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TEXAS A&M UNIVERSITY

COLLEGE OF AGRICULTURE
AND LIFE SCIENCES

Texas A&M University – Lake Granbury and Lake Whitney Assessment Initiative

Annual Progress Report

July 14, 2010

DOE Award Number: DE-FG02-08ER64604

Recipient: Texas AgriLife Research, Bryan, Texas

Project Director: Dr. B.L. Harris, Texas AgriLife Research

Texas Water Resources Institute
make every drop count

This report includes project activities conducted from October 2008 to July 2010.

4. Progress Report Narrative:

The "Texas A&M University – Lake Granbury and Lake Whitney Assessment Initiative" project was developed to address water quality issues in Central Texas. Both Lake Granbury and Lake Whitney, reservoirs constructed on the main stem of the Brazos River, have experienced recent toxic blooms of *Prymnesium parvum* (Golden algae) that have resulted in massive fish kills and concerns about general water quality. In general terms, the project aims to address these concerns by providing critical information about the relationships between the Golden algae and environmental factors (i.e. salinity, nutrients, and bacteria) in these lakes. Significant progress in laboratory and in-lake experiments has been made thus far and activities will continue through the remainder of the project period.

5. Established Goals and Current Project Accomplishments:

The overarching objectives of this research are two-fold. The first addresses the role of interactions between *P. parvum* and phytoplankton competitors through the mechanism of allelopathy as it relates to bloom initiation, persistence and termination. The second objective focuses on the continued development of a predictive numerical model where competitive interactions, life history, the physicochemical environment, and lake dimensions are more accurately depicted. We will accomplish our overarching objectives by achieving the following specific objectives:

Role of allelopathy:

- To conduct system-wide, year-round sampling at monthly intervals in Lakes Granbury and Whitney where parameters measured include multiple characterizations of water quality (including allelopathy potential and toxicity) and plankton community composition. This effort will include high-resolution spatial mapping of these lakes to document the spatial extent of blooms and locate potential bloom initiation "hot spots," which may be targeted by fisheries scientists for preemptive management (e.g., targeted nutrient, algaecide treatment).
- To perform multivariate statistical analysis (non-metric multidimensional scaling) of the field data where correlations between phytoplankton biomass and composition, allelopathy potential, toxicity, and multiple characterizations of the physicochemical environment as they may occur at different times of the year and in different locales of each lake are the primary focus.
- To perform controlled laboratory experiments using cultured competitors and grazers common to Lakes Granbury and Whitney, as well as cultured P. parvum, to investigate the potential roles of allelopathy from cyanobacteria in P. parvum bloom formation, persistence and termination.

Further development of model:

- To build phytoplankton competitors into our existing numerical model where interactions between species through allelopathy are represented. The laboratory

experiments mentioned in specific objective #3 will be used for validation of this portion of the model.

- To perform controlled laboratory experiments focused on the role of mixotrophy in P. parvum bloom formation and termination.
- To build P. parvum mixotrophy effects into the numerical model where the laboratory experiments mentioned in specific objective #5 will be used for validation.
- To expand a P. parvum population dynamics "box" model into a 1-dimensional, spatially explicit model more representative of a reservoir environment, thereby enabling the continued study of the factors influencing P. parvum bloom demographics. Data products from specific objective #1 will be used for validation.

This research, coupled to findings from previous research and a concurrent project at Lake Waco funded by Texas Parks and Wildlife Department, will increase the understanding of *P. parvum* blooms in Texas, and better enable the development of mitigation and management strategies aimed at preventing harmful blooms.

List of Primary Deliverables

- High-resolution spatial maps of Lake Granbury and Lake Whitney to be used for system-wide characterizations of chlorophyll *a*, dissolved organic matter, transparency, photosynthetically active radiation, conductivity, and temperature. The maps will also be used for validation of the numerical model (TAMU, UTA).
- Multivariate statistical analyses and interpretation of temporal and spatial relationships between inorganic nutrients (NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, SiO_2), total and dissolved organic carbon, phytoplankton biomass (chlorophyll *a*) and community composition (ChemTax), *P. parvum* population density, cyanobacteria density, toxicity, coliform bacteria, DO, pH, temperature, conductivity, turbidity, oxidation-reduction potential, and secchi disk (TAMU, BU).
- Continued model development which will produce a 1-D spatially explicit, time-dependant numerical model focused on *P. parvum* demographics in Texas reservoirs (UTA, TAMU).

