R.B. ANNIS WATER RESOURCES INSTITUTE

2016 YEAR IN REVIEW

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.

GRAND VALLEY STATE UNIVERSITY
ROBERT B. ANNIS WATER RESOURCES INSTITUTE

Photo Credit: Emily Kindervater

2016: **SOLVING PROBLEMS** WITH **TECHNOLOGY** AND **INTUITION**

DR. ALAN STEINMAN, DIRECTOR

The challenges facing the aquatic resources within the Great Lakes region are diverse, vary 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.

TABLE OF CONTENTS

AWRI RECEIVES THE **2016 EDUCATION AWARD** FROM THE **MICHIGAN ENVIRONMENTAL HALL OF FAME**

Dr. Richard Rediske accepts the 2016 Education/ School Award from the Michigan Environmental Hall of Fame.

AWRI was inducted into the 2016 class of the Michigan Environmental Hall of Fame. The Environmental Hall of Fame honors individuals and organizations that have made a significant contribution to the protection and preservation of Michigan's natural resources.

ISRAELI DELEGATION **VISIT**

A delegation from Israel visited AWRI in September, as part of a visit titled: *"Sustainable Management of Iconic Lakes—Lessons Learned from Lake Michigan and Lake Kinneret (Sea of Galilee)"*. AWRI faculty and Israeli scientists were joined by representatives from the state and federal government to discuss the similarities and contrasts of the two famous water bodies, and how we can collaborate in the future. A book proposal has already emerged.

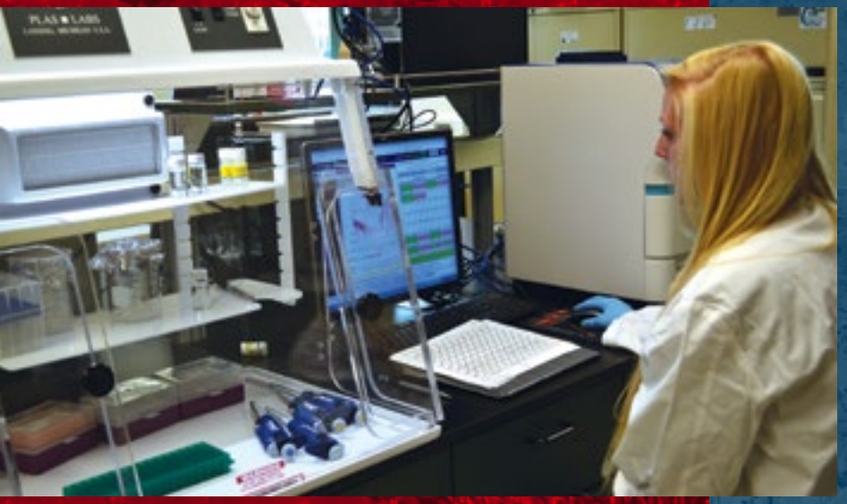
Al Steinman (center) pointing out features to Drs. Tamar Zohary (former director of Lake Kinneret Laboratory – left) and Doron Markel (Director of Lake Kinneret Watershed Management, Israel Water Authority – right).

Dan Yates talking about the influence of Bob Annis.

R.B. ANNIS RECOGNIZED

Robert B. Annis was recognized posthumously with the Grand Valley University Foundation's Enrichment Award at the 2016 Enrichment Dinner. Dan Yates, Director of the R.B. Annis Foundation, accepted the award and a video honoring Bob Annis' life was played (www.gvsu.edu/wri/videos-102.htm).

AWRI IMPLEMENTS qPCR METHODS FOR BEACH MONITORING



Graduate student Tori Harris conducts qPCR testing of beach monitoring samples.

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.

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

Invasive baby's breath patch in Sleeping Bear Dunes National Shoreline. Photo Credit: Hailee Pavisich.

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.

Matt Kienitz and Hailee Pavisich collecting baby's breath tissue for genetic analysis. Photo Credit: Emma Rice.

