In situ Monitoring of Cyanobacterial HABs in Western Lake Erie using Buoy-mounted Sensors

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Overview

The Toledo Harbor Light and Navigation Light #2 Real-time Environmental Coastal Observation Network (ReCON) systems are well-positioned for the detection of HABs. The Toledo Harbor Light on Maumee Bay is often a hot spot for cyanobacterial blooms, in a large part due to the nutrient input from the Maumee River, and is hypothesized to be a source of cells for the rest of the western basin of Lake Erie. We propose to deploy environmental sensors at these sites for the purpose of detecting the development and persistence of cyanobacterial blooms in western Lake Erie and collecting high temporal frequency nutrient data in order to better predict bloom development and intensity. The first sensor is a fluorescence-based detector of phycocyanin, a pigment found predominantly in cyanobacteria, and the second is an in situ reagent-based nutrient analyzer that is used for measuring phosphorus and nitrogen concentrations. Both of these were deployed during the summer 2007 and are proposed to be deployed again in the summer 2008. Biweekly (from July to September) samples for phycocyanin, chlorophyll a, nutrients and microcystin would be also be collected in order to validate sensor and analyzer outputs. The proposed deployment will be to more specifically integrate them into an early warning system for the development of cyanobacterial HAB blooms in western Lake Erie and to further understand the environmental factors contributing to the initiation and persistence of blooms in the western basin.

Proposed Work

The Turner phycocyanin sensor is capable of fluorometric detection of pigments which are found predominantly in cyanobacteria. This phycocyanin sensor was deployed on the Toledo Harbor Light buoy in the summer of 2007 and proved to be effective in detecting a cyanobacterial bloom in October. We propose to deploy this sensor again in 2008 in order to better understand the temporal variability and dynamics of cyanobacterial bloom development in this area, as well as evaluate its capacity to be used in the early warning of blooms. Data from the sensor will be relayed back to shore and monitored daily.

In addition, we propose to continue testing of the Envirotech EcoLab in situ nutrient analyzer. The system uses reagent-based wet chemistry techniques to measure phosphorus and nitrogen concentrations. This system is currently being utilized for nutrient detection, specifically phosphorus, which is of significant relevance to eutrophication issues as well as the development of cyanobacterial HAB blooms in western Lake Erie. This sensor was also deployed during the summer 2007, but was only recently retrieved due to small boat and weather problems. Instrument data will be available in time for internal presentations, but laboratory ground truth data collected during the deployment has not yet been processed.

The sensors will be put in the water in late spring when the RECON buoys are deployed in Lake Erie. A phycocyanin sensor, chlorophyll a sensor and the nutrient analyzer will be installed on the Toledo Harbor Light buoy and an additional phycocyanin and chlorophyll a sensor will be installed on Navigation Light #2. Biweekly sampling of surface and integrated water samples for nutrients (NH4, NO3, PO4), phycocyanin, chlorophyll a, and microcystin at both buoys during the bloom season (July – September) will provide validation and context for the data retrieved from the sensors.

Scientific Rationale

The ultimate goal is to forecast the presence, extent and timing of cyanobacterial HAB blooms in Lake Erie. However, as good as our predictions become, there will always be a need for real-time monitoring of both cells and toxins in order to provide model input and confirm predictions. Initially, an in situ autonomous monitoring system would be used as an indicator of when a bloom begins which would then trigger ship-based sampling at the appropriate locations. Eventually, a combination of model predictions confirmed with an in situ monitoring platform would be the most effective in protecting human health from toxic HAB blooms. In needs assessment workshops (held by Sonia Joseph), one consistent need expressed by stakeholders, such as water utility operators and beach managers, was for a early warning system so that they would have time to prepare either with increased monitoring, advanced treatment or sign posting. Ship-based sampling with the frequency that would be required for this is prohibitively time-consuming and expensive. Therefore, a buoy-based system which could be placed at a water intake or recreational beach could be a very effective early warning system.

