lu+490	1.3547	1.5615	1.3460	0.9808	0.9676	0.3525
$L_{u}+510$	0.9839	1.1747	1.2111	0.7811	0.7504	0.3173
Lu+555	0.5018	0.6169	0.8648	0.4509	0.4216	0.2264
Lu+683	0.0392	0.0398	0.0738	0.0400	0.0362	0.0270
Es380	83.0804	54.0220	52.4726	31.9462	39.4985	12.2564
Es412	128.1168	80.9772	82.2762	49.2976	64.1512	20.7618
Es443	150.2051	92.4450	96.9226	57.0165	76.7487	25.7060
Es490	161.1108	96.0821	105.0866	60.4339	84.7890	29.7159
Es510	162.8269	96.4733	106.8868	61.1946	86.7237	30.7507
Es555	159.0002	93.2918	105.5142	59.6442	86.5069	31.2249
Es380Err	1.6%	25.3%	4.0%	21.4%	1.4%	1.8%
Es412Err	1.8%	29.0%	4.5%	27.0%	1.6%	3.3%
Es443Err	1.9%	32.0%	4.9%	31.6%	1:8%	4.3%
Es490Err	2.0%	35.9%	5.6%	37.7%	1.9%	6.0%

Table 5 Algorithm Evaluation

Es55Err 2.1% 38.9% 5.8% 43.2% 2.0% 8.3% ds380 11% -11% 15% 18% ds412 -24% -117% 10% 9% ds443 -14% -22% 8% 5% ds490 10% -39% 6% 6% ds510 2% -34% 8% 9% ds555 -6% -19% 7% 13% Rrs490 0.0045 0.0088 0.0064 0.0026 0.0039 OC2-Chla 0.2204 0.2594 0.6679 0.3403 0.2858 0.6023 CZCS Pig 0.3044 0.3571 0.9022 0.4660 0.3926 0.8154 MeasPig 0.229 0.256 0.499 0.269 0.269 0.433 sat/meas 1.30 1.40 1.81 1.73 1.46 1.88 Station 8A 8C 8C 8 8 36.73 Jongitude <	Es510Err	2.0%	37.0%	5.8%	39.6%	1.9%	6.8%	
	Es555Err	2.1%	38.9%	5.8%	43.2%	2.0%	8.3%	
	ds380	11%	,	-11%		15%	18%	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	ds412	-24%	,	-17%		10%	9%	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	ds443	-14%	I	-22%		8%	5%	
	ds490	10%		-39%		6%	6%	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	ds510	2%		-34%		8%	9%	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	ds555	-6%		-19%		7%	13%	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Rrs490	0.0045	0.0088	0.0069	0.0088	0.0062	0.0064	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Rrs555	0.0017	0.0036	0.0044	0.0041	0.0026	0.0039	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	OC2-Chla	0.2204	0.2594	0.6679	0.3403	0.2858	0.6023	
MeasChla0.1380.1510.2590.1450.1450.249sat/meas1.601.712.582.341.962.42MeasPig0.2290.2560.4990.2690.2690.433sat/meas1.331.401.811.731.461.88Station8A8A8C8C8E8EBate5/8/975/8/975/8/975/8/975/8/975/8/97Time GMT17:4017:4018:2518:2518:4018:40Longitude35.24735.24735.19735.16635.16635.083Longitude-76.009-76.084-76.084-76.168-76.251155TSS mg/L18181814149ChlF ug/l4.5384.5383.6733.6733.5923.5924.302Chla HPLC2.6122.6121.9901.9901.8031.8032.115Ed+380329.60015.3218241.1810267.9270397.9440Ed+443318.4070300.8500141.9910234.1050269.8040245.0660439.0940Ed+450262.8080295.0300165.3600204.4010229.1140211.2920301.5530Ed+555257.6770247.4940157.9700169.5560189.4301178.1250231.9300Lu+3800.16380.86220.01980.22140.14961.4684Lu+4431.56811.78880.55171.	CZCS Pig	0.3044	0.3571	0.9022	0.4660	0.3926	0.8154	
sat/meas1.601.712.582.341.962.42MeasPig0.2290.2560.4990.2690.2690.433sat/meas1.331.401.811.731.461.88Station8A8A8C8C8E8EBate5/8/975/8/975/8/975/8/975/8/97Time GMT17:4017:4018:2518:2518:4018:40Latitude35.24735.24735.19735.19735.16635.166Longitude-76.009-76.009-76.084-76.168-76.168-76.251TSS mg/L1818181814149ChlF ug/l4.5384.5383.6733.6923.5924.302Chla HPLC2.6122.6121.9901.9901.8031.8032.115Ed+380329.660015.3218241.1810267.9270Ed+412388.4960347.961078.4023259.1750397.9440Ed+443318.4070300.8500141.9910234.1050269.8040245.0660Ed+450276.5950301.4110170.1470190.5200211.40211.2920301.530Ed+55257.6770247.4940157.9700169.5560189.4350178.1250231.9300Lu+4800.16380.86220.01980.22140.1496Lu+4902.30092.41931.41052.03792.43542.5752Lu+4831.	MeasChla	0.138	0.151	0.259	0.145	0.145	0.249	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	sat/meas	1.60	1.71	2.58	2.34	1.96	2.42	
sat/meas1.331.401.811.731.461.88Station8A8A8C8C8E8E8GDate $5/8/97$	MeasPig	0.229	0.256	0.499	0.269	0.269	0.433	
Station8A8A8C8C8C8C8E8GDate $5/8/97$ <td< td=""><td>sat/meas</td><td>1.33</td><td>1.40</td><td>1.81</td><td>1.73</td><td>1.46</td><td>1.88</td><td></td></td<>	sat/meas	1.33	1.40	1.81	1.73	1.46	1.88	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Station	8A	8A	8C	8C	8E	8E	8G
Time GMT17:4017:4018:2518:2518:4018:4119:10Latitude 35.247 35.247 35.197 35.197 35.166 35.166 35.083 Longitude -76.009 -76.009 -76.084 -76.084 -76.168 -76.168 -76.251 TSS mg/L1818181814149ChlF ug/l 4.538 4.538 3.673 3.592 3.592 4.302 Chla HPLC 2.612 2.612 1.990 1.990 1.803 1.803 2.115 Ed+380 329.6600 15.3218 241.1810 267.9270 Ed+412 388.4960 347.9610 78.4023 259.1750 397.9440 Ed+443 318.4070 300.8500 141.9910 234.1050 269.8040 245.0660 439.0940 Ed+450 262.8080 295.0300 165.3600 204.4010 229.1140 211.2920 301.5530 Ed+55 257.6770 247.4940 157.9700 169.5560 189.4350 178.1250 231.9300 Lu+380 0.1638 0.8622 0.0198 0.2214 0.1496 Lu+412 1.2028 1.5278 0.1863 0.7602 1.6684 Lu+443 1.5681 1.7888 0.5517 1.1440 1.1701 1.1627 Lu+450 2.6577 2.8237 1.4901 2.4530 2.3679 2.4354 2.5752 Lu+55 3.2769 3.5099 2.6968 3.2	Date	5/8/97	5/8/97	5/8/97	5/8/97	5/8/97	5/8/97	5/8/97
Latitude 35.247 35.197 35.197 35.197 35.166 35.063 Longitude -76.009 -76.009 -76.084 -76.084 -76.168 -76.168 -76.251 TSS mg/L18181814149ChIF ug/l 4.538 4.538 3.673 3.592 3.592 4.302 ChIa HPLC 2.612 2.612 1.990 1.990 1.803 1.803 2.115 Ed+380 329.6600 15.3218 241.1810 267.9270 Ed+412 388.4960 347.9610 78.4023 259.1750 397.9440 Ed+443 318.4070 300.8500 141.9910 234.1050 269.8040 245.0660 Ed+490 262.8080 295.0300 165.3600 204.4010 229.1140 211.2920 301.5530 Ed+55 257.6770 247.4940 157.9700 169.5560 189.4350 178.1250 231.9300 Lu+380 0.1638 0.8622 0.0198 0.2214 0.1496 Lu+412 1.2028 1.5278 0.1863 0.7602 1.0684 Lu+443 1.5681 1.7888 0.5517 1.1440 1.1701 1.1627 1.3659 2.3009 2.4993 2.4902 2.3079 2.4354 2.5752 Lu+453 1.3768 1.3513 0.9825 1.2106 1.2053 1.2251 1.3551 Es+380 75.3898 75.1179 80.9012 80.6914 79.3116 79.114	Time GMT	17:40	17:40	18:25	18:25	18:40	18:40	19:10
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Latitude	35.247	35.247	35.197	35.197	35.166	35.166	35.083
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Longitude	-76.009	-76.009	-76.084	-76.084	-76.168	-76.168	-76.251
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	TSS mg/L	18	18	18	18	14	14	9
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	ChlF ug/l	4.538	4.538	3.673	3.673	3.592	3.592	4.302
Ed+380 329.6600 15.3218 241.1810 267.9270 Ed+412 388.4960 347.9610 78.4023 259.1750 397.9440 Ed+443 318.4070 300.8500 141.9910 234.1050 269.8040 245.0660 439.0940 Ed+490 262.8080 295.0300 165.3600 204.4010 229.1140 211.2920 301.5530 Ed+510 276.5950 301.4110 170.1470 190.5200 217.2920 203.4000 267.6930 Ed+555 257.6770 247.4940 157.9700 169.5560 189.4350 178.1250 231.9300 Lu+380 0.1638 0.8622 0.0198 0.2214 0.1496 Lu+412 1.2028 1.5278 0.1863 0.7602 1.0684 Lu+443 1.5681 1.7888 0.5517 1.1440 1.1701 1.1627 Lu+490 2.3009 2.4193 1.4105 2.0313 1.9744 1.9848 2.2159 Lu+490 2.3009 2.4193 1.4105 2.0313 1.9744 1.9848 2.2159 Lu+510 2.6577 2.8237 1.4901 2.4530 2.3679 2.4354 2.5752 Lu+555 3.2769 3.5099 2.6968 3.2705 3.1114 3.1965 3.2732 Lu+683 1.3768 1.3513 0.9825 1.2106 1.2053 1.2251 1.3551 Es+380 75.3898 75.1179 80.9012 80.6914 79.3116 79.1145 7	Chla HPLC	2.612	2.612	1.990	1.990	1.803	1.803	2.115
Ed+412 388.4960 347.9610 78.4023 259.1750 397.9440 Ed+443 318.4070 300.8500 141.9910 234.1050 269.8040 245.0660 439.0940 Ed+490 262.8080 295.0300 165.3600 204.4010 229.1140 211.2920 301.5530 Ed+510 276.5950 301.4110 170.1470 190.5200 217.2920 203.4000 267.6930 Ed+555 257.6770 247.4940 157.9700 169.5560 189.4350 178.1250 231.9300 Lu+380 0.1638 0.8622 0.0198 0.2214 0.1496 Lu+412 1.2028 1.5278 0.1863 0.7602 1.0684 Lu+443 1.5681 1.7888 0.5517 1.1440 1.1701 1.1627 Lu+490 2.3009 2.4193 1.4105 2.0313 1.9744 1.9848 2.2159 Lu+490 2.3009 2.4193 1.4105 2.0313 1.9744 1.9848 2.2159 Lu+510 2.6577 2.8237 1.4901 2.4530 2.3679 2.4354 2.5752 Lu+555 3.2769 3.5099 2.6968 3.2705 3.1114 3.1965 3.2732 Lu+683 1.3768 1.3513 0.9825 1.2106 1.2053 1.2251 1.3551 Es+380 75.3898 75.1179 80.9012 80.6914 79.3116 79.1145 76.7443 Es+443 142.2725 146.4432 145.2907 1	Ed+380	329.6600		15.3218	241.1810			267.9270
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Ed+412	388.4960	347.9610	78.4023	259.1750			397.9440
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Ed+443	318.4070	300.8500	141.9910	234.1050	269.8040	245.0660	439.0940
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Ed+490	262.8080	295.0300	165.3600	204.4010	229.1140	211.2920	301.5530
Ed+555257.6770247.4940157.9700169.5560189.4350178.1250231.9300Lu+3800.16380.86220.01980.22140.1496Lu+4121.20281.52780.18630.76021.0684Lu+4431.56811.78880.55171.14401.17011.16271.3659Lu+4902.30092.41931.41052.03131.97441.98482.2159Lu+5102.65772.82371.49012.45302.36792.43542.5752Lu+5553.27693.50992.69683.27053.11143.19653.2732Lu+6831.37681.35130.98251.21061.20531.22511.3551Es+38075.389875.117980.901280.691479.311679.114576.7443Es+412119.1203121.7287123.9480123.5525121.2498120.8742117.6106Es+443142.2725146.4432145.2907144.7905141.5946141.1014137.6481Es+490155.3894159.9576154.5753153.9763150.7009150.2226146.2744Es+510158.4342162.5434155.3863154.7278151.9258151.5209146.7285Es+555156.0523160.7882151.6197150.9293148.6836148.3307143.3869Es380Err0.6%0.4%0.5%0.4%0.6%0.2%0.2%Es412Err0.8%0.4%0.6%0.5%0.7% <td>Ed+510</td> <td>276.5950</td> <td>301.4110</td> <td>170.1470</td> <td>190.5200</td> <td>217.2920</td> <td>203.4000</td> <td>267.6930</td>	Ed+510	276.5950	301.4110	170.1470	190.5200	217.2920	203.4000	267.6930
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Ed+555	257.6770	247.4940	157.9700	169.5560	189.4350	178.1250	231.9300
Lu+412 1.2028 1.5278 0.1863 0.7602 1.0684 Lu+443 1.5681 1.7888 0.5517 1.1440 1.1701 1.1627 1.3659 Lu+490 2.3009 2.4193 1.4105 2.0313 1.9744 1.9848 2.2159 Lu+510 2.6577 2.8237 1.4901 2.4530 2.3679 2.4354 2.5752 Lu+555 3.2769 3.5099 2.6968 3.2705 3.1114 3.1965 3.2732 Lu+683 1.3768 1.3513 0.9825 1.2106 1.2053 1.2251 1.3551 Es+380 75.3898 75.1179 80.9012 80.6914 79.3116 79.1145 76.7443 Es+412 119.1203 121.7287 123.9480 123.5525 121.2498 120.8742 117.6106 Es+443 142.2725 146.4432 145.2907 144.7905 141.5946 141.1014 137.6481 Es+490 155.3894 159.9576 154.5753 153.9763 150.7009 150.2226 146.2744 Es+510 158.4342 162.5434 155.3863 154.7278 151.9258 151.5209 146.7285 Es+55 156.0523 160.7882 151.6197 150.9293 148.6836 148.3307 143.3869 Es380Err 0.6% 0.4% 0.5% 0.4% 0.6% 0.2% 0.2% Es412Err 0.8% 0.4% 0.6% 0.5% 0.7% 0.1% 0.2% Es443Errr	Lu+380	0.1638	0.8622	0.0198	0.2214			0.1496
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Lu+412	1.2028	1.5278	0.1863	0.7602			1.0684
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Lu+443	1.5681	1.7888	0.5517	1.1440	1.1701	1.1627	1.3659
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Lu+490	2.3009	2.4193	1.4105	2.0313	1.9744	1.9848	2.2159
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Lu+510	2.6577	2.8237	1.4901	2.4530	2.3679	2.4354	2.5752
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Lu+555	3.2769	3.5099	2.6968	3.2705	3.1114	3.1965	3.2732
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Lu+683	1.3768	1.3513	0.9825	1.2106	1.2053	1.2251	1.3551
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Es+380	75.3898	75.1179	80.9012	80.6914	79.3116	79.1145	76,7443
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Es+412	119.1203	121.7287	123.9480	123.5525	121.2498	120.8742	117.6106
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Es+443	142.2725	146.4432	145.2907	144.7905	141.5946	141.1014	137.6481
Es+510158.4342162.5434155.3863154.7278151.9258151.5209146.7285Es+555156.0523160.7882151.6197150.9293148.6836148.3307143.3869Es380Err0.6%0.4%0.5%0.4%0.6%0.2%0.2%Es412Err0.8%0.4%0.6%0.5%0.7%0.1%0.2%Es443Err1.0%0.4%0.6%0.5%0.7%0.1%0.2%	Es+490	155.3894	159.9576	154.5753	153.9763	150.7009	150.2226	146.2744
Es+555156.0523160.7882151.6197150.9293148.6836148.3307143.3869Es380Err0.6%0.4%0.5%0.4%0.6%0.2%0.2%Es412Err0.8%0.4%0.6%0.5%0.7%0.1%0.2%Es443Err1.0%0.4%0.6%0.5%0.7%0.1%0.2%	Es+510	158.4342	162.5434	155.3863	154.7278	151.9258	151.5209	146.7285
Es380Err0.6%0.4%0.5%0.4%0.6%0.2%0.2%Es412Err0.8%0.4%0.6%0.5%0.7%0.1%0.2%Es443Err1.0%0.4%0.6%0.5%0.7%0.1%0.2%	Es+555	156.0523	160.7882	151.6197	150.9293	148.6836	148.3307	143,3869
Es412Err 0.8% 0.4% 0.6% 0.5% 0.7% 0.1% 0.2% Es443Err 1.0% 0.4% 0.6% 0.5% 0.7% 0.1% 0.2%	Es380Err	0.6%	0.4%	0.5%	0.4%	0.6%	0.2%	0.2%
Es443Err 1.0% 0.4% 0.6% 0.5% 0.7% 0.1% 0.2%	Es412Err	0.8%	0.4%	0.6%	0.5%	0.7%	0.1%	0.2%
	Es443Err	1.0%	0.4%	0.6%	0.5%	0.7%	0.1%	0.2%

