Researchers attempt to understand how Mobile Bay deals with excess nutrients

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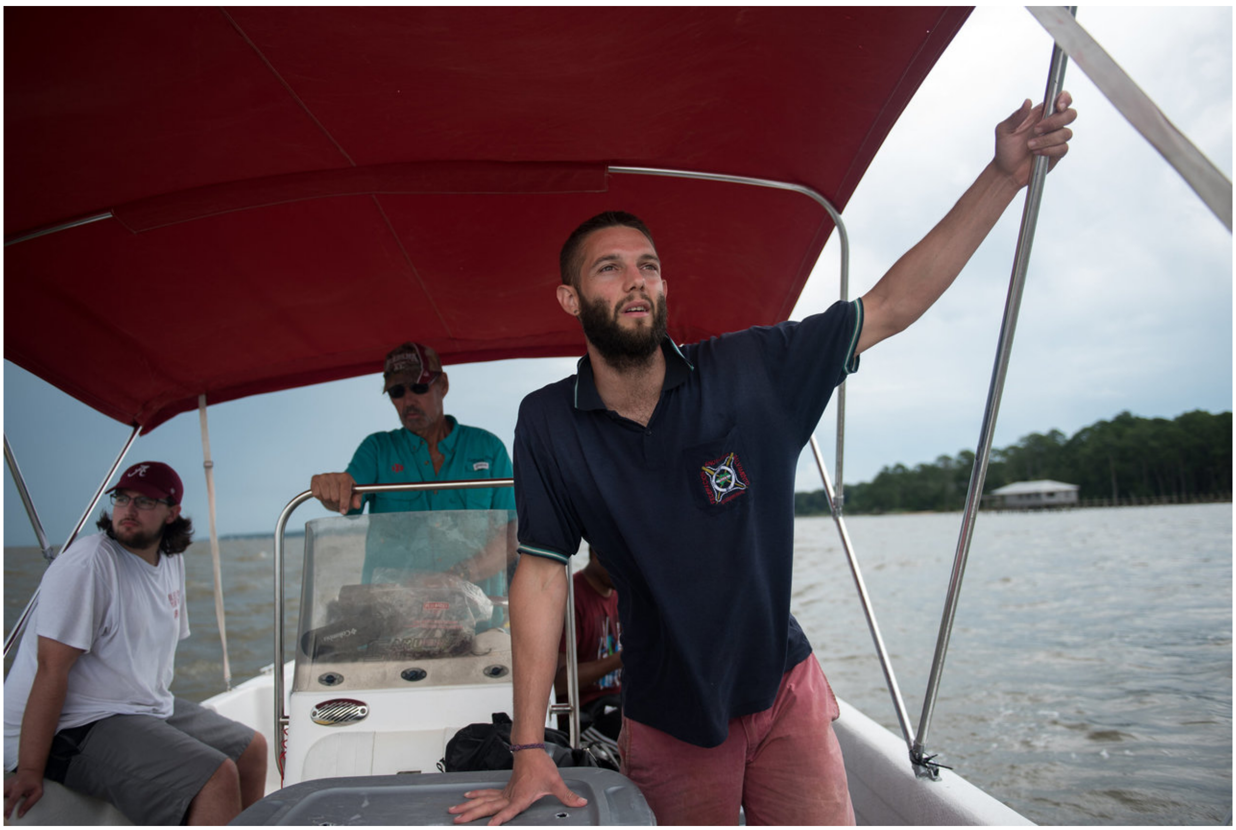


Graduate student Daniel Montiel scans Mobile Bay in summer 2017. “We explore the shoreline of Mobile Bay for groundwater discharge,” he said. Credit: University of Alabama in Tuscaloosa

Nutrients. Just the word sounds good. Wholesome. We want food packed with nutrients. Everything a growing child needs. Junk food doesn't have nutrients, we believe. Nutrient-rich food keeps us healthy.

