

Harmful Algal Blooms Monitoring, Modeling and Remote Sensing: Advancing Predictions of Bloom Intensity and Movement

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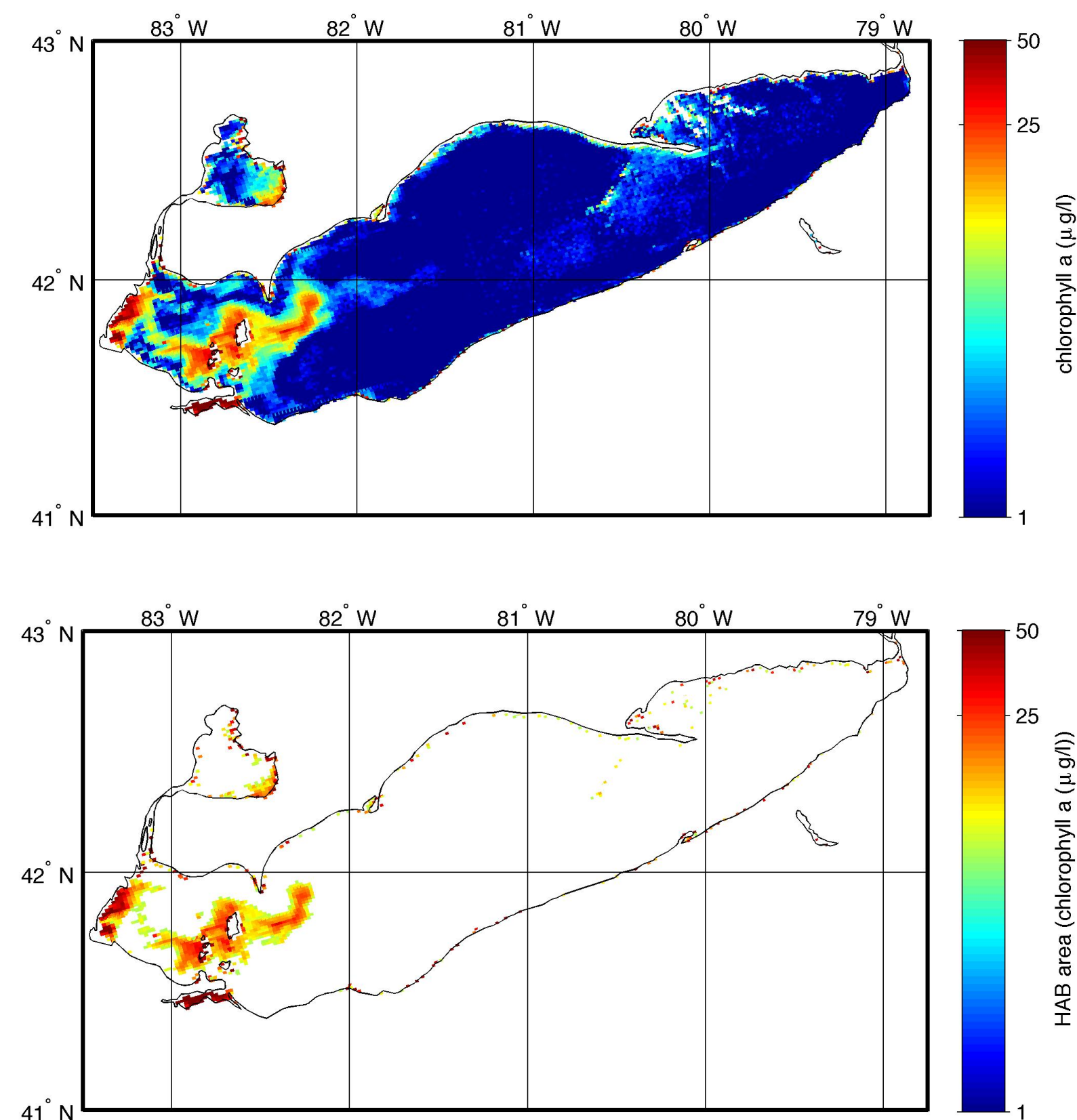
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Abstract

The NOAA Great Lakes Environmental Research Laboratory's comprehensive harmful algal bloom (HAB) program, which is coordinated in partnership with the Cooperative Institute for Limnology and Ecosystems Research (CILER), investigates HAB events through the use of satellite images, advanced algorithms, hyperspectral overflights and in situ technologies (e.g. Environmental Sample Processor, gliders), and down to the ecology of bloom forming cyanobacteria at a genomics level. These on-lake experimental and monitoring efforts allow us to develop advanced models (e.g. HAB tracker) that not only predict *Microcystis* bloom size and intensity but also the movement of HABs around the western basin of Lake Erie. The products developed by our program are of critical importance to regional stakeholders including, but not limited to Ohio EPA, City of Toledo (OH), City of Cleveland (OH), City of Monroe (MI), Old Woman Creek NERR, Cuyahoga County Board of Health, Michigan Department of Environmental Quality and Ohio Department of Health. The data that we collect is distributed to the aforementioned water utility managers, beach managers, citizen groups and academic partners on a weekly basis. During the 2014 Toledo water crisis, our website was heavily used as a central source of information on bloom toxicity and location as well as general HAB information. GLERL's long-standing HABs program continues to lead the region in advancing the understanding of HABs in the Great Lakes.

