Researchers examine the role of food web structures in adaptive management of Harmful Algal Blooms

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Why this research was needed

Shallow lakes are the most common inland waterbody and are highly susceptible to receiving an excess of nutrients from agricultural runoff. This excess of nutrients, in combination with other factors such as temperature, can cause a concentrated growth of algae that deprives oxygen from the rest of the aquatic environment. This occurrence, also called eutrophication, can form frequent severe harmful algal blooms. Harmful algal blooms contain toxin-producing cyanobacteria, which can lead to poor drinking water quality and fish kills within the aquatic environment. Reducing the occurrence of harmful algal blooms is a critical priority for lake managers, however the restoration of lakes is often slow and unsuccessful. This is due to significant physical and biological barriers. Reductions in nutrient losses to shallow lakes can occur, but it takes a significant amount of time to see positive changes within lakes. Living organisms within the aquatic environment can also intensify nutrient loading within the lakes. Aquatic food webs can impact the health of the lake habitat. A food web is a framework to understand who eats who or what within a habitat. Adding or removing a species can affect the overall health of the ecosystem. Researchers in this project sought to examine the relationship between the food web structure and ecosystem health to determine a potential adaptive management strategy for harmful algal blooms.

How was it done?

Researchers had two objectives in this study. The first was to assess whether a strong or weak food web interaction would result in greater resilience to nutrients. The second, to assess whether food web structures affect greenhouse gas flux. Greenhouse gases are gases in the earth's atmosphere that trap heat and elevate the temperature of environments. Elevated temperature plays a role in the development of harmful algal blooms. Greenhouse gas flux is a measure of the flow of greenhouse gases through the aquatic environment in this study.

Researchers experimentally tested ecosystem resilience of food web structures to nutrient exposures in six large ponds at the Iowa State University Horticultural Research Station located at just outside of Ames, IA. They tested three food web structures with varying levels of complexity accomplished by increasing the number of generalist fishes. Combinations included zooplankton, phytoplankton, largemouth bass, yellow perch, and flathead minnow. A nutrient exposure, similar to runoff after a storm, was performed on some of the ponds with a control pond for each of the food web structures. Researchers measured the ecosystem response to the nutrient pulse to mediate harmful algal blooms and greenhouse gas flux following the event. Routine sampling throughout the experiment included algal biomass, dissolved oxygen, and gas flux prior to and

Photo of the research site at the Horticultural Research Station in Ames, Iowa.

following the nutrient pulse event.

What the researchers discovered

Results indicate that food web structures with more connections between food chains in the shallow (benthic zone) and deeper (pelagic zone) areas of the lake resulted in greater resilience to pulse nutrient loading. The interaction between these lake layers is known as benthic-pelagic coupling. Food web structures with the highest degree of benthic-pelagic coupling showed no increases in algal biomass following the nutrient pulse. On the other hand, food web structures with the lowest degree of benthic-pelagic coupling produced significant responses in algal biomass following the nutrient pulse. Biological data indicates zooplankton biomass and periphyton areal biomass was highest in ponds with greater benthic-pelagic coupling compared to ponds with lower benthic-pelagic coupling. As a result, the food web structures were found to affect the differences in algal biomass response across the ponds, and therefore, have differences in ecosystem resilience to harmful algal blooms. This research indicates that lake managers could incorporate food web structures into adaptive lake management to address the challenges that storm-driven nutrient loading poses to shallow lakes across Iowa. Ensuring there are fishes feeding on both benthic and pelagic food chains within their lakes, or protecting the species that do, like largemouth bass and omnivorous minnows, should be important priorities to lake managers.

What's next?

The researchers are continuing to work with the data to analyze further findings. The data from this project will lead to undergraduate research projects. These projects will focus specifically on the macroinvertebrate communities within the ponds to investigate how the different food web structures affected macroinvertebrate density and community composition. This closer examination will look into one part of the food web with the expectation that greater benthic-pelagic coupling within a food web would weaken predation pressure on macroinvertebrates.

Learn more about Iowa Water Center sponsored research at iowawatercenter.org.

Photo of the research site at the Horticultural Research Station in Ames, Iowa.