How harmful algae respond to rising water temperatures

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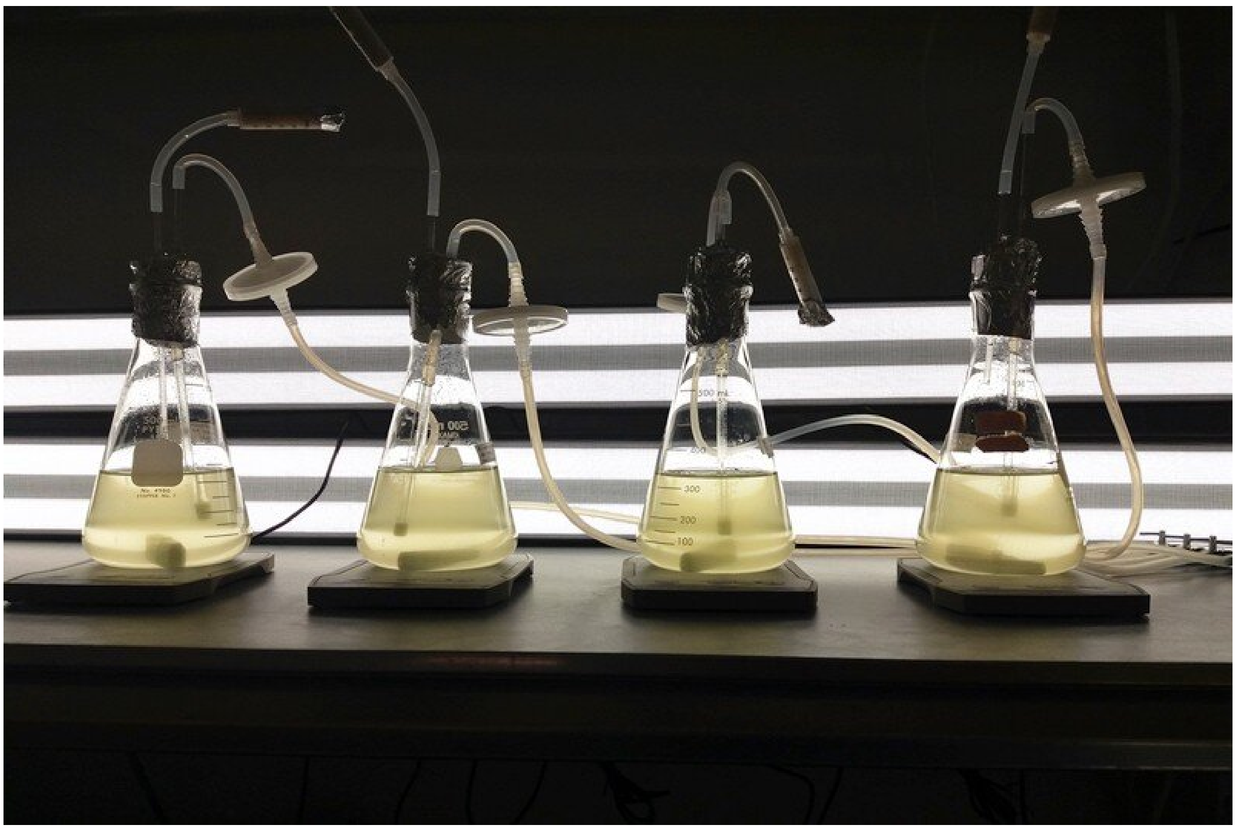

To help better understand how temperature influences harmful algal blooms (HABs) in Delaware, University of Delaware researchers looked at the effect of temperature changes on the physiology of three species that live in the Delaware Inland Bays. The photo above shows the research group's algal cultures of the harmful dinoflagellate, Karlodinium veneficum, which was used in the study, growing in the lab. Credit: University of Delaware

As climate change leads to rising global ocean temperatures, the past few decades have witnessed a significant increase in the frequency, intensity and geographic range of harmful algal blooms (HABs).

HABs occur when a small portion of the marine phytoplankton community that consist of harmful algal species produce in high numbers, causing adverse effects on their ecosystems. This can be witnessed in Delaware and throughout the world when bodies of water turn green or brown in summer. Some of these HABs produce toxins that pass through the food web and cause fish and shellfish kills, which can affect human health.

To help better understand how temperature influences HABs in Delaware, University of Delaware researchers looked at the effect of temperature changes on the physiology of three HAB species that live in the Delaware Inland Bays: Karlodinium veneficum, Heterosigma akashiwo and Chattonella subsalsa.

The researchers included Nayani Vidyarathna, the lead author on a recently published paper and a post-doctoral researcher in UD's College of Earth, Ocean and Environment (CEOE); Mark Warner, professor in the School of Marine Science and Policy; Erin Papke, who graduated from UD in 2018 and worked in Warner's lab; Jonathan Cohen, associate professor in CEOE; and Kathy Coyne, an associate professor of marine biosciences in CEOE and director of the Delaware Sea Grant program.