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Es490Err	1.3%	0.5%	0.7%	0.6%	0.8%	0.1%	0.2%
Est 10Err	1.5%	0.5%	0.8%	0.6%	0.9%	0.1%	0.2%
Essibli	1.1%	0.5%	0.9%	0.6%	0.9%	0.1%	0.2%
F22222FU	-355%	010 /0	80%	-211%			-263%
ds/12	-239%	-197%	34%	-118%			-252%
de412	-133%	-114%	-2%	-68%	-98%	-81%	-232%
ds443	-76%	-92%	-11%	-38%	-58%	-46%	-114%
da510	-87%	-93%	-14%	-28%	-49%	-40%	-90%
de555	-72%	-60%	-8%	-17%	-33%	-25%	-68%
usjjj Dre400	0.0080	0.0082	0.0049	0.0071	0.0071	0.0071	0.0082
R18490	0.0000	0.0118	0.0096	0.0117	0.0113	0.0116	0.0123
VIS222	7 3411	7 8825	31.3484	13.7258	12.1142	13.2971	9.4240
CZCS Big	9 4 5 2 6	10 1353	39.2099	17.4539	15.4431	16.9194	12.0741
CZCS Fig	2 612	2 612	1.990	1.990	1.803	1.803	2.115
Measelina	2.012	3 02	15 75	6.90	6.72	7.37	4.46
sau/meas	1 538	1 538	3 673	3.673	3.592	3.592	4.302
Measrig	4.558	 2 22	10.67	4.75	4.30	4.71	2.81
sau/meas	2.00	2.23	10.07				

Summary

The waters of Onslow Bay and especially Pamlico Sound are sediment dominated and can be considered typical Case II waters. The OC2 algorithms over-estimate the chlorophyll and CZCS pigment concentrations by a factor of at least 1.5 and up to 15, showing that this algorithm has to be greatly refined to be applicable to shallow coastal sediment dominated waters.

V. References

Parsons, T. R., Y. Maita and C. M. Lalli (1984). A Manual For Chemical And Biological Methods For Seawater Analysis, Pergamon Press.

Siegel, D. A., M. C. O'Brien, J. C. Sorensen, D. A. Konnoff and E. Fields (1995). BBOP Data Processing and Sampling Procedures. Vol: 19, Institute for Computational Earth System Science, UC Santa Barbara, Santa Barbara, CA, 23 pp.

Smith, R. C., K. S. Baker and P. Dustan (1981). Fluorometric Techniques for the Measurement of Oceanic Chlorophyll in the Support of Remote Sensing. *SIO Ref.* 81-17, Visibility Laboratory, Scripps Institution of Oceanography, La Jolla, CA 92093, 14 pp.

Tester, P.A., M.E. Geesey, C. Guo. H.W. Paerl and D.F. Millie (1995) Evaluating phytoplankton dynamics in the Newport River estuary (North Carolina, USA) by HPLC-derived pigment profiles. *Mar. Ecol. Prog. Ser.* **124**:237-245.

VI. Metadata

The metadata, including point of contacts, parameters measured, and measurement methods for the cruise are given below.

