

Patterns and Scales of Variability in the Optical Properties of Georges Bank Waters, with Special Reference to Phytoplankton Biomass and Production

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LONG TERM GOALS

My long term goal is to contribute to a fundamental understanding of the sources of optical variability in coastal ocean systems. Particular focus is on applications useful for studying important ecological processes and the links between phytoplankton properties and physical processes in coastal regions.

OBJECTIVES

The objectives of this project are focused on making measurements of time series and spatial distributions of both apparent and inherent optical properties in the waters of Georges Bank and the Gulf of Maine. Optical properties are strongly affected by phytoplankton, however, in a dynamic coastal environment such as the Gulf of Maine, other water constituents and a range of physical processes may also be important. We wish to determine which factors most strongly affect optical variability at a range of space and time scales. The observations are being used to describe patterns of variability and to identify the dominant sources of variability in optical and phytoplankton properties in the region.

APPROACH

The approach we are pursuing is to integrate and deploy commercially available spectral radiance, irradiance, absorption and scattering sensors on existing oceanographic platforms with widely different spatial and temporal sampling regimes. Two platforms have been adapted, a profiling oceanographic mooring and a towed underwater vehicle. In coordination with the GLOBEC Georges Bank study, we aim to use these sampling platforms to construct an observational data set for the waters on and around the bank, with temporal scales spanning hours to seasons and spatial scales of meters to hundreds of kilometers. Ultimately this will be accomplished by combining measurements conducted from the mooring and towed vehicle with remotely-sensed surface ocean optical properties from global ocean color missions (e.g., SeaWiFS) and with conventional ship-based sampling.

WORK COMPLETED

BIOMAPER II – While initial adaptation and integration of sensors into the BIOMAPER II (Bio-Optical Multifrequency Acoustical and Physical Environmental Recorder) towed vehicle was completed

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last year (Sosik et al. 1998, see also project web site), we have recently extended the payload to include a Hydrocat-6 Multispectral Backscattering Sensor (HOBILabs, Inc.). After relocation of some electronics, the backscattering sensor has been positioned just aft of ac-9 spectral absorption and attenuation meters (see Sosik 1997 for details), with the sensor viewing below the vehicle through an opening in the bottom. Using a leased Hydrocat-6, this new configuration was successfully tested on a recent cruise to the Gulf of Maine (R/V Endeavor cruise #330, 14-26 Oct 1999). An additional cruise was also completed in FY99 before the addition of the backscattering sensor (R/V Oceanus cruise #334, 1-13 Dec 1998; Greene et al. 1998). During the last year we have also redesigned some of the ac-9 mounting hardware (to facilitate water calibrations at sea) and substantially improved our capability to rapidly process and view the large quantities of data generated on these cruises.

AVPPO – The AVPPO (Autonomous Vertically Profiling Plankton Observatory) coastal mooring system with integrated optical sensors (see Sosik 1998 for details) was fully operational this year. Extensive testing was completed in the dive well at the WHOI dock during October and November 1998 and a 3-month deployment on Georges Bank was carried out between December 1998 and March 1999. Unfortunately, due to a power failure on the main winch, no profiles were conducted during the deployment and data was not collected. During future work with the AVPPO, communication with shore will be implemented to avoid extended deployments with undetected major system failures.

SeaWiFS – In conjunction with the current and planned BIOMAPER II and AVPPO sampling, we have been processing and interpreting SeaWiFS ocean color images for the Georges Bank/Gulf of Maine region. This work has been delayed due to problems with standard SeaWiFS data processing methods applied to this region. Our in situ observations are an important asset in trying to solve these problems and we have been working with other members of the SeaWiFS science team towards this goal.

RESULTS

Recent observations from BIOMAPER II surveying in the Gulf of Maine look very promising. We have fully processed a small portion of the spectral absorption, scattering and backscattering observations from one of the deep basins in the Gulf. Both the relative magnitudes and spectral shapes provide information about the types and size distribution of the water constituents determining the optical properties (Figures 1 and 2).

We have compared some of our in situ observations of ocean color to those estimated from SeaWiFS images of the Gulf of Maine and found large discrepancies. Examination of standard SeaWiFS data processing procedures points to problems with atmospheric correction in this region. The problems are so severe that normalized water-leaving radiance values generated from SeaWiFS data are often negative in the near UV and blue channels (Figure 3). Obviously this has a dramatic impact on the accuracy with which SeaWiFS data can be interpreted and improved atmospheric correction procedures are necessary.