More than just our bodies thrive on nutrients. At its foundation, the world's ecosystem is based on the consumption of nutrients that begins with tiny plant and animal life in water. Without nutrients, life does not thrive.

Excess nutrients, the inverse, can be just as damaging. With increased population along the world's coasts and industrialization of more economies, excess nutrients are a global problem.

Mobile Bay in Alabama is no different.

"The productivity of Mobile Bay depends on nutrients coming into the system, but too much nutrients flip it to the point where it's no longer productive," said Dr. Behzad Mortazavi, a marine scientist at The University of Alabama who works out of Dauphin Island Sea Lab near Mobile. "Too much nutrients is the cause of a lot of problems in our near-shore waters."

Mortazavi is one of several researchers from the University studying nutrients in and around Mobile Bay, attempting to increase understanding, a necessary step to raise awareness and improve solutions to excess nutrients.

"The broad picture is all about maintaining water resources in Alabama," said Dr. Natasha Dimova, an environmental geochemist at UA.

Mobile Bay is the fourth largest estuary in the United States with 413 square miles, fed by the second largest delta in the country, the Mobile–Tensaw River Delta. Water flows out of the bay at 62,000 cubic feet of water per second. Hugged by rivers and the Gulf of Mexico, it is a critical resource for jobs, recreation and goods for Alabama and the nation.

"Recreation and the seafood industry are treasures, resources from the bay, that provide economic development along the bay," Mortazavi said.

Nitrogen and phosphorus are necessary nutrients in a healthy aquatic system, but too much causes an overgrowth of algae, or small marine plants. Some algae produce toxins and are known as harmful algal, and when they bloom, it can be detrimental to fish and other marine life. Fish kills are often associated with blooms of harmful algae. These blooms can have severe economic impact on the seafood industry and tourism.

While rivers bring spikes of nutrients from human and animal waste, along with agriculture and industrial run-off, into the bay when heavy rains usher them downstream, there are also harmful algal blooms in the dry season. Why? Groundwater, according to Dimova.

As large as the system is, it is difficult to imagine groundwater as a major player in the bay's ecology, but, simply put, it is. Accounting for a trickle of water, 2.5 percent, in the bay compared to water from the Mobile River, groundwater punches above its weight class during the dry season, delivering half of the nitrogen derived from ammonium into the bay, according to studies by Dimova.

"Although everybody assumes that the river is the major player in terms of nutrient fluxes, we found very recently that groundwater plays an important role during certain times of the year, and thus cannot be neglected," Dimova said.

