DDE Annual Report

Title of Investigation:

A Harmful Algal Bloom Observing System for Coastal Regions Using a Surface Autonomous Vehicle (OASIS)

Principal Investigator:

Dr. Tiffany A. Moisan (Code 972)

Other In-house Members of the Team:

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External Collaborators:

Matt Hull (Luna Innovations) and Donald Shrewsbury (Virginia Tech)

Initiation Year:

FY 2003

Aggregate Amount of Funding Authorized in FY 2003 and Earlier Years:

$0

FY 2004 Authorized Funding:

$50,000

Actual or Expected Expenditure of FY 2004 Funding:

In-house: $20,000;
Contracts: $30,000

Status of Investigation at End of FY 2004:

Completed in FY 2004 and augmented by funding from NOAA ($50,000). To be continued in FY 2005, pending $50,000 in additional FY 2005 Director's Discretionary Funding

Expected Completion Date:

December 2004

Purpose of Investigation:

The purpose of this investigation was to develop a multi-wavelength hyperspectral fluorometer, an instrument that measures light emitted by a phytoplankton cell. This instrument would be capable of monitoring phytoplankton concentrations as well as identifying the dominant species present in an algal bloom. The instrument eventually would be attached to a surface autonomous vehicle for long-term deployment in the Atlantic Ocean and Chesapeake Bay. The sensor uses four light-emitting diodes (LEDs) to stimulate pigment fluorescence in a continuously flowing water sample. The spectrum of light fluoresced is then analyzed to determine estimated pigment concentrations and to identify species, if possible. The LEDs are cycled on one at a time and different information is collected from each excitation.

Accomplishments to Date:

A working prototype of the instrument has been constructed and tested. In its initial design, the prototype is controlled by a laptop computer and is plumbed into a ship's flow-through water sampling line. It was tested onboard Old Dominion University's research vessel, Fay Slover, in early September during a cruise along the James River. The prototype demonstrated its ability to stimulate fluorescence using the four LEDs and recorded the resulting emission spectrum semi-autonomously for an 8-hour sampling period.

The instrument also was tested extensively with several phytoplankton cultures grown in the Ocean Biogeochemical Laboratory at Wallops Flight Facility. The following figure shows the results of some of the testing. Figure 1 shows the emission spectrum of a culture of Dunaliella tertiolecta upon excitation with 470-nm light. The wide peak around 470 nm is the signal from the excitation source and the smaller peak around 685 nm represents the chlorophyll a fluorescence. Figure 2 shows the emission spectrum of a culture of Synechococcus sp., with excitation from the 395-nm LED. The large peak around 400 nm indicates the excitation light, while the two peaks near 580 nm and 685 nm represents pigment fluorescence from phycoerythrin and chlorophyll a, respectively.

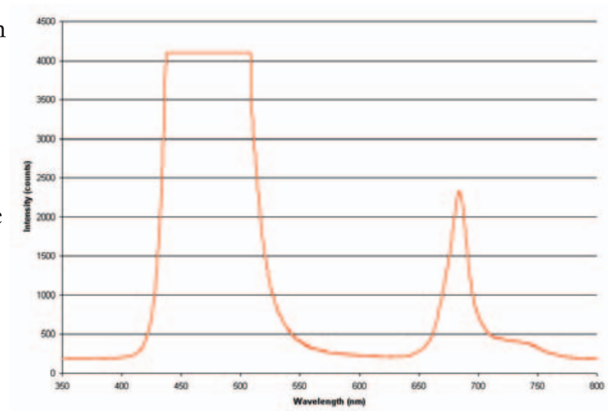

Figure 1. Dunaliella tertiolecta excited with 47-nm LED

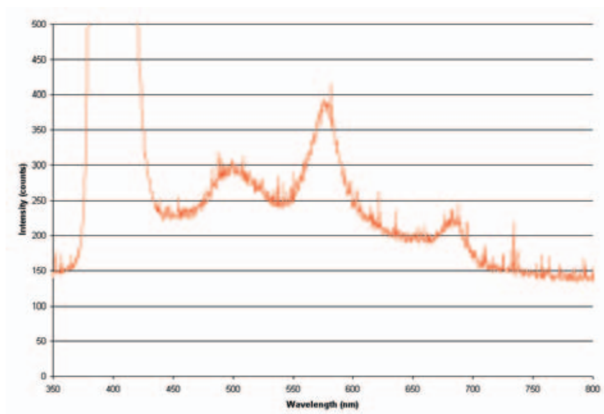

Figure 2. Synechococcus sp. excited with 39-nm LED

Figure 3 shows the prototype of the multi-wavelength hyperspectral fluorometer controlled by a laptop during operation in the laboratory. Figure 4 illustrates the portability and compactness of the shipboard prototype instrument and Figure 5 shows the laboratory version of the instrument used to test the different components before the prototype's fabrication.

Figure 3. Prototype of Multi-Wavelength Hyperspectral Fluorometer

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Figure 4. Rugged housing for field deployment

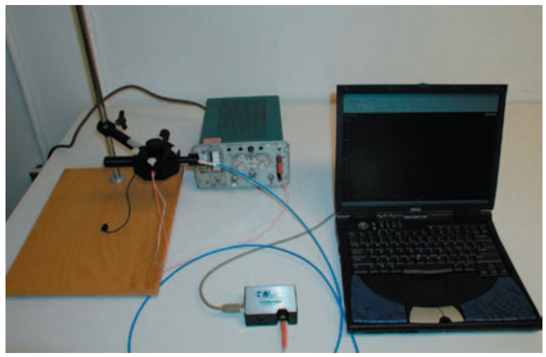

Figure 5. Laboratory model of the Multi-Wavelength Hyperspectral Fluorometer

Planned Future Work:

The working prototype for the multi-wavelength hyperspectral fluorometer is limited to operation in a laboratory setting or onboard a ship. Future funding is expected for the purpose of diminishing its size and power consumption so that it could eventually be deployed on a mooring or surface autonomous vehicle. We also are investigating the use of a fiber optic probe to replace the current sample chamber and optics.

Summary:

The multi-wavelength hyperspectral fluorometer has two innovative features. First, its use of multiple-excitation wavelengths enhances the ability of the sensor to discriminate between different species of phytoplankton and to provide information about the presence of certain distinct pigments. Also, by using a detector that looks at the entire visible-light spectrum, instead of one or more distinct wavelengths to analyze the emission spectrum, we can collect more information from a sample—including measurements of light scattering and colored dissolved organic matter (CDOM). Combined, these two advantages could be of great use in distinguishing the harmful algal blooms from the harmless ones. With this technology, NASA will be able to determine the different classes of phytoplankton present in a certain area. This will give us a better understanding of the carbon cycle. In addition, it will present a new avenue for understanding the link between biology and ocean optics. The criterion for success is whether the instrument can measure the emission spectra of the phytoplankton with broadband excitation sources. We have demonstrated the value of this instrument onboard a ship. We have run across several risk factors, including the performance of the LEDs and issues involving a noisy baseline. In addition, we have encountered a few complications with the optical geometry, including focusing the excitation light on the sample, reducing the light scattering from the instrument housing, and delivering enough light from the excitation sources to the sample.