After a validated model is produced, all PIs will be involved in model simulations focused on potential management solutions to *P. parvum* blooms.

Current Accomplishments

- Our laboratory experiments have shown that growth of golden algae can occur at salinities ~1-2 psu but only when temperatures are also low. This is a new finding, and helps to explain why blooms are possible during winter months in Texas lakes.
- Our laboratory and in-lake experiments have shown that nutrient additions will remove toxicity and prevent golden algae from blooming. In fact, other algae displace the golden algae.

- Our laboratory and in-lake experiments have also shown that additions of barely straw extract (useful for controlling some nuisance algae) have no effect on golden algae blooms.
- Our in-lake monitoring has revealed that golden algae are present throughout the year, even in lakes where blooms do not occur.
- Our in-lake monitoring showed that the highly toxic bloom that occurred in Lake Granbury in the winter of 2006/2007 was obliterated by high river inflow events. It appears as though the bloom was flushed from the system. The lower salinities that resulted might have contributed to golden algae not blooming in the winter of 2007/2008. The bloom is starting again, however, our January 2009 sampling revealed a bloom in the upper reaches of the lake and fish are dying.
- In Lake Whitney, the highly toxic bloom that occurred in the winter of 2006/2007 was also obliterated by high river inflow events. Flushing, however, did not terminate this bloom as the lake rose 10 feet but no water was released from the dam at this time. The influx of nutrients is likely what stopped toxin production and allowed other phytoplankton to out-compete golden algae.
- Our in-lake experiments in Lake Whitney and Lake Waco revealed that cyanobacteria from Lake Waco, or some other bacteria capable of producing algicides, is cable of preventing golden algae from blooming in Lake Whitney. Identification of this organism is a very high priority as it may be a key to managing golden algae blooms.
- Our numerical modeling results support the idea that cyanobacteria, through production of chemicals harmful to golden algae, control the timing of golden algae blooms in Lake Granbury.
- Our in-lake experiments in Lake Whitney and Lake Waco also revealed that as golden algae blooms develop there are natural enemies (a species of rotifer, and a virus) that slow down the growth of the golden algae. Again, better characterization of these organisms is a very high priority as it may be key to managing golden algae blooms.

6. Cost Status:

Collectively, the total project budget for the project was $479,000. The original agreement was scheduled to terminate on 7/15/2009; however, a one-year no-cost extension was requested. Upon receipt of project funds, sub-accounts were set up for the individual tasks. As of March 31, 2009, $403,724 or 84 percent of the originally allotted $479,000 had not been spent. It was anticipated that a total of $386,300 would be expended by the contract closing date on 7/15/2009.

7. Schedule Status:

Deliverables/Milestones

- The overall results of the sampling efforts, high-resolution spatial maps, multivariate statistical analyses, and 1-D numerical model simulations of bloom

dynamics and potential management strategies will be included in the Final Scientific Report.

Scheduled Delivery Date: 10/15/2009
Actual Delivery Date: 10/15/2010

8. Changes in Approach or Aims:
No changes are needed with this project. All deliverables will be completed for this task by the end of the contract period.

9. Actual or Anticipated Problems and Corrective Actions:
No actual or anticipated problems exist related to this project.

10. Absence or Changes in Key Personnel:
As the current Acting Director for TWRI, Dr. B. L. Harris replaced Dr. C. Allan Jones as project director. Separate documentation noting this change was provided.

11. Product Descriptions:

a. Publications/presentations:

Publications:

Baker, J.W., J.P. Grover, R. Ramachandrannair, C. Black, T.W. Valenti, Jr, B.W. Brooks, D.L. Roelke. Growth at the edge of the niche: an experimental study of the harmful alga Prymnesium parvum. Limnology and Oceanography. In Review.

