The Mission of the Robert B. Annis Water Resources Institute (AWRI) at Grand Valley State University is to integrate education, outreach, and research to enhance and preserve freshwater resources.

Located in Muskegon, Michigan, the Institute’s work centers around three main focal areas:

Research into major questions about aquatic ecology, chemistry and toxicology, fisheries ecology, hydrology, microbial ecology, aquatic molecular ecology, ecosystem restoration, and ecological modeling.

Information Services use state-of-the-art geospatial technology to collect and analyze data, and condense them into useful information for those who make critical decisions about natural resources management.

Education & Outreach to graduate and undergraduate students, K-12 students, policymakers, educators, and the general public.
2016: SOLVING PROBLEMS WITH TECHNOLOGY AND INTRUITION

DR. ALAN STEINMAN, DIRECTOR

The challenges facing the aquatic resources within the Great Lakes region are diverse, very by location, and change over time. The challenge of harmful algal blooms facing the western basin of Lake Erie is different than the fear surrounding an Asian carp invasion in the Chicagoland region of Lake Michigan. The toxic sediments that plagued the Great Lakes in the past are being removed, but new stressors are taking their place in the form of microplastics, climate change, and groundwater depletion.

Addressing these emerging issues requires a combination of more powerful technology and human insight. As you will see in this 2016 AWRI Year in Review, several of our new projects involve emerging technologies and instrumentation to allow us to better understand the organisms and processes taking place in our region. At times, it is easy to become seduced by new technology, as these instruments spit out enormous amounts of information at ever finer temporal and spatial scales. However, we never want the technology to drive the research questions; quite the opposite—we want to make sure we use the best possible technology as tools to answer the critical questions of our time. It takes insight, deep thinking, and intuition to understand the problems, and to then design the experiments or fieldwork necessary to address these challenges. And that is exactly what we aim to do at AWRI.

As you will see in this Year in Review, we are asking how do we manage and control unwanted invasive species, such as baby’s breath? We are using new genetic sequencing instruments to produce information on the amount of genetic variation in this organism, to determine the most effective strategy to manage and control them. We are asking how do we know if an algal bloom is toxic or not? We are using flow cytometers, most often used in hospital settings, along with emerging molecular techniques, to determine in near real time if that algal bloom in your lake is toxic or not.

And because one of our key missions is to educate the water stewards of the future, we continue to provide real world, hands-on learning experiences for students ranging in age from 9 to 90. Our research and education vessels have now provided on-board learning experiences for over 165,000 passengers. That number continues to stagger me. Our summer undergraduate programs provide about 20 internships for students both at GVSU and around the country. And our graduate program continues to thrive—some of their exciting projects, and the awards they have received, are highlighted in the following pages.

As always, on behalf of the faculty, staff, and students at AWRI, I thank you for your interest, support, and feedback. Please don’t hesitate to contact us if you have questions.
**AWRI IMPLEMENTS qPCR METHODS FOR BEACH MONITORING**

AWRI completed its second year of polymerase chain reaction (qPCR) testing of Muskegon County beaches. qPCR is the quantitative amplification of DNA conducted in real time. For the 2016 program, AWRI collected and analyzed beach samples for E. coli by traditional culture-based techniques and the more rapid qPCR method. AWRI research assistant Brian Scull and a group of Michigan State University and U.S. Environmental Protection Agency staff provided a training workshop for laboratories involved in qPCR methods implementation and also organized a validation study to determine method precision and accuracy. Dr. Richard Rediske presented a comparison of qPCR and culture-based methods at the Great Lakes Beach Conference in Marquette MI. Brian Scull made a presentation on the implementation of qPCR methods in water quality laboratories and was part of the conference program organization. The qPCR beach monitoring program is in partnership with Public Health Muskegon County and can provide results in 4 hours. Future applications of qPCR include waterborne parasites and microbial source tracking.

**USING MOLECULAR TECHNIQUES TO RAPIDLY ASSESS HARMFUL ALGAL BLOOMS**

AWRI began the development of quantitative polymerase chain reaction (qPCR) and imaging flow cytometry (IFC) methods as part of a Michigan Department of Environmental Quality grant to rapidly assess harmful algal blooms. The qPCR techniques will assess genetic capability of cyanobacteria cells to produce toxins and the degree of toxin production. The IFC methods have the potential to provide near real-time confirmation of toxin production in algal blooms. AWRI Drs. Richard Rediske, Charlyn Partridge, and Kevin Strychar are co-principal investigators.

