

# Emerging solutions supporting ecosystem research, monitoring, and forecasting



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**Pls: Tom Johengen, Andrea Vanderwoude, Tim Davis, Eric Anderson, Rick Stumpf, George Leshkevich, Mark Rowe, Craig Stow**



# Partners & Collaborators

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Heidi Purcell<sup>2</sup>

Mike Sayers<sup>4</sup>

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Bob Shuchman<sup>4</sup>

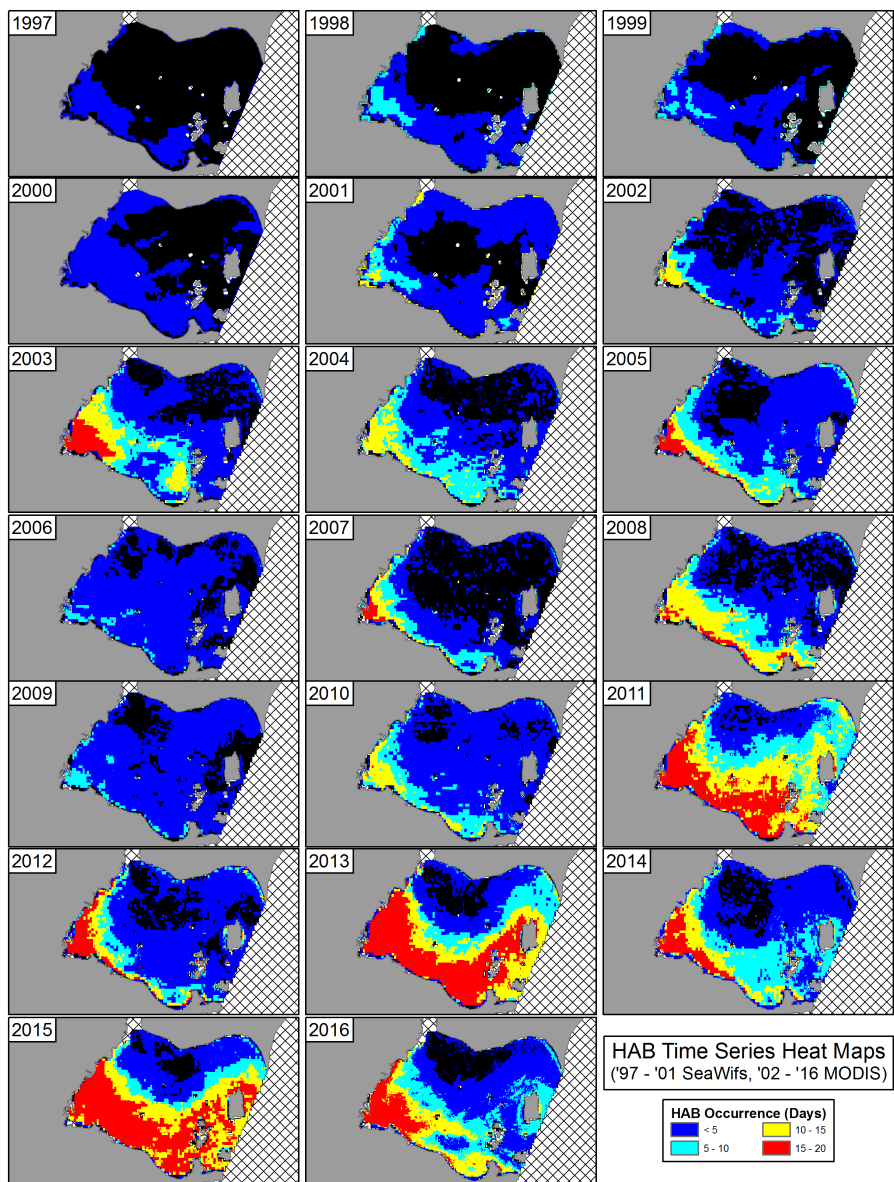
Craig Stow<sup>1</sup>

Dack Stuart<sup>2</sup>

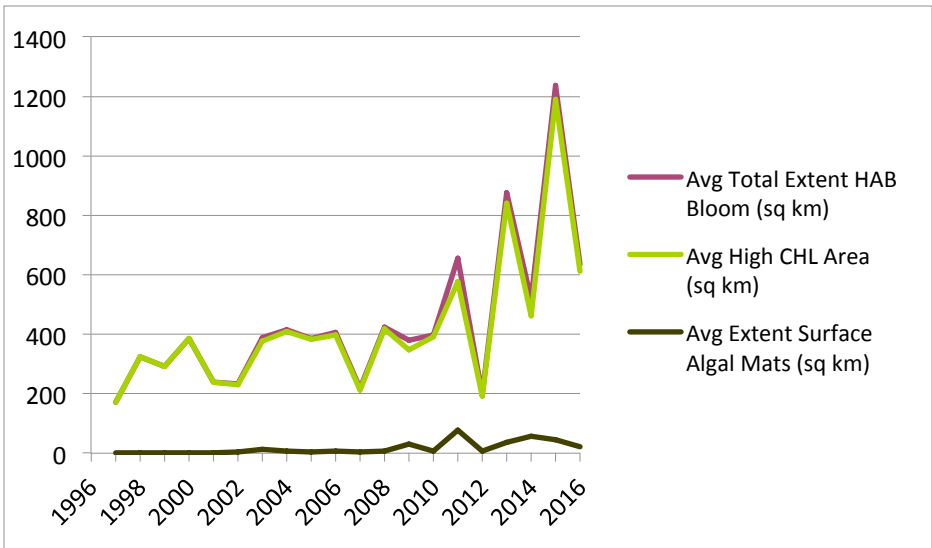
Andrea VanderWoude<sup>5</sup>







# MODIS Satellite Western Lake Erie HAB Trends



Sayers, Fahnenstiel, et al

Semi-analytical algorithm  
transitioning to operations under  
NOAA CoastWatch in 2018