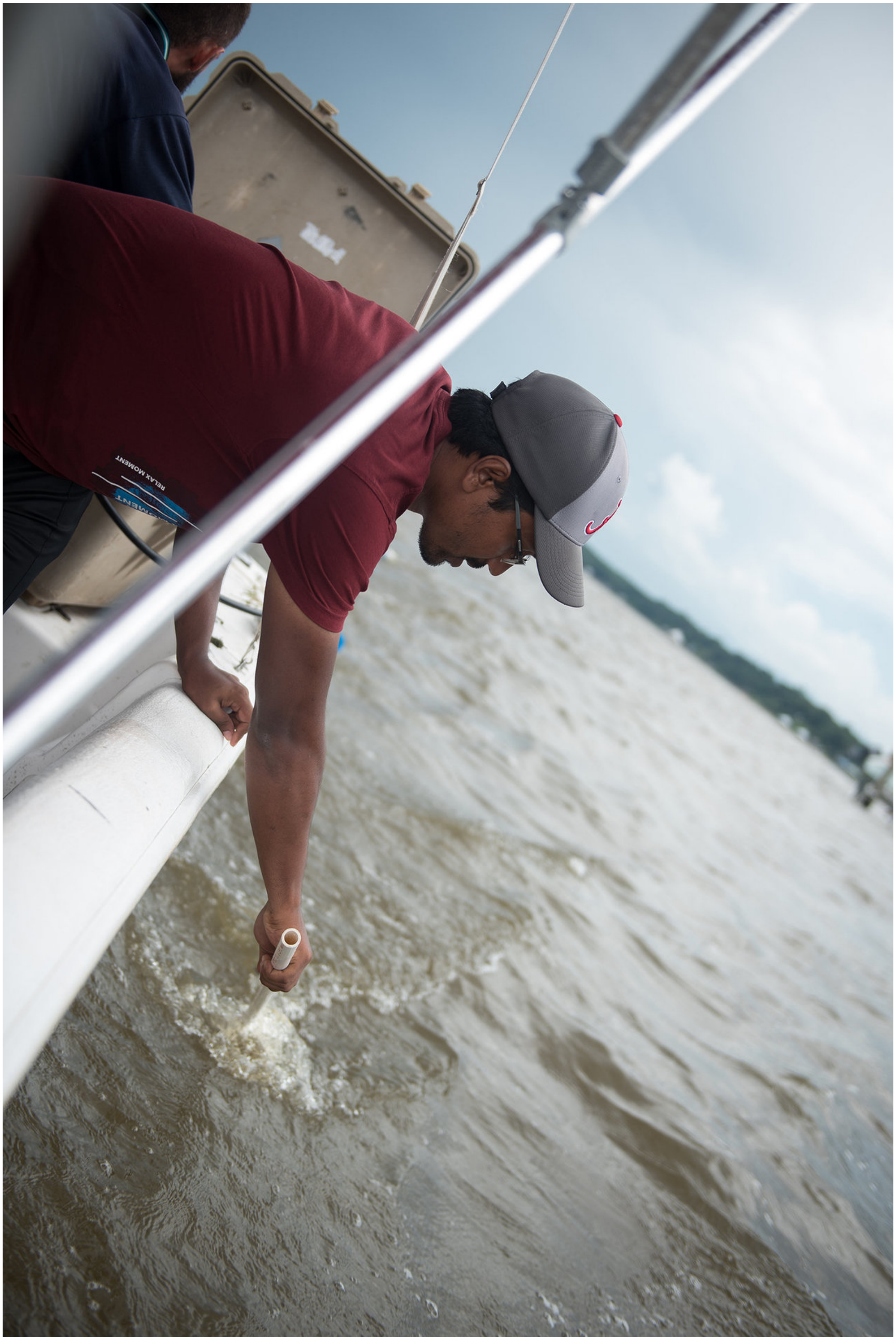
Common sense reveals this, too. Since groundwater takes longer to reach the ocean than a river, groundwater has the time to accumulate more chemicals, nutrients and heavy metals.

Dimova's work studying submarine groundwater discharge around the Mobile Bay and Delta point to the possibility of something else boosting groundwater's potency just before it leaks into the bay – coastal sediments. This is the first time Dimova's group considered the sediments as a source of contaminants.

"What we sample immediately at the point of discharge in the bay has a very different composition than what is on land," she said. "All the data falls in this corner. That tells us the quality of the groundwater coming out is largely determined by what happens in the coastal sediments just before the discharge."

When sorting out the influence of groundwater on the health of the bay and influence on harmful algal blooms, Dimova wants to know what is in the sediment. Below the surface, the sediment can tell the history of the bay, shedding light on when there have been harmful algal blooms.

Along with the nutrients affecting the bay today and potentially affecting it in the future, the sediment tells an intricate history of sea level and environmental changes in the bay. That is where Dr. Rebecca Totten Minzoni, a UA assistant professor of geological sciences, comes in.



Graduate student Tazmul Islam collects samples of water to determine sediment concentrations in the bay. Credit: University of Alabama in Tuscaloosa

Sediment cores provide a longer timeline to help understand how and when increased contributions of nutrients occurred. Totten Minzoni can reconstruct long-term climatic and environmental changes since Mobile Bay formed roughly 8,200 years ago.

