Environmental Monitoring with Airborne Hyperspectral Imagery (HAB Prediction)

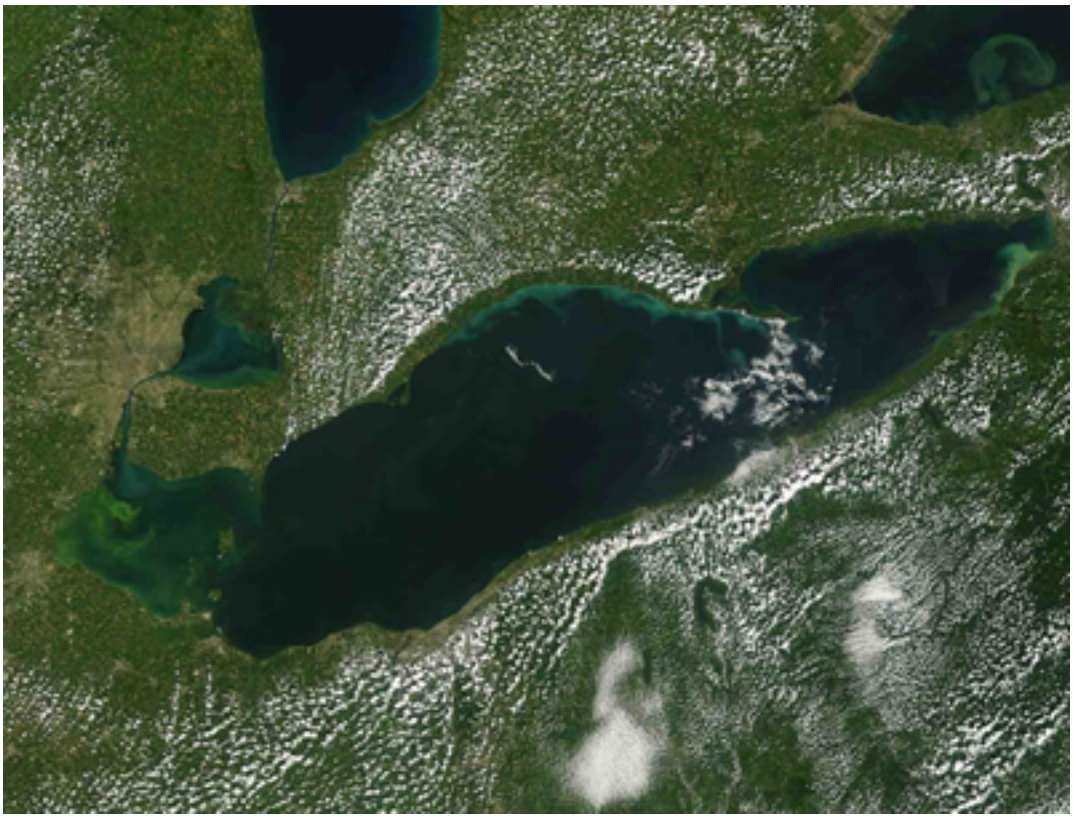
Primary Investigator: George Leshkevich - NOAA GLERL

Co-Investigators: John Lekki - NASA Glenn Research Center

Overview

NASA and NOAA are planning to utilize manned and unmanned (UAV) aircraft to monitor Harmful Algal Blooms (HABs) in the western basin of Lake Erie. Blooms form, spread and disappear within a four to eight week time period in late summer and are a concern for human health, fish and wildlife because they can contain the toxin microcystin.

In the Great Lakes, a common form of microcystin is Microcystin-LR, one of the most toxic strains of microcystin. Because of this toxicity, blooms must be continually monitored. This mission is well suited for UAVs because the blooms are highly dynamic events spread over large areas. High resolution satellite data (such as Landsat) will provide spatial data, but will not give temporal resolution because of the infrequent overpasses and the blooms quick spread. Blooms recent reoccurred in the Great Lakes is not presently understood; however, it is hypothesized that the introduction of zebra mussels is part of the cause.



MODIS satellite image of Lake Erie algal bloom. August 13, 2009.