MODIFIED DETECTION METHOD FOR FECAL INDICATOR BACTERIA

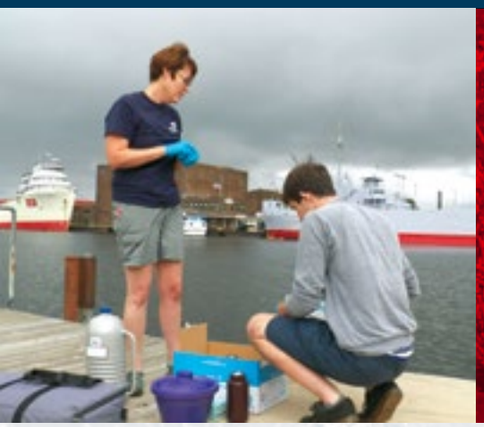
Graduate student Ben Giffin is working to modify a method for rapid detection of fecal indicator bacteria. This new method will greatly reduce analysis time and be able to differentiate live versus dead bacteria.

Ben Giffin testing new *E. coli* detection methods. Photo Credit: Hailee Pavisich.

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.

USING MOLECULAR TECHNIQUES TO RAPIDLY ASSESS HARMFUL ALGAL BLOOMS



Dr. Charlyn Partridge and graduate student Andrew Pyman process cyanobacteria samples for qPCR analysis.

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.

Dr. Richard Rediske, graduate student Rajesh Sigdel, undergraduate student Amanda McCarthy, and NSF REU interns Valerie Martin and McKenna Burns examine benthic macroinvertebrate samples from Indian Mill Creek.

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

Gabrielle Thelen with AWRI's BoatBot and commercially available quadcopter to be used together to test their wireless tether capability for water quality research.

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.

John Smutny displays AWRI designed and built Conductivity, Temperature, and Depth (CTD) sonde for "Citizen Scientist" led research.

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.

AWRI "BOATBOT" UNDERGOES INITIAL **TESTING**

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.

First "in-lake" trial of the AWRI BoatBot held in Muskegon Lake adjacent to the GVSU Lake Michigan Center.

DISCOVERY OF **NEW ZEALAND MUDSNAILS** IN **MICHIGAN RIVERS**

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.

New Zealand mudsnail with eggs taken from the Au Sable River. Photo Credit: Mark Luttenton.

ALTERNATIVE APPROACHES TO ESTIMATING STREAM METABOLISM

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.

GREAT LAKES FISH SUPPLEMENT COASTAL RIVER ENERGY BUDGETS

Ecologists have widely acknowledged that organisms move from one habitat to another and from ecosystem to ecosystem; in stream ecosystems, this movement is from upstream to downstream. However, a study recently completed by Emily Dean, a graduate student working with Dr. Mark Luttenton, has shown that organisms moving upstream may play an important role in stream ecology. Emily found that fish migrating upstream from Lake Michigan transport a significant amount of energy in the form of biological tissues which can be measured as calories. These calories can be used by stream organisms for basic metabolism and growth. If migratory fish in Lake Michigan decline, coastal streams may lose an important source of energy causing a substantial change in stream communities.

GRADUATE STUDENT RECEIVES FUNDING TO STUDY STREAM FISHES

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.

Suse LaGory clips the pelvic fin to mark a mottled sculpin.

Brown trout captured in a tributary of the Rogue River, Kent County.

Suse LaGory samples stream fishes with a backpack electrofisher.

PROJECT CLARITY: RESTORING THE LAKE MACATAWA WATERSHED

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.

Dr. Carl Ruetz holding a bowfin taken from Lake Macatawa.