**AWRI INVESTIGATES SOURCES OF FISHERIES IMPAIRMENT IN INDIAN MILL CREEK**

AWRI is working with the Grand Valley Metropolitan Council to investigate the source(s) of fisheries impairment in Indian Mill Creek. The creek is the only coldwater rated fishery within the greater Grand Rapids area.

**ADAPTIVE MANAGEMENT OF INVASIVE BABY’S BREATH IN GREAT LAKES SAND DUNES**

The Great Lakes sand dunes comprise the largest freshwater sand dune system in the world and are a vital resource for the Great Lakes region. One challenge impacting this ecosystem is the colonization of invasive species, which alter community biodiversity and affect native species. Within Sleeping Bear Dunes National Lakeshore (SBDNL), one of the most aggressive invasive plants is baby’s breath (Gypsophila paniculata). This species outcompetes native vegetation and over-stabilizes the naturally shifting dunes. Drs. Charlyn Partridge, Jim McNair, and Kevin Strychar at AWRI, along with partners at The Nature Conservancy (TNC), were awarded an Environmental Protection Agency – Great Lakes Restoration Initiative grant to evaluate the effectiveness of different techniques used to remove this invasive plant. Students, along with TNC crews, spent this summer in SBDNL removing roughly 30 acres of baby’s breath from previously untreated areas. They also collected tissue from over 800 plants across 7 populations for genetic analysis.

**MODIFIED DETECTION METHOD FOR FECAL INDICATOR BACTERIA**

Graduate student Ben Giffin is working to modify a method for rapid detection of fecal indicator bacteria. This new method will greatly reduce analysis time and be able to differentiate live versus dead bacteria.

**PUSHING FORWARD WITH TECHNOLOGY TRANSFER AT AWRI**

With aid from AWRI and GVSU’s technology transfer experts, previous AWRI graduate student Syndell Parks has developed a full-service genetic identification technology under the name of GenPass, LLC. While housed in rented laboratory space at AWRI and incubator space out of the Muskegon Innovation Hub, 2016 marked the first year for GenPass to operate independently of the University. GenPass has worked with customers from Maine to California and continues to grow the business and the possible services it can offer.
Researchers at AWRI are often asked a simple question—“Is the water quality of my lake good or bad?” Unfortunately, there is no guarantee that anyone has ever tested their water. One AWRI researcher has been giving some thought as to how a non-scientist might measure water quality in a cost-effective and reliable fashion.

Associate research scientist John Koches has built, tested, and assessed the use of drones and other autonomous vehicles to collect environmental data. In 2016, Koches was assisted by GVSU Engineering students Gabrielle Thelen (left) and John Smutny (right). Thelen, a grant recipient from the Michigan Space Grant Consortium, helped create an autonomous vessel called the BoatBot. Smutny helped design and build a monitoring probe that can measure water temperature, conductivity (dissolved ions), and depth. Both the BoatBot and the monitoring probe offer a low cost solution for property owners and others interested in learning more about their environment.

Initial testing of the autonomous research vessel designed and built by AWRI staff and student researchers began in earnest during fall 2016. The one-meter BoatBot is intended to carry AWRI’s own suite of water quality probes and will be tethered wirelessly to one of AWRI’s existing UAVs (unmanned aerial vehicles), so as to simultaneously gather aerial data from surrounding waters and shoreline.

While sampling in the Au Sable River system, AWRI affiliate scientist Dr. Mark Luttenton discovered the presence of the invasive New Zealand mudsnail (Potamopyrgus antipodarum). Mudsnails had previously been reported from the Pere Marquette River. Reproduction is one key to the mudsnail’s success as an invasive species; they reproduce asexually, allowing a single individual to start a new population and they can produce many offspring very quickly. Mudsnails can reach densities of over a half million per square yard, overwhelming the native invertebrates.

AWRI graduate student Jay Zuidema is embarking on a research project comparing several approaches to estimating rates of stream ecosystem metabolism. Working with AWRI scientist Dr. Jim McNair, Jay will compare estimates based on four variants of the free-water dissolved-oxygen method. This method uses time series of dissolved-oxygen concentration, temperature, and light in streams to estimate rates of carbon uptake and loss by living organisms. These rates are significant components of the global carbon cycle.