Remote Sensing

We use a combined algorithm approach, using Fluorescent Line Height (FLH) and Chlorophyll Index (CI) which has an atmospheric correction. We have found that using the combined algorithms provide a better estimate of HAB extent. MODIS images have been processed for 2008-2013 using daily images. In addition, a program was written to do matchups for this time period using the satellite data and taking a 3x3 mean box around the latitude and longitude points that our in situ data was collected at. We compared our in situ chlorophyll against FLH and CI values to convert to chlorophyll. Using this combined algorithm approach has applications not just for HABs but for other environmental parameters such as suspended solids or bacteria.

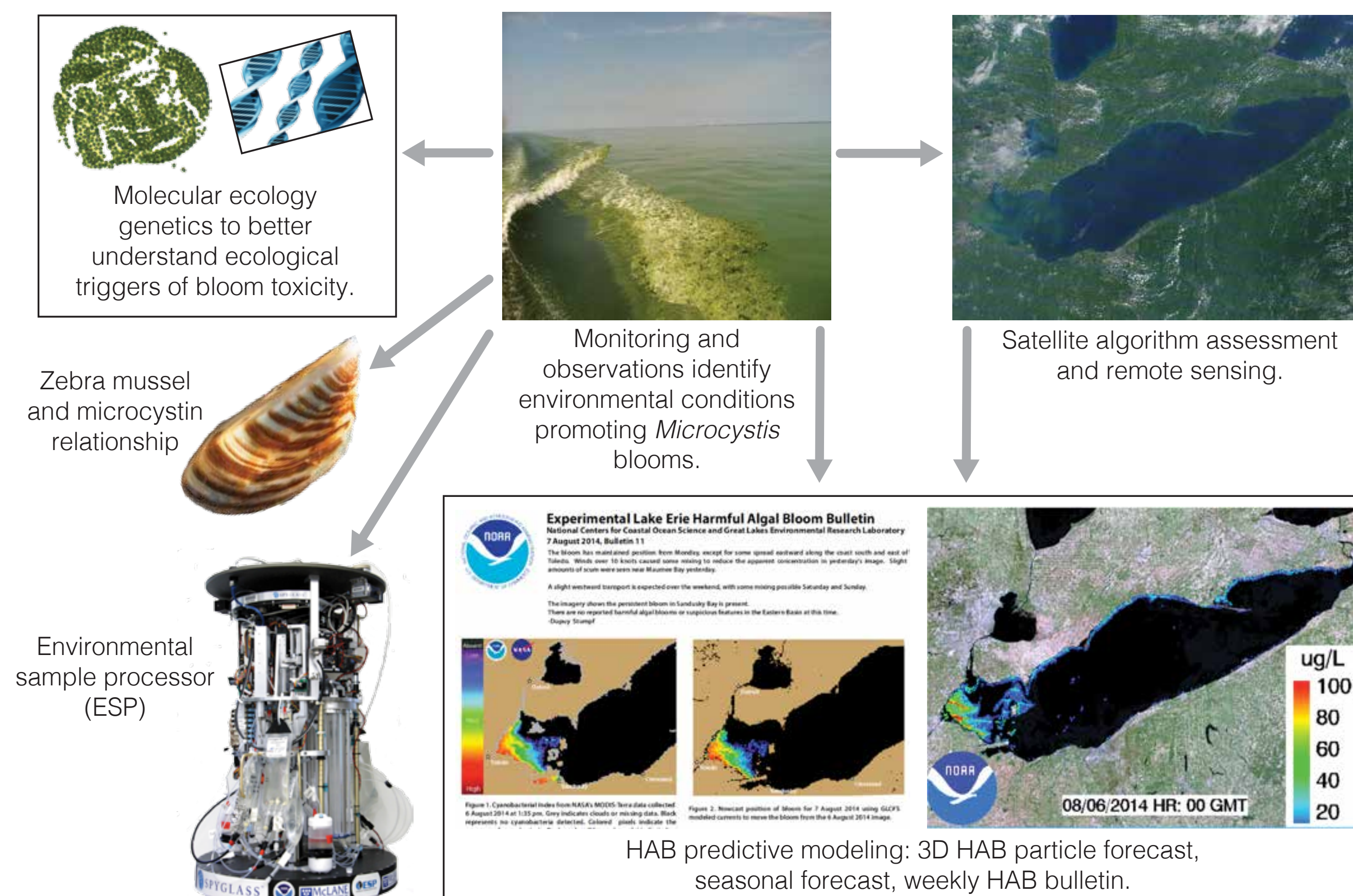


Top image: Satellite-derived HAB using FLH & CI algorithms after converted to chlorophyll on September 3, 2014. Bottom image: The extent of HAB on the same day (September 3, 2014).

