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NOAA CSC/CRS Cruise MAY96NY: New York Bight Apex Cruise

Ajit Subramaniam
Edward M. Armstrong
Technology Planning and Management Corporation
2234 South Hobson Avenue
Charleston, SC 29405

Kirk J. Waters
John C. Brock
NOAA Coastal Services Center
2234 South Hobson Avenue
Charleston, SC 29405

Andrew W. Meredith
REMSA
2234 South Hobson Avenue
Charleston, SC 29405

Robert O. Ranheim
New York City Department of Environmental Protection
Marine Sciences Section, Room 213
Wards Island
New York, NY 10035

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

This is a National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center (CSC) Technical Report. The NOAA CSC Coastal Remote Sensing Program intends to publish forthcoming reports as official NOAA Technical Reports.

Abstract

The Hudson River is a major source of freshwater to the coastal ocean of the northeastern United States. It flows through the New York metropolitan area, one of the most populated regions in the country. The average freshwater discharge at the Battery for the Hudson River in 1991 was 27,000 cubic feet per second, of which 5,300 cubic feet per second was municipal waste water. Thus, water quality in the New York Harbor and in the bight apex are of concern to coastal resource managers. Ocean color satellites provide daily synoptic data of the region and could be of significant value to both scientists and resource managers. In order to be able to use satellite ocean color data in these urban estuaries, robust algorithms that work in case II waters are required. To construct such algorithms, there is a need to understand the spatial and temporal variability in the optical properties of the local waters.

Measurements of surface spectral absorption, attenuation, chlorophyll pigment biomass, particulate absorption, and dissolved organic material absorption were made during a cruise on May 14 and 15, 1996, in the New York Bight Apex. Water column profiles of temperature, chlorophyll fluorescence, scattering, beam transmittance, upwelling radiance, and downwelling irradiance were made at 10 stations around the Ambrose Light Tower and across the Hudson River plume. The measurements revealed that coastal waters influenced by rivers have complex optical properties. The Hudson River plume could be identified by higher attenuation and absorption of light. The plume could be seen in reflectance difference images constructed using bands 1 and 2 of the Advanced Very High Resolution Radiometer.

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Acknowledgments

We thank Rodney Riley and Ed Kearns, Computer Sciences Corporation - National Data Buoy Center Technical Services Contractors, for assistance in the field work. We also acknowledge assistance provided by the master and crew of *HSV Osprey*, New York City Department of Environmental Conservation. The chlorophyll and absorption sample analyses were performed by David and Douglas Phinney, Jeff Brown, and Sara Woodman, Bigelow Laboratory for Ocean Sciences, West Boothbay Harbor, Maine.

Data Usage Constraints

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.

I. Introduction

The coastline along the New York Bight is home to more than 20 million people. Green tides, red tides, and other phytoplankton blooms are recurrent features throughout the New York Bight, particularly off the New Jersey coast (Ohla, 1990). The economic impact of these phytoplankton blooms is difficult to quantify, but harmful algal blooms in this region have led to beach closures and fish kills due to hypoxia. Hypoxia events in the New York Bight Apex, especially in the Christiaensen Basin have been identified as major concerns to the health and management of this ecosystem (Swanson *et al.,* 1991). These phytoplankton blooms could be caused by nutrient enrichment due to either anthropogenic activity or as a response to natural events such as coastal upwelling, or the blooms may result as a combination of both. The exact frequency, location, and causes of these events are poorly understood. Ocean color satellites are ideal instruments for routine monitoring of phytoplankton biomass and primary production because they cover large areas synoptically and at regular intervals. However, determining chlorophyll biomass from ocean color satellite data has had very limited success in "case II" waters such as the New York Bight that have high concentrations of colored dissolved organic material (CDOM) and suspended solids.

The optical variability of the waters in the New York Bight Apex is not well known. The Hudson River, a major source of freshwater to the coastal ocean of the northeastern United States flows into the New York Bight Apex. It is anticipated that this freshwater plume has optical properties quite different from the surrounding oceanic continental shelf waters. The goal of this cruise was to characterize the optical properties of the plume and surrounding waters for development of satellite ocean color algorithms and their validation.

II. Objectives

The primary objective of this cruise was to collect bio-optical data to support regional case II algorithm development. A secondary objective was to validate Advanced Very High Resolution Radiometer (AVHRR)-derived products such as the diffuse attenuation coefficient of photosynthetically available radiation (K_{PAR}) and the beam attenuation coefficient (C_{660}).

III. Methods

A description of the sample collection methods and of instruments used is detailed in the following sections.

A. Sampling Locations

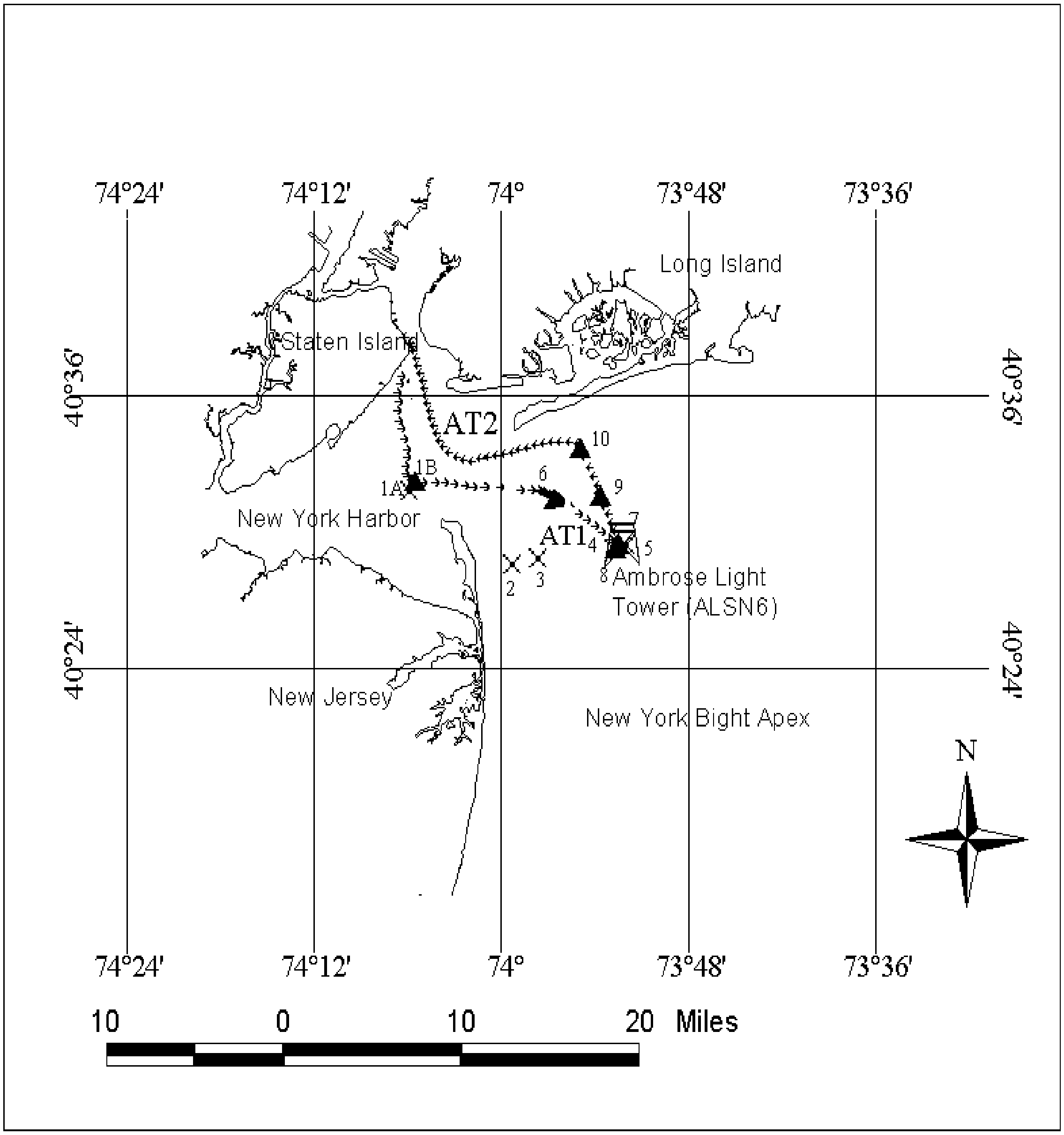

Figure 1. Station Locations and Cruise Track for Along-Track Sampling

Stations occupied on May 14 are indicated by "X" and stations occupied on May 15 are indicated by "Δ". "AT1" and "AT2" refer to the sections in which surface along-track measurements were taken.

Five stations were occupied on May 14 and five stations on May 15, 1996 (Table 1, Figure 1), to make vertical profile measurements. Surface water samples were acquired at all stations for chlorophyll and absorption analyses. An along-track system was used to map the surface optical properties along the cruise track on May 15.

B. Sampling Platform

The *HSV Osprey*, belonging to the New York City Department of Environmental Conservation, was used for this cruise. The *HSV Osprey* is a 17-meter (m) aluminum hull twin engine diesel craft specially designed for water quality sampling in the New York Harbor.

Date	Station	Lat Deg	Lat Min	Latitude	Long Deg	Long Min	Longitude	Time On	Time Off	Total Depth	Sky Conditions
5/14/96	1A	40	29.90	40.498	-74	3.15	-74.053	15:20	15:30	6.7 m	clear
5/14/96	2	40	26.71	40.445	-73	56.62	-73.944	14:26	14:40	11.0 m	clear
5/14/96	3	40	27.02	40.450	-73	55.00	-73.917	13:55	14:15	16.2 m	clear
5/14/96	4	40	27.40	40.457	-73	50.10	-73.835	12:30	12:40	25.6 m	clear
5/14/96	5	40	27.61	40.460	-73	49.38	-73.823	11:21	12:28	24.4 m	clear
5/15/96	1B	40	30.31	40.505	-74	2.82	-74.047	9:40	10:00	6.7 m	high thin clouds
5/15/96	6	40	29.59	40.493	-73	53.90	-73.898	10:45	11:05	10.7 m	clear
5/15/96	7	40	27.62	40.460	-73	49.79	-73.830	11:25	11:45	21.3 m	clear
5/15/96	8	40	27.44	40.457	-73	50.01	-73.834	11:55	12:15	24.4 m	clear
5/15/96	9	40	29.72	40.495	-73	50.94	-73.849	12:40	12:55	16.5 m	clear
5/15/96	10	40	31.77	40.530	-73	52.25	-73.871	13:00	13:20	11.6 m	clear

Table 1. Station Notes Indicating Date, Time, Location, Sky Conditions

Lat Deg, Lat Min, Long Deg, and Long Min refer to the station position in degrees and minutes, Latitude and Longitude refer to the station position in decimal degrees. Total depth is the water depth at station.

