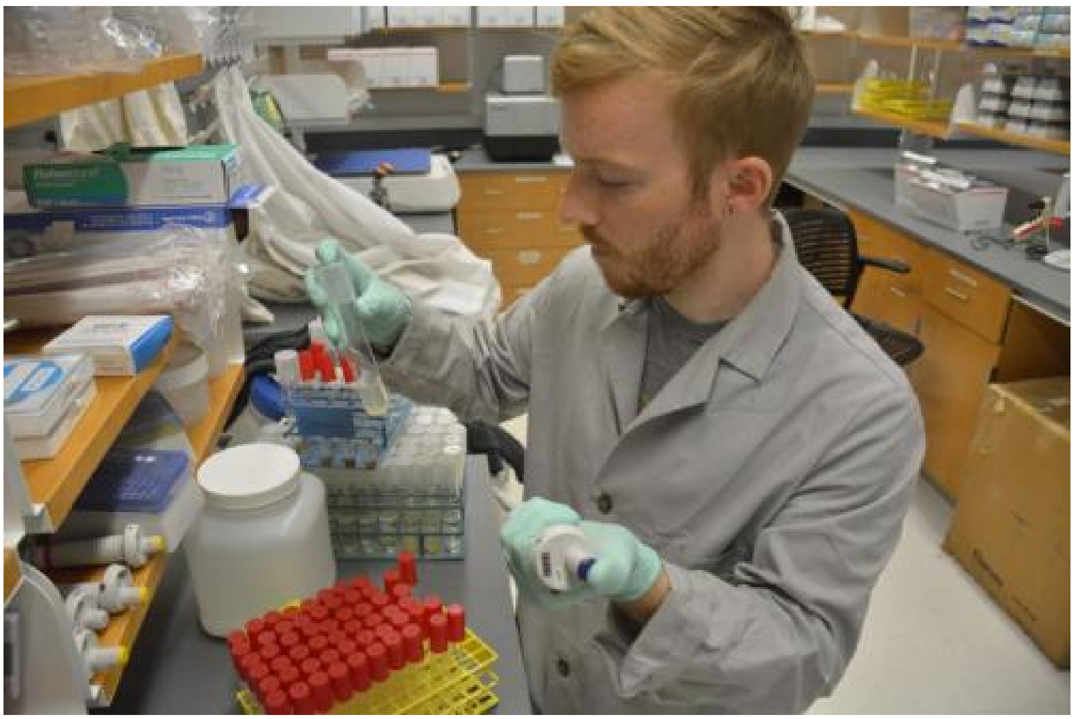
Like weeds of the sea, 'brown tide' algae exploit nutrient-rich coastlines

September 6 2014, by Kim Martineau



A new study led by Lamont-Doherty graduate student Kyle Frischkorn shows how 'brown tide' algae thrive in waters that are murky and low in inorganic nutrients. Credit: Kim Martineau

The sea-grass beds of Long Island's Great South Bay once teemed with shellfish. Clams, scallops and oysters filtered nutrients from the water and flushed money through the local economy. But three decades after the algae that cause brown tides first appeared here, much of the sea grass and the bounty it used to provide is gone.

Spring on eastern Long Island is now marked by dense blooms of *Aureococcus anophagefferens*, which turn estuaries like Great South Bay the color of mud and crowd out native sea grass and stunt or poison shellfish. For years, researchers have puzzled over *Aureococcus*'s success. How has this microscopic algae adapted so well to coastlines built up with roads and homes? Since surfacing off Long Island in 1985, brown tides now appear as far south as Virginia, and have become a recurring problem off South Africa and northern China.

A new study by researchers at Columbia University's Lamont-Doherty Earth Observatory and Stony Brook University highlights up close the survival skills that have made *Aureococcus* the bane of fishermen, boaters and real-estate agents. Building on previous mapping of *Aureococcus*' genome, the study, published in the journal *Frontiers in Microbiology* this summer, confirms that the genes previously hypothesized to help *Aureococcus* survive in murky nutrient-rich waters, switch on in conditions typical of estuaries degraded by human activity.

While other photosynthetic algae crave sunlight, *Aureococcus* can live for days in the dark. When other algae run out of their preferred inorganic nutrients and die, *Aureococcus* is able to feast on the all-you-can-eat buffet of organic nutrients, sometimes derived from lawn fertilizers and sewage. "They are opportunists," said study lead author Kyle Frischkorn, a graduate student at Lamont-Doherty. "They can exploit the low inorganic nutrient situations that other algae can't, and they continue to grow even when high cell densities shade out light."

Their secret lies in their DNA. In sequencing *Aureococcus*' genome, researchers discovered it has up to three times as many light-harvesting genes as competing algae. *Aureococcus* also has the capacity to make enzymes that can break down organic nitrogen and phosphorus when inorganic nutrients run low. Further, its tiny stature—about the size of most bacteria—means it needs fewer resources like nitrogen and phosphorus to compete.

Brown tide usually appears after the spring diatom bloom has depleted estuaries of inorganic nutrients. *Aureococcus* is able to take over by using alternative organic forms of nitrogen and phosphorus and crowding out remaining competitors as it blooms and blocks out still more light. "We knew *Aureococcus* could survive and even thrive under adverse conditions," said Sonya Dyhrman, a microbiologist at Lamont-Doherty and a senior author on both studies. "Studying their genes allows us to understand how they are able to do this."

