

A Trip to the Beach: Untangling the Mystery of Algal Blooms in the Great Lakes

by

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Part I – The Problem

Matt and Flora are college sophomores studying biology who had met in their freshman biology lab. Matt had invited Flora up to his summer cottage on Lake Michigan to spend a week with his family and was excited to show her the beautiful beach. He hadn't been to the cottage in a couple of years because he had been working in the city to save up money for college. After arriving on a hot August evening, they decided to go straight out to the beach and chatted as they walked along the path.

"I can't wait for you to see the beach. I've been walking and swimming here since before I can remember. It even inspired me to study biology," Matt explained.

"It sounds really beautiful. Maybe we can take a dip in the lake to cool down after the long drive," said Flora.

When they arrived, there was a bad smell in the air and there were piles of brown goop along the water's edge. This wasn't how Matt remembered the beach.

"What's that lined up along the shore? And that smell! Do you think there's been a sewage leak?" Flora asked.

"I'm not sure, but I don't think we should stick around to find out. Let's go back to the cottage and ask my parents if they know what's going on," Matt replied.

When they got back to the cottage, Matt's parents told them that for the past two years large quantities of green algae had washed up on the beach. The rotting algae formed stinking clumps along the shore. Fewer tourists had been coming to visit the area since the beach was so unpleasant when this happened. Their neighbors were worried about the impact on the value of their lake property.

"I wonder what's going on?" Matt asked.

"I think we should find out," Flora replied.

"My Aunt Janet works for the Department of Natural Resources. I'm going to send her an email and ask if she knows anything about this," said Flora.

"Great idea. I'm so sorry, Flora, that wasn't the romantic walk I had in mind," said Matt.

Questions

1. What could have caused a recent increase in the amount of algae washing up on the beach? Brainstorm a list of possibilities.
2. Choose three of your ideas from the above list and write a testable hypothesis for each one. Describe the data that you would need to test each hypothesis. *(Remember that a testable hypothesis is a falsifiable statement that could explain an observation. For example, when Matt and Flora see the brown piles, they think it might be fecal material. Their testable hypothesis would be that if there had been a recent sewage leak, then it could have resulted in the foul smell and rotting piles. They immediately falsify this hypothesis when they find out from Matt's parents that the piles are made up of algae and that they have been forming for several years.)*

Part II – Could It Be Phosphorus?

Flora received an email response from her Aunt Janet.

Hi Flo,

Great to hear from you. Yes, the algae in question are called *Cladophora glomerata*. This species of algae grows on rocks just out in the water along the shore and has had a long history here in the Great Lakes, but has recently become a problem (again) for many beaches across the basin. Back in the 1960s and '70s, a large increase in phosphorus pollution in the Great Lakes caused the algal growth to proliferate. Phosphorus is a limiting nutrient for algae in freshwater ecosystems. In the 1970s, laws were put in place to reduce the phosphorus inputs and the problem all but disappeared.

I need to run-meeting in 5 mins. More later.

Love Aunt Janet

Since Matt and Flora had internet access at the cottage, they decided to investigate further.

“Maybe there’s another source of phosphorus pollution in our lake?” suggested Matt.

“Yeah, good idea. Let’s see if we can find any data on recent phosphorus levels,” said Flora.

Question

- Examine the figure below and predict what the data would look like if phosphorus in Lake Michigan is the cause of the recent excessive growth (bloom) in algae.