# Lake Erie HAB Bulletin since 2009, move to operations in 2017



## Experimental Lake Erie Harmful Algal Bloom Bulletin

25 August, 2016, Bulletin 14

With calm winds, the cyanobacterial (*Microcystis*) bloom has reformed along the coast in the western basin. Moderate to high concentrations continue in Maumee Bay and extend up the Michigan coast and eastward from Maumee Bay along the Ohio coast. Pockets of low concentrations extend further east along the Ohio coast of the western basin. Areas of scum are present in Maumee Bay. Low concentrations continue in the center of the western basin, north and west of West Sister Island; and also east of Pelee Island in the central basin. Toxin concentrations are above recreational risk thresholds in Maumee Bay.

Some mixing today with only light mixing through the weekend. Southerly winds will favor northward transport toward Ontario well east of the Detroit River. Toxin concentrations may be a risk for recreational exposure in areas shown as orange in the Figure 1 (around Maumee Bay), but especially in scums.

The persistent cyanobacteria bloom continues in Sandusky Bay. No other blooms have been detected in the central basin or the eastern basin.

Keep yourself and your pets out of scums. Please check Ohio EPA's site on harmful algal blooms for safety information.

<http://epa.ohio.gov/habalgae.aspx> Thunderstorms remain a greater risk. --Stumpf, Dupuy

The images below are "GeoPDF". To see the longitude and latitude under your cursor, select "Tools > Analyze > Geospatial Location

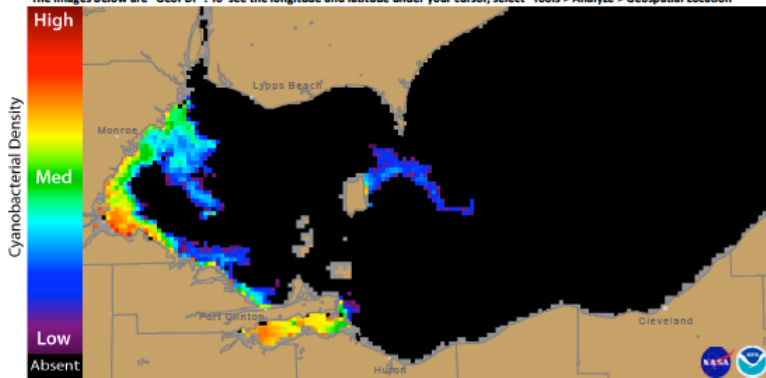


Figure 1. Cyanobacterial Index from NASA's MODIS-Terra data collected 23 August, 2016 at 12:26 EST. Grey indicates clouds or missing data. The estimated threshold for cyanobacteria detection is 20,000 cells/mL.

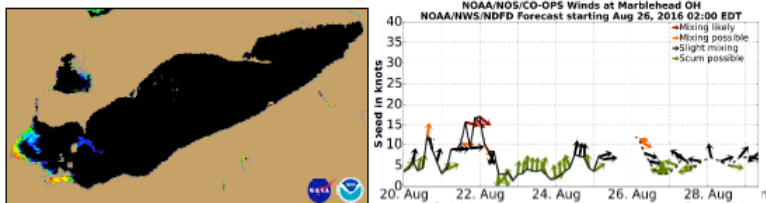


Figure 2. Cyanobacterial index from NASA's MODIS-Terra data collected 23 August, 2016 at 12:26.

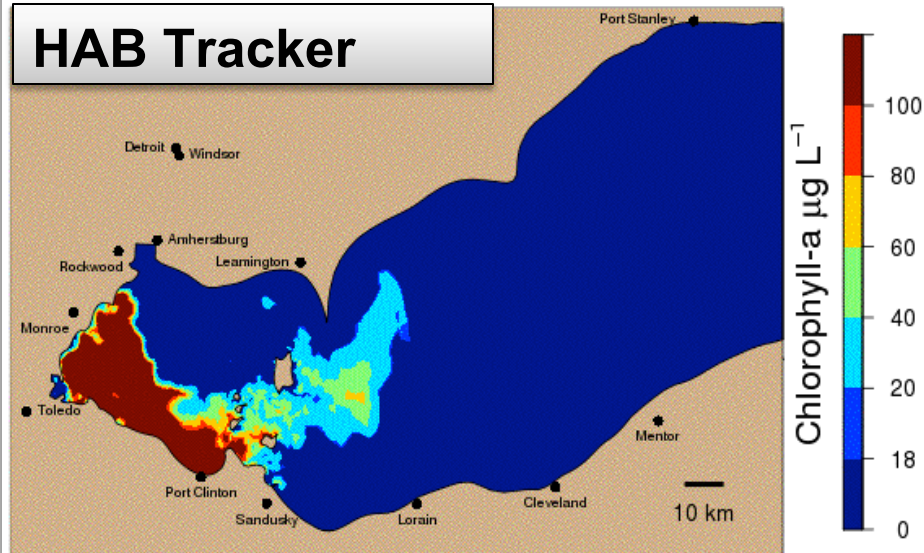
Wind speed and direction from Marblehead, OH. Blooms mix through the water column at wind speeds greater than 15 knots (or 7.7 m/s).