C. Sample Collection Methods Summary

The Profiling Reflectance Radiometer (PRR) cage, described below, was deployed using a davit off the stern of the boat, to measure *in-situ* spectral downwelling irradiance, spectral upwelling radiance, temperature, chlorophyll fluorescence, light scattering, quantum scalar irradiance, and beam attenuation. An along-track system was used to measure the position (latitude, longitude), time, course and speed of the vessel, temperature, salinity, spectral absorption, and spectral attenuation. The along-track system used water pumped through a deck hose by a bilge pump from an intake located about a meter below the sea surface. *In-situ* temperature, salinity, and density were also measured at some stations with a Conductivity-Temperature-Depth (CTD) instrument. Water samples for chlorophyll biomass, particulate, and dissolved absorption, were obtained from just below the sea surface using a Niskin bottle. The parameters measured are summarized in Table 2.

Date	Station	Latitude	Longitude	PRRFile	SunPos	SamDep	Chl	Ap	ADOM	CTD	PRR	AC9
5/14/96	1A	40.4983	-74.0525	P960514E	5	surface	2	1	1	0	1	0
5/14/96	2	40.4452	-73.9437	P960514D	6	surface	2	1	1	0	1	0
5/14/96	3	40.4503	-73.9167	P960514C	5	surface	2	1	1	0	1	0
5/14/96	4	40.4567	-73.8350	P960514B	4	surface	3	0	1	0	1	0
5/14/96	5	40.4602	-73.8230	P960514A	3	surface	3	0	1	0	1	0
5/15/96	1B	40.5051	-74.0470	P960515A	6	surface	2	1	0	0	1	0
5/15/96	6	40.4932	-73.8983	P960515B	2	surface	2	1	0	0	1	1
5/15/96	7	40.4603	-73.8298	P960515C	5	surface	2	1	0	1	1	1
5/15/96	8	40.4573	-73.8335	P960515D	5	surface	0	0	0	1	1	0
5/15/96	9	40.4954	-73.8490	P960515E	6	surface	2	1	0	1	1	0
5/15/96	10	40.5295	-73.8708	P960515F	3	surface	2	1	0	1	1	1

Table 2. Sampling Details

PRRFile: file name containing the raw data acquired by the instruments in the PRR cage
SamDep: sample depth
SunPos: sun position relative to the boat, where 1 is sun on the bow, 2 is sun on starboard foredeck, 3 is sun on the starboard quarter deck, 4 is sun on the starboard aft deck, 5 is sun off the stern, and so on up to 8 with the sun on the fore port deck
Chl: chlorophyll biomass determined by fluorescence of extracted chlorophyll
Ap: absorption of particulate material
ADOM: absorption of dissolved material
CTD: measurements made with a SeaBird SEACAT profiler
PRR: measurements by the instruments on the PRR cage
AC9: measurements by a WETLabs AC9.
The numbers below each of these measurement types refer to the number of samples obtained for each of these measurements.

D. Sampling Gear

The PRR cage (Figures 2 and 3) contained a split PRR600s (Serial No. 9643) that measured seven channels of downwelling irradiance, seven channels of upwelling radiance, depth, tilt, roll, and temperature. A reference surface unit (PRR610 Serial No. 9644) that measured seven matched channels of surface downwelling irradiance on deck was also used. Channels 1 to 6 were narrow band (10-nanometer [nm] full width half maximum [FWHM]) centered at the indicated wavelengths, while channel 7 on the downwelling sensor and PRR610 measured broad band Photosynthetically Available Radiation (PAR) (400 to 700 nm).

Channel No.	PRR600s Downwelling Light Sensor	PRR600s Upwelling Light Sensor	PRR610
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 3. Center Wavelengths for the PRR System

The cage also contained a 10-centimeter (cm) pathlength, 660 nm Light Emitting Diode (LED) based SeaTech transmissometer (Serial No. 664), a Biospherical Instruments Quantum Scalar Profiling sensor (QSP200, Serial No. 4443), a SeaTech light scattering sensor (LSS, Serial No. 281), and a WETLabs Wetstar chlorophyll fluorometer (Serial No. Ws3-088). Water was drawn through the fluorometer using a SeaBird pump (Serial No. 051363) running at 2,000 revolutions per minute. The data from all these instruments were multiplexed through the PRR600s such that each record contained a depth and parameters from every instrument. Figure 2 shows the cabling diagram for these instruments. The calibration history for all these instruments is given in Appendix D.

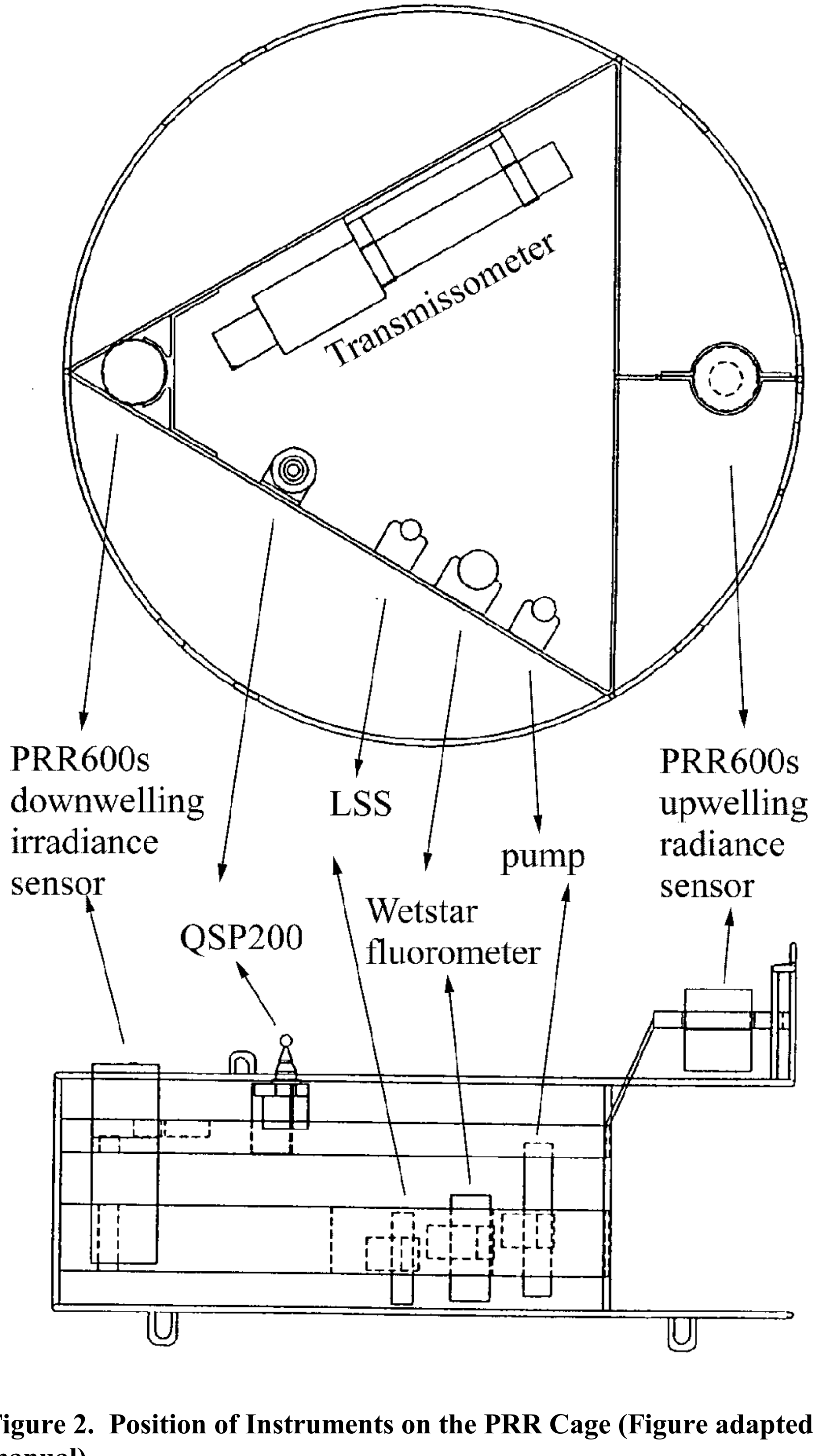

Figure 2. Position of Instruments on the PRR Cage (Figure adapted from BSI manual).

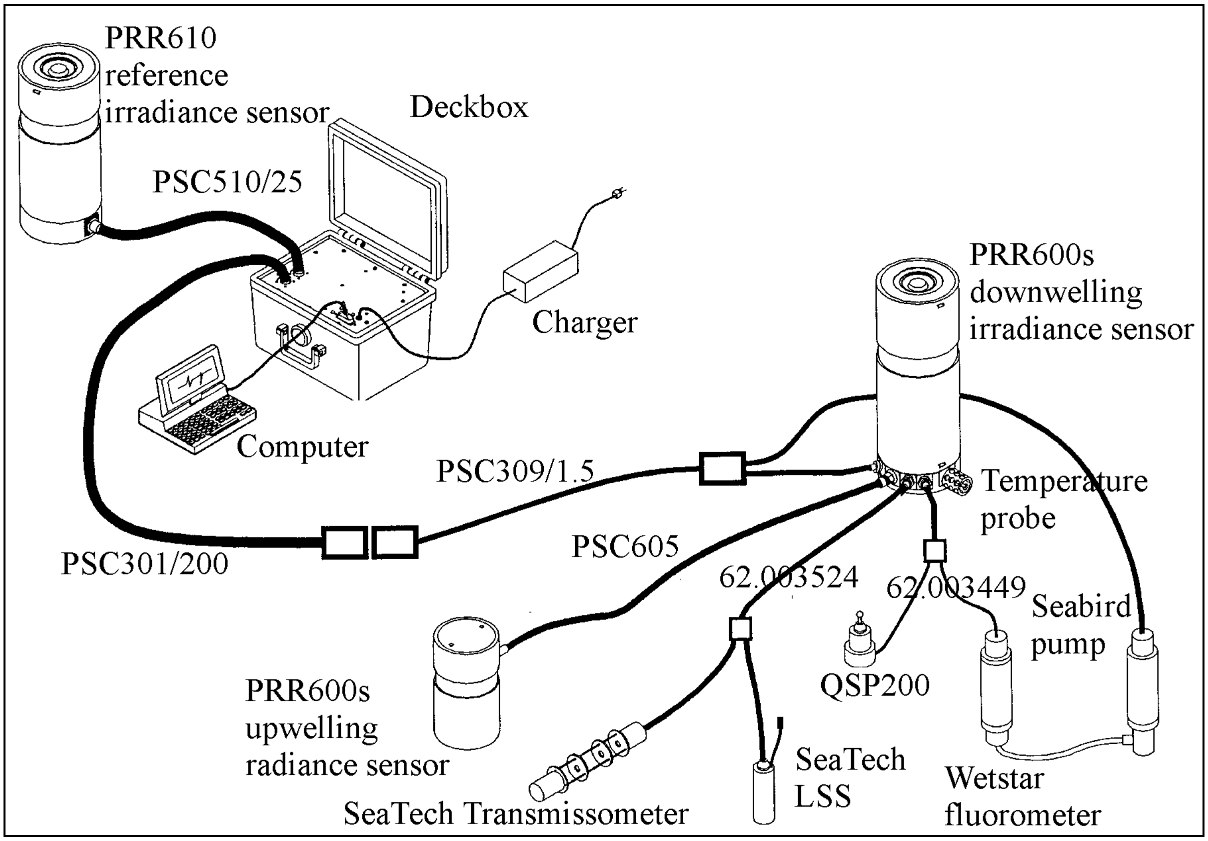

Figure 3. Cabling Diagram for the PRR Cage (Figure adapted from BSI manual)