Forecasting

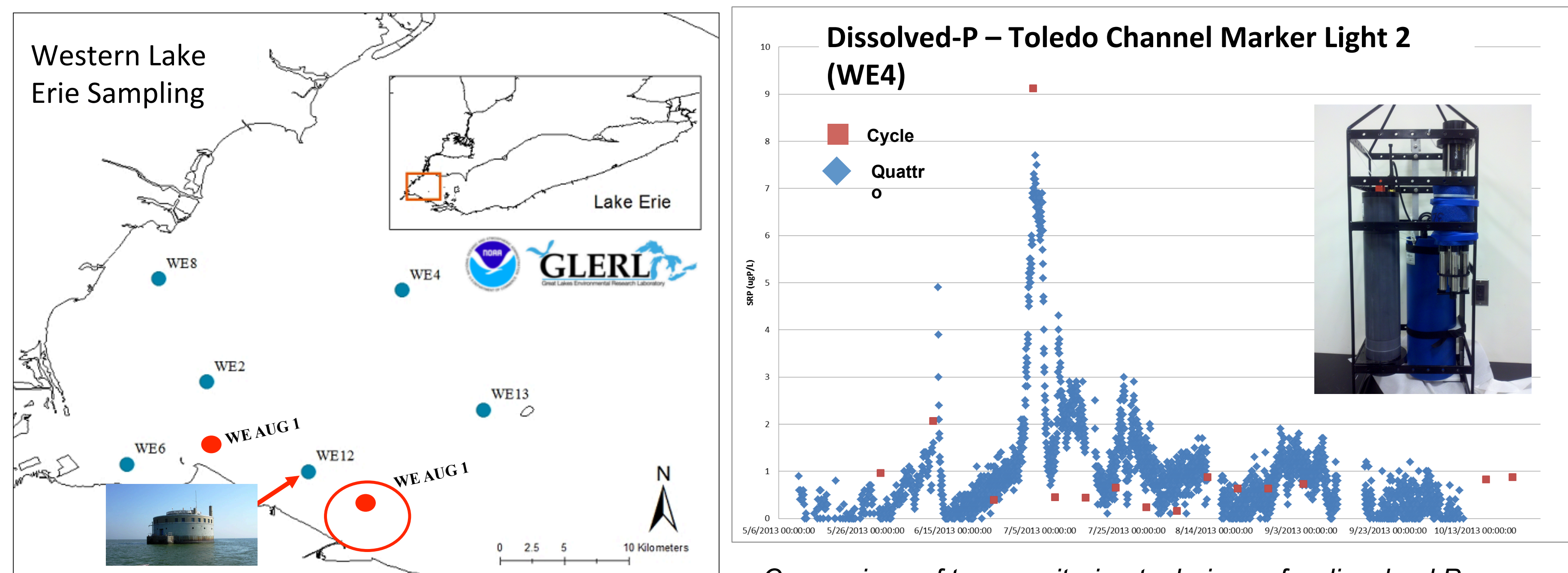
Daily forecasts are made using the combined algorithm approach, which are then translated into 3-dimensional particles using the P3D particle trajectory model. Horizontal diffusion is calibrated to drifters and vertical distribution/ mixing as well as buoyancy is included as well. Developing the forecast to include the influence of hydrodynamics on a 3D scale leads to a more robust product as the particles simulate the movement of HABs. We also make daily 5 day forecasts of the 3D currents using Lake Erie Operational Forecasting System.