A. Core Documentation

Identification_Information

Citation

Citation_Information

Originator: National Oceanic and Atmospheric Administration Coastal Services Center

Publication_Date: 1998

Title: NOAA NMFS Cruise MAY970B: Onslow Bay and Pamlico Sound Cruise Online Linkage: http://www.csc.noaa.gov/crs/cruises/may97ob/index.html

Description

Abstract: See Abstract, page iii

Purpose: See Objectives, page 1

Supplemental_Information: StartDate: 19970505 StopDate: 19970505 Preview: http://www.csc.noaa.gov/crs/cruises/SCROL.html

Time_Period_of_Content Time_Period_Information Single_Date/Time Calendar_Date: 1997 Currentness_Reference: Publication Date

Status

Progress: Complete Maintenance_and_Update_Frequency: Unknown

Spatial Domain

Bounding Coordinates: West Bounding Coordinate: -76.652 East Bounding Coordinate: -76.652 North Bounding Coordinate: 34.433 South Bounding Coordinate: 34.433

Keywords

Theme

Theme_Keyword_Thesaurus: None

Theme_Keyword: oceanography

Theme_Keyword: bio-optical

Theme_Keyword: turbidity

Theme_Keyword: blooms

Theme_Keyword: resuspension

Theme_Keyword: river plumes

Theme_Keyword: coastal water optics

Theme_Keyword: case II algorithms

Theme_Keyword: absorption

Theme_Keyword: attenuation

Theme_Keyword: in-situ optical profiling

Theme_Keyword: ocean color satellites

Theme_Keyword: coastal ocean algorithm development

Place

Place_Keyword_Thesaurus: None

Place_Keyword: Onslow Bay

Place_Keyword: Pamlico Sound

Place_Keyword: Beaufort, NC

Place_Keyword: South Atlantic Bight

Place_Keyword: United States

Time

Temporal_Keyword: Spring

Temporal_Keyword: May, 1997

Parameters measured

Parameter_Keyword: spectral downwelling irradiance

Parameter_Keyword: spectral upwelling radiance

Parameter_Keyword: temperature

Parameter_Keyword: total suspended solids

Parameter_Keyword: chlorophyll pigment

Parameter_Keyword: phytoplankton pigments

Point_of_Contact:

Contact_Information: Contact_Organization_Primary: Contact_Organization: NOAA Coastal Services Center Dr. A. Subramaniam Contact_Person: Contact_Address: Address_Type: mailing and physical NOAA Science Center, Room 711B Address: Address: E/RA3 4700 Silver Hill Road, Stop 9910 Address: Washington City: **District of Columbia** State: Postal_Code: 20233-9910

Country: USA Contact_Voice_Telephone: (800)789-2234 Contact_Electronic_Mail_Address: crs@csc.noaa.gov Hours_of_Service: 8 a.m.-5 p.m., M-F

B. Citation Information

Source Citation: Subramaniam, A., M.E. Culver, J.C. Brock, P.A. Tester, E. Haugen, and R.P. Stumpf. 1998. NOAA NMFS Cruise MAY97OB: Onslow Bay and Pamlico Sound Cruise. CSC Technical Report CSC/2-98/001. NOAA Coastal Services Center. Charleston, SC. Pp18.

Currentness: February 1998

Access Constraints: None

Use Constraints: This data was acquired for scientific research and is applicable for algorithm validation purposes. Knowledge of in-water optics is expected of users for interpretation of the data. Users of this data are required to provide appropriate attribution in the form of co-authorship for any publications that use this data, unless formal permission to do otherwise is granted by NOAA/CSC.

C. Data Quality

Process Description: See Methods, page 2

Spectroradiometer measurements: Spectral downwelling irradiance,
spectral upwelling radiance, temperatureInstrument:PRR600s, PRR610Operator:Ajit SubramaniamAddress:see point of contactManufacturer:Biospherical Instruments, Inc.Address:5340 Riley Street
San Diego, CA 92110-2621Phone:(619) 686.1888

Chlorophyll measurements:

Methods reference: Parsons, T. R., Y. Maita and C. M. Lalli (1984). A manual for chemical and biological methods for seawater analysis, Pergamon Press. Pp107-110.
Variations: Smith, R. C., K. S. Baker and P. Dustan (1981).
Fluorometric Techniques for the Measurement of Oceanic Chlorophyll in the Support of Remote Sensing. SIO Ref. 81-17, Visibility Laboratory, Scripps Institution of Oceanography, La Jolla, CA 92093, 14 pp. Analyst: Elin Haugen Address: National Marine Fisheries Service

Southeast Fisheries Science Center - Beaufort Laboratory 101 Pivers Island Road Beaufort, NC 28516-9722 Telephone: (919) 728.2747

Phytoplankton pigment measurements:

Methods reference: Tester, P.A., M.E. Geesey, C. Guo. H.W. Paerl and
D.F. Millie (1995) Evaluating phytoplankton dynamics in the Newport
River estuary (North Carolina, USA) by HPLC-derived pigment profiles.
Mar. Ecol. Prog. Ser. 124:237-245.
Analyst: Pat Tester
Address: National Marine Fisheries Service
Southeast Fisheries Science Center - Beaufort Laboratory
101 Pivers Island Road
Beaufort, NC 28516-9722Telephone:(919) 728.2747

Attribute Accuracy: See Appendix B

Spectroradiometer Calibration:

1 st Calibration:	1/24/96
2 nd Calibration:	3/26/96
3 rd Calibration:	2/10/97

Horizontal Positional Accuracy: 400 m

Entity and Attribute Overview Description: See Methods, page 2

D. Metadata Reference Information

Metadata Date:

Contact Organization: NOAA/Coastal Services Center

Contact Person: Lauren Parker

Full Address: see point of contact

The core documentation section is designed for the purposes of the Coastal Information Directory (CID). The metadata in this section is used in building the CID's database.

VII. Appendix A - Example Profile Header information

The following information is found as a header on all BBOP processed files. <cruise_info> filename p970313a date 03-13-1997 day_of_year 72 day_since_010192 1899 file_created 11:03:50 cruise station 1 position 76 39.137 34 25.975 longitude 76 39.137 latitude 34 25.975 sky_state clear operator_name ajit sun_position 2 cruise_id cope i sep96cop cruise session_started 11:04:02 session_stopped 11:07:29 depth_offset .32 cal_date_uw9643 021097 cal_date_sfc9644 021097 downcast_ended 11:07:25.738 337 upcast_ended 11:07:27.558 340 yoyo no closest_CTD_cast none sun_intensity bright cloud_type 30% clouds on horizon cloud_amt 30% (high clouds) wind_speed_and_dir 20 kts? north-northeast swell 5-6ft collection_software_version prrprof_002086c number_units 1 collection_cal_file 96439644.cfl;prr-600 #9643/9644 calibration file 2/10/96 cac lcd_calib_file 0 /csc/nep1/coors/bbops/BUILD/calib/unit0_021097.cfl 1 /csc/nep1/coors/bbops/BUILD/calib/unit1_021097.cfl 2 /csc/nep1/coors/bbops/BUILD/calib/unit2_021097.cfl lcdfile_created Mar 19 1997 16:59:38 castid index lprr_record 1depth p970313a.dt1 9.900000e+01 9.900000e+01 1.9616880e+00 p970313a.db1 1.790000e+02 1.790000e+02 1.4350000e+01 p970313a.ub1 2.290000e+02 2.290000e+02 1.4603000e+01p970313a.ut1 3.290000e+02 3.290000e+02 8.3759400e-02 <sampled_parameters>
1prr_record 110 1ed380 0 -0.008317 0.000146 1ed412 0 -0.021345 0.000551 1ed443 0 -0.021874 0.000189 1ed490 0 -0.02298 0.000282 1ed510 0 -0.022313 0.000171 1ed555 0 -0.022801 0.00048 1par 0 -9.05594 0.000371 1edgnd 0 1 0 1temp 0 0.1421 0.0889 0. 9.38300e-01 8.31773e+01 2.65899e+01 0.9383 83.1773 26.9099 0 1depth 0 1tilt 0 0.04178 2.68617 1roll 0 0.041514 2.69727 2lu380 0 -0.151929 0.000198 2lu412 0 -0.498479 -0.000103 2lu443 0 -0.90121 0.000203 2lu490 0 -0.996381 0.00016 2lu510 0 -1.24348 0.00033 2lu555 0 -1.74733 0.000162 2lu683 0 -1.52118 0.000105 2lugnd 0 1 0 3es380 0 -0.031424 0.00024 3es412 0 -0.03211 -0.000879 3es443 0 -0.033785 -2.1e-05 3es490 0 -0.032938 -0.000256 3es510 0 -0.032641 -0.000241 3es555 0 -0.032326 0.000203 3par 0 - 10.5311 - 6.9e-05 3edgnd 0 1 0 <derived_parameters> aq-1Tilt-1Roll d-1temp d-d-1temp m-d-d-1temp bin_0.5_1depth ptsbin_0.5 kc-1ed380 kc-1ed412 kc-1ed443 kc-1ed490 kc-1ed510

<filters_used>

prrrecalz -o 1depth 0.9383 83.1773 26.5899

/csc/nep1/coors/bbops/BUILD/mar97occ/lcd/p970313a.lcd outfile27050 bbopradq -fa 1ed380 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa led412 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa 1ed443 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa 1ed490 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa 1ed510 2.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa led555 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa 3es380 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa 3es412 1.000000e-03 p970313a.lcd outqp970313a.lcd bbopradq -fa 3es443 1.000000e-03 p970313a.lcd outgp970313a.lcd bbopradq -fa 3es490 1.000000e-05 p970313a.lcd outqp970313a.lcd bbopradq -fa 3es510 1.000000e-05 p970313a.lcd outqp970313a.lcd bbopradq -fa 3es555 1.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa 3par 1.000000e-01 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu380 1.000000e-02 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu412 1.000000e-02 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu443 1.000000e-03 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu490 1.000000e-03 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu510 1.000000e-03 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu555 2.000000e-04 p970313a.lcd outqp970313a.lcd bbopradq -fa 2lu683 2.000000e-04 p970313a.lcd outqp970313a.lcd bbopangq 1Tilt 1Roll 10 2 inqp970313a.lcd outqp970313a.lcd bbopdespike -d 1temp 0.05 10 indqp970313a.lcd outdqp970313a.lcd bbopdespike -d d-1temp 0.05 10 indqp970313a.lcd outdqp970313a.lcd bbopmovavg -f d-d-1temp 5.0 dqp970313a.lcd mdqp970313a.lcd bbopbin -b 0.5 mdqp970313a.lcd bbopkc -s 1ed380 5 inkbmdqp970313a.lcd.1 outkbmdqp970313a.lcd.1 bbopkc -s led412 5 inkbmdqp970313a.lcd.1 outkbmdqp970313a.lcd.1 bbopkc -s 1ed443 5 inkbmdqp970313a.lcd.1 outkbmdqp970313a.lcd.1 bbopkc -s 1ed490 5 inkbmdqp970313a.lcd.1 outkbmdqp970313a.lcd.1 bbopkc -s led510 5 inkbmdqp970313a.lcd.1 outkbmdqp970313a.lcd.1

VIII. Appendix B - Calibration Certificates

The following pages contain the calibration history of the PRR600 instrument.