E. Bottle Samples

Discrete water samples were collected at the same time as the PRR cast, from just below the sea surface using a Niskin bottle. Sample volumes indicated in Table 4 were filtered through glass fiber (GF/F) filters for particulate and CDOM absorption, and for chlorophyll biomass determinations. The particulate and CDOM spectral absorption were measured using a Bausch and Lomb dual beam spectrophotometer between 350 and 750 nm at 1.6 nm resolution following the method of Yentsch and Phinney (1989) and Phinney and Yentsch (1991), respectively. Particulate absorption was calculated as:

$$a_p(m^{-1}) = 2.3 * OD_s * (\frac{\Pi r^2}{V}) * 100$$

where a_p is the particulate absorption (m^{-1}), OD_s is the β corrected optical density in suspension, Πr^2 is the area of particles on the filter pad and V is the volume filtered in milliliters (mL). The chlorophyll *a* samples were cold extracted in 10 mL of 85 percent acetone for 24 hours in the dark and the biomass was determined fluorimetrically with a Turner Designs 111 fluorometer using the method of Yentsch and Menzel (1963).

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 light to the sub-surface. An example header is presented in Appendix C. 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° (flag value greater than 0 in the "aq-1Tilt-1Roll" field), and records where the surface incident irradiance was not uniform (flag value greater than 0 in the "kq-1ed412" field). The temperature, transmissometer, and fluorometer data were despiked, in two passes, with a difference threshold. A moving average was calculated for these channels. The data were separated into upcast and downcast profiles and then binned to 0.5-m bins. Spectral attenuation coefficients were calculated for the optical channels over a five point moving window. Subsurface downwelling irradiance and upwelling radiance were extrapolated to just below the surface using data from the top 3 meters. The statistics for calculation of subsurface irradiance and radiance are shown in Appendix B.

G. Along-Track Measurements

Water from about 1 meter below the sea surface was pumped through a hose with a Y connector using a bilge pump at about 10 gallons a minute. One hose from the Y connector was attached to a WETLabs AC-9 (Serial No. AC90169). The AC-9 was used to measure absorption and beam attenuation at 412, 440, 488, 510, 532, 555, 650, 676, and 715 nm. The filters were narrow band with 10 nm FWHM. The calibration sheet for this instrument can be found in Appendix D. A computer running the WETView software was used to log data at 6 Hertz (Hz) from the AC-9 and each measurement was time stamped. Because the same computer was used to acquire data from the PRR cage, the AC-9 was used only while underway between stations. The AC-9 was strapped inside a bucket and the overflow from this instrument into the bucket was used to maintain it at ambient sea water temperature. Another hose from the Y connector was used to fill a bucket in which a Hydrolab Datasonde 3 Multiprobe logger was immersed. The Datasonde was used to measure temperature, specific conductivity, and salinity. This instrument had an internal data logger with a clock that time stamped each measurement and was set to sample every two minutes. A computer equipped with a Socket Communications PCMCIA card using Trimble Navigation's Global Positioning System (GPS) was used to log time, latitude, longitude, speed, and course of vessel. The clocks on the various computers were synchronized to GPS time and the time stamp on each measurement was used to merge the GPS location with the parameters measured.

IV. Results

The measurements shown here are from extremely complex waters influenced by strong tidal currents and river discharge. The *in-situ* profile data (Figures A1-A25, Appendix A) reveal that there are at least three types of waters that interact with each other at the New York Bight Apex. The Hudson River plume forms a shallow near surface layer that is highly attenuating and rich in phytoplankton (stations 2, 3, 4, 7, 8, and 9). The continental shelf water underlying the plume and north of the plume (station 10) is much less attenuating. The New York Harbor water seems to have a high scattering component, but less phytoplankton biomass (stations 1a, 1b, and 6).

A. Bottle Samples

The surface chlorophyll concentration measured at the various station are shown in Table 4. Particulate absorption measurements are shown in Figure 4 and the dissolved organic matter absorption measurements are shown in Figure 5. Although these absorption measurements were not taken on the same day as the along-track measurements (Figure 6) with the AC-9, the results are comparable (1.25 m^{-1} at 412 nm, outside the plume, to 4.5 m^{-1} at 412 nm, just inside the plume).

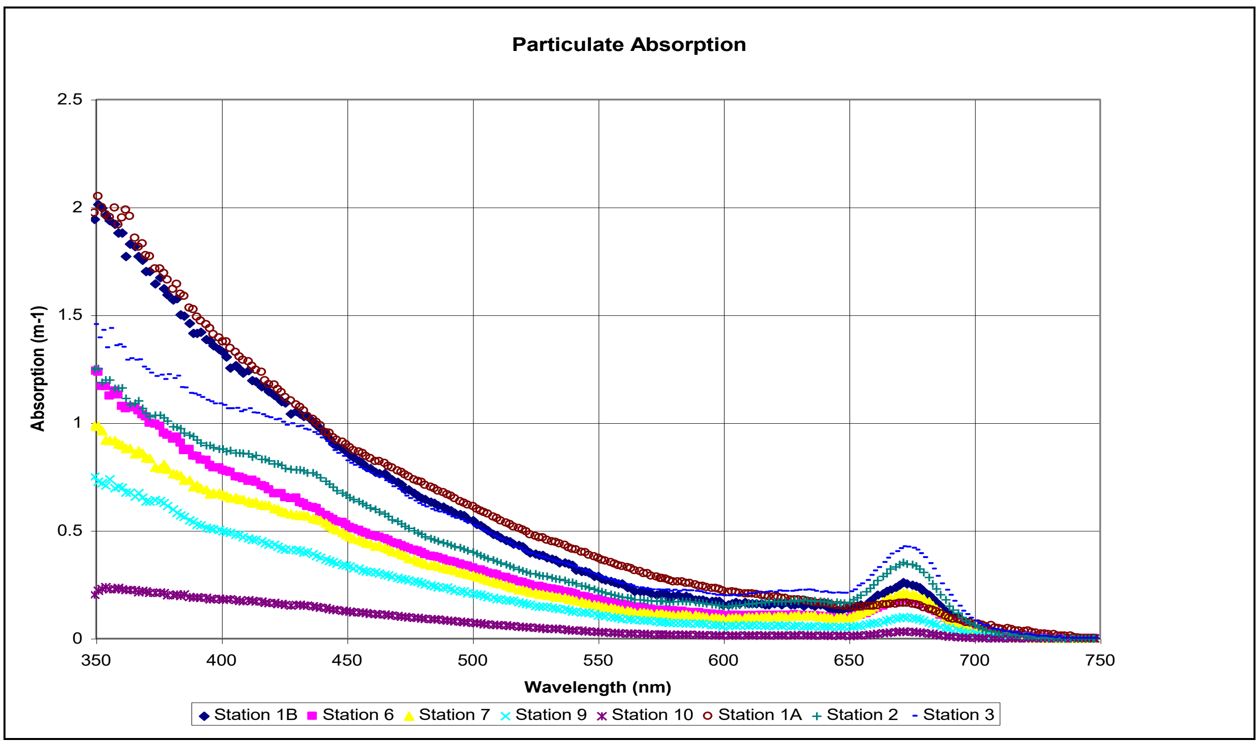

Figure 4. Particulate Absorption

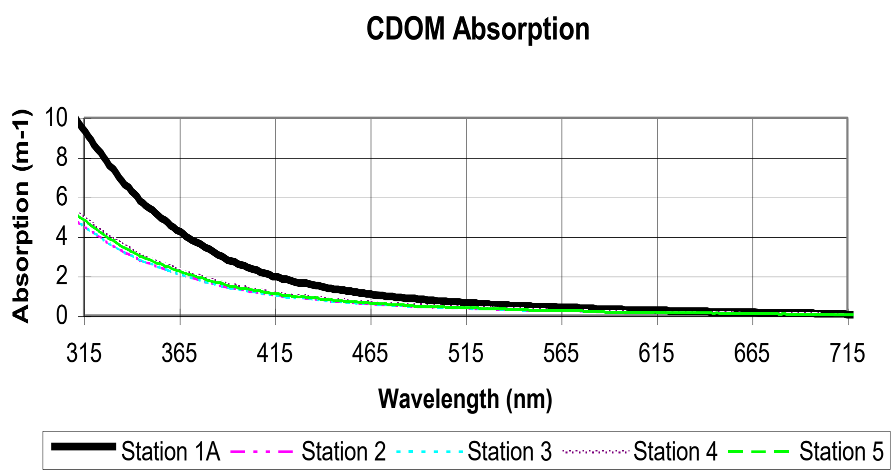

Figure 5. Dissolved Organic Matter Absorption

Date	Station	Latitude	Longitude	ChlVolFil	ChlVolExt	Chlμg/l
5/14/96	1A	40.4983	-74.0525	250	10	2.965
5/14/96	2	40.4452	-73.9437	250	10	17.435
5/14/96	3	40.4503	-73.9167	250	10	21.953
5/14/96	4	40.4567	-73.8350	250	10	15.482
5/14/96	5	40.4602	-73.8230	250	10	14.871
5/15/96	1B	40.5051	-74.0470	100	10	8.529
5/15/96	6	40.4932	-73.8983	250	10	8.047
5/15/96	7	40.4603	-73.8298	250	10	11.294
5/15/96	9	40.4954	-73.8490	250	10	3.576
5/15/96	10	40.5295	-73.8708	250	10	1.212

Table 4. Surface Chlorophyll Concentration

B. Optical Data

It is obvious that the shallow overlying plume severely complicated the interpretation of the measurements in these waters. Dissolved organic matter absorbed light at 380 and 412 nm to an extent that at many stations, there was no measurable upwelling radiance at these wavelengths (stations 1a, 1b, 2, 3, 4, 5, and 6). Valid estimations of the subsurface light field was difficult at the plume-influenced stations. The highly attenuating shallow surface plume often caused an over estimation of the sub-surface light field (stations 4 downcast, and 3 downcast). The upcasts at these stations seem more reasonable. The other peculiar phenomenon seen at some of the deeper plume-influenced stations was the convergence of the spectral attenuation coefficients at 490, 510, and 555 nm. It is possible that the attenuating components of the continental shelf water compensated for the difference in attenuation at these wavelengths due to the absorption of water, but this requires further exploration. Swift tidal currents and vessel traffic in the region affected the maneuverability of the boat. The boat drifted on top of the PRR cage at two stations (station 5 and station 1b) and this can be seen in the much reduced estimated sub-surface downwelling irradiance compared to the surface reference downwelling irradiance (Figures A.2a, A.11a and A.12a). The sub-surface radiance calculated at these stations are not valid.

