The State of the Lake: Water Quality, Land Use, and Algal Blooms in Lake Erie

Kopo Oromeng and Val Masters, Oberlin College, OH

Background

Lake Erie provides drinking water to over 11 million people supports an economy that generates 12 billion dollars a year and over 100,000 jobs (Tuholske & Kilbert 2015). This project investigates harmful algal blooms (HABs) in Lake Erie by comparing land use to surface water temperature, chlorophyll *a* concentration, and sediment concentration. Sources of water quality problems that increase the likelihood of HABs include replacement of wetlands and forests with urban area and agriculture, increased runoff where impermeable surfaces replaces vegetation, and excessive fertilizer applied to farms washes into rivers and eventually the lake (Ohio EPA 2002).

Algae blooms are toxic, and uptake all available nutrients and oxygen in the water, creating dead zones that kill fish. This hurts Ohio's ecosystems and economy, so it is important to understand when and where these blooms form, and find concrete ways to prevent them.

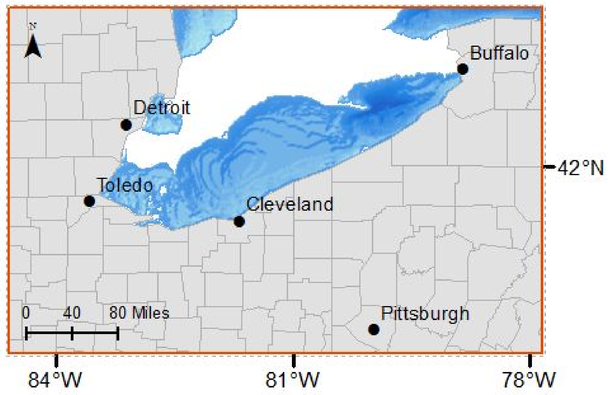

Figure 1. Location of study area in the Midwestern United States. We focused on Toledo, in Lucas county, and Cleveland, in Cuyahoga county.

Figure 2: Harmful Algal Blooms in Lake Erie, Summer 2016. Green regions showing dense algal blooms are seen on the western side of Lake Erie, near Toledo. Algae blooms also occur along the southern coast from rural areas, meaning they source from farms. Sediment runoff is also draining into the lake from Cuyahoga, Erie and Lucas counties. This image may have been taken after a rainstorm, which would cause high sediment runoff; average summer 2016 and 2017 sediment concentration mapping revealed no sediment plumes near Cleveland (see figure 6). Imagery sourced from Earth Observatory- NASA MODIS Imagery Archives.

Methods

Raster calculator was used to find mean water temperature, chlorophyll concentration, and suspended sediment concentration. We worked with selected features from land cover and land use datasets to classify and map the different uses of land in Cuyahoga and Lucas counties. The Image Classification toolbar (Spatial Analyst) was used to make and edit different classes of land use and land cover. All data was projected into NAD_1927_StatePlane_Ohio_North_FIPS_3401 (Lambert Conformal Conic).

Analysis and Results

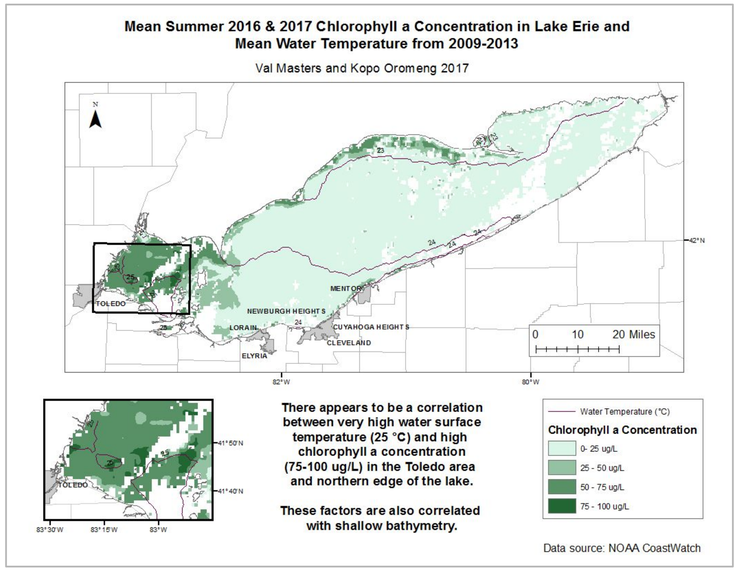

Figure 3. Mean Chlorophyll *a* concentration in Lake Erie in summer 2016 and 2017 compared with mean water temperature. More recent water temperature data was not available, so an average of the most recent data was taken.