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Figure A.1.a - Station C Downcast





BIJ



Figure A.2.a - Station C Upcast



BZI



Figure A.3.a - Station D Downcast











Figure A.4.a - Station D Upcast







Figure A.5.a - Station E Downcast





Figure A.6.a - Station E Upcast





Figure A.7.a - Station F Downcast





Figure A.8.a - Station F Upcast







Figure A.9.a - Station G Downcast









Figure A.11.a - Station 8A Downcast



Figure A.11.b - Station 8A Downcast





Figure A.12.a - Station 8A Upcast







Figure A.13.a - Station 8C Downcast







Figure A.14.a - Station 8C Upcast







Figure A.15.a - Station 8E Downcast







Figure A.16.a - Station 8E Upcast





Figure A.17.a - Station 8G Downcast






Figure A.18.a - Station 8G Upcast



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Appendix C. Calibration Certificates for Biospherical Instruments Inc. PRR-600s (S/N# 9643) and PRR-610 (S/N# 9644).

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E	ios	spheric	al Instru	iments Ir	1C.				DC	DINUT DE	STROY	
c	ALI	BRATIO		CATE for PI	RR Spectro	radiometer			Biosof	nerical astru	ments Inc.	
			0-//h		4/00/00		-	4104100	C	ALIBRATION	DATA	
				ration Date:	1/23/96	-	Form:	1/24/96				
,			MOC	iel Number:	PRV-6005	<u>-</u>					Ĺ	
			Ser		9643	_						
				Operator:	JCE/LFG							
			Stan	dard Lamp:	91771 (05/	30/95)						
					Calibration	Calibration	Calibration	Calibration				
			Lamp	Immersion	Voltage -	Voltage -	Factor - Dry	Factor - Wet				
	Ta	g λ (nm)	Irradiance	Coefficient	Dark ³⁾	Light	(V/µW)	(V/µW)	Max E (Dry)			
		DOWNWE	LLING IRRAL	DIANCE CHAN	VELS	Irradiance Uni	its: µW/cm ² ·nr	n, E = Irradian	ce			
	0	380	1.397	0.671	0.000132	-0.018129	-0.013074	-0.008775	764.9			
1 2	0	412	2.411	0.677	0.000516	-0.077541	-0.032371	-0.021906	306.9			
4	0	490	6 159	0.690	0.000113	-0.120950	-0.032714	-0.022313	293.8			
5	a	510	7.302	0.694	0.000168	-0.209004	-0.034039	-0.023459	303.4			
6	ō	555	10.041	0.701	0.000465	-0.332822	-0.033194	-0.023279	301.3			
7	0	PAR*)	0.014	0.686	0.000330	-0.194557	-13.767821	-9.442522	0.726	4}		
8	0	Gnd. ³⁾	0.000291	Voits								
			Ca	libration Factor:	WET = ((Light	- Dark) x Imme	rs. Coeff.)/Lam	p Output				
ļ	DRY = (Light - Dark)/Lamp Output											
1			Lamp				Calibration	Calibration	Calibration	Calibration		
~	τ		Irradiance @	Immersion	Plaque		Voltage -	Voltage -	Voltage -	Factor - Wet		
Cn	Tag			COEfficient	Reflectivity	Radiance"	Dark	Blocked	Light	(0/μνν)	Max L (Wet)	
1	1	380	1 307	1 765	0.095	Radiance Unit	s: µW/cm~nm	esr, L = Radiai	0.003021	0 150639	66.4	
2	1	412	2 411	1.765	0.965	0.012	0.000221	0.000214	-0.003021	-0.505131	19.8	
3	1	443	3.701	1.752	0.985	0.021	0.000233	0.000215	-0.050659	-0.900887	11.1	
4	1	490	6.159	1,745	0.984	0.054	0.000180	0.000150	-0.092345	-0.988998	10.1	
5	1	510	7.302	1.743	0.984	0.064	0.000363	0.000337	-0.136471	-1.235454	8.1	
6	1	555	10.041	1.738	0.984	0.087	0.000180	0.000128	-0.263356	-1.734900	5.8	
7	1	683	16.897	1.730	0.984	0.147	0.000095	-0.000003	-0.394184	-1.550051	6.5	
8	1	Gnd. ⁵⁾	0.00019	Voits		· · · · · · · · · · · · · · · · · · ·						
				ry Radiance =	(Lamp Output :	k Plaque Reflect	tivity x Lamp Di	stance Factor)/	π			
			Lamp Dis	tance Factor =	(50 cm) ² /(300 c	cm) ²						
		TEMPERA	Call	bration Factor:	WET = (Light -	Dark)/(Dry Rad	liance x Immer	sion Coefficient	:)			
9	U	IEMPERA Secio	IURE '	r	Temperature	(°C) = (Voltage	- Offset)/Scal	e				
		Offect		Ł.	0.1419					;)		
10	0	PRESSUR	E/DEPTH ^{a)}		- 1080.0 j		4	4 2	N - 14 1 +			
	•	Scale Facto	or "a"	Ľ	0 9374	in (dbars or me	eters) = (a x v	oltage") + (D X	voltage) + c			
		Scale Facto	or "b"	ŀ	83.8842							
		Offset "c"		F	26.9635							
		NOMINAL "	TO ACTUAL V	OLTAGE CON	VERSION FA	CTCRS (For us	e with externa	al sensors, on	ly, see manua	1)		
			_	Irr. Array	Rad. Array	•						
		Scale Facto	or [1.057679	1.074227							
		Offset	F	0.000205	0.000278							
		rull Scale \	voltage	9.4547	9.3090							
		FIRMWARE	E VERSIONS									
			_	Tag 0	Tag 1							
		Underwater		2765B	2043A							
		Notes:										
		1. Annual ca	libration is reco	ommended								
		2. Calibration	ns were perform	ned at approxim	ately 20 to 30	•C.						
		3) "Dark" irra	adiance and "B	locked" radiance	e values repres	ent a blocking o	of the calibratio	n source. Thes	e values should	i not be used		
		as the "Of	ffset" when ent	ering values into	the calibration	file. Use the to	tally dark sense	or values obtair	ned at the temp	erature where		
		the instrur	ment will be use	ed.					•			
		4) PAR irrad	iance units are	µEinsteins/cm ²	² ·sec.							
	ļ	5) Typical va	lue(s).									
	9	5) For conve	rsion of area to	solid angle, a fi	actor (divisor)	of Pilis incorpor	ated.					
		 Water terr A above 	iperature sensi									
		b) A change	in depth of 1 m	ieter in seawate	r corresponds	to approximately	y a 1 dbar char	nge in pressure	·			



Biospherical Instruments Inc. CALIBRATION CERTIFICATE for PRR Spectroradiometer

Calibration Date: 1/23/96 Model Number: PRV-600S Serial Number: 9643 Operator: JCE/LFG Form: 1/24/96

OPTIONAL CHANNELS

Ch	Та	g		
11	0	Transmissometer ¹⁾	Output = (Vo	Itage - Offset)/Scale
		Scale Factor	1.0	Volts/Volt
		Offset	0.0	Volts
12	0	Scalar PAR: QSP-200 S/N 4443	quanta/(cm ² ·	sec) = (Voltage - Offset)/Scale
1		Scale Factor (Wet)	-1.161E-17	Volts/(quanta/cm ² ·sec)
۱ 		Offset	0.0009	Volts
13	0	AXIS 1 ANGLE SENSOR - "TILT"	Degrees = (V	oltage - Offset)/Scale
		Scale Factor	0.0418	
		Offset	2.6862	
14	0	AXIS 2 ANGLE SENSOR - "ROLL"	Degrees = (V	oltage - Offset)/Scale
		Scale Factor	0.0415	
		Offset	2.6973	
15	0	Light Scattering Sensor ¹⁾	"Output = (Vo	Kage - Offset)/Scale
		Scale Factor	1.0	Volts/Volt
		Offset	0.0	Volts
16	0	Fluorometer ¹⁾	Output = (Vo	itage - Offset)/Scale
		Scale Factor	1.0	Volts/Volt
		Offset	0.0	Volts

Notes:

1) These sensors are not calibrated at BSI. When applicable, see the manufacturers' specifications.