Brooks, B.W., S.V. James, T.W. Valenti Jr., F. Urena-Boeck, C. Serrano, L. Schwierzke, L.D. Mydlarz, J.P. Grover, D.L. Roelke. Comparative toxicity of Prymnesium parvum in inland waters. Journal of American Water Resources Association. In Review

Grover J.P., J.W. Baker, D.L. Roelke, B,W. Brooks. Mathematical models of population dynamics of Prymnesium parvum in inland waters. Journal of American Water Resources Association. In Review.

Roelke, D.L., L. Schwierzke, B.W. Brooks, J.P. Grover, R.M. Errera, T.W. Valenti Jr., J.L. Pinckney. Factors influencing Prymnesium parvum population dynamics during bloom formation: Results from in-lake mesocosm experiments. Journal of American Water Resources Association. Accepted.

Schwierzke, L., D.L. Roelke, B.W. Brooks, J.P. Grover, T.W. Valenti, Jr., M. Lahousse, C.J. Miller, J.L. Pinckney. The role of grazers and viruses in Prymnesium parvum bloom development: In situ experiments from a subtropical lake. Journal of American Water Resources Association. In Review.

Errera, R.M., D.L. Roelke, R. Kiesling, B.W . Brooks, J.P. Grover, L. Schwierzke, F. Ureña-Boeck, J.W. Baker, J.L. Pinckney. 2008. The effect of imbalanced nutrients and immigration on Prymnesium parvum community dominance and toxicity: Results from in-lake microcosm experiments, Texas, USA. Aquatic Microbial Ecology. 52: 33-44.

Roelke, D.L., R. Errera, R. Kiesling, B.W. Brooks, J.P. Grover, L. Schwierzke, F. Ureña-Boeck, J. Baker, J.L. Pinckney. 2007. Effects of nutrient enrichment on Prymnesium parvum population dynamics and toxicity: Results from field experiments, Lake Possum Kingdom , USA. Aquatic Microbial Ecology. 46:125-140.

Harman, J.G., and J.P. Grover. 2008. Mixotrophy and the persistence of Prymnesium parvum when in competition with bacteria. Internationale Vereinigung für Theoretische und Angewandte Limnologie, Verhandlungen 30, part 2: 231-234.

Baker, J.W., J.P. Grover, B.W. Brooks, F. Ureña-Boeck, D.L. Roelke, R.M. Errera, R. Kiesling. 2007. Growth and toxicity of Prymnesium parvum (Ha ptophyta) as a function of salinity, light and temperature. Journal of Phycology. 43:219-227.

Grover, J.P., J.W. Baker, F. Ureña-Boeck, B.W. Brooks, R. Errera, D.L. Roelke, R.L. Kiesling. 2007. Laboratory tests of ammonium and barley straw extract as agents to suppress abundance of the harmful alga Prymnesium parvum and its toxicity to fish. Water Research. 41: 2503-2512.

Presentations:

Brooks, B.W., Theodore W. Valenti Jr ., Susan V. James, Fabiola Urena-Boeck, Laura D. Mydlarz, James P. Grover, Daniel L. Roelke. Factors influencing ambient toxicity associated with Prymnesium parvum in inland waters. Golden Algae Sym posium, Fort Worth, TX, January 27-31, 2009.

Gable, G., Roelke, D., Grover, J., Brooks, B. Spatiotemporal water quality monitoring for Lakes Granbury, Whitney and Waco, Texas. Golden Algae Symposium, Fort Worth, TX, January 27-31, 2009.

Glass, J, H-P. Li, D.L. Roelke. Prymnesium parvum cell counts, intensity of fish kills and in-situ water quality monitoring of two winters on three Brazos River lakes - 2006 to 2008. Golden Algae Symposium, Fort Worth, TX, January 27-31, 2009.

Grover, J.P., Jason W. Baker, Daniel L. Roelke, Bryan W. Brooks. Mathematical models of population dynamics of Prymnesium parvum in inland waters. Golden Algae Symposium, Fort Worth, TX, January 27-31, 2009.

Hewitt, N., Roelke, D., Grover, J., and Brooks, B. Numerical approach to modeling Prymnesium parvum population dynamics under varied conditions of nutrient availability: Validation with in-lake mesocosm data. Golden Algae Symposium, Fort Worth, TX, January 27-31, 2009.