For more information and to subscribe to this bulletin, go to:  
<http://coastalscience.noaa.gov/research/habs/forecasting>

# Lake Erie HAB Tracker since 2014, scheduled for transition in 2018

2015-08-05 12:00 EDT

## HAB Tracker



GLERL  
Great Lakes Environmental Research Laboratory

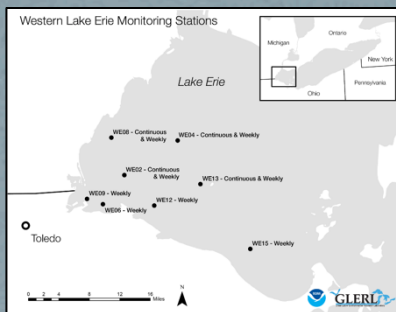
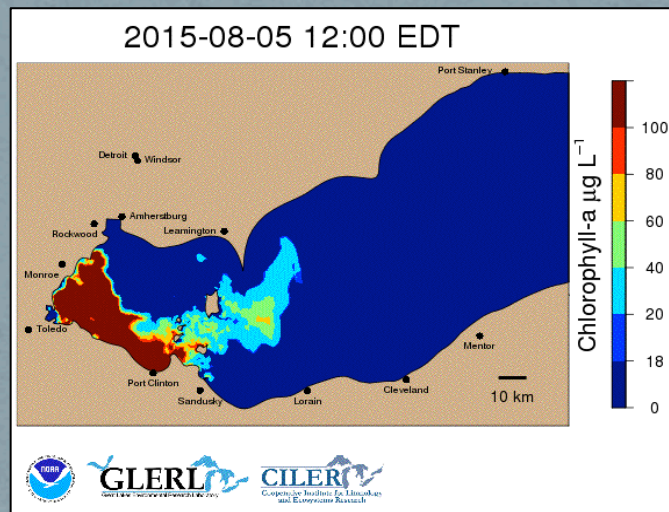
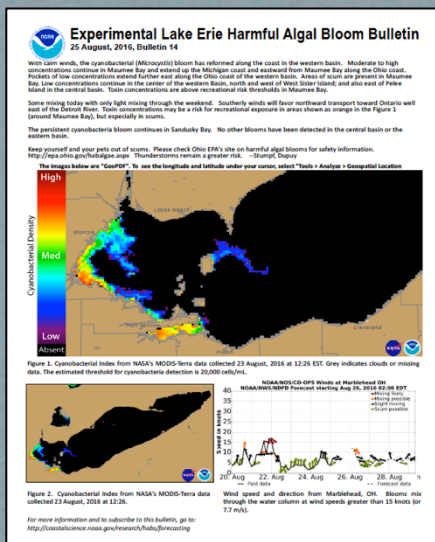
CILERL  
Cooperative Institute for Lakes and Estuarine Research