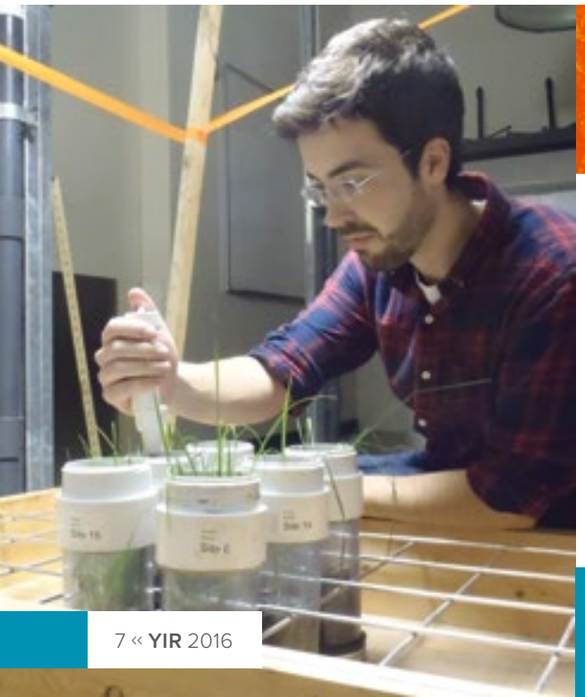
AWRI research assistant Maggie Oudsema and graduate student Emily Kindervater taking a snowmelt sample from the Macatawa River.

HABITAT RESTORATION AT VETERANS MEMORIAL PARK

Staff and students working with Dr. Carl Ruetz are conducting fish and water quality monitoring to evaluate the benefits of habitat restoration at Veterans Memorial Park along the Muskegon River.

Fyke net installed in Veterans Memorial Park pond for fish monitoring.

Aerial image of Veterans Memorial Park in Muskegon, Michigan.



INITIATION OF LOWER MUSKEGON RIVER RECONNECTION PROJECT

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.

Scientific technician Mike Hassett measuring sediment moisture content from Bosma wetland sediment cores.

PATRICIA B. JOHNSON AWARD

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."

KEISER DISTINGUISHED LECTURER IN LIFE SCIENCES

Al Steinman was awarded the Keiser Distinguished Lecturer in Life Sciences for 2016-2017 from Ohio Northern University. He spent three days on campus in October, giving numerous presentations and working with students. Previous awardees include marine biologists Sylvia Earle and James Estes.

AWRI at work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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.

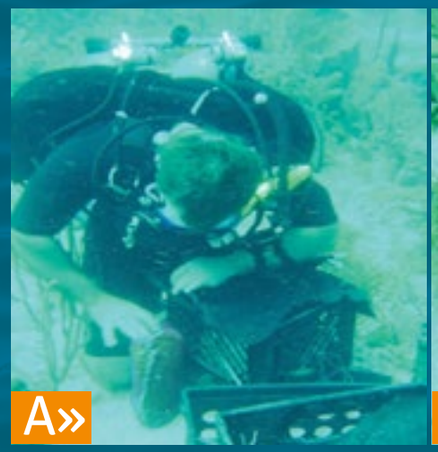
8 » Scientech Club Foundation intern Macy Doster (left), technical call-in Morgan Lindback (center), and graduate student Katie Knapp (right) retrieve the underwater buoy from Muskegon Lake for sensor check and maintenance.

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 Veneklasen (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**

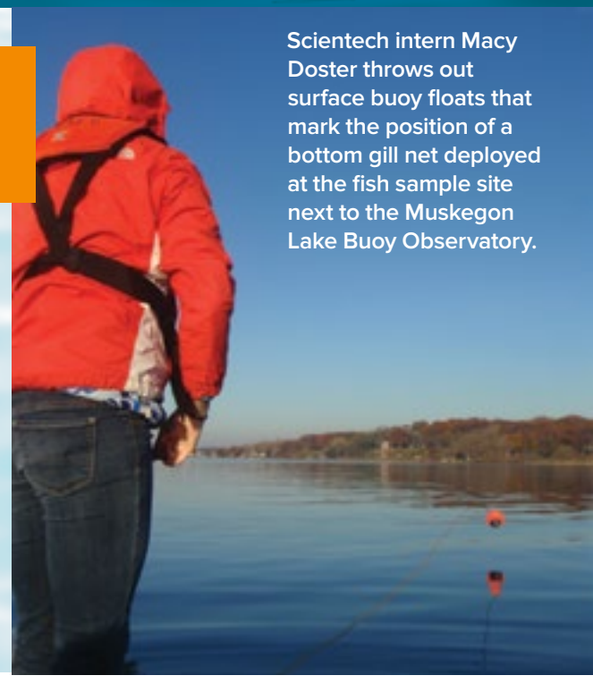


(A) John Skutnik underwater collecting coral (*Montastraea cavernosa*) samples for study.
(B) *Montastraea cavernosa*.
Photo Credit: K.B. Strychar.

