Lake Erie Harmful Algal Bloom Capstone Proposal

The Great Lakes comprise 21% of Earth's surface freshwater by volume.[1] They are a vital resource that provides water for consumption, power, recreation, and other uses. The Great Lakes as a whole provide drinking water for 10% of the U.S. population and 30% of the Canadian population.[2] Lake Erie alone provides drinking water to 11 million people.[3] Unfortunately, pollution from human activity and climate change pose threats to the ecological stability of the Great Lakes as a whole, but Lake Erie in particular. Lake Erie is ecologically vulnerable for three key reasons:

1. It is the shallowest of the Great Lakes, which makes it the most susceptible to warming.[4]
2. It receives a large influx of industrial and agricultural runoff that introduces bioavailable nutrients and impacts its water quality.
3. It has been exposed to invasive species, notably zebra mussels and Asian carp.[5]

Lake Erie's water quality has been a concern since the 1960s, and has again become an issue in the 2000s as the lake has begun to once again experience Harmful Algal Blooms (HABs) in the summer months. HAB refers to the rapid growth of algae that produce harmful toxins, the most common of which is microcystin. Microcystins can cause liver damage, and are harmful if ingested or, at high enough concentrations, through skin contact.[6] In 2014 the Western Basin of Lake Erie experienced an HAB that caused microcystin concentrations to exceed allowable limits for water purification, and 400,000 area residents were without drinking water for several days.[7] As this incident demonstrates, HABs are incredibly disruptive events economically and ecologically.

Several government and academic agencies have sought to gather data on HABs for various purposes, including the Environmental Protection Agency (EPA) whose research is available through the Great Lakes Environmental Database (GLENDA)[8], the National Oceanic and Atmospheric Administration (NOAA), and the Great Lakes Environmental Research Agency (GLERL).[9] While the data collection methods, sampling locations, and frequencies have not always been extremely consistent the following data is available through these institutions:

1. Measurement indicating the presence of algal blooms, most importantly microcystin concentrations, and chlorophyll-a values.
2. Conductivity-Temperature-Depth (CTD) measurements such as temperature, dissolved oxygen, and turbidity. Warmer temperatures are known to promote algal blooms, and

[1] https://www.epa.gov/greatlakes
[2] epa.gov/greatlakes/facts-and-figures
[3] https://phys.org/news/2019-11-lake-erie-people-algae-blooms.html
[4] https://www.epa.gov/greatlakes/lake-erie
[5] https://lakeeriefoundation.org/issues/invasive-species/
[6] https://oehha.ca.gov/media/downloads/ecotoxicology/document/microcystin031209.pdf
[7] https://earthobservatory.nasa.gov/images/84125/algae-bloom-on-lake-erie
[8] https://cdx.epa.gov/
[9] https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/

HABs consume dissolved oxygen which impacts the ecosystem. Wind speed and turbidity reflect the tendency of water to mix vertically and horizontally, which can cause HABs to spread.

3. General water quality chemical analysis, notably the concentrations of nitrogen- and phosphorus-containing compounds, both of which are fuels for HABs.

I propose to use data collected from the Western Basin of Lake Erie to investigate the relationships between water quality and environmental conditions and the presence of algal blooms. The main goal would be to **create a statistical model that can predict microcystin concentrations based on given water quality data (temperature, nutrients, etc.).** Other guiding questions could include:

1. What is the typical spatial and temporal profile of nutrients and conditions (phosphorus, nitrogen, oxygen, temperature, etc) in Lake Erie in the absence of an HAB event?
2. Which water quality features are most predictive of an HAB event?
3. If a statistical model can be developed, how early can one expect to see reasonable indications that an HAB will form?