5-day Forecast

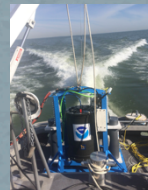




# Further development and support for operational products






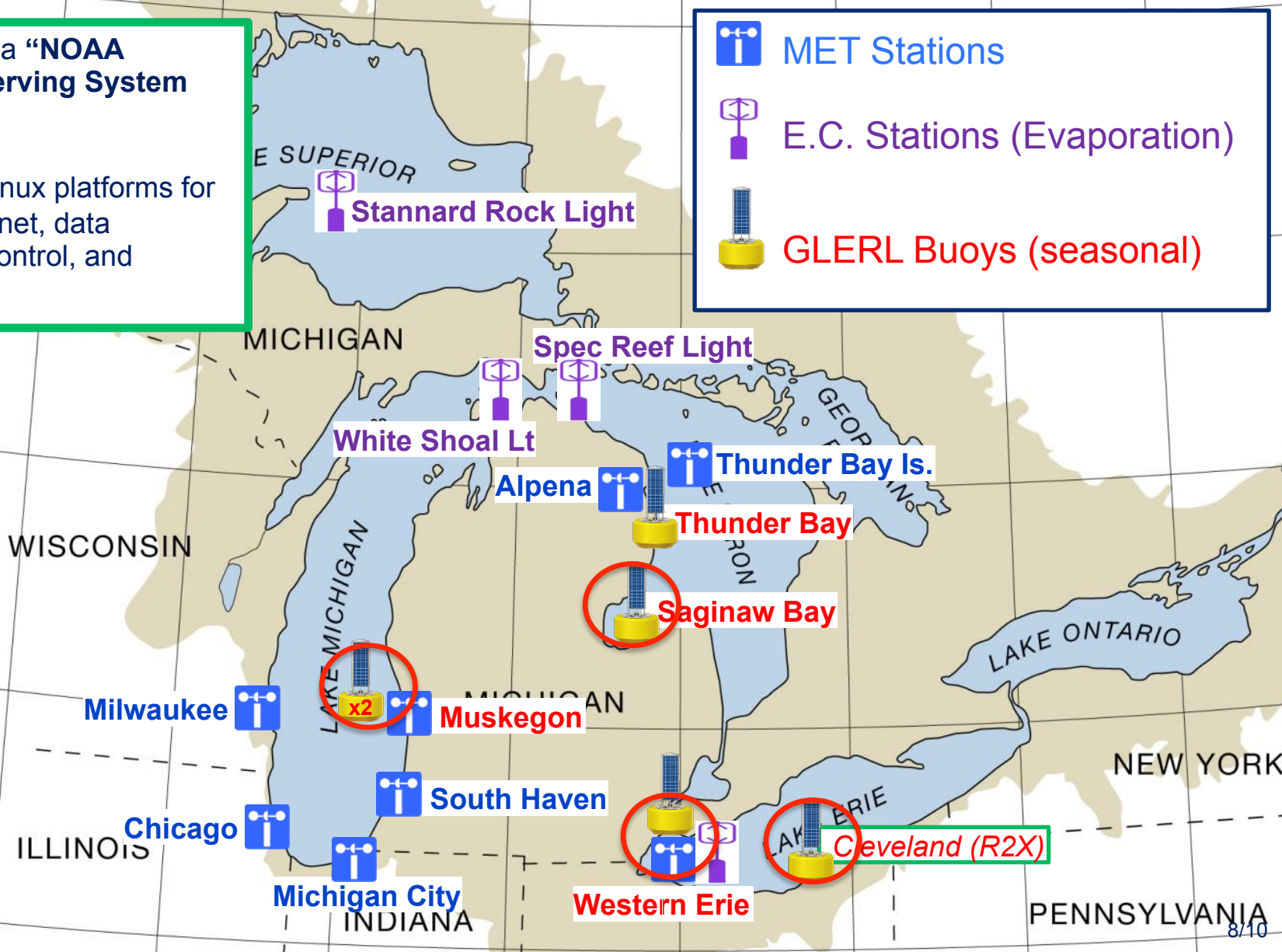
## Observations



# Real-time Coastal Observation Network: Buoys

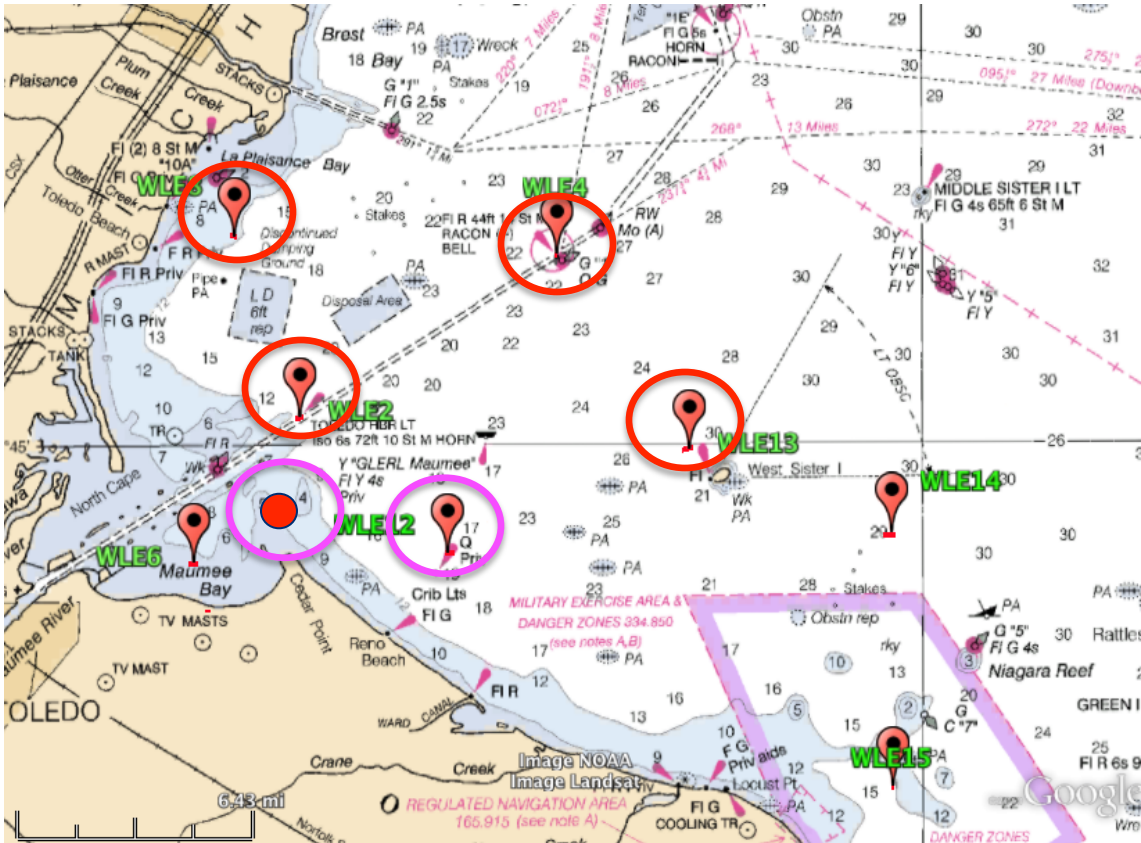
- Classified as a “**NOAA Critical Observing System of Record**”
- Embedded Linux platforms for internal Ethernet, data processing, control, and diagnostics

-  MET Stations
-  E.C. Stations (Evaporation)
-  GLERL Buoys (seasonal)