C. Along-Track Data

The surface absorption and attenuation measurements were well correlated with surface temperature and salinity, demonstrating that the freshwater plume had distinct optical properties (Figure 6). Track AT2 (13:53 to 14:25) showed the sharp increase in absorption and attenuation as the boat steamed from a station dominated by continental shelf water, up the Hudson River. The core of the plume can be identified by the higher absorption, attenuation, temperature, and lower salinity (after 13:53 in Figure 6). The continental shelf water in contrast can be seen as lower attenuation, absorption, temperature, and higher salinity (13:21 to 13:35 in Figure 6).

D. AVHRR-Derived Data

Percent red reflectance, K_{PAR}, and C_{660} were derived from an AVHRR satellite image for each day of the cruise using methods described by Stumpf (1992) and Gould and Arnone (Submitted) respectively. These values were compared to the *in-situ* measurements of K_{PAR} and C_{660} (Table 5). The satellite-derived values were not calculated for stations 1B and 6 because these pixels were covered by clouds. The C_{660} images (Figures 7 and 8) do not map the entire extent of the Hudson River plume; they show only the most turbid waters. The extension of the highly turbid waters to the Ambrose Light Tower occurred on only eight days of the 12 clear AVHRR images for the month of May 1996. This behavior of the plume front is consistent with other observations (Bowman, 1978) - that the direction and extent of the plume was influenced by local wind stress, prevailing shelf currents, tides, and the rate of discharge. The plume has been described as being very dynamic, reversing itself in less than six hours due to changes in local wind stress (Bowman, 1978).

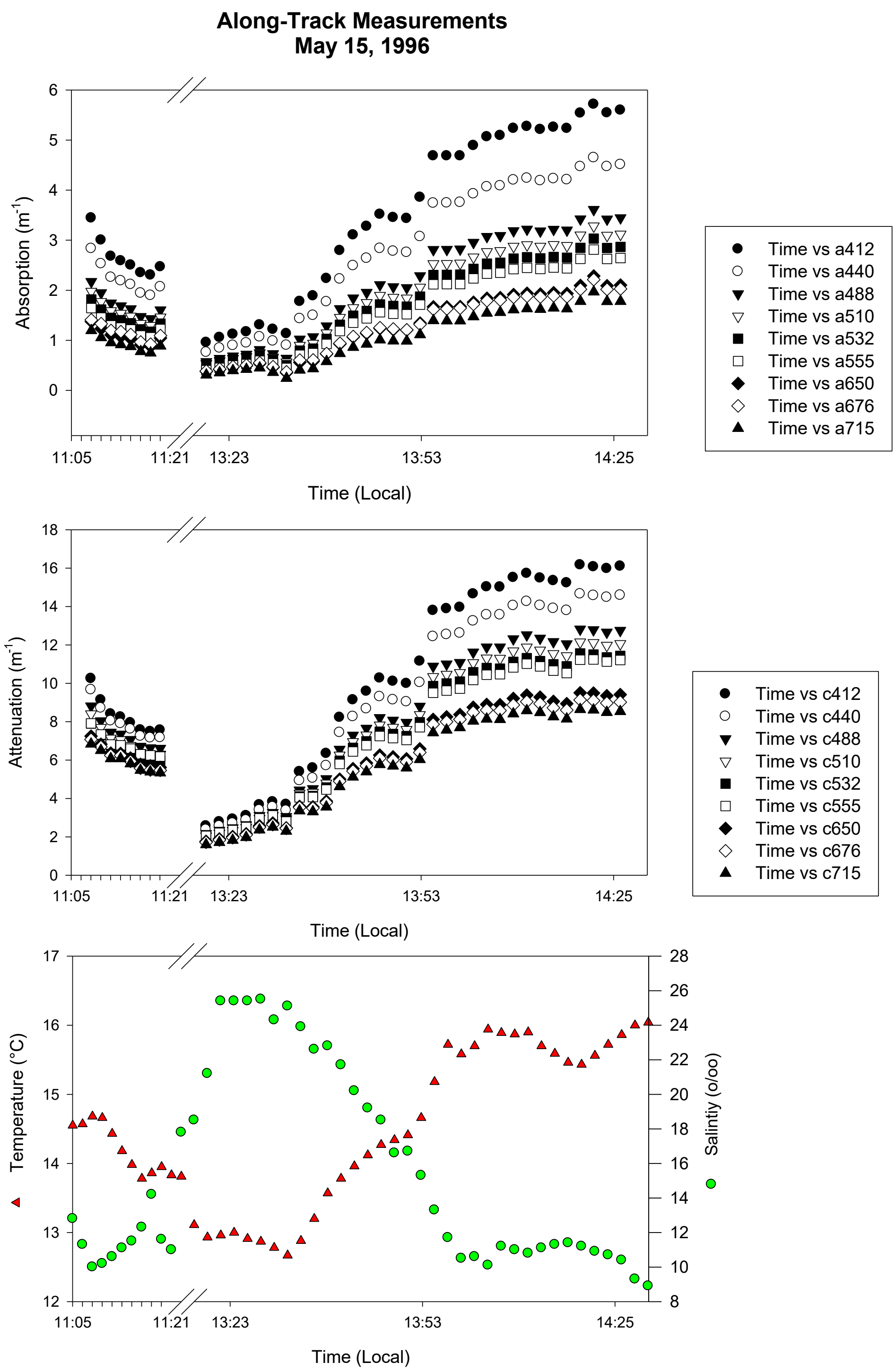

Figure 6. Along-Track Absorption, Attenuation, Temperature, and Salinity

Station	RD DN	%Rd	Satellite K_{PAR}	Satellite C_{660}	*In situ* K_{PAR}	*In situ* C_{660}
1A	42	2.10	2.625	7.259		7.1310
2	17	0.85	0.950	2.275		3.6581
3	30	1.50	1.725	4.525		3.8259
4	22	1.10	1.250	3.125		2.8836
5	19	0.95	1.075	2.600		3.9157
1B						4.5049
6						3.5687
7	11	0.55	0.598	1.302		2.4538
8	13	0.65	0.714	1.614		2.2598
9	7	0.35	0.374	0.730		2.4851
10	1	0.05	0.052	0.060		0.7505

Table 5. AVHRR-Derived Percent Red Reflectance (%Rd), KPAR, C660 and Corresponding In-situ Values

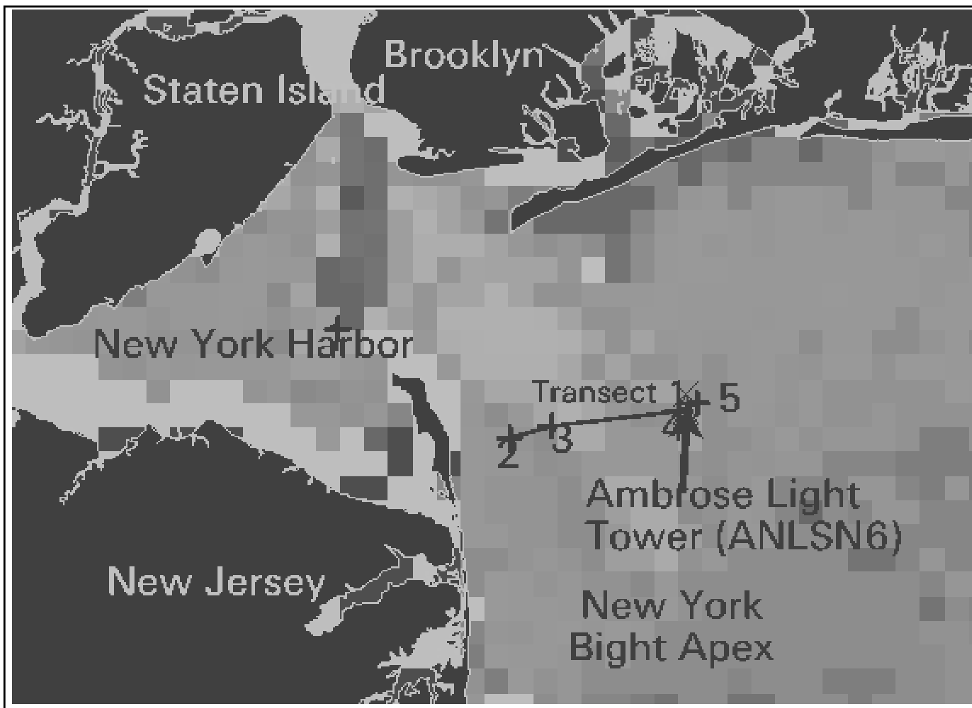

Figure 7. Reflectance Difference Image Calculated Using Bands 1 and 2 of the AVHRR on Board NOAA14 for May 14, 1996