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AWRI RESEARCHER MENTORS GVSU ENGINEERING STUDENTS TO DEVELOP TOOLS FOR CITIZEN SCIENTIST

AWRI “BOATBOT” UNDERGOES INITIAL TESTING

HOW TO MAKE IT CHEAP, ACCESSIBLE, DURABLE AND ACCURATE

The challenge facing anyone looking to equip today’s “citizen scientist” is to find tools that are inexpensive, readily available, durable, and reasonably accurate. The answer lies in the use of off-the-shelf components and “open source” technology. AWRI researchers use microprocessors like Arduino and credit card size computers like Raspberry Pi to develop sophisticated scientific instruments capable of remote deployment and hours of dependable operation for a fraction of the usual cost.

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Suse LaGory, a graduate student working with Dr. Carl Ruetz, was awarded the George L. Disborough Trout Unlimited Research Grant from the Kalamazoo Community Foundation to support her thesis research on brown trout and mottled sculpin. Suse is tagging fish in a local stream to assess how survival and movement vary between summer and winter. Suse completed her summer research in 2016, tagging over 400 fish. She will begin her winter research in January 2017.

Al Steinman was awarded the 17th annual Patricia B. Johnson Community Leadership Award, in recognition of a dynamic individual or organization with visionary leadership and a strong spirit of innovation by the Community Foundation for Muskegon County. Al was almost at a loss for words (which is saying something), but spoke from the heart when he said “the two greatest assets in Muskegon are the water and its people… Muskegon’s support of our work and, certainly, the distinguished work of past Patricia B. Johnson Award recipients, remind me why I am deeply grateful and proud to call Muskegon my home.”

Now in its third year, AWRI continues to assist with ecological monitoring for Project Clarity—the restoration of Lake Macatawa and its watershed. Monthly stream monitoring for sediment and nutrients by the Steinman lab helps assess both watershed health and the effectiveness of newly restored wetlands in the watershed. Additionally, graduate student Emily Kindervater’s thesis research on the use of two-stage ditches as tools to retain sediment and phosphorus from agricultural fields could lead to the ditches being more widely adopted as a best management practice. Complementary annual fish monitoring in Lake Macatawa by the Ruetz lab allows AWRI scientists to gauge the response of the fish community to watershed restoration efforts, as well as compare Lake Macatawa fish population trends to those in Muskegon Lake.

Restoring habitat for fish and wildlife is a critical need to remove Muskegon Lake from the list of Great Lakes Areas of Concern. A major step to meeting our habitat restoration goal has now been taken with the start of reconnecting the former Bosma property to the lower Muskegon River. The Steinman lab, in collaboration with Dr. Steve Hamilton’s lab at Michigan State University, is simulating the impact of reconnecting this former celery field to the Muskegon River using field surveys and laboratory experiments, to test whether inundating this property with river water results in a major flush of phosphorus from the former farm sediments to the river, and ultimately to Muskegon Lake and possibly Lake Michigan.
AWRI at work

1 » Undergraduate student Evan Hausig (left) and R.B. Annis Foundation intern Michael MacEachron (right) conduct invertebrate sampling in Great Lakes coastal wetlands.

2 » Grad students Suse LaGory (left) and Greg Chorak (right) identify and measure fish captured during a stream electrofishing survey.

3 » Graduate student Kim Oldenborg filters Spring Lake water samples for phosphorus analysis.

4 » Research assistant Andrya Whitten with largemouth bass captured during a boat electrofishing survey.

5 » Undergraduate student assistant Nicole Hahn collects water during seasonal Muskegon Lake monitoring.

6 » Captain John Bontrager (left) and marine engineer Dave Fisher (right) prepare for a W.G. Jackson outreach trip in Hammond, Indiana.

7 » Graduate student Emily Kindervater (left) and research assistant Maggie Oudsema (right) collect a sediment core from a two-stage ditch in an agricultural field in Allegan County.

8 » Scientech Club Foundation intern Macy Doster (left), technical call-in Morgan Lindback (center), and graduate student Katie Knapp (right) retrieve the underwater buoy from Muskegon Lake for sensor check and maintenance.

9 » Grad student Travis Ellens with brown trout captured during electrofishing survey in a west Michigan stream.

10 » Scientific technician Mike Hassett samples water quality in the lower Muskegon River wetland restoration area.

