Developing Predictive Models for Cyanobacterial Blooms in Western Lake Erie

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Real-time monitoring of in-situ phosphate and phycocyanin fluorescence in Western Lake Erie to develop predictive models for cyanobacterial blooms.

Western Lake Erie (WLE) suffers from widespread microcystis blooms in late summer to early fall (Figure 1). These blooms can produce toxins that severely impact fisheries, recreation, and drinking water sources. Sea-Bird Scientific, in collaboration with Dr. Timothy Moore at the University of New Hampshire, was funded by the National Institute of Health and the National Science Foundation, to optimize statistical ecological niche models to develop predictive models for cyanobacterial blooms. Toward this end, in collaboration with the NOAA Center of Excellence for Great Lakes and Human Health run by the Great Lakes Environmental Research Laboratory, a suite of in-situ sensors was deployed to continuously monitor water quality, nutrients, and algal blooms.

Figure 1. Mycrocystis bloom in Western Lake Erie (WLE).

Sample Design

The sensor suite, called a LOBO – which is short for Land Ocean Biogeochemical Observatory – was pioneered by Dr. Ken Johnson's group from Monterey Bay Aquarium Research Institute (Figure 2). The platform uses high-quality Sea-Bird sensors for measurement of conductivity, temperature, dissolved oxygen, chlorophyll fluorescence (WQM), phycocyanin fluorescence (ECO), turbidity, and phosphate (Cycle-PO4) (Figures 3 and 4; others parameters such as nitrate are available; http://sea-birdcoastal.com/lobo). These parameters were chosen to understand the relationships between physical forcing, phosphate, and microcystis development. The Erie LOBO is seasonally located next to the Toledo Light #2 on Maumee Bay, which is often a hot spot for cyanobacterial blooms (http://algae.loboviz.com/, Figure 5). Blooms are thought to begin here fueled by nutrients brought to the surface by wind mixing, although the spring nutrient input from the Maumee River plays a significant role in pre-determining overall nutrient levels. Usually in the hypolimnetic Great Lakes systems, PO_4 is very low, but anthropogenic pulses from runoff cause PO_4 spikes and subsequent phycocyanin fluorescence indicative of mycrocystin blooms. Phycocyanin is an algal pigment common to microcystis. Fluorescence, using an LED to excite pigment emission of light, facilitates semi-quantitative estimations of pigment concentration, which is related to biomass and algal health.

Results

Preliminary results from the first seasonal deployment in summer of 2013 monitored surface phosphate pulses from wind mixing in WLE. As phosphorus was consumed by the phytoplankton and its concentration decreased, phycocyanin fluorescence spiked in conjunction with blooms observed from ships and satellite imagery (Figure 6). Understanding this

Figure 2. LOBO platform. Float and telemetry are visible; sensors are submerged.

Figure 3. Cycle-PO4, in-situ phosphate sensor. Note colored reagent cartridges for in-situ wet chemical analysis and mussel fouling which did not impact data quality.

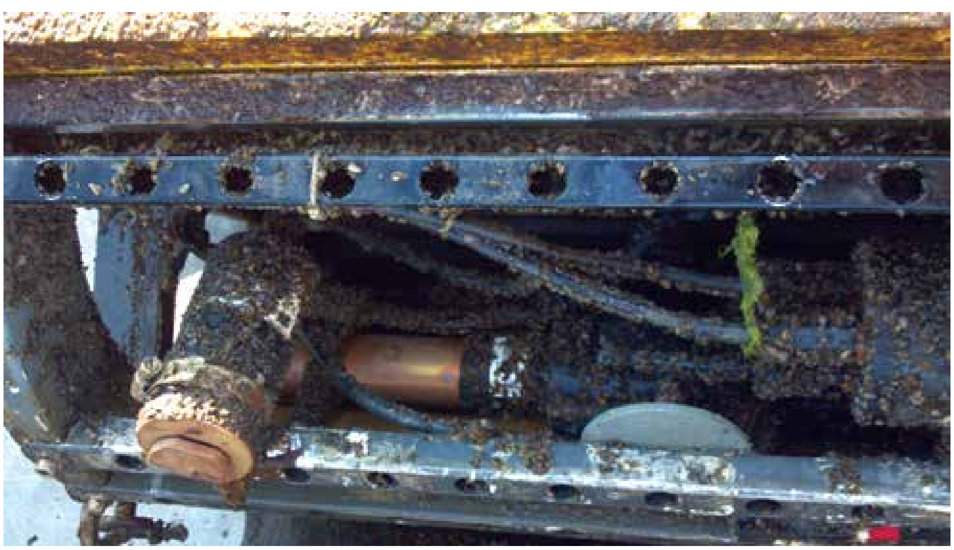


Figure 4. Underside of LOBO buoy, showing bio-optics and CTD. Note that copper surfaces and optical wipers keep measurement surfaces free of fouling.

