Story by Danielle Supercinski

Battling Golden Algae

Results suggest preventative lake management approaches

Golden algae blooms, or the explosive growth of algae, are known to be toxic, but recent findings from three university researchers from Texas provide potential methods to prevent these harmful algal blooms.

Dr. Daniel Roelke with Texas AgriLife Research at Texas A&M University, Dr. James Grover with the University of Texas at Arlington, and Dr. Bryan Brooks at Baylor University, working jointly, recently completed the Lake Granbury and Lake Whitney Assessment Initiative project studying the biology and ecology of golden algae (*Prymnesium parvum*) in Texas lakes. First appearing in Texas in 1985 in the Pecos River, golden algae has since appeared in most of the 25 major river systems throughout the state. Although it can exist in waters without being harmful, the algae caused major fish kills in five of the state's river systems.

As a result of their research, they discovered three approaches to lake management that seem to work in preventing and/or reducing golden algae blooms in Lake Granbury.

"We were able to effectively utilize pH manipulation; hydrologic flushing manipulation, where we used water deeper within the lake and brought to the surface; and ammonia addition manipulation," said Roelke, associate professor in Texas A&M's Departments of Wildlife and Fisheries Sciences and Oceanography. "All three treatments prevented blooms from developing in prebloom conditions, and an experiment during a bloom lessened the effect of the bloom."

Roelke said that pH manipulation is the most promising lake management approach, and it wouldn't cost as much to implement as other approaches. "We only reduced the pH down to seven, so those conditions are not stressful to other organisms (within in the lake), and we quantified that. It negatively affected the *P. parvum* but didn't affect other plankton."

Brooks, associate professor in Baylor's Department of Environmental Science and Biomedical Studies, added: "These relationships between lower pH and reduced toxicity were consistent with our previous experiments with *P. parvum* in the laboratory and observations in Lakes Granbury and Whitney."

For the hydrologic flushing, Roelke said, "We took water from deeper within the lake, using the lake's own water for the treatment and moving it around within the lake. That seemed to work too, but the downside would be the infrastructure costs would be high."

While the ammonia treatment worked, it does have some pitfalls, Roelke said. "The low level of ammonia stimulated the bloom, and it became more toxic. When more ammonia was added, that quickly killed the *P. parvum*. However, the downside with that higher level of ammonia addition is there was a four-fold increased production of other algae, which could be bad because of downstream effects."

In addition to the three treatments researched during in-lake experiments, their research showed that inflows of river and stream water also have an effect on golden algae blooms.

"We were very fortunate in observing a clear example of how a strong inflow event can terminate blooms, and this inspired us to look closely at historical data and discover strong relationships between flow and the occurrence of blooms," said Grover, a professor in UT-Arlington's Department of Biology. "Basically a period of low flow is a prerequisite for bloom formation. This was also demonstrated some in the mathematical models we developed. The spatial model we developed treats inflow more realistically than our other models."

While the model has not been extensively calibrated against observations, Grover said, in general it shows that high inflow has a very strong potential to terminate blooms and suppress or remove *P. parvum* populations. The model also suggests that high inflow events can have a long-lasting effect with many months passing before *P. parvum* becomes abundant again.

"First, (the model) provides us a way to examine the role of processes, such as inflows, we hypothesize to be important," Grover said. "We can build models with and without the process to see what happens. Second, modeling can allow forecasting, prediction, and evaluation of management and treatment scenarios.

"Achieving this with a model is challenging, and it usually requires several rounds of building models and comparing them to observations to have credible forecasting and prediction. We have at least been able to move our modeling in the right direction during this project."

Roelke said when they started these studies, they knew very little about golden algae. Information from the Texas Parks and Wildlife Department (TPWD) and the Brazos River Authority (BRA), combined with the extensive monitoring efforts of this research team, revealed the influence inflow and salinity have on bloom formation, and added historical context and extended the researchers' ability to reach conclusions about the factors of inflow and salinity.

An inflow event during winter of 2006-2007 eliminated the toxic bloom in Lake Granbury and lowered salinity, resulting in golden algae not blooming.