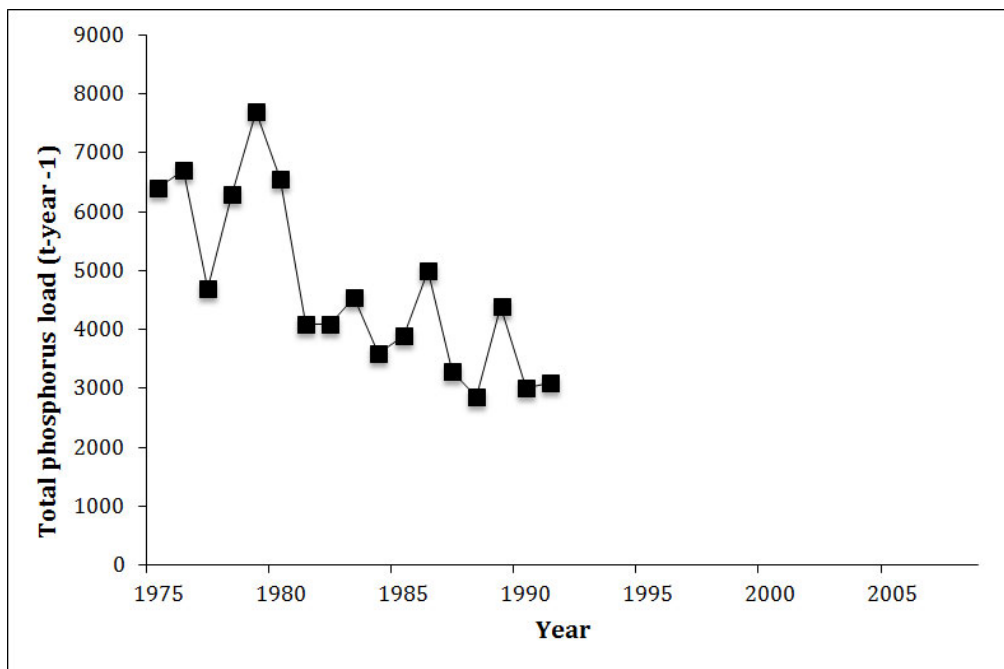


Figure 1. Total phosphorus entering Lake Michigan. (Redrawn with data from Madenjian et al., 2002.)

Part III – More about Algae

“So if it’s not phosphorus then what could it be?” asked Matt.

“We know that algal growth is limited by light so maybe something is going on there. Let’s look into this and see what we find,” said Flora.

Flora found out that the Great Lakes also have phytoplankton, single-celled algae that float around in water and can affect water clarity. She followed this lead and found some data on what was happening with phytoplankton in the lake (see Figure 2).

Question

- Describe in words what has happened to phytoplankton in Lake Michigan.

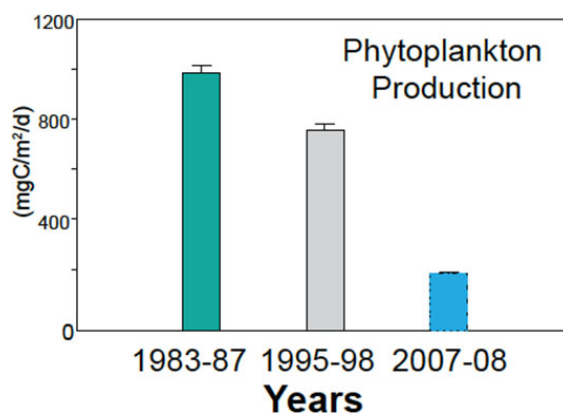


Figure 2. Springtime primary production in southern Lake Michigan has declined since the mid-1990s. Bars represent average amount of phytoplankton (measured in mg carbon/m²/day) in repeated samples with lines above bars showing variation in the data. From: http://www.glerl.noaa.gov/pubs/brochures/mussel_dipo.pdf. Original data from Fahnenstiel et al. (2010).

Matt found a report describing 20 years of data on the water clarity of the lake. The data came from Secchi disk readings reported from a school ship program in Lake Michigan. A Secchi disk is a circle divided into alternating black and white quarters (Figure 3). As the disk is lowered into the lake water, the depth at which the distinction between the black and white quarters can no longer be made is recorded, indicating the clarity or absence of phytoplankton. In the first years of the school ship program in Grand Traverse Bay, the Secchi disk could be seen down to about 6–8 m.



Figure 3. Secchi disk being lowered into water to measure clarity. (https://www.flickr.com/photos/usace_albuquerque/5999717664)