	1	٠										
./	B	io	spheri	ical Insti	ruments I	10.	· · · · · · · · · · · · · · · · · · ·	·····				
	E	/Al		N FORM fo	or PRR Spec	troradiome	ter					
				Cali	bration Date	: 3/26/96		Form:	7/11/96			
	•			M	odel Number	PRV-6005	5			-		
	1			Se	erial Number	9643	-					
				-	Operator	- JCEAFG	-					
				Sta	indard Lamp:	<u>94531 (10/</u>	11/95) for Iri	radiance, 94	532 (10/11/	95) for Radi	ance.	•
					· · ·	Calibration	Calibration	Calibration	Calibration			
	Сħ	Tar	a) (nm)	Lamp irradiance	Coefficient	Vortage - Dark ³⁾	Voltage -	Factor - Dry	Factor - Wet			
			DOWNW	ELLING IRR	ADIANCE CHAN	NELS	Irradiance Un	its: µW/cm ² ·nn	n, E = Irradian	Ce		
	1	0	380	1.486	0.671	0.000160	-0.019050	-0.012927	-0.008677	773.6		
	2	0	412	2.559	0.877	0.000095	-0.081553	-0.031907	-0.021592	313.4		
	3	0	490	3.900 8.483	0.682	0.000116	-0.126520 -0.218429	-0.032421	-0.022113	308.4		
	5	0	510	7.683	0.694	0.000108	-0.210429	-0.032609	-0.023280	290.3 306.7		
	6	0	555	10.536	0.701	0.000459	-0.345228	-0.032809	-0.023010	304.8		
	7	0	PAR*)	0.0152	0.686	0.000337	-0.200664	-13.196577	-9.050741	0.758	4)	
ļ	8	0	Gnd."	0.000309	Voits							
				ι L	alloration Factor:	WEi ≃ ((Light	- Dark) x Imme	rs. Coeff.)/Lamj doud	o Output			
ł				Lamp	· · · · · · · · · · · · · · · · · · ·			Calibration	Calibration	Calibration	Calibration	
				Irradiance @) Immersion	Plaque	-	Voltage -	Voitage -	Voltage •	Factor - Wet	
-	Ch	Tag				Reflectivity	Radiance ⁿ	Dark	Blocked ³⁾	Light	(V/µW)	Max L (Wet)
┝	1	1	380	1.308	1.765	0.985	C 011	s: µw/cm ^{-,} nm-	sr, L = Radiar	-0.002922	-0.151959	65 A
	2	1	412	2.275	1.758	0.985	0.020	0.000209	0.000202	-0.017559	-0.509911	19.6
	3	1	443	3.514	1.752	0.985	0.031	0.000192	0.000186	-0.048676	-0.911266	11.0
	4	1	490	5.911	1.745	0.984	0.051	0.000122	0.000106	-0.090184	-1.005825	9.9
ſ	5 1	1	510	7.038 9.746	1.743	0.984	0.061	0.000272	0.000261	-0.133038	-1.248987	8.0
,	7	1	683	16.755	1.730	0.984	0.146	0.000124	-0.000057	-0.250077	-1.555169	5.7
Ē	8	1	Gnd.31	0.000124	Volts							
				Lama Di	Dry Radiance = (Lamp Output x	Plaque Reflect	ivity x Lamp Dis	tance Factor)/:	π		
				Ca	libration Factor: \	,50 cm)-/(300 c NET ≈ (Light -	m) ⁻ Dark\/(Dry Rad	lance v immers	Ion Coefficient	h		
	9	0	TEMPER	ATURE		l'emperature (C) = (Voltage	- Offset)/Scale	ion coemcient,	/	· · · · · · · · · · · · · · · · · · ·	
		:	Scale		Ĺ	0.1419	, , .				•	
			Offset		Ŧ	0.0801					- 1.	
	U	0	PRESSUR Scale Fac	tor "a"	٢	Pressure/Depti	h (dbars or me	eters) = (a x Vo	ltage ²) + (b x '	Voltage) + c		
			Scale Fac	tor "b"	- F	83,8842						
			Offset "c"	,	P	26.9635						
		1	NOMINAL	TO ACTUAL	VOLTAGE CON	VERSION FAC	TORS ⁷ (For u	se with extern	al sensors, or	niy, see manua	ai)	
			Conto End		Irr. Array	Rad. Array						
		Ċ	offset		0.000206	0.000278						
		F	Fuli Scale	Voltage	9.4547	9.3090						
		F		E VERSIONS								
		•			Tag 0	Tag 1						
		Ľ	Inderwate	r ROM	2765B	2043A						
		N	lotes:									
		1	. Annual c	alibration is rec	commended.		_					
		3) "Dark" in	radiance and "E	med at approxima Blocked" radiance	ately 20 to 30 *	C. Intablocking o	f the calibration	course Theor	unium abouid	not be used	
			as the "C	ffset" when en	tering values into	the calibration	file. Use the tot	ally dark senso	r values obtaine	ed at the tempe	rature where	
1		A	the instru PAR ima	iment will be us diance units are	ied. t uEinsteine/cmf	5.0C						
		5) Nominal/	Typical value(s		- -						
1		6) For conv	ersion of area t	o solid angle, a fa	ictor (divisor) ol	f Pi is incorpora	ited.				
		8) A change	in depth of 1 r	neter in seawater	corresponds to	aporoximately	a 1 dbar chang	se in pressure			
L		9) These ch	annels/sensor	s were not evalua	ted during this	service period.		j - 117 pri velavi a.			

Biospherical Instruments Inc. CALIBRATION CERTIFICATE for PRR Spectroradiometer

Calibration Date: 3/26/96 Model Number: PRV-600S Serial Number: 9643 Operator: JCE/LFG

Form: 7/11/96

OPTIONAL CHANNELS

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Ln.	a c	

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Ch	Tag	9		
11	0	Transmissometer ¹⁾	Output = (Vo	itage - Offset/Scale
		Scale Factor	1.0	Volts/Volt
		Offset	0.0	Volts
12	0	Scalar PAR: QSP-200 S/N 44432	quanta/(cm ² ·	sec) = (Voltage - Offset)/Scale
		Scale Factor (Wet)	-1.161E-17	Volts/(quanta/cm ² ·sec)
		Offset	0.0009	Volts
13	0	AXIS 1 ANGLE SENSOR - "TILT"	Degrees = (V	oltage - Offset)/Scale
		Scale Factor	0.0418	
		Offset	2.6862	
14	0	AXIS 2 ANGLE SENSOR - "ROLL"	Degrees = (V	oltage - Offset)/Scale
		Scale Factor	0.0416	
		Offset	2.6973	
15	0	Light Scattering Sensor ¹⁾	Output = (Vo	tage - Offset//Scale
		Scale Factor	1.0	Volts/Volt
		Offset	0.0	Volts
16	0	Fluorometer ¹⁾	Output = (Voi	itage - Offset//Scale
		Scale Factor	1.0	Volts/Volt
		Offset	0.0	lvons

Notes:

1) These sensors are not calibrated at BSI. When applicable, see the manufacturers' specifications.

2) These channels/sensors were not evaluated during this service period.

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biospherical Instruments Inc.												
	<u> </u>	RRATIO		ATE for P	28 Snectro	radiometer				o not di	ESTROY	
101					ar opecao	autometer			0:00	nharies Inc.	umante Ine	
I			Calib	ration Date:	2/10/97		Form:	2/10/97	DIOS	pherical ins	- 0.571 A. AUG.	
			Mod	loi Numbor	DOV 6005	-				CALIBRATIO	ALAU	
1			MICC		FRV-0003	-			<i>1_,</i> ,,,,,,,,,,,,,,,,,,,,,,,,,,,			
			Ser	ial Number:	9643	-			1.1			
				Operator:	TMM							
			Stan	dard Lamp:	94531 (01/	- 02/97) for Ir	radiance, 94	1532 (10/11/	95) for Rad	iance.		
					Calibration	Calibration	Calibration	Calibration				
			Lamp	Immersion	Voltage -	Voitage -	Factor - Dry	Factor - Wet				
Ch	Tag	ງ λ (nm)	irradiance	Coefficient	Dark ³⁾	Light	(V/µW)	(V/µW)	Max E (Dry)			
		DOWNW	ELLING IRRAD	MANCE CHANN	VELS	Irradiance Un	its: µW/cm ² ·nr	n, E = Irradiano	:8			
1	0	380	1.578	0.671	0.000146	-0.019400	-0.012390	-0.008317	807.1			
2	ō	412	2 595	0 677	0.000551	-0.081300	-0.031541	-0.021345	317.0			
-	ň	443	4 003	0.682	0.000189	0 128186	-0.032071	-0.021874	311.8			
		400	4.000	0.002	0.000109	-0.120100	-0.002071	0.021074	300.3			
4		490	0.04/	0.090	0.000282	-0.221050	-0.033297	-0.022900	210.8			
5	0	510	7.880	0.694	0.000171	-0.253324	-0.032171	-0.022313	310.8			
6	0	555	10.730	0.701	0.000480	-0.348378	-0.032511	-0.022801	307.6	4)		
7	0	PAR*	0.0154	0.686	0.000371	-0.202865	-13.204159	-9.055940	0.757			
8	0	Gnd. ⁵⁾	0.000318	Volts						····		
	Calibration Factor: WET = ((Light - Dark) x Immers. Coeff.)/Lamp Output											
DRY = (Light - Dark)/Lamp Output												
			Lamp				Calibration	Calibration	Calibration	Calibration		
			Irradiance @	Immersion	Plaque		Voltage -	Voltage -	Voltage -	Factor - Wet		
Ch	Tad	λ (nm)	50 cm	Coefficient	Reflectivity	Radiance ⁶⁾	Dark	Blocked ³⁾	Light	(V/µW)	Max L (Wet)	
		HPWELL	ING RADIANCE	CHANNELS		Radiance Uni	ts: uW/cm ² ·nm	sr. I. = Radian				
4	4	380	1 308	1 765	0.088	0.011	0.000198	0.000206	-0.002858	-0.151929	65.8	
1	4	110	0.075	1.700	0.900	0.011	0.000130	0.000008	0.017528	-0 498479	20.1	
4	1	412	2.275	1.750	0.969	0.020	-0.000103	-0.00090	0.048370	_0.901210	11 1	
3	1	443	3.514	1.752	0.990	0.031	0.000203	0.000203	-0.040370	0.006294	10.0	
4	1	490	5.911	1.745	0.990	0.052	0.000160	0.000151	-0.089873	-0.990301	10.0	
5	1	510	7.038	1.743	0.990	0.062	0.000330	0.000321	-0.133200	-1.243485	8.0	
6	1	555	9.746	1.738	0.991	0.085	0.000162	0.000123	-0.259162	-1.747331	5.7	
7	1	683	16.755	1.730	0.990	0.147	0.000105	0.000026	-0.385980	-1.521184	6.6	
8	1	Gnd.5)	0.000179	Volts								
			0	ry Radiance =	(Lamp Output)	x Plaque Reflec	tivity x Lamp Di	stance Factor)/	r.			
			Lamp Dis	tance Factor =	$(50 \text{ cm})^2/(300 \text{ cm})^2$	cm) ²	-					
			Cali	bration Factor	WET = (Light	Dark)/(Dry Ra	diance x immer	sion Coefficient))			
à	0	TEMPER	ATURE7. 9		Temperature	(C) = 0(o)tage	- Offeet\/Scal	9				
3	v	Coolo		г	A 4404	(C) - (Voitage	- Onselpocal	c				
		Scale			0.1421					-1-1		
		Onset		1	0.0889							
10	0	PRESSU	KE/DEPTH""	-	Pressure/Dep	th (dbars or m	eters) = (a x V	oltage*) + (b x '	Voltage) + c			
		Scale Fac	tor "a"	Ļ	0.9383							
		Scale Fac	tor "b"		83.1773							
		Offset "c"	•		26.9099					<u> </u>		
		NOMINAL	TO ACTUAL V	OLTAGE CON	VERSION FA	CTORS ³⁾ (For	use with exter	nal sensors, or	niy, see manu	ial)		
				Irr. Array	Rad. Array							
		Scale Fac	tor [1.057679	1.074227	(Calibrated on	3-96)					
		Offset	F	0.000205	0.000278	••••••						
		Full Scale	Voltage	9 4647	9 3090							
		run ocere		0.1011	3.5030							
		FIRMWAR	RE VERSIONS									
				Tag 0	Tag 1							
		Underwat	er ROM	2765B	20434							
		Notes:										
		1. Annual o	calibration is rec	ommended.								
		2. Calibrati	ions were perform	med at approxin	nately 20 to 30	•C.			- univer chauli	d not be used		
		3) "Dark" II	madiance and "B	locked" radianc	e values repre	sent a blocking	of the calibratic	n source. I nes	e values should			
		as the "(Unset" when ent	ering values into	o the calibration	n file. Use the t	otally dark sens	or values obtain	ied at the temp	GIALLIE WIELE		
			ument will De US	eu. Cinoteine/emi	2							
		4) MAR IITZ 5) Nominal	Autance units are	rµ⊏insteins/cm \	·Sec.							
		D) NORMAN	version of area to). S solid secie - f	fantor (divises)	of Di in incomo	rated					
		uj rui cuni 7) \//star fa		v sona angle, a l Ar	actor (uivisor)							
		i) vvalet le 8) & chang	in death of 1	natar in ecounts	r comencode	to approvimate	lv a 1 dhar cha	nae in pressure				
		0) These ~	hannele/eener		ated during this	e cervice rarior		An in broadie	•			
		97 I HE36 C	man in retar set i sul 3	- HELE HUL EVELU	area aaning thi	a ani vive periot						