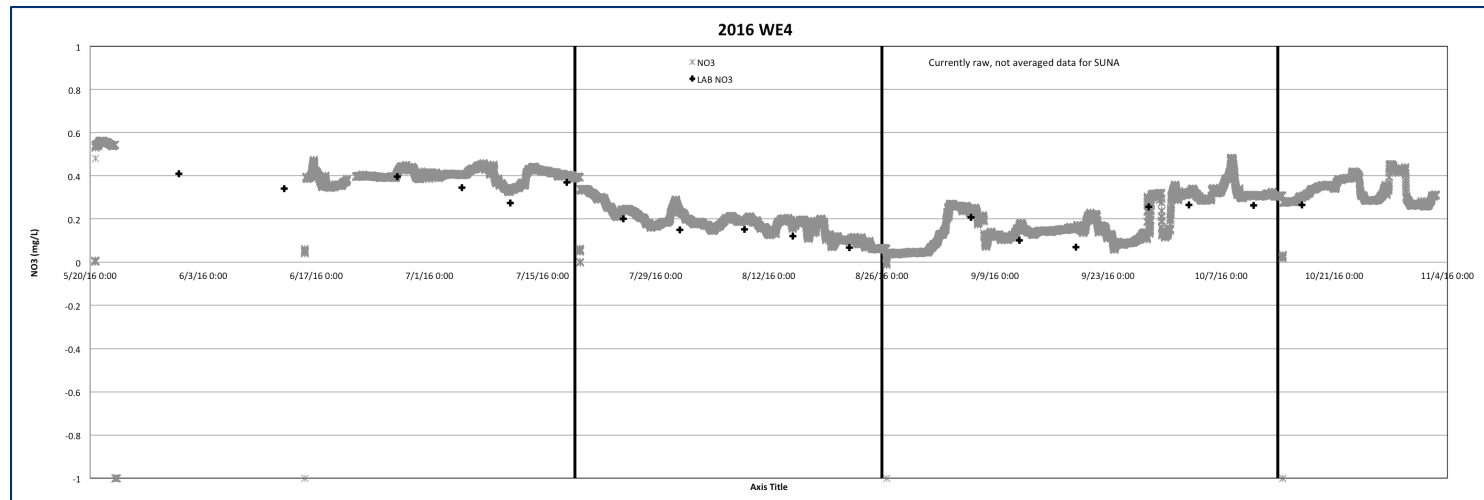
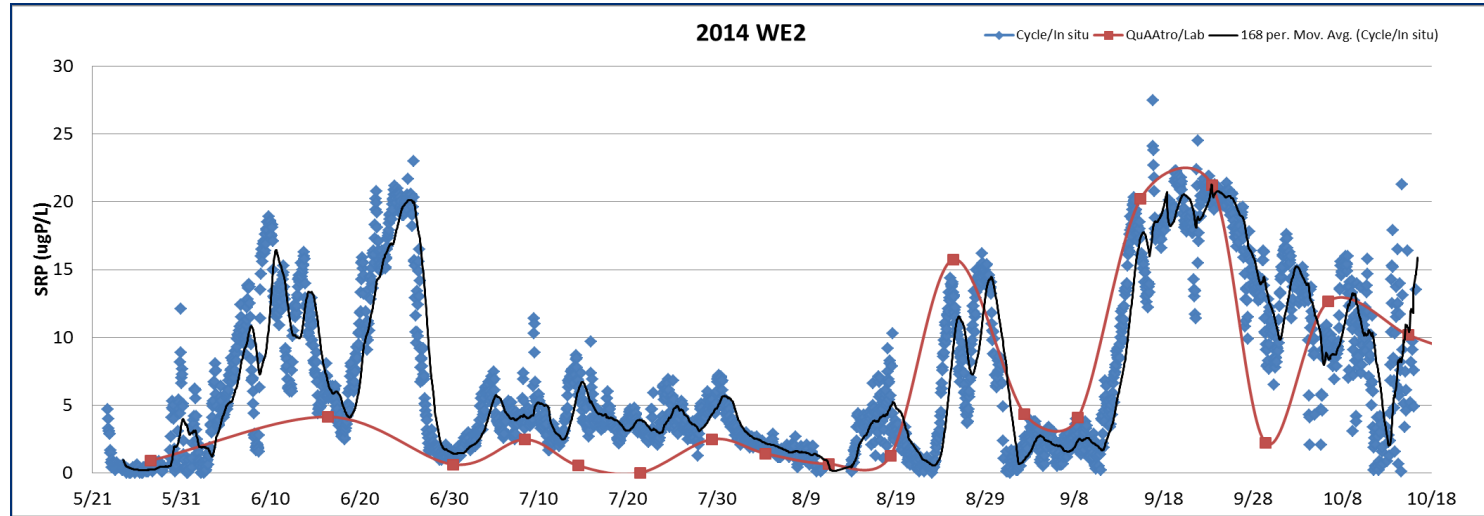