Questions

5. Given Flora's finding, fill in the missing data on the axes of Figure 4 below to depict the data Matt found.

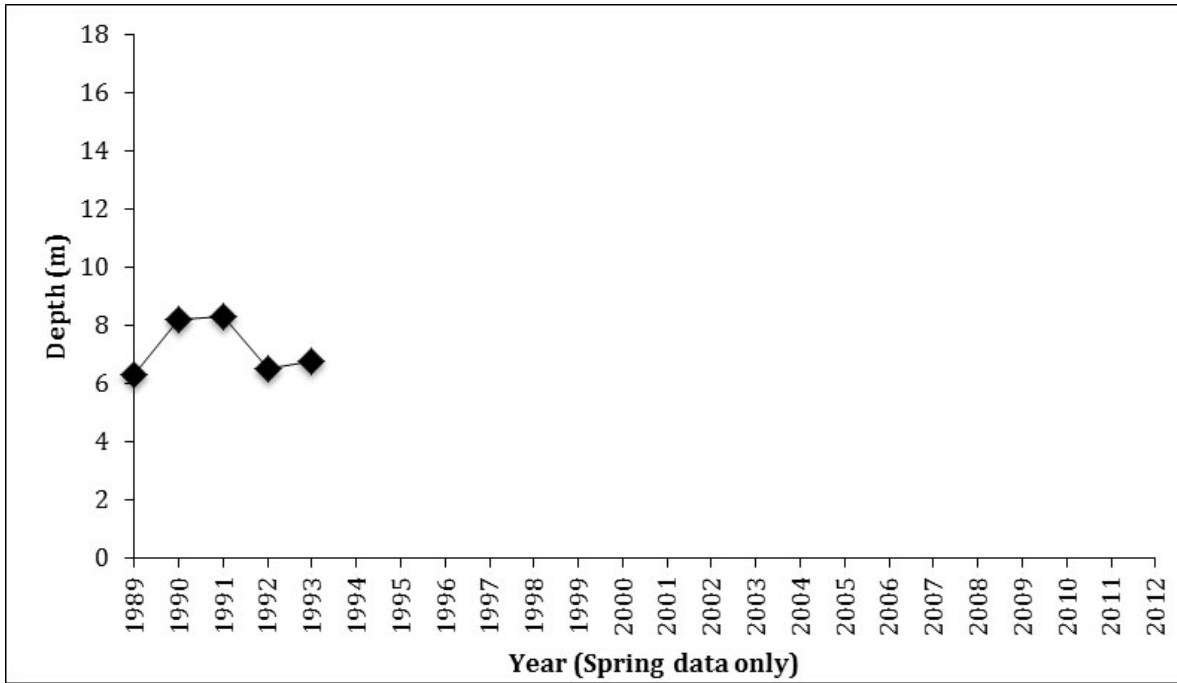


Figure 4. Secchi disk depths taken from Lower West Arm Grand Traverse Bay during a school science ship program “Inland Seas” in Sutton’s Bay, Michigan.

6. What factors in the environment would make one kind of alga increase while another decreases?

Part IV – The Rest of the Story

As Matt and Flora were looking over the information that they had found and trying to make sense of it all, Flora received another email from Aunt Janet:

Hi Flo,

I wanted to follow up on your question. We've been working on some research connecting the *Cladophora* blooms with the invasion of zebra and quagga mussels in the lakes. I've attached some maps showing the invasions...

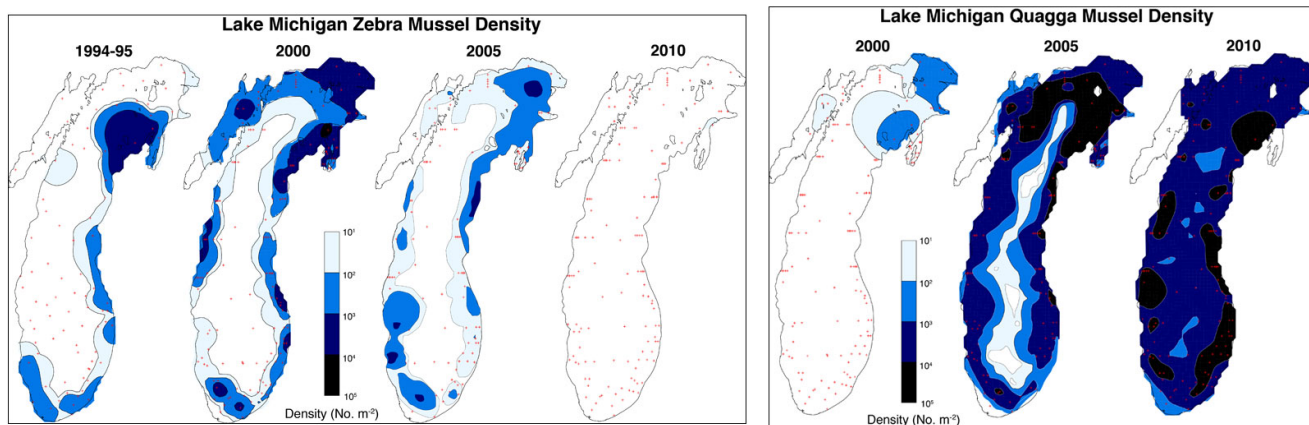


Figure 5. Zebra mussel and quagga mussel densities in Lake Michigan. Source: Figure 36 from *Thunder Bay National Marine Sanctuary 2013 Condition Report*, <http://sanctuaries.noaa.gov/science/condition/tbnms/pressures.html>.

It turns out that the mussels are so efficient at filter feeding they have removed enough phytoplankton from the lake system to significantly increase the water clarity of the lake, allowing more light in for the *Cladophora*. The mussels also may be recycling phosphorus in the water and shifting it from the water column down to the lake bed, thus directly feeding the *Cladophora*. There is still a lot more research to be done to fully understand this story but we're making headway.

Flo, I hope this info helps answer your question. You and Matt should come out with me on my next field trip!

Love, Aunt Janet

Question

- Examine the information about these two species of filter feeding mussels. Return to Question 6 and reconsider using this new information.

Additional Questions

8. Speculate about how water temperature changes could influence the success of *Cladophora*.

9. Do you think recent changes in atmospheric carbon could play a role in problems with algae? Why or why not?

10. What actions could we take in response to these problems with *Cladophora*?

11. What is the likely interaction between zebra and quagga mussels?

12. What characteristics make an invasive species successful?

13. What are the likely economic impacts of the mussel invasion?

14. Non-native Asian carp are very close to entering Lake Michigan from the Mississippi River watershed where they have caused huge changes to the ecosystem. These fish are voracious filter feeders. Speculate on what may happen to the ecosystem of Lake Michigan if these new fish invade.

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