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Biospherical Instruments Inc. CALIBRATION CERTIFICATE for PRR Spectroradiometer

Calibration Date:	2/10/97
Model Number:	PRV-600S
Serial Number:	9643
Operator:	TMM

Form: 2/10/97

OPTIONAL CHANNELS

Ch	Тас	

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Ch	Tag				
11	0	Transmissometer ¹⁾	Output = (Vo	bitage - Offset)/Scale .	
		Scale Factor	1.0	Volts/Volt	
		Offset	0.0	Volts	
12	0	Scalar PAR: QSP-200 S/N 44432)	quanta/(cm2.	·sec) = (Voltage - Offset)/Scale	
		Scale Factor (Wet)	-1.020E-17	Volts/(quanta/cm ² ·sec)	
		Offset	0.0009	Volts	
13	0	AXIS 1 ANGLE SENSOR - "TILT"2)	Degrees = (V	/oltage - Offset)/Scale	
		Scale Factor	0.0418	(Calibrated on 3-96)	
		Offset	2.6862		
14	0	AXIS 2 ANGLE SENSOR - "ROLL"2)	Degrees = (V	/oltage - Offset)/Scale	
		Scale Factor	0.0415	(Calibrated on 3-96)	
		Offset	2.6973		_
15	0	Light Scattering Sensor ¹⁾	-Output = (Vo	pitage - Offset)/Scale	
		Scale Factor	1.0	Volts/Volt	
İ		Offset	0.0	Volts	
16	0	Fluorometer ¹⁾	Output = (Vo	pitage - Offset)/Scale	
		Scale Factor	1.0	Volts/Volt	
		Offset	0.0	Volts	

Notes:

1) These sensors are not calibrated at BSI. When applicable, see the manufacturers' specifications.

2) These channels/sensors were not evaluated during this service period.

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B	105	spheri	cal Instru	uments li	nc.						
C	ΔI 1	BRATIC	N CERTIFI	CATE for P	RR Spectro	radiometer				o noi di	YCARC:
					in opecat	naurometer			Biogr	haricai Inves	umante las
			Calib	ration Date	· 2/10/07		Form	2/18/07	Diost		an ants mc.
			Jan		- 210/97	-	Form.	2/10/37	n n	CALIBICATION	I DAIA
			MO	del Number	: <u>PRV-6005</u>	5			NAL		
1			Sei	rial Number:	: 9643	_					
				Operator	Thana	-			•		
1			-	operator	1 14/141	-					
			Star	idard Lamp:	: 94531 (01/	/02/97) for Ir	radiance, 94	4532 (10/11/	95) for Rad	iance.	_
					Calibration	Calibration	Calibration	Calibration			
			Lamp	Immersion	Voltage -	Voltage -	Factor - Dry	Factor - Wet			
Ch	Tag	ງ λ (nm)	Irradiance	Coefficient	Dark ³⁾	Light	(V/µW)	(V/µW)	Max E (Dry)		
		DOWNW	ELLING IRRA	DIANCE CHAN	NELS	Irradiance Un	its: uW/cm ² ·nr	n. E = Irradiano	:8		
1	0	380	1 578	0.671	0.000146	_0.019400	-0.012300	_0.008317	807.1		
		412	2.505	0.677	0.000740	-0.010400	-0.012030	-0.000017	217.0		
4	U	412	2.395	0.077	0.000551	-0.081300	-0.031541	-0.021345	317.0		
3	0	443	4.003	0.682	0.000189	-0.128186	-0.032071	-0.021874	311.8		
4	0	490	6.647	0.690	0.000282	-0.221058	-0.033297	-0.022980	300.3		
5	0	510	7.880	0.694	0.000171	-0 253324	-0.032171	-0.022313	310.8		
		555	10 720	0.701	0.000480	0.200024	-0.002111	0.022010	207.6		
<u> </u>		300	10.730	0.701	0.000480	-0.346376	-0.032511	-0.022801	307.0	•	
1	0	PAR"	0.0154	0.686	0.000371	-0.202865	-13.204159	-9.055940	0.757		
8	0	Gnd. ³⁾	0.000318	Volts							
			Ca	libration Factor:	WET = ((Light	t - Dark) x Imme	rs. Coeff.VLam	p Output			
					DRY = (light)	Dark)/Lamn O	utruit	F F			
	*****		1.2000		Utti (Ligiti	Bark/ Camp C		Calibration	Calibration	Calibration	
							Calibration	Vallage	Calibration	Calibration	
	_		irradiance @	Immersion	Plaque		Voltage -	vonage -	Voltage -	Factor - Wet	
Ch	Tag	<u>λ (nm)</u>	50 cm	Coefficient	Reflectivity	Radiance [®]	Dark	Blocked	Light	(V/µW)	Max L (Wet)
		UPWELL	ING RADIANC	E CHANNELS		Radiance Unit	ts: µW/cm ² ·nm	sr, L = Radian	ce		
1	1	380	1.308	1.765	0.988	0.011	0.000198	0.000206	-0.002858	-0.151929	65.8
2	1	412	2 275	1 758	0.080	0.020	.0.000103	0.000008	0.017526	1 408470	20.1
		442	2.270	4.750	0.303	0.020	-0.000103	-0.00036	-0.017520	-090-779	20.1
3	1	445	3.514	1.752	0.990	0.031	0.000203	0.000203	-0.048370	-0.901210	11.1
4	1	490	5.911	1.745	0.990	0.052	0.000160	0.000151	-0.089873	-0.996381	10.0
5	1	510	7.038	1.743	0.990	0.062	0.000330	0.000321	-0.133200	-1.243485	8.0
3	1	555	9 746	1 738	0.001	0.095	0.000163	0.000122	0.250162	1 747331	57
÷		602	48 765	4,700	0.391	0.005	0.000102	0.000125	-0.235102	-1.747301	5.7
·		000	10,755	1.730	0.990	0.14/	0.000105	0.000026	-0.385960	-1.321104	0.0
8	1	Gna."	0.000179	Voits						···· ···· ·····	
			(Dry Radiance =	(Lamp Output :	x Plaque Reflec	tivity x Lamp Di	stance Factor)/1	r		
			Lamp Dis	tance Factor =	$(50 \text{ cm})^2/(300 \text{ cm})^2$	cm) ²					
			Cali	bration Factor:	WET = (Light -	· Dark)/(Dry Rad	tiance x Immer	sion Coefficient)			
9	ò	TEMPER	ATURE ⁷¹		Temperature	(C) = 0	OffectVSeek	•			
•	-	Coole		r	Temperature	(C) - (Voitage	• Onset#Stan	6			
		Scale			0.1421					• 1	
		Offset		·F	0.0889					-	
10	0	PRESSUF	RE/DEPTH ^{II}		Pressure/Depi	th (dbars or m	eters) = (a x Vo	$p(tage^2) + (b x)$	(oltage) + c		
		Scale Fac	tor "a"	Г	0.9383				3.,		
		Scale Fac	tor "b"	ŀ	93 1771						
		Offect "e"			03.1173						
		Unset C			26.9099						
		NUMINAL	TO ACTUAL V	UL TAGE CON	VERSION FAC	CTORS" (For u	ise with exteri	nal sensors, or	ily, see manua	21)	
			_	Irr. Array	Rad. Array						
		Scale Fac	tor [1.057679	1.074227						
		Offset	ŀ	0.000205	0.000279						
		Cull Coolo	Vallage F	0.000200	0.000278						
		ruii Scale	voitage	9.404/	9.3090						
			FVERSIONS								
			-	lag 0	Tag 1						
		Underwate	er ROM	27658	2043A						
		Votes	-								
	1	Actives.	allastas !								
				unmended,							
	2	2. Calibrati	ons were perfor	med at approxim	nately 20 to 30	•C.					
	:	3) "Dark" ir	radiance and "B	locked" radianc	e values repres	sent a blocking (of the calibratio	n source. These	values should	not be used	
		as the "C	Offset" when ent	ering values into	the calibration	n file. Use the to	tally dark sense	or values obtain	ed at the tempe	erature where	
		the instri	ument will be us	ed.	_				•		
	4	4) PAR irra	idiance units are	µEinsteins/cm ²	^{z.} sec.						
	ę	5) Nominal	(Typical value(s)								1
	6	6) For conv	ersion of area to	solid angle, a f	actor (divisor)	of Pilis incornor	ated				
	-) Water te	mperature sens	or.							
	ş	A chang	a in depth of 1 m	leter in seawate	r corresponde	to approvimatel	v a 1 dhar chan	ne in pressure			
	à)) These ri	annels/sensore	were not evalue	ated during this	service revised	ya i ubar çildi"	Ne in hiessoie.			
		,		evalue	acea aarniy tilis	- Jeivice period.	•				

DO FROT DESTROY Biospherical Incomments Inc. CALIBRATION DATA

Biospherical Instruments Inc. CALIBRATION CERTIFICATE for PRR Spectroradiometer

		Calibration Date Model Numbe Serial Numbe Operato	e: 2/10/97 r: PRV-600s r: 9643 r: TMM	Form: <u>2/18/97</u>
		OPTIONAL CHANNELS		
Ch	Та	g		
11	0	Transmissometer ¹⁾	Output = (Vo	itage - Offset)/Scale
		Scale Factor	1.0	Volts/Volt
		Offset	0.0	Volts
12	0	Scalar PAR: QSP-200 S/N 4443	quanta/(cm ²	sec) = (Voltage - Offset)/Scale
		Scale Factor (Wet)	-1.020E-17	Volts/(quanta/cm ² ·sec)
		Offset	0.0009	Volts
13	0	AXIS 1 ANGLE SENSOR - "TILT"2)	Degrees = (V	oltage - Offset)/Scale
		Scale Factor	0.0418	
		Offset	2.6862	
14	0	AXIS 2 ANGLE SENSOR - "ROLL"2)	Degrees = (V	oltage - Offset)/Scale
		Scale Factor	0.0415	
		Offset	2.6973	
15	0	Light Scattering Sensor ¹⁾	Output = (Vol	tage - Offset)/Scale
		Scale Factor	1.0	Volts/Volt
		Offset	0.0	Voits
16	0	Fluorometer ¹⁾	Output = (Vol	tage - Offset)/Scale
		Scale Factor	1.0	Volts/Volt
		Offset	0.0	Volts
		Notes: 1) These sensors are not calibrated at BS	SI. When applic	able, see the manufacturers' specifications.

