A Practical Application of Ocean Color Methodology to an Undergraduate Curriculum

Tiffany A. Moisan (972), Brian A. Campbell, SAIC (970), Madhumi Mitra (Univ. of Maryland, ES), Matthew Linkswiler, EG&G (972),
Jim Yungel, EG&G (972), Bob Swift, EG&G (972), Julie Ambler (Millersville University), and Eric Sherry (Marine Science Consortium)
NASA Goddard Space Flight Center, Wallops Flight Facility

Background

Phytoplankton play a critical role in regulating global carbon dioxide (CO_2) and climate. Yet within education, there is little or no understanding of the importance of microscopic marine algae or how their abundance and productivity can be monitored at global scales. Phytoplankton account for approximately 50% of global photosynthesis. The carbon dioxide that has been incorporated in their systems is eventually buried in marine sediments. As a result, phytoplankton play a vital role in regulating the amount of carbon in the atmosphere.

There is a critical need for experiential learning experiences at the undergraduate level. Classical techniques in biology have utilized microscopy to study phytoplankton. Our project aim is to update classroom learning experiences utilizing technology, biology, and optics by incorporating these variables into the context of remote sensing applications.

Objectives

The major objectives for this project focus on the critical need for re-developing and updating marine phytoplankton education at the undergraduate level through teacher and faculty enhancement that will translate to classroom learning, real-world research and hands-on discovery by students.

Major Achievements of the Project:

- NASA engineers have developed a low-cost hand-held radiometer for classroom use which samples remote sensing reflectance;
- This grant allowed UMES undergraduates to attend several oceanographic cruises; and
- Students learned about satellite ocean color remote sensing as well as utilized the newly developed instrument and were introduced to coastal oceanography.

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Poster designed by Brian A. Campbell, SAIC (970)

Hands-On Approaches to Measuring Phytoplankton Concentration and Abundance

OPTICS


Calibration of Instruments/Field-of-View

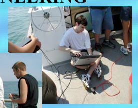
BIOLOGY

Filtering of Phytoplankton

Collecting Trawl Samples

Filtering of Phytoplankton

ENGINEERING



Use of Hand-Held Spectroradiometer

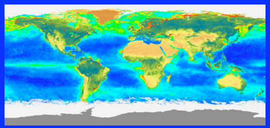
Conductivity-Temperature-Depth Profiler

Educational Need and Approach

Teacher Training and Oceanographic Cruise

TEACHERS:

- *Demonstrate knowledge of the basic principles of coastal oceanography (physical oceanography, microscopy, and optical data) including the use of a hand-held spectroradiometer*
- *Correlate spectroradiometer information and data from the observed hands-on ship board measurements and the MODIS/SeaWiFS satellite measurements of phytoplankton concentration in the Middle Atlantic Bight and participate in a calibration/validation exercise.*
- *Prepare classroom lessons that are scientifically and pedagogically-sound and emphasize the science of ocean color measurement, including laboratory experiments that mirror the experiments performed during the teacher training sessions.*

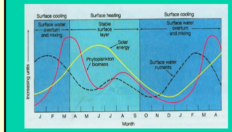



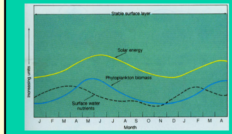
Student Instruction

STUDENTS:

- *Demonstrate knowledge of the engineering aspects related to ocean color measurements (i.e. field-of-view, signal-to-noise-ratios, and sensitivity detection).*
- *Download, graphically analyze, and interpret hands-on and observed data and predict how this analyzed data will affect other ecosystems, such as rivers and lakes.*
- *Compare and contrast observations and data with students from other participating institutions through the "Foundations of Phytoplankton" web site's education portal and ftp site.*

Phytoplankton Biomass, Nutrient Supply, and Surface Water Stability





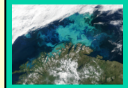
Relationship to Ocean Color Remote Sensing

Satellite ocean color sensors offer oceanographers the potential capability of observing the phytoplankton community over synoptic and global scales with sufficient temporal resolution and conventional methods for measuring in-water spectral reflectance. The advent of ocean color remote sensing has provided oceanographers with the ability to synoptically observe the temporal and spatial variability of bulk phytoplankton pigment concentrations. Oceanographers must calibrate these global observations. Estimating phytoplankton abundance from ocean color satellite data is based upon the principles of spectral absorption and backscatter which together contribute to remote sensing reflectance. These coefficients are linked to pigment concentrations by ocean color (chlorophyll a + phaeopigments) or the reflectance spectrum of the ocean,

$$Rrs(\lambda) \propto bb(\lambda)/a(\lambda)$$

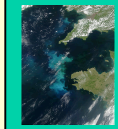
Where, Rrs is remote sensing reflectance, bb (λ) is the total backscatter coefficient and a(λ) is the total absorption coefficient.

Concentrated Phytoplankton Blooms



Norway

The Florida Keys, USA



England and France

Newfoundland, Canada

MODIS images from the MODIS instrument aboard the Terra (EOS AM) and Aqua (EOS PM)

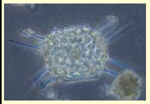
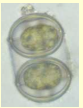
http://modis.gsfc.nasa.gov/

Laboratory Phytoplankton Information

Algal Divison/Class	Common Name	Genera	Approximation of number of living species
Golden-brown algal line (chlorophylls *a* and *c*)			
Bacillariophyta	Diatoms	210	Unknown (5,500-10,000)
Dinophyta	Dinoflagellates	550	4,000
Chrysophyta	Golden-brown flagellates		
Chrysophyceae	Chrysophytes, silicoflagellates	120	1,000
Raphidophyceae	Raphidophytes, (=chloromonads)	4	9
Haptophyta	Golden-brown flagellates		
Prymnesiophyceae	Coccolithophorids	50	500
Xanthophyta	Yellow-green algae	90	600
Cryptophyta	Cryptomonads	8	>50
Eustigmatophyta	Yellow-green algae	6	12
Green algal line (chlorophylls *a* and *b*)			
Chlorophyta			
Chlorophyceae	Green algae	350	2,500
Prasinophyceae	Green flagellates	13	120
Euglenophyta	Euglenoids	43	650-800 (?)
Red algal line (chlorophyll *a* and biliproteins)			
Rhodophyta	Red algae	3	10 (?)
Blue-green algae (cyanobacteria) (chlorophyll *a* and biliproteins)			
Cyanophyta	Cyanobacteria	Under revision	(>10,000 spp. ?)
Prochlorophyta	Prochlorophytes	3	3

Diversity of microalgae found in marine and freshwater phytoplankton

Examples of Phytoplankton


Phytoplankton Lab Cultures


Cultures Grown at the Wallops Flight Facility

Future Directions of the Project

NATIONAL PHYTOPLANKTON OBSERVATION AND DISTRIBUTION SYSTEM (NPODS):

Students will communicate with other students and teachers from participating nationwide institutions. This will be accomplished through the currently existing "Foundations of Phytoplankton" web site that will host an "ocean color measurement education portal" that will contain pertinent course, laboratory, observational, satellite, and communicative information. NPODS will be become a major phytoplankton and ocean color measurements network in the near future and will provide an ever increasing venue for the study of ocean color measurements through the collaborative utilization of current, ground-breaking NASA science.

http://phytoplankton.gsfc.nasa.gov