11 » Science instructors Diane Venneklausen (left) and Michele Svoboda (right) during an educational cruise this summer aboard the D.J. Angus.
**The Impact of Climate Change on Deep-Water Coral**

Climate change is "warming" oceans globally, including a poorly studied region called the mesophotic zone (~30-150 m). Mesophotic zones are a potential refuge where coral from these depths may be used to "reseed" reefs at shallower depths. John Skutnik, who conducted his MS thesis research with Kevin Strychar at AWRI, found that chronic heat exposure elicited a physiological response at 30°C, which he proposed as a heat-stress threshold for Montastrea cavernosa at this depth. Hence, these coral are as susceptible to heat-stress as their shallow-water counterparts and may not be the refuge scientists once thought.

**ARE VIRUSES IN LAKE MICHIGAN “RESIDENTS” OR PRODUCTS OF INVASIVE AQUATIC SPECIES?**

This summer, AWRI researchers examined multiple cores taken in deep water (~300 ft.) from Lake Michigan’s bottom to establish what viruses exist in the aquatic sediments at these depths. The project’s goal is to determine what “resident” viruses are present versus those potentially brought in during the establishment of invasive Quagga mussels. Initial results show high viral loads in the deeper water sediments.

**ARE VIRUSES IN LAKE MICHIGAN “RESIDENTS” OR PRODUCTS OF INVASIVE AQUATIC SPECIES?**

AWRI’s graduate student Nick Gezon sampling cores from Lake Michigan in 300 ft. of water.

**Bottom Water Hypoxia: A Fishy Housing Crisis**

The biologically productive Muskegon Lake ecosystem experiences low concentrations of dissolved oxygen (~4 mg/L; hypoxia) in its bottom waters during the summer each year when the lake is stratified. Most desirable fish taken for sport or consumption require higher concentrations of dissolved oxygen to survive, thus hypoxia presents a problem. Graduate student Anthony Weinke sampled the bottom water fish community at the Muskegon Lake Buoy Observatory before, during, and after the 2015 hypoxic season. During hypoxia, there were fewer fish species, fewer total fish, and smaller fish as opposed to high dissolved oxygen periods in spring or fall. Hypoxia may act as a barrier that limits fish habitat in Muskegon Lake, affecting approximately a quarter of the lake volume during peak hypoxic periods. This would force fish to move to shallower, warmer waters where they may be at increased risk of predation or in suboptimal habitat for growth and reproduction.

**Finding a Lake’s Productivity Peak and Nap Time**

Graduate student Angela Defore and advisor Bopi Biddanda examined seasonal changes in plankton biomass, production, and respiration in Muskegon Lake. Results published in Aquatic Microbial Ecology (2016), reveal that phytoplankton biomass and productivity peak during the summer – explaining the productive fisheries. However, net respiration prevailed during the winter, regenerating nutrients phytoplankton need to grow. Slow, yet significant winter metabolic activity may play a critical role in the annual carbon and nutrient balance of temperate lakes. Whether the seasonal occurrence of bottom water hypoxia (described above) has the net effect of increasing or decreasing the annual phytoplankton and fish production in the lake, is a question we are trying to answer.

**TIME-TRAVELING IN LAKE HURON’S UNDERWATER SINKHOLES**

As part of a multi-institutional collaborative National Science Foundation-funded research project to understand life in low-oxygen, high-sulfur ecosystems, the Biddanda lab and collaborators are diving to study purple cyanobacterial mats that cover the lake floor in Lake Huron’s sinkholes. Could modern-day microbial mats such as these have oxygenated the Earth during life’s turbulent childhood?

Graduate student Angela Defore sampling Muskegon Lake water and incubating bottles underwater through a hole in the ice during the winter.
Modeling Persistence of Bacteroidales Bacteria in Stream Water and Sediment

Bacteria of order Bacteroidales are a promising alternative to E. coli as an indicator of recent fecal contamination in the environment. Working with data from stream water and sediment microcosms provided by Auburn University collaborator Dr. Yucheng Feng, AWRI scientist Dr. Jim McNair developed a semi-mechanistic statistical model that makes it possible to estimate the apparent mortality rate, mean persistence time, and percentiles of persistence time of bacterial populations in the microcosms. Drs. McNair and Feng used these new statistical tools to compare mortality and persistence of Bacteroidales bacteria and E. coli. They also compared genetic bacterial abundance estimates based on qPCR (quantitative polymerase chain reaction) with and without using PMA (propidium monoazide), a chemical additive that in effect prevents qPCR from counting dead cells. The results show that Bacteroidales persisted much shorter than E. coli and therefore, should be a better indicator of recent contamination. Additionally, qPCR with PMA appeared to provide more accurate estimates of Bacteroidales abundance; and hence the degree of contamination, than did qPCR without PMA.