# Establishing a Western Lake Erie Monitoring Capacity



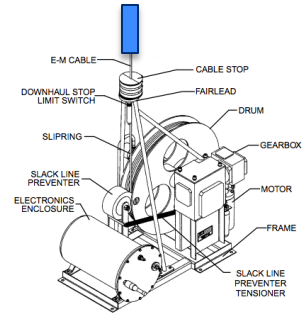


## Western Lake Erie Nutrient Monitoring Buoys

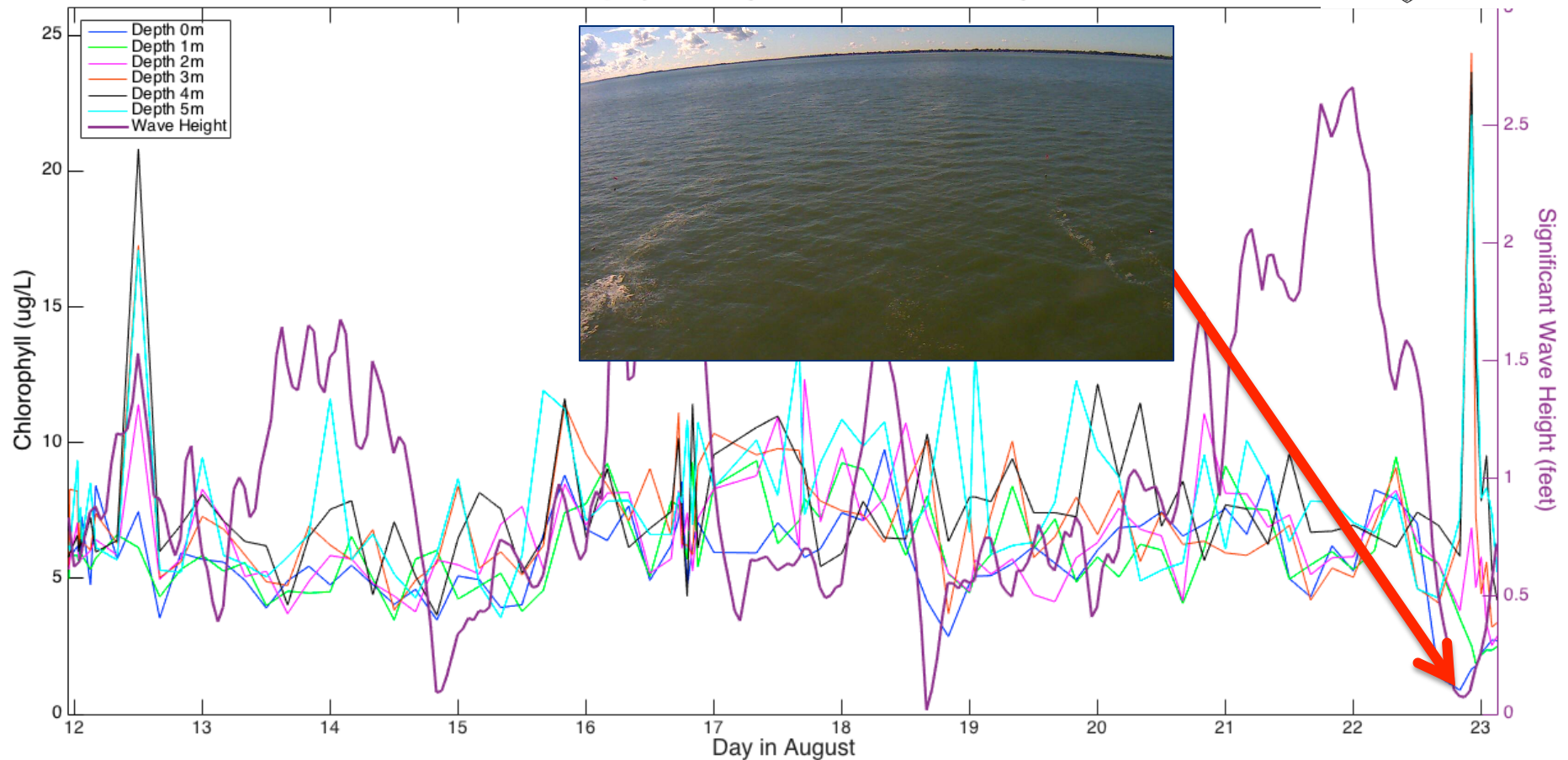


# Chlorophyll Profiles Near Toledo Water Intake

## Improve mixing component of 3D model



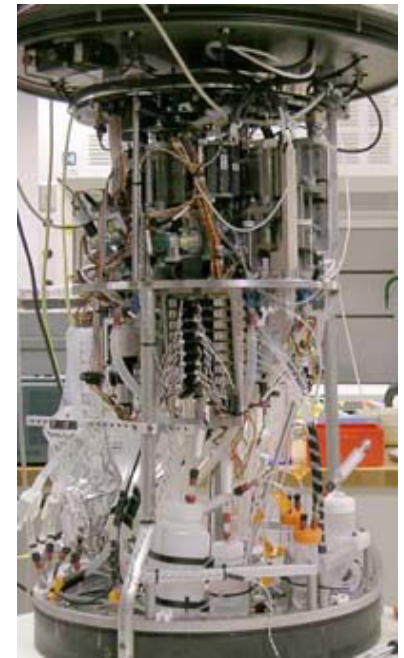
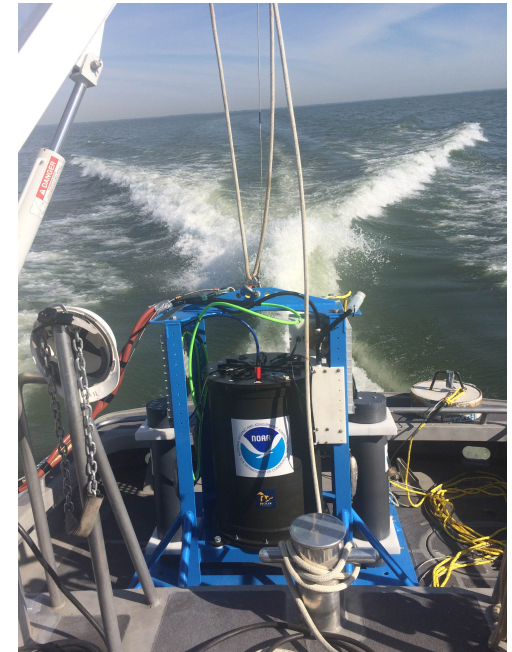
### Chlorophyll & Significant Wave Height



# Autonomous near real-time toxin detection for Lake Erie

Lead by Timothy Davis

- Environmental Sample Processor
- Collaboration between NOAA, MBARI, WHOI, OSU
- Successfully deployed in Lake Erie in 2016
- Two deployments scheduled for 2017
- Truly emerging technology
  - Fewer than 20 worldwide
  - ESPniagara is the first to study freshwater CHABs
  - Fine-scale microcystins observations are critical for toxicity models