Their findings were published in the scientific journal *Harmful Algae* and their work is part of a larger study known as the "Ecology and Oceanography of HABs," (ECOHAB), funded by the National Oceanic and Atmospheric Administration (NOAA).

Temperature and HABs

Warner said that when they started doing the work on HABs in Delaware, they realized that they didn't have a good idea about how different kinds of harmful algae respond to increases in temperature.

"With this paper, we examined the patterns of growth across a broad temperature range and also examined how those patterns of growth compare to patterns of toxicity and other parameters of the algal physiology," said Warner.

One of the reasons they chose to focus on Karlodinium veneficum is that it frequently blooms in the Chesapeake Bay.

"It causes fish kills and it's also a small alga which means things like oysters could potentially be trying to eat this alga so it's ecologically important for a lot of reasons," said Warner.

The algae form blooms that are associated with fish kills in estuarine and coastal waters around the world. The toxin it produces has been chemically characterized so the researchers were aware of the way in which it produces its toxins.

The other two algal species that they studied—Heterosigma akashiwo and Chattonella subsalsa—are found, especially in Asia, to be important harmful algal species but unlike Karlodinium, their mode of toxicity is not known and it is not completely understood how they are toxic.

Measuring Toxicity

To measure the change in toxicity with regards to rising water temperatures, the researchers first exposed the algae to a range of temperatures, from about 64 to 89 degrees Fahrenheit, extracted everything out of the harmful algal cells, and exposed them to mammalian red blood cells or the fish gill cells in cultures. The toxicity was measured by how quickly the extracts of harmful algal cells broke apart the other cells.

Vidyarathna said that an increase in temperature also increased the growth of the harmful algae and widened the temperature range at which the growth rates are positive.

The lab work is part of research led by Mark Warner, who is a professor in the School of Marine Science and Policy within UD's College of Earth, Ocean and Environment. Credit: University of Delaware

"Overall, our results suggest that climate change—ocean warming—may promote the blooms of toxic harmful algae, leading to significant negative ecological effects," said Vidyarathna. "Temperature increases also elevated the cell toxicity of K. veneficum, which means when temperature increases, K. veneficum may promote blooms that are potentially more toxic."

Though Karlodinium veneficum had increased toxicity as the temperature increased, the actual growth of the alga peaked at 83 degrees Fahrenheit (28.6 degrees Celsius).

"If you keep raising the temperature, the growth goes down, but the toxicity stays high," said Warner. "So for that particular alga, we realized "Ok, maybe they won't bloom as much, but when they do bloom, if the water temperature is warmer—which we expect the water temperatures to keep increasing through time—they could potentially be more toxic." "

Likewise, Heterosigma akashiwo showed a similar growth pattern, peaking at a thermal optimum temperature—in this case, 81 degrees Fahrenheit (27.3 degrees Celsius)—and then rapidly declining. Neither species grew at 89 degrees Fahrenheit (32 degrees Celsius) during the experiment.

Greater amounts of C. subsalsa

With regards to Chattonella subsalsa, which is a bigger cell compared to the other two, the researchers found that it kept increasing its growth as the temperature was raised.

"C. subsalsa was quite resilient to temperature increase, which means this species may bloom at temperatures that suppress the growth of other HAB species," said Vidyarathna.

In contrast to the K. veneficum, while Chattonella can grow faster at high temperatures, it doesn't seem to be as toxic at high temperatures.

However, Warner pointed out that because the mode of toxicity for that particular species is not known, it doesn't necessarily mean that Chattonella subsalsa won't be more toxic under elevated temperatures if the research group was not measuring toxicity exactly the right way.

"There's different ideas about how they're toxic, and they could be using a different mode of toxicity that we didn't measure in this paper," said Warner.

Citizen Monitoring Group

When the researchers checked the historical data on the algal species in the Delaware Inland Bays that has been collected by the Citizen Monitoring Program, a dedicated corps of citizen monitoring volunteers that have been taking water samples on a regular basis throughout Delaware's coastal watershed since 1991, they saw a nice correlation with the results they found in the lab.

Using data from 2002-2018, they found that Heterosigma akashiwo and Karlodinium veneficum tend to be found heavily in water temperatures in Delaware below 30 degrees Celsius and that Chattonella subsalsa keeps growing at higher temperatures.

"I was very surprised to see how closely our results match with those historical data," said Vidyarathna. "This shows the importance of local monitoring programs like the UD Citizen Monitoring Program who collected the data and shared them with us."

The next steps for the research are to look at the combined effects of ocean warming and ocean acidification on harmful algal species. This is important because global warming leads not only to higher ocean temperatures but also to increasing ocean acidification, which may alter the physiology of harmful algal species.

More information: Nayani K. Vidyarathna et al. Functional trait thermal acclimation differs across three species of mid-Atlantic harmful algae, *Harmful Algae* (2020). DOI: 10.1016/j.hal.2020.101804

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