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 *Montastraea 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.

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.



Scientech intern Macy Doster throws out surface buoy floats that mark the position of a bottom gill net deployed at the fish sample site next to the Muskegon Lake Buoy Observatory.

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.

Graduate student Angela Defore sampling Muskegon Lake water and incubating bottles underwater through a hole in the ice during the winter.

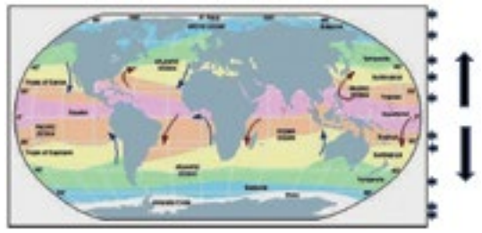
ARE **VIRUSES** IN **LAKE MICHIGAN "RESIDENTS"** OR PRODUCTS OF **INVASIVE AQUATIC SPECIES?**

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.

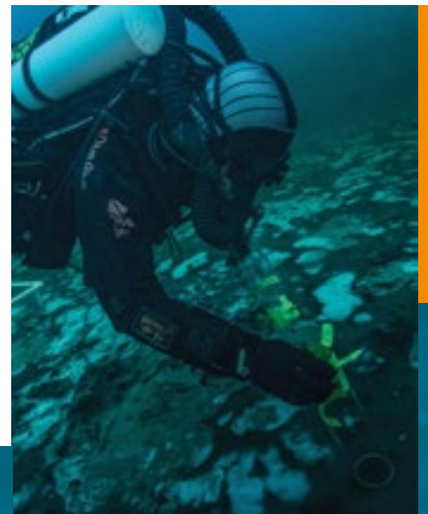
AWRI's graduate student Nick Gezon sampling cores from Lake Michigan in 300 ft. of water.

CLIMATE CHANGE IMPACTS AT **UNPRECEDENTED RATES**

The effects of climate change and global warming including the poleward movement of our current climatic zones are coming at the expense of the polar and subpolar zones. We predict the creation of a new "Hyper-Tropical Zone" at the center of the Equatorial Zones, characterized by mass mortalities causing both local endemic and global pandemic extinctions.



Oceanic climatic zones defined in 2015. The Equatorial Zone may expand northward and southward at the expense of the Sub-polar and Polar zones, which will shrink in size. (Adapted from Sammarco and Strychar in Goffredo and Dubinsky, 2016)



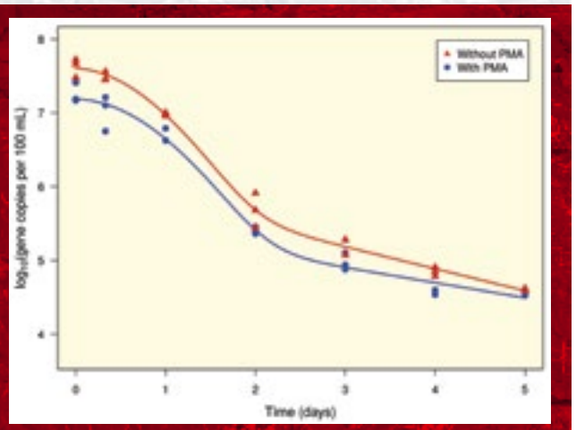
TIME-TRAVELING IN **LAKE HURON'S** UNDERWATER **SINKHOLES**

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?

Diver collecting an intact core of the microbial mats carpeting the Lake Huron sinkhole floor. Photo Credit: Phil Hartmeyer, NOAA-Thunder Bay National Marine Sanctuary.

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 Bacteriodales 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.



qPCR abundance estimates (triangles, circles) and predicted curves for Bacteroidales survival in stream water microcosms. Results are shown for abundance estimates based on qPCR both without PMA (red) and with PMA (blue).