There are a number of steps that are required before a sensor for toxic cyanobacteria will be available. Currently available is a fluorescence-based sensor that will detect the cyanobacteria-specific pigment phycocyanin. This sensor was deployed on a buoy at the Toledo Harbor Light in Maumee Bay during the summer 2007 and the fluorescence data was relayed back to GLERL. A spike in the sensor output on October 8 triggered Steve Ruberg to download the MODIS imagery (Figure 1) from the day before, detecting a widespread algal bloom in the central and western basins of Lake Erie. Sampling from the southern edge of the bloom confirmed that at least this section of the bloom was predominantly comprised of the cyanobacteria *Microcystis* and *Anabaena*. Lab analyses were necessary to determine the toxicity of the bloom (which was very low). This bloom likely would not have been detected otherwise since the bloom season is generally thought to end by mid to late September. This phycocyanin sensor will detect all cyanobacteria and is not specific to toxic strains or even *Microcystis*. However, this is a good first step and will still provide valuable information on the patchiness of cyanobacterial blooms (since it can sample with such high frequency) and be used in combination with other tools and technologies to start developing an in situ early warning system for cyanobacterial blooms.

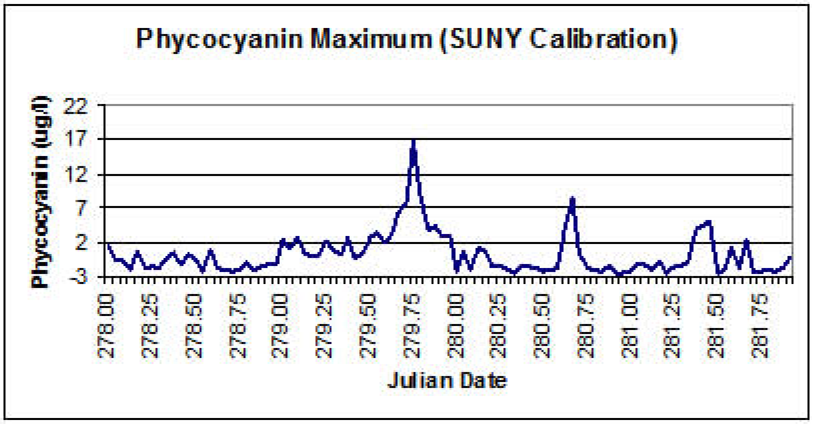

Figure 1: *The plot of phycocyanin concentration using the fluorescence based sensor. The raw voltage from the sensor has been converted to phycocyanin concentrations using a calibration by SUNY-Syracuse (Boyer). The peak indicates the bloom detected on October 7, 2007.*

Figure 2: *The MODIS image shows the bloom occurring not only in the western Basin of Lake Erie but to a greater extent in the central basin*.

Governmental/Societal Relevance

Harmful algal blooms are of great importance to NOAA, the scientific community and the public due their potentially significant detrimental impact on ecosystem and human health. Real-time information regarding HABs is of great interest to water treatment facilities throughout the Great Lakes (re: 2007 phone conversations with Sandusky and Cleveland managers). In light of this, mandates for their study have come from both the legislature and the scientific community. The widespread presence of microcystin concentrations above the WHO recommended limit of 1 µg L-1 in western Lake Erie and Saginaw Bay stresses that detection of toxic *Microcystis* blooms and understanding the mechanisms stimulating toxin production are highly relevant to both the

Great Lakes community and to GLERL. Traditional measures of detecting *Microcystis* by microscopic cell counts have proven insufficient due because the time required for analysis is not conducive to rapid management decisions. Developing an in situ monitoring system for cyanobacterial blooms and their toxins will be a significant benefit to protecting human and ecosystem health in this region.

Relevance to Ecosystem Forecasting

This project has direct links to forecasting the timing and spread of toxic *Microcystis* blooms in the lower Great Lakes. Maumee Bay is an important site due to the high nutrient input and the combination of nutrient and cyanobacterial data from this key location at frequent time intervals over the course of a bloom season will provide very useful data for developing models of bloom development. These buoy-based sensors also have great potential as an early warning system for HAB blooms in locations such as swimming beaches or drinking water intakes.