In the *Frontiers* study, researchers grew a strain of *Aureococcus* in the lab under conditions of low light, inorganic nitrogen and phosphorus, and also in a control environment of abundant light and inorganic nutrients. They analyzed more than 100 million fragments of RNA, which tell *Aureococcus* which proteins to make to exploit its environment. Sure enough, *Aureococcus* turned on its light-harvesting genes in murky water, and its ability to scavenge those alternative organic forms of nitrogen and phosphorus in low inorganic nutrient conditions.

Brown tide has decimated eastern Long Island's shellfishing industry. Credit:

Chris Gobler, Stony Brook University.

The experiments also turned up a surprise. *Aureococcus* has developed a way to pump a toxic form of arsenic from its cells. In low-phosphorus conditions, *Aureococcus* inadvertently draws in arsenate, a form of naturally occurring arsenic that chemically resembles phosphate. To avoid exposure, *Aureococcus* reduces the arsenate to arsenite, an even more toxic form of arsenic, and pumps it from its cells into the water. The extent to which this toxic byproduct is produced during brown tides, and its effect on the environment and humans is so far unknown.

Researchers suspect that *Aureococcus* has always lived in the coastal environments where it now thrives. As Long Island's population has boomed, rising nutrient loads from septic systems, aging sewer plants and lawns have seeped into the groundwater, which recharges Long Island estuaries. In these degraded waters, Aureoccocus appears to be uniquely suited to exploit the low light and high organic nutrient levels. "The organism is probably more widespread than we know," said study coauthor Christopher Gobler, a marine biologist at Stony Brook University who led the earlier genome study.

The link between algae blooms and excess nutrients from sewage and fertilizers has been known for decades. Still, towns and cities have been slow to build and upgrade sewer plants, and homeowners and farmers reluctant to change growing practices. Excess manure and fertilizers spread on farms is thought to have fueled the toxic algae bloom that covered Lake Erie in green slime this summer, leaving nearly half a million people in Ohio without water for two days.

On Long Island, the main culprit producing the excess nutrients appears to be faulty septic systems. An estimated 350,000 septic systems on eastern Long Island's South Shore are considered failing, according to a January report by the Suffolk County Executive. Between 1987 and 2001, nitrogen levels in the county's groundwater (which also supplies its drinking water) jumped 40 percent to 200 percent in places. More than half of the nitrogen in Great South Bay has been traced to septic tanks and cesspools, according to a recent study. Algae blooms and excess nitrogen led New York's Department of Environmental Conservation in 2008 to declare the South Shore's 60-mile long estuary impaired.

Local government has begun to act. Suffolk County Executive Steven Bellone recently declared nitrogen "public enemy number one" and is lobbying New York Gov. Andrew Cuomo for state funding to offset the cost of connecting eastern Long Island to a sewage treatment plant.

The economic stakes go beyond the 6,000 jobs that clamming alone once provided in Great South Bay. Tourism pumps nearly $5 billion a year into Long Island's economy, and many worry that brown tide and its ilk will scare away boaters, beachgoers and homebuyers. "Who wants to live in an expensive coastal community where you can't swim in the water and the water's the color of coffee with skim milk?" said Carl LoBue, a marine scientist with the Nature Conservancy.

Continued shoreline growth may signal more brown tides globally. Beyond the nutrient loading that development brings, coastlines hardened with houses and roads leave less room for ocean tides to sweep in and flush out estuaries. Two of the three inlets to Great South Bay opened by Hurricane Sandy have been closed by bulldozers, closing off ocean inflows again. Rising ocean temperatures could further extend *Aureococcus*' range, though the effects of a warming climate and rising carbon dioxide levels have not yet been studied.

To expand on the *Frontiers* study, the researchers hope to observe brown tides in the field. "The RNA signals we tracked in the lab could be examined in field populations to see how *Aureococcus* responds to excess nitrogen and warmer air and sea temperatures," said Dyhrman. "This could help us predict when a brown tide is coming and mitigate its impact."

Against all odds, a few fishermen on Great South Bay are trying to bring back the oysters, which seem more resilient to brown tide than scallops or clams. For four years, retired sound engineer Chuck Westfall has been raising Bluepoint oysters which he markets as "Fire Island Blues" after the barrier island just beyond his oyster beds. Under the great span speeding beachgoers to Robert Moses State Park, Westfall scooped out oysters from several wire cages submerged in knee-deep water. Those exposed to more brown tides were measurably stunted.

Despite the recurring brown tides and other obstacles, what keeps him going, Westfall said, is the potential for success. If he can make it, other shellfishermen will follow and join him in advocating for the bay's protection.

"If we can get enough stakeholders in the bay—people who care about what's going on in the water and not just on top of it—we might be able to induce politicians to make some constructive changes that would help this bay quite a bit," he said.

Provided by Columbia University

Citation: Like weeds of the sea, 'brown tide' algae exploit nutrient-rich coastlines (2014, September 6) retrieved 26 June 2024 from https://phys.org/news/2014-09-weeds-sea-brown-tide-algae.html