AWRI'S NSF-FUNDED **REU PROGRAM** ENTERS YEAR 2

Student participants in AWRI's 2016 REU program. Back row: Drs. Strychar (left) and McNair (right).

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/reuquest).

Al Steinman addresses stakeholders at the first Integrated Watershed Commission project workshop.

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.

D.J. Angus

W.G. Jackson

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/meecs/.

Rachel Kent (left) and Amanda Syers (right) preparing students for taping of a video lesson.

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

Science instructor Sherry Claflin was awarded the 2016 Earth Science Teacher of the Year by the Michigan Earth Science Teachers Association.

AWRI FACULTY & STAFF

Photo Credit: Emily Kindervater

Director:
Alan Steinman, Professor

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

Facilities/Maintenance:
Roger Hillstead, Maintenance
Leonard Wittlieff, 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 Claflin, Science Instructor
- Lea Dyga, Reeths Puffer High School intern
- Cheri Gerhart, Science Instructor
- Ann Hesselsweet, Science Instructor
- Shirley McIntire, Science Instructor
- Penny Reid, Science Instructor
- Michele Smith, Science Instructor
- Michele Svoboda, Science Instructor
- Diane Veneklasen, Science Instructor

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

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

Ecological Research, Environmental Biology:
Bopaiah 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 Preville, Undergraduate Student Assistant
- Andrya Whitten, Adjunct Research Assistant

Alan Steinman, Professor
- Nicole Hahn, Undergraduate Student Assistant
- Mike Hassett, Scientific Technician
- Dave Kraff, 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 Giffin, 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
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Gary Lamberti, University of Notre Dame, Chair
Don Scavia, University of Michigan

INTERNSHIPS & SCHOLARSHIPS

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 Kienitz
Michael MacEachron
Amanda McCarthy
John Smutny
Rebecca Soll

Bill and Diana Wipperfurth 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
Krystle Saylon
Mary Szoka

PEER-REVIEWED PUBLICATIONS

Photo Credit: Suse LaGory

AWRI staff in bold
Undergraduate Students*
Graduate Students**
Post-doctoral Fellows***

Baskaran, M., T. Novell, K. Nash, S.A. Ruberg, T. Johengen, N. Hawley, J.V. Klump, and **B.A. Biddanda**. 2016. Tracing the seepage of subsurface sinkhole vent waters into Lake Huron using radium and stable isotopes of oxygen and hydrogen. Aquatic Geochemistry 22(4):349-374.

Bhagat, Y.***, **C.R. Ruetz III**, and **A.L. (Koster) Akins***. 2015. Differential habitat use by the round goby (*Neogobius melanostomus*) and *Dreissena* spp. in coastal habitats of eastern Lake Michigan. Journal of Great Lakes Research 41(4):1087-1093.

Brennan, A.K., C.J. Hoard, J.W. Duris, **M.E. Ogdahl**, and **A.D. Steinman**. 2016. Water quality and hydrology of Silver Lake, Oceana County, Michigan, with emphasis on lake response to nutrient loading, 2012–14. U.S. Geological Survey Scientific Investigations Report 2015–5158, 75 pp. http://dx.doi.org/10.3133/sir20155158

Defore, A.L.**, **A.D. Weinke****, **M.M. Lindback***, and **B.A. Biddanda**. 2016. Year-round measures of planktonic metabolism reveal net autotrophy in surface waters of a Great Lakes estuary. Aquatic Microbial Ecology 77(3):139-153.

Dila, D.K.** and **B.A. Biddanda**. 2015. From land to lake: contrasting microbial processes across a Great Lakes gradient of organic carbon and nutrient inventories. Journal of Great Lakes Research 41:75-85. DOI: 10.1016/j.jglr.2015.04.014

Duhamel, S., **G. Nogaro*****, and **A.D. Steinman**. 2016. Effects of water level fluctuation and sediment–water nutrient exchange on phosphorus biogeochemistry in two coastal wetlands. Aquatic Sciences. DOI: 10.1007/s00027-016-0479-y

Gerig, B.S., D.T. Chaloner, **D.J. Janetski*****, **R.R. Rediske**, **J.P. O'Keefe**, A.H. Moerke, G.A. Lamberti. 2016. Congener patterns of persistent organic pollutants establish the extent of contaminant biotransport by Pacific Salmon in the Great Lakes. Environmental Science & Technology 50(2):554-63.