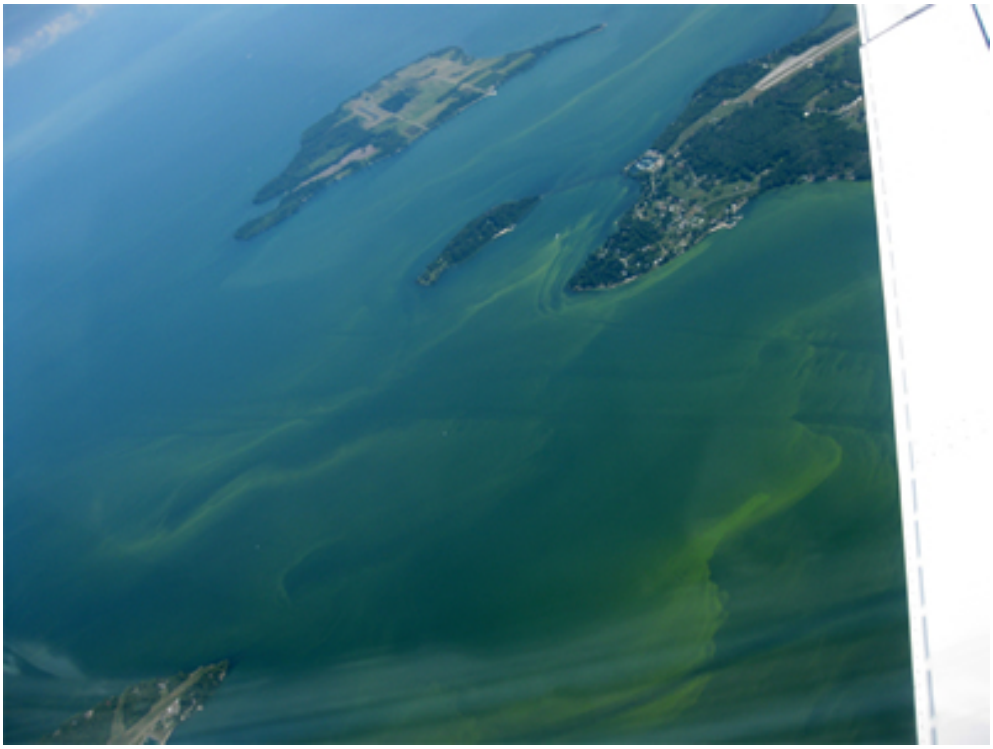
Proposed Work

This project, in collaboration with John Lekki at the NASA Glenn Research Center focuses on early detection of harmful algal blooms (HAB's). This year, the cooperative project developed in 2006 continues with NASA Glenn Research Center to:

1. Investigate the utility of hyperspectral data for early HAB detection and monitoring
2. Investigate the use of unmanned autonomous vehicles (UAV's) for monitoring of Lake Erie

The hyperspectral scanner, built at the NASA Glenn Research Center, was flown on a NASA aircraft on several missions over Lake Erie and Saginaw Bay during August and September 2006, coinciding with in situ water sample collections. During mid-September, the instrument was flown over several sites on the central and western basins of Lake Erie to collect imagery documenting concentrations of the pigment phycocyanin and of blue-green algae (Microcystis). Concurrent water samples and optical data were also collected from the R/V Lake Guardian. Water samples will be processed for phycocyanin, Microcystis content, and chlorophyll while the airborne hyperspectral data is geometrically calibrated and atmospherically corrected.

- Radiometrically and geometrically calibrate 2007 airborne hyperspectral data and in situ water samples for phycocyanin
- Begin algorithm development for early HAB detection using hyperspectral data



Aerial photo of algal bloom west of Bass Islands, Lake Erie. August 11, 2009. Photo from J. Lekki, NASA Glenn Research Center

Scientific Rationale

Microcystis aeruginosa is a dominant bloom-forming, toxic cyanobacterium occurring in the Great Lakes. Microcystis aeruginosa produces cyclic heptapeptide hepatotoxins, known as microcystins. Microcystin-LR is the most prevalent toxin in the Great Lakes, thus most relevant for monitoring with regards to human health effects.

Microcystis has become a dominant component of the summer phytoplankton in both Saginaw Bay and western Lake Erie. Preliminary studies have verified the presence of microcystin in both systems (Brittain et al. 2000, Vanderploeg et al. 2001, Murphy et al. 2003). The recent expansive blooms of Microcystis have caused considerable concern because of our dependence on these waters as a resource and the health risks attributable to microcystins. Higher resolution capabilities of hyperspectral data will offer better detection than current methods.

Governmental/Societal Relevance

The Great Lakes are the nation’s most important freshwater resource from an economic, geographic, international, ecological, and societal perspective. Here’s why:

- Combined, the lakes cover an area of over 94,000 square miles (245,000 square kilometers) and contain 5,400 cubic miles (23,000 cubic kilometers) of water
- The Great Lakes contain about 18 percent of the world's freshwater supply and over 80% of the U.S. supply (EPA, 1995)
- 6,700 miles of coastline are the longest in the nations, providing over 500 beaches for recreational activities
- Great Lakes provide drinking water to over 40 million U.S. and Canadian citizens. The Lakes also provide about 56 billion gallons of water DAILY for municipal, agricultural, and industrial use.

Because of the magnitude of the Great Lakes, water quality and water security are imperative concerns for the region. Therefore, addressing threats to water quality is of utmost importance. The region's 60 million people place significant demands on this water resource for drinking water, transportation, recreation, food production, and manufacturing.

Relevance to Ecosystem Forecasting

Because of the increased incidence of cyanobacterial blooms in the Great Lakes and the public health concerns attributable to microcystins, significant research is devoted to Microcystis blooms and associated toxins. Relatively high concentrations of microcystin have been found in Saginaw Bay, western Lake Erie, and in the western region of Lake Ontario (Brittian et al. 2000; Vanderploeg et al. 2001; Murphy et al 2003).

These concentrations are presented in Table 1.

Area	Microcystin Concentration	WHOs Limit
Saginaw Bay	3.5 ug/l	1 ug L-1
Western Lake Erie	24 ug/l	1 ug L-1
Western Lake Ontario (2001 data)	400 ug/l	1 ug L-1

Table 1: Microcystin concentrations in selected areas (1995)

Through the forecasting and monitoring of toxic blooms, Regional managers can be provided with information to minimize human health threats.