Harmful Algal Blooms in Western Lake Erie

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Background

In the 1950s and 1960s, population growth and industrialization in the Lake Erie watershed led to increases in municipal and industrial waste discharges to tributaries leading to the Lake. These waste streams were rich in phosphorus and nitrogen (nutrients) which act as fertilizers for the growth of algae and toxic cyanobacteria (also known as blue-green algae). Moderate levels of nutrients support the growth of beneficial algae that serve as the base of the Lake Erie food web. Excessive nutrients, however, favor the growth of nuisance green algae (*Cladophora* sp.) and toxic cyanobacteria. Cyanobacteria growth, typically greatest in late summer, increased until large swaths of western Lake Erie were covered for a few weeks each summer. These massive growths of cyanobacteria became known as Harmful Algal Blooms (HABs) and adversely affected the ecology of the lake – contributing to the popular notion of Lake Erie as a 'dead lake' in the late 1960s (Beeton, 1961). The prevalence of HABs led to the creation of the Great Lakes Water Quality Agreement (GLWQA) between the USA and Canadian governments in the early 1960s that greatly limited the annual input of phosphorus into the lake by controlling phosphorus in discharges from waste-water treatment plants, from industrial sources, and by eliminating phosphorus in laundry detergents. The GLWQA was successful in reducing phosphorus inputs to the lake and consequently the late 1970s-early 1990s were a period of greatly improved water quality with HABs appearing only infrequently and being small in size.

Status and Trends

Unfortunately, in the mid-1990s, phosphorus inputs (known as 'loads') to Lake Erie began to rise, particularly in the form of dissolved phosphorus, and particularly from largely agricultural watersheds such as the Maumee and Sandusky River watersheds (Figure 1; Ohio Department of Agriculture, Ohio Department of Natural Resources, Ohio Environmental Protection Agency, and Lake Erie Commission, 2013.

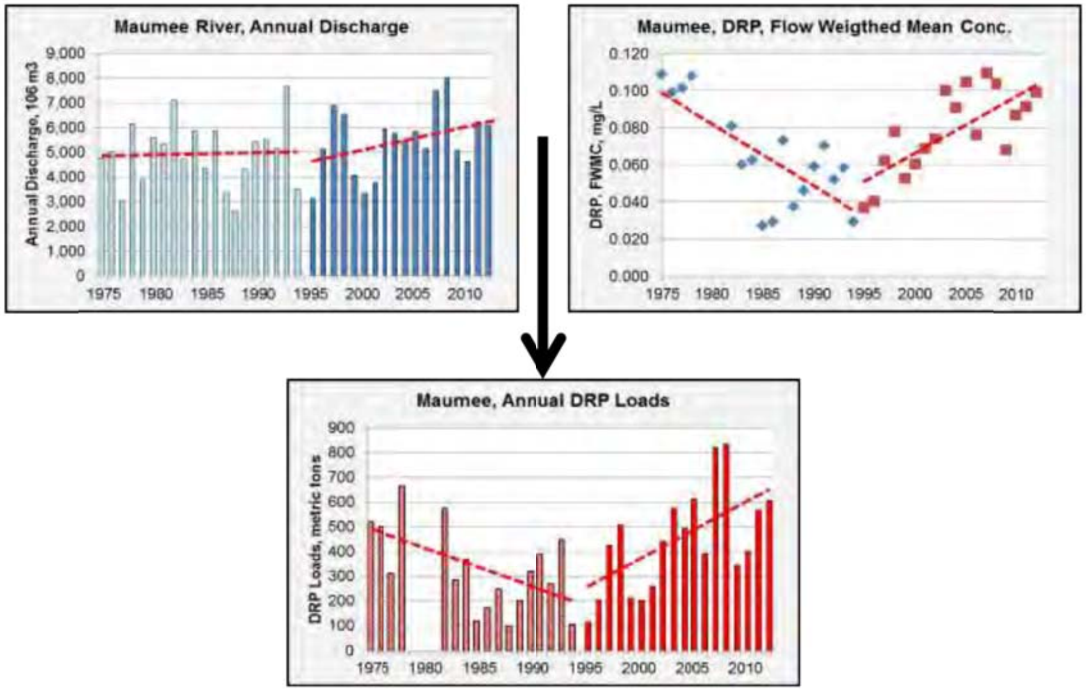

Figure 1. Annual discharge and dissolved reactive phosphorus concentrations and loadings of the Maumee River, 1975-2012.

As annual phosphorus loads increased, HABs began to return to Lake Erie in the late 1990s. Availability of satellite imagery beginning in 2002 has allowed NOAA to track the blooms each year, and to compare overall bloom size and severity between years. A suite of models developed by NOAA and others attempt to predict the severity of the annual HAB based on past years and the springtime loading of phosphorus to Lake Erie in the current year (Figure 2). The severity of blooms generally increased throughout the 2000s to the present. Most of the phosphorus delivered to Lake Erie from tributaries is believed to be the result of fertilizer runoff from farmlands during rain events. Occasional small bloom years (2012, 2016) coincide with severe dry springtime conditions.