2) These channels/sensors were not evaluated during this service period.

B	ios	pheri	cal Instru	ments Inc.	•				DON		OY	
C		BRATIO	N CERTIFIC	ATE for PRR	Spectrorad	liometer			Ricenharic	el lastannen	ts Inc	l
			6.2	libration Date	1/7/08		Form	1/8/98		2ΦΑ.:ΝΕ Ο Α.)	'A IIC.	
				Indel Number	DDV 6005	-	10111.	1/0/50	-INTILLIL	SATION DA	~	
				iodel Number:	PRV-0003	-						
			3		9043	-						
				Operator:					E) for Dodior			
			St	andard Lamp:	94531 (01/	02/97) for Im	adiance, 945	532 (10/11/9	5) for Radian	ice		
			Lamp	Immersion	Calibration	Calibration	Calibration	Calibration				
			Irradiance @	Coefficient	Voltage -	Voltage -	Factor - Dry	Factor - Wet				
Ch	Та	λ (nm)	50 cm	(Type P6-2)	Dark ³⁾	Light	(V/µW)	(V/µW)	Max E (Dry)			
		DOWNW	ELLING IRRAL	DIANCE CHANNE	LS	Irradiance Ur	nits: µW/cm² n	m, E = Irradia	nce			_
1	0	380	1.578	0.671	0.000216	-0.019687	-0.012617	-0.008469	792.6			
2	0	412	2.595	0.677	0.000144	-0.082185	-0.031725	-0.021469	315.2			
3	0	443	4.003	0.682	0.000186	-0.129799	-0.032473	-0.022149	307.9			
4	0	490	6.647	0.690	0.000293	-0.223611	-0.033683	-0.023246	290.9			
5	0	510	7.880	0.694	0.000160	-0.255997	-0.032509	-0.022547	307.9			
5	0	555 DAD ⁴⁾	10.730	0.701	0.000461	-0.351496	-0.032602	-0.023003	0 752	5)		
	0	Gnd ³⁾	0.01339	Volts	0.000000	-0.204234	-13.230013	-5.130271				
<u>ا</u>				Calibration Factor:	WET = ((Liah	t - Dark) x Imm	ers. Coeff.)/Lar	np Output				
					DRY = (Light	- Dark)/Lamp C	Dutput ズルー			Lin-		
			Lamp	Immersion	Plaque		Calibration	Calibration	Calibration	Calibration		
			Irradiance @	Coefficient	Reflectivity	6)	Voltage -	Voltage -	Voltage -	Factor - Wet	May 1 /M	
Ch	Ta	<u>λ (nm)</u>	50 cm	(BK7 window)	S/N 20166	Radiance"	Dark	Blocked"		(0/μνν)		reg
4		UPWELL	ING RADIANC	E CHANNELS	0.097		0.000199	0.000189	-0.002868	-0 154031	64.9	
1	1	412	2.300	1.700	0.987	0.011	-0 0000199	-0.000103	-0.002000	-0 503175	19.9	
4	1	412	2.273	1.750	0.991	0.030	0.000239	0 000220	-0.048862	-0.923407	10.8	
4	1	490	5.911	1.745	0.991	0.051	0.000197	0.000169	-0.090176	-1.014244	9.9	
5	1	510	7.038	1.743	0.991	0.061	0.000331	0.000308	-0.133501	-1.262725	7.9	
6	1	555	9.746	1.738	0.991	0.084	0.000171	0.000118	-0.260191	-1.779516	5.6	
7	1	683	16.755	1.730	0.991	0,145	0.000091	0.000001	-0.383667	-1.533607	6.5	
8	1	Gnd."	0.000164	Volts								
				Dry Radiance =	(Lamp Output	x Plaque Refle	ectivity x Lamp 0	Distance Factor	-)/π			
			Lamp	Distance Factor =	(50 cm) ² /(300	cm)*		anian Caeffiein	-*)			
0	~	TEMPES		Jailbration Factor:		- Dark)/(Dry Ra	adiance x imme	ersion Coefficie	nu			
3	v	Scale			n 1419	(C) = (Voltay)	je - Olisethista					
		Offset		-,	0.0919				•	3 1 :		
10	0	PRESSU	RE/DEPTH *	••	Pressure/Dec	oth (dbars or n	neters) = (a x \	Voltage ²) + (b	x Voltage) + c			
		Scale Fa	ctor "a"		0.9298			••••				
		Scale Fa	ctor "b"		83.3548	\checkmark						
		Offset "c	**		26.8924							
		NOMINA	L TO ACTUAL	VOLTAGE CONV	ERSION FAC	TORS (For us	e with externa	l sensors, oni	y, see manual)		
			Г	Irr. Array	Rad. Array	I						
		Scale Fa		1.05/6/9	1.0/422/							
		Unset Full Scal		9 4547	9 3090							
		run Scar	e voltage [5.4647	3.0000							
		FIRMWA	RE VERSION(S	5)								
		Umdamum		lag 0	1 ag 1	I						
		Underwa	ter ROM	27658	2043A							
		Notes:										
		1. Annual	calibration is re-	commended.								
		2. Calibra	tions were perfo	rmed at approxima	ately 20 to 30 °	C.			والمتعام ممرياهم	not be used		
		3) "Dark"	irradiance and "	Blocked" radiance	values represe	ent a blocking o	or the calibration	n source. These	e values should	not de usea		
		as the	"Offset" when er	ntering values into	the calibration	rile. Use the to	tally dark sense	or values obtain	eo at the tempe			
			rument Will De U radiance unite a	sed. re uFinsteins/cm ²	SPC							
		5) Nomine	al/Tynical value/	s)								
		6) For cor	version of area	to solid angle, a fa	ictor (divisor) o	f Pi is incorpora	ated.					
		7) Water	temperature sen	sor.					•			
		8) A chan	ge in depth of 1	meter in seawater	· corresponds t	o approximately	y a 1 dbar chan	ige in pressure				
		-										

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Biospherical Instruments Inc. CALIBRATION CERTIFICATE for PRR Spectroradiometer Form: 1/8/98 1/7/98 Calibration Date: Model Number: PRV-600S Serial Number: 9643 Operator: TMM/DAN **OPTIONAL CHANNELS** Ch Tag 11 0 Transmissometer¹⁾ Output = (Voltage - Offset)/Scale Volts/Volt 1.0 Scale Factor Offset 0.0 Volts 12 0 Scalar PAR: QSP-200 S/N 44432) quanta/(cm²-sec) = (Voltage - Offset)/Scale Scale Factor (Wet) -1.020E-17 Volts/(quanta/cm²-sec) 0.0009 Volts Offset 13 0 AXIS 1 ANGLE SENSOR - "TILT"2) Degrees = (Voltage - Offset)/Scale Scale Factor 0.0418 2.6862 Offset 14 0 AXIS 2 ANGLE SENSOR - "ROLL"2) Degrees = (Voltage - Offset)/Scale 0.0415 Scale Factor 2.6973 Offset Output = (Voltage - Offset)/Scale 15 0 Light Scattering Sensor¹⁾ •• 1 1.0 Volts/Volt Scale Factor 0.0 Volts Offset Output = (Voltage - Offset)/Scale 16 0 Fluorometer¹⁾ Volts/Volt Scale Factor 1.0 Offset 0.0 Volts Notes: 1) These sensors are not calibrated at BSI. When applicable, see the manufacturers' specifications. 2) These channels/sensors were not evaluated during this service period.

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DO NOT DESTROY Biospherical construments Inc. CAUGULAU UN DATA

B	io	spheri	cal Instru	ments In	c.							
C	ALI	BRATIC	ON CERTIFIC	CATE for PR	R Spectro	radiometer						
	Calibration Date: 1/21/96 Form: 1/25/96											
	Calibration Date: <u>1/24/96</u> Form: <u>1/25/96</u>											
	Model Number: PRV-610 Seriel Number: 0644											
	Serial NUMBER:											
				Operator:	JCE/LFG							
			Stan	dard Lamp:	91771 (05/	(30/95)						
				Calibration	Calibration	Calibration						
	.	- 1 ()		Voltage -	Voltage -	Factor - Dry	Max E (Dry)					
	1 1 4				Light	(v/µvv)	E a Irradiance					
		SURPA	1 307	0.000205	-0.045775		303.8					
	4	<u>, 300</u> ∕	2 411	-0.000888	-0 079748	-0.002910 -0.032704	305.8					
3	2	443	3,701	-0.000036	-0.126600	-0.034201	292.4					
	2	490	6.159	-0.000291	-0.206142	-0.033424	299.2					
5	2	510	7.302	-0.000277	-0.242508	-0.033173	301.5					
6	2	555	10.041	0.000142	-0.328101	-0.032691	305.9					
7	2	PAR*	0.0142	-0.000040	-0.153967	-10.874195	0.920	•				
1	2	Gnd.5)	0.000095	Volts								
<u> </u>			Calil	bration Factors:	DRY = (Light	- Dark)/Lamp Output						
Г		NOMINA	AL TO ACTUAL	VOLTAGE CO	VERSION FA	ACTORS (For use with external	sensors, only, see manual)					
				Irr. Array								
		Scale		1.061494								
		Offset		0.000049								
		Full Sca	le Voltage	9.4207			••	١				
		FIRMW	ARE VERSION									
				Tag 2								
		Surface	ROM	21068								
		Notes:										
		1. Annua	al calibration is re	commended.								
		2. Calibr	ations were made	e at approximate	ity 20 to 30 °C.	b b} b b b b b b b b b b b b b b b b b b 	1					
		3) Dark v	alues represent	a blocking of the	e calibration so	urce. These values should not be	used as the "offset" when					
		enterir	ng values into the	calibration file.	Use the totally	dark sensor values obtained at th	e temperature where the					
			ment will de used	i. 19 11 Einstein - /	-2							
		4) PAR I	rradiance units a	re µ⊂insteins/cr	n 'Sec.							
		5) Typica	a value(s).									

