What's really feeding Long Island's destructive brown tides?

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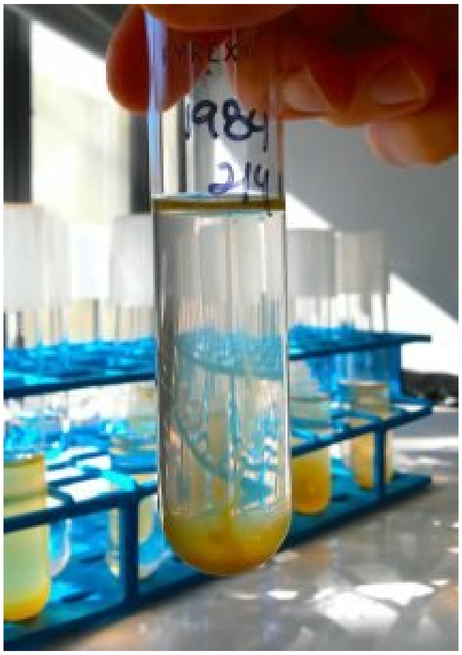
Harmful algae blooms known as brown tides can crowd out native seagrasses and poison shellfish. Credit: Florida Fish and Wildlife

Researchers at Columbia University's Lamont-Doherty Earth Observatory may have found a new strategy to limit the growth of an algae species called Aureococcus anophagefferens, which at high densities can result in devastating brown tides. Leveraging a genomic approach called metatranscriptomics, the researchers determined that phosphorus management may be important to controlling brown tides.

Aureococcus anophagefferens surfaced off Long Island in 1985, turning estuaries the color of mud, crowding out native seagrass, and poisoning shellfish. The algae flourished, choking a once thriving shellfish industry and detracting from the region's all-important tourism trade. It continues to plague Long Island's Great South Bay and other mid-Atlantic waters.

Scientists wanted to know how Aureococcus anophagefferens managed to grow so well along coastlines that are heavily impacted by human activities. A 2011 study provided a critical starting point by sequencing this alga's genome—identifying that it had capabilities which allowed it to thrive in anthropogenically modified ecosystems high in organic matter. In a 2014 study, follow-up research uncovered the phytoplankton's survival secret, which lies in its DNA; Aureococcus can make enzymes that break down organic nitrogen and phosphorus when inorganic nutrients run low, allowing it to beat out competing organisms and flourish. The nitrogen and phosphorus Aureococcus needs to bloom often come from storm water run-off and other land-based sources.

Based on the DNA and other research, scientists learned how the genes encoded in the genome turned on and off in response to the supply of nutrients like nitrogen and phosphorus, developing a metatranscriptomic approach to identify the activities of Aureococcus in a mixed community of other algae. Traditionally, researchers track the blooms by counting the cells in the water and measuring water chemistry to see if the algae are limited for nitrogen or phosphorus.



Aureococcus growing in a test tube in the Dyhrman laboratory at the Lamont-Doherty Earth Observatory. Credit: Sheean Haley

"You monitor water chemistry and how many cells are there, and that can tell you whether the algal community is getting enough nitrogen or enough phosphorus, and that influences management and mitigation decision making," said Lamont microbial oceanographer and senior author Sonya Dyhrman. This has typically meant focusing efforts on reducing nitrogen inputs into the estuaries that host brown tides.

However, in the study published this week in *Frontiers in Microbiology*, Dyhrman and her colleagues took a different, more direct approach to assess what is feeding these cells, bringing their inquiry to the cells in the waters off the Hamptons. Dyhrman compares the traditional way of gauging the Aureococcus activities to going into a refrigerator and deciding whether a person is healthy based on what is in that refrigerator.

"It's this idea that we are making inferences about the health or activity of the algae based on what's in the water rather than looking at the cells themselves. A much better way than looking in the refrigerator would be to test you to see if you are healthy or not. What we set about to do with this study is to ask the algae themselves if they are getting enough nitrogen or enough phosphorus," explained Dyhrman.

In effect, they asked which genes are turned on and off, knowing—from previous findings—that distinct, specific genes are activated by nitrogen and others by phosphorus availability. What they found was surprising.

Louie Wurch, assistant professor at James Madison University and lead author of the study, prepares brown tide samples for metatranscriptome analyses. Credit: Sonya Dyhrman

"The chemistry of the water (the refrigerator approach) was telling us they're not getting enough nitrogen. But when we looked at the cells, they were turning on all of their genes that indicated they were not getting enough phosphorus. Not what we expected," said Dyhrman.

It was the first time scientists were able to use the gene expression approach to specifically ask this harmful alga species what resources it's using in the field—something that hasn't been trackable until recently.

"The cells were telling us something different than the water chemistry," said Dyhrman. "Which means that we need to think about not just nitrogen but also phosphorus when we think about controlling or mitigating these blooms."

"We have shown with this method that the algal cells are rapidly responding to variables in their environment that we either cannot, or have not, yet detected," said Louie Wurch, lead author and assistant professor at James Madison University. "We have a lot more to learn and this has really opened the door for a lot of exciting future research!"

More information: Louie L. Wurch et al. Transcriptional Shifts Highlight the Role of Nutrients in Harmful Brown Tide Dynamics, *Frontiers in Microbiology* (2019). DOI: 10.3389/fmicb.2019.00136

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