Cornell University & Finger Lakes Community College

Effects of Climate Warming in NY's Shallow Large Lakes

(Temperature Stratification and Water Quality)

A simple question with a complex answer….

The Hypothesis being researched is that climate warming is causing the surface water to be warmer creating stronger and longer time periods of stratification. This causes the water near the lake bottom to be anoxic (no dissolved oxygen) for longer periods of time increasing the amount of phosphorus being released from bottom sediments.

From mid-May to mid-October 2016 and 2017 the research team collected a large set of water quality related data:

- Weather data – Air temperature, wind direction & speed, rainfall, humidity.

- Water Temperature (once per minute) every meter (~3.3 feet) from lake bottom to surface using two water quality buoys

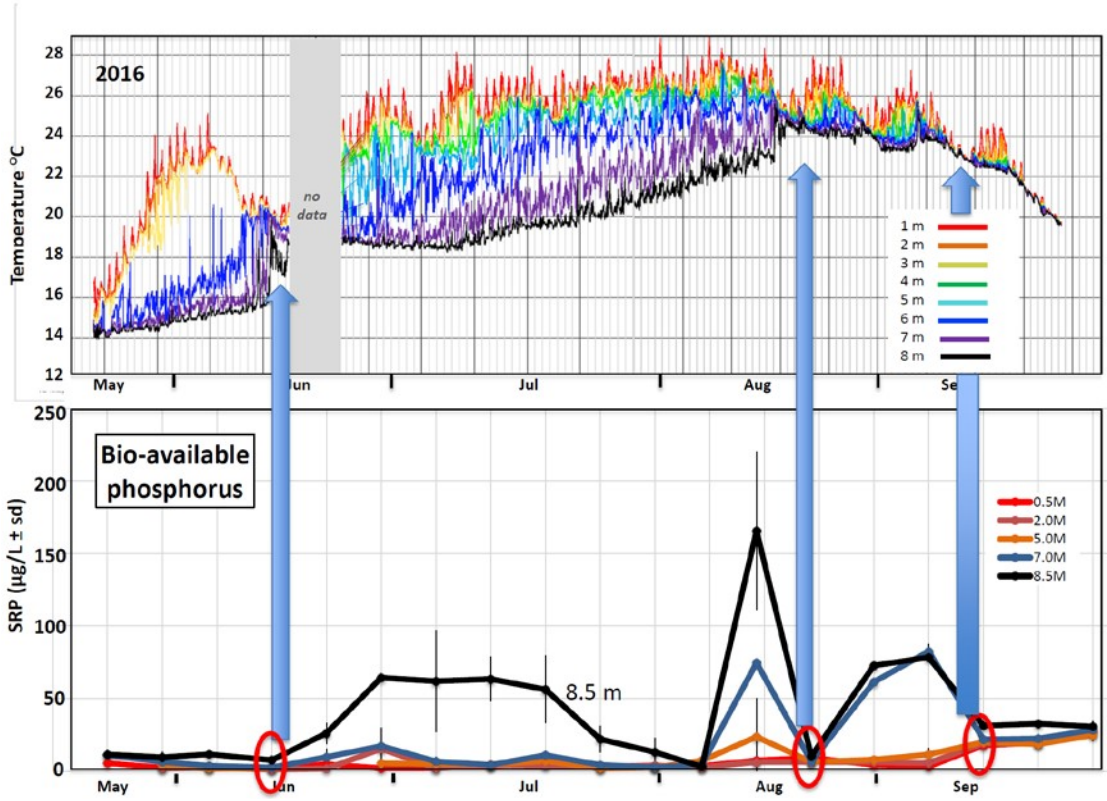
- Water column monitoring
  - Temperature & Dissolved Oxygen
  - Chlorophyll-a (algae level) top 5 m
  - Zooplankton & Phytoplankton
  - Phosphorus, Nitrogen, Iron & Sulfur samples 5 different water depths

- This data are currently being analyzed.

A few significant observations from the first two years of research are:

- The prevailing winds were out of the South or North aligned with the long axis of the lake.
- The amount of rainfall during 2016 was significantly below long-term averages.
- The amount of rainfall during 2017 was a record high for the last ~30 years.

- In 2016 the lake stratified (thermocline present) in May, destratified in an early June storm and restratified by June 20th and remained stratified until August 21st (two months)
- Normally the lake experiences strong wind generated vertical water column mixing events every few
- Weeks during the summer (i.e.Polymictic Lake) because it is realtively shallow (9m/30ft.)
- The impact of the 2-month stratification period is showed graphically below along with the corresponding trends of soluble reactive phosphorus (SRP):



During the two-month time (mid-Jun to mid-Aug) when the lake was stratified, SRP released from the bottom sediments under anoxic (no dissolved oxygen) conditions built up to a high level at 8.5 m during July.

Then in late July/early August the SRP declined to almost zero at 8.5 m. Normally, the SRP level at the bottom would be expected to build up and remain at a high level until a strong wind or cold rain caused a vertical water column mixing event.