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DO NOT DESTROY	
Biospherical Astruments Inc. CAUSTAS JN DATA	6
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B	ios	pherio BRATIO	cal Instru	ments In	C. RR Spectro	oradiometer		
			Calibr Mod Seri Stand	ation Date: el Number: al Number: Operator: dard Lamp:	1/24/96 PRV-610 9644 JCE/LFG 91771 (05/	Form:_ [30/95]	1/25/96	
				Calibration	Calibration	Calibration		
				Voltage -	Voltage -	Factor - Dry		
Ch	Та	<mark>) λ(nm)</mark>	Lamp Output	Dark ³⁾	Light	(V/µW)	Max E (Dry)	
		SURFAC	E IRRADIANCE	CHANNELS		Irradiance Units: µW/cm ² ·nm	, E = Irradiance	
1	2	380	1.397	0.000205	-0.045775	-0.032918	303.8	
2	2	412	2.411	-0.000888	-0.079748	-0.032704	305.8	
3	2	443	3.701	-0.000036	-0.126600	-0.034201	292.4	
4	2	490	6.159	-0.000291	-0.206142	-0.033424	299.2	
5	2	510	7.302	-0.000277	-0.242508	-0.033173	301.5	
6	2	555	10.041	0.000142	-0.328101	-0.032691	305.9	、
7	2	PAR ⁴⁾	0.0142	-0.000040	-0.153967	-10.874195	0.920	·····
8	2	Gnd.5)	0.000095	Volts				
1			Calib	pration Factors:	DRY = (Light	- Dark)/Lamp Output		
		NOMINA Scale Offset Full Scal	L TO ACTUAL	VOLTAGE CO Irr. Array 1.061494 0.000049 9.4207	NVERSION FA	ACTORS (For use with externa	il sensors, only, see manual))
		FIRMWA	RE VERSION					
		Surface	ROM [Tag 2 2106B				
		Notes:						
		1. Annual 2. Calibra	l calibration is red Itions were made	commended. at approximate	ly 20 to 30 °C.			
		3) Dark v enterin instrun 4) PAR ir	alues represent a g values into the nent will be used, radiance units ar	a blocking of the calibration file. e µEinsteins/cr	e calibration so Use the totally n ² .sec.	urce. These values should not b dark sensor values obtained at t	e used as the 'offset' when he temperature where the	
		5) Typica	I value(s).					

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B	ios	pheri	cal Instru	iments In	iC.						
C	LIE	3RATIC	ON CERTIFIC	CATE for PF	R Spectro	pradiometer					
	Calibration Dates 2/10/07										
	Calibration Date: <u>2/10/97</u> Form: <u>2/18/97</u>										
	Model Number: <u>PRV-610</u> Serial Number: <u>9644</u>										
	Operator: TMM										
			Stand	dard Lamp:	95431 (01/	<u>[</u> 02/97)					
				Calibratian							
				Voltage	Calibration	Calibration					
<u> </u>	Taa	1 (nm)		voirade -	Voltage -	Factor - Dry					
<u>u</u>	Tay				Light	(V/µW)	Max E (Dry)				
1	2	308540	1 578	0.000240	0.040333	irradiance Units: µW/cm ^{-,} nm,	E = irradiance				
2	2	412	2 595	-0.0002-0	-0.049332	-0.031424	310.2				
3	2	443	4 003	-0.000073	-0.004200	-0.032110	311.4				
4	2	490	6 647	-0.000256	-0.710210	-0.03789	290.0				
5	2	510	7 880	-0.000241	-0/213210	-0.032908	306 A				
6	2	555	10 730	0.000203	-0.237	-0.032041	309.4				
7	2	PAR ⁴⁾	0.0154	0.000069	-0.162024	-0.002020	0.950	4)			
1	2	Gnd. ⁵⁾	0.000101	Volta	-0.102024	-10.331113	0.300	·····.		·	
	-		Calib	ration Factors:	DRY = (Light	- Dark)/Lamn Output	· · · · · · · · · · · · · · · · · · ·	-		<u> </u>	
					(,						
	-	NOMINAI	L TO ACTUAL V	OLTAGE CON	IVERSION FA	CTORS (For use with external	sensors, only, see manu	ai)	<u>1</u>		
				Irr. Array		·	•				
		Scale	[1.061494							
		Offset	[0.000049							
		Full Scale	e Voltage	9.4207							
		FIRMWA									
				Tag 2							
	:	Surface F	ROM	2106B							
	I	Notes:									
		t. Annual	calibration is rec	ommended.							
	:	2. Calibrati	ions were made :	at approximately	/ 20 to 30 °C.						
	:	3) Dark vai	lues represent a	blocking of the	calibration sou	Irce. These values should not be	used as the 'offset' when				
		entering	values into the c	alibration file. U	Jse the totally c	dark sensor values obtained at the	e temperature where the				
		instrum	ent will be used.								
	4	I) PAR im	adiance units are	+ µEinsteins/cm ²	^{2,} sec.						
	Ę) Typical	value(s).	•							

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DO NOT DESTROY Biospherical Instruments Inc. MALIBRATION DATA

B	105	pheric	cal Instru	ments In	IC.				
CA	'TIE	RATIC	N CERTIFIC	ATE for PF	R Spectro	oradiometer			
			Calibr Mod	ation Date: el Number:	2/10/97 PRV-610	Form:	2/10/97		
			Seri	al Number:	9644	-			
				Operator:	TMM	-			
			Stand	lard Lamp:	95431 (01/	<u>/</u> 02/97)			
\vdash				Calibration		-	·		
				Calibration Voltage	Calibration	Calibration			
Ch	Таа	1 (nm)	Lamo Output	Dark ³⁾	Voltage -	Factor - Dry	Max E (Drv)		
		SURFAC	EIRRADIANCE	CHANNELS	Ligin	Irradiance Units: UW/cm ² ·nm. F	F = Irradiance		
1	2	380	1.578	0.000240	-0 049332		318.2		
2	2	412	2.595	-0.000879	-0.084205	-0.032110	311.4		
3	2	443	4.003	-0.000021	-0.135255	-0.033785	296.0		
4	2	490	6.647	-0.000256	-0.219210	-0.032938	303.6		
5	2	510	7.880	-0.000241	-0.257444	-0.032641	306.4		
6	2	555	10.730	0.000203	-0.346664	-0.032326	309.4		
7	2	PAR4)	0.0154	0.000069	-0.162024	-10.531115	0.950	4)	
8	2	Gnd.3)	0.000101 \	Volts					
	Calibration Factors: DRY = (Light - Dark)/Lamp Output								
	7	IOMINAL		OLTAGE CON	IVERSION FA	CTORS (For use with external s	ensors, only, see manu	al)	
	(0-ala	г	Irr. Array	·- m				
		Scale	-	1.061494	(Calibrated of	n 1-96)			
	Ì	Jiiser Suit Scale		9.4207					
		Uli Scare		9.4201				·= 1	
	F	IRMWAF	RE VERSION						
			-	Tag 2					
	S	iurface R	KOM L	2106B					
	1	lotes:							
	1	. Annual	calibration is recc	ommended.					
	2	. Calibrat	ions were made a	at approximately	v 20 to 30 °C.				
	3) Dark val	lues represent a !	blocking of the	calibration so	urce. These values should not be ur	used as the 'offset' when		
		entering Instrume	values into the c ent will be used.	alibration file. U	ise the totally	dark sensor values obtained at the f	temperature where the		
	5) Typical v	value(s).						

CAL	-IB	RATIO	Cal Instru N CERTIFIC Calibr Mod Seri Stand	Iments In CATE for PF ration Date: lel Number: ial Number: Operator: dard Lamp:	R Spectroradic PRV-610 9644 TMM/DAN 95431 (01/02/93	ometer 1/7/98 Form: 1/8 7)	3/98	
				Calibration	Calibration	Calibration	······································	
				Voltage -	Voltage -	Factor - Dry		
ch T	ag	λ (nm)	Lamp Output	Dark ³⁾	Light	(V/μW)	Max E (Dry)	
		SURFAC	E IRRADIANCE	CHANNELS	Irradi	iance Units: µW/cm² nm, E = I	rradiance	
1	2	380	1.578	0.000250	-0.050046	-0.031883	313.6	
2	2	412	2.595	-0.000869	-0.084474	-0.032217	310.4	
3	2	443	4.003	-0.000011	-0.136253	-0.034036	293.8	
4	2	490	6.647	-0.000248	-0:221013	-0.033211	301.1	
5	2	510	7.880	-0.000220	-0.259113	-0.032856	304.4	
6	2	555	10.730	0.000225	-0.348584	-0.032507	307.6	
7	2	PAR*)	0.0154	0.000105	-0.161913	-10.526242	0.950 *)	
-	-		Calit	pration Factors:	DRY = (Light - Dark)	/Lamp Output		
	l S C F	NOMINAL Scale Offset Full Scale	TO ACTUAL Y	VOLTAGE CON Irr. Array 1.061494 0.000049 9.4207	NVERSION FACTOR	S (For use with external sens	sors, only, see manual)	
	F	IRMWA	RE VERSION		•		··· 1	
	S	Surface F	ROM [Tag 2 2106B				
	N 1 2	Notes: I. Annual 2. Calibrat	calibration is rec	commended.	lv 20 to 30 °C			
	3	3) Dark va entering	lues represent a yalues into the ent will be used.	a blocking of the calibration file.	calibration source. T Use the totally dark so	hese values should not be used ensor values obtained at the terr	as the 'offset' when perature where the	
		4134 011			•			

DO NOT DESTROY

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