IMPACT/APPLICATIONS

This research will contribute to a fundamental understanding of the sources of optical variability in coastal ocean systems. This in turn has implications for better understanding of ecological processes in

R/V Endeavor 330 - October 1999 - BIOMAPER - Wilkinson Basin

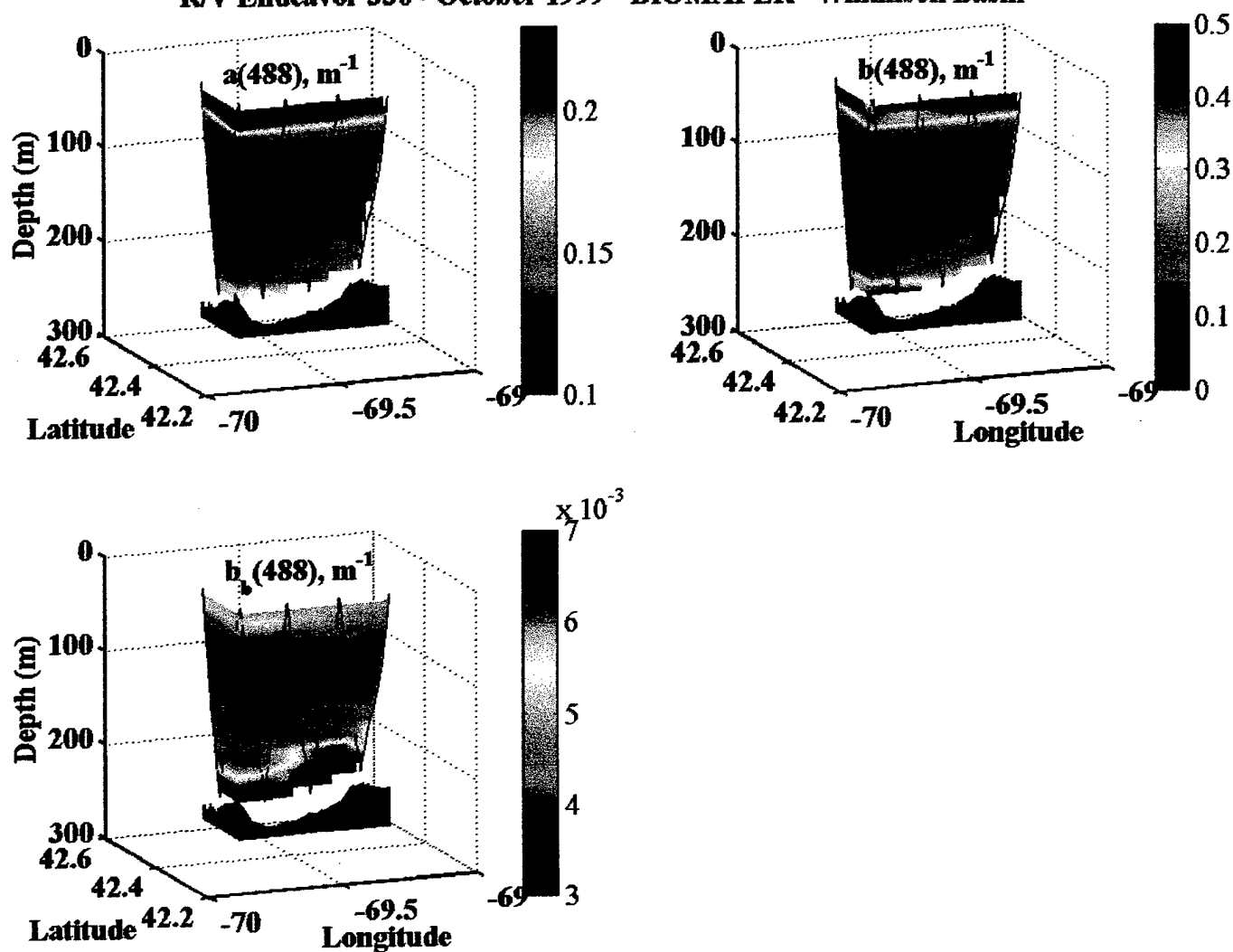


Figure 1. Three-dimensional representation of inherent optical property distributions in a small section (6 hours on 16 Oct 1999) of BIOMAPER surveys conducted in the Gulf of Maine on R/V Endeavor cruise 330. All coefficients are for 488 nm and reflect absorption and scattering by dissolved and particulate constituents (water removed). The black area at the bottom of the plots shows bathymetry along the tow track and the black dashed lines indicate the path of the tow vehicle through the water column. All properties show strong vertical gradients with mid-water minima along the entire section. Distributions below 200 m reflect the bottom topography and those in the surface layer reflect hydrographic stratification. In contrast to absorption (top left) and scattering (top right), which tend to be highest in the surface layer, backscattering coefficients (bottom) are highest near the bottom, consistent with a relatively small particle size distribution in these waters.

these regions, since there are strong connections between optical characteristics and plant biomass and primary production. These connections span scales from single cells to the global ecosystem and optical techniques provide the potential for measurements that cover this range. This work will also contribute to the development of approaches and methods for merging information from widely different