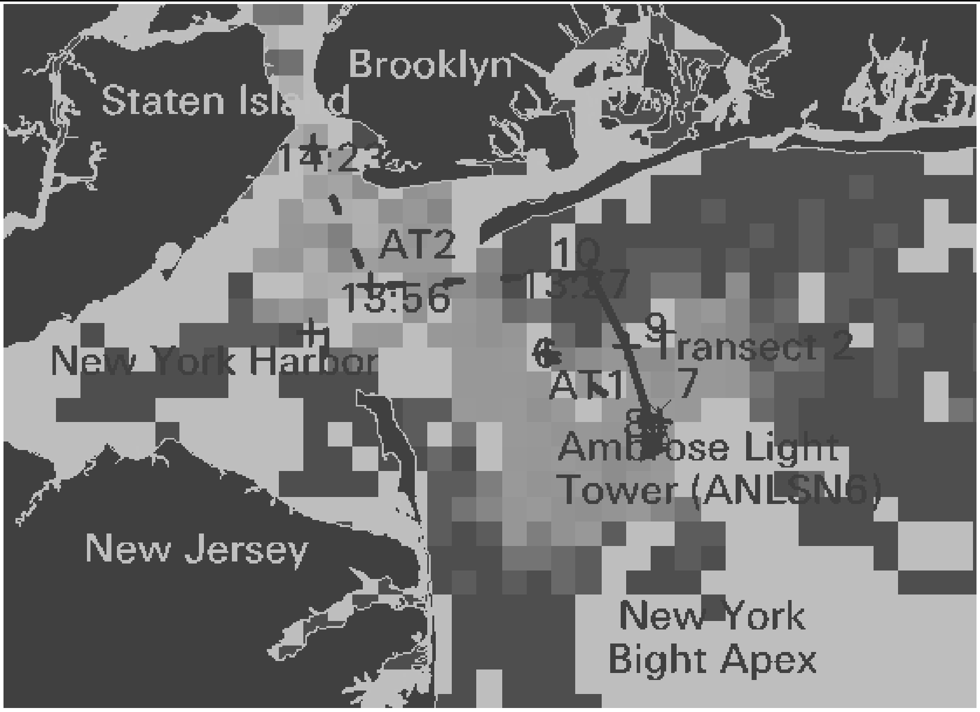

Figure 8. Reflectance Difference Image Calculated Using Bands 1 and 2 of the AVHRR on Board NOAA14 for May 15, 1996

The turbid water associated with the Hudson River plume has a higher reflectance difference, seen as the lighter gray pixels emerging from the Harbor mouth, towards the Ambrose Light Tower. The location of the stations occupied is shown, as is the Ambrose Light Tower. AT1 and AT2 refer to the along-track surface absorption and attenuation measurements shown in Figure 6.

V. Summary

These results show that the Hudson River plume forms quite a sharp front that moves rapidly in the New York Bight Apex, past the Ambrose Light Tower. This suggests that local optical variability due to the Hudson River plume must be considered in any efforts to develop and validate case II bio-optical algorithms for this region. The optical variability provides the opportunity for fusing of data from different satellite sensors to examine problems such as sub-pixel variability.

VI. References

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VII. Metadata

The metadata, including points of contact, 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: 1997
Title: NOAA CSC/CRS Cruise MAY96NY: New York Bight Apex Cruise
Online Linkage: http://www.csc.noaa.gov/crs/cruises/may96ny/index.html

Description
Abstract: See Abstract, page iii
Purpose: See Objectives, page 1

Supplemental_Information:
StartDate: 19961405
StopDate: 19961505
Preview: http://www.csc.noaa.gov/crs/cruises/index.html

Time_Period_of_Content
Time_Period_Information
Single_Date/Time
Calendar_Date: 1996
Currentness_Reference: Publication Date

Status
Progress: Complete
Maintenance_and_Update_Frequency: Unknown

Spatial Domain
Bounding Coordinates:
West Bounding Coordinate: -74.07
East Bounding Coordinate: -73.82
North Bounding Coordinate: 40.62
South Bounding Coordinate: 40.43

Keywords
Theme
Theme_Keyword_Thesaurus: None
Theme_Keyword: oceanography
Theme_Keyword: bio-optical
Theme_Keyword: turbidity
Theme_Keyword: water clarity
Theme_Keyword: blooms
Theme_Keyword: resuspension
Theme_Keyword: spatial variability
Theme_Keyword: river plumes
Theme_Keyword: coastal water optics
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Theme_Keyword: absorption
Theme_Keyword: attenuation
Theme_Keyword: AVHRR
Theme_Keyword: reflectance difference
Theme_Keyword: in-situ optical profiling
Theme_Keyword: ocean color satellites
Theme_Keyword: coastal ocean algorithm development
Place
Place_Keyword_Thesaurus: None
Place_Keyword: Ambrose Light Tower
Place_Keyword: Hudson River
Place_Keyword: New York Bight Apex
Place_Keyword: New York Harbor
Place_Keyword: New York
Place_Keyword: United States
Time
Temporal_Keyword: Spring freshet
Temporal_Keyword: May, 1996
Parameters Measured
Parameter_Keyword: spectral downwelling irradiance
Parameter_Keyword: spectral upwelling radiance
Parameter_Keyword: temperature
Parameter_Keyword: Chlorophyll concentration
Parameter_Keyword: Particulate absorption
Parameter_Keyword: Dissolved absorption
Parameter_Keyword: salinity
Parameter_Keyword: spectral attenuation
Parameter_Keyword: spectral absorption
Parameter_Keyword: beam attenuation at 660 nm
Parameter_Keyword: *in-situ* fluorescence
Parameter_Keyword: Scalar quantum irradiance
Parameter_Keyword: Light scattering

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
Address: 2234 South Hobson Avenue
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: 8AM-5PM, M-F

B. Citation Information

Source Citation: Subramaniam, A., K.J. Waters, E.M. Armstrong, J.C. Brock, A.W. Meredith, and R.O. Ranheim. 1997. NOAA CSC/CRS Cruise MAY96NY: New York Bight Apex Cruise. CSC Technical Report CSC/6-97/001. NOAA Coastal Services Center. Charleston, SC. Pp30.

Currentness: June 1997

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 1

Spectroradiometer measurements:	Spectral downwelling irradiance (*in-situ* and above surface), spectral upwelling radiance, temperature
Instruments:	PRR600s, PRR610
Manufacturer:	Biospherical Instruments, Inc.
Address:	5340 Riley Street San Diego, CA 92110-2621
Phone:	(619) 686.1888

Beam attenuation: C660
Instrument: SeaTech transmissometer
Manufacturer: Sea Tech, Inc.
Address: 825 NE Circle Blvd.
Corvallis, OR 97330
Phone: (206) 757-9716

Fluorescence: Fluorometer
Instrument: WetStar fluorometer
Manufacturer: WET Labs, Inc
Address: 620 Applegate Street
Philomath, OR 97370
Phone: (541) 929-5650

Light scattering
Instrument: SeaTech LSS
Manufacturer: Sea Tech, Inc.
Address: 825 NE Circle Blvd.
Corvallis, OR 97330
Phone: (206) 757-9716

Quantum scalar irradiance.
Instrument: QSP200
Manufacturer: Biospherical Instruments, Inc.
Address: 5340 Riley Street
San Diego, CA 92110-2621
Phone: (619) 686.1888

Spectral attenuation and absorption
Instrument: WetLabs AC-9
Manufacturer: WET Labs, Inc
Address: 620 Applegate Street
Philomath, OR 97370
Phone: (541) 929-5650

GPS position and time
Instrument: Socket Communications PCMCIA GPS Card
Manufacturer: Socket Communications
6500 Kaiser Drive
Fremont, CA 94555
Phone: 1-800-552-3300

Surface temperature, salinity.
Instrument: Hydrolabs Datasonde-3
Manufacterer: Hydrolab Corporation

P.O. Box 50116
Austin, TX 78763
Phone: 1-800-949-3766

Operator: Ajit Subramaniam
Address: see point of contact

Chlorophyll measurements:
Methods reference: Yentsch, C.S. and D.W. Menzel, 1963. A method for determination of phytoplankton chlorophyll and phaeophytin by fluorescence. *Deep Sea Research*, **10**, 221-231.

Absorption measurements:
Yentsch, C.S. and D.A. Phinney, 1989. "A bridge between ocean optics and microbial ecology". Limnology and Oceanography. **34**: 1698-1709.

Phinney, D.A. and C.S. Yentsch, 1991. On the contribution of particles to blue light attenuation in the sea. Journal of Plankton Research. **13** Supplement, 143-152.

Analysts: David and Douglas Phinney, Jeff Brown and Sara Woodman
Address: Bigelow Laboratory for Ocean Sciences
McKown Point Road
West Boothbay Harbor, ME, 04575
Telephone: (207) 633-9600.

Attribute Accuracy: See Appendix D

Horizontal Positional Accuracy: 400 m

Entity and Attribute Overview Description: See Methods, page 1

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.

VIII. Appendix A - Water Column Profile Data Figures

The following pages contain figures that show the *in-situ* water column profile data.

IX. Appendix B - Sub-Surface Light Field Estimation Statistics

The following pages contain tables with the statistics for calculation of the sub-surface light field. The column "channel" refers to the optical channel, "min depth" and "max depth" are the minimum and maximum depths used in the calculation, and "n points" is the number of points used in the calculation. "b0" is the intercept of the regression - the estimated sub-surface light (irradiance and radiance). "b1" is the slope of the regression - the estimated attenuation coefficient. The columns "min", "max", and "mean" refer to the minimum, maximum and mean irradiance or radiance values used in the calculation. The columns "std dev", "var", "uncertainty", and "abdev" refer to the estimates of the intercept.