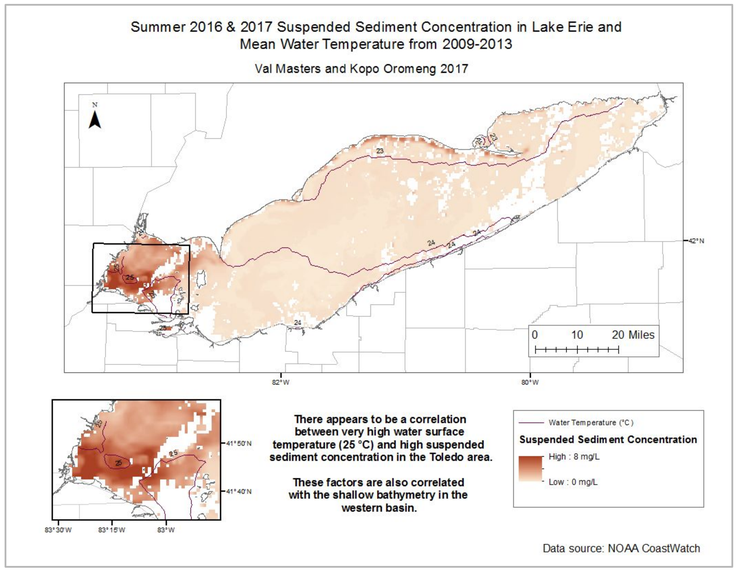

Figure 4. Mean suspended sediment concentration in Lake Erie for summer 2016 and 2017 compared with mean water temperature. As with the chlorophyll *a* concentration map, sediment is concentrated near Toledo.

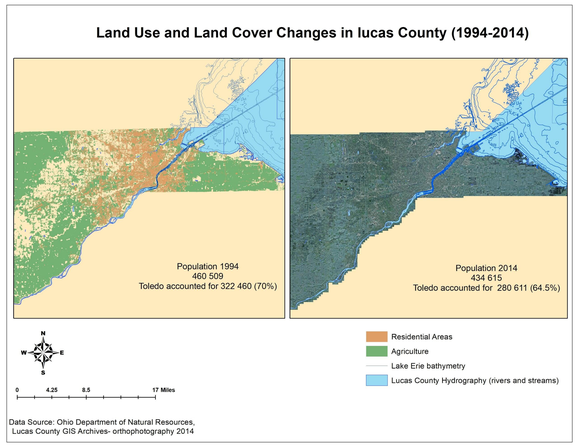

Figure 5. Similar to Cuyahoga, Lucas County's population decreased over 20 years. Since land use and and land cover data was not available for Toledo or Lucas County post 1994, we used landsat imagery along with land use data from 1994. Landsat imagery show that there is a visible significant increase in plant cover. Perhaps additional information on inorganic fertilizer use as well as soil types might give better insights on the reasons why almost all HABs started in the region of the lake closest to Toledo.

Figure 6. Land use changes in Cuyahoga county from 1994 to 2017. Though Cleveland's population decreased from 1994 to 2017, the percent of land used for residential and urban functions increased by about 22%, while agriculture decreased by about 2%. The area converted for urban use was likely previously undeveloped. The 2017 land use map also shows that agricultural land use has consolidated around major waterways. This likely means that management style has shifted to be controlled by major companies, which have less sensitivity to the requirements of the local environment and are less invested in maintaining its quality so long as the farm stays productive.

Conclusions

The clear positive correlation between water surface temperature, suspended sediment concentration, chlorophyll *a* concentration, and proximity to Toledo suggests that Toledo, despite no longer being a bastion of Midwest industry, has a large impact on water quality with ramifications for its economy and ecology of the lake. While Cleveland also likely has an impact on the lake, this is not as visible in the datasets we considered. To ameliorate the impacts of agriculture and urbanization, stormwater control projects should be implemented in the cities, and wetlands restored along riparian corridors, especially near major farms.

Literature Cited

Ohio EPA, 2002, Drinking Water Source Assessment for the City of Lorain. http://wwwapp.epa.ohio.gov/gis/swpa/OH4700711.pdf

Tuholske, J., and Kilbert, K., 2015, Moving Forward: Legal Solutions to Lake Erie's Harmful Algal Blooms: The Lucas County, Ohio Board of County Commissioners.