In August of 2014, a bloom of the cyanobacterium *Microcystis* sp. resulted in a ‘Do Not Drink’ advisory in the City of Toledo for 2 days due to levels of the toxin microcystin in finished drinking water that exceeded guidelines for safety recommended by the World Health Organization. The 2014 bloom, while not the largest bloom of the decade, had several unfortunate characteristics that precipitated the water crisis:

1. Persistent strong northeast winds pushed the bloom against the Ohio shoreline, concentrating it in the vicinity of the Toledo Lake Erie water intake located three miles from the south shore.

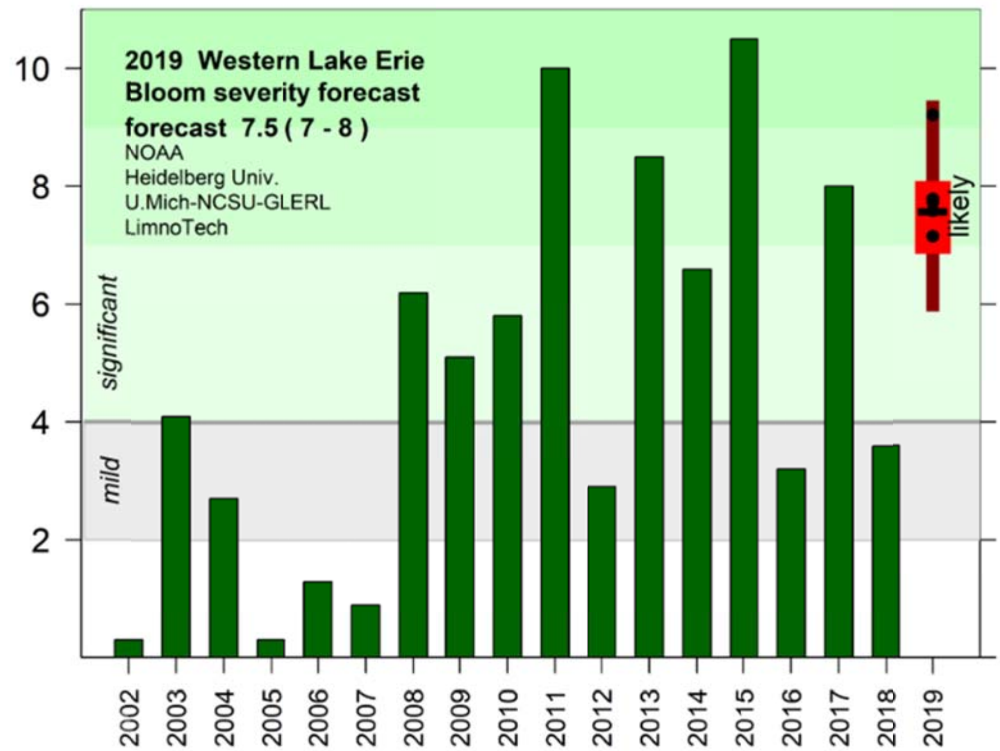

Figure 2. Western Lake Erie algal bloom severity forecast (National Oceanic and Atmospheric Administration, Heidelberg University, University of Michigan, and LimnoTech).

2. The strength of the wind circulated bloom-rich water from the surface to the lake bottom where the city intake is located.
3. There is evidence that a virus (bacteriophage) was present in the bloom that may have attacked the cyanobacterial cells, causing them to release dissolved toxin into the water (Steffen et al., 2017). Dissolved toxin is much more difficult for water treatment plant to remove.
4. Water treatment plants had no early warning capability in 2014 and could not react fast enough to a rapid increase in toxin levels.
5. Overall, the bloom was more highly toxic in 2014 compared to other years. That is, a given amount of cyanobacteria collected with standardized methods was several times more toxic in 2014 than in previous years.

Early Warning System and Rapid Response

Since 2014, in an effort to prevent any future drinking water incidents, several measures have been introduced. Lake Erie now has a robust early warning system of buoys that detect cyanobacterial blooms and their movements. Robotic sensors are also being developed that can automatically measure toxin levels in the lake and transmit data to the internet in near real-time. Water treatment plants have increased their capacity to respond quickly and with redundant measures to remove any algal toxins. The issue of bloom toxicity is an active area of research at present. Scientists are able to predict bloom size and hope in the future to be able to predict bloom toxicity and perhaps develop early warning of viruses that may cause cyanobacterial cells to release toxin.

Open Water Impairment

In 2018, following several years of large algal blooms in the western basin, the State of Ohio declared the Ohio open waters of the western basin to be officially Impaired for recreational use. The impairment designation followed the recommendation of a committee of lake researchers that created a set of criteria based on bloom size and duration that was used to define the impairment designation. These criteria can also be used to remove the impairment designation in the future if conditions improve (Davis et al., 2019).

References

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