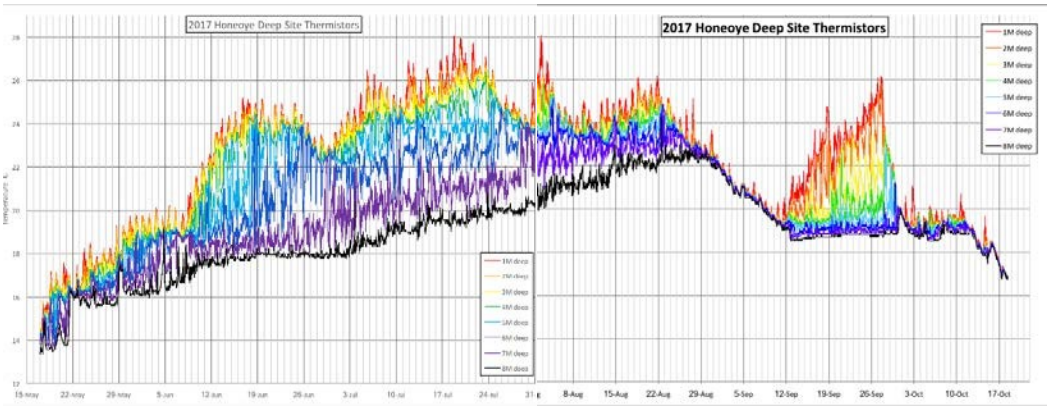
The research team's hypothesis as to how the SRP at 8.5 m was transported to the surface in Late July/early August is that the prevailing winds from the North and South caused the thermocline to rock (under water seiches) along a North/South axis.

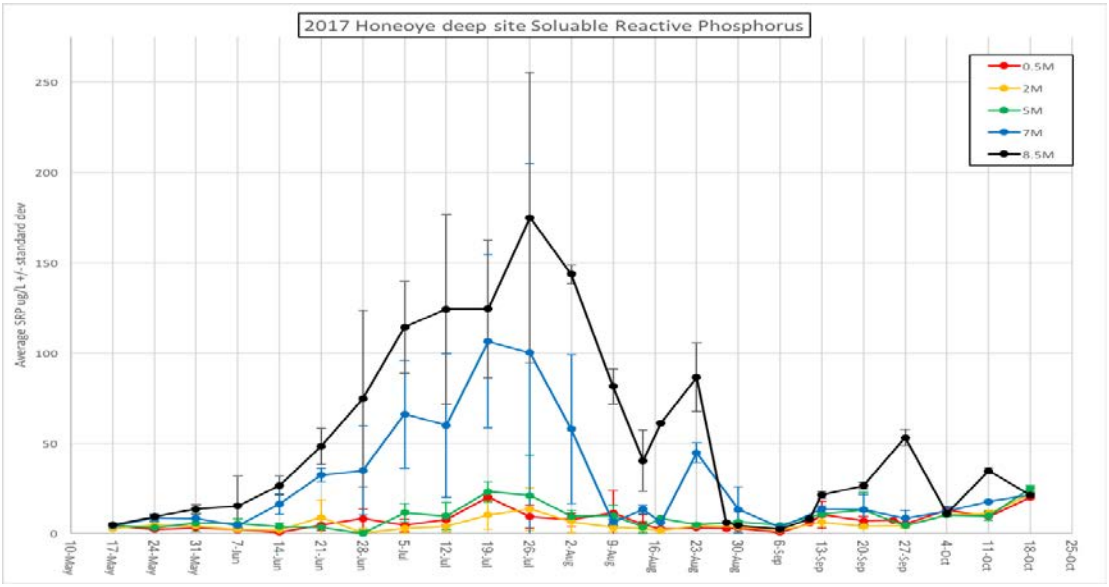
Basically, the wind generated under water waves that disturbed the water causing mixing of the water above the thermocline with surface water. The waves can be seen in the top graph as fluctuating water temperatures at 6m and 7 m. Additional data collection will be made in the summer of 2018 to try and confirm this as the transport mechanism.

On August 21st, 2016 there was ¾'s of an inch of cold rain and strong winds causing a complete vertical

water column mixing event. By August 21st the SRP at 8.5 m had built up to its peak high for the summer. A few days later the SRP 8.5 m was almost zero indicating it had complexly mixed vertically in the water column. This would be the expected outcome of a complete vertical mixing event.

2017 showed a similar pattern of underwater seiches and mixing events:





In 2018 Cornell University will create a complete computer model of Honeoye Lake using the "CE-QUAL-W2" platform based on all the data collected during 2016 and 2017. Additional water quality data will be collected in 2018 to validate the lake model. Then various legacy nutrient mitigation strategies will be modeled to gauge how effective they would be for Honeoye Lake.

The objective of this 3-year research project is to determine if the legacy nutrients in the bottom sediments play a significant role in fueling the lake's blue-green algae blooms in late summer. Preliminary results indicate that the legacy nutrients in the lake bottom sediments do significantly contribute to the lake's blue-green algae blooms. Although there are also external nutrient inputs from the watershed, input from legacy nutrients in the bottom sediments was sufficient to account in 2016 (a dry year) for between 68% to 100%, and 2017 (a wet year) 41% to 78%, of the phosphorus in the surface lake phytoplankton during July-September. Specific mitigation strategies will be recommended to the HLWTF in 2018.