channel	min depth	max depth	n points	b0	b1	min	max	mean	std dev	var	uncertainty	abdev
5 Downcast												
ed380	0.5	6	6	31.9801	0.09	0.02	10.19	0.31	10.16	215.65	1.51	0.09
ed412	0.5	3	6	74.7320	0.14	0.13	25.58	1.64	6.57	34.66	1.23	0.05
ed443	0.5	3	6	92.6655	0.21	0.67	40.05	4.55	4.36	8.72	1.19	0.03
ed490	0.5	3	6	115.0751	0.33	3.44	63.34	13.53	2.85	3.00	1.11	0.02
ed510	0.5	3	6	119.4230	0.38	5.73	71.25	18.74	2.48	2.27	1.08	0.02
ed555	0.5	3	6	127.2310	0.50	14.14	87.57	33.79	1.93	1.54	1.04	0.01
lu380	0.5	3										
lu412	0.5	3										
lu443	0.5	3	6	0.1778	0.22	0.00	0.08	0.01	4.36	8.74	1.24	0.04
lu490	0.5	3	6	0.4169	0.34	0.01	0.23	0.05	2.81	2.91	1.14	0.03
lu510	0.5	3	6	0.5334	0.39	0.03	0.32	0.09	2.45	2.23	1.11	0.02
lu555	0.5	3	6	0.9389	0.50	0.10	0.64	0.25	1.96	1.57	1.07	0.02
lu683	0.5	3	6	0.3617	0.36	0.01	0.21	0.05	2.68	2.65	1.08	0.02
4 Upcast												
ed380	0.5	6	6	15.5313	0.07	0.00	2.03	0.08	10.78	284.98	1.68	0.12
ed412	0.5	3	6	78.3556	0.10	0.02	10.31	0.65	9.53	160.92	1.90	0.12
ed443	0.5	3	6	113.3116	0.17	0.30	23.49	2.99	5.20	15.17	1.23	0.05
ed490	0.5	3	6	138.6259	0.28	2.09	45.06	10.51	3.20	3.87	1.15	0.03
ed510	0.5	3	6	140.8529	0.33	3.55	52.49	14.60	2.78	2.84	1.12	0.02
ed555	0.5	3	6	131.7043	0.44	9.08	66.31	25.30	2.13	1.77	1.04	0.01
lu380	0.5	3										
lu412	0.5	3										
lu443	0.5	3	4	0.3451	0.14	0.00	0.06	0.02	3.22	3.92	1.73	0.05
lu490	0.5	3	6	0.8265	0.23	0.01	0.21	0.04	3.80	5.94	1.30	0.05
lu510	0.5	3	6	0.9619	0.27	0.01	0.28	0.07	3.29	4.12	1.26	0.05
lu555	0.5	3	6	1.1981	0.38	0.05	0.51	0.17	2.41	2.17	1.13	0.03
lu683	0.5	3	6	0.4230	0.30	0.01	0.13	0.04	3.01	3.37	1.34	0.07

channel	min depth	max depth	n points	b0	b1	min	max	mean	std dev	var	uncertainty	abdev
3 Upcast												
ed380	0.5	6	3	23.6508	0.02	0.03	2.98	0.22	10.64	267.77	5.85	0.13
ed412	0.5	3	4	60.6750	0.06	0.09	12.41	0.88	7.99	75.09	1.30	0.04
ed443	0.5	3	6	83.7598	0.12	0.08	25.64	1.19	8.22	84.65	1.08	0.02
ed490	0.5	3	6	109.9955	0.22	0.76	46.24	5.44	4.45	9.27	1.07	0.02
ed510	0.5	3	6	119.3484	0.26	1.46	54.08	8.31	3.72	5.61	1.08	0.02
ed555	0.5	3	6	124.6230	0.37	4.67	68.30	17.01	2.66	2.60	1.07	0.02
lu380	0.5	3										
lu412	0.5	3										
lu443	0.5	3	3	0.3193	0.08	0.00	0.08	0.01	4.91	12.61	2.09	0.05
lu490	0.5	3	6	0.6214	0.18	0.00	0.26	0.02	5.32	16.31	1.15	0.03
lu510	0.5	3	6	0.8068	0.22	0.01	0.36	0.04	4.41	9.07	1.13	0.03
lu555	0.5	3	6	1.2261	0.32	0.03	0.66	0.13	3.00	3.35	1.08	0.01
lu683	0.5	3	6	0.5694	0.23	0.01	0.26	0.03	4.12	7.43	1.07	0.02
2 Downcast												
ed380	0.5	6	6	22.5491	0.08	0.01	8.91	0.16	13.89	1017.16	1.69	0.12
ed412	0.5	3	6	87.4408	0.09	0.03	22.82	0.73	11.86	452.43	1.45	0.10
ed443	0.5	3	6	103.9653	0.14	0.20	36.27	2.38	6.80	39.50	1.15	0.04
ed490	0.5	3	6	126.1298	0.25	1.43	56.62	8.33	3.91	6.40	1.15	0.03
ed510	0.5	3	6	129.5520	0.30	2.59	62.38	12.11	3.24	4.00	1.17	0.04
ed555	0.5	3	6	133.1862	0.42	8.05	77.16	24.37	2.31	2.01	1.16	0.03
lu380	0.5	3										
lu412	0.5	3										
lu443	0.5	3	4	0.2534	0.12	0.00	0.09	0.01	4.62	10.39	1.09	0.01
lu490	0.5	3	6	0.4758	0.23	0.01	0.23	0.03	4.09	7.28	1.19	0.03
lu510	0.5	3	6	0.5969	0.28	0.01	0.32	0.05	3.47	4.70	1.10	0.02
lu555	0.5	3	6	0.9923	0.41	0.06	0.63	0.17	2.46	2.25	1.05	0.01
lu683	0.5	3	6	0.4721	0.27	0.01	0.22	0.04	3.58	5.10	1.18	0.04
2 Upcast												
ed380	0.5	6	6	16.6552	0.08	0.01	5.67	0.12	11.77	435.71	1.92	0.17
ed412	0.5	3	6	70.3623	0.08	0.02	16.30	0.53	11.45	381.39	1.54	0.08
ed443	0.5	3	6	79.8769	0.14	0.17	27.85	1.82	6.49	33.05	1.12	0.03
ed490	0.5	3	6	101.5760	0.25	1.26	48.08	6.92	3.81	5.97	1.07	0.02
ed510	0.5	3	6	108.2007	0.30	2.35	56.50	10.49	3.21	3.91	1.07	0.02
ed555	0.5	3	6	115.4721	0.42	7.48	72.32	22.08	2.30	2.00	1.07	0.01
lu380	0.5	3										
lu412	0.5	3										
lu443	0.5	3	4	0.1491	0.13	0.00	0.05	0.01	4.32	8.49	1.06	0.01
lu490	0.5	3	6	0.3180	0.26	0.00	0.15	0.02	3.65	5.35	1.16	0.04
lu510	0.5	3	6	0.4106	0.30	0.01	0.22	0.04	3.14	3.70	1.10	0.02
lu555	0.5	3	6	0.7351	0.43	0.05	0.47	0.14	2.28	1.97	1.06	0.01
lu683	0.5	3	6	0.3182	0.28	0.01	0.16	0.03	3.42	4.54	1.16	0.03

channel	min depth	max depth	n points	b0	b1	min	max	mean	std dev	var	uncertainty	abdev
1A Downcast												
ed380	0.5	6	3	8.8885	0.01	0.00	0.76	0.03	19.18	6161.13	1714.74	0.53
ed412	0.5	3	2	84.3262	0.00	0.08	3.69	0.54	14.97	1514.40	inf	0.00
ed443	0.5	3	5	55.9098	0.04	0.01	9.18	0.20	14.90	1478.97	1.73	0.10
ed490	0.5	3	6	54.3123	0.12	0.06	19.49	0.79	8.45	94.98	1.29	0.06
ed510	0.5	3	6	59.2461	0.15	0.13	23.28	1.37	6.67	36.54	1.21	0.04
ed555	0.5	3	6	71.2806	0.22	0.52	32.28	3.36	4.58	10.16	1.12	0.03
lu380	0.5	3										
lu412	0.5	3										
lu443	0.5	3	2	0.2596	0.02	0.00	0.03	0.01	6.11	26.54	inf	0.00
lu490	0.5	3	4	0.4854	0.10	0.00	0.13	0.02	5.53	18.59	1.58	0.05
lu510	0.5	3	6	0.4200	0.16	0.00	0.20	0.01	6.37	30.84	1.46	0.09
lu555	0.5	3	6	0.7518	0.23	0.01	0.39	0.04	4.48	9.45	1.28	0.06
lu683	0.5	3	6	0.5855	0.20	0.00	0.26	0.02	5.06	13.86	1.22	0.05
1A Upcast												
ed380	0.5	6	3	1.7048	0.04	0.01	0.30	0.02	9.43	153.62	784.25	0.48
ed412	0.5	3										
ed443	0.5	3	5	73.0868	0.02	0.00	6.70	0.10	24.64	28766.50	1.86	0.12
ed490	0.5	3	6	60.8590	0.08	0.03	15.86	0.47	11.03	317.91	1.80	0.12
ed510	0.5	3	6	69.3541	0.11	0.07	20.67	0.87	8.69	107.11	1.69	0.10
ed555	0.5	3	6	78.6495	0.16	0.30	29.51	2.26	5.73	21.04	1.59	0.09
lu380	0.5	3										
lu412	0.5	3										
lu443	0.5	3										
lu490	0.5	3	4	0.3489	0.12	0.00	0.11	0.02	4.88	12.30	1.13	0.02
lu510	0.5	3	5	0.4706	0.15	0.00	0.17	0.02	5.15	14.71	1.10	0.02
lu555	0.5	3	6	0.8317	0.22	0.01	0.37	0.04	4.38	8.86	1.21	0.04
lu683	0.5	3	6	0.5960	0.20	0.00	0.25	0.02	4.91	12.62	1.21	0.04
6 Downcast												
ed380	0.5	6	6	13.0363	0.07	0.00	8.13	0.07	19.22	6240.48	5.69	0.39
ed412	0.5	3	5	119.3507	0.06	0.04	21.34	0.92	10.84	292.98	1.75	0.10
ed443	0.5	3	6	121.7009	0.14	0.19	34.89	2.13	7.07	45.78	1.48	0.09
ed490	0.5	3	6	129.8997	0.25	1.43	54.60	8.02	3.96	6.66	1.21	0.05
ed510	0.5	3	6	118.2897	0.31	2.58	57.32	11.50	3.25	4.02	1.11	0.03
ed555	0.5	3	6	121.7557	0.43	7.23	69.99	22.11	2.38	2.12	1.09	0.02
lu380	0.5	3										
lu412	0.5	3										
lu443	0.5	3	4	0.3241	0.13	0.00	0.11	0.02	4.60	10.27	1.63	0.07
lu490	0.5	3	6	0.7014	0.24	0.01	0.31	0.04	4.23	8.02	1.18	0.04
lu510	0.5	3	6	0.8893	0.29	0.01	0.42	0.07	3.53	4.92	1.12	0.03
lu555	0.5	3	6	1.4041	0.39	0.06	0.78	0.21	2.61	2.51	1.06	0.01
lu683	0.5	3	6	0.5476	0.28	0.01	0.25	0.04	3.65	5.34	1.08	0.02