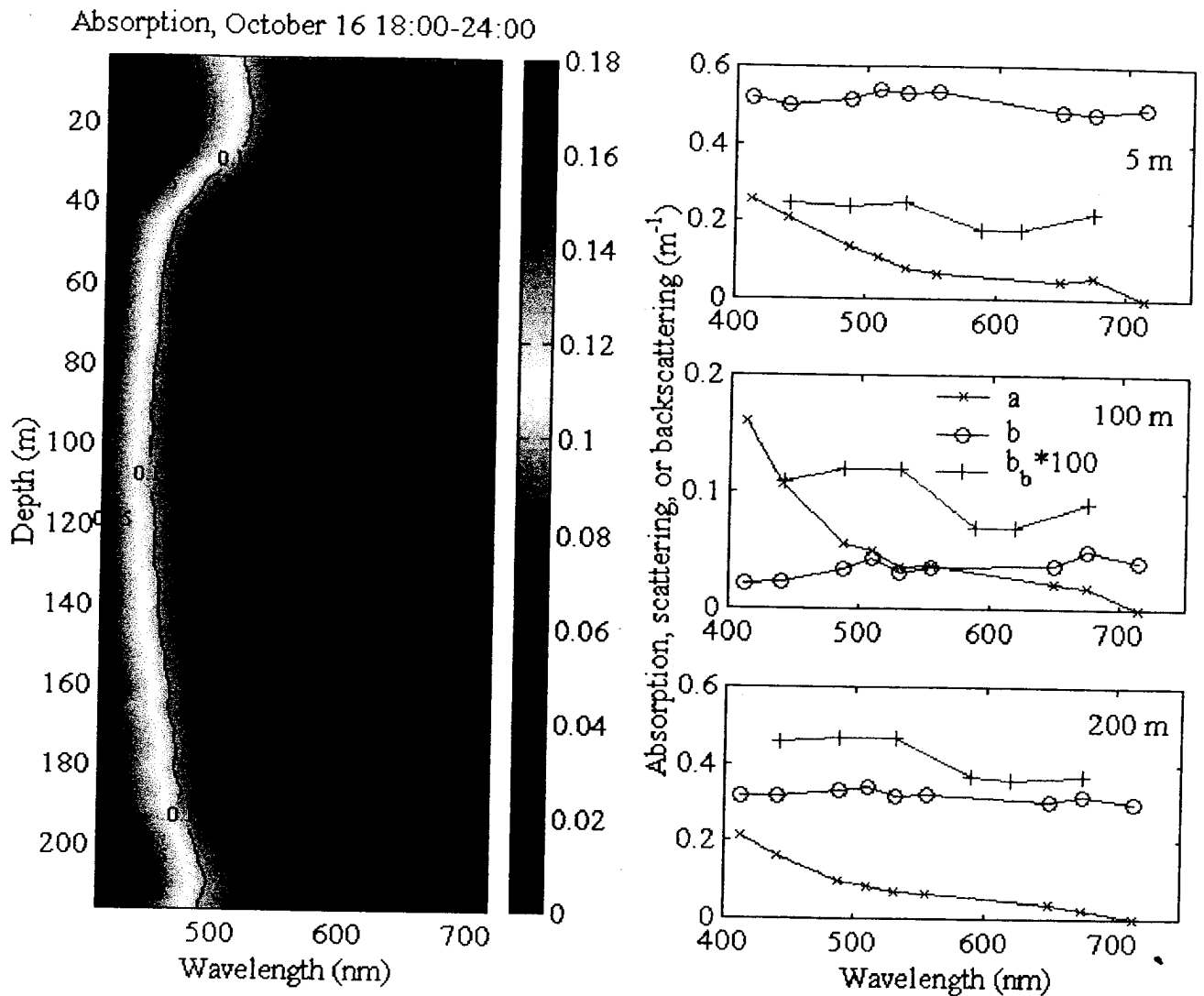


Figure 2. Spectral characteristics of absorption, scattering and backscattering coefficients from the same observation period presented in Figure 1. Average depth dependence of the spectral absorption coefficient for dissolved plus particulate material is shown on the left and absorption, scattering and backscattering spectra are plotted for selected depths on the right (5, 100 and 200 m from top to bottom). Note: Backscattering coefficients are multiplied by 100 and the scale is different for the 100 m observations for better viewing of spectral dependence. The peak in absorption near 675 nm evident in the top 30 m is characteristic of phytoplankton, while absorption is dominated by detrital material at other depths. Scattering spectra are relatively flat regardless of depth and the backscattering spectra have the steepest wavelength dependence ($\sim \lambda^{-1.2}$) at 100 m.