Gillett, N.D.***, **M.R. Luttenton**, and **A.D. Steinman**. 2015. Spatial and temporal dynamics of phytoplankton communities in a Great Lakes drowned river-mouth lake (Mona Lake, USA). Journal of Limnology 74(3):453-466.

Hauff, B., **J.A. Haslun**, **K.B. Strychar**, P.H. Ostrom, J.M. Cervino. 2016. Symbiont diversity of Zooxanthellae (*Symbiodinium* spp.) in *Porites astreoides* and *Montastraea cavernosa* from a reciprocal transplant in the lower Florida Keys. International Journal of Biology 8(2):9-22. DOI: 10.5539/ijb.v8n2p9

Homola, J.J.**, **C.R. Ruetz III**, S.L. Kohler, and R.A. Thum. 2016. Complex postglacial recolonization inferred from population genetic structure of mottled sculpin *Cottus bairdii* in tributaries of eastern Lake Michigan, U.S.A. Journal of Fish Biology. DOI:10.1111/jfb.13101

Madenjian, C.P., **R.R. Rediske**, D.P. Krabbenhoft, M.A. Stapanian, S.M. Chernyak, and **J.P. O'Keefe**. 2016. Sex differences in contaminant concentrations of fish: a synthesis. Biology of Sex Differences 7(1):42. DOI: 10.1186/s13293-016-0090-x

Madenjian, C.P., O.P. Jensen, **R.R. Rediske**, **J.P. O'Keefe**, A.R. Vastano, S.A. Pothoven. 2016. Differences in energy expenditures and growth dilution explain higher PCB concentrations in male Summer Flounder. PLoS ONE 11(1):e0147223. DOI: 10.1371/journal.pone.0147223

Nogaro, G.***, **A.M. Harris***, and **A.D. Steinman**. 2016. Alum application, invertebrate bioturbation, and sediment characteristics interact to affect phosphorus exchange in eutrophic ecosystems. Freshwater Science 35(2):597-610.

Parks, S.R.**, **J.N. McNair**, P. Hausler, P. Tyning, and R.A. Thum. 2016. Divergent responses of cryptic invasive watermilfoil to treatment with auxinic herbicides in a large Michigan lake. Lake and Reservoir Management. DOI: 10.1080/10402381.2016.1212955

Qin, L., Q. Zeng, W. Zhang, X. Li, **A.D. Steinman**, and X. Du. 2016. Estimating internal P loading in a deep water reservoir of northern China using three different methods. Environmental Science and Pollution Research 23:18512-18523. DOI: 10.1007/s11356-016-7035-0

Rutherford, E.S., **J. Allison****, **C.R. Ruetz III**, J.R. Elliott, J.K. Nohner, M.R. DuFour, R.P. O'Neal, D.J. Jude, and S.R. Hensler. 2016. Density and survival of walleye eggs and larvae in a Great Lakes tributary. Transactions of the American Fisheries Society 145(3):563-577. DOI: 10.1080/00028487.2016.1145135

Sammarco P.W. and **K.B. Strychar**. 2016. Ecological and evolutionary considerations regarding corals in a rapidly changing environment. In: S. Goffredo, Z. Dubinsky (eds.), The Cnidaria, Past, Present and Future, pp.553-576. DOI 10.1007/978-3-319-31305-4_34

Steinman, A.D. and **M.E. Ogdahl**. 2016. From wetland to farm and back again: phosphorus dynamics of a proposed restoration project. Environmental Science and Pollution Research. DOI 10.1007/s11356-016-7485-4

Steinman, A.D., **M. Abdimalik***, **M.E. Ogdahl**, and **M. Oudsema**. 2016. Nutrient impact on planktonic vs benthic algae in a eutrophic lake. Lake and Reservoir Management.