channel	min depth	max depth	n points	b0	b1	min	max	mean	std dev	var	uncertainty	abdev
6 Upcast												
ed380	0.5	6	4	21.3891	0.03	0.01	2.52	0.10	12.09	499.69	2.08	0.10
ed412	0.5	3	5	52.8681	0.07	0.03	10.81	0.50	9.62	167.92	1.26	0.04
ed443	0.5	3	6	73.6554	0.15	0.16	23.90	1.64	6.15	27.12	1.15	0.03
ed490	0.5	3	6	96.9252	0.26	1.32	44.06	6.76	3.56	5.00	1.13	0.03
ed510	0.5	3	6	98.2530	0.32	2.50	51.53	10.04	2.99	3.33	1.11	0.03
ed555	0.5	3	6	96.1126	0.44	6.85	63.61	18.87	2.24	1.91	1.12	0.02
lu380	0.5	3										
lu412	0.5	3										
lu443	0.5	3	4	0.1038	0.16	0.00	0.04	0.01	3.59	5.13	1.27	0.03
lu490	0.5	3	6	0.2456	0.31	0.01	0.12	0.02	3.14	3.71	1.20	0.04
lu510	0.5	3	6	0.3097	0.37	0.01	0.17	0.04	2.64	2.56	1.23	0.04
lu555	0.5	3	6	0.5328	0.50	0.05	0.35	0.13	1.97	1.59	1.19	0.04
lu683	0.5	3	6	0.1454	0.41	0.01	0.09	0.02	2.45	2.22	1.32	0.06
7 Downcast												
ed380	0.5	6	6	14.7059	0.20	0.09	9.12	0.61	5.48	18.07	1.96	0.15
ed412	0.5	3	6	45.7027	0.27	0.73	27.67	3.48	3.79	5.91	1.45	0.09
ed443	0.5	3	6	72.9203	0.35	2.62	48.09	9.14	2.92	3.15	1.33	0.07
ed490	0.5	3	6	99.9322	0.47	9.30	74.34	22.71	2.15	1.80	1.21	0.05
ed510	0.5	3	6	106.2137	0.51	13.08	80.50	28.61	1.96	1.57	1.16	0.04
ed555	0.5	3	6	116.6059	0.60	23.84	92.25	43.04	1.65	1.29	1.08	0.02
lu380	0.5	3										
lu412	0.5	3	2	0.1553	0.17	0.02	0.06	0.03	2.46	2.24	inf	0.00
lu443	0.5	3	6	0.2031	0.29	0.00	0.12	0.02	3.36	4.35	1.43	0.09
lu490	0.5	3	6	0.4384	0.42	0.03	0.31	0.08	2.35	2.07	1.31	0.07
lu510	0.5	3	6	0.5601	0.45	0.05	0.41	0.12	2.17	1.82	1.27	0.06
lu555	0.5	3	6	0.9282	0.50	0.12	0.68	0.25	1.92	1.53	1.19	0.04
lu683	0.5	3	6	0.3799	0.34	0.01	0.21	0.05	2.75	2.78	1.12	0.02
7 Upcast												
ed380	0.5	6	6	17.0709	0.15	0.04	8.08	0.44	6.89	41.58	1.54	0.11
ed412	0.5	3	6	54.9031	0.20	0.35	23.71	2.48	4.81	11.82	1.13	0.02
ed443	0.5	3	6	77.5145	0.28	1.34	40.10	6.69	3.55	4.99	1.07	0.02
ed490	0.5	3	6	100.8060	0.41	5.56	62.98	17.76	2.48	2.28	1.07	0.02
ed510	0.5	3	6	110.3056	0.45	8.35	72.56	23.45	2.24	1.91	1.05	0.01
ed555	0.5	3	6	122.0804	0.54	16.91	88.57	37.12	1.84	1.45	1.03	0.01
lu380	0.5	3										
lu412	0.5	3										
lu443	0.5	3	6	0.2116	0.24	0.00	0.11	0.01	4.11	7.35	1.33	0.07
lu490	0.5	3	6	0.4628	0.36	0.02	0.30	0.07	2.74	2.76	1.24	0.05
lu510	0.5	3	6	0.5820	0.40	0.03	0.39	0.10	2.47	2.27	1.20	0.05
lu555	0.5	3	6	0.9517	0.47	0.09	0.66	0.22	2.11	1.74	1.11	0.02
lu683	0.5	3	6	0.4363	0.31	0.01	0.20	0.04	3.14	3.71	1.24	0.05

channel	min depth	max depth	n points	b0	b1	min	max	mean	std dev	var	uncertainty	abdev
8 Downcast												
ed380	0.5	6	6	35.8297	0.11	0.02	12.12	0.39	11.00	314.56	1.57	0.11
ed412	0.5	3	6	99.5963	0.16	0.19	30.95	2.53	6.52	33.53	1.42	0.08
ed443	0.5	3	6	123.1292	0.25	1.08	49.38	7.63	4.09	7.26	1.33	0.07
ed490	0.5	3	6	145.3355	0.37	4.87	72.51	19.74	2.71	2.71	1.28	0.06
ed510	0.5	3	6	144.5218	0.42	7.30	81.85	25.17	2.43	2.21	1.18	0.04
ed555	0.5	3	6	144.6441	0.51	14.81	96.34	38.51	1.98	1.60	1.13	0.03
lu380	0.5	3										
lu412	0.5	3	2	0.1671	0.20	0.02	0.07	0.04	2.21	1.87	inf	0.00
lu443	0.5	3	6	0.4060	0.23	0.00	0.17	0.02	4.58	10.12	1.30	0.06
lu490	0.5	3	6	0.9127	0.33	0.02	0.42	0.10	2.99	3.33	1.32	0.06
lu510	0.5	3	6	1.0957	0.38	0.04	0.55	0.15	2.64	2.57	1.29	0.05
lu555	0.5	3	6	1.6089	0.46	0.12	0.92	0.35	2.14	1.78	1.23	0.05
lu683	0.5	3	6	0.4422	0.38	0.02	0.24	0.07	2.66	2.60	1.18	0.04
8 Upcast												
ed380	0.5	6	6	15.91	0.10	0.01	6.77	0.17	11.29	356.30	1.99	0.18
ed412	0.5	3	6	54.36	0.15	0.09	19.50	1.16	7.14	47.67	1.24	0.04
ed443	0.5	3	6	74.55	0.23	0.58	34.46	3.89	4.51	9.68	1.20	0.04
ed490	0.5	3	6	94.61	0.34	2.82	52.64	10.93	2.96	3.26	1.17	0.03
ed510	0.5	3	6	92.23	0.40	4.44	55.87	14.46	2.58	2.46	1.15	0.03
ed555	0.5	3	6	94.63	0.49	9.39	64.55	22.90	2.07	1.70	1.15	0.03
lu380	0.5	3										
lu412	0.5	3	2	0.17	0.15	0.02	0.06	0.03	2.44	2.21	inf	0.00
lu443	0.5	3	6	0.39	0.20	0.00	0.15	0.02	5.12	14.40	1.16	0.03
lu490	0.5	3	6	0.85	0.31	0.02	0.41	0.08	3.27	4.08	1.17	0.03
lu510	0.5	3	6	1.03	0.35	0.03	0.54	0.13	2.86	3.01	1.15	0.03
lu555	0.5	3	6	1.51	0.44	0.10	0.90	0.30	2.25	1.94	1.13	0.03
lu683	0.5	3	6	0.43	0.37	0.01	0.24	0.06	2.82	2.92	1.18	0.04
9 Downcast												
ed380	0.5	6	12	19.7078	0.18	0.00	15.59	0.06	17.02	3086.73	4.41	0.72
ed412	0.5	3	6	104.7150	0.17	0.31	37.55	3.09	5.98	24.48	1.28	0.07
ed443	0.5	3	6	135.5787	0.24	1.22	55.68	7.91	4.20	7.87	1.35	0.07
ed490	0.5	3	6	149.4834	0.36	5.23	77.22	19.84	2.76	2.81	1.30	0.06
ed510	0.5	3	6	143.5129	0.41	7.57	79.53	24.44	2.44	2.21	1.29	0.06
ed555	0.5	3	6	139.8076	0.52	16.00	89.25	37.94	1.92	1.54	1.24	0.05
lu380	0.5	3										
lu412	0.5	3	2	0.2094	0.14	0.02	0.08	0.04	2.79	2.87	inf	0.00
lu443	0.5	3	6	0.3197	0.21	0.00	0.16	0.01	4.87	12.29	1.20	0.05
lu490	0.5	3	6	0.5928	0.34	0.02	0.37	0.07	3.01	3.37	1.14	0.04
lu510	0.5	3	6	0.6898	0.39	0.03	0.45	0.11	2.64	2.57	1.12	0.03
lu555	0.5	3	6	1.0344	0.50	0.11	0.75	0.26	2.05	1.67	1.06	0.02
lu683	0.5	3	6	0.4289	0.35	0.01	0.23	0.05	2.83	2.95	1.15	0.03