observational perspectives to obtain consistent and unbiased views of how large natural systems function. We anticipate that complementary spatial and temporal information will contribute to better understanding of the sources and mechanisms leading to optical variability in an important region of the coastal ocean.

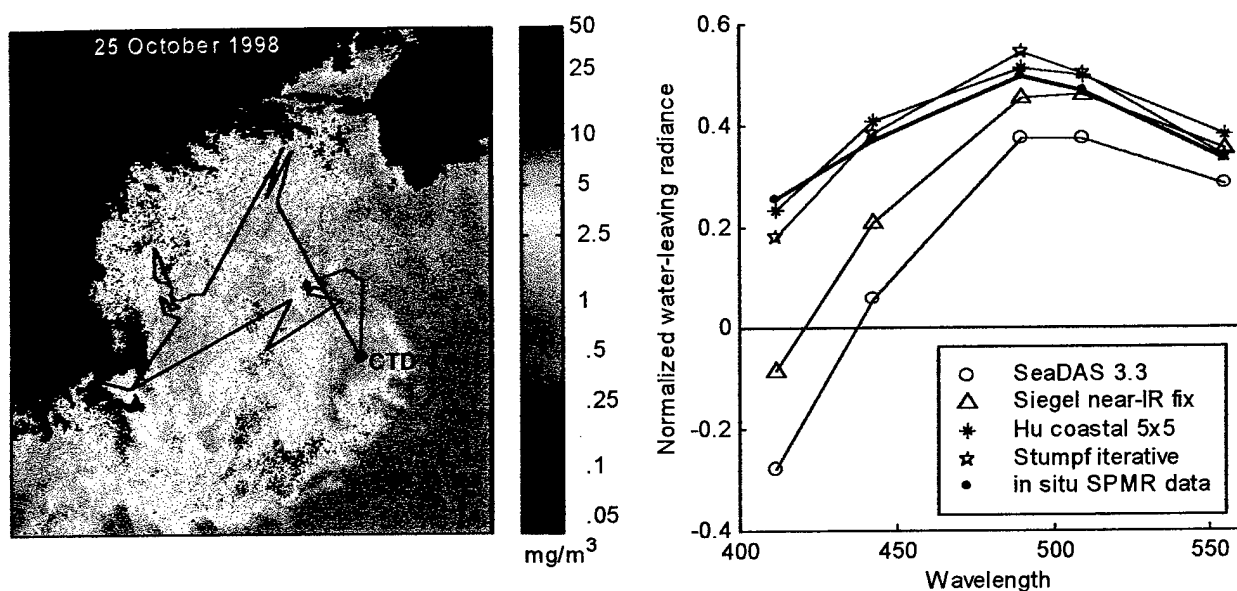


Figure 3. Satellite-derived chlorophyll image (left panel) for Gulf of Maine/Georges Bank region on 25 Oct. 1998 and normalized water leaving radiance (L_{wn}) spectra (right panel, $\text{W cm}^{-2} \text{ nm}^{-1} \text{ str}^{-1}$). Our BIOMAPER cruise track from Oct. 1998 (R/V Oceanus 332) is superimposed on the satellite image, with location of sampling station for that day indicated. L_{wn} measured in water (thick red line) differs markedly from the satellite-derived spectrum (blue open circles) for the station pixel.