Uzarski, D.G., V.J. Brady, M.J. Cooper, D.A. Wilcox, D.A. Albert, R. Axler, P. Bostwick, T.N. Brown, J.J.H. Ciborowski, N.P. Danz, J. Gathman, T. Gehring, G. Grabas, A. Garwood, R. Howe, L.B. Johnson, G.A. Lamberti, A. Moerke, B. Murry, G. Niemi, C.J. Norment, **C.R. Ruetz III**, **A.D. Steinman**, D. Tozer, R. Wheeler, T.K. O'Donnell, and J.P. Schneider. 2016. Standardized measures of coastal wetland condition: implementation at the Laurentian Great Lakes basin-wide scale. Wetlands. DOI:10.1007/s13157-016-0835-7

Wampler, P.J., A.R. Molla, and **R.R. Rediske**. 2016. Transdisciplinary approaches to sustainable water resources and treatment in developing countries. Water Resources IMPACT. 18(1):20-21.

Xue, Q., **A. D. Steinman**, X. Su, Y. Zhao, and **L. Xie*****. 2016. Temporal dynamics of microcystins in *Limnodrilus hoffmeisteri*, a dominant oligochaete of hypereutrophic Lake Taihu, China. Environmental Pollution. 213:585-593. DOI: 10.1016/j.envpol.2016.03.043

Xue, Q., X. Su, **A.D. Steinman**, Y. Cai, Y. Zhao, and **L.Xie*****. 2016. Accumulation of microcystins in a dominant Chironomid Larvae (*Tanypus chinensis*) of a large, shallow and eutrophic Chinese lake, Lake Taihu. Scientific Reports 6, 31097. DOI: 10.1038/srep31097

Zhao, Y., 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 humans and the involved potential biomarkers. Environmental Science & Technology 50(6):3137-44. DOI: 10.1021/acs.est.5603369

Zuiderveen, G., T. Evans, T. Schmidt, and **M. Luttenton**. 2015. A survey of the native and invasive genotypes of *Phragmites australis* along Michigan's west coast. The Michigan Botanist 54(3-4):82-91.

NON-PEER REVIEWED PUBLICATIONS

AWRI staff in bold
Undergraduate Students*
Graduate Students**
Post-doctoral Fellows***

Biddanda, B. and **D. Koopmans*****. 2016. Freshwater furnace: global significance of the changing freshwater carbon cycle. InterChange Newsletter: Regional Math and Science Center, GVSU 23(1) Connections for the STEM Classroom, http://www.gvsu.edu/rmsc/interchange/z2016-february-connections-1104.htm

Biddanda, B. 2016. The Anthropocene: defining a human-dominated earth. InterChange Newsletter: Regional Math and Science Center, GVSU 23(3) Connections for the STEM Classroom, http://www.gvsu.edu/rmsc/interchange/z2016-april-connection-1128.htm

Biddanda, B., **M. Lindback*** and **K. Ringler****. 2016. Saving the Biosphere by conserving half of Earth. A book review of Half Earth: Our Planet's Fight for Life by E. O. Wilson (Liveright, 2016). InterChange Newsletter: Regional Math and Science Center, GVSU 23(5) Connections for the STEM Classroom, http://www.gvsu.edu/rmsc/interchange/2016-september-connections-1162.htm

Denning, R. and **J. Koches**. Critical lands mapping project – Muskegon River Watershed, Wexford and Missaukee Counties, Michigan. AWRI Publication # MR-2016-01.

Denning, R. and **J. Koches**. Critical lands mapping project – Muskegon River Watershed, Osceola County, Michigan. AWRI Publication # MR-2016-02.

Koches, J., **R. Denning**, **B. Gajewski**, **A. Ebenstein***, **S. Stamann****, **C. Hamilton***, **C. Vandenberg***, and J. Gibson. Upper Muskegon River Watershed Management Plan, AWRI Publication # MR-2015-01, December 2015.