channel	min depth	max depth	n points	b0	b1	min	max	mean	std dev	var	uncertainty	abdev
9 Upcast												
ed380	0.5	6	11	1.5984	0.37	0.01	1.48	0.03	6.61	35.43	3.72	0.59
ed412	0.5	3	5	52.6376	0.18	0.18	7.03	1.09	4.40	9.00	1.32	0.04
ed443	0.5	3	5	95.6514	0.23	0.75	15.73	3.33	3.41	4.51	1.29	0.04
ed490	0.5	3	5	115.5263	0.35	3.59	33.78	10.71	2.47	2.26	1.15	0.02
ed510	0.5	3	5	127.6746	0.38	5.46	41.46	14.68	2.28	1.97	1.18	0.03
ed555	0.5	3	5	131.1176	0.49	12.08	56.47	25.76	1.87	1.48	1.17	0.03
lu380	0.5	3										
lu412	0.5	3										
lu443	0.5	3	5	0.1029	0.27	0.00	0.03	0.01	3.01	3.36	1.33	0.04
lu490	0.5	3	5	0.2821	0.40	0.01	0.10	0.04	2.17	1.82	1.13	0.02
lu510	0.5	3	5	0.3638	0.45	0.03	0.15	0.06	1.99	1.60	1.09	0.01
lu555	0.5	3	5	0.6967	0.53	0.09	0.34	0.17	1.69	1.32	1.07	0.01
lu683	0.5	3	5	0.2909	0.36	0.01	0.09	0.03	2.37	2.11	1.13	0.01
10 Downcast												
ed380	0.5	6	12	55.0671	0.43	0.30	31.34	3.12	4.56	9.98	1.15	0.07
ed412	0.5	3	6	97.1773	0.57	15.54	66.67	32.52	1.71	1.33	1.09	0.02
ed443	0.5	3	6	119.5759	0.68	31.69	92.13	55.74	1.48	1.17	1.10	0.02
ed490	0.5	3	6	140.4445	0.77	54.44	117.35	82.55	1.32	1.08	1.12	0.03
ed510	0.5	3	6	142.5764	0.78	57.38	120.69	86.14	1.30	1.07	1.15	0.03
ed555	0.5	3	6	139.5443	0.81	62.94	120.78	90.59	1.27	1.06	1.13	0.02
lu380	0.5	3	5	0.1191	0.45	0.01	0.07	0.03	1.94	1.55	1.09	0.02
lu412	0.5	3	6	0.2905	0.57	0.05	0.21	0.10	1.78	1.39	1.10	0.02
lu443	0.5	3	6	0.5315	0.65	0.13	0.40	0.22	1.56	1.22	1.07	0.01
lu490	0.5	3	6	1.0403	0.74	0.39	0.85	0.58	1.35	1.09	1.06	0.01
lu510	0.5	3	6	1.1586	0.77	0.48	0.96	0.68	1.30	1.07	1.05	0.01
lu555	0.5	3	6	1.3488	0.80	0.66	1.15	0.88	1.24	1.05	1.04	0.01
lu683	0.5	3	6	0.2115	0.66	0.05	0.16	0.09	1.51	1.19	1.06	0.01
10 Upcast												
ed380	0.5	6	12	50.22	0.43	0.28	25.29	2.62	4.45	9.30	1.09	0.04
ed412	0.5	3	6	92.27	0.56	13.01	58.97	28.02	1.77	1.38	1.11	0.03
ed443	0.5	3	6	122.20	0.64	27.89	87.25	49.44	1.53	1.20	1.08	0.02
ed490	0.5	3	6	137.11	0.75	50.45	109.72	74.74	1.34	1.09	1.08	0.02
ed510	0.5	3	6	134.81	0.77	55.45	110.33	78.58	1.29	1.07	1.10	0.02
ed555	0.5	3	6	132.31	0.80	61.63	111.11	82.87	1.25	1.05	1.13	0.02
lu380	0.5	3	4	0.10	0.46	0.02	0.05	0.03	1.70	1.32	1.51	0.04
lu412	0.5	3	6	0.27	0.55	0.04	0.17	0.08	1.78	1.39	1.13	0.02
lu443	0.5	3	6	0.50	0.63	0.11	0.35	0.19	1.56	1.22	1.10	0.02
lu490	0.5	3	6	0.99	0.74	0.35	0.78	0.52	1.35	1.10	1.06	0.01
lu510	0.5	3	6	1.10	0.76	0.43	0.89	0.63	1.31	1.08	1.06	0.01
lu555	0.5	3	6	1.27	0.81	0.60	1.08	0.82	1.24	1.05	1.06	0.01
lu683	0.5	3	6	0.20	0.66	0.05	0.14	0.08	1.51	1.19	1.08	0.02

X. Appendix C - Example Profile Header Information

The following text is an example of the header information found in each BBOP processed profile file.

<cruise_info>
filename p960514a
date 05-14-1996
day_of_year 135
day_since_010192 1596
file_created 11:43:44
cruise station 5 ambrose light tower
position 73 49.38 40 27.61
longitude 73 49.38
latitude 40 27.61
sky_state clear
operator_name ajit
sun_position 3
cruise_id new york harbor ambrose light cruise
session_started 11:43:59
depth_offset 0.32
transmiss_offset .0032
trans_air_calib 4.821
trans_factory_air_calib 4.711
trans_sn 664
most_recent_dark_file d960515a
deck_comparison_file
cal_date_uw9643 032696
cal_date_sfc9644 032696
downcast_ended 11:46:12.941 224
upcast_ended 11:49:40.890 577
yoyo no
closest_CTD_cast none
sun_intensity bright
cloud_type
cloud_amt
wind_speed_and_dir
swell
collection_software_version prrprof_002086c
number_units 1
collection_cal_file 96439644.cfl;prr-600 #9643/9644 calibration file 3/26/96 cac
lcd_calib_file 0 /csc/nep1/coors/bbops/BUILD/calib/unit0_032696.cfl
 1 /csc/nep1/coors/bbops/BUILD/calib/unit1_032696.cfl
 2 /csc/nep1/coors/bbops/BUILD/calib/unit2_032696.cfl

```
lcdfile_created Apr 9 1997 16:52:22
castid index     1prr_record     1depth
p960514a.dt1     7.3000000e+01   7.3000000e+01   2.6938630e-01
p960514a.db1     2.0200000e+02   2.0200000e+02   2.1301000e+01
p960514a.ub1     2.0400000e+02   2.0400000e+02   2.1288300e+01
p960514a.ut1     5.5900000e+02   5.5900000e+02   8.5411040e-01
<sampled_parameters>
1prr_record  1 1 0
1ed380 0 -0.008677 0.00016
1ed412 0 -0.021592 9.5e-05
1ed443 0 -0.022113 0.000116
1ed490 0 -0.02328 0.000272
1ed510 0 -0.022617 0.000108
1ed555 0 -0.02301 0.000459
1par 0 -9.05074 0.000337
1edgnd 0 1 0
1temp 0 0.141923 0.080084
1depth      0.    9.37400e-01    8.38842e+01    2.63535e+01    0.9374 83.8842 26.6735 0 0
1xmiss      0.    5.25490e-02    -1.83626e-03    0.05 0
1qsp 0 -1.61e-17 0.0018
1tilt 0 0.04178 2.68617
1roll 0 0.041514 2.69727
1scat 0 1 0
1fluor 0 1 0
2lu380 0 -0.151959 0.000221
2lu412 0 -0.509911 -6.8e-05
2lu443 0 -0.911266 0.000233
2lu490 0 -1.00583 0.00018
2lu510 0 -1.24899 0.000363
2lu555 0 -1.75531 0.00018
2lu683 0 -1.55517 9.5e-05
2lugnd 0 1 0
3es380 0 -0.03292 0.000205
3es412 0 -0.0327 -0.000888
3es443 0 -0.0342 -3.6e-05
3es490 0 -0.03342 -0.000291
3es510 0 -0.03317 -0.00028
3es555 0 -0.03269 0.000142
3par 0 -10.8742 -4e-05
3edgnd 0 1 0
<derived_parameters>
aq-1Tilt-1Roll
kq-1ed412
d-1fluor
d-1temp
```

d-1xmiss
d-d-1fluor
d-d-1temp
d-d-1xmiss
m-d-d-1temp
bin_0.5_1depth
ptsbin_0.5
kc-1ed380
kc-1ed412
kc-1ed443
kc-1ed490
kc-1ed510
kc-1ed555
<data>

<filters_used>
bboprecal -r 1xmiss 0.052549 -0.00183626
/csc/nep1/coors/bbops/BUILD/may96ny/lcd/p960514a.lcd outfile6554
prrrecalz -o 1depth 0.9374 83.8842 26.3535
/csc/nep1/coors/bbops/BUILD/may96ny/lcd/p960514a.lcd outfile7076
bbopradq -fa 1ed380 1.000000e-04 p960514a.lcd outqp960514a.lcd
bbopradq -fa 1ed412 1.000000e-04 p960514a.lcd outqp960514a.lcd
bbopradq -fa 1ed443 1.000000e-04 p960514a.lcd outqp960514a.lcd
bbopradq -fa 1ed490 1.000000e-04 p960514a.lcd outqp960514a.lcd
bbopradq -fa 1ed510 2.000000e-04 p960514a.lcd outqp960514a.lcd
bbopradq -fa 1ed555 1.000000e-04 p960514a.lcd outqp960514a.lcd
bbopradq -fa 3es380 1.000000e-04 p960514a.lcd outqp960514a.lcd
bbopradq -fa 3es412 1.000000e-03 p960514a.lcd outqp960514a.lcd
bbopradq -fa 3es443 1.000000e-03 p960514a.lcd outqp960514a.lcd
bbopradq -fa 3es490 1.000000e-05 p960514a.lcd outqp960514a.lcd
bbopradq -fa 3es510 1.000000e-05 p960514a.lcd outqp960514a.lcd
bbopradq -fa 3es555 1.000000e-04 p960514a.lcd outqp960514a.lcd
bbopradq -fa 3par 1.000000e-01 p960514a.lcd outqp960514a.lcd
bbopradq -fa 2lu380 1.000000e-02 p960514a.lcd outqp960514a.lcd
bbopradq -fa 2lu412 1.000000e-02 p960514a.lcd outqp960514a.lcd
bbopradq -fa 2lu443 1.000000e-03 p960514a.lcd outqp960514a.lcd
bbopradq -fa 2lu490 1.000000e-03 p960514a.lcd outqp960514a.lcd
bbopradq -fa 2lu510 1.000000e-03 p960514a.lcd outqp960514a.lcd
bbopradq -fa 2lu555 2.000000e-04 p960514a.lcd outqp960514a.lcd
bbopradq -fa 2lu683 2.000000e-04 p960514a.lcd outqp960514a.lcd
bbopradq -fa 1xmiss 3.000000e+01 p960514a.lcd outqp960514a.lcd
bbopradq -fa 1fluor 1.000000e-03 p960514a.lcd outqp960514a.lcd
bbopangq 1Tilt 1Roll 10 2 inqp960514a.lcd outqp960514a.lcd
bbopkq -s 1ed412 10 0.9 4.5 inqp960514a.lcd outqp960514a.lcd
bbopdespike -d 1fluor 0.03 10 indqp960514a.lcd outdqp960514a.lcd

```
bbopdespike -d 1temp 0.05 10 indqp960514a.lcd outdqp960514a.lcd
bbopdespike -d 1xmiss 0.05 10 indqp960514a.lcd outdqp960514a.lcd
bbopdespike -d d-1fluor 0.03 10 indqp960514a.lcd outdqp960514a.lcd
bbopdespike -d d-1temp 0.05 10 indqp960514a.lcd outdqp960514a.lcd
bbopdespike -d d-1xmiss 0.05 10 indqp960514a.lcd outdqp960514a.lcd
bbopmovavg -f d-d-1temp 5.0 dqp960514a.lcd mdqp960514a.lcd
bbopbin -b 0.5 mdqp960514a.lcd
bbopkc -s 1ed380 5 inkbmdqp960514a.lcd.1 outkbmdqp960514a.lcd.1
bbopkc -s 1ed412 5 inkbmdqp960514a.lcd.1 outkbmdqp960514a.lcd.1
bbopkc -s 1ed443 5 inkbmdqp960514a.lcd.1 outkbmdqp960514a.lcd.1
bbopkc -s 1ed490 5 inkbmdqp960514a.lcd.1 outkbmdqp960514a.lcd.1
bbopkc -s 1ed510 5 inkbmdqp960514a.lcd.1 outkbmdqp960514a.lcd.1
bbopkc -s 1ed555 5 inkbmdqp960514a.lcd.1 outkbmdqp960514a.lcd.1
```

XI. Appendix D - Calibration Certificates

The following pages contain the calibration certificates for the PRR600s system, and the AC-9.