The standard satellite processing algorithms (i.e., SeaDAS 3.3) fail to apply appropriate atmospheric correction for this region. Our in situ data is being used in efforts to improve the atmospheric correction scheme for this region; two different techniques, the Hu coastal 5x5 (green asterisk) and the Stumpf iterative (turquoise star) approaches, result in significant improvements to the satellite-derived spectrum. The Siegel near-IR fix (pink triangle), which has improved satellite retrievals in other regions (e.g., near Bermuda), does not work well in the Gulf of Maine.

TRANSITIONS

We have exchanged preliminary results from the BIOMAPER II cruises with investigators conducting acoustic research using the vehicle (P. Wiebe, WHOI & C. Greene, Cornell U.). Transitions from the AVPPO work are in progress as part of the new NOPP-supported FRONT (Front-Resolving Observational Network with Telemetry) project. This project includes deployment of the mooring as part of an observational network to be located near the mouth of Long Island Sound. See FRONT web site (<http://nopp.uconn.edu/>) for details. As described above, our radiometric observations are also being used for NASA-funded efforts to improve SeaWiFS processing methods.

RELATED PROJECTS

Observational work with BIOMAPER II in the Gulf of Maine and Georges Bank is dependent on close collaboration with a GLOBEC program project (NOAA, C. Greene, M. Benfield and P. Wiebe). We have a similar collaboration with ongoing projects supporting development of the AVPPO (NSF, S. Gallagher and C. Davis). In addition, there is a strong relationship with NASA-supported work in our laboratory (H. Sosik and L. Martin Traykovski), aimed at developing classification methods for optical water types based on remotely-sensed ocean color imagery of the northwest Atlantic.

REFERENCES

Greene, C., M. Benfield, H. Sosik, P. Wiebe, A. Bucklin, L. McGarry and K. Fisher. 1998. U.S. GLOBEC: R/V Oceanus Cruise OC334 to the Gulf of Maine, (3-13 December 1998), 58 pp.

Sosik, H. M. 1997. Patterns and scales of variability in the optical properties of Georges Bank waters, with special reference to phytoplankton biomass and production. FY97 ONR Year End Report.

Sosik, H. M., R. E. Green and R. J. Olson. 1998. Optical variability in coastal waters of the Northwest Atlantic. In: Ocean Optics XIV, S. G. Ackleson (ed.). 14 pp.

PUBLICATIONS

Sosik, H. M., R. E. Green and R. J. Olson. 1998. Optical variability in coastal waters of the Northwest Atlantic. In: Ocean Optics XIV, S. G. Ackleson (ed.). 14 pp.

Martin Traykovski L. V. and H. M. Sosik. 1998. Optical classification of water types based on ocean color. In: Ocean Optics XIV, S. G. Ackleson (ed.). 12 pp.

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13. Abstract The goal of this research program is to contribute to a fundamental understanding of the sources of optical variability in coastal ocean systems. This is being achieved through a field effort to make measurements of time series and spatial distributions of both apparent and inherent optical properties in the waters of Georges Bank and the Gulf of Maine. Optical properties are strongly affected by phytoplankton, however, in a dynamic coastal environment such as the Gulf of Maine, other water constituents and a range of physical processes may also be important. We have successfully integrated optical sensors into two new sampling platforms, a towed vehicle and a profiling mooring, and have collected a large data set with the tow vehicle. These observations, combined with ocean color satellite imagery and conventional ship-based water sampling, are being used to describe patterns of variability and to determine which factors most strongly affect optical variability at a range of space and time scales in the Gulf of Maine region. Preliminary results suggest that variability in the type and spatial distribution of particulate material is very important, and that variations in water masses due to circulation patterns in the region may also play a critical role.			
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