Hewitt, N., Roelke, D., Grover, J., and Brooks, B. Numerical approach to modeling Prymnesium parvum population dynamics under varied conditions of nutrient availability: Validation with in-lake mesocosm data. Graduate Student Research Symposium, College Station, TX, March 7, 2009.

Roelke, D.L., Leslie Schwierzke, Bryan W. Brooks, James P. Grover, Reagan M. Errera, Theodore W. Valenti Jr., James L. Pinckney. Factors influencing Prymnesium parvum population dynamics: The potential role of cyanobacterial allelopathy during in-lake experiments at the time of bloom initiation. Golden Algae Symposium, Fort Worth, TX, January 27-31, 2009.

Schwierzke, L., Daniel L. Roelke, Bryan W. Brooks, James P. Grover, Theodore W. Valenti, Jr., Mieke Lahousse, Carrie J. Miller, James L. Pinckney. The role of grazers and viruses in Prymnesium parvum bloom development: In situ experiments from a subtropical lake. Golden Algae Symposium, Fort Worth, TX, January 27-31, 2009.

Valenti, T.W., Mieke Lahousse, Susan V. James, Daniel R . Roelke, James P. Grover, Kevin A. Schug, Bryan W. Brooks. A potential explanation for pH-dependant potency of Prymnesium parvum toxins. Golden Algae Symposium, Fort Worth, TX, January 27-31, 2009.

Grover, J.P., Jason W. Baker, Daniel L. Roelke, Bryan W. Brooks. Mathematical models of population dynamics of Prymnesium parvum in inland waters. Oklahoma-Texas Aquatics Research Group-Great Plains Limnology Conference, Oklahoma Biological Station, October 2008.

James, S., T.W. Valenti, F. Urena-Boeck, B.W. Brooks, J. Grover, D. Roelke. Comparative Sensitivity of Select Aquatic Organisms to the

Harmful Algae Prymnesium parvum. Society of Environmental Toxicology and Chemistry. Tampa Bay, Florida. November, 2008.

Roelke, D.L., Leslie Schwierzke, Bryan W. Brooks, James P. Grover, Reagan M. Errera, Theodore W. Valenti Jr., James L. Pinckney. Factors influencing Prymnesium parvum population dynamics in subtropical lakes: The potential role of cyanobacterial allelopathy. Oklahoma-Texas Aquatics Research Group-Great Plains Limnology Conference, Oklahoma Biological Station, October 2008.

Roelke, D.L., Leslie Schwierzke, Bryan W. Brooks, James P. Grover, Reagan M. Errera, Theodore W. Valenti Jr., James L. Pinckney. Factors influencing Prymnesium parvum population dynamics: The potential role of cyanobacterial allelopathy during in-lake experiments at the time of bloom initiation. Texas Aquatic Plant Management Society, Bandera, Texas, September 8-10, 2008.

Valenti, T.W., M. Lahousse, S. James, B.W. Brooks, J. Grover, D. Roelke. Factors that influence the potency of toxins released by Prymnesium parvum Carter (Golden Algae). Society of Environmental Toxicology and Chemistry. Tampa Bay, Florida. November, 2008.

Valenti, T., Mieke Lahousse, Susan James, Daniel Roelke, James Grover, Bryan Brooks. Potential factors influencing the pH-dependent aquatic toxicity of Prymnesium parvum Carter (golden algae). Society of Environmental Toxicology and Chemistry. Houston, Texas. May, 2008.

b. Websites: Information from this project, as well as other projects in the watershed, is available online at: http://lakegranbury.tamu.edu. A general project description, a list of collaborators, funding agencies, news stories, technical reports and quarterly progress reports are all available at this site.

c. Networks or collaborations fostered: Through this and previous projects conducted in the Lake Granbury Watershed, continued collaboration and support has been received from the following groups:

Texas Water Resources Institute
Texas AgriLife Research
Texas AgriLife Extension Service
Texas Commission on Environmental Quality
Brazos River Authority
USDA Natural Resources Conservation Service
Texas Parks and Wildlife Department
Baylor University
University of Texas at Arlington
Hood County, Texas

d. Technologies/Techniques: N/A

e. Inventions/Patent Applications: N/A

f. Other Products: N/A