# Airborne Hyperspectral Detection of Cyanobacteria: Resonon Pika II Sensor

Vander Woude, Ruberg



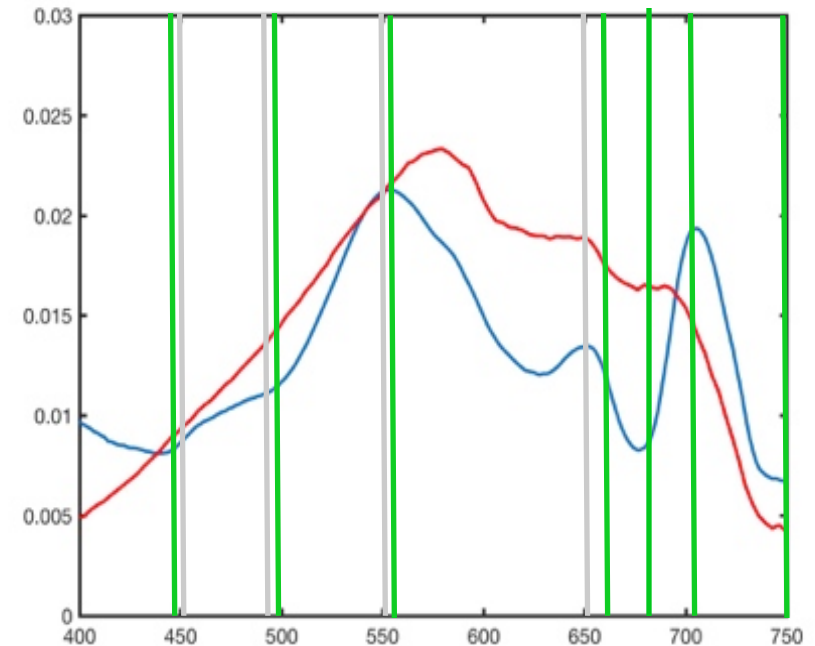
**Typical swath is 640 m**

**240 spectral bands**

**1.1 m spatial resolution**

**400-900 nm**

**17.6 degree FOV**

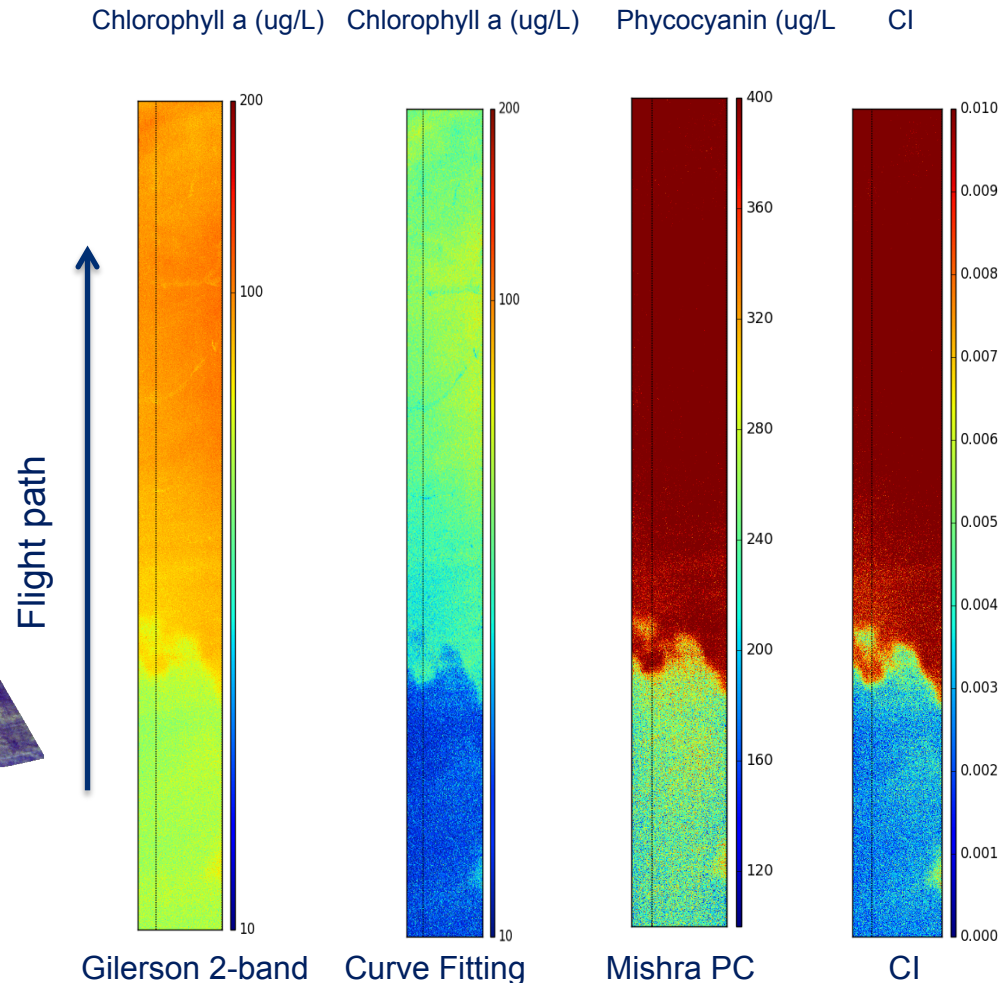
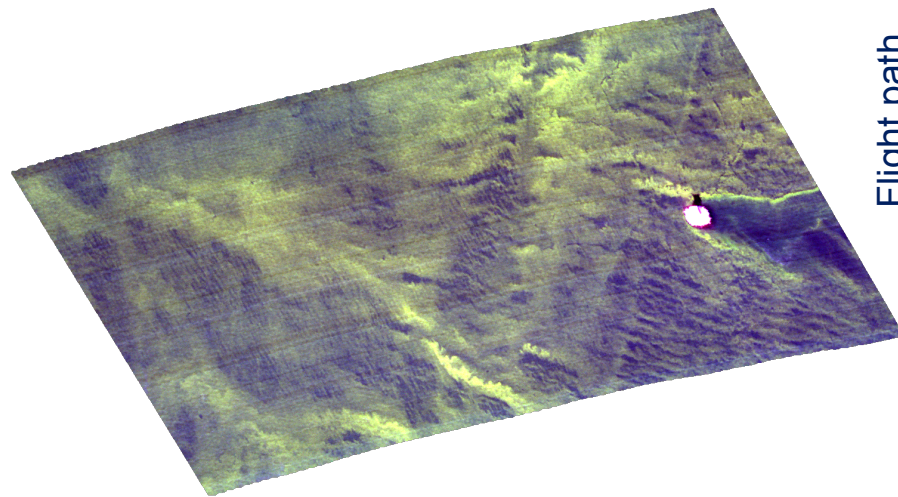