2016 MASTER OF SCIENCE THESES

Clement, D. (Advisor: **Steinman**). *Does phosphorus from agricultural tile drains fuel algal blooms?*

Dila, D. (Advisor: **Biddanda**). *From land to lake: contrasting microbial processes across a Great Lakes gradient of organic and inorganic nutrient inventories.*

Skutnik, J. (Advisor: **Strychar**). *Examining the effect of climate change on an upper mesophotic threshold community: Montastraea cavernosa.*

Weinke, A. (Advisor: **Biddanda**). *Green and choking: exploring the dynamics of seasonal productivity and hypoxia in a Great Lakes Area of Concern and habitat blueprint estuary using time-series measurements.*

Zaparzynski, G. (Advisor: **Luttenton**). *Evaluating foraging habits, and estimating prey consumption and growth of brook trout in a coolwater Michigan stream.*

IF YOU WOULD LIKE MORE INFORMATION ABOUT **AWRI'S PROGRAMS,** PLEASE CONTACT US.

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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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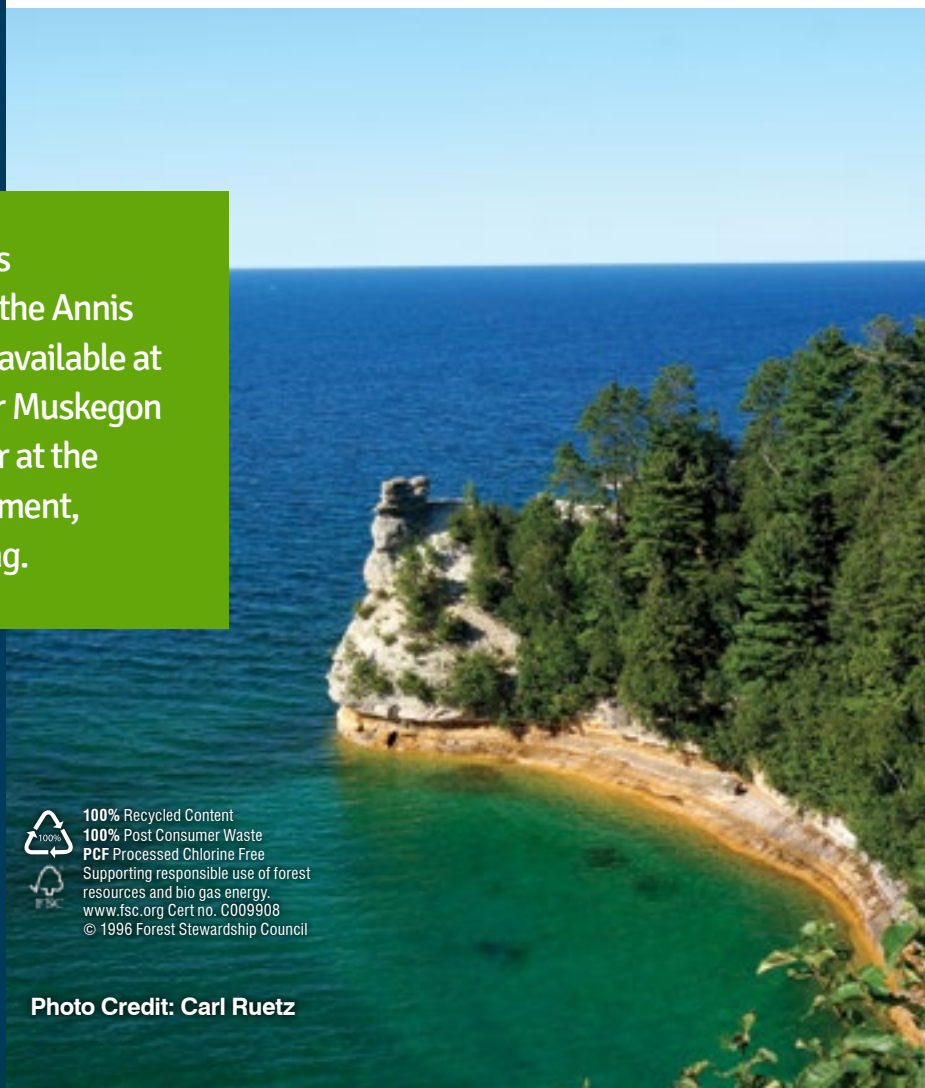

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