AWRI’s NSF-Funded REU Program Enters Year 2

Summer 2016 marked the second year of AWRI’s 3-year Research Experiences for Undergraduates program, operated with funding obtained from the National Science Foundation by AWRI scientists Drs. Jim McNair and Kevin Strychar. The 2016 class of 10 students hailed from Puerto Rico, North Carolina, New Jersey, Missouri, Minnesota, Michigan, Iowa, Indiana, and Alabama and included Hispanic, indigenous American, African American, and Asian students. Further information about AWRI’s REU program is available online (www.gvsu.edu/wri/mcnair/reu-request).

Integrated Watershed Commission Project

Funded by the C.S. Mott Foundation, the Frey Foundation, and the Community Foundation for Muskegon County, AWRI’s Integrated Watershed Commission project explores innovative strategies to govern Michigan’s water resources in a more coordinated fashion. Stakeholders from various sectors have assembled in downtown Grand Rapids for a series of workshops on water management topics, helping develop a more collaborative network of water-related thought leaders and decision makers. The project will produce a report assessing the feasibility of moving Integrated Watershed Commissions forward in Michigan.

Celebrating 20 and 30 Years of Service

Over 165,000 students and others have experienced hands-on science on AWRI’s D.J. Angus and W.G. Jackson vessels since 1986. Additionally, the vessels are used for research projects. In 1986, the D.J. Angus was delivered to Grand Haven, Michigan. The vessel was named after Donald J. Angus, who had donated his yacht, the original Angus, to GVSU in 1965. Fleet Captain Tony Fiore notes that many improvements have been made to the vessel throughout the years.

As the aquatic education program grew, a second vessel was needed. After less than a year of fundraising, the W.G. Jackson (named in honor of Dr. William G. Jackson) was launched in 1996. Its home port is in Muskegon. The 65-foot vessel has traveled to 33 ports of call in Lake Michigan delivering onboard activities to thousands of people. More on the history of the vessels and AWRI can be found in Dedicated to Our Aquatic Resources – A History of the Robert B. Annis Water Resources Institute by Gordon Olson (accessible at http://www.gvsu.edu/wri/history).

Project Reunites Education Staff

AWRI hosted the filming of online lessons for the Michigan Environmental Education Curriculum Support’s (MEECS) Air Quality and Energy Units. According to Amanda Syers, MEECS Project Assistant from the GVSU College of Education, educators will be able to gain insight into the practical application of the curriculum through these online videos. Rachel Kent and her students from Fruitport Middle School were featured in the video lessons. When Amanda and Rachel were education assistants at AWRI, they helped in AWRI’s development of lessons for the MEECS Climate Change and Air Quality units, respectively. The videos can be found at http://wgvu.pbslearningmedia.org/collection/meeecs/.

Research scientist Janet Vail received the 2016 Informal Science Educator of the Year Award from the Michigan Science Teachers Association.

Science instructor Sherry Claffin was awarded the 2016 Earth Science Teacher of the Year by the Michigan Earth Science Teachers Association.
AWRI FACULTY & STAFF

Director:
Alan Steinman, Professor

Staff/Administrative:
Tonya Brown, AWRI Assistant
Roxana Taylor, Secretary
Paula Wicklund, Office Coordinator

Facilities/Maintenance:
Roger Hillstead, Maintenance
Leonard Wittlief, Maintenance

Information Services Center:
John Koches, Associate Research Scientist
Rod Denning, Research Associate
Betty Gajewski, Technical Call-in
Gabrielle Thelen, Undergraduate Student Assistant

Outreach & Education:
Janet Vail, Research Scientist
Paula Capizzi, Lead Instructor DJA
Sherry Claffin, Science Instructor
Lea Dyga, Reeths Puffer High School intern
Cheri Gerhart, Science Instructor
Ann Hesselswee, Science Instructor
Shirley McIntire, Science Instructor
Penny Reid, Science Instructor
Michele Smith, Science Instructor
Michele Svoboda, Science Instructor
Diane Veneklassen, Science Instructor

GVSU Vessels/Field Station Operations:
Anthony Fiore, Jr., Captain
John Bontrager, Captain WGJ
Jonathan Brewster, Deckhand DJA
Dave Fisher, Marine Engineer WGJ
Kevin Fitch, Captain DJA
Allan Girvin, Dockhand WGJ
Pete Hewett, Dockhand WGJ
Emily Morris, Dockhand
Brad Nieboer, Marine Electrician
Jim Rahe, Dockhand WGJ
Peter Stoeckle, Dockhand DJA