relationship could permit nutrient and water quality monitoring to predict blooms days in advance. This early warning will help resource managers minimize the impact to recreation and water treatment facilities. The LOBO will be deployed again in the 2014 summer season, remaining vigilant for water quality drivers and bloom responses. Extensive field sampling is also being conducted, including phytoplankton cell identification/counts and toxin (mycrocystin) analysis. Continuous monitoring data, results from field campaigns, and detailed optical studies will be combined with remote sensing data to develop bio-optical and predictive models to enhance our understanding of bloom dynamics and provide for early

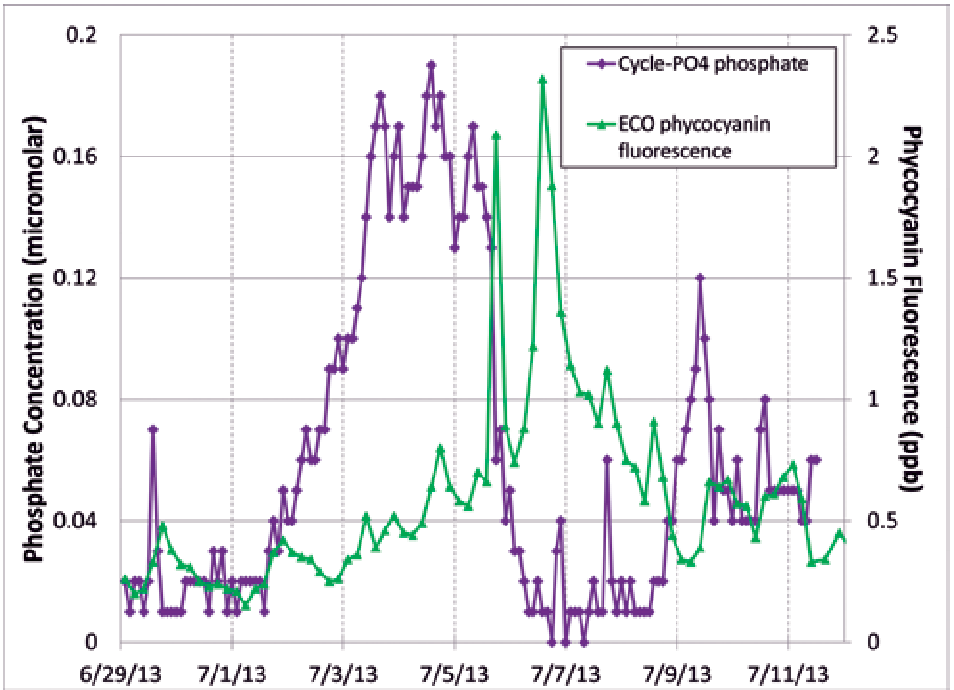
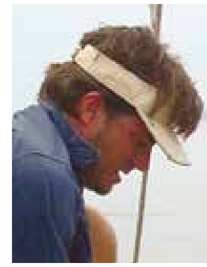


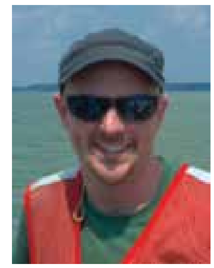
Figure 5. Preliminary, real-time, continuous monitoring data from WLE LOBO. In-situ phosphate concentration is shown in purple, with phycocyanin fluorescence in green. A pulse of phosphate into the system results in a bloom three to four days later, demonstrating the predictive capacity of continuous nutrient monitoring.

warning of harmful conditions. Detailed optical studies with Sea-Bird sensors include high-sensitivity hyperspectral absorption measurements (ACS), evaluation of particulate scattering from 0-180° to determine the volume scattering function (MASCOT), and using lasers to generate holographic images of microscopic particles such as plankton formations and inorganic particles (HOLOCAM).

Dr. Timothy Moore is a research scientist at the University of New Hampshire. He has over 15 years of experience working with remote sensing data related to the analysis of ocean color and primary productivity. Dr. Moore's work involves breaking the world into ocean color "provinces" for applying regionally tailored bio-optical algorithms. Algorithms are used to relate what is actually measured in the water optically to what the satellite imagery is producing, and then assign uncertainties to them so that scientists can reliably gauge how accurate these satellite-derived physical/biological data are.



Michael Twardowski is Director of Research at Sea-Bird Scientific. His research interests are inherent and apparent optical properties, relationships between particles and optical properties, the design of optical instrumentation, and using optical sensing techniques such as backscattering and remote sensing as proxies to investigate the biogeochemistry of natural waters.



Corey Koch is a biogeochemist and Associate Product Manager at Sea-Bird Scientific. His research focuses on in-situ chemical sensor development, miniaturization, and environmental chemistry. His interests lie in nutrification, biogeochemistry, oil spill science, fate and transport, microfluidics, reagent chemistry, spectroscopy, and instrument design.

Next Issue – Summer 2014 *LakeLine*

Our next issue will feature "Lake Associations." Lake associations accomplish some truly remarkable things, often with limited resources. We'll highlight some of these lake association accomplishments from maintaining the dam on a Maine reservoir, to organizing homeowners on one of Canada's largest lakes, to a small lake association in Minnesota that rose to the challenge.