NOAA GLERL/ CILER's HAB Program



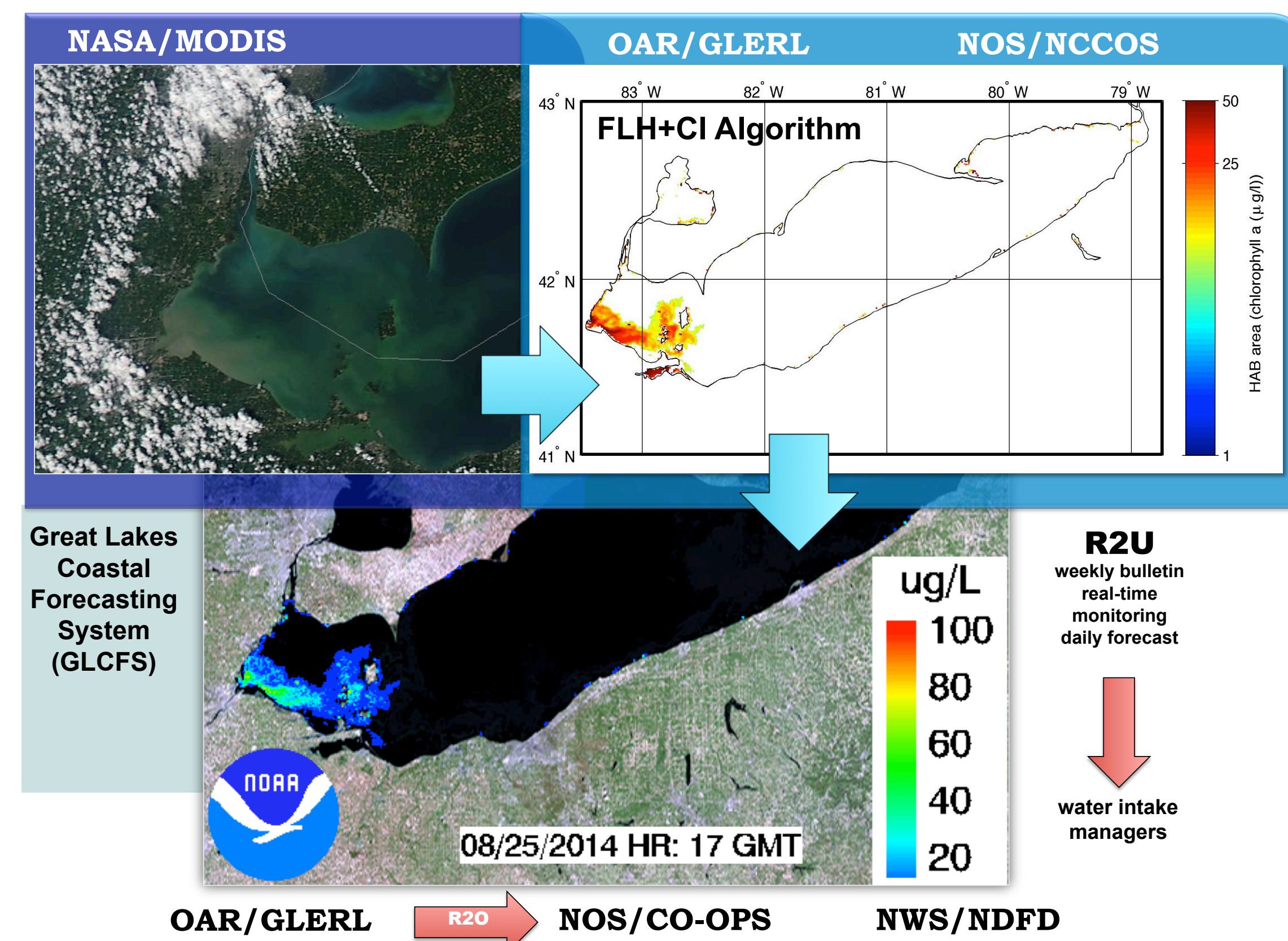
Monitoring

For nearly a decade, NOAA GLERL and CILER have been monitoring at specific sampling locations in western Lake Erie on a weekly basis. The map below displays sampling stations. In 2015, there will be two additional sampling sites, which are represented by the red circles. In addition to weekly sampling, we are conducting continuous monitoring at Stations 2,6, and 8. Through the use of sensors and other instrumentation, we are able collect hourly soluble reaction phosphorus (SRP) measurements, chlorophyll, phycocyanin, phycoerytherin, turbidity, and CDOM measurements, as well as 15 minute conductivity-temperature-depth (CTD) readings among other data. This has given us a robust data set to research environmental factors that contribute to the growth and proliferation of *Microcystis* and the initiation of microcystin. Monitoring data is also used to ground-truth remotely sensed bloom extent, distribution, and to validate our forecasting models.



Comparison of two monitoring techniques for dissolved P. This underscores the value of continuous monitoring to obtain a more accurate picture of what occurs in western Lake Erie.

Lake Erie HABs Tracker



HAB Tracker is the next generation of the current NOAA HAB Forecast Bulletin. Improvements include:

- Developing new algorithms to derive satellite based HAB detection that contains an atmospheric correction to remove haze (clouds) as well as parse out resuspended sediment from the algal bloom
- Using a higher-resolution 3D hydrodynamic model for Lake Erie
- By also using a 3D Lagrangian particle model to represent the algal bloom, which incorporates vertical mixing and biological processes such as buoyancy and migration
- updating the forecast on a daily time step.