Flyovers of western Lake  
Erie, Saginaw Bay and  
Lake St. Clair in US and  
CA waters



# Hyperspectral Imagery and Algorithm Development

- Ability to detect and map HABs under clouds and near coastline
- Imaging system transferable to UAS



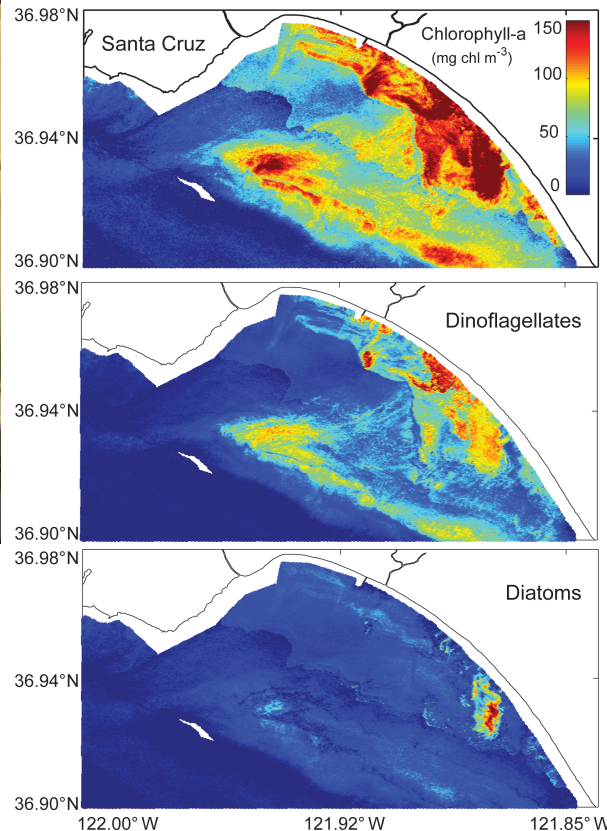


# NESDIS funded algorithm development for 2016/17 –

## Maps of **Phytoplankton Functional Types** from Rrs signatures from mono-cultures



- Cyanobacteria
- Diatoms
- Dinoflagellates
- Chrysophytes
- Chlorophytes



*Monterey Bay, Central  
California, Sherry Palacios &  
Raphael Kudela, PHYDOTax*

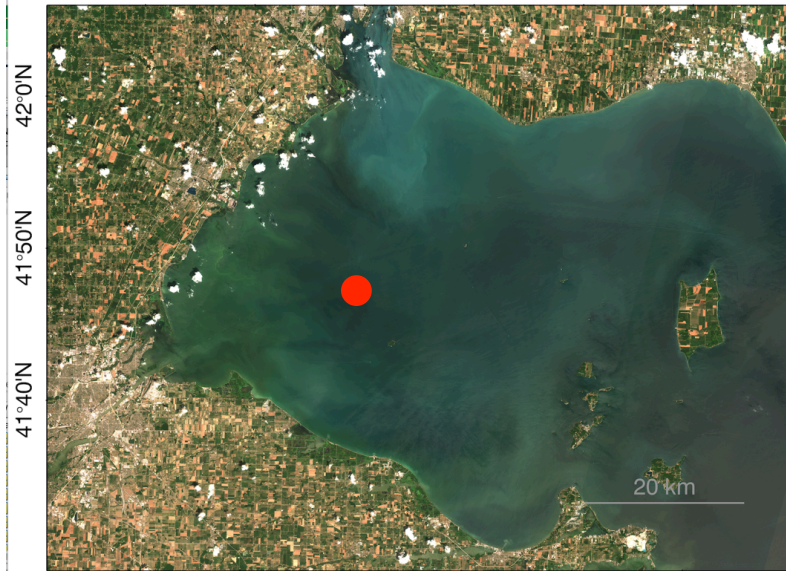


Algorithm research also applies to  
NASA PACE (Plankton, Aerosol,  
Cloud, Ecosystem) satellite  
operational 2023

# Lake Erie SeaPRISM Installation

Tim Moore, University of New Hampshire  
Funded by NOAA NESDIS and NASA

- Standard radiometric observation tool for MODIS, VIIRS, Sentinel 2/3, Landsat satellite imagery validation and algorithm development
- Unique freshwater contribution to the international NASA AERONET system
- Combine SeaPRISM and buoy observations to develop algorithms relating turbidity to HABs for band-limited satellite sensors



# Conclusion / Future Directions

- Initial work on the hypoxia observations and warning system – forecast system development by Stow, Rowe under CHRP
- Developed airborne and satellite remote sensing products
- Developed offshore nutrient monitoring buoys
- Deployed first Great Lakes Environmental Sample Processor for HAB toxicity observations
- Move towards year-round, under-ice ecosystem observations
- Expand nutrient monitoring buoy capacity into Saginaw Bay