"This event demonstrated in a striking way that inflow has an important influence," Grover said. "Additionally, we were able to verify that some of the equations used in our modeling approaches can make short-term forecasts of the influence of such events."

Roelke added that the time scales under which salinity and inflow work are different.

"Salinity, when it gets reduced, stays low for years," he said. "Salinity increases happen over years, typically during extended periods with low precipitation. The really wet winter during 2006-2007 lowered lake-wide salinity, below a bloom threshold for golden algae. The salinity has not gone back up from that year, and *P. parvum* is even further removed from its growth optimum."

Grover said when they first started this research, they had two important questions about golden algae. "First, we had noted that within the Brazos River basin, Lake Waco had never experienced blooms, even though a sparse population was present, while Lakes Possum Kingdom, Granbury, and Whitney had experienced fish-killing blooms. We also had reason to suspect that cyanobacteria in Lake Waco were producing something that suppressed growth of *P. parvum*."

From that information, their two main questions were: 1) What is keeping *P. parvum* out of Lake Waco, and is it something produced by cyanobacteria? and 2) What factors allow *P. parvum* to bloom in cool weather while keeping it sparse during summer?

The researchers generalized their hypothesis about cyanobacteria and allelopathy (chemical warfare between species) keeping *P. parvum* from blooming in Lake Waco to say that whenever cyanobacteria are abundant, they will limit growth of *P. parvum*.

"We didn't get a clear answer to our questions about the allelopathy of cyanobacteria towards *P. parvum*," Grover said. "When we tested microcystin, a chemical commonly produced by cyanobacteria, it did not have a negative effect on *P. parvum*, and small amounts were even positive. However, cyanobacteria produces a variety of other chemicals that remain to be examined."

When looking at how seasons affect the blooms, they were able to gather some helpful information using current and historical information regarding inflows and salinity.

"In Texas waters, *P. parvum* blooms occur in relatively cool weather, usually starting in autumn or winter and then ending in late winter or spring," Grover said. "*P. parvum* populations are consistently low during summer. In contrast, laboratory growth ⇨

Through previous funding, researchers conducted in-lake experiments using limnocorrals at Lake Granbury focused on mitigation of golden algae blooms.

experiments have consistently shown very rapid population growth at temperatures characteristic of summer, and slow to moderate growth at the cooler temperatures of other seasons."

Roelke, Grover, and Brooks have learned a great deal more than was previously known about golden algae and their blooms through these past six years of research. However, more information is still needed.

"We know of many factors that influence golden algae blooms, but we need to understand them better to put into the model to better enhance our predictive availability," Roelke said. "The bulk of our human population in Texas is centered around our urban centers; our urban centers are growing, and they're not located in areas where there is a lot of water. So what that means is there is going to be less flow through our reservoirs and rivers."

He added that since inflows strongly influence blooms, if urbanization causes less inflow, then there is the risk of having stronger golden algae blooms.

"Lessons learned from our work in these heavily impacted Texas reservoirs are now supporting efforts in the northeastern United States, where *P. parvum* blooms have recently caused devastating fish kills in Pennsylvania and West Virginia," Brooks said. "For example, salinity and instream flow thresholds for harmful *P. parvum* blooms are critical in Pennsylvania and West Virginia, too. In fact, the approach employed in this project, which couples laboratory and in situ experiments with field monitoring and predictive modeling, is applicable to other regions of the United States."

Roelke said, "What we can do right now with very limited funding is get a detailed morphology of Lake Granbury. We need to know the contours of the coves because we need a better feel of hydrologic residence times in the coves, because if we pursue pH manipulation, we need to know the volume of the cove and how much chemical to add."

The researchers continue to study the effects of these treatments and management options using experiments and models working toward a larger in-lake demonstration, implementing some of these treatments to see their large-scale effects.

"We are in a strong position to plan careful pilot experiments at scales larger than those we've used before," Grover said.

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For more information about this research, please visit *twri.tamu.edu/txH2O*.