Ecological Research, Environmental Chemistry:
Richard Rediske, Professor
Jessica Daie, Undergraduate Student Assistant
Drew McWilliams, Technical Call-in
Brian Scull, Research Assistant

Ecological Research, Environmental Biology:
Bopaiash Biddanda, Professor
Fallon Januska, Technical Call-in
Scott Kendall, Technical Call-in
Dirk Koopmans, Postdoctoral Researcher
Morgan Lindback, Technical Call-in
Collin Saunders, Technical Call-in
Mark Luttenton, Professor of Biology
Jim McNair, Associate Professor
Charlyn Partridge, Assistant Professor
Syndell Parks, Technical Call-in
Carl Ruetz III, Professor
Evan Hausig, Undergraduate Student Assistant
Sarah Koeber, Technical Call-in
Nick Previle, Undergraduate Student Assistant
Andrys Whitten, Adjunct Research Assistant
Alan Steinman, Professor
Nicole Hahn, Undergraduate Student Assistant
Mike Hassett, Scientific Technician
Dave Kraft, Adjunct Research Assistant
Maggie Oudsema, Research Assistant
Kurt Thompson, Research Associate
Kevin Strychar, Associate Professor

Graduate Students:
Biddanda, major advisor
Katie Knapp, AWRI Assistantship
Anthony Weinke, AWRI Assistantship
Luttenton, major advisor
Justin Wegner, AWRI Assistantship
Graeme Zaparzynski, AWRI Assistantship
McNair, major advisor
Emma Rice, AWRI Assistantship
Jay Zuidema, AWRI Assistantship
Partridge, major advisor
Ben Griffen, AWRI Assistantship
Hailee Pavisich, AWRI Assistantship
Andrew Pyman, AWRI Assistantship
Rediske, major advisor
Victoria Harris, AWRI Assistantship
Daniel Myers, AWRI Assistantship
Rajesh Sigdel, AWRI Assistantship
Ruetz, major advisor
Greg Chorak, AWRI Assistantship
Travis Ellens, AWRI Assistantship
Kaitlyn Emelander, AWRI Assistantship
Susanna LaGory, AWRI Assistantship
Jason Lorenz
Steinman, major advisor
Delilah Clement, AWRI Assistantship
Emily Kindervater, AWRI Assistantship
Kimberly Oldenborg, AWRI Assistantship
Xiaomei Su, University of Chinese Academy of Sciences Assistantship
Strychar, major advisor
Nick Gezon, AWRI Assistantship
John Skutnik, AWRI Assistantship

AWRI Science Advisory Board
Harvey Bootsma, University of Wisconsin – Milwaukee
Carol Johnston, South Dakota State University
Gary Lambert, University of Notre Dame, Chair
Don Scavia, University of Michigan

AWRI provides opportunities for students to pursue their interests in our environment. The following students received internships during 2016.

Scientech Club Foundation Intern:
Macy Doster

Herbert VanderMey Intern:
Jacob Rumschlag

Robert B. Annis Foundation Interns:
Matthew Kienitza
Michael MacEachron
Amanda McCarthy
John Smutny
Rebecca Soll

Bill and Diana Wiperfurth Scholarship:
Zakry O’Brien

Ron Ward Scholarship:
Kaitlin Camp
Michaela Castleman
Jacob Chapman
Bryan Flannery
Katherine Foy

NSF-REU Quest Students:
Katherine Bonilla
McKenna Burns
Alexandra Crum
Eli Jacobson
Valerie Martin
Pamela Martinez-Oquendo
Alan Mock
Marielys Santana
KrystleSaylon
Mary Szoka
J.P. O'Keefe
2015. Spatial and temporal dynamics of phytoplankton


Zhao, Q., Q. Xue, X. Su, L. Xie, Y. Yan, L. Wang, and A.D. Steinman. 2016. First identification of the toxicity of microcystins on pancreatic islet function in human and the involved potential biomarkers. Environmental Science & Technology 50(9):3137-44. DOI: 10.1021/acs.est.5b03369


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Giving opportunities to support the operations of the Annis Water Resources Institute are available at the Community Foundation for Muskegon County, www.cffmc.org or at the GVSU Office of Development, www.gvsu.edu/giving.

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