"With the cores we collect in Mobile Bay, we can step back in time with each layer to tell us about how environments changed and, ultimately, produce a long-term frequency of the harmful algal blooms over time," Totten Minzoni said.

While nutrients themselves do not preserve well in the sediment record, silica walls of microscopic, single-celled organisms called diatoms, a large part of harmful algal blooms, are left behind, preserved for millions of years.

These microscopic fossils in the sediment mark occurrences of past algal blooms in Mobile Bay. Their presence in a core of course sediment sourced from rivers can help determine whether the ancient blooms were triggered by nutrients from rivers or from other sources such as groundwater.

That can show whether the blooms and jubilees seen since European settlement, and the subsequent industrialization, are normal compared to the pre-recorded history.

"Once we understand the significance of human impact – specifically whether there is significant human impact – then we can help steer restoration efforts and any kinds of policies and best practices we should apply to water or agriculture in our state, for instance," Totten Minzoni said. "Ultimately, we need a baseline of what was normal before land use changed, so we can really assess human environmental impacts and how to mitigate them."

Sediments might also tell us about the bay once their contents begin leaching into it. That's the hope of a collaboration between Dr. Sagy Cohen, in geography, and Dimova. The goal is to use satellite imaging to gauge where nutrients and heavy metals are in the bay.

"We can see sediments, but we can't see the heavy metals or nutrients themselves," Cohen said. "If we know the average concentration of heavy metals or nutrients attached to the sediment, then we will have a good sense of the concentration and where it is moving."

Cohen's and Dimova's labs are calibrating water samples and turbidity measurements, or the cloudiness of the water with particles, with imaging from satellites. Once the data taken by hand and instruments in the bay matches with the imaging, Cohen hopes to use only the imaging to understand the flow of nutrients and heavy metals around the bay.

"It will give us not only a near real-time estimate of sediment and nutrients and heavy metal concentrations in the bay, but can also give us quite a long record in the past because there's a good archive of satellite imagery going back to the 1970s," he said.

When heavy metals and nutrients come downstream from the Mobile River Basin, they lodge in the sediment. The Gulf of Mexico is rising at a rate not seen since the period when the bay formed, and, as sea level rises, it changes the interaction with the sediment, Cohen said. Saltier water reacts different chemically from freshwater.

"We need to get a better sense of both how fast things are moving, some insight into how the mechanism works," Cohen said. "A healthy ecological system can only tolerate so much specific nutrients and pollutants.

"We need that for a healthy aquatic environment both in the rivers and in the coasts," he continued. "It's very easy to pollute the water source, but it's not that easy to clean it and reestablish a healthy ecosystem."

For Mortazavi, who works in Dauphin Island, maintaining the health of the bay requires marshes. Besides removing nutrients, marshes stabilize the shoreline, buffer waves, and serve as habitats for wildlife. However, they are disappearing along the world's coasts, and Mobile Bay has been no different, he said.

About half of the marshes along Mobile Bay have disappeared in the last 200 years. A number of factors—ranging from dams along rivers holding back sediment that build the marshes to sea level rise drowning them—contribute to this.

"Marshes have this amazing capacity to permanently remove nitrogen," Mortazavi said. "If the marshes disappear, there is potential for excessive nutrients to come into the bay."

In a recent work, Mortazavi and his colleagues documented how effectively marshes remove nitrogen. They estimate a marsh the size of a football field can remove as much as 12 pounds of nitrogen annually and, more importantly, when a marsh erodes, this capacity drops by a factor of four.

Understanding more about the critical role marshes play can help guide restoration efforts, he said.

"Marshes aren't the magic solution to all our water quality problems, but they have a pretty important role to play," Mortazavi said. "Understanding that role gives justification to policymakers for why they would want to do something with the marshes."

